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Buckley Barracks – Hangar 3 Refurbishment

Vivo Defence Services
Job No. 4000034

Proposed Roof Works Justification Technical Note

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CONTENTS

1.0 INTRODUCTION 3
1.1 Planning background and scope of technical note 3
1.2 Hangar description 3
1.3 Scope and guidance 4
2.0 ROOF REPAIRS 5
2.1 Scope of the proposed roof repairs 5
2.2 Design changes and reviews since submission of applications 5
2.3 Previous Design iterations 7
3.0 FABRIC & MATERIAL ANALYSIS 9
3.1 Existing Roof Structure 9
3.2 Roof Alteration 10
3.3 New Roof Coverings 10
3.4 Impact on Historic Character and Significance 11
4.0 JUSTIFICATION 12
4.1 Overview 12
5.0 NEXT STEPS 15
6.0 Appendix A: Consultations with Planning Officer 16
7.0 Appendix B: Structural Design Calculations 18
8.0 Appendix C: Carbon Emission Calculations 19

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1.0 INTRODUCTION

1.1 Planning background and scope of technical note

1.1.1 A planning application for refurbishment works to the Grade II listed Hangar 3 at Buckley Barracks, Hullavington, (NHLE 1393020; listed as a group of three hangars), was submitted to Wiltshire Council in September 2023 (planning ref: PL/2023/07689). The planning application and the Listed Building Consent (LBC) application were accompanied by a Heritage Statement produced by Wessex Archaeology in August 2023.

1.1.2 The applications are currently under review. Following consultations with Mr Guy Bentham-Hill, Planning Officer assigned to the applications, carried out on 28th November 2023 (during an on-site meeting) and on 19th January 2024 (during a digital Teams meeting), it was determined that a technical note should be produced as a supporting document to focus on providing additional information and/or justification in relation to the proposed roof works. All other proposed works to the hangar are acceptable and do not require further supporting information. Details of the consultations to date are included in **Appendix A**.

1.1.3 The proposed roof works discussed in this technical note relate only to those intended for the original main hangar. The scope of roof works to the flat-roofed modern annexes to the north and south elevation of the main hangar are acceptable and do not require further information and/or justification.

1.1.4 This technical note should be read in conjunction with the 2023 Heritage Statement which includes a full assessment of the condition, significance and setting of the listed hangar.

1.2 Hangar description

1.2.1 The hangar is located at Buckley Barracks, an active military site formerly known as RAF Hullavington. It is a 'C' type storage hangar built between 1935 and 1936 to the designs of Bulloch, the architectural adviser to the Air Ministry's Directorate of Works and Buildings. 'C' type hangars were designed to house heavy bombs and accommodate workshops and squadron offices. A total of 155 hangars were built during the 1930s expansion period.

1.2.2 The hangar is steel framed with Bath stone ashlar on concrete with an asbestos slate roof. The dimensions of 'C' type hangars are typically 300ft long, 150ft wide, and 35ft in height.

1.2.3 Hangar 3 forms the most southernly of the 'C' type hangars listed under the same listing entry, with Buildings 6 and 7 to its north/north-east (between 40m to 140m).

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1.3 Scope and guidance

1.3.1 The scope of this technical note is to present the additional information required in support of the proposed roof works to Hangar 3.

1.3.2 Pertinent guidance considered in shaping this technical note is as listed below. For any other heritage specific guidance considered in the preparation of the Heritage Statement, Sections 2-3 of the statement should be consulted.

- BS 7913:2013 *Guide to the Conservation of Historic Buildings*; and
- Historic England, 2019. Statements of Heritage Significance: Analysing Significance in Heritage Assets (Historic England Advice Note 12).

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2.0 ROOF REPAIRS

2.1 Scope of the proposed roof repairs

2.1.1 The current scope of the proposed roof works presented in the planning and LBC applications is as follows:

- Removal of existing asbestos cement slates, ridge and hip tiles, battens, underlay, sarking boards, timber purlins, flashings, trim, rainwater gutters, valley gutters, hoppers and downpipes.
- Installation of Joris Ide Slate 1000 SF PIR composite panel roofing system (colour RAL7024).
- Installation of boundary gutter overflow pipes, including dressing in by single ply gutter linings, integral with composite panels roofing installation.
- Installation of tapered rainwater outlets within composite valley and boundary wall gutters to Contractor's Design.
- Installation of 80mm PIR insulation core composite galvanised steel, single ply membrane lined valley and boundary wall gutters, integral with composite panel roofing installation. Above ground rainwater disposal installations to Contractor's Design.
- Installation of Alumasc Heritage Cast Aluminium cast iron effect HR6 (150mm) gutter to canopy, colour: Textured Black. Alumasc Heritage Cast Aluminium cast iron effect 150mm dia downpipes, colour: Textured Black.

2.1.2 Further detailed information of the proposed roof structure is provided in Section 3 of **Appendix B**.

2.2 Design changes and reviews since submission of applications

2.2.1 Since the submission of the planning and LBC applications, there have been further consultations with manufacturers, in particular Joris Ide ('the manufacturer'), in regard to details of the composite panel roofing system. The most recent key points/correspondences with the manufacturer following the meeting on 19th January 2024 are as follows:

- It is possible and essential that the slat bond in ridge flashings lines through with that in the main panels below. This is because the three dimensional profiles in the flashings need to fully 'dovetail' into those of the panels. Drawing 4000034-Z1-ZZ-DR-A-2701_P03 now includes this requirement.

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- The suggestion that slate bond in hip and valley flashings should be orientated into and lined through with that in the roof panels was put to the roofing manufacturer. They do not manufacture these flashings and have said that fabricators will make planar flashings as it is not feasible to manufacture slate bonded patterns into these types of flashings (i.e., it is not considered prudent to have tow halves of a flashing re-manufactured into one, using a weld and re-finished; steel coil comes pre-finished) as the weatherability of the join cannot be guaranteed. As the manufacturer will not support the use of such a detail, Ingleton Wood does not have confidence in this and would have no comfort in using it. This detail will not be specified.
- The suggestion that flashings might be secret fastened or resin fixed was put to the roofing manufacturer. They stated that they neither manufacture nor supply materials for such details, and they are not included in their installation guides. As such they cannot support the suggestion and Ingleton Wood has no confidence in the weatherability and durability of such details and would have no comfort in using it. These details will not be specified.
- The suggestion of in situ formed glass fibre mat reinforced epoxy resin ridge, hip and valley flashings was put to the roofing manufacturer. They stated that they neither manufacture nor supply materials to form these specific flashings in this way and they are not included in their installation guides. As such, they cannot support the suggestion. As a result, Ingleton Wood does not have enough confidence in the weatherability and durability of such specific details to be able to include these in the design.

Concrete tiles

2.2.2 As part of the meeting on 19th January, the Planning Officer advised that the option of concrete tiles should be considered as they would be one of the most suitable like-for-like options. This option was investigated in February 2024 by the appointed Structural Engineer. The results of the investigations presented in **Appendix B** showed that a concrete tiled roof would not be suitable as there is not sufficient structural capacity in the underlying roof structure to support this. This is because a more heavyweight roof option (i.e., the use of concrete tiles) would nearly double the dead loading on the structure. Furthermore, originally exposed elements of the structure would need to be concealed with a heavyweight option by extensive and intensive reinforcing works and will render some areas inaccessible for inspection and maintenance works.

2.2.3 A full description of the existing roof structure is outlined in Section 1 of the resultant report which is appended to this technical note for reference (see **Appendix B**).

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2.3 Previous Design iterations

2.3.1 A key point raised during the consultations was to provide an account of how the design of the roof repairs has evolved in order to ensure that the best suitable option was taken forward. In light of this, the following sections present an account of previous options considered which were not presented in the planning and LBC applications due to them being considered unsuitable and unsustainable options.

Pre application iterations considered

2.3.2 Initially, an uninsulated roof was considered as an option using fibre cement slates and battens, counter-battens, underlay, plywood sarking, and timber purlins, as this would be as close to the existing build up as possible, and closest to the existing asbestos cement slates. This option would not, however, have satisfied the DIO carbon emission targets (see Section 4) and it would also have been difficult to meet and sustain comfortable working temperatures within the hangar during the heating seasons (see Section 4). For these reasons, this option was rejected.

2.3.3 An uninsulated roof using concrete roof tiles instead of cement slates (but otherwise similar to the above) was also considered. However, as presented in Section 4 of this technical note, the existing steel structure would not withstand the weight of this build-up. For this reason, this option was rejected.

2.3.4 Another option considered was for an insulated roof utilising fibre cement slates, battens, counter-battens, underlay, a combination of mineral wool and polyisocyanurate insulation slabs and a steel deck liner. While this option would have likely met the DIO's carbon targets (see Section 4), this build up would have caused the roof structure to fail and had to be rejected.

2.3.5 A roof utilising a single-ply polymeric membrane, PIR insulation and a plywood deck was initially assessed as that could have been within structural capacity and achieved a good degree of reduction in carbon emissions. This, however, would not have been in keeping with the context of the Hullavington Airbase Conservation Area and with the original roof coverings on the Grade II Listed Building.

2.3.6 As a final option, a roof utilising Kingspan K1000 RW composite panels was also considered. This is a typical insulated roof panel with a trapezoidal outside profile and finished in plastisol. This roof would have made significant inroads into DIO carbon targets and could have been supported by the existing roof structure. This roof would not, however, have been in keeping with the appearance of the Grade II Listed Building and would have borne no resemblance to its original roof covering. In

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addition, the wider site (that is, Buckley Barracks) falls within Hullavington Airbase Conservation Area and it is considered that this option would not have been sympathetic to its surrounding built environment which forms part of the special interest of the conservation area.

3.0 FABRIC & MATERIAL ANALYSIS

3.1 Existing Roof Structure

3.1.1 The main roof structure of this hanger appears to be largely as it was built with and in retains the form of a typical 1934 model C type. This is a series of hip ended roofs spanning across the building with a half roof at each end, in the form of a mono pitch structure against the end walls. In long section through the building this created a saw tooth roof arrangement with valley gutters between each section and another behind a low parapet wall to the perimeter at the bottom of the hips.

3.1.2 Each span section of the roof was framed-up with a large and deep central open lattice beam spanning from side to side manufactured from angle iron so as to create strong, but lightweight unit. Once these were in place then they were braced to the beams on either side with steel angle iron from the top of one to the bottom of the other so as to form an X shaped frame at 15’ 0” (4.6 m) centres.

3.1.3 Over the tops of where the side braces crossed a beam ran though to connect them and provide some additional rigidity to the overall structure and would then be used as the support under the valley gutters. Other beams and connecting steelwork ran horizontally below the cross braces to couple the bottoms of the long beams together to prevent displaced or potential wind load lean or displacement.

3.1.4 On to the upper faces of the diagonal cross bracing above the level of the valley gutter 9” x 3” (215 x 70 mm) purlins were fixed to angle iron brackets at 3’ 0” (900 mm) centres. This in turn supported 1” (25 mm) thick timber sarking boards, which were often creosote treated, with asbestos cement slates fixed directly on top without the use of battens.

3.1.5 Ridges were dressed in a traditional manner either with lead or zinc sheeting as would have been the hips. Flashing to brickwork would be traditional soakers and stepped cover flashing and at upstands to parapets they would have upstand and cove flashing, again in lead or zinc.

3.1.6 The overall impression of the roof when seen from above would have a multi pitch structure with hip ends softening its appearance and covered with slates, most probably of a traditional grey colour, set with a perimeter of upstand and parapet walls and of what would now be considered a traditional appearance. From ground level, because of the hipped ends to the roof spans, only the ends would have been readily seen and then producing a somewhat softened appearance.

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3.2 Roof Alteration

3.2.1 In replacing the current roof coverings there is no intention to undertake significant changes of modifications to the main framing or structure of the roof. It is only the secondary level upper roof that is to be altered to allow a new energy efficient roof to be installed to allow the continued and effective use of the internal space that it covers.

3.2.2 To enable work to commence on this structure the existing covering of asbestos cement slates are to be removed in a safe and regulated manner. This is to be strictly in accordance with the regulations covering this aspect of work as well as the disposal of the material.

3.2.3 Depending on the level of contamination found to the sarking boards and any underlining felt that may have been installed these will also be properly disposed of offsite. In addition, the remaining steelwork structure properly and thoroughly cleaned and prepared prior to repainting.

3.2.4 The timber purlins supporting the sarking boards are to be removed and the metal angle iron cleats that fix them to the tops of the roof frames will also be removed. Any de-rusting, further cleaning and necessary repairs are likely to be undertaken as part of this phase of the project to ensure the roof structure as a whole has a continued life and remains stable, secure and upright. Then when this part has been complete the re-roofing can commence.

3.3 New Roof Coverings

3.3.1 It is proposed to change the roof covering form to use a form of interlocking preformed thermally insulated panels to replace the original form of roof to greatly improve the energy efficiency of the building as well as remove asbestos with its associated health risks. These panels have an embossed outer face to produce the appearance of slates when seen from a distance and finished with a colour that is appropriate to match the previous covering to this roof.

3.3.2 The new roofing panels will be 120 mm deep and laid parallel to the roof slope. They will be laid up the slope from the valley gutters and finish with an insulated closer block under the ridge at the top, as well as under the panels at the bottom of the slope.

3.3.3 Z section purlins, 142 mm deep at 1.8 m centres, will span between the diagonal cross braces and carry counter channels 60 mm deep at 500 mm centres to support the new roof panels. When taken together with the thickness of the insulated panels the combined depth of roof build-up will be 322 mm compared with approximately 262 mm for a roof of more original form. Because of the general large extent of the roof and the bulk of the structure as a whole this increase will not be noticeable nor likely cause any visual discordance with how it would originally have been seen.

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3.3.4 New preformed and thermally insulated gutter sections will be installed to the central and perimeter gutters around the building supported on a combination of the original gutter beams as well as to tops the bottom Z purlins. This later installation method will help ensure the roof is weather tight from driving rain and snow. At the eaves to the overhang section a new fascia arrangement will be formed to close off the bottom of the roof slope as well as carry gutters in that position.

3.3.5 Flashings to achieve the appearance of those that would have been formed to the original roof will be achieved with having them formed in colour coated galvanised steel to match the roofing panels.

3.4 Impact on Historic Character and Significance

3.4.1 When completed the roof should, from external ground level viewing, achieve the retention of most of the appearance it would have if this were to be covered with slating, whether natural or asbestos cement, as might originally be fitted. The use of flashings matching to the new covering will provide a sufficient level of detailing to maintain the overall visual character of this historic roof.

3.4.2 Internally the roof will have a slightly different appearance on completion of the work when seen from ground level. One change will be to difference in colour and texture between the underside of undecorated timber sarking boarding and the colour smooth colour coated of the insulated panels, which will probably look brighter and reflect more light. The change from a simple set of timber purlins to their replacement with modern lightweight metal purlins and sheeting rails is likely to be less noticeable due to their height and being lost amongst the other elements of the roof framing.

3.4.3 In terms the effect of this work on the historic character and significance of this proposed roof material change it is likely to be slight overall. Externally there will be some minor alteration in terms of the aesthetics, where because of the distances involved these are unlikely to be readily noticeable. However, the greatly improved energy efficiency of the new roof covering will ensure that this whole building is able to remain in what can only be considered to be economic use and therefore help ensure its retention as part of our national built heritage and so it can only be judged as being very positive in is significance.

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4.0 JUSTIFICATION

4.1 Overview

4.1.1 As part of the consultations, it was requested that further justification for the roof works should be presented and that this does not necessarily have to be specific to heritage considerations only. As such, the following sections present additional justifications covering a variety of topics and reasonings for further context.

Current condition of Hangar 3

4.1.2 The current roof is no longer weatherproof, allowing water ingress. Furthermore, the asbestos cement slates are no longer in a fit or stable condition, thereby increasing the risk for the release of asbestos fibres. Damp and mould in particular have already caused harm to much of the building, and the building has now had to be closed off for health and safety reasons.

4.1.3 Should the roof not be repaired/replaced, there is the potential for further damage to Hangar 3 which could lead to the complete failure of the roof, its underlying structure and consequently its interior.

4.1.4 A DIO Facility Condition Management Condition Assessment Survey (CAS) was carried out on 18th May 2023. The survey showed that, on a scale of 0-5, the hangar was given a score of '1' meaning 'currently critical – not operational, unrepairable, unsafe to use'. In regard to the roof, the CAS made the following comments:

- Significant leaks present through roof.
- Timber sarking boards appear to have areas of rot.
- Asbestos slate roofing present minimises options available for repair.
- Valley gutter joints appear to be leaking.
- Valley gutter throats appear to be shallow and insufficient depth available in gutter to cope with intensity of rainfall causing internal overflows.
- Downpipes are cast iron and showing signs of corrosion.

Structural justification

4.1.5 As presented in **Appendix B**, the existing structure has been modified in parts. Based on historic drawings of the steel frame, the original roof trusses are designed with a pre-camber to reduce deflection and ensure adequate drainage. However, it is noted that one of the design flaws of Type

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C hangars in general is the poor roof drainage which makes the structure susceptible to degradation. Based on observations of the hangar, this poor roof drainage is one of the reasons for the water ingress, resulting in damp and mould spreading throughout the building.

4.1.6 As presented in **Section 2**, a more heavyweight option (for example, concrete tiles) would not be suitable considering the current capacity of the roof structure. A lighter-weight option would be required to not drastically exceed the current weight capacity of the roof structure. Details of the current roof system are as follows (which is an excerpt from **Appendix B**). For comparisons of the lightweight and heavyweight options against this, Section 3 of **Appendix B** should be consulted.

Existing Roof	Dead	Live
25mm Sarking boards	0.10	
215x70 Timbers @ 1100mm c/c (avg)	0.02	
Asbestos Cement Tile	0.20	
Services	0.10	
Imposed		0.60
Total	**0.42**	**0.60**

Working conditions & temperature control

4.1.7 The current hangar does not offer suitable temperature control features for effective and suitable managing working conditions. In line with DIO Performance Standard 5.0, an internal temperature of at least 16 degrees is required in workshops and CIBSE Guide A recommends a temperature between 16-19 degrees for vehicle servicing.

4.1.8 The current heating system at the hangar does not meet this requirement, and as such the proposed refurbishment works propose the upgrade of the heating system. In terms of how this relates to this technical note, the proposed roof works would allow for better heat retention, insultation and prevent water ingress.

Carbon emissions

4.1.9 The *DIO Strategy 2020-2030* notes that they intend to meet zero-carbon emissions by 2050. An important element of this will be to provide robust measurement of carbon emissions and other sustainability related data across the Defence Estate which will be captured by a Sustainability Management System. The roof works form part of this wider aim to reduce carbon emissions to ensure that the hangar meets the carbon emissions goal as DIO is keen to "*take proactive steps to support pilot initiatives such as zero-carbon buildings, as well as better understanding the historic estate and its resilience to climate change*".

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4.1.10 The current carbon emission of the hangar is at 33.95 $kgCO_2/m^2$ per annum. Taking into consideration the scope of the proposed works to the hangar, including the roof repairs, the levels could be improved to 17.82 kgCO2/m².annum. The carbon emission calculations are based on the existing roof (uninsulated) and can be seen in **Appendix C**.

Reversibility

4.1.11 A key component of the proposed roof works to consider is its reversibility. The current proposed composite slate tiles mean that, should it be needed, the tiles can easily be repaired and/or replaced as required. Furthermore, the proposal will not alter or damage the overall structure of the hangar. Notably, this is where the majority of the significance of the hangar is derived from (see Section 8 of the 2023 Heritage Statement).

4.1.12 The level of reversibility also means that future maintenance and replacements can more easily be managed in the future, thereby contributing to the overall long term preservation of the building.

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5.0 NEXT STEPS

5.1.1 Considering the presence of asbestos in the current cement slates, it is considered that it will not be suitable to undertake any kind of building recording or watching brief during their removal. However, once asbestos containing materials (ACMs) have been removed, and there is no further threat of ACM contamination, there is an option for recording works during the removal of the underlying roof structure to enhance our understanding of its original materials and composition.

5.1.2 Based on the above, it may be suitable for the planning and / or LBC application to be accompanied by an appropriately worded condition such as the following:

"No demolition of the existing roof (including the underlying roof structure) with the exception of the removal of the asbestos cement slates shall take place until a programme of archaeological building recording has been undertaken in line with an approved Written Scheme of Investigation (WSI) to be submitted to and approved by the Local Planning Authority prior to the commencement of the recording."

5.1.3 However, it must be noted that the scope of any conditions will need to be confirmed by the Planning Officer.

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6.0 APPENDIX A: CONSULTATIONS WITH PLANNING OFFICER

2023 (28th November 2023)

2024 (19th January 2024)

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Minutes

Project:	Hangar 3 Refurbishment, Hullavington Barracks
Subject:	Hangar Area Roof Justification Statement for Listed Building Consent Application
Job No:	4000034
Date/time:	19th January 2024. 12:30 hrs
Venue:	Microsoft Teams
Client:	Vivo Defence
Attendees:	1. Ben Bettle – Senior Associate, Ingleton Wood (BB) 2. Jonathan Fairbairn – Project Architect, Ingleton Wood (JF) 3. Guy Bentham-Hill – Senior Conservation Officer, Wiltshire Council (GB-H) 4. Sarah Generalski-Sparling – Principal Consultant, Wessex Archaeology (SG-S) 5. Paul Dayment – Project Manager, Vivo Defence (PD)
Distribution:	To those present plus: 1. N/A 2. 3. 4. 5.

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quantity surveying
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Item	Description/Notes	Action By
1.00	GB-H said that it will be acceptable to use both BS 7913: 2013 and Historic England Advice Note 12: 2019 as references for the hangar area roof justification statement and analysis. The overall justification statement is being prepared by Wessex Archaeology.	
2.00	GB-H has seen the samples of Joris Ide Slate 1000SF and Kingspan KS1000RW roof panels and says that the rejection of the latter is appreciated.	
3.00	Having seen images of completed Joris Ide Slate 1000SF roofing installations, GB-H has said that attention should be given to 'slate' perpends lining through with roof panel perpends in the next but one course down from the ridge flashing and that fasteners for the flashing should be coloured as for the roof and positioned in a regular pattern (preferring secret fix if possible). Ingleton Wood will consult Joriside and will be providing Wessex Archaeology with a technical statement to explain the manufacturer's requirements for the fixing of flashings. On hips the desire to line through perpends with those in the roof panels will mean that the metal for the flashings will have to be cut in the angular direction to allow this and the flashings will have to be in two parts, butt strapped and sealed at their apex. Ingleton Wood will provide drawn details to indicate the required flashing configurations. Ingleton Wood will seek the manufacturer's confirmation that these aspects are feasible.	**JF**
4.00	Ingleton Wood are to provide calculations and engineer's statement to show that the existing building structural frame will not sustain a roof finish closely resembling the existing asbestos cement slates. The finish suggested as acceptable to GB-H was a concrete roof tile.	**JF**
5.00	It was noted that the building's optimum viable use is now as a vehicle workshop as opposed to the original 1930's aircraft hangar. Technicians working in the hangar area will need to work in acceptable conditions of temperature. Currently, there are a small number of low-capacity heaters within the main hangar space and these will not be adequate to obtain reasonable internal winter temperatures. A considerable number of high-level radiant heat panels will be required, suspended from the roof structure. This information will be included in the justification statement and their weight will be included in the structural calculation referenced above.	**JF**
6.00	Efforts to reduce energy use and carbon emission will be included in an item within the justification statement. Part L / TM54 reports based on the proposed roof construction and also on the existing will be used to demonstrate the reduction in these commodities. The National Planning Policy Framework recognises a transition to a low carbon future.	**JF**
7.00	The standards required to limit energy use and carbon emissions from the developments on the MOD estate will be referenced into the justification statement. Ingleton Wood will be able to provide details.	**JF**

8.00	GB-H said that it is apparent that other listed building consent applications for assets on Station are including measures to reduce energy usage / carbon emissions and that SG-S would be able to see how others have presented these aspects in the current, 'live' applications.	**SG-S**
9.00	It is proposed that the justification statement will indicate that the roof replacement will be reversible. GB-H said that this will need to state that photographs will need to be taken and issued to the Local Authority showing the existing roof construction as it is stripped down. This will be in order to record what is there. Wessex Archaeology will request a condition to be included into the listed building consent and present suggested wording, accordingly.	**SG-S**
10.00	Some comfort was gained from GB-H in that the listed building consent is being looked well upon by the local authority and that the justification statement is being requested in order that it may be given full backing.	
11.00	Once drafted, Wessex Archaeology will provide the structure of the proposed roof justification statement for consideration.	**SG-S**
12.00	An extension of time on the listed building consent application will be granted till 31st January 2024 (post meeting note: now granted). If further time is required following that, this will be reviewed in order to keep the application 'live'.	**JF**

- End of document-

7.0 APPENDIX B: STRUCTURAL DESIGN CALCULATIONS

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Buckley Barracks, Hangar 3

CBP Architects

Job No. 4000034

Structural Design Calculations

Author:	J. Martin
Checked by:	J. Farrer
Date:	29/08/2023
Status:	S2



DOCUMENT CONTROL

Project Information

Job no:	4000034
Project Title:	Buckley Barracks, Hangar 3
Client:	CBP Architects

Document Check

Prepared by:	**JM**	Signed:
Checked by:	**JF**	Signed:

Issue	Date	Status
1 First issue.	29/08/23	Building Regulations
2		
3		
4		

CONTENTS

1.0 DESIGN PHILOSOPHY 4
2.0 DESIGN NOTES 9
3.0 DESIGN CALCULATIONS 9

1.0 DESIGN PHILOSOPHY

1. Description of the Existing Structure

The building is an original 12 bay Type C34 hangar which would have been constructed in the 1930's, the hangar is full height with gabled ends and clad in masonry so was likely constructed before the war as later versions constructed during the war tend to be smaller versions with hipped ends and sheet cladding. There are many variations of this type of hangar but the primary differences tend to be in height, length, use of gabled or hipped ends over the hangar doors or cladding material.

The original Type C hangar is a portal frame structure across each bay which is braced on its side elevations and on plan at the hangar door ends. The roof structure is formed with primary lattice girders at approximately 7.62m centres with secondary valley trusses spanning between at 4.572m centres to form a multipitch roof with a number of ridges and valleys. Originally the roof structure would have supported runway beams to enable loading of aircraft.

The existing steel stanchions are encased in concrete up to roof level and founded on concrete pad footings (assumed to be similar to those identified on the historical Defence Estate drawings).

The perimeter walls for the main hangar are constructed in masonry (assumed to be of cavity construction as per Design and Maintenance Guide 24 (DMG 24)– Guide to World War II Hangars 03 – Type C Hangars.), a continuous exposed concrete lintel over the external high level side elevation windows was also visible. The annexe roofs are of traditional timber flat roof construction supported on masonry walls.

The slab internally is a ground bearing concrete slab, with contraction joints at regular centres.

The existing structure has been modified since its original construction primarily the main hangar door tracks have been cut back and doors stowed in an 'open' position with new infills/ internal structure provided.

2. Proposed Development

The proposed development intends to undertake the following structural works:

- Removal of existing hangar door infills and internal structures
- Removal of existing vehicle inspection pit
- Construction of new hangar door infill sections with new foundations and connection to the existing door head tracks
- Construction of a new vehicle inspection pit
- Construction of a new fire escape corridor and roof enclosure
- Replacement of the existing annex roof structure where required
- Removal of the existing roof coverings/ purlins and replacement with new purlins/ finishes
- Repair of the existing cracked stone outer leaf brickwork

3. Proposed Roof Structure

Two options for roof replacement have been considered, namely a lightweight solution to closely match the weight of the existing roof finishes and a heavier system to match the 'traditional' nature of the existing roof finishes but with additional layers of construction to meet modern standards. Comparison of the existing, lightweight and heavyweight roof systems is presented below.

Existing Roof	Dead	Live
25mm Sarking boards	0.10	
215x70 Timbers @ 1100mm c/c (avg)	0.02	
Asbestos Cement Tile	0.20	
Services	0.10	
Imposed		0.60
Total	**0.42**	**0.60**

Proposed 'Heavyweight' Roof	Dead	Live
Concrete Roof Tiles	0.44	
Battens & Underlay & VCL	0.03	
Plywood Sarking & Timbers	0.10	
Services	0.20	
Imposed		0.60
Total	**0.77**	**0.60**

Proposed 'Lightweight' Roof	Dead	Live
Joriside Cladding Panel	0.13	
Purlins & Omega Profiles	0.10	
Services	0.20	
Imposed		0.60
Total	**0.43**	**0.60**

Due to the presence of asbestos it has not been possible to undertake a detailing 'touching distance' survey of the existing structure to confirm the existing member sizes and exact structural arrangement. However from ground level the primary steel roof structure appears to closely match the structural arrangement and section sizes as presented on historical drawings of Type C hangars. In the experience of Ingleton Wood having surveyed a number of Type C hangars both at Buckley barracks and other MOD sites it is expected that the historic drawings will provide an accurate representation of the existing structure.

Based on the historic drawings, the section sizes stated and connection details have been assessed for the loading from the existing roof loading, the proposed 'lightweight' roof replacement and the proposed 'heavyweight' roof option. The following issues have been identified with the potential increase in loading on the roof structure.

<u>Deflection, Roof Drainage & Parapets</u>
Both the existing loading and proposed lightweight roofing options have similar dead loadings and the existing structure has been found to adequately support these loads.

Based on the historic drawings for the steel frame the original roof trusses are designed with a pre-camber to reduce deflection and ensure adequate drainage of the roof valleys. The pre-camber following installation of the dead loads is 4 ¼" (108mm) which equates to a fall of approximately 1:212 (0.27°) over a 22.960m length.

The original dead load deflection of the primary truss is anticipated to be in the region of 31mm. The increase in the dead load on the structure will reduce the pre-camber and increase the dead load deflection to approximately 43mm, reducing the fall within the valleys to approximately 1:239 (0.24°), increasing eaves spread and further affecting the cracking at external parapets.

One of the primary flaws of the Type C hangar design is the poor roof drainage, worsening this situation and using materials such as timber which will be susceptible to degradation particularly at the valley gutters is believed to be unacceptable.

It is also believed that high level parapet cracking observed is due to spread of the columns due to settlement/ deflection of the primary trusses and the addition of additional dead load will likely exacerbate this issue. Repairs to the external parapets are proposed as part of the repair works to this project and the increase in dead loading will likely prove detrimental to these safety critical repairs.

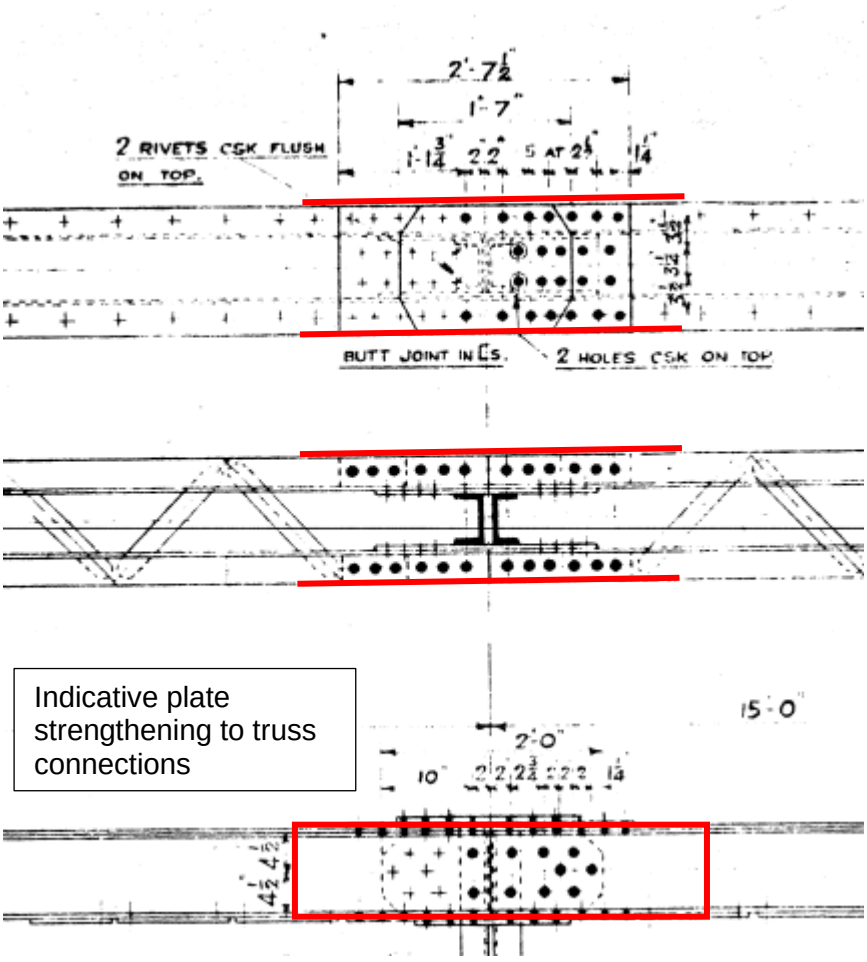
Structural Capacity

The proposed 'heavyweight' roof option nearly doubles the dead loading on the structure compared to the existing. Whilst the primary members have been found to have sufficient capacity the majority of connections have been found to require strengthening. Connection details have been assumed to match those detailed on the original structural drawings.

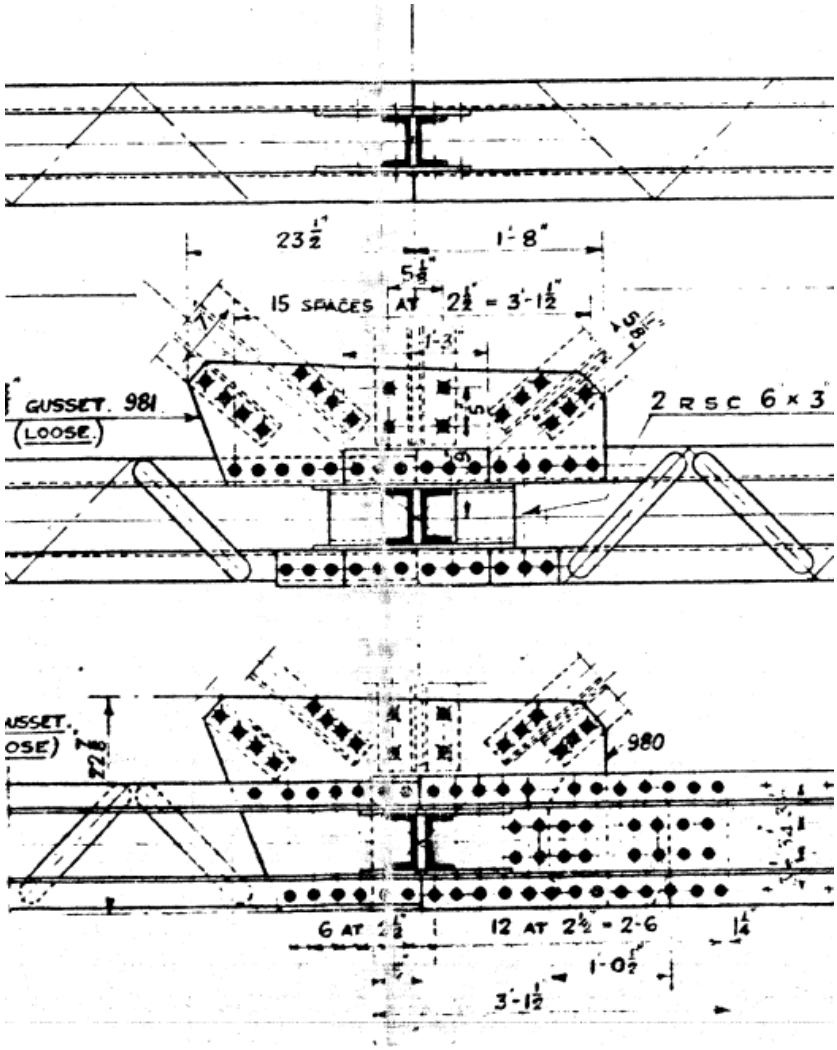
The capacity of internal truss connections may be increased with additional welds being placed. The quantity of connections requiring strengthening is significant however and it may be difficult to adequately clean, prepare and the access the structure to ensure satisfactory welds can be placed to guarantee the safety of the structure.

Primary truss connections however are unlikely to be feasibly strengthened, without significantly altering the appearance of the truss. These connections contain approximately 40 plus bolts and rivets at close centres either side of the member joint which connect the joint plate to the members. It will not be possible to add additional bolts to strengthen the plate – member connection nor will it be possible to add additional plates to strengthen the actual joint. It may be possible to install additional members or weld plates over the toes of the top/ bottom chords either side of the splice connections however these would conceal the original connection making them inaccessible for future maintenance. Note at the end girders additional plan bracing is incorporated and it is not believed to be possible to strengthen these connections with plates as per the typical truss.

Connection Type to be upgraded	No. Per Truss	No. Trusses	Total
Primary Truss Plated Splice	6	13	78
Primary Truss Internal Connection	40	13	520
Secondary Truss Internal Connection	2	108	216
			814



Typical Primary Truss Connection Detail



Primary Truss With Plan Wind Bracing

4. Summary

With the increase in services loading on the structure to accommodate the proposed use of the space we do not believe it is feasible to also increase the permanent loading on the structure and as such a lightweight roof replacement to ensure the loadings on the structure remain as close to those imposed in the original construction should be employed.

If a 'heavyweight' roof replacement is to be considered it should be noted that the appearance of the visible elements of the structure will be significantly altered and the ongoing maintenance issues associated with a Type C hangar (roof drainage & parapet cracking) will be exacerbated reducing the longevity of any works undertaken. Additionally originally exposed elements of the structure will become concealed and inaccessible for routine inspection/ maintenance as required in accordance with MOD documents PG04/11 & PG05/11.

2.0 DESIGN NOTES

The following British Codes of Practice and other information have been used to produce these calculations.

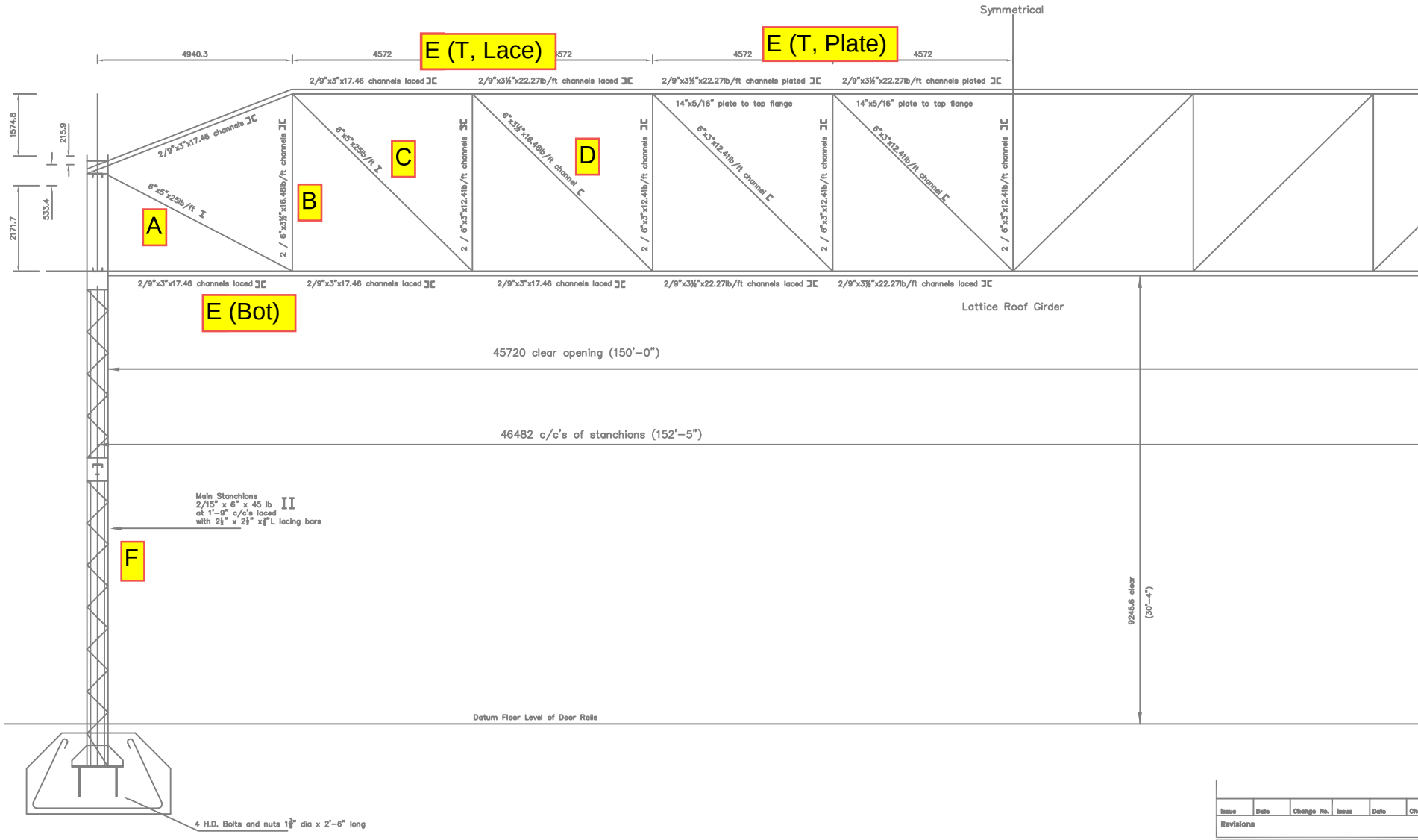
Basis of design	BS EN 1990
Actions	BS EN 1991
Concrete	BS EN 1992
Structural steelwork	BS EN 1993
Timber	BS EN 1995
Masonry	BS EN 1996
Building Regulations	

3.0 DESIGN CALCULATIONS

Existing Roof	Dead	Live
25mm Sarking boards	0.10	
215x70 Timbers @ 1100mm c/c (avg)	0.02	
Asbestos Cement Tile	0.20	
Services	0.10	
Imposed		0.60
Total	**0.42**	**0.60**

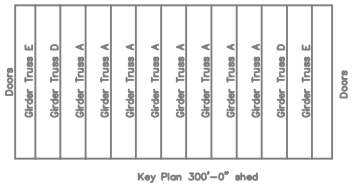
Proposed 'Lighweight' Roof	Dead	Live
Joriside Cladding Panel	0.13	
Purlins & Omega Profiles	0.10	
Services	0.20	
Imposed		0.60
Total	**0.43**	**0.60**

Proposed 'Heavyweight' Roof	Dead	Live
Cedral Thrutone Smooth cement-fibre slates	0.44	
Battens & Underlay & VCL	0.03	
Sarking & Timbers	0.10	
Services	0.20	
Imposed		0.60
Total	**0.77**	**0.60**



Typical Elevation on Main Roof Girder and Column

scale 1:50



Key Plan 300'–0" shed

THE DETAILS GIVEN ON THIS DRAWING ARE FOR INFORMATION ONLY AND MUST NOT BE CONSIDERED AS DEFINITIVE. THIS DRAWING HAS BEEN PREPARED FROM ORIGINAL AIR MINISTRY DRAWINGS OF VARIOUS SOURCES AND ITS RELEVANCE TO A PARTICULAR SITE MUST BE DETERMINED. THE ORIGINAL DRAWINGS WERE PREPARED IN IMPERIAL. THEREFORE DURING THE PROCESS OR METRIFICATION SOME ROUNDING ERRORS MAY HAVE OCCURRED.

Issue	Date	Change No.	Issue	Date	Ch
Revisions					

DEFENCE ESTATES
Blakemore Drive
Sutton Coldfield
West Midlands
B75 7RL
Technical Authority: Sp/S/Wind Sensitive Structures

	Company	Contract No.	Signature	Dat
Drawn	M.F.M.	WS 41/029	T.M.R.	Nov
Design				
Checked	M.F.M.	WS 41/029	G.C.S.	Nov
Approved				
Date				

Security Classification: Unclassified

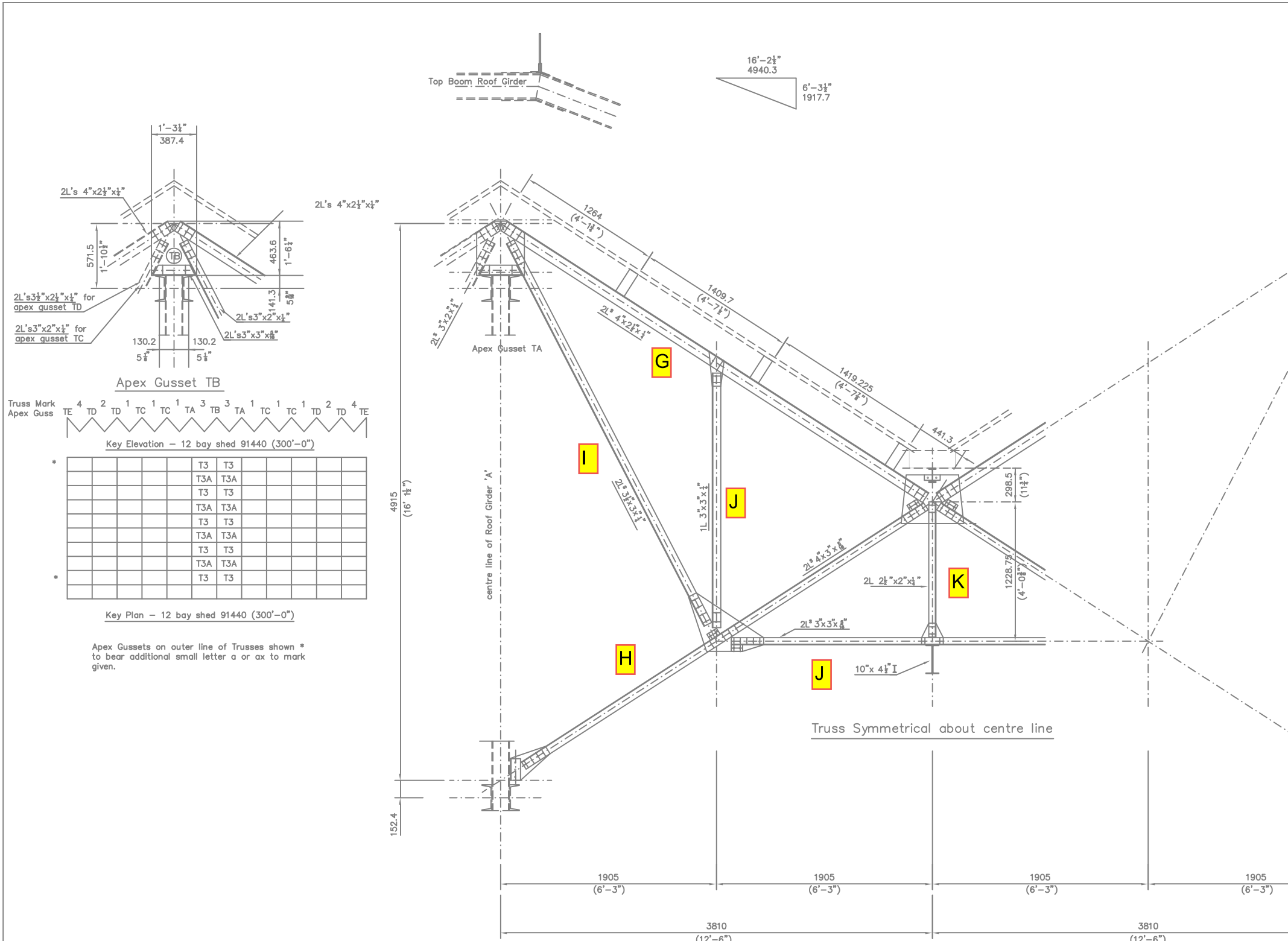
DE File. Ref.: D/DE/C1/02011

Facility / Location Name: C Type Hangar – Hipped (1938

Associated Drg. Nos.: DE/H1/001/201, DE/H1/001/202, DE/H1/001/203, DE/H1/001/204, DE/H1/001/206

Drawing Title: Line Diagram showing layout an member sizes for Girder Truss

DE Drawing No.



Top Boom Roof Girder
16'-2½"
4940.3
6'-3½"
1917.7
1'-3¼"
387.4
2L's 4"x2½"x¼"
2L's 4"x2½"x¼"
571.5
1'-10½"
463.6
1'-6¼"
141.3
5 9/16"
TB
2L's3½"x2½"x¼" for apex gusset TD
2L's3"x2"x¼" for apex gusset TC
2L's3"x2"x¼"
2L's3"x3"x5/16"
130.2
130.2
5⅛"
5⅛"
Apex Gusset TB
Truss Mark
Apex Guss
TE 4 TD 2 TD 1 TC 1 TC 1 TA 3 TB 3 TA 1 TC 1 TC 1 TD 2 TD 4 TE
Key Elevation – 12 bay shed 91440 (300'-0")
Key Plan – 12 bay shed 91440 (300'-0")
Apex Gussets on outer line of Trusses shown * to bear additional small letter a or ax to mark given.
1264
(4'-1¾")
1409.7
(4'-7½")
1419.225
(4'-7⅞")
441.3
2Ls 3"x2"x¼"
Apex Gusset TA
2Ls 4"x2½"x¼"
G
I
J
K
H
J
1L 3"x3"x¼"
2Ls 3½"x3"x¼"
2Ls 4"x3"x5/16"
2L 2½"x2"x¼"
2Ls 3"x3"x5/16"
10"x 4½" I
298.5
(11¾")
1228.75
(4'-0⅜")
4915
(16' 1½")
centre line of Roof Girder 'A'
152.4
1905
(6'-3")
1905
(6'-3")
1905
(6'-3")
1905
(6'-3")
3810
(12'-6")
3810
(12'-6")
Truss Symmetrical about centre line

ANALYSIS

Tedds calculation version 1.0.37

Loading

Self weight included

Load combination factors

Load combination	Self Weight	Permanent	Imposed	Snow Drift	Wind
Down (ULS) (Strength)	1.35	1.35	1.50		
Down (SLS) (Service)	1.00	1.00	1.00		
Dead (SLS) (Service)	1.00	1.00			
Snow Drift (Strength)	1.10	1.10		1.00	

Element Loads

Element	Load case	Load Type	Orientation	Description
5	Permanent	UDL	GlobalZ	3.52 kN/m
6	Permanent	UDL	GlobalZ	3.52 kN/m
7	Permanent	UDL	GlobalZ	3.52 kN/m
8	Permanent	UDL	GlobalZ	3.52 kN/m
5	Imposed	UDL	GlobalZ	2.74 kN/m
6	Imposed	UDL	GlobalZ	2.74 kN/m
7	Imposed	UDL	GlobalZ	2.74 kN/m
8	Imposed	UDL	GlobalZ	2.74 kN/m
8	Snow Drift	VDL	GlobalZ	0.43 kN/m to 0.85 kN/m
7	Snow Drift	VDL	GlobalZ	0 kN/m to 0.43 kN/m
5	Snow Drift	VDL	GlobalZ	0.85 kN/m to 0.43 kN/m
6	Snow Drift	VDL	GlobalZ	0.43 kN/m to 0 kN/m
5	Wind	UDL	LocalZ	0.3 kN/m
6	Wind	UDL	LocalZ	0.3 kN/m
7	Wind	UDL	LocalZ	0.3 kN/m
8	Wind	UDL	LocalZ	0.3 kN/m

Results

Reactions

Load combination: Down (ULS) (Strength)

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	45.7	0
3	0	45.7	0

Load combination: Down (SLS) (Service)

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	32.5	0
3	0	32.5	0

Load combination: Dead (SLS) (Service)

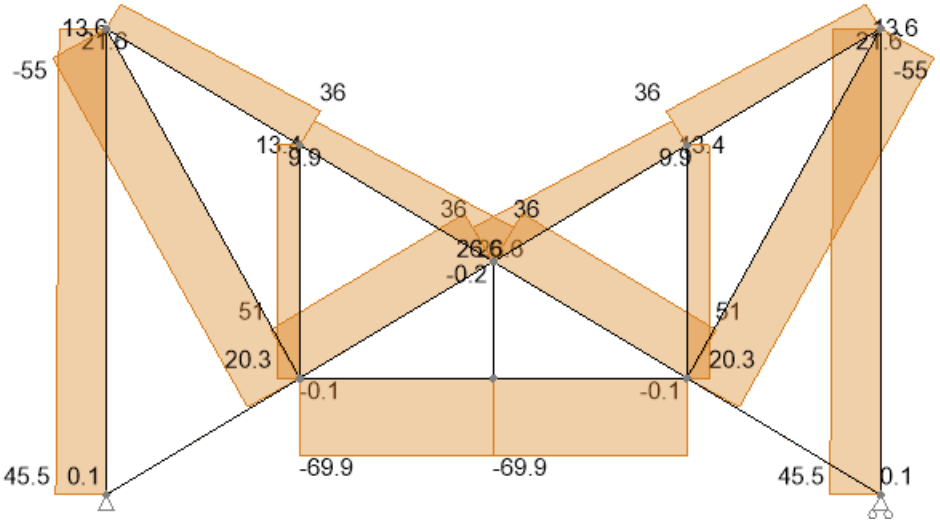
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	20.4	0
3	0	20.4	0

Load combination: Snow Drift (Strength)

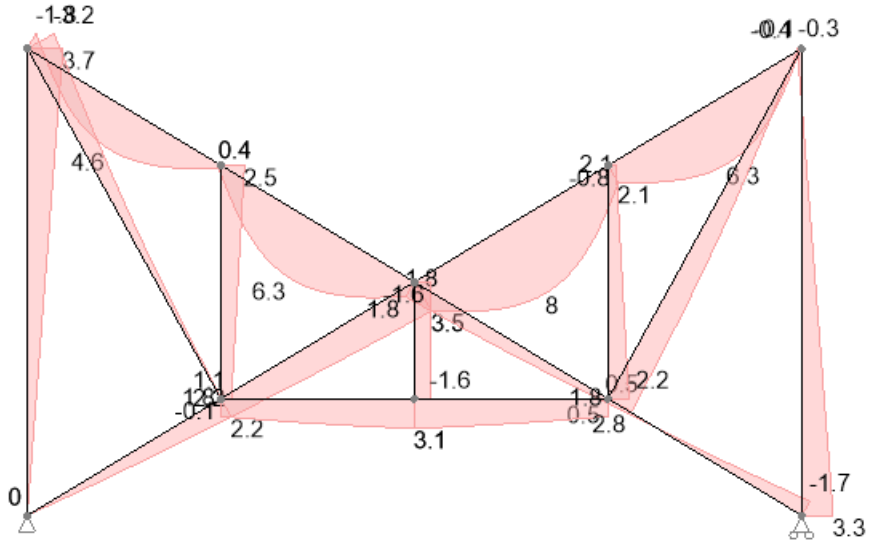
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	24.4	0
3	0	24.4	0

Forces

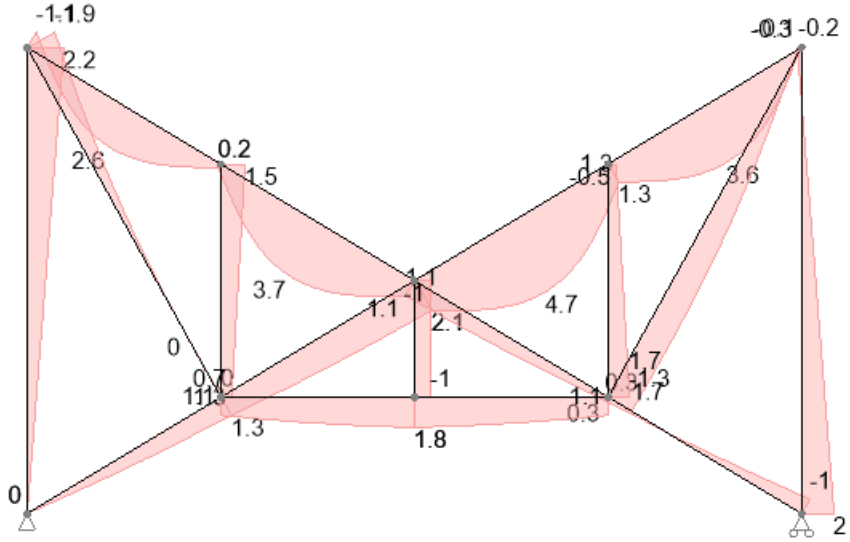
Strength combinations - Axial force envelope (kN)



Down (SLS) (Service) - Deflection (mm)



Dead (SLS) (Service) - Deflection (mm)



ANALYSIS

Tedds calculation version 1.0.37

Loading

Self weight included

Load combination factors

Load combination	Self Weight	Permanent	Imposed	Wind
Down (ULS) (Strength)	1.35	1.35	1.50	
Down (SLS) (Service)	1.00	1.00	1.00	
Dead (SLS) (Service)	1.00	1.00		
Lat (ULS) (Strength)	1.35	1.35		1.50
Lat (SLS) (Service)	1.00	1.00		1.00

Node loads

Node	Load case	Force		Moment
		X (kN)	Z (kN)	(kNm)
2	Permanent	0	20.5	0
4	Permanent	0	40.9	0
6	Permanent	0	40.9	0
8	Permanent	0	40.9	0
10	Permanent	0	40.9	0
12	Permanent	0	40.9	0
14	Permanent	0	40.9	0
16	Permanent	0	40.9	0
18	Permanent	0	40.9	0
20	Permanent	0	40.9	0
22	Permanent	0	20.5	0
2	Imposed	0	12.1	0
4	Imposed	0	24.2	0
6	Imposed	0	24.2	0
8	Imposed	0	24.2	0
10	Imposed	0	24.2	0
12	Imposed	0	24.2	0
14	Imposed	0	24.2	0
16	Imposed	0	24.2	0
18	Imposed	0	24.2	0
20	Imposed	0	24.2	0
22	Imposed	0	12.1	0

Element Loads

Element	Load case	Load Type	Orientation	Description
42	Wind	UDL	GlobalX	5.44 kN/m
1	Wind	UDL	GlobalX	5.44 kN/m

Results

Reactions

Load combination: Down (ULS) (Strength)

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
23	20.1	667.1	0
24	-20.1	667.1	0

Load combination: Down (SLS) (Service)

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
23	14.4	480.7	0
24	-14.4	480.7	0

Load combination: Dead (SLS) (Service)

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
23	9.8	359.7	0
24	-9.8	359.7	0

Load combination: Lat (ULS) (Strength)

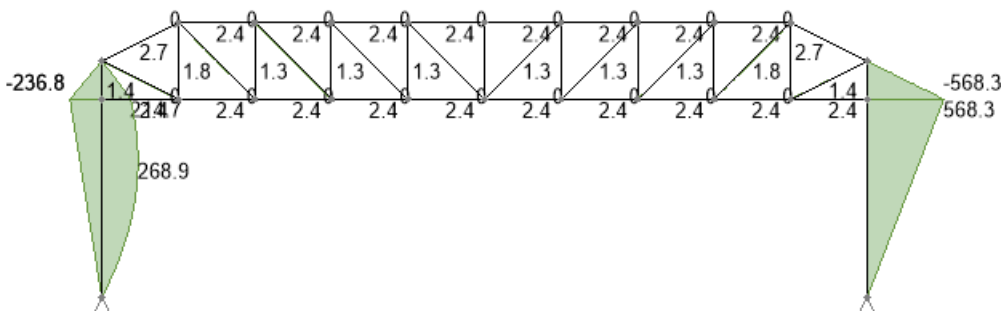
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
23	-66.2	467.9	0
24	-48.3	503.2	0

Load combination: Lat (SLS) (Service)

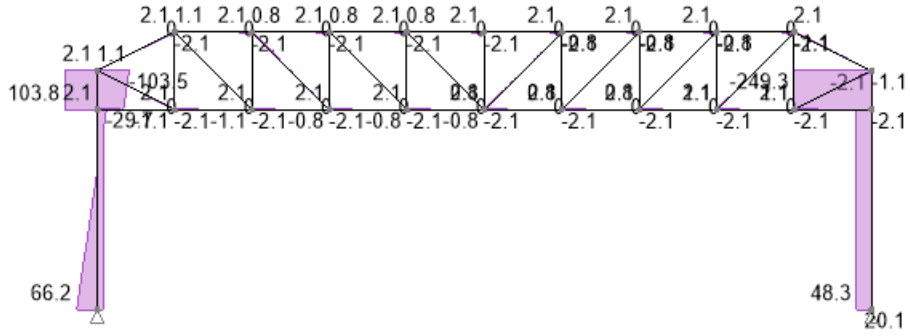
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
23	-43.2	347.9	0
24	-33.2	371.4	0

Forces

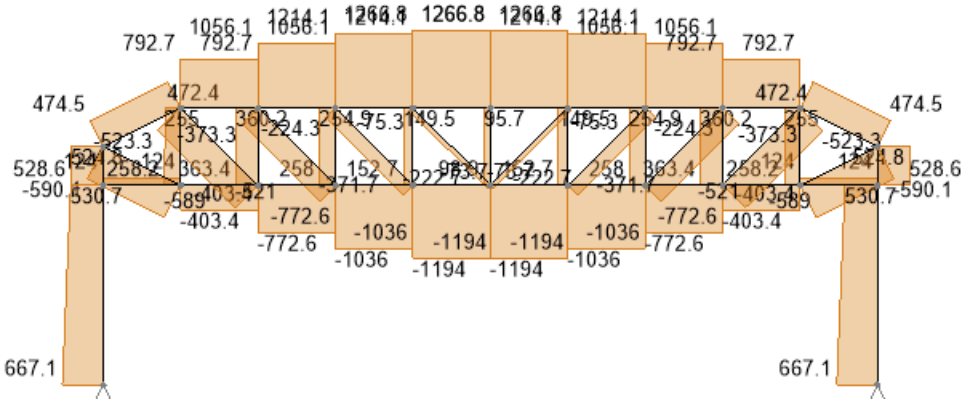
Strength combinations - Moment envelope (kNm)



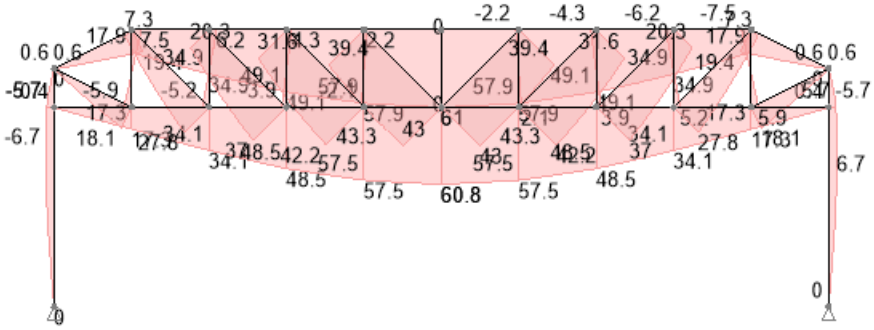
Strength combinations - Shear envelope (kN)



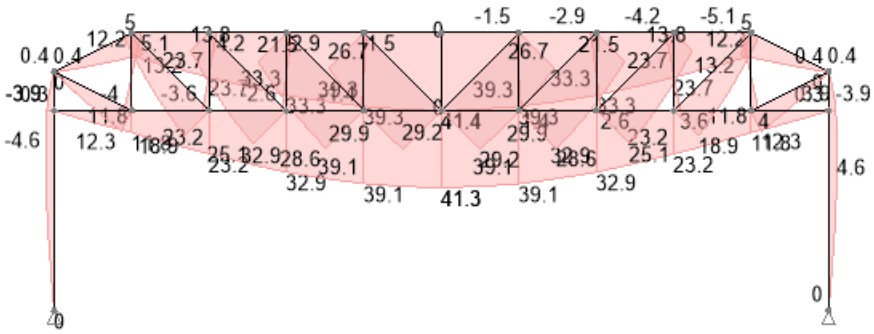
Down (ULS) (Strength) - Axial force (kN)



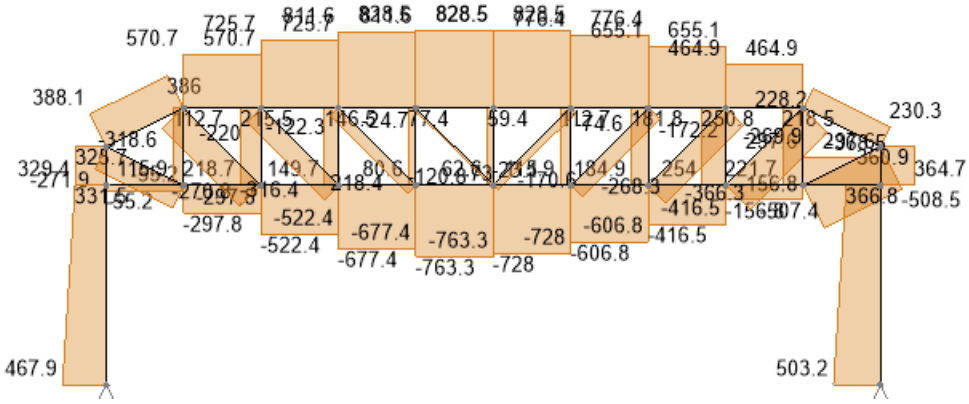
Down (SLS) (Service) - Deflection (mm)



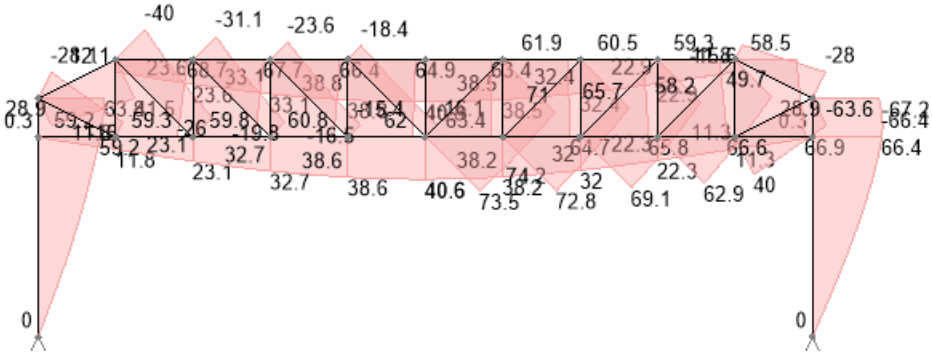
Dead (SLS) (Service) - Deflection (mm)



Lat (ULS) (Strength) - Axial force (kN)



Lat (SLS) (Service) - Deflection (mm)



Member Capacities

		Minor Axis					
Element	Area (mm²)	Effective Length (mm)	r (mm)	λ Slenderness	Φ	χ reduction factor	Maximum Allowable Compression Stress (N/mm²)
A	4742	5098	29.5	2.0	2.79	0.21	**49.62**
B	6542	4560	37.7	1.4	1.76	0.35	**82.64**
C	4742	6449	29.5	2.5	4.07	0.14	**32.38**
D	3329	6449	22.4	3.3	6.76	0.08	**18.56**
E (T,Lace)	6330	4560	93.9	0.6	0.74	0.81	**190.15**
E (T, Plate)	9330	4560	93.1	0.6	0.75	0.81	**189.49**
E (BOT)	6330	4560	93.9	0.6	0.72	0.86	**201.37**
F	16954	5880	154.90	0.4	0.64	0.91	**214.08**
G	2974	2207	27.6	0.9	1.10	0.59	**137.91**
H	1998	2207	28.1	0.9	1.08	0.60	**140.26**
I	2700	3907	28	1.6	2.14	0.28	**66.29**
J	1348	2280	22.9	1.1	1.39	0.46	**108.06**
K	684	1140	15	0.9	1.05	0.61	**144.50**

		Major Axis					
Element	Area (mm²)	Effective Length (mm)	r (mm)	λ Slenderness	Φ	χ reduction factor	Maximum Allowable Compression Stress (N/mm²)
A	4742	5098	63	0.9	1.01	0.71	**167.41**
B	6542	4560	58.7	0.9	1.07	0.60	**141.69**
C	4742	6449	63	1.2	1.30	0.54	**127.65**
D	3329	6449	58.4	1.3	1.57	0.40	**94.18**
E (T, Lace)	6330	4560	96.1	0.5	0.73	0.82	**191.88**
E (T, Plate)	9330	4560	94.9	0.6	0.74	0.81	**190.95**
E (BOT)	6330	4560	96.1	0.5	0.73	0.82	**191.88**
F	16954	11760	392.5	0.3	0.57	0.97	**227.17**
G	2974	2207	32.5	0.8	0.87	0.81	**189.32**
H	1998	2207	34	0.7	0.84	0.82	**193.67**
I	2700	3907	28.6	1.6	1.88	0.34	**80.59**
J	1348	2280	22.9	1.1	1.26	0.56	**132.61**
K	684	1140	19.8	0.7	0.77	0.86	**203.11**

Maximum Allowable Tension Stress (N/mm²)
235.00

Member Load Summary

Element	Max Compression (kN)	Max Compression Capacity (kN)	Utilisation	Max Tension (kN)	Max Tension Capacity (kN)	Utilisation	**Max Utilisation**
A	0.00	235.31	0%	591.00	1114.37	53%	**53.03%**
B	258.00	540.60	48%	0.00	1537.37	0%	**47.72%**
C	0.00	153.55	0%	524.00	1114.37	47%	**47.02%**
D	0.00	61.80	0%	374.00	782.32	48%	**47.81%**
E (T, Lace)	1056.10	1203.63	88%	0.00	1487.55	0%	**87.74%**
E (T, Plate)	1267.00	1767.96	72%	0.00	1487.55	0%	**71.66%**
E (BOT)	0.00	1214.63	0%	1194.00	1487.55	80%	**80.27%**
F	REFER TO CHECK BELOW						
G	36.00	675.61	5%	0.00	698.89	0%	**5.33%**
H	51.00	378.27	13%	0.10	469.53	0%	**13.48%**
I	0.00	522.91	0%	55.00	634.50	9%	**8.67%**
J	0.00	108.63	0%	69.90	316.78	22%	**22.07%**
K	0.00	90.70	0%	0.20	160.74	0%	**0.12%**

Moment =	574.2	kNm
Dist. Between columns	0.63	m
Axial from moment	911.43	kN
Axial	680.2	kN
Total Axial	1591.63	kN

Columns are tied together, encased in concrete and are considered not to be locally affected by buckling, overall slenderness for the concrete section is okay

Compressive resistance = 1814.76 kN

Connection Summary

Element	Max Force (SLS)	No. Bolts	Bearing Capacity (kN)	Shear Capacity (kN)	Capacity (kN)	Utilisation
A	417.46	20.00	22.44	17.62	352.42	**118.45%**
B	182.24	8.00	22.44	17.62	140.97	**129.28%**
C	370.14	16.00	22.44	17.62	281.94	**131.28%**
D	264.18	12.00	22.44	17.62	211.45	**124.94%**
E (T, Lace)	745.99	30.00	22.44	17.62	528.64	**141.12%**
E (T, Plate)	894.97	40.00	22.44	17.62	704.85	**126.97%**
E (BOT)	843.40	32.00	22.44	17.62	563.88	**149.57%**
F	N/A					
G	25.43	3.00	22.44	17.62	52.86	**48.10%**
H	36.02	4.00	22.44	17.62	70.48	**51.11%**
I	38.85	3.00	22.44	17.62	52.86	**73.49%**
J	49.38	2.00	22.44	17.62	35.24	**140.10%**
K	0.14	2.00	22.44	17.62	35.24	**0.40%**

From historic drawings all bolts are 3/4" diameter 'black bolts'

TABLE N0.7.1 ALLOWABLE STRESSES IN RIVETS AND BOLTS in tons/sq inch

Detail		Rivets		Bolts		
	Type	MS	HT	Type	MS	HT
1932						
Tension	Shop	5		≥0.75"ϕ	5	
	Site	4		<0.75"ϕ	0	
Shear	Shop	6		Turned	6	
	Site	5		Black	4	
Bearing	Shop	12		Turned	12	
	Site	10		Black	8	

From assessment of existing connections, the structure is fully utilised under the existing loading and the roof loading should not be increased beyond the existing, it unlikley to be feasible to sufficiently strengthen the existing connections to enable additional loading to be imposed upon the structure

8.0 APPENDIX C: CARBON EMISSION CALCULATIONS

Solving global challenges one building at a time

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Hangar Refurbishments, Hullavington Barracks

Hangar 3

Job No. 4000034

Part L and TM54 Summary Report

Author: Jason Page
Date: 8th August 2023
Status: P03



DOCUMENT CONTROL

Revision	Stage		Date	Author	Check
P01	Draft		09/08/2023	JP	
P02	Final	Minor changes to Design model	30/08/2023	JP	
P03	Final	Grammar changes	01/09/2023	JP	

CONTENTS

1.0 Executive Summary 4
2.0 Identify Data Inputs 5
Opening / Working Hours 5
Weather File 5
Construction Data 5
Part L Compliance 6
Limitations 6
Energy Use Intensity Targets 6
Occupancy 7
Internal and External Lighting 7
Server Room 7
Small Power and Equipment 8
Lift System 8
Hot Water 8
Heating 8
3.0 Energy Use Intensity Target 8
End Use Benchmarks 9
Energy Consumption Predictions 9
Appendix 1 – TM54 Assumptions 11
Appendix 2 – Proposed SBEM Results 15

1.0 Executive Summary

This document demonstrates how the scheme intends to meet the energy performance standards required by Part L Volume 2 2021 and BPS 0.1 as part of the proposed refurbishment of Hangar 3.

Where a thermal element is changed as part of a refurbishment it should be upgraded to at least the value in Column 2 of Table 2. The building exceeds the minimum values where possible, however does not exceed them all due to restrictions due to the listed status of the building. The building has therefore been accessed through the more flexible method. A notional refurbishment has been undertaken using the improved values in Table 2.

The building is compliant if the notional building is worse than the proposed. Figure 1 and Figure 2 show the SBEM results for the notional and proposed buildings respectively. It can be seen that the proposed building exceeds the notional 25.8% in carbon compliance and by 29.7% for primary energy compliance. It is therefore considered that the building is complaint with Part L Volume 2 2021.

To evaluate the operational energy use of the proposed extension to Hangar 3 in greater detail, the methodology outlined in CIBSE TM54:2022 guidance will be followed where applicable with the input design information and assumptions made detailed within this report.

For the purposes of this report the modelling has been developed for the proposed element of the site only.

The aim of the TM54 assessment is to include additional energy loads within the building to closer estimate the final usage once occupied.

The design is modelled in IESVE 2023 to generate a baseline energy consumption including lighting, small power, heating and hot water.

The TM54 assessment furthers this with estimated loads from external lighting, servers and IT equipment, individual small power equipment and accessible lift systems.

Total estimated EUI for the building is **81.2 kWh/m^2/yr**, which does not meet the target for a workshop which is 66 kWh/m^2/yr.

The major energy consumptions are the heating systems and internal lighting. For a large space this is expected, and particularly in space heating where the building does have restrictions on the options available for insulation, a result that is higher than the target can be expected. This building uses approx 18.8% more energy then a building that would meet the target. This is consided to be an acceptable level considering the refurbishment nature of the building and the restrictions listed status has on some of the construction elements.

2.0 Identify Data Inputs

Opening / Working Hours

The operational hours are based a typical office and used to simulate the operational hours of the HVAC and fixed equipment such as lighting, fans, pumps etc for their usage and energy consumption throughout the year, as detailed within the following tables.

Timetable	Operating Range
Opening Timetable	8 hrs per day
Working Week	Monday - Sunday

Table 1 Operation Hour Assumptions

The days above that the building is open is used for the building energy load, and the remainder is set as standby energy loads and parasitic loads that cannot be turned off such as emergency lighting charging, fire alarm, servers etc.

Weather File

The CIBSE Test Reference year (TRY) was used to investigate the energy usage for the proposed design. The Southampton TRY weather file was selected to be used for the assessment as the closest weather file.

Construction Data

As part of the concept energy modelling the scheme, a concept energy model comparison would need to be carried out to provide an indication as to the improvements that are proposed for the building.

The target U-Values of the construction are shown against Part L requirements for refurbishing existing elements, where the existing construction is worse than the threshold it should be improved to the Improved Value in column 2.

Category	Threshold	Improved		Current Design
	U value ($W/m^2 \cdot K$)	U value ($W/m^2 \cdot K$)		U value ($W/m^2 \cdot K$)
Door Vehicle Door		1.6 1.3		2.2 0.62
External Window Polycarbonate Window		1.6 1.6		2.0 0.99
Ground/Exposed Floor	0.70	0.25		0.22
Roof – Hangar Annex	0.35 0.35	0.18 0.18		0.19 0.18
External Wall – Hangar Annex	0.70 0.70	0.30 0.30		0.15 0.70
Air Permeability		10 $m^3/m^2.h$ @ 50 Pa		10 $m^3/m^2.h$ @ 50 Pa

Table 2 U value Comparison

Part L Compliance

As a refurbishment which does not have a change in energy status, the building does not need to comply with the new build Part L Volume 2 requirements, or the requirements for extension/conversion. However, where a thermal element is changed it should be upgraded to at least the value in Column 2 of Table 2.
The building exceeds the minimum values where possible, however does not exceed them all, particularly in the case of the annex wall where complying with the energy regulations would change the aesthetic of the listed building. The building has therefore been accessed through the more flexible method. A notional refurbishment has been undertaken using the values in Column 1 of Table 2.

The building is compliant if the notional building is worse than the proposed. Figure 1 and Figure 2 show the SBEM results for the notional and proposed buildings respectively. It can be seen that the proposed building exceeds the notional 25.8% in carbon compliance and by 29.7% for primary energy compliance. It is therefore considered that the building is complaint with Part L Volume 2 2021.

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	10.2	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	23.99	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	74.17	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	212.63	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

Figure 1 Notional SBEM Results

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	10	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	17.82	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	72.07	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	149.67	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

Figure 2 Proposed SBEM Results

Full SBEM Results, can be found in Appendix 2

Limitations

The building simulation carried out using IES VE provides an estimate of the building's anticipated performance and is based on a necessarily simplified and idealised version of the building that does not and cannot fully account for the intricacies of end user's operation of the building.

As a result, the simulation results only represent an interpretation of the potential performance of the building and offers no guarantee or warranty of the building's performance when occupied.

Energy Use Intensity Targets

The Following table details how the calculated EUI for the new build compares against the benchmarks outlined for relevant building typologies from JSP 850 BPS 0.1 V9.0.

Building Type	EUI Target mark
Workshops	66 kWh/m^2
Storage and Garages	43 kWh/m^2

Table 3 EUI Typologies

Workshops has been used as the most appropriate building typology as it is considered that storage and garages are inactive low use spaces, whereas the hangar is intended for industrial processes.

Occupancy

The building has been assumed to have a capacity of 55 persons.

Internal and External Lighting

Lighting is assumed to be LED throughout with total design wattage as follows:

- Circulation – 1.62 W/m^2
- Main Hangar, WC and Plant areas – 3.25 W/m^2
- Offices – 4.87 W/m^2
- Kitchenette – 8.05 W/m^2

External lamps are assumed to be on 16 hours per day for security.

- Annex Lighting – 15.4W
- Bay Door – 37W
- Columns – 20W

Server Room

The server power requirements are based on number of Power Over Ethernet (POE) and non-POE points based on an occupancy of 55 persons.

Appliance Type	Qty	Average Power Consumption (Full Port Traffic)	Average Power Consumption (No Link Traffic)	Power units
Server	1	1600	160	W
Patch Panels	3	Passive	Passive	W
Switches (POE)	2	2000	100.84	W
Switches (Standard)	0	0	0	W
Routers	1	500	50	W
Hardware-Based Firewall	1	2200	220	W

Power Supply Unit	1	0	0	W
Project Specific Item	0	0	0	W
Total		6300	530.84	W
With Contention Ratio Applied		3150	265	W

Table 4 ICT Assumptions

Small Power and Equipment

Small power and plugged in equipment was assumed based on the room description.
The office accomodation is assumed to be able to acocmodate 55 workstations including monitor and laptop. With 1 laser printer and multifunctional device. The power demands for both in-use and standby for this equipment was taken from TM54 estimations.

Equipement in the main hangar was assumed as follows:

- Welder – 5 kW
- Grinder – 2.5 kW
- Hydralic Ramps – 14 kW x 4
- Compressor – 3 kW
- Brake Tester – 7.4 kW
- Beam Tester – 1 kW

The total power output for each room was then multiplied by the usage in an 8-hour day and the expected days of the year in operation together with the total annual standby consumption.

Further breakdown of the systems can be found in the Appendix.

Lift System

There is no lift system as the accomodation is on a single storey.

Hot Water

The hot water demand is taken from building regulation profiles for Industrial Process buildings.

Heating

The heating within the building is provided by LTHW via an LPG boiler on a district system which provides a route to net zero due to the ability to upgarde the district system remotely to an electrical based system in the future without effecting the buidling services. Heating is distributed via a radiator system in the annex, and radiant heater panels within the hangar.

3.0 Energy Use Intensity Target

The technical Energy Use Intensity (EUI) target for various building typologies is set out in BPS 0.1 V9.0.

End Use Benchmarks

THe overall EUI target for the building is taken as 66 kWh/m^2 per year for workshops as the closest building type for this refurbishment.

System	Estimated Energy (kWh/m^2)
Heating	66.0
Hot water	0.3
Internal Lighting	10.7
External Lighting	1.0
Fans & Pumps	0.4
Cooling	0.0
Lifts	0.0
Catering	0.1
Small Power	0.6
ICT Equipment	2.1

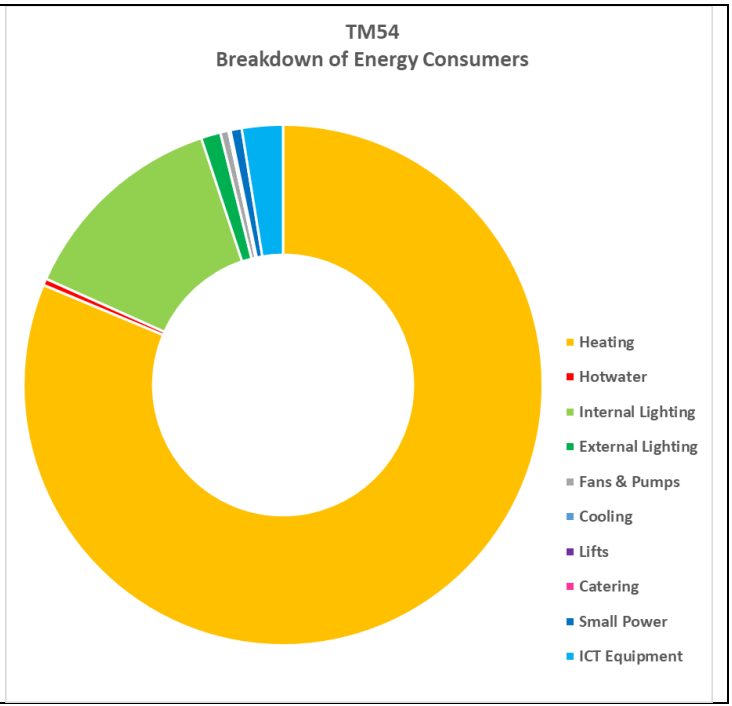


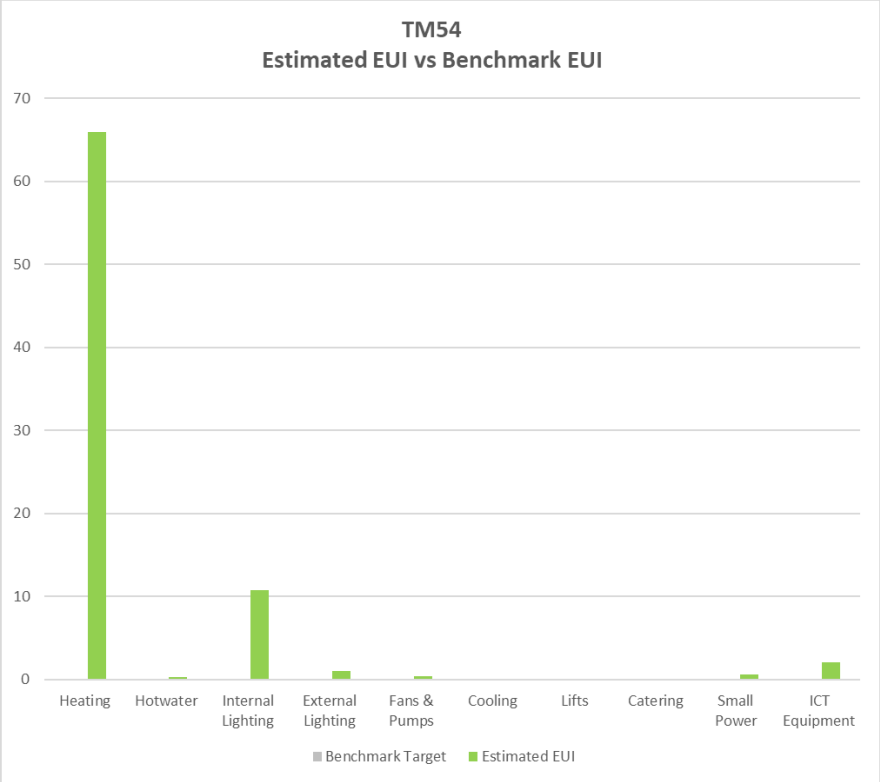
Table 5 TM54 Results

Total estimated EUI for the building is **81.2 kWh/m^2/year** taking into account the assumptions made in this report. Further calculations can be made at the later design stages of the project to provide closer estimations still to the final consumption expected once in operation.

The major energy consumptions are the heating systems and internal lighting. For a large space this is expected, and particularly in space heating where the building does have restrictions on the options available for insulation, a result that is higher than the target can be expected. This building uses approx 18.8% more energy then a building that would meet the target. This is consided to be an acceptable level considering the refurbishment nature of the building and the restrictions listed status has on some of the construction elements.

Energy Consumption Predictions

Further breakdown and comparison of the estimated EUI figures are shown in the graph below.



Month	Heating	Hotwater	Internal Lighting	External Lighting	Fans & Pumps	Cooling	Lifts	Catering	Small Power	ICT Equipment	Est PV Offset
Jan	70.2887	0.1457	4.8048	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Feb	50.1646	0.1316	4.2594	0.4258333	0.1658	0	0	0.041683	0.244832	0.895671	0
Mar	49.5334	0.1457	4.597	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Apr	20.152	0.141	4.623	0.4258333	0.1776	0	0	0.041683	0.244832	0.895671	0
May	14.8427	0.1457	4.7009	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Jun	8.378	0.141	4.5191	0.4258333	0.1776	0	0	0.041683	0.244832	0.895671	0
Jul	1.5224	0.1457	4.8048	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Aug	2.8805	0.1457	4.597	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Sep	7.265	0.141	4.623	0.4258333	0.1776	0	0	0.041683	0.244832	0.895671	0
Oct	25.5577	0.1457	4.8048	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0
Nov	40.5359	0.141	4.4152	0.4258333	0.1776	0	0	0.041683	0.244832	0.895671	0
Dec	50.8097	0.1457	4.8048	0.4258333	0.1836	0	0	0.041683	0.244832	0.895671	0

Table 6 Building Energy Demands

Appendix 1 – TM54 Assumptions

Estimation of Small Power Equipment

Typical Energy Consumption for Office Equipment

Appliance Type	Average Power Consumption (Operation)	Average Power Consumption (Standby)	
Desktop Computer	65	6.6	W
Laptop Computer	40	4	W
Flat Screen Monitor	30	1.54	W
Interactive Smart	80	8	W
Laser Printer	110	20	W
Multifunction Device	135	80	W
Photo Copier	1100	300	W

Typical Energy Consumption for Non Commercial Kitchen Equipment

Appliance Type	Average Power Consumption (Operation)	Average Power Consumption (Standby)	
Undercounter Fridge	50	0	W
Undercounter Freezer	220	0	W
Larder Fridge Freezer	400	0	W
Dish Washer	1500	0	W
Washing Machine	500	1	W
Domestic Oven / Hob	2150	0	W
Microwave	1700	3	W
Toaster	1800	0	W
Kettle	3000	0	W

Typical Energy Consumption for Project Specific Appliances

Appliance Type	Average Power Consumption (Operation)	Average Power Consumption (Standby)		Comments
Welder	5000		W	
Grinder	2500		W	
Ramps	3500		W	
Compresser	3000		W	
Brake Tester	7400		W	
Beam Tester	1000		W	
Project Specific 7			W	
Project Specific 8			W	
Project Specific 9			W	
Project Specific 10			W	

Room Ref	Room Name	Appliance #1	Qty	Appliance #	Qty	Appliance #3	Qty	Appliance #4	Qty	Appliance #5	Qty	Appliance #6	Qty	Appliance #7	Qty	Estimated Loads (W) Operation	Standby
																0	0
	Offices	Laptop Computer	55	Flat Screen Monitor	55	Laser Printer	1	Multifunction Device	1							4095	404.7
	Hanger	Welder	1													5000	0
		Grinder	1													2500	0
		Ramps	4													14000	0
		Compresser	1													3000	0
		Brake Tester	1													7400	0
		Beam Tester	1													1000	0
																0	0
																0	0

Estimation of External Lighting Consumption

External Ltg Circuit Ref	External Area Served	Nr	Luminaire Power load (W)	Lighting Control Standby Power (W)	Emergency Standby Power (W)	Estimated Total Lighting Energy (W)
Ext LTG 1	Annex Lighting	25	15.4	0		15.4
	Bay Doors	10	37			37
	Columns	6	20			20
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
						0
				Total External Lighting Load		72.4

Data Points Total

Estimated Quantity and Power Loads

Appliance Type	Qty	Average Power Consumption (Full Port Traffic)	Average Power Consumption (No Link Traffic)	Power units
Server	1	1600	160	W
Patch Panels	3	Passive	Passive	W
Switches (POE)	2	2000	100.84	W
Switches (Standard)	0	0	0	W
Routers	1	500	50	W
Hardware-Based	1	2200	220	W
Power Supply Unit	1	0	0	W
Project Specific Item	0	0	0	W
Total		6300	530.84	W
With Contention Ratio Applied		3150	265	W

Appendix 2 – Proposed SBEM Results

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Hull Hanger 3

As built

Date: Wed Aug 30 14:06:01 2023

Administrative information

Building Details

Address: Address 1, Address 2, City, Postcode

Certification tool

Calculation engine: SBEM
Calculation engine version: v6.1.e.0
Interface to calculation engine: Virtual Environment
Interface to calculation engine version: v7.0.21
BRUKL compliance module version: v6.1.e.1

Certifier details

Name: Name
Telephone number: Phone
Address: Street Address, City, Postcode

Foundation area [m²]: 5223.49

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	10	
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	17.82	
Target primary energy rate (TPER), $kWh_{PE}/m^2.annum$	72.07	
Building primary energy rate (BPER), $kWh_{PE}/m^2.annum$	149.67	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

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

Fabric element	$U_{a\text{-}Limit}$	$U_{a\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.21	1.79	SP000005_W8_A6
Floors	0.18	0.22	0.22	SP000005_F
Pitched roofs	0.16	-	-	No heat loss pitched roofs
Flat roofs	0.18	0.19	0.19	SP000005_C
Windows** and roof windows	1.6	1.06	1.6	SP000002_W2_O0
Rooflights***	2.2	-	-	No external rooflights
Personnel doors^	1.6	2.2	2.2	SP000005_W8_O0
Vehicle access & similar large doors	1.3	0.62	0.62	SP000005_W4_O2
High usage entrance doors	3	-	-	No external high usage entrance doors

$U_{a\text{-}Limit}$ = Limiting area-weighted average U-values [W/(m²K)] $U_{i\text{-}Calc}$ = Calculated maximum individual element U-values [W/(m²K)]
$U_{a\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]
* 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. *** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	10

Page 1 of 6

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Hanger

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.8	-	0.4	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

2- Annex Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	-	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

1- SYST0003-DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	-
Standard value	N/A	N/A

1- District heating network

	Emission factor [$kgCO_2/kWh$]	Primary energy factor [kWh_{PE}/kWh]
This building	0.36	1.58
Standard value	0.35	N/A

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	**General luminaire**	**Display light source**	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m^2]**
Standard value	95	80	0.3
Main Hanger Space	93	-	-
R27 Locker Room	99	-	-
R35 Male WC	105	-	-
R34 Lobby	173	-	-
R36 Female WC	169	-	-
R33 Lobby	171	-	-
R32 Kitchenette and Rest Room	97	-	-
R31 Lobby	111	-	-
R28 Lobby	160	-	-
R20 Office	110	-	-
R19 Office	123	-	-
R18 Office	114	-	-
R17 Office	117	-	-
R16 Office	141	-	-
R15 Office	114	-	-
R14 Office	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
R13 Office	114	-	-
R12 Office	99	-	-
R11 Office	99	-	-
R10 Lobby	114	-	-
R09 Office	99	-	-
R08 Office	118	-	-
R07 Office	102	-	-
R06 Office	110	-	-
R05 Office	116	-	-
R04 Lobby	169	-	-
R03 Store	110	-	-
R02 Store	115	-	-
R01 Store	103	-	-
R25 Corrdior	103	-	-
R24 Corrdior	102	-	-
R23 Corridor	109	-	-
R22 Corridor	102	-	-
R21 Corrdior	104	-	-
R30 Plant	193	-	-
R29 Plant	130	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Main Hanger Space	NO (-19.6%)	NO
R27 Locker Room	NO (-33.6%)	NO
R20 Office	N/A	N/A
R19 Office	N/A	N/A
R18 Office	NO (-43.9%)	NO
R17 Office	NO (-37%)	NO
R16 Office	N/A	N/A
R15 Office	NO (-58%)	NO
R14 Office	NO (-52.4%)	NO
R13 Office	NO (-43.5%)	NO
R12 Office	NO (-35.4%)	NO
R11 Office	NO (-49.5%)	NO
R09 Office	NO (-48.6%)	NO
R08 Office	NO (-35.9%)	NO
R07 Office	NO (-44.5%)	NO
R06 Office	NO (-51.7%)	NO
R05 Office	NO (-52%)	NO
R03 Store	YES (+11.4%)	NO
R02 Store	NO (-9.6%)	NO
R01 Store	YES (+16.2%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	5214.5	5214.5
External area [m²]	14627	14627
Weather	SOU	SOU
Infiltration [m³/hm²@ 50Pa]	10	5
Average conductance [W/K]	3820.82	4836.26
Average U-value [W/m²K]	0.26	0.33
Alpha value* [%]	11.09	25.52

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

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
100	**General Industrial and Special Industrial Groups**
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	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/m²]

	Actual	Notional
Heating	80.97	101.67
Cooling	0	0
Auxiliary	0.54	0.26
Lighting	10.41	7.73
Hot water	5.24	4.03
Equipment*	32.64	32.64
TOTAL**	**97.16**	**113.68**

* 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/m²]

	Actual	Notional
Photovoltaic systems	0	67.48
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*67.48*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	303.32	574.44
Primary energy [kWh_{PE}/m²]	149.67	72.07
Total emissions [kg/m²]	17.82	10

HVAC Systems Performance										
System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Unflued radiant heater, [HS] Unflued radiant heater, [HFT] Electricity, [CFT] Electricity										
	Actual	216.6	71.7	80.5	0	0	0.75	0	0.8	0
	Notional	516.7	95.3	107.1	0	0	1.34	0	----	----
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	272	93.3	84.7	0	3.4	0.89	0	1	0
	Notional	268.2	93.3	74.5	0	1.6	1	0	----	----
[ST] No Heating or Cooling										
	Actual	0	1329.3	0	0	0	0	0	0	0
	Notional	0	1332.7	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

Notional SBEM Results

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

Hull Hanger 3 — As built

Date: Fri Aug 11 10:30:44 2023

Administrative information

Building Details

Address: Address 1, Address 2, City, Postcode

Certifier details

Name: Name

Telephone number: Phone

Address: Street Address, City, Postcode

Certification tool

Calculation engine: SBEM

Calculation engine version: v6.1.e.0

Interface to calculation engine: Virtual Environment

Interface to calculation engine version: v7.0.21

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 5223.49

The CO_2 emission and primary energy rates of the building must not exceed the targets

The building does not comply with England Building Regulations Part L 2021

Target CO_2 emission rate (TER), $kgCO_2/m^2.annum$	10.2	
Building CO_2 emission rate (BER), $kgCO_2/m^2.annum$	23.99	
Target primary energy rate (TPER), $kWh_{PE}/m^2.annum$	74.17	
Building primary energy rate (BPER), $kWh_{PE}/m^2.annum$	212.63	
Do the building's emission and primary energy rates exceed the targets?	BER > TER	BPER > TPER

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

Fabric element	$U_{e\text{-}Limit}$	$U_{e\text{-}Calc}$	$U_{i\text{-}Calc}$	First surface with maximum value
Walls*	0.26	0.34	1.79	SP000005_W8_A6
Floors	0.18	0.22	0.22	SP000005_F
Pitched roofs	0.16	-	-	No heat loss pitched roofs
Flat roofs	0.18	0.18	0.18	SP000005_C
Windows** and roof windows	1.6	1.6	1.6	SP000005_W1_O0
Rooflights***	2.2	-	-	No external rooflights
Personnel doors^	1.6	2.2	2.2	SP000005_W4_O2
Vehicle access & similar large doors	1.3	-	-	No external vehicle access doors
High usage entrance doors	3	-	-	No external high usage entrance doors

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

$U_{e\text{-}Calc}$ = Calculated area-weighted average U-values [W/(m²K)]

* 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. *** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m²K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
$m^3/(h.m^2)$ at 50 Pa	8	10

Page 1 of 6

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Hanger

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	0.8	-	0.4	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

2- Annex Heating

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	1	-	-	-	-
Standard value	N/A	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					NO

1- SYST0003-DHW

	Water heating efficiency	Storage loss factor [kWh/litre per day]
This building	Hot water provided by HVAC system	-
Standard value	N/A	N/A

1- District heating network

	Emission factor [$kgCO_2/kWh$]	Primary energy factor [kWh_{PE}/kWh]
This building	0.36	1.58
Standard value	0.35	N/A

"No zones in project where local mechanical ventilation, exhaust, or terminal unit is applicable"

General lighting and display lighting	**General luminaire**	**Display light source**	
Zone name	**Efficacy [lm/W]**	**Efficacy [lm/W]**	**Power density [W/m²]**
Standard value	95	80	0.3
Main Hanger Space	93	-	-
R27 Locker Room	99	-	-
R35 Male WC	105	-	-
R34 Lobby	173	-	-
R36 Female WC	169	-	-
R33 Lobby	171	-	-
R32 Kitchenette and Rest Room	97	-	-
R31 Lobby	111	-	-
R28 Lobby	160	-	-
R20 Office	110	-	-
R19 Office	123	-	-
R18 Office	114	-	-
R17 Office	117	-	-
R16 Office	141	-	-
R15 Office	114	-	-
R14 Office	100	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
R13 Office	114	-	-
R12 Office	99	-	-
R11 Office	99	-	-
R10 Lobby	114	-	-
R09 Office	99	-	-
R08 Office	118	-	-
R07 Office	102	-	-
R06 Office	110	-	-
R05 Office	116	-	-
R04 Lobby	169	-	-
R03 Store	110	-	-
R02 Store	115	-	-
R01 Store	103	-	-
R25 Corrdior	102	-	-
R24 Corrdior	102	-	-
R23 Corridor	109	-	-
R22 Corridor	102	-	-
R21 Corrdior	104	-	-
R30 Plant	193	-	-
R29 Plant	130	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
Main Hanger Space	NO (-18.8%)	NO
R27 Locker Room	NO (-33.6%)	NO
R20 Office	N/A	N/A
R19 Office	N/A	N/A
R18 Office	NO (-43.9%)	NO
R17 Office	NO (-37%)	NO
R16 Office	N/A	N/A
R15 Office	NO (-58%)	NO
R14 Office	NO (-52.4%)	NO
R13 Office	NO (-43.5%)	NO
R12 Office	NO (-35.4%)	NO
R11 Office	NO (-49.5%)	NO
R09 Office	NO (-48.6%)	NO
R08 Office	NO (-35.9%)	NO
R07 Office	NO (-44.5%)	NO
R06 Office	NO (-51.7%)	NO
R05 Office	NO (-52%)	NO
R03 Store	YES (+11.4%)	NO
R02 Store	NO (-9.6%)	NO
R01 Store	YES (+16.2%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	NO
Is evidence of such assessment available as a separate submission?	NO
Are any such measures included in the proposed design?	NO

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	5215.2	5215.2
External area [m²]	14627	14627
Weather	SOU	SOU
Infiltration [m³/hm²@ 50Pa]	10	5
Average conductance [W/K]	4927.68	4932.36
Average U-value [W/m²K]	0.34	0.34
Alpha value* [%]	42.04	25.02

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

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
100	**General Industrial and Special Industrial Groups**
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
	Residential Institutions: Universities and Colleges
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
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	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/m²]

	Actual	Notional
Heating	121.23	103.05
Cooling	0	0
Auxiliary	0.54	0.26
Lighting	10.41	7.73
Hot water	5.24	4.03
Equipment*	32.64	32.64
TOTAL**	**137.42**	**115.07**

* 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/m²]

	Actual	Notional
Photovoltaic systems	0	67.46
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*67.46*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	387.44	580.64
Primary energy [kWh_{PE}/m²]	212.63	74.17
Total emissions [kg/m²]	23.99	10.2

HVAC Systems Performance										
System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Unflued radiant heater, [HS] Unflued radiant heater, [HFT] Electricity, [CFT] Electricity										
	Actual	345.1	43	128.3	0	0	0.75	0	0.8	0
	Notional	524.7	94.7	108.8	0	0	1.34	0	----	----
[ST] Central heating using water: radiators, [HS] District heating, [HFT] District Heating, [CFT] Electricity										
	Actual	274.6	92.7	85.5	0	3.4	0.89	0	1	0
	Notional	268	93.3	74.4	0	1.6	1	0	----	----
[ST] No Heating or Cooling										
	Actual	0	1329.3	0	0	0	0	0	0	0
	Notional	0	1332.7	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
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