



AXIS MANCHESTER



PROPOSED ROOF WORKS WIND STUDY REPORT

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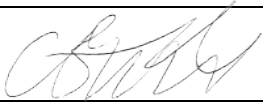
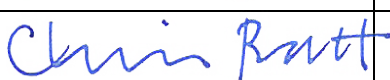
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Document Verification

Prepared For	Mills and Co, 107 Cheapside, London, EC2V 6DN
Prepared By	Westlakes Engineering, 20 Dale Street, Manchester, M1 1EZ
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Signatures and Approvals

Author:	C Burton		Date:	02/06/2023
Checker:	C Pratt		Date:	02/06/2023
Approver:	C Pratt		Date:	02/06/2023

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Contents

1.0	Terms of Reference	4
2.0	The Existing Building	4
3.0	Proposed Structures	4
4.0	Wind Loading	5
5.0	Bar	6
6.0	Gym	6
7.0	Pool	6
8.0	Other Wind Effects	6

References

Appendices

Appendix A – Figures

Appendix B - Calculations

1.0 Terms of Reference

- 1.1 Mills & Co. are acting for the owner ("the Client") of the penthouse apartment ("the Apartment") at the Axis Tower in Manchester. The Client wishes to make use of part of the roof space above to create a bar, a gym and a swimming pool and intends to make an application for Planning Permission for the associated building works.
- 1.2 Westlakes have been appointed by Mills & Co., on behalf of the Client, to conduct a Wind Study in support of the Planning Application. The purpose of the study is to assess wind loadings on the proposed roof structures and to advise on any measures needed to resist wind uplift.

2.0 The Existing Building

- 2.1 The Axis Tower is a 28-storey residential building in Manchester city centre. The structure of the tower is a reinforced concrete (rc) frame, comprising slabs supported on a combination of columns and walls. In order to minimise their thickness, the floor slabs were constructed in post-tensioned (pt) concrete.
- 2.2 The 28th floor is the roof and, apart from an enclosure over the core area, is currently open space with storey height screens along the north and south elevations. The east and west ends of the roof are currently protected by 1100mm high glass balustrades. Finishes to the roof slab are understood to comprise a waterproof membrane, covered by rigid insulation laid to falls, topped by 80mm thick concrete paving flags (see figure 1).
- 2.3 A mobile crane, referred to as the Building Maintenance Unit ("BMU"), is mounted on a fixed track along the centre of the roof slab and has a cradle which can be suspended over the sides of the roof to allow maintenance or cleaning of the tower façades.
- 2.4 The structural design of the Axis Tower was undertaken by WSP Group but the final design of the pt floor slabs was carried out by CCL, a specialist sub-contractor who also constructed the floors. Details of the existing structure used in this study have been taken from WSP drawings provided by the Developer to Mills and Co.

3.0 Proposed Structures

- 3.1 The Client's proposals are shown on planning drawings prepared by Fairhursts Design Group ("FDG", see References 1-5) and briefly comprise 3 separate steel-framed, single-storey structures. Each structure has cladding over its entire roof but one or more of the elevations would be open. Westlakes have prepared preliminary structural designs for each of the 3 structures, as shown on References 6-8. In addition to the 3 structures, new 2.5m high glass screens are proposed at both ends of the roof to provide additional shielding for users of the new amenity spaces.
- 3.2 In order to minimise their effect on the structural design of the existing building, the proposed bar and gym structures are designed such that the combined effect of their self-weight and occupancy live loading will not exceed the available load capacity of the roof slab. It is intended that they be placed directly onto the existing roof and, as far as possible, avoid the need for any mechanical fixing which might damage the roof waterproofing or insulation systems. Similarly, in order to avoid attracting additional wind loading onto the building, the proposed structures reach a maximum height of only 2.9m above roof level such that they would remain lower than the existing 3m high screens along the north and south sides of the roof.

- 3.3 In addition to the 3 new structures and the glass screens at each end of the roof, there would also be extra partitioning to separate the Client space from the plant maintenance areas. These partitions would comprise 2.5m high perforated metal screens, and their arrangement is shown on the Proposed GA Roof Layout by FDG (see figure 2).
- 3.4 It is envisaged that the new structures would be pre-assembled off-site and delivered ready for lifting into place directly onto the roof using a telescopic mobile crane, sited temporarily for the purpose on Whitworth Street West.

4.0 Wind Loading

- 4.1 Wind loading on the proposed roof structures has been calculated in accordance with BS EN 1991-1-1:2005 and the National Annex (Reference 9). A preliminary, quantitative assessment of wind loading has been undertaken to check wind forces on the structures and a qualitative assessment has then been made of other wind effects on the roof space. Calculations are appended at Appendix B and the results are summarised in sections 5.0 – 7.0 for each of the new structures in turn.
- 4.2 In deriving the wind loads on the proposed structures, account has been taken of the shielding effects of the existing 3m high screens which are located along the north and south sides of the roof. As noted, the new proposals also include additional glass and perforated metal screens, of slightly lower height. At this stage no account has been taken of any shielding effect of these extra screens in assessing the forces on the proposed structures, but they are considered in the qualitative assessment.
- 4.3 The height of the proposed structures has been limited to remain below the height of the existing 3m high screens, along the north and south sides of the roof, in order to avoid increasing the building height and attracting additional wind load onto the building structure itself. This is discussed further by considering wind in two orthogonal directions:
- Wind in the **south-north** direction at roof level will currently strike the 3m high screens and, as it then blows across the top of the roof above that level, will apply some force to the vertical surfaces of the core enclosure and the rear of the 3m screen on the far side of the roof. The insertion of the additional partitions will influence this load path by creating additional surfaces to which force may be applied by the passage of wind, but also by reducing the force on other surfaces due to screening effects of the new structures. Overall, any change is considered to be marginal and likely to be within the capacity of the substantial shear wall provision in this direction.
 - Wind in the **west-east** direction at roof level will currently strike the 1.1m high balustrades on each gable end and, as it then blows across the top of the roof beyond, be funnelled between the tapering 3m tall sides screens to which some longitudinal force will be applied. The proposed additional 2.5m high glass screen across each end of the building will also influence the overall wind loading marginally. Some additional wind force will be attracted at the gable ends of the structure but there may be some reduction in the funnelling effect as a result of their presence. Any additional wind load transferred into the roof slab would be resisted by the shear wall system below which, in this direction, is eccentric and more complex. However, the actual increase in screen height (1.5m) represents only about 1.5% of the overall building height such that any consequence should be acceptable for building stability.

5.0 Bar

- 5.1 The bar enclosure will be a lightweight, single-storey steel frame measuring 7.0m x 6.1m on plan and 2.9m in height. The bar will have a glass roof and screen walls to its north elevation only, with the remaining elevations being permanently open. No details of the proposed furniture are available beyond what is noted on the FDG planning drawings, i.e. “monolithic seating and serving bar”. These items would be permanently fixed to the floor of the new structural frame.
- 5.2 In order to spread the load of the unit as evenly as possible over the roof slab, the frame includes multiple baseplates on a regular grid (see reference 6).
- 5.3 Based on these assumptions, and assuming no concurrent occupancy (live) loading, the effect of the maximum design wind load on the bar unit is calculated to be a total net uplift of 9.0kN (unfactored). The frame would therefore need to be restrained against uplift by the self-weight of some of the 80mm thick, 400mm square ballast paving slabs. A single strip of 400mm square slabs around the full 26m perimeter of the unit weighs approximately 20kN and would be sufficient to provide an ample factor of safety against uplift. The baseplate detail for the unit would be adjusted and enlarged from that shown on Reference 6 such that, around the perimeter, it would rest below the paving flags. The flags would be locally removed prior to installation and re-laid to cover and weigh on an extended linear baseplate.

6.0 Gym

- 6.1 The gym enclosure would comprise a lightweight, single-storey steel structure with a glass roof and glass wall to its east elevation only. The south and west elevations would be clad with a lightweight perforated steel mesh screen whilst the north would be open. The structure is 5.5m x 4.4m on plan and 2.8m in height. Furniture would comprise exercise machines only which would be permanently fixed in place to the structural frame of the unit.
- 6.2 From the calculations in Appendix B, the effect of the maximum design wind load on the gym enclosure would be insufficient to create net uplift on the unit. Therefore peak wind pressure on the frame will not cause a risk of net uplift on the gym frame and no further ballast loading is required.

7.0 Pool

- 7.1 The pool will be 1.5m deep enclosed in a steel-framed unit with a glass roof, a glass wall to its north and east elevations and a metal screen to the south. The west end of the unit would be open. The weight of the unit will be carried by the steel frame and transferred directly into the shear walls below on gridlines 3 and 5 of the Axis Tower.
- 7.2 The self weight of the water in the pool is 15kN/m² which by inspection is sufficient to prevent risk of uplift of the unit. However, even if the pool were to be drained the need to support and transfer the weight of water means that the structure of this unit is much more substantial than the other two such that there is no risk of uplift to the pool unit.

8.0 Other Wind Effects

- 8.1 Under the design proposals the open roof space will become a series of discrete areas separated by 2.5m high perforated metal screens, sheltered from the external environment by similar height glazed screens to the east and west and taller screens to the north and south. Apart from the covered units, the entire area will remain open to the sky and the effects of wind blowing across the top of the tower.
- 8.2 For users of the new units the combined effect of the additional screens would be expected to create an environment that was reasonably sheltered from the wind, but it is not anticipated that there is any requirement to maintain that standard in all weathers. It is to be assumed that use of the units would be unlikely in bad weather.
- 8.3 Any furniture to be permanently left on the roof would need special consideration due to the wind effects that apply at roof level on a tower of this height. Any furniture to be used on the roof would have to be robust and securely fixed in place and any loose items would have to be put away in a suitable storage area or taken back down to the Apartment.
- 8.4 Strong wind blowing across the roof could be sufficient to pick up loose items, however the subdivision of the roof space by the additional 2.5m high screens greatly reduces the risk of any loose items left behind actually being blown off the roof, it being more likely they would hit a screen and simply fall to the floor. In this respect, therefore, the design proposals are consistent with guidance within British Standard BS8579: 2020 Guide to the Design of Balconies and Terraces, which recognises the effect of wind on high rise buildings and considers minimum balustrade heights and the need for shelter and containment. It suggests that to ensure that items do not become dislodged mitigation measures may include subdivision and raised side balustrades.
- 8.5 It is noticeable that other nearby rooftop amenity spaces, such as those in the Great Jackson Street cluster, are typically deliberately design as being completely open plan. There is also considerable evidence from residential buildings in Manchester city centre that items, including laundry, are routinely left on balconies without causing harm or damage. By comparison, and as shown by the Architectural 3D drawing in figure 2, the proposed Axis roof, with its discrete enclosures, is considered to present a very low risk in this regard.
- 8.6 It is anticipated that the pool may have a cover to prevent loss of heat but it is possible that some water from the surface of the pool could be blown out under certain wind conditions if it was left uncovered. However, the pool unit is only open at its western end and it is anticipated that any water lost in this way would simply be spray which would fall into the pool seating area, thereby causing only a similar effect to that of pool users getting in and out.



References

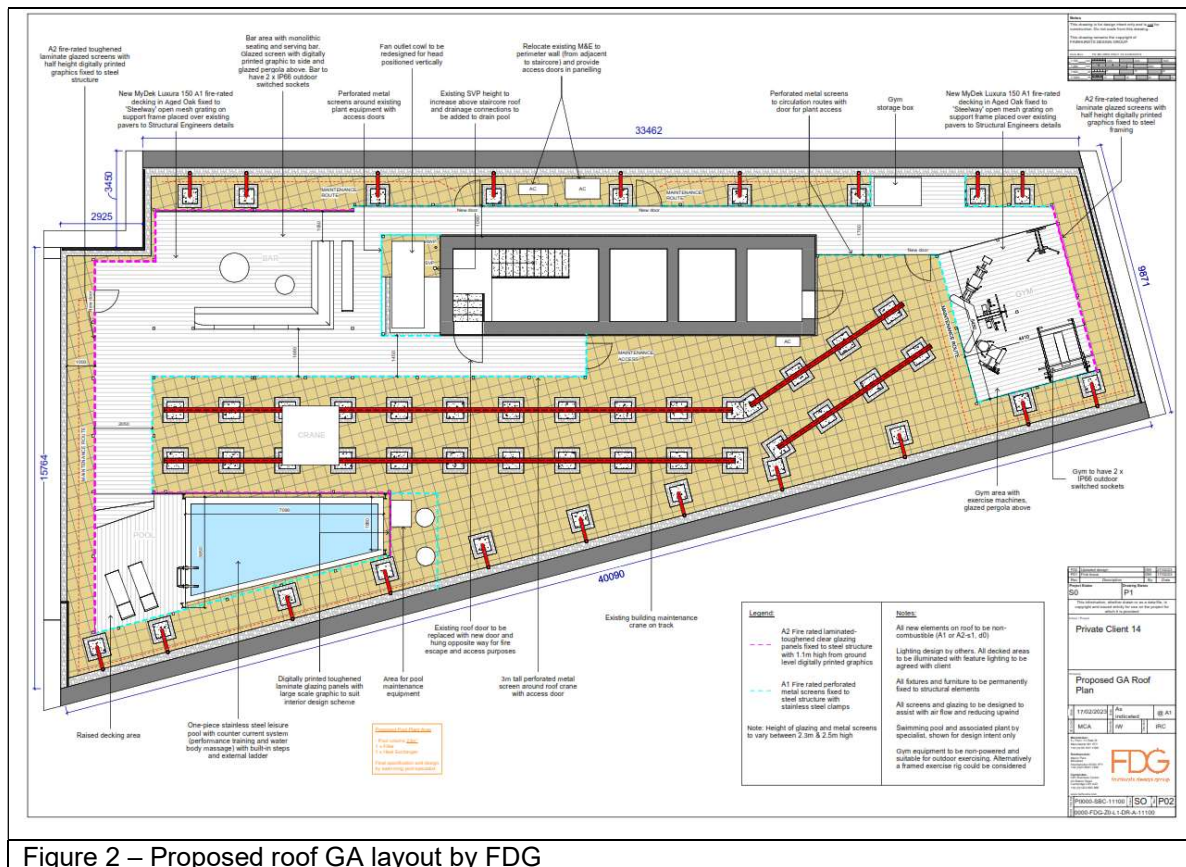
1. FDG drawing "FDG-11100-Proposed GA Roof Plan-P02
2. FDG drawing "FDG-11110-Proposed Roof Pergola Plan-P02
3. FDG drawing "FDG-11300-Proposed Pool Plan-P02
4. FDG drawing "FDG-12100-GA Sections-P02
5. FDG drawing "FDG-11200-3d Drawings-P02
6. Westlakes drawing "WL_2043_SK01_POOL STRUCTURE GA
7. Westlakes drawing "WL_2043_SK02_BAR UNIT GA
8. Westlakes drawing "WL_2043_SK03_GYM UNIT GA's



Appendix A – Figures



Figure 1 – Roof finishes topped by 80mm thick concrete paving flags



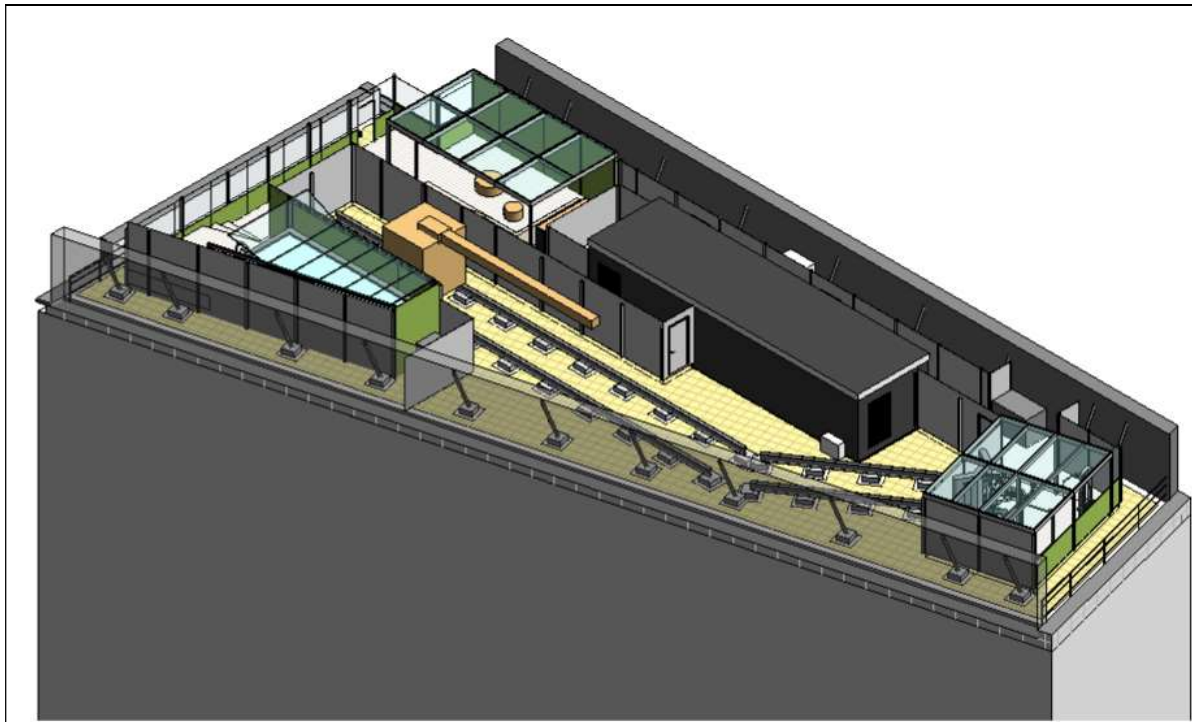


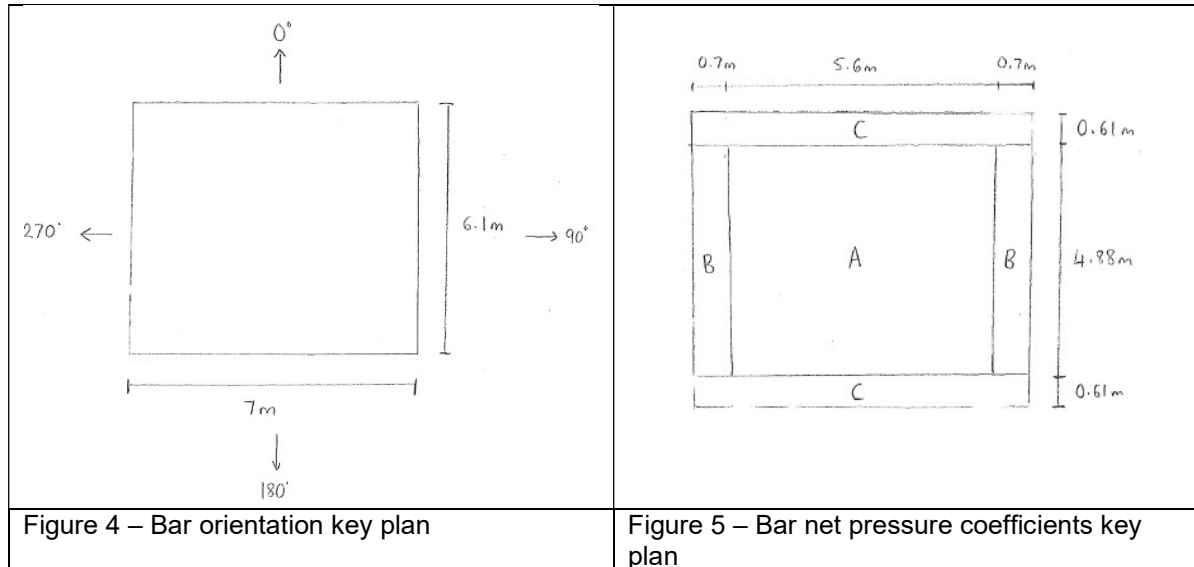
Figure 3 – Architectural 3D view



Appendix B - Calculations

Calculation of Uplift and Peak Pressures on Bar

Using Section 7.3 of BS EN 1991-1-1-4:2005



Wind acting at 0°

Blockage, $\phi = 1$ (conservative, Note 2)

Roof angle, $\alpha = 0^\circ$

Overall force coefficient, $C_f = -1.3$ (Table 7.6)

Dead Load of bar = 60.4kN

$$Uplift = C_f * Q_p(Z) * A$$

$$\text{Where } A_{bar} = 6.1 * 7 = 42.7m^2$$

$$Uplift \text{ on bar} = -1.3 * 1.25 * 42.7 = -69.4kN \text{ (See Note 5 Section 7.3)}$$

$$Net \text{ uplift on bar} = 60.4 - 69.4 = -9.0kN$$

$$FOS = \frac{60.4}{69.4} = 0.87$$

For peak pressures (Table 7.6)

$$A = -1.5 * 1.25 = -1.88kN/m^2$$

$$B = -1.8 * 1.25 = -2.25kN/m^2$$

$$C = -2.2 * 1.25 = -2.75kN/m^2$$

Wind acting at 90° = 270°

Blockage, $\phi = 0.5$ (conservative, Note 2)
Roof angle, $\alpha = 0^\circ$
Overall force coefficient, $C_f = -0.9$ (Table 7.6)
Dead Load of bar = 60.4kN

$$Uplift = C_f * Q_p(Z) * A$$

$$\text{Where } A_{bar} = 6.1 * 7 = 42.7m^2$$

$$Uplift \text{ on bar} = -0.9 * 1.25 * 42.7 = -48.0kN$$

$$Net \text{ uplift on bar} = 60.4 - 48.0 = 12.4kN$$

$$FOS = \frac{60.4}{48.0} = 1.25$$

For peak pressures (Table 7.6)

$$A = -1.05 * 1.25 = -1.31kN/m^2$$

$$B = -1.55 * 1.25 = -1.94kN/m^2$$

$$C = -1.8 * 1.25 = -2.25kN/m^2$$

Wind acting at 180°

When wind acts at 180° , the gym will be protected by the 3m high parapet wall which is approximately 2m North of the glazed elevation of the bar.

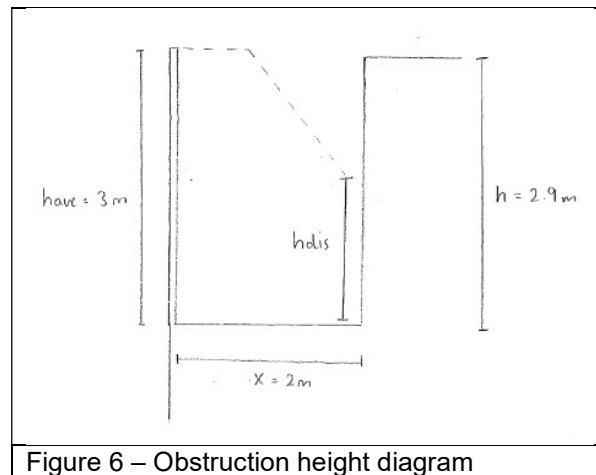


Figure 6 – Obstruction height diagram

Section A.5 states when $x \leq 2 * have$, $hdis$ is the lesser of $0.8 * have$ or $0.6 * h$

$$0.8 * have = 2.4m$$

$$0.6 * h = 1.74m$$

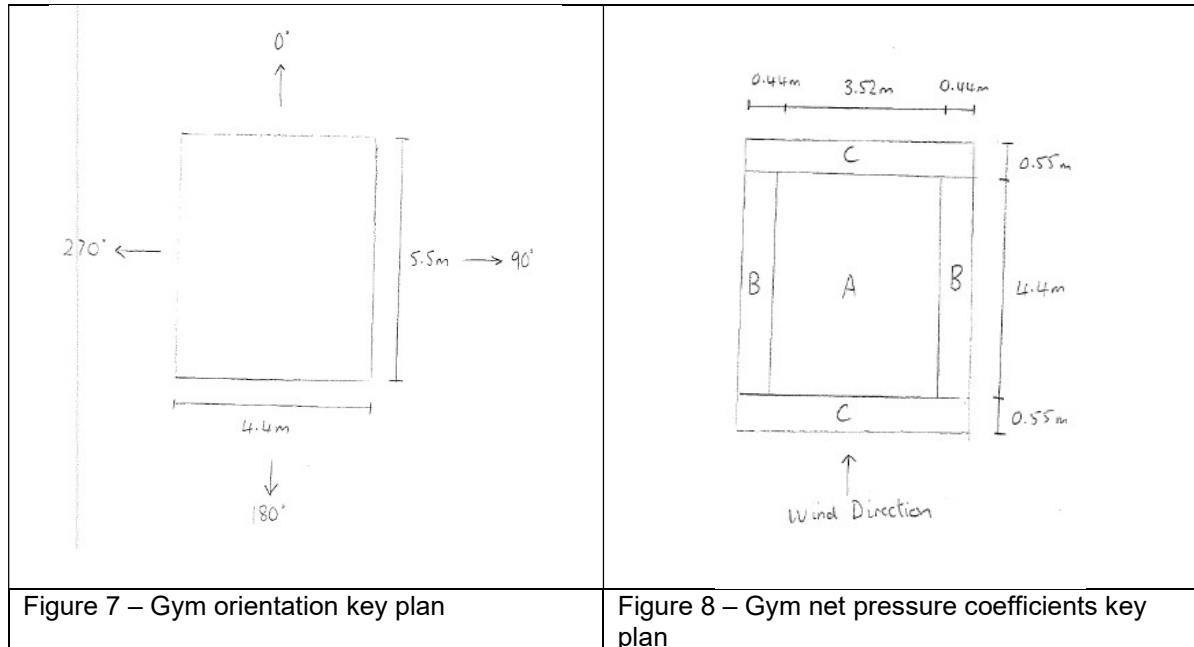
Therefore, $hdis = 1.74m$

Building height can be reduced by 1.74m to $89 - 1.74 = 87.26m$

Height reduction provides insignificant decrease to peak velocity, therefore wind acting at $180^\circ = 0^\circ$ (conservative)

Calculation of Uplift and Peak Pressures on Gym

Using Section 7.3 of BS EN 1991-1-1-4:2005



Wind acting at $0^\circ = 90^\circ$

Gym will be blocked by existing 3m high parapet walls in these directions, but as seen in Appendix B, this makes negligible difference to peak wind pressures.

Blockage, $\phi = 0.5$ (conservative, Note 2)

Roof angle, $\alpha = 0^\circ$

Overall force coefficient, $C_f = -0.9$ (Table 7.6)

Dead Load of bar = 44.9kN

$$Uplift = C_f * Q_p(Z) * A$$

$$\text{Where } A_{gym} = 4.4 * 5.5 = 24.2m^2$$

$$Uplift \text{ on gym} = -0.9 * 1.25 * 24.2 = -27.2kN \text{ (See Note 5 Section 7.3)}$$

$$Net \text{ uplift on gym} = 44.9 - 27.2 = -17.7kN$$

$$FOS = \frac{44.9}{27.2} = 1.65$$

For peak pressures (Table 7.6)

$$A = -1.05 * 1.25 = -1.31kN/m^2$$

$$B = -1.55 * 1.25 = -1.94kN/m^2$$

$$C = -1.8 * 1.25 = -2.25kN/m^2$$



Wind acting at $90^\circ = 270^\circ$

Blockage, $\phi = 1$ (conservative, Note 2)

Roof angle, $\alpha = 0^\circ$

Overall force coefficient, $C_f = -1.3$ (Table 7.6)

Dead Load of bar = 44.9kN

$$Uplift = C_f * Q_p(Z) * A$$

$$\text{Where } A_{gym} = 4.4 * 5.5 = 24.2m^2$$

$$Uplift \text{ on bar} = -1.3 * 1.25 * 24.2 = -39.3kN \text{ (See Note 5 Section 7.3)}$$

$$Net \text{ uplift on bar} = 44.9 - 39.3 = -5.6kN$$

$$FOS = \frac{44.9}{39.3} = 1.14$$

For peak pressures (Table 7.6)

$$A = -1.5 * 1.25 = -1.88kN/m^2$$

$$B = -1.8 * 1.25 = -2.25kN/m^2$$

$$C = -2.2 * 1.25 = -2.75kN/m^2$$