Case Study

ENVIRONMENTAL ANALYSIS REFLECTED GLARE

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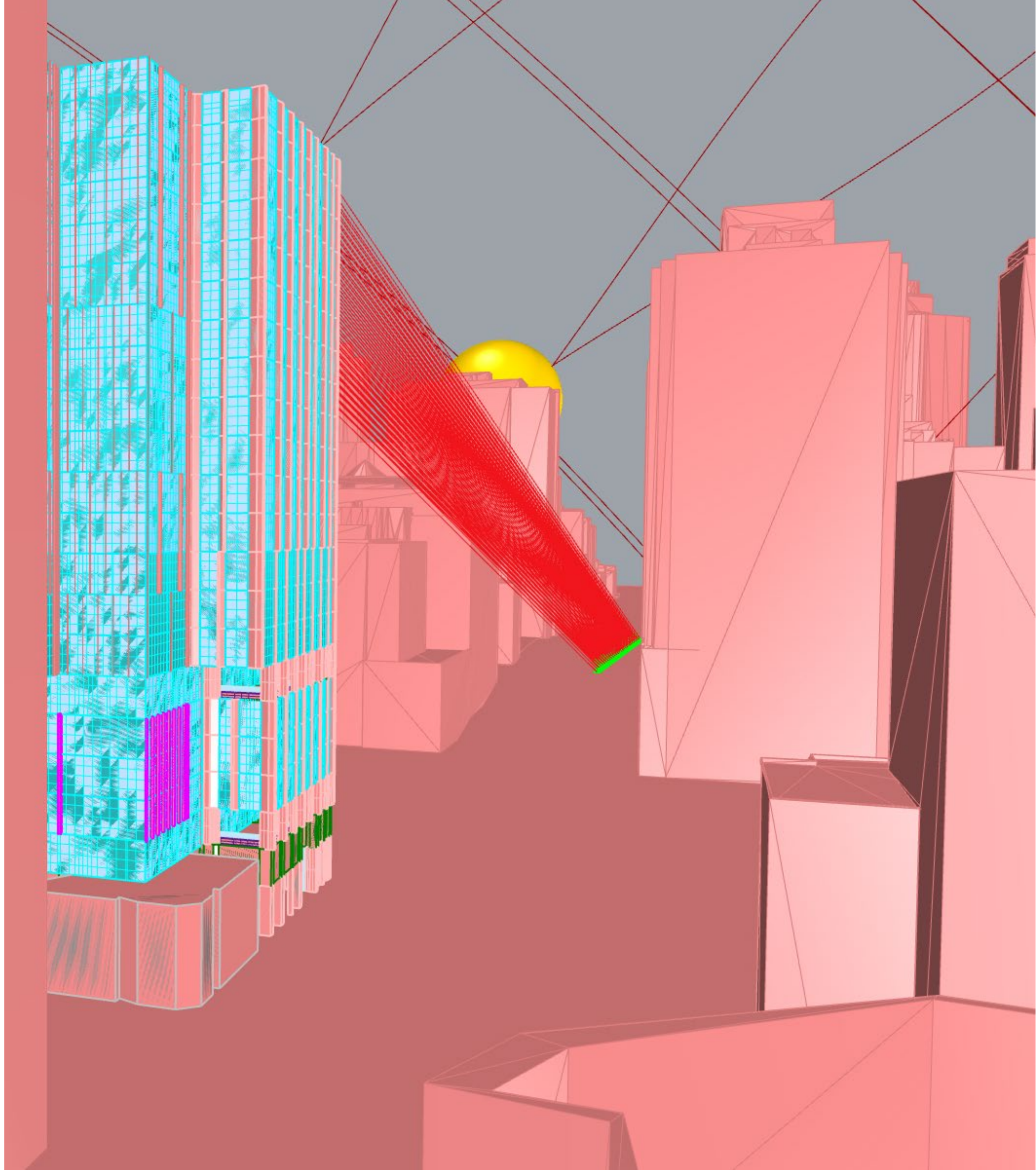
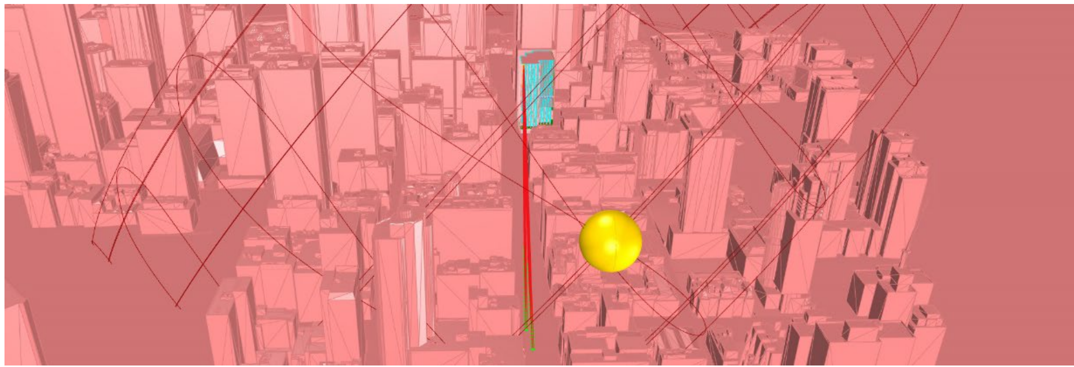
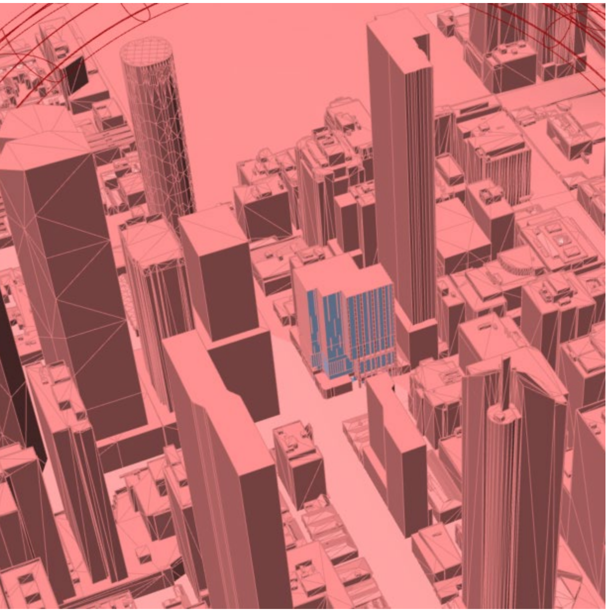
Climate responsive design goes beyond the architectural form, building fabric and occupant experience. Responsive design includes the impacts and considerations of the building on the urban fabric. Inhabit are expert advisors on Building Physics, inclusive of related assessments on the urban environment and occupant experience.

Reflected glare to nearby roads was assessed against a veiling luminance performance criterion, to support Local Town Planning requirements, and to demonstrate that the design does not adversely affect the urban fabric and public occupant experience. This glare assessment has been calculated using a veiling luminance of 500 Cd/m² as a practical limit and the amount of reflected solar glare to which a driver should be exposed. The corner stands commercial tower's most public façades are on the South and West faces along two arterial routes in the Melbourne CBD and it has a tram route along its Southern face.

Inhabit's Building Physics team determined that glare which exceeded the criterion was experienced in a single location, within a driver's field of vision, which could be mitigated by a typical sun visor to reduce the field of vision. Additional mitigation measures could include alternative glazing reflectivity properties, or by manipulating the architectural form to the causal zone of the Eastern façade.







Reflected Glare

Reflective glazed façades with high-performance and/or low-emissivity coatings will almost always cause a degree of reflected glare impact to the surrounding urban space. Non-matte surfaces including shiny metallic cladding can also result in reflected glare. The solar reflections off a building façade can lead to a number of visual issues.

In addition to causing nuisance to pedestrians or occupants of nearby buildings, visual glare may create a safety hazard to motorists, train drivers and others whose tasks restrict them from simply looking away. Glare can also create undesirable patterns of light throughout the urban environment.

To quantify the impact of solar reflections from the development, the following glare factors must be considered:

- Frequency
- Duration
- Intensity
- Receiving location
- Viewing direction

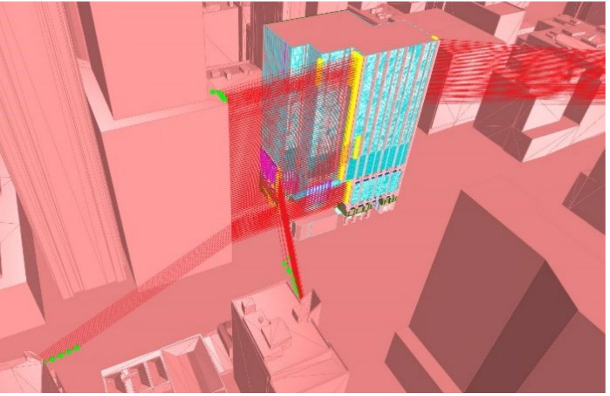
The issue of solar glare and its effect on human vision is very complex and one for which science has not so far provided a definitive answer. One of the main problems is the great variation in individual human response to a given amount of glare. One person's slight inconvenience is another's blinding light.

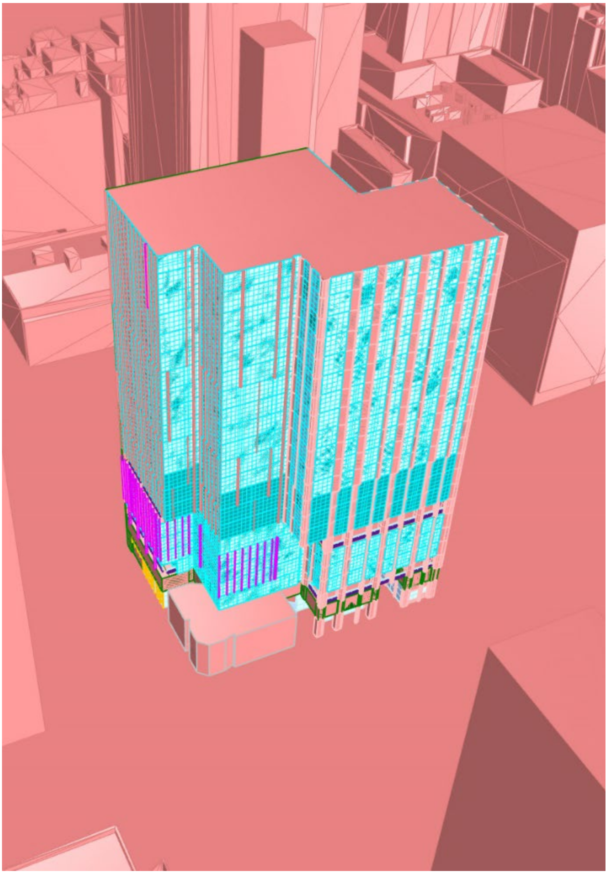
The veiling luminance method models the sun path in relation to the proposed building development. Reflection conditions are modelled for all daylight hours throughout the year. This method is more accurate as it depends on the power of the solar radiation (W/m²) for various altitudes, luminance efficacy (lumens/watt), sun position (azimuth and altitude) for various times of the day, observer's viewing direction (bearing), aspect of reflecting surface, reflectivity and specularity of surface.

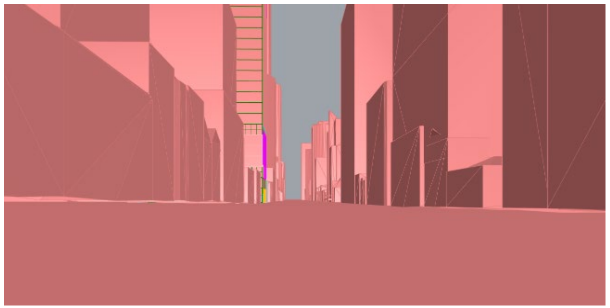
This assessment assumes specular reflective façade surfaces, where the reflected ray angle is equal to the incident solar ray angle. It assumes that the equivalent veiling luminance is only calculated for periods of the day when the sun's azimuth is no greater than 90° of the various aspects of the proposed development.

Limitations

This simulation has been based on the methodology and the assumptions included in a related confidential report prepared for a specific project and client, using material performance values







specific to the project. Where specific material performance values are not available, standard industry values are used as default. Due to the subjectivity of visual amenity and comfort, a standard does not exist, and therefore this report does not assess comfort.
The veiling luminance criteria used in this assessment are based on current industry best practice. These limits on reflected glare do not prevent solar reflection from occurring and they do not prevent the possibility that these reflections may still cause annoyance or act as a distraction to motorists.

Tools and Software

The proposed development and the surrounding buildings have been modelled in 3D modelling software, Rhinoceros 7. An in-house simulation tool developed by Inhabit using Grasshopper was then used to assess the spatial range of glare and quantify the luminance values across the 3D environment. The results are then collated to quantify the annual frequency that the criterion is exceeded. This tool is a 3D implementation of the industry standard Hassall Method, which allows for complex façade and shading geometry to be dynamically assessed.

Veiling Luminance

For both road and rail driver safety, Hassall (1991) nominates a veiling luminance of 500 candelas per square metre (Cd/m^2) as a practical limit for safety. This limit has been derived using the Holladay (1927) formula to determine the risk of glare due to light reflections.

Weber-Fechner Law

When considering glare and the relative impact to the sensory system, the relationship between light and perception is logarithmic. This means that for every unit increase in veiling luminance, the increase in perception is only a factor of the change in veiling luminance. This phenomenon can be described by the Weber-Fechner Law of psychophysics and applies to all senses: vision, hearing, taste, touch, and smell.
As this relationship is logarithmic and not linear, the relative impact on the receiver's perception is difficult to quantify and can sometimes be imperceptible to the human eye. As it is not always possible to eliminate reflected glare with glazed facades, understanding this relationship allows for qualitative discussion to contextualise any glare exceedance.

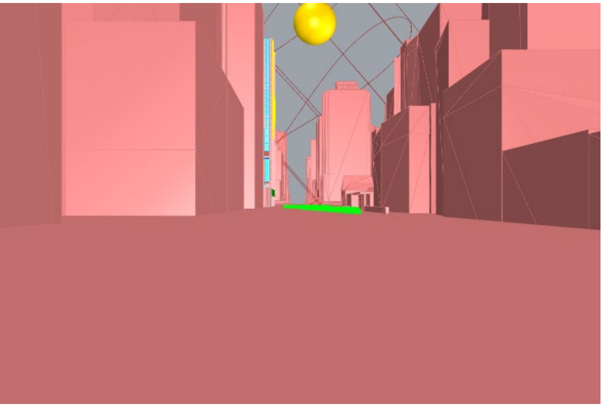
Spectral and Diffuse Reflection

Reflected glare is defined by the McGraw-Hill Dictionary of Architecture and Construction (2003) as glare resulting from specular reflection of high brightness in polished or glossy surfaces in the field of view. Therefore, when considering the impact of reflected glare, the critical material properties are the combination of reflectivity and specularity together. Reflectivity in the context of this assessment is a measure of visible light that is reflected from a surface when illuminated by a light source such as the sun. Specularity

South Adjacent Road, East Bound

	AM							PM								
	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8
Jan	0	0	0	0	284	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	563^	0	0	0	0	0	0	81	0	0	0	0
Mar	0	0	0	499	0	0	0	0	0	0	0	62	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	69	0	0	0	0
Oct	0	0	0	561^	0	0	0	0	0	0	63	0	0	0	0	0
Nov	0	0	0	0	308	0	0	0	0	0	73	0	0	0	0	0
Dec	0	0	0	0	231	0	0	0	0	0	70	0	0	0	0	0

500	Veiling Luminance Criterion (Cd/m²)
98.6%	Acceptable - Within performance criteria
1.4%	Acceptable - Exposure to direct and reflected glare
0.0%	Criteria exceeded - Exposure to reflected glare only



South Adjacent Road, West Bound

	AM							PM								
	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	114	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	252	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	699'	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	802'	0	0	0	0	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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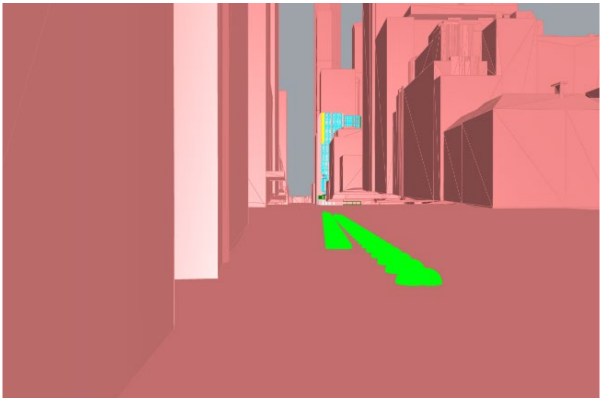


can be described as how smooth a surface is on a microscopic level. The higher the surface specularity, the more mirror-like or shiny the surface is. Specular reflection reflects all light which arrives from a given direction at the corresponding opposite angle. Conversely, surfaces with low specularity results in a diffuse reflection caused by light being reflected in a broad range of directions.

It is important to note that a material with high reflectivity and low specularity has less potential to result in reflected glare when compared to a high reflectivity and high specularity. This is due to a lower specular reflection which predominantly drives glare impact. In this assessment, glazed and non-matte metallic façade elements have been defined conservatively as having high specularity.

Direct Glare and Reflected Glare

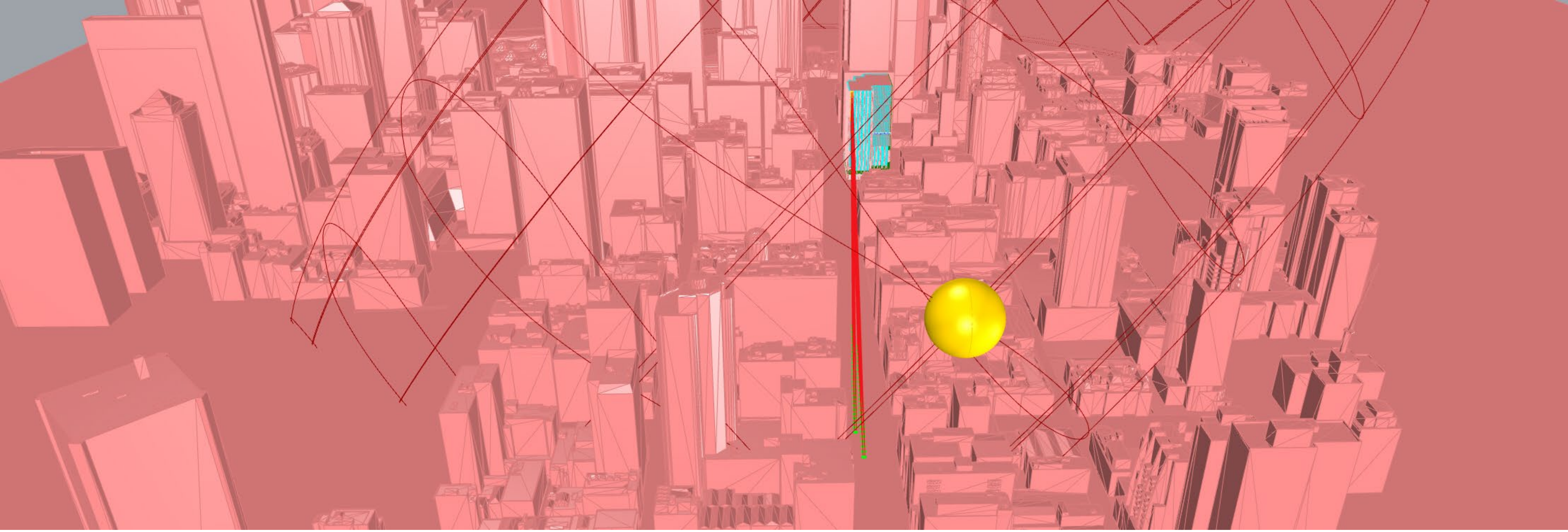
For periods when the unobstructed sun is within the observer's field of view, the veiling luminance caused by the sun (i.e. direct glare) and the reflected sun (i.e. reflected glare) are calculated based on the corresponding angle between the field of view and the glare source. For instances where the direct glare from the sun is the dominant source of glare when compared to the reflected glare, glare identified as reflected off the façade is considered acceptable, even if the reflected glare exceeds the veiling luminance performance criterion.

Results

In general, all regions were free from adverse glare effects aside from the westbound drivers on South Adjacent Road (refer images) affected by early morning reflections from the South façade, occurring around 8am in April and August. Closer examination of these occurrences show these glare sources will appear approximately 10 degrees above the drivers field of view; this is within a driver's field of vision, though high enough such that it could be blocked by a typical sun visor, which cuts the field of view to about 5 degrees. Alternatively, adopting a glass reflectance of 13% or lower (measured normal to surface) on the east tower façade can bring the veiling luminance value within the acceptable limit of 500 Cd/m^2. The causal zone on the architectural form could be redesigned to consider reflectivity and resulting urban experience.

Mitigation Strategies

Reflections will always occur on a glazed façade. Modern high-performance low-emissivity coatings can typically increase the reflectivity of the material, therefore increasing the potential for reflected glare. For this project, glare is mitigated largely through form, glazing properties and shading fins on the façade. Further strategies could include informing the architectural design for the causal zones, or improving the glazing and fin properties.



Conclusion

Reflected glare to nearby roads was assessed against a veiling luminance performance criterion of 500 Cd/m² defined by Hassall (1991) using the Holladay (1927) formula. This assessment considered a reflectivity of 20% (measured normal to surface) for all glazing to allow for design flexibility.

Based on findings from this assessment, adverse reflected glare was identified to one road region. Reflected glare exceeding the road veiling luminance criterion was identified along South Adjacent Road travelling West. Closer examination of these occurrences show that the glare will be within the driver's field of vision, though could be blocked by a typical car sun visor, which cuts the driver's field of view to about 5 degrees. Alternatively, adopting a glass reflectance of 13% or lower (measured normal to surface) on the East tower façade can bring the veiling luminance value for these occurrences within the acceptable limit of 500 Cd/m². Further architectural form exploration into the causal zone may result in further glare mitigation.

References

- Hassall, David N. H. 1991, Reflectivity: dealing with rogue solar reflections / written and illustrated by David N.H. Hassall D.N.H. Hassall] [Newport, N.S.W].
- Holladay, L. L. 1927, Action of a Light-Source in the Field of View in Lowering Visibility, J. Opt. Soc. Am. 14, 1-15.
- Ho, C.K., Ghanbari, C.M. and Diver, R.B., 2011. Methodology to assess potential glint and glare hazards from concentrating solar power plants: Analytical models and experimental validation, Journal of Solar Energy Engineering