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External Envelope:
Glazing, Insulated Render and Stone Façade Elements

AERCAP HOUSE METROLINK INTERFACE

Aercap House, St. Stephens Green, Dublin

Info

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Mar 2024

For
Hines Real Estate Ireland Ltd.

By
Billings Design Associates Ltd.

REVISIONS

Revision	Date	Issue Status	Change Description	Author	Check
C01	20.03.2024	Internal review	-	CB	CB
C02	21.03.2024	Final	-Updated based on comments received.	CB	CB

New documents received:

- EIAR Addendum Downward Realignment St Stephens Green Station to Charlemont Station (1)
- Further updated Tunnel Alignment Saint Stephens Green_Charlemont RO Application Alignment and Deeper Vertical Alignment Option_2 Sheets_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-01027 (P03)
- Further updated Tunnel Alignment Saint Stephens Green_Charlemont RO Application VS Deeper Vertical Alignment Option_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-02027 (P03)
- Tunnel Alignment Saint Stephens Green_Charlement RO Application Alignment and Deeper vertical Alignment Option_2 Sheets_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-0102
- Tunnel Alignment Saint Stephens Green_Charlement RO Application VS Deeper vertical Alignment Option_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-02027
- Updated Tunnel Alignment Saint Stephens Green_Charlement RO Application Alignment and Deeper Vertical Alignment Option_2 Sheets_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-0102
- Updated Tunnel Alignment Saint Stephens Green_Charlement RO Application vS Deeper Vertical Alignment Option_Drawing Number ML1-JAI-RTA-ROUT_XX-DR-Y-02027
- Working Draft - Process for the oversight and implementation of Phase 3 assessments

CONTENTS:

1 INTRODUCTION

I am Colman Billings (BDesHons), owner, and managing director of Billings Design Associates Limited (BDA). I am an industrial designer, specializing in the design, procurement and inspection of façade systems for buildings. I have been working as a façade consultant, involved in the detail design and specification of bespoke curtain walling and other façade systems for the last 30 years. I have worked on projects ranging from high-rise residential towers in the UK in excess of 50 floors, to designing the unitised curtain walling for hurricane and earthquake resistant office buildings in the Caribbean.

Billings Design Associates Limited (BDA) were the façade consultants on the Aercap House project, (formerly known as Canada House) located on St. Stephens Green. We performance specified the façade elements of Aercap House. Final detail design, manufacture and installation was carried out by a specialist façade contractor, Gunn Lennon Fabrications Limited (GLF) and Stone Systems.

BDA has been asked to review the installed façade with regard to the potential effects of the MetroLink construction works and operation and to prepare this document in response to TIIs replies to the submission made on the Metrolink on behalf of Hines Real Estate Ireland Limited in connection with Aercap House.

2 EXECUTIVE SUMMARY

BDA has reviewed TII's replies to Hines Real Estate Ireland submission and we respectfully disagree about the characterisation of damage to the building as described as being 'very slight' as stated in the new document 'Addendum to the EIAR – Downward Tunnel Realignment: St Stephen's Green Station to Charlemont Station (P01 06.03.2024)' and are concerned, for the reasons set out below, that damage to the building has been under-estimated and that the building will be damaged as a result of settlement or vibrations.

2.1 Ground Settlement

The TII document ML1-JAI-EIA-ROUT_XX-DR-Y-21146 P02 dated 23.02.2024 indicated the settlement of maximum 10mm under Aercap House. With reference to TII Document: 'Addendum to the EIAR – Downward Tunnel Realignment: St Stephen's Green Station to Charlemont Station (P01 06.03.2024)' the ground settlement has dramatically increased. There is no explanation in the document as to why the conditions have worsened to such an extent. The document does not give clarity on the settlement gradient to be expected at Aercap House. There is no Phase 3 assessment and apparently no review of how the particular facades on Aercap House will perform. As a result, we raise the following concerns:

1) An updated contour map indicating the predicted settlement should be provided.
2) The latest information from TII indicates maximum settlement of 22mm under Aercap House. This figure, which is far higher than previously advised, has the possibility of causing damage depending on the settlement contours.

3) Portland Roach-bed limestone rainscreen cladding, 50mm thick. Differential settlement predicted across the North elevation and South elevation could cause cracking of stone panels. Worst case, stone could fall from the building to the public pathway below.

4) Portland Roach-bed limestone canopies 70mm thick with lead roofing. Located on the East and South elevations. These induce high stresses into the primary structure. They are suspended on local anchors. Differential movement and vibration could cause cracking.

5) Timber framed stick system curtain walling 'windows'. Depending on the extent of differential settlement between columns these could suffer racking and cracking of glass.

6) Courtyard insulated render. This is a liquid applied finish to rigid insulation in the courtyard. The West elevation aligns with the centre-line of the proposed tunnel. The action of the TBM traversing the building from North to South will rack the structure, potentially cracking the render causing risk of water ingress and damage to finishes.

7) Ground level glazing to the North elevation. This is floor to ceiling free-spanning glazing. If the structure deforms to the settlement profile predicted this glass may suffer racking and glass to metal contact causing breakage.

We recommend there is a full Phase 3 assessment the façades on Aercap House prior to grant of approval. We recommend there should be full consultation in relation to this. In addition, we recommend the facades and canopies are monitored prior to the TBM arriving, during the TBM tunnelling under the building and for a period afterwards in order to fully understand and see in real-time the deformation of the facades and ensure against damage.

2.2 Vibration

1) There is insufficient information available to assess the risk of damage due to vibration. We ask that the TII provide detailed information on the proposed frequency and quantum, and duration predicted at the Aercap House location during the MetroLink works.

2) There is limited guidance on design for vibration other than design for earthquake conditions. The building envelope has not been designed for vibration or earthquake conditions.

3) The area of most concern would be the cantilever stone-clad canopies which rely on threaded anchors for support. Loosening of these due to vibration could create a risk of falling stone.

4) Vibrations can cause loosening of fixings, dislodging of packers and movement of components, outside of their design parameters which could potentially cause damage. Monitoring of the façades, before, during and directly after tunnelling operations would be recommended to ensure there is no degradation due to vibration.

3 EFFECTS OF METROLINK CONSTRUCTION WORKS

3.1 Ground Settlement

TII Reference: Submission Number 117. Hines Real Estate Ireland Limited, Page 3, and TII response. We also refer to 'Addendum to the EIAR – Downward Tunnel Realignment: St Stephen's Green Station to Charlemont Station (P01 06.03.2024)' indicating significant differential settlement across the site of Aercap House.

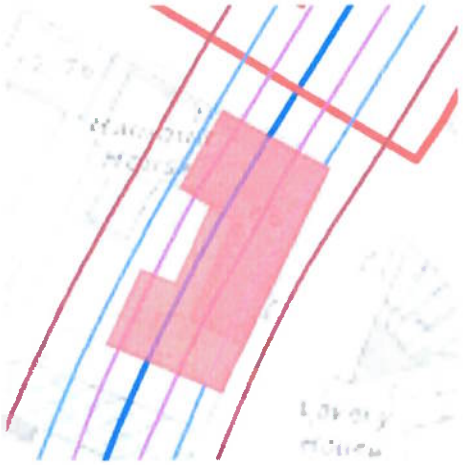

Figure 1 Plan of Aercap House with TII predicted ground settlement. Max. settlement is now predicted as 22.14mm

MetroLink has assessed the predicted "Settlement" and presents its findings on drawing no. ML1-JAI- EIA-ROUT-XX-DR-Y-21146 rev P02. This drawing indicates MetroLink will be causing a 10mm settlement directly under the location of our client's building which is unacceptable. We have not received an update of this drawing.

However, the new document 'Addendum to the EIAR – Downward Tunnel Realignment: St Stephen's Green Station to Charlemont Station (P01 06.03.2024)' indicates a revised settlement of maximum 22.14mm. Settlements of this magnitude cannot be accommodated by the building's facades. Such settlement, particularly if introducing differential settlement between columns, will cause damage.

From the published response received from TII, we understand they will be reviewing in more detail, the potential for ground settlement. The notes below are intended to assist TII in understanding the effect ground settlement could have on the facades at Aercap House. As there is risk of damage from the action of tunnelling and the subsequent settlement of the ground, we recommend the façades and canopies on Aercap are monitored prior to the TBM arriving, during the TBM tunnelling under the building and for a period afterwards in order to fully understand and see in real-time the deformation of the facades and ensure against damage.

3.1.1 Portland Roach-bed Limestone Rainscreen Cladding

Figure 2 North Elevation Portland Stone

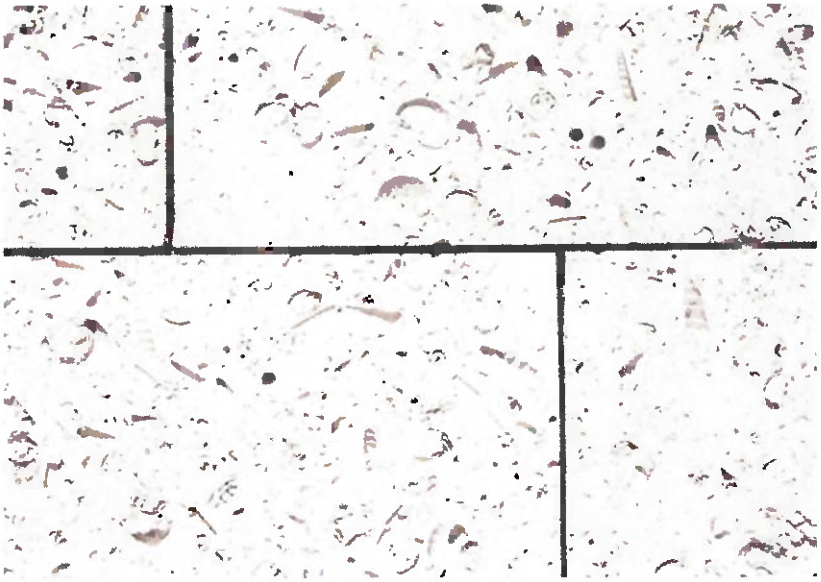

Figure 3 Portland Stone close-up

The stone on Aercap House is categorised as a low strength limestone. The stone on Aercap House is 50mm thick supported on stainless steel shelf angles at each floor level. Should the primary structure deform due to tunnelling below the building, there is a likelihood the façade system will suffer damage. Damage can occur due to differential settlement of a column along the elevation. With the current tunnel position as illustrated in Figure 1 above, the highest risk locations for damage to the Portland stone cladding are the North and South elevations.

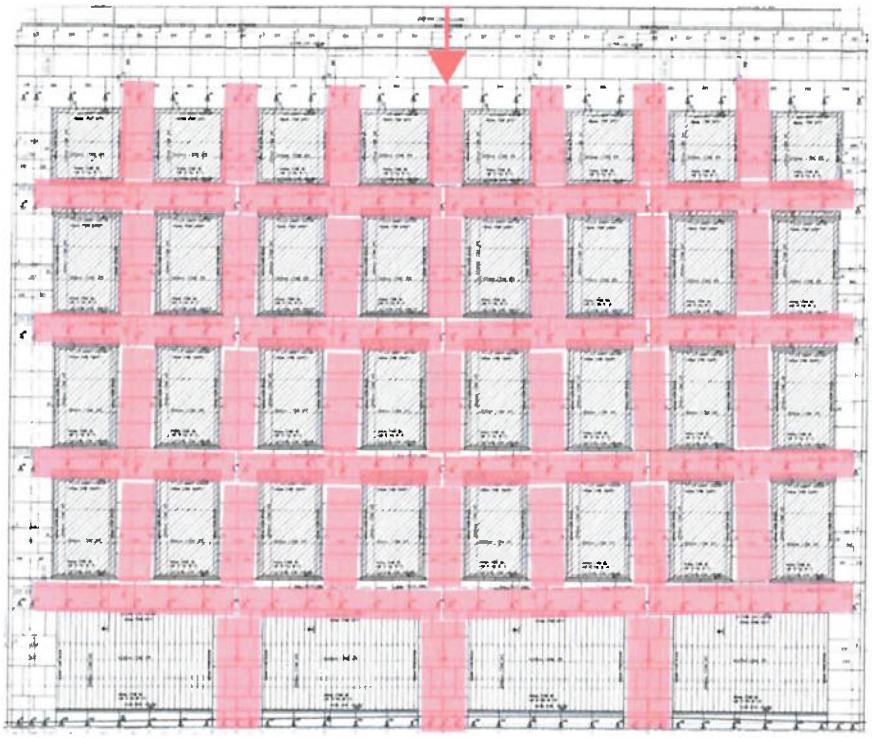

Figure 4 South elevation. Differential settlement causes rocking of stone piers.

Racking of the stone piers is caused by rotation of the slab as a result of differential settlement between columns. Assuming a 22mm drop along a 12m width (to be confirmed by TII) from centre-line of tunnel to perimeter of settlement, we could expect the base of a stone pier which is 1000mm wide to rotate approximately 1.8mm at its base. Each pier is approximately 3.8m tall. The pier of stone will want to rotate 7.2mm at the top.

As the stone is restrained by local stainless steel rods which can accommodate some bending, the stone is likely to move less than this, but as the structure moves, stress in the stone to fixing interface will increase. The stone to stone joints are open and such racking could result in closing of joints at interfaces with canopies on the South elevation. Stone to stone contact could result in cracking. In worst case scenario, stone could be over-stressed locally, crack and fall.

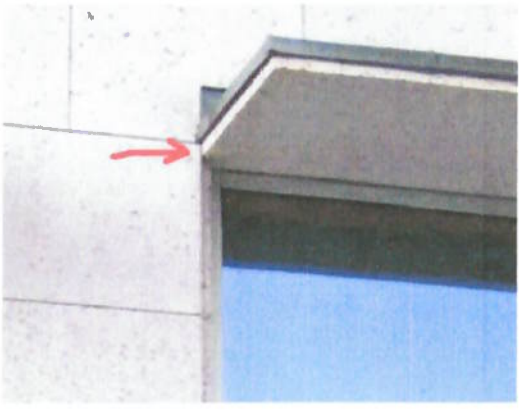

Figure 5 Stone pier to stone canopy interface. Possible contact-stress location.

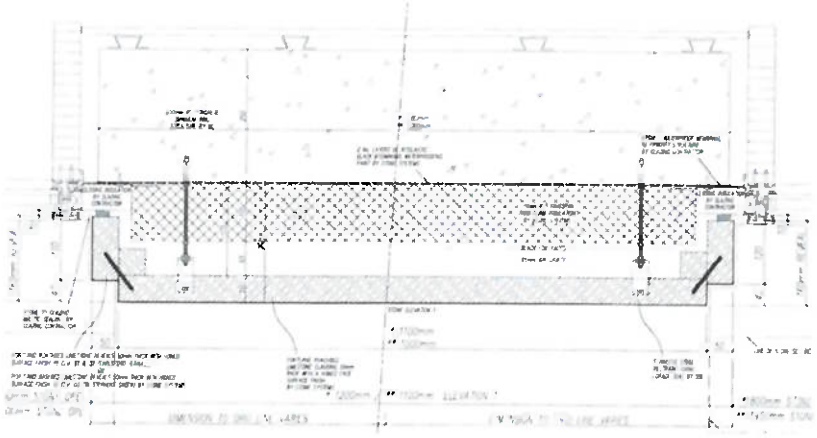

Figure 6 Typical stone pier plan section

3.1.2 Timber Framed Stick System Curtain Walling 'Windows'

The timber framed curtain wall is a Raico gasket net system with external pressure-caps retaining the glass. These are located on North, South, East and West elevations. The windows on North and South elevations will be subject to long-term racking if the predicted ground settlement occurs. The large windows on the West elevation will be subjected to racking during the period the TBM traverses the building from North to South. The width of the windows varies depending on location.

Assuming a 22mm drop along a 12m width (to be confirmed by TII) from centre-line of tunnel to perimeter of settlement, we could expect the base of a typical window which is 1800mm wide to rotate approximately 3.3mm at its base. Each window is approximately 2.8m tall. The glass within the frame will want to rotate approximately 5mm at the top corner. Due to the fact the system is a gasket net, this rotation would result in glass to epdm profile contact rather than glass to metal contact.

However, as the inner glass is 12.8mm laminated annealed glass, it is susceptible to edge damage and has very limited capacity for edge stress. As a result, there is a risk of the inner glass cracking.

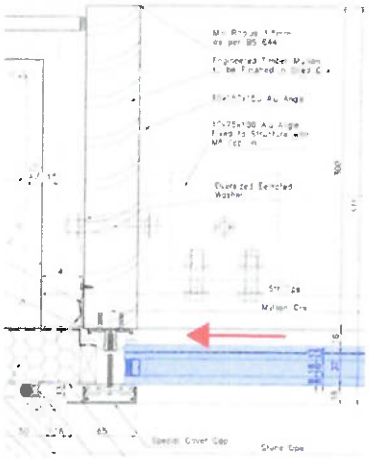

Figure 7 Timber framed curtain wall. Racking of glass within frame

3.1.3 Courtyard Insulated Render

The courtyard elevations of Aercap House are clad in insulated render. This is a liquid applied finish onto a rigid insulation. The courtyard West facing elevation is approximately on the centre-line of the TBM route. As the TBM traverses under the building, this will result in differential settlement of the columns along the East elevation. This is likely to result in cracking of the insulated render as it is not designed to take such movements.

Cracks in the render could cause water ingress and damage to finishes including the timber curtain wall frames noted above.

3.1.4 Ground Level Glazing

The ground level glazing to the North elevation will suffer racking due to the predicted ground settlement. The individual panels of glass are approximately 1.6m wide and 2.9m tall. They are free spanning from floor to ceiling.

Assuming a 22mm drop along a 12m width (to be confirmed by TII) from centre-line of tunnel to perimeter of settlement, we could expect the base of a typical glass panel which is 1630mm wide to rotate approximately 3mm at its base. Each panel of glass is approximately 2.9m tall. The glass will want to rotate approximately 5.3mm at the top corner. Due to the fact the system is a bespoke shuffle-glazed solution, the perimeter glass at the column should be free to rotate in the channel.

However, as the inner glass is 15.5mm laminated annealed glass, it is susceptible to edge damage and has very limited capacity for edge stress. As a result, there is a risk, although low, of the inner glass cracking where it presses against the the stainless steel clad fin which will be caught between glass panels.

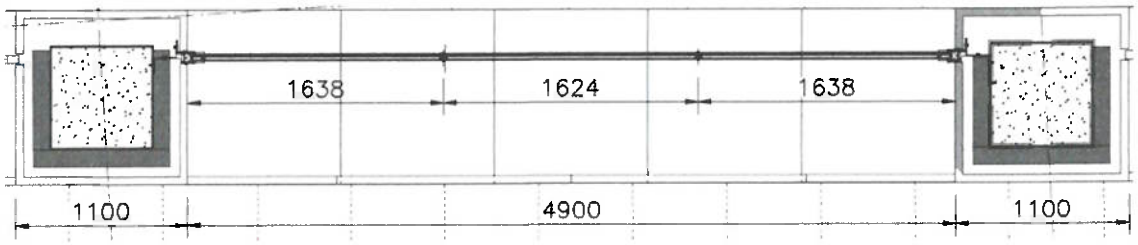

Figure 8 Plan view of North elevation ground level glazing

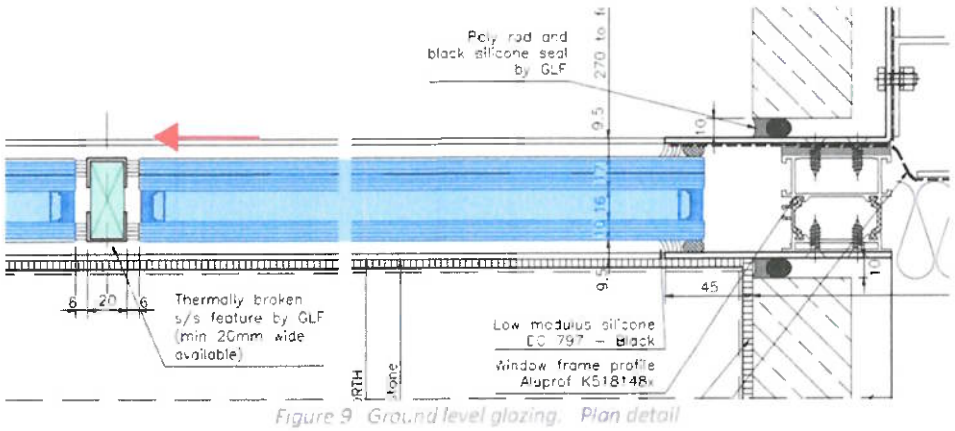

Figure 9 Ground level glazing. Plan detail

3.2 Vibration

As can be seen from the notes above, the envelope on Aercap House is bespoke and has been designed to suit the project specific performance criteria, including structural movements. We note there is limited information available as to what vibrations will act upon the building during the MetroLink works.

Vibration can cause working loose of fixings, working loose of shims, and movement of components where they would otherwise not be at risk. There is limited guidance available for design of façade systems for specific vibration events other than earth-quakes. As the facades have not been designed for earthquake conditions, we cannot ascertain whether vibrations from MetroLink works would cause damage to the facades on Aercap House.

We would recommend careful consideration and monitoring, particularly of the canopies to the South and East elevations. We believe the South elevation will suffer significant vibration during the tunnelling under the building. The canopies are cantilever steel frames with 70mm Portland stone suspended from them. Any loosening of fixings due to vibrations could be hazardous.

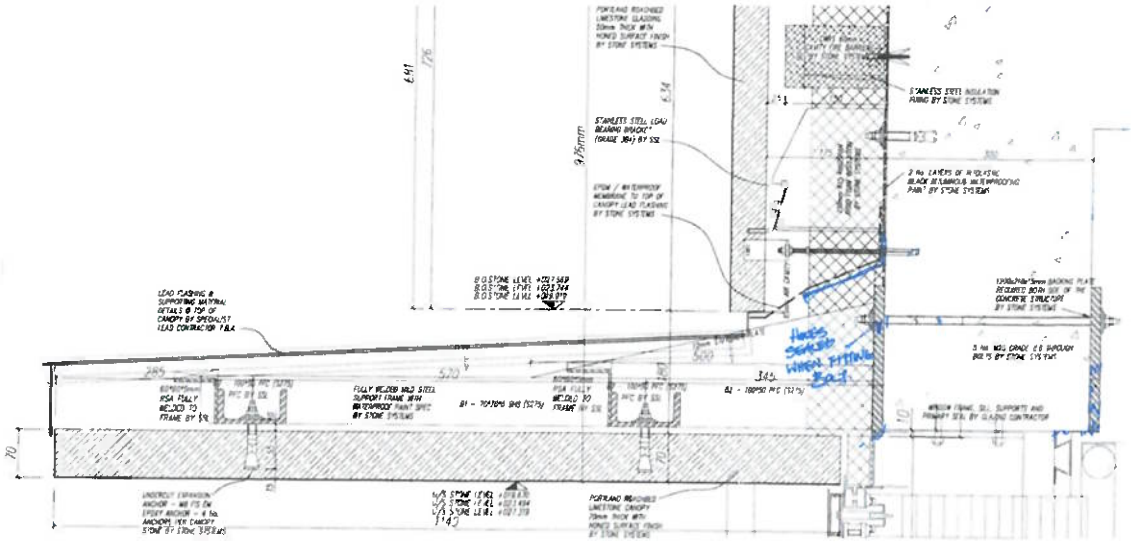

Figure 10 Vertical section through the 70mm thick stone canopy

We recommend monitoring of each façade prior to tunnelling, during tunnelling and directly afterwards to ascertain any degradation of the systems.

4 CONCLUSION AND RECOMMENDATIONS

1. The TII should carry out a Phase 3 assessment on Aercap House, including detailed review of the facades by suitably qualified façade specialists.
2. TII should provide further information on the likely 'actual' ground settlement conditions that Aercap House will suffer.
3. TII should liaise with the Hines team to demonstrate how they ensure against any damage to the building envelope in design and in practice during the tunnelling works. We recommend this is carried out prior to grant of approval.