University of Technology, Sydney

UTS Broadway Redevelopment

Reflectivity Assessment

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EXECUTIVE SUMMARY

VIPAC Engineers & Scientists Ltd. has been commissioned by University of Technology, Sydney to assess the interaction of the UTS Broadway Redevelopment with the local environment in terms of Reflectivity.

The site is located on a block bounded by Thomas Street to the North, Broadway to the South, Jones Street to the East, and Wattle Street to the West. Existing residential and commercial buildings surround the site.

The proposed development will comprise of:

- Twelve levels of offices, laboratories, classrooms and plant room (on level 13).

The glazing elements of the proposed building facades have been investigated in this report as a potential source of road traffic disability discomfort glare.

The analysis has identified no instances in which reflections from the proposed building could cause a persistent disability glare to motorists & pedestrians. Furthermore, the exposed glazing (not behind the screen) should have a visible light reflectivity of 10% or less to decrease the likeliness of adverse glare.

Additionally, the anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

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1. INTRODUCTION

VIPAC Engineers & Scientists Ltd. has been commissioned by University of Technology, Sydney to assess the interaction of the proposed UTS Broadway Redevelopment development with the local environment in terms of Reflectivity.

This study uses the results of a simulation that models the solar movements in relation to the proposed building development. Reflection conditions were modelled for all daylight hours throughout the year.

When analysing effects of building reflections the first consideration is the geometry of the possible incoming solar rays relative to the building. Below in Figure 1 shows the geometry of solar rays striking a flat surface.

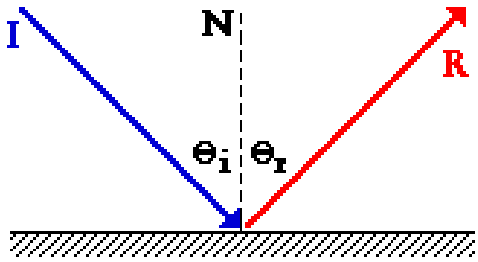

Figure 1: Reflection Geometry

Angle of incidence (θ_i) is the angle the incoming solar rays make with the surface normal. Angle of reflection (θ_r) is the angle the reflected solar rays make with the surface normal.

Figure 2 shows the percentage of reflected light as a function of angle of incidence. As shown, as the angle of incidence increases the percentage of reflected light increases. Hence the higher the angle of incidence, the more glare occurrences may be experienced.

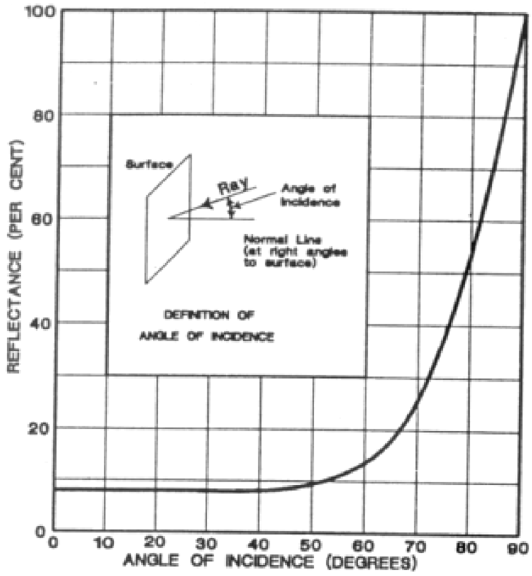

Figure 2: Graph showing change of reflection factor with change of incidence[1]

The level of glare discomfort and visual disability is evaluated using a calculated parameter called the Threshold Increment* (TI). TI is based on the perception of an object, which is dependant on the luminance of that object relative to the illumination of the background. For example, if the target and the background have the same colour and the same level of illumination, then it will be impossible to distinguish the target from the background.

**A description of the TI concept is given in "Occasional Paper No.11 – Building Reflectivity: Quantitative Assessment of Solar Glare from Vertical Glazed Curtain Walls. Vipac Engineers and Scientists".*

The approach VIPAC applies uses the maximum recommended TI of 20[2]. The maximum TI used in each analysis varies with respect to the class type of the road and traffic activity that surrounds the development. Two separate TI criteria values in the analysis outlined in this report have been implemented. All roads surrounding the residence would be classified as 'important urban road with heavy traffic & moderate speed" with a criteria value of TI=20.

These and other considerations affecting glare potential are discussed further in Appendix A of this report. The methodology used by VIPAC to calculate and assess potential rogue building reflections is outlined in Appendix A.

Following is a listing of factors by which reflections can be limited or eliminated from consideration.

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[1] Hassall, D.N.H., *Reflectivity: Dealing with rouge solar reflections* pg 1, 1991

[2] Australian Standard ® AS1158.1.1-1997: Road Lighting Part 1.1:- Vehicular traffic (Category V) lighting – Performance and installation design requirements, page 10.

A. Incident angles of solar rays relative to cladding

Mullions on facades will tend to intersect (block) incident and/or reflected solar rays with high incident angles. The specific incident angle is a function of mullion depth and spacing.

B. Lateral Vision

Reflections to a receiver occurring outside of 45° to the direction of travel will not cause any disability to the receiver.

C. Solar Altitude

Reflected rays will be intersected by vehicle windscreen line and/or windscreen sun-visor when the sun is above a certain altitude. The sun angle at this cut-off altitude is called the visual cut-off angle and is taken to be 20°.

D. Façade surfaces have diffuse reflective properties.

Diffuse reflection (see Figure 3a) is the reflection of light from an uneven or granular surface such that an incident ray is seemingly reflected at a number of angles. It is the complement to specular reflection (See Figure 3b), which is the perfect, mirror-like reflection of light from a surface, in which light from a single incoming direction is reflected into a single outgoing direction.

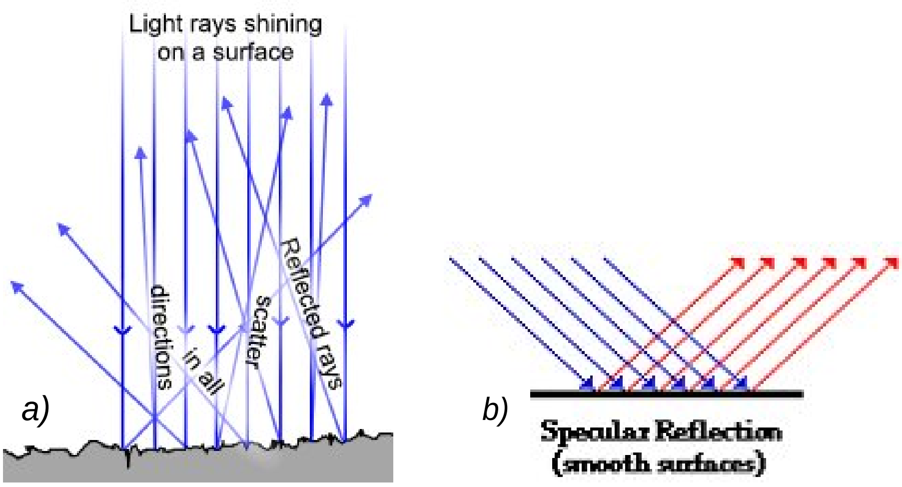

Figure 3: Diffuse (a) and Specular (b) reflection

E. Direction of travel relative to the reflection direction

The degree to which the direction of the reflection coincides with the direction of travel and/or the required line of vision, thereby creating the potential for a persistent reflection.

F. Shading from surrounding structures

Surrounding buildings that block:

- Incident solar rays from reaching the buildings
- Reflections from reaching the plane of the road.

G. Threshold Increment Value (TI)

Reflections that reach observers on the plane of the road are assessed for the level of discomfort and visual disability using a measure based on the TI value that fall below the critical level.

2. DESCRIPTION OF FACADES

Figure 4 shows an overall plan view of the development, outlining its location with respect to the surrounding roadways, waterways and buildings. The building reaches a height of approximately RL 61.84 (Plant Room roof RL).

Figure 4 – Outline of Proposed Building Site[3] (marked blue). Not to scale.

The following features comprise of the facades exposed to motorists and pedestrians. Estimates of proportions of façade details are obtained from the drawings and information provided and are approximate.

- *North façade*
  - ❖ 70% perforated anodised aluminium screen
  - ❖ 30% glazing
- *East façade*
  - ❖ 90% perforated anodised aluminium screen

[3] Compiled from Google maps ©2010

  - 10% glazing
- *South façade*
  - 90% perforated anodised aluminium screen
  - 10% glazing
- *West façade*
  - 100% perforated anodised aluminium screen

In the analysis, over the external glazing on all façade faces are to have a visible light reflectivity coefficient of 10% and 11%. Remaining façade areas comprise of perforated anodised aluminium screen having a 'diffuse' and less 'specular' reflection properties compared to that of the glazing.

The shading effect of articulated facades are also taken into account when determining the reflections off any façade in the assessment.

Local Traffic Environment ...

Thomas Street is located to the north of the site with low road traffic flow while Broadway is located to the south with medium to heavy traffic flow. Jones Street is located to the east of the site with low road traffic flow and Wattle Street is located to the west with medium to heavy traffic flow. All traffic areas exposed to the facades of the development were examined for disability and discomfort glare.

Local Built-Up Environment ...

Low to Medium-rise buildings surrounds the site to the west & southwest elevations. New Frasers site to the south of the development will consist of medium to high-rise buildings. Other UTS buildings to the north & east of the site range from medium to high-rise buildings.

3. OBSERVER LOCATIONS

Some of the "observer" locations monitored for reflected glare located on surrounding roadways and pedestrian areas are indicated in Figure 5, specified by numerical, "1","2", etc.

1-9	East/Westbound on Thomas St	45-51	North/Southbound on Jones St
9-15	Northbound on Abercrombie St	52-54	East/Westbound between Broadway Building & Building 10
16-23	Eastbound on Broadway	55-57	North/Southbound on Wattle St
24-37	Westbound on Broadway	58-59	East/Westbound on Wattle Pl
38-44	North/Southbound on Harris St	60	North/Southbound on Harris St

Figure 5 - Location of Drivers & Pedestrians Relative to the Development.

The area bounded in blue denotes the proposed building site[4]. Not to scale.

[4] Compiled from Google maps ©2010

4. SOLAR ANALYSIS RESULTS

This analysis determines the possibility of adverse glare effects on motorists and pedestrians from facades of the development that may cause visual impairment. This is assessed on all positions along adjacent roads (refer to Figure 5) irrespective of any mitigation factors described in Section 1.

4.1 NORTH FAÇADE FACING THOMAS STREET

The potential for high adverse glare events to impact drivers and pedestrians on Thomas Street reaches a peak due to the relative geometric positions of sun, façade and position and direction of travel of the motorist & pedestrian:

- During mid afternoon (2 – 3 hours before sunset) between May to July.

At these times of day the driver/pedestrian may experience an exceedence of the predicted discomfort glare acceptable criteria (TI >20). The likelihood of the glare occurrence from Ground Level to Level 3 are eliminated due to the following factors:

- The building facade is predominantly perforated anodised aluminium screen has a visible light reflectivity, which has a more 'diffuse' and less 'specular' reflection. The perforation detail on the screen also allows the direct incident light to be scattered (D).
- Building 10 to the north of the site provides solar blockage that eliminates some glare effects (F).
- The pedestrians have the ability to adjust their line of sight.

The anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

Occupants of the residential building located west of the site will not experience any glare discomfort due to Building 10 to the north blocking all reflections that exceed the predicted discomfort glare acceptable criteria.

Accordingly with all the conditions outlined above, these reflections are unlikely to cause adverse glare conditions for pedestrians and motorists.

4.2 EAST FAÇADE FACING JONES STREET

The potential for high adverse glare events to impact drivers and pedestrians on Thomas Street reaches a peak due to the relative geometric positions of sun, façade and position and direction of travel of the motorist & pedestrian:

- During mid afternoon (2 – 3 hours before sunset) between May to July.

At these times of day the driver/pedestrian may experience an exceedence of the predicted discomfort glare acceptable criteria (TI >20). The likelihood of the glare occurrence from Ground Level to Level 2 are eliminated due to the following factors:

- The building facade is predominantly perforated anodised aluminium screen has a visible light reflectivity, which has a more 'diffuse' and less 'specular' reflection. The perforation detail on the screen also allows the direct incident light to be scattered (D).
- Building 10 to the north & the Thomas Street development to the northeast of the site provides solar blockage that eliminates some glare effects (F).
- The pedestrians have the ability to adjust their line of sight.

The anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

Accordingly with all the conditions outlined above, these reflections are unlikely to cause adverse glare conditions for pedestrians and motorists.

4.3 SOUTH FAÇADE FACING BROADWAY

The potential for high adverse glare events to impact drivers and pedestrians on Broadway reaches a peak due to the relative geometric positions of sun, façade and position and direction of travel of the motorist & pedestrian:

- During early morning (1 – 2 hours after sunrise) between March & October.
- During late afternoon (1 – 2 hours before sunset) between March & October.

At these times of day the driver/pedestrian may experience an exceedence of the predicted discomfort glare acceptable criteria (TI >20). The likelihood of the glare occurrence from Ground Level to Level 2 are eliminated due to the following factors:

- The building facade is predominantly perforated anodised aluminium screen has a visible light reflectivity, which has a more 'diffuse' and less 'specular' reflection. The perforation detail on the screen also allows the direct incident light to be scattered (D).
- Self-shading of the façade shape and articulation reduce glare effects (D).
- The terrain and blockage from upstream buildings to the east and west (F).
- The pedestrians have the ability to adjust their line of sight.

The anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

Accordingly with all the conditions outlined above, these reflections are unlikely to cause adverse glare conditions for pedestrians and motorists.

4.4 WEST FAÇADE FACING WATTLE STREET

The potential for high adverse glare events to impact drivers and pedestrians Wattle Street & Broadway reaches a peak due to the relative geometric positions of sun, façade and position and direction of travel of the motorist helmsmen & pedestrian:

- During early afternoon (1 – 2 hours after midday) all year round.
- During late afternoon (1 – 2 hours before sunset) between November to January.

At these times of day the driver/pedestrian does not experience predicted discomfort glare exceeding the acceptable criteria (TI >20) due to the following factors:

- The building facade is predominantly perforated anodised aluminium screen has a visible light reflectivity, which has a more 'diffuse' and less 'specular' reflection. The perforation detail on the screen also allows the direct incident light to be scattered (D).
- Self-shading of the façade shape and articulation reduce glare effects (D).
- The pedestrians have the ability to adjust their line of sight.

The anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

Occupants of the residential building located west of the site will not experience any glare discomfort due to the large tree and buildings to the west blocking all reflections that exceed the predicted discomfort glare acceptable criteria.

Accordingly with all the conditions outlined above, these reflections are unlikely to cause adverse glare conditions for pedestrians and motorists.

5. SUMMARY

The analysis has identified no instances in which reflections from the proposed building could cause a persistent disability glare to motorists & pedestrians. Furthermore, the exposed glazing (not behind the screen) should have a visible light reflectivity of 10% or less to decrease the likeliness of adverse glare.

Additionally, the anodised aluminium screen should be of a matte finish and is to be specified as not buffed or polished.

In summary, through a combination of choice of cladding, façade orientation and design, and special façade treatments, no facades of the proposed development will produce reflections causing either disability glare for passing motorist or unacceptable discomfort glare for passing pedestrians.

6. ARCHITECTURAL DRAWINGS

The environmental assessment carried out in this report was based on the following architectural drawings supplied by Denton Corker Marshall Pty Ltd.

File	Document No	Revision	Deliverable Date	Title	Status
	CB11__AG-00031	A		Roof	Schematic
	CB11__AG-00041	B		Curtain Wall	Schematic
	CB11__AG-00042	A		Corner Glazing (shingle glazing)	Schematic
	CB11__AG-00043	C		Shop Front Glazing	Schematic
	CB11__AG-00044	A		Crevasse Rooflights	Schematic
	CB11__AG-00051	B		Binary Screen	Schematic
	CB11__AG-00052	B		Covered Walkway	Schematic
	CB11__AK-00322	D		Broadway Elevation	Design
	CB11__AK-00323	D		Jones Street Elevation	Design
	CB11__AK-00324	D		Wattle Street Elevation	Design
	CB11__AK-00325	D		Laneway Elevation	Design
	CB11CXAP-20001	0		Context Site Plan	Construction
	CB11EXAP-20002	0		Existing Site Plan	Construction

This Report Has Been Prepared

For

UNIVERSITY OF TECHNOLOGY, SYDNEY

by

VIPAC ENGINEERS & SCIENTISTS Ltd

APPENDIX A

Considerations Affecting Glare Potential & General Procedure

Several factors must be borne in mind in considering the potential for rogue building reflections, particularly in the case of traffic disability glare.

- The glass chosen for this project will have a reflectivity value described as a percentage of the intensity of the solar ray striking the glass. This reflectivity percentage would be taken at "incident angles" less than 70^o. The incident angle is defined as 0^o for a solar ray striking perpendicular to the plane of the glass.
- Thus, for reflections to occur which have the capacity to induce disability or discomfort glare, the oncoming solar rays would have to impact on the building at relatively high incident angles, greater than 70^o, ie. close to parallel to the plane of the glazing.
- Studies on the visual cut-off angle of windscreens show that the sun altitude angle must be less than 25^o to produce a disability glare event. In fact, on a practical level, solar altitudes greater than 20^o are intersected and obstructed by a typical windscreen roofline.
- A further requirement regarding the sun position is that the full solar disc must be above the horizon. Since the solar disc subtends a finite angle of 1.5^o, glare events will only occur when the solar altitude is greater than about 3^o.
- Finally, the class of road (ie. freeway, trunk road, local street etc.) influences the acceptability level of building reflections. For example, some level of solar reflection may be acceptable for local traffic where the limiting speed is low but be unacceptable for freeway conditions with heavy, high-speed traffic.

Thus, the range of sun positions for which reflections off a vertical glazing element have the potential to produce a disability glare event can be greatly reduced.

In practice, the time of the day that a vertical glazing element can produce a disability glare event for motorists is typically early morning and late afternoon and when the incident radiation is close to parallel to the glazing element of interest and also has a low altitude angle. This restricts the incoming angles of solar radiation which can produce rogue reflections depending upon the time of the year.

Pedestrian discomfort glare can occur at other times of the day when the sun altitude is greater than 20^o above the horizon. However, in assessing the potential for glare in these cases, it should be borne in mind that a pedestrian has the ability (in most instances) to adjust his/her line of sight to a more horizontal view away from the glare source.

From the range of sun positions on days of interest throughout the year and the position and orientation of the glazing element of interest in a building, the resultant reflection envelope on the ground can be calculated using simple trigonometry.

Given a set of reflections, the issue of most significance is the effect of these reflections on the ability of a driver or pedestrian to perceive an object in their vision field. The perception of an object depends on the luminance of that object relative to the illumination of the background. For example, if the target and the background have the same colour and the same level of illumination, then it will be impossible to distinguish the target from the background.

VIPAC's glare recognition methodology uses target recognition procedures originally developed by NASA and also used by NATO.