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10 March 2017

Dear Rain

Wanda Sydney Tower B
Reflectivity Statement for Development Application - update

Arup have been engaged by Wanda One Sydney to review the potential of glare due to external sun reflections off the façade for the proposed Tower B at 1 Alfred St, Sydney.

This letter is an update to the letter with the subject "Wanda Sydney Tower B – Reflectivity Statement for Stage 2 Development Application", dated 13th October 2016, and submitted with the Stage 2 Development Application. The update was made in response to comments from the City of Sydney received by Wanda One Sydney. It notes the selection of a reference glass product with lower reflectivity in response to the comments. There is no change to the calculations described within the letter.

The letter is provided in response to Section 3.2.7 of the Sydney Development Control Plan 2012. This section seeks to limit reflected glare from sunlight through the following development controls:

- General limitation of the specular reflectivity of façade materials to 20%
- Where required, analysis of potential solar glare from the proposed building design

The first point is addressed and exceeded by selection of a reference glass product submitted with the response to DA comments (ASG Visualite S65-0) with a significantly lower reflectivity of **12%**.

In order to address the more detailed investigation referred by the second point above, this letter comments on the nature of expected reflections and our expectation of their potential to cause glare to drivers, pedestrians and building occupants in the area surrounding the site.

The statement is based on desktop studies following the Hassall methodology for detailed glare analysis (see below), and our opinion from experience on numerous previous reflectivity studies.

General

The proposal is for a 25-storey hotel tower (Tower B) as one of two buildings occupying the site at 1 Alfred St, Sydney. The podium incorporates lobby and retail spaces.

The plan shape of the main tower volume is roughly rectangular, with individual sections of façade shifted in and out of the general plans. All façades above level 6 are generally aligned with the structural grid, which is rotated approximately 26° against true north. Floors level 6 and below have north and west façade rotated clockwise against the grid individually per floor.

The tower is located in the dense urban context of the CBD, but adjacent to the Cahill Expressway and Circular Quay, so that much of its façade is visible from further afield in northern directions. Within the CBD its visibility will be mainly limited to immediately adjacent streets, due to its limited height.

Materials

The predominant reflecting elements of the buildings consist of window and curtain wall glazing. Calculations have been carried out conservatively assuming reflectivity up to the allowed limit of 20%, but it is noted that the proposed reference glazing product submitted with the response to DA comments (ASG Visualite S65-0) has a significantly lower reflectivity of 12%.

Solid façade cladding materials used at opaque walls are intended to be masonry-like materials and vertical planting. They are not expected to be specularly reflective, and would thus not produce a concerning mirror type reflection.

Methodology

A desktop study has been carried out for selected road locations in accordance with the methodology developed by Hassall, which derives an Equivalent Veiling Luminance for reflections from a specific point on a reflecting surface towards a specific observer location and view direction.

It considers visibility of the sun in the reflected sky portion, typical luminance of the sun at the reflected altitude, angle of incidence of reflection, surface reflectivity, and angle of reflection direction to view direction. It further stipulates a threshold for this Equivalent Veiling Luminance of 500Cd/m², as a limit for acceptability of reflections in particular considering the visual needs of vehicle drivers.

Arup use in-house developed software to carry out the Hassall calculation based on 3d models, capable of checking for annual worst case reflections anywhere off the façade towards locations along a stretch of road. We have applied this software to a simplified model of the glazing planes of the three buildings, for all façade orientations.

Road locations

Sun reflections are unlikely to be cast far to the north, due to incoming sun from northern aspects being reflected downwards from the vertical building facades. From a review of a computer 3d massing model of the building and context, the following locations are considered as those where it is likely that drivers observe the building relatively close to their direction of travel, and have thus been selected for the desktop study:

1. Cahill Expressway, heading E and W
2. Alfred St, heading W
3. George St, heading S
4. Pitt St, heading N

Outcomes of checks

1. Cahill Expressway
    a. Travelling east

For observers travelling south from the Harbour Bridge and towards east on the Cahill Expressway, the north facades can reflect lower angle sun from the east. For a short stretch of road (approx. 50m) along the curve changing the road direction to the east, while the proposed building is close to the centre of vision, the Equivalent Veiling Luminance calculated for reflections can exceed the threshold of acceptability stipulated by Hassall, for any practicable glazing normal reflectivity. These reflections are limited in duration and extent as follows:

- Sun may be reflected within about 6 weeks per year, in April and October
- Within these times, reflections can occur for up to 15min on single day, at varying times between 7.45 – 8.30am
- Reflections occur from the north façade of the upper part of the building, above level 6. Lower level glazing in altered directions does not reflect the sun towards this section of road
- Lowering reflectivity does not fully avoid issues, as these occur at relatively shallow angles of reflection, where the reflectivity of any glass increases substantially from the nominal (normal incidence) value.

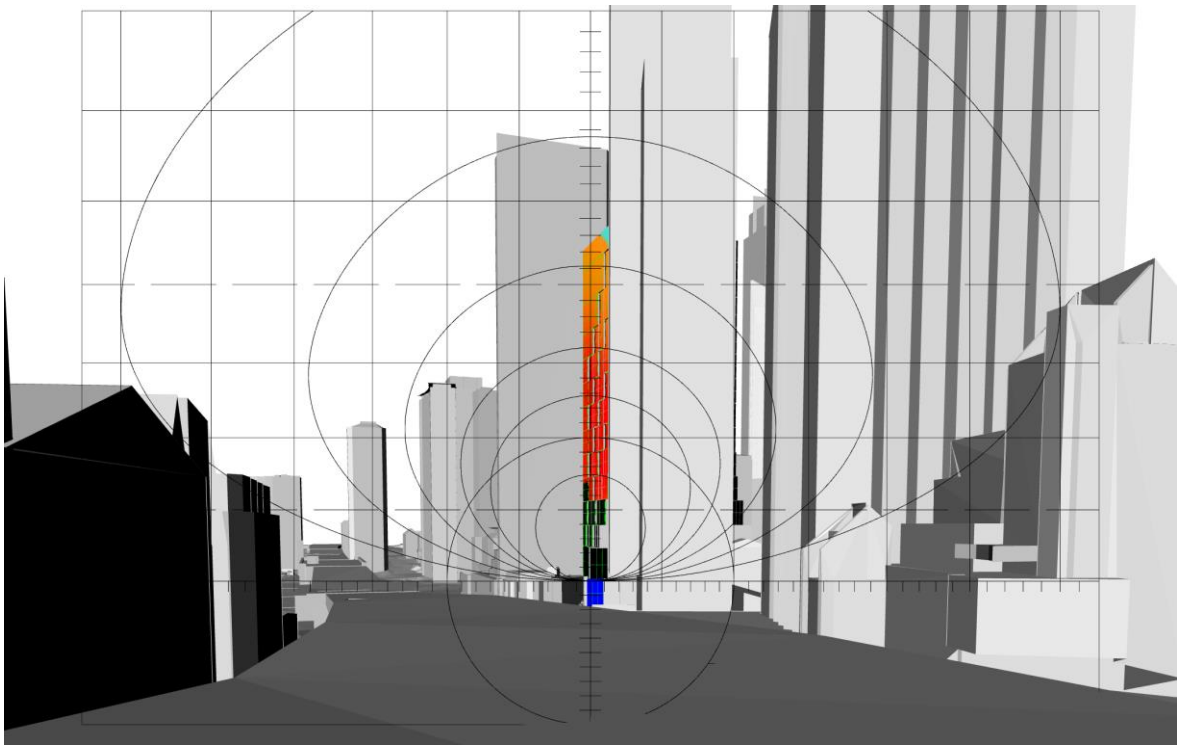

Figure 1: Maximum façade reflections towards Cahill Expressway heading east, assuming normal specular glazing reflectivity of 20% or less. Colour key: blue to cyan – reflections with Equivalent Veiling Luminance below 500Cd/m²; orange to red – reflections above 500Cd/m²; black – incident sun obscured by CBD buildings

The following mitigating aspects are noted:

- These reflections occur above 5° upwards from the driver's centre of vision. According to the Hassall methodology, at these angles reflections can be effectively blocked using a car's sun visor to reducing or eliminating the cause of visual discomfort. However, for high speed traffic Hassall does not consider this as appropriate as the only means of mitigation. It is noted that this section of road has a speed limit of 70km/h.
- While the peak intensity of reflections calculated per the Hassall methodology exceeds the threshold value of 500Cd/m², the stepped façade configuration of the proposed tower means that strong reflections are intermittent for an observer moving along the road. After a brief duration, the reflected sun position will be located on a step in the façade, resulting in only part of the sun disk being reflected and the intensity being reduced proportionally.

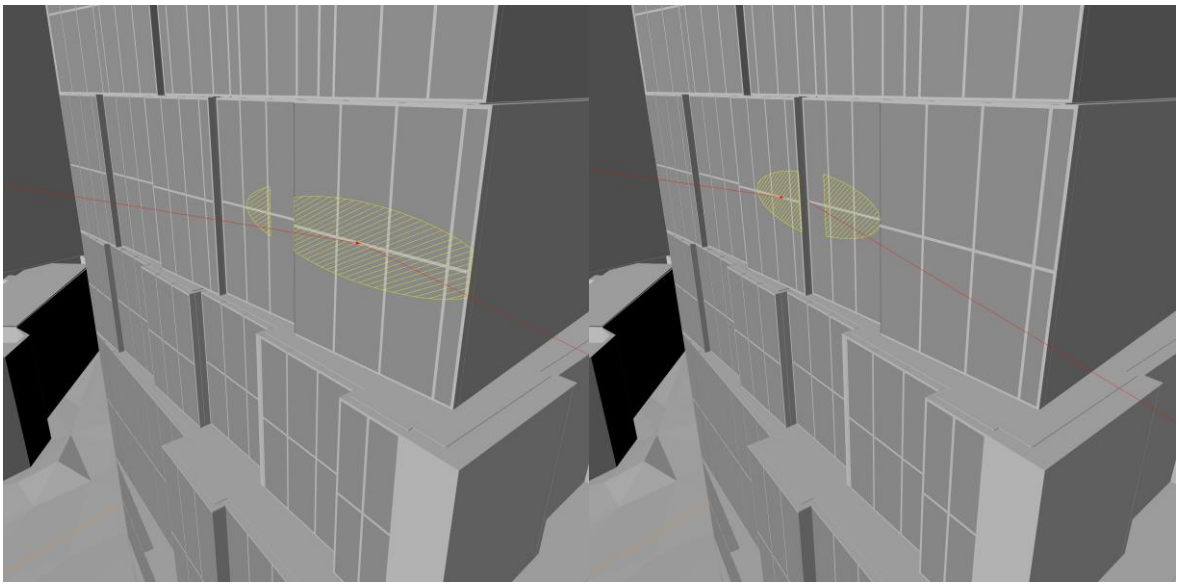

Figure 2: Sun reflections from stepped facade. Yellow hatch highlights two example area over which the sun disk can be seen reflected from Cahill Expressway at two individual points in time. Where the sun reflection overlaps a step in the façade, the proportion of the sun disk reflected is reduced by up to 40%.

Overall, the reflection effect of the proposed façade would be very similar to that of the eastern half of the currently existing façade of the existing building on the project site. The existing building has glazing in the same plane orientation as the north façade of the proposed building, which would reflect sun at same times. Reflections would be intermittent as they are on the existing building due to spandrel areas / columns between windows. In fact the extent of façade in this orientation is reduced by the redevelopment, which reduces the times within a year when sun reflections can be observed on the façade.

While for brief moments the threshold stipulated by Hassall can be exceeded, it can therefore be argued that the risk of glare is not compounded by the proposed redevelopment.

It is noted that the proposed reference glass has a low reflectivity of 12%, significantly below the generally applicable council limit of 20%. While as noted above this does not fully avoid nominally excessive reflections, it will mean that the intensity of reflections drops off much more quickly with change in angle of incidence i.e. away from a narrow area close to the façade plane.

b. Cahill Expressway travelling west

For observers travelling west, the north façades of the building generally reflect the northern half of the western sky. The reflected sun can be visible at low angles during winter. For a stretch of road approx. 150m long, the Equivalent Veiling Luminance calculated for reflections can exceed the threshold of acceptability stipulated by Hassall, for any practicable glazing normal reflectivity. These reflections are limited in duration and extent as follows:

- Sun may be reflected within about 6 weeks per year, in April and September
- Within these times, reflections can occur for up to 5-10min on single day, at varying times between 4 – 5pm
- Reflections occur from the north façade of the upper part of the building, above level 6. Lower level glazing in altered directions does not reflect the sun towards this section of road
- Lowering reflectivity does not fully avoid issues, as these occur at relatively shallow angles of reflection, where the reflectivity of any glass increases substantially from the nominal (normal incidence) value.

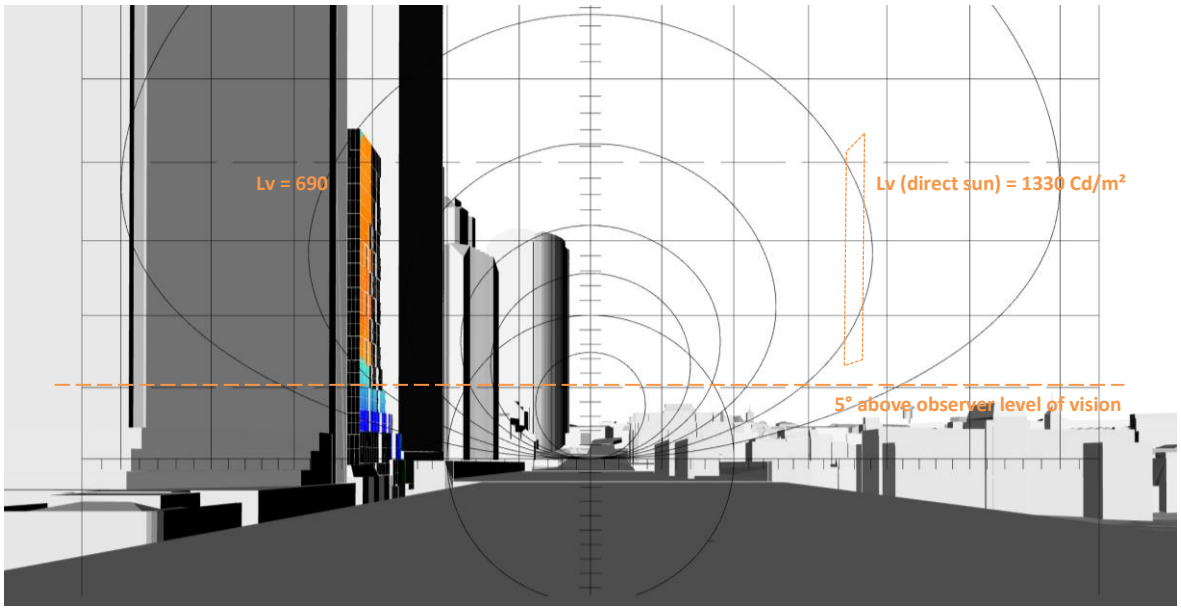

Figure 3: Maximum façade reflections towards Cahill Expressway heading west, assuming normal specular glazing reflectivity of 20% or less.

Reflections above the intensity threshold are above the 5° sun visor cut-off and have less glare potential than direct sun visible concurrently However, these are glancing angle reflections off a façade plane close to parallel to the road. Apart from likely scattering effects from non-planarity of glazing (insulated glazing pillowing, roller wave, construction tolerances) reducing reflections, this means that the sun will be visible at a similar angle from the heading direction, not obstructed by buildings or other features in this case, at the same time. The glare potential from this concurrent direct view of the sun has been calculated to be significantly higher than that from the façade reflections. It can thus be argued that these reflections do not significantly compound glare risks that are pre-existing on this stretch due to its orientation and exposure to on the north side.

It is also noted that the reflection effect of the proposed façade would be very similar to that of the currently existing building, as detailed under 1a.

The east facades do not reflect the sun to this location.

2. Alfred St

For observers travelling west towards the site, the north facades of the building reflect the western sky. Incoming sun is generally blocked from being reflected off the main façade plane above level 6 by the proposed Tower A building volume. The facades at levels 5 and 6 can reflect late afternoon sun towards drivers, and the Equivalent Veiling Luminance calculated for such reflections can exceed the threshold of acceptability stipulated by Hassall, regardless of glazing normal reflectivity, due to high reflectivity of glass at shallow angles of incidence.

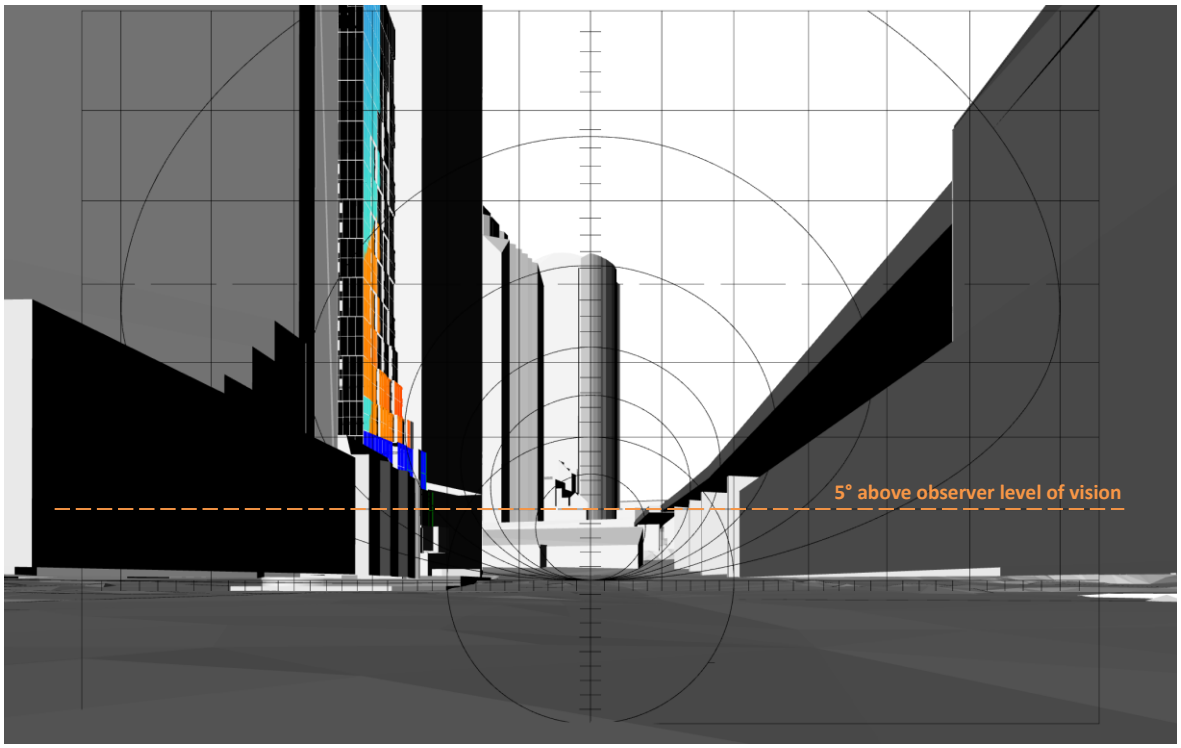

Figure 4: Maximum façade reflections towards Alfred St heading west, assuming normal specular glazing reflectivity of 20% or less. Reflections are above the 5° sun visor cut-off.

However, sun reflections only occur well above 5° upwards from the driver's centre of vision. According to the Hassall methodology, at these angles it can be assumed that drivers will be able to block reflections from the building using the sun visor, reducing or eliminating the cause of visual discomfort. The use of the sun visor is considered acceptable in the traffic situation in Alfred St, as it is not considered a high speed traffic road.

View of the facades will also be reduced by trees planted along Alfred St.

3. George St

For observers travelling south, the north facades generally reflect the northern sky. Reflected sun is thus only visible at angles high above the plane of view. The Equivalent Veiling Luminance calculated for such reflections remains well below the threshold of acceptability stipulated by Hassall, for glazing normal reflectivity assumed up to the maximum value allowed by the Sydney DCP 2012 of 20%.

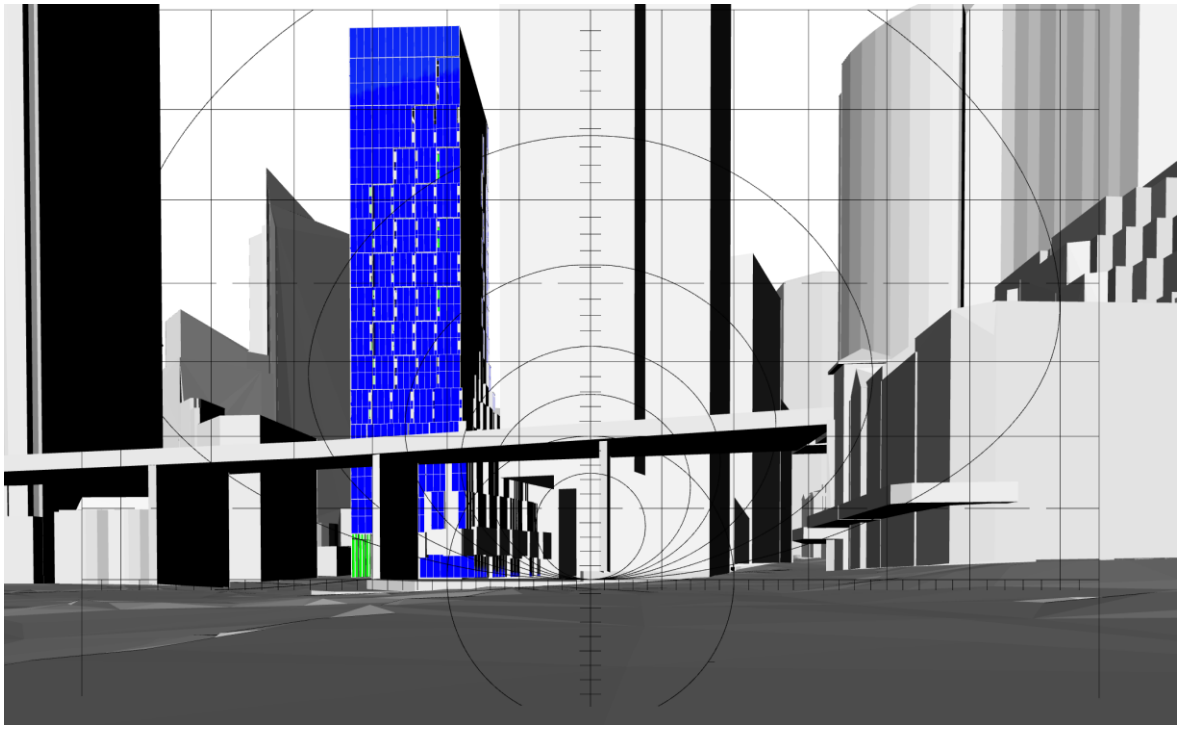

Figure 5: Maximum façade reflections towards George St heading south, assuming normal specular glazing reflectivity of 20% or less. No reflections above 500 Cd/m²

4. Pitt St

For observers travelling north, the east façades of the building generally reflect a small segment of sky just east of due north. The reflected sun is thus only visible at angles high above the plane of view. The Equivalent Veiling Luminance calculated for such reflections can exceed the threshold of acceptability stipulated by Hassall.

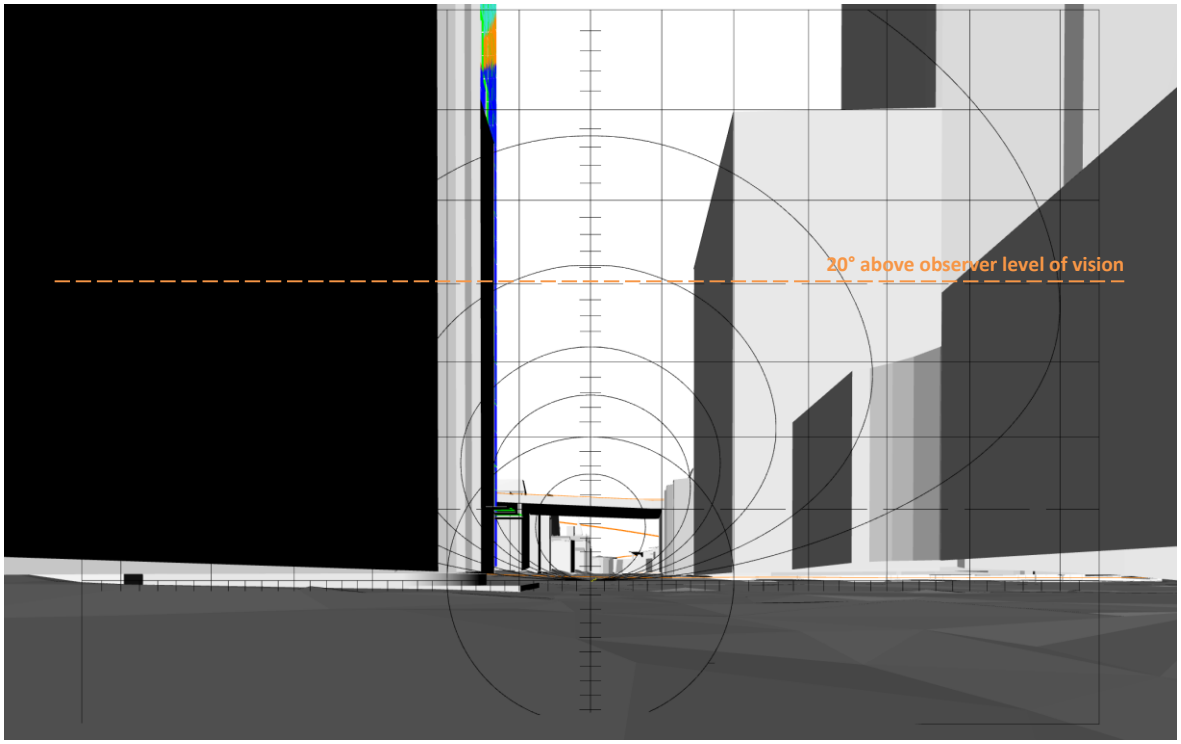

Figure 6: Maximum façade reflections towards Pitt St heading north, assuming normal specular glazing reflectivity of 20% or less. Reflections are above the 20° car windscreen cut-off

However, view of the building only occurs above 20° upwards from the driver's centre of vision. According to the Hassall methodology, at these angles it can be assumed that the average car windscreen cut-off will block reflections from the building, eliminating the cause of visual discomfort.

Impact on pedestrians and occupants of neighbouring buildings

For pedestrians moving along roadways, the incidence of reflections from the buildings is generally similar to the examined road traffic locations. In case of encountering occasional rogue reflections, pedestrians are able to adjust their viewing directions or shade their field of view with hand or hat much more readily than drivers. Unacceptable glare from reflections is therefore not expected as per the findings noted above.

In general, reflections from façade with normal external reflectance below 20% are much less likely to cause discomfort to occupants of surrounding buildings than facades with strongly reflective glazing. The proposed reference glass product has a low reflectivity of 12%, significantly below the limit of 20% allowed by the Sydney DCP 2012, which will serve to further reduce any potential glare reflections that may occasionally be produced towards pedestrians and other buildings.

Summary

In summary, we expect the proposed Wanda Sydney Tower B not to compound the exposure of traffic to reflected glare according to the Hassall methodology, as long as specular normal external reflectivity of glazing is kept within the following limits:

- **All glazing: 20%** (as per Sydney Central DCP limitations)

Any potential for reflections exceeding the general threshold of acceptance of 500Cd/m² stipulated by Hassall is limited in time and duration, and is not expected to exceed glare potential found in the current situation, either from reflections off the existing building on the project or from concurrent view of the direct sun.

It is noted that the proposed reference glazing product submitted with the response to DA comments (ASG Visualite S65-0) has a low reflectivity of **12%**, significantly below this limit. This will further restrict the extent of any reflected glare including rogue reflections towards neighbouring buildings and public space.

Yours sincerely

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