Lend Lease

ICC Hotel

Facade Lighting Review

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Arup
Arup Pty Ltd ABN 18 000 966 165

Arup
Arup
Level 10, 201 Kent Street,
Sydney NSW 2000

www.arup.com

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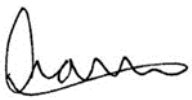
		Signature			
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Contents

1 Executive summary

This report details a review of the proposed lighting integrated with the ICC Hotel facade design. To complete the review, the relevant Australian Standards have been identified as to quantify any potential adverse effects from the installation upon the nearby stakeholders.

The stakeholders considered are:

- Road users
- Aviation authority
- Light rail
- Adjacent residential

Furthermore the relevant Secretary's of Environmental Assessment Requirements have been addressed within this report.

This report concludes that the lighting installation integrated with ICC Hotel facade design does not result in any unacceptable impacts as per Australian Standards which protect against the potential obtrusive effects that may be caused by outdoor lighting.

2 Introduction

Arup has been requested by Lend Lease to undertake a review of the proposed lighting integrated with the ICC Hotel having consideration for the proposed compliance with Australian Standards and any adverse impacts and surrounding infrastructure or stakeholders. This report considers:

- Site location review and analysis
- Collation and review of technical specifications of the proposed lighting systems
- Consideration and summary of relevant codes, standards and requirements regarding the potential obtrusive effects of outdoor lighting; and
- Calculated lighting performance estimates based upon the specification of the proposed lighting system against relevant standards

Figure 1 Architectural render – View from South East

3 Technical lighting terminology and definitions

Within this report the following technical lighting terminology is used. This section provides definitions of those terms.

Illuminance (E): The physical measure of illumination is illuminance. It is the luminous flux arriving at a surface divided by the area of the illuminated surface. Unit: lux (lx)

Luminance (L): The physical quantity corresponding to the brightness of a surface (eg. Luminaire or reflecting material such as the road surface) when viewed from a specified direction. Unit: candela per square metre (cd/m^2)

Luminance Intensity (I): The concentration of luminous flux emitted in a specified direction. Unit: candela (cd)

Obtrusive Light: Spill light which, because of quantitative, directional or spectral attributes in a given context, gives rise to annoyance, discomfort, distraction or a reduction in the ability to see essential information

Threshold Increment (TI): The measure of disability glare expressed as the percentage increase in contrast required between a standard object and its background for it to be seen equally as well with the source of glare present as with it absent, derived in the specified manner

Pre curfew hours: Illuminance and luminaire limits apply to a specific time of day at relevant boundaries of nearby residential properties, in a vertical plane parallel to the relevant boundary, to a height commensurate with the height of the potential affected dwellings. A typical pre-curfew period is between sunset and 11.00pm

Curfew hours: Limits apply in the plane of the windows of habitable rooms of dwellings on nearby residential property. As above. A typical curfew period is between 11.00pm and sunrise

4 Identification of applicable standards

Arup recommends that the following standards are relevant in the assessment of the ICC Hotel façade lighting as they protect against potentially obtrusive effects caused by illuminated structures and direct views of luminaires.

4.1 Australian standards (including road users)

The following Australian Standard provides recommendations for the control of outdoor lighting to limit potentially obtrusive effects:

- AS/NZS4282 1997 Control of the obtrusive effects of outdoor lighting

AS/NZS4282-1997 provides design recommendation for the potential impact of lighting installation adjacent to residential and mixed use developments in terms of illuminance (amount of luminous flux arriving at a site boundary/residential window), luminous intensity (the perceived brightness of a light source) and threshold increment (the potential glare that may affect a nearby transport system), all during night time.

AS/NZS4282-1997 recommends design benchmarks based on the surrounding environment in which a building element is located. Based on the assessment of the area, it was determined that the applicable category is as follows:

- Commercial area or at [the] boundary of commercial areas and residential areas

The determination of the above category is based upon the following clarification within the standards:

"*Applies to residential accommodation in commercial areas or at the boundary between commercial and residential areas. The term 'commercial' is used as a generic description for zoning which provides for urban uses other than residential*"

Based on this description, the ICC Hotel is a commercial zone.

Within a residential built environment, AS/NZS4282 recommends that during pre-curfew hours a maximum illuminance level of 25 lux is permitted in the vertical plane at the boundaries of nearby residential properties. Within curfew hours this level is reduced to 4 lux.

For luminous intensity, the maximum recommended value per luminaire is 100,000 cd during pre-curfew hours as determined in Table 2.2 of the standard and the determination that the minimum distance to the nearest residential premises is above 75m away . For curfew hours a limit of 2,500 cd is recommended. Refer to Appendix B for a full extract of AS4282 with the target recommendations highlighted.

Threshold increment concerns transport/road users and recommends to not exceed 20% during both curfew and non-curfew hours.

As stated in the Standard, it currently excludes:

a) Internally illuminate advertisement signs

b) The obtrusive effects of brightly lit surfaces eg. floodlit buildings, and externally lit advertising signs

c) Lighting systems which are of a cyclic or flashing nature

Clarifications c) above suggests that the proposed façade lighting to the ICC Hotel would in fact be excluded from compliance with the Australian Standard. While the standard would not apply to the facade lighting because it is intended to potentially 'cyclic', the recommended limits remain a relevant local benchmark in reducing obtrusive effects in residential/mixed used environments.

4.2 The Civil Aviation Safety Authority (CASA)

The CASA Manual of Standards Part 139 – Aerodromes restricts the maximum brightness of luminaires above the horizontal plain that are within a 6km radius of an aerodrome.

These restrictions are covered in Chapter 9 of the manual, and summarised in the below figure 9.21-1: Maximum lighting intensities

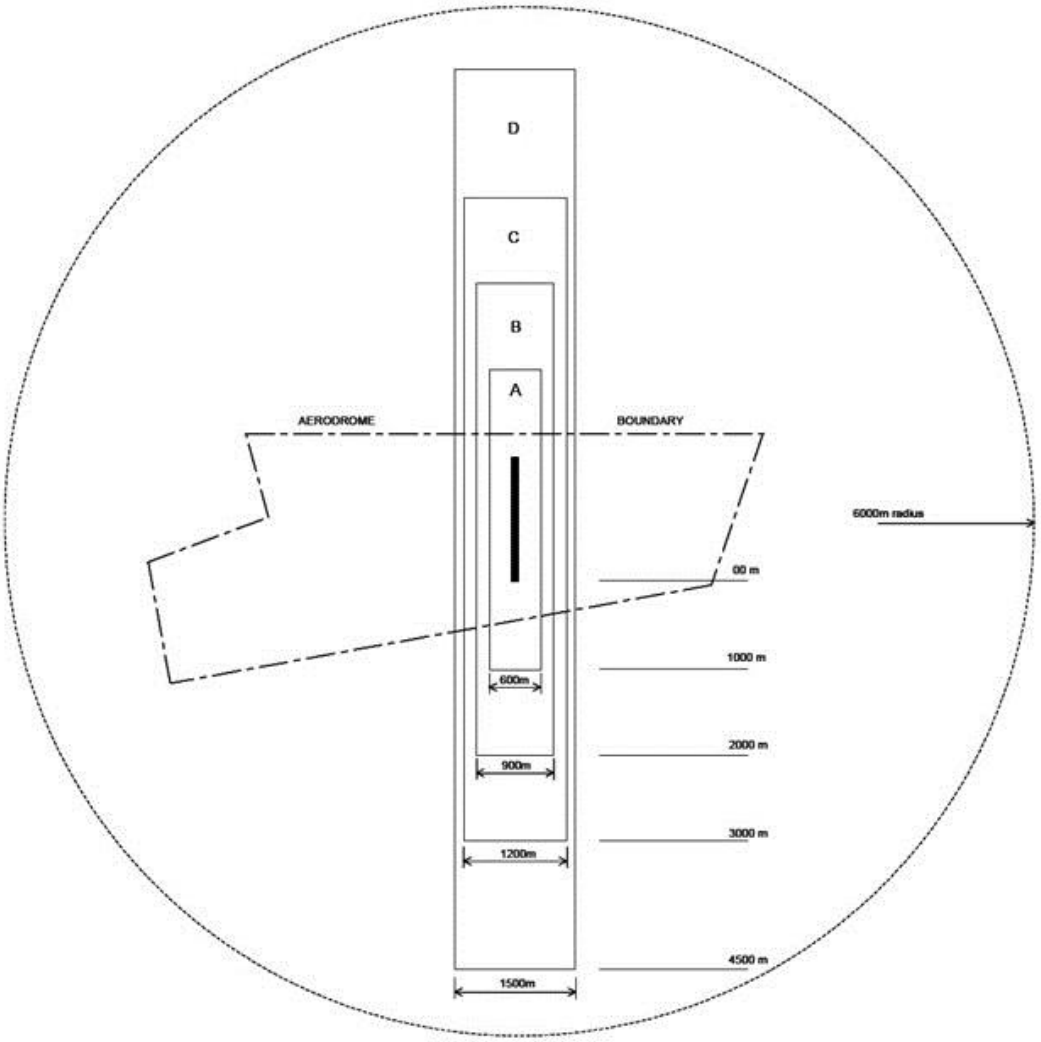

Figure 2 CASA diagram showing restrictions applicable to 6km radius

The proposed site of the ICC Hotel falls outside of the restricted area.

4.3 Light Rail

It is the understanding of Arup that no standards currently exist to control any potential obtrusive lighting effects on light rail operations. However the potential impact from a lighting installation is likely to occur when a light source (either viewed directly, or reflected off a surface) may become confused with a signal light.

In the case of Sydney light rail, the operation will be generally line of sight driving, and there will be very little signally except at the road traffic junctions.

It should be noted that the intensity and beam angle differ greatly between typical signal lights at 1200cd approximately whereas the proposed façade luminaire is 215cd. The shape/form of the light sources are also very different and unlikely to be confused.

5 Site appraisal

The below diagram illustrates the proposed location of the ICC Hotel

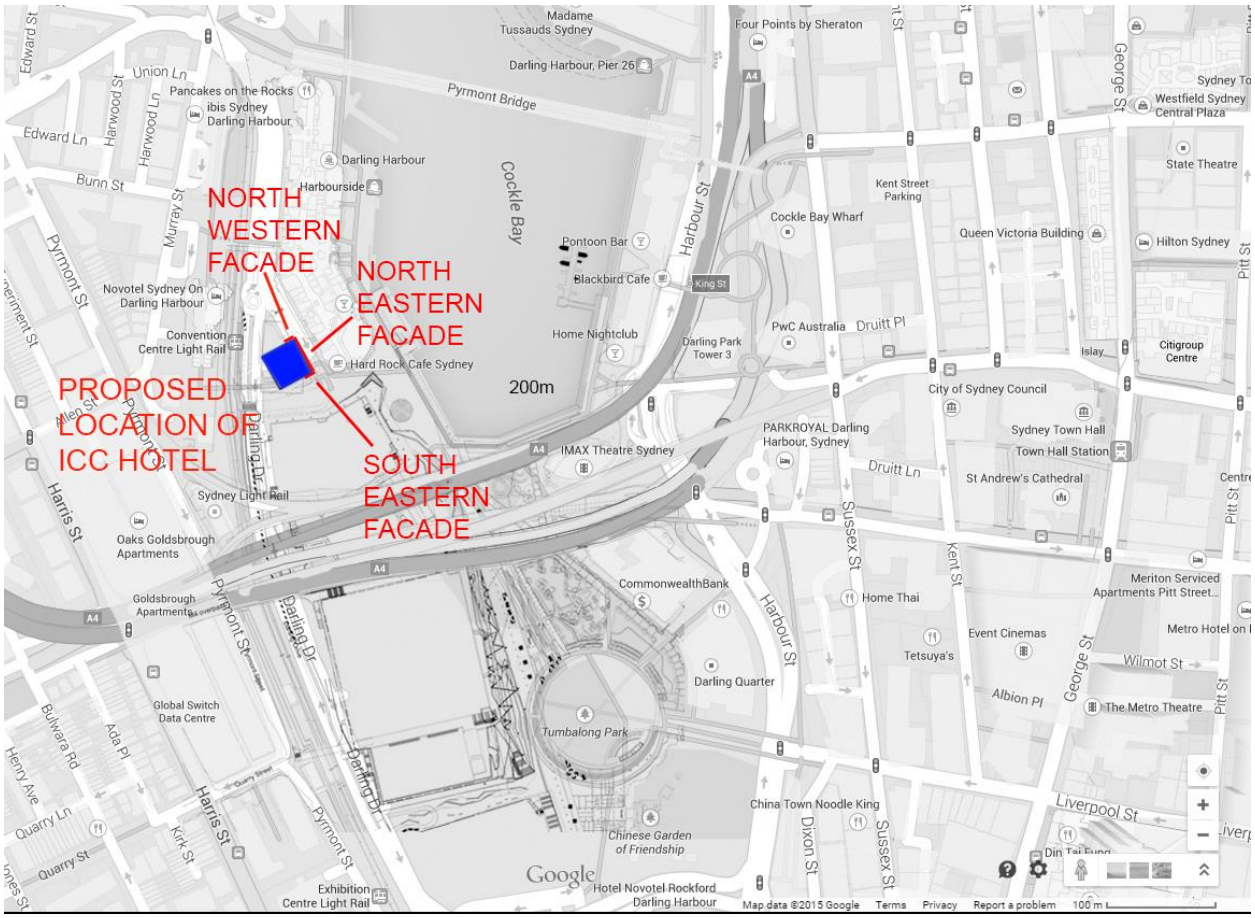

Figure 3 Proposed site and lit façade summary

The below diagram illustrate the potential maximum viewing angles of the ICC Hotel to the surrounding district

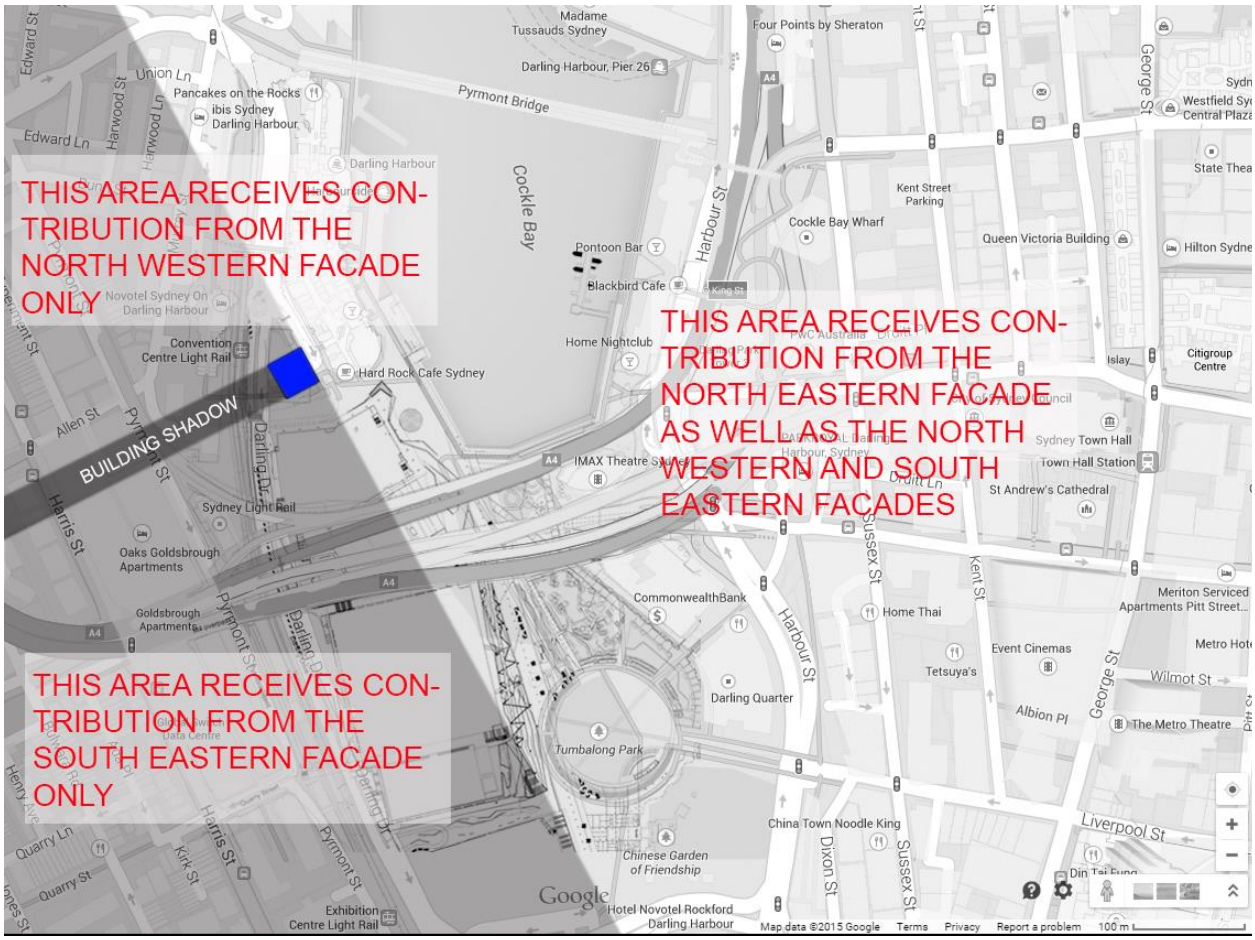

Figure 4 Areas that may receive some light contribution from the lit facades

6 Luminaire details

All analysis has been based upon the technical test data provided. The following luminaire is to be integrated into the proposed building façade.

The system used red, green and blue (RGBW) LED's with a diffuser to produce a continuous linear colour change effect.

It should be noted that Arup has not inspected a physical sample and all analysis is based upon test data supplied by Lend Lease.

The outline specification of the installed system is as follows:

Manufacturer	**XLUX**
Product	RGB Line flex
Product code	C-FR-F21A-24V-60-RGB-R+G+B
Typical power of each node	12W per 600mm
Peak intensity	43 cd per 600mm
Total flux	155 lumens per 600mm

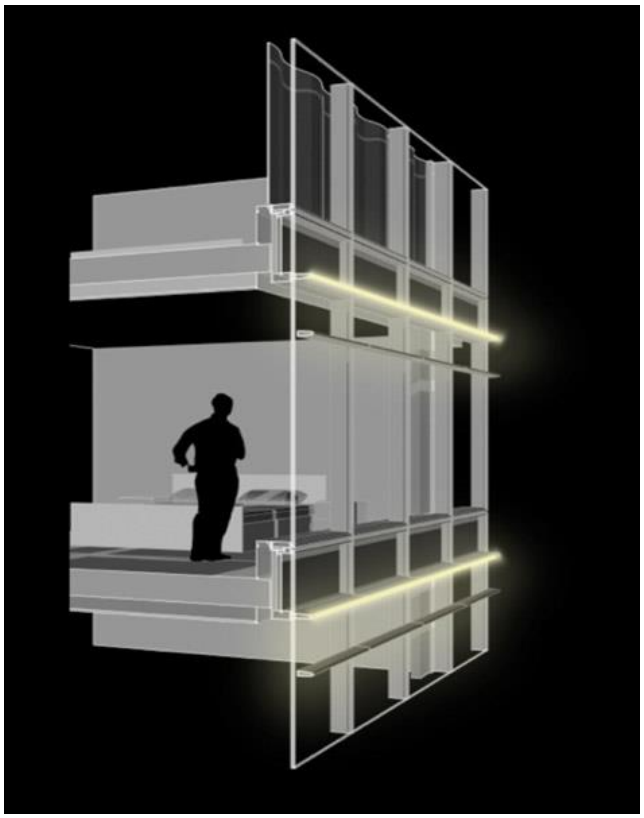

Figure 5 Architectural sketch showing luminaire location and direction

Further installation details of the LED system can be found in the architectural report prepared by FJMT Architects.

7 Lighting control and content

The lighting installation is proposed to operate within the standard pre-curfew and curfew hours as recommended within the Australian Standards.

8 Lighting impact analysis

Based upon the luminaire technical specification the following requirements have been investigated as part of the lighting impact analysis.

- Illuminance
- Luminous intensity
- Threshold increment

Full details and calculation assumptions can be found in Appendix B.

8.1 Illuminance (Adjacent residential stakeholders)

Based on the luminaire data and architectural information of the proposed luminaire type, the below desktop study has been completed to estimate the theoretical maximum vertical illuminance that may be potentially received by vertical surfaces surrounding the hotel. The intent of this exercise is to understand the worst case vertical illuminance that may enter a residential window.

To complete this exercise a number of significant assumptions have been made to ensure the worst case (highest light output) has been assessed. This theoretical study is therefore rigorous in its findings and recommendations.

The assumptions are as follows:

- The peak intensity emitted from the luminaires has been adapted for the calculations
- Calculations assume that each of the 3 RGB channels is assumed to be operating at 100%
- In the areas shown the calculation assumes that the entire lighting installation is visible from a single location

Furthermore it should be noted that a maintenance factor (MF) as per the Australian Standard has not been applied, and that this is typically assumed as 0.8.

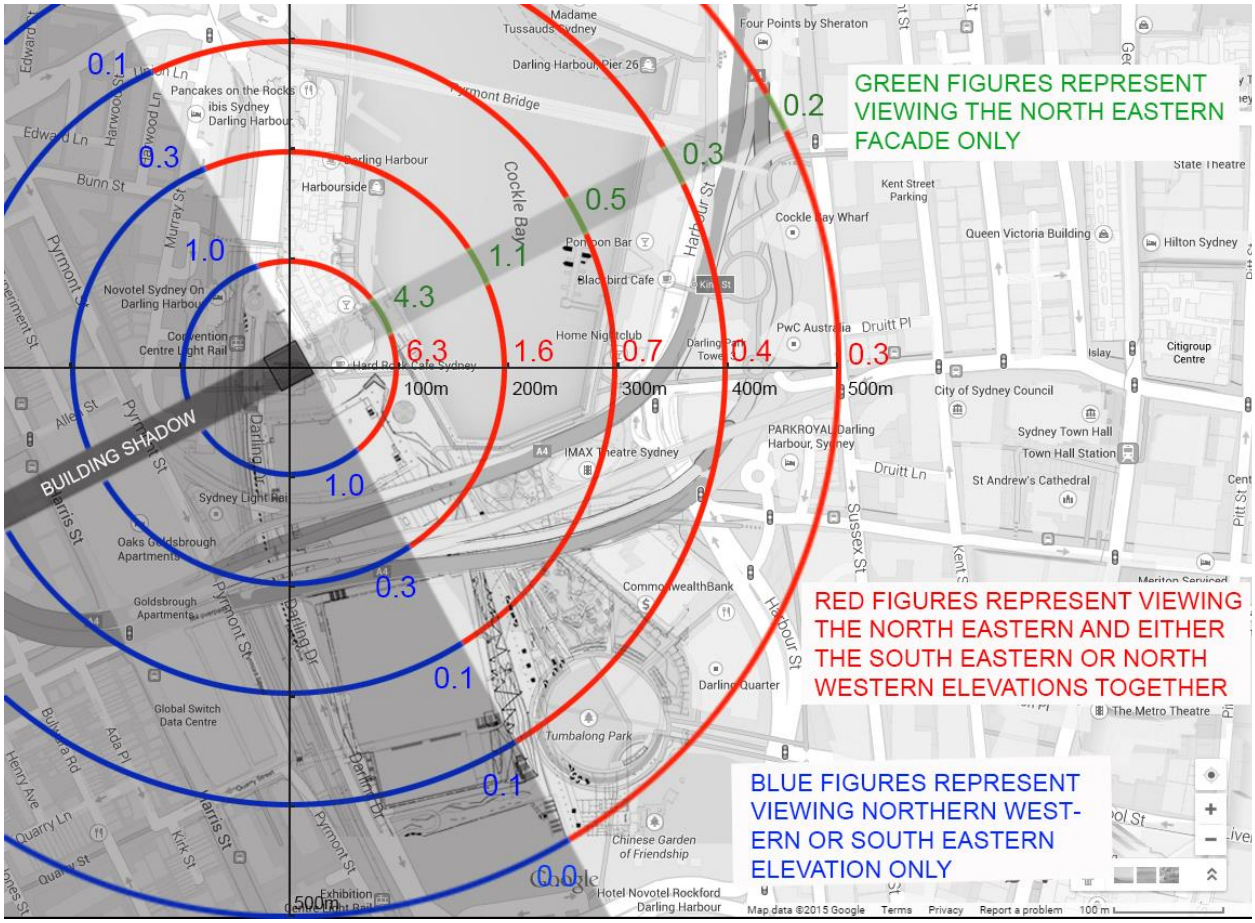

Figure 6 Theoretical illuminance contour diagram

The above diagram indicates the theoretical maximum achievable from each façade at various distance. As per section 4.2 of this report the maximum permissible illuminance recommended to reach residential properties within the Australian Standard is 25 lux. This is during non-curfew hours. During curfew hours the maximum is 4 lux.

At 100m form the façade a theoretical maximum of 5.3 lux is achievable when the North Eastern façade is combined with one of the other facades.

This is therefore compliant with the Australian Standard.

8.2 Luminous intensity

The limits to luminous intensity is based upon the light emitted by the luminaires. The peak intensity of the selected luminaire is shown as 216 cd per 600mm. This equates to 301 cd per meter. Full details of this can be found in Appendix B.

Using this approach the installation falls significantly below the maximum recommendations of 100,000 cd for pre curfew hours and 2,500 cd for curfew hours as detailed in section 4.1 of this report.

8.3 Threshold increment

The calculation of threshold increment is to control the effect of lighting installations on transport users.

Given the site conditions, the view of the ICC hotel façade will be very brief from the surrounding roads and outside of the typical 20° from forward viewing angle used when assessing glare source for vehicles.

Figure 7 View of ICC hotel façade from Western Distributor

It should also be noted that the shape/form of the light source when compared to the highway luminaires within the typical view are significantly different to the façade proposals. A typical street lantern has a peak intensity of 10,000 approximately, whereas the proposed façade has a peak of 215 cd.

Secretary's Environmental Assessment Requirements (SEARs)

The following requirements have been prepared with relation to the proposed façade lighting:

- Sunday to Thursday – dusk to 12.00pm

Monochromatic, gentle, subtle colour and movement.

- Friday and Saturday – dusk to 12.00am

Dynamic colour and movement

- Operate to 1.00am during special events

SEAR's requirement	**Arup response**
The visual impacts of the proposed illumination/lighting of the hotel building from both the surrounding residential properties and key vantage points in the public domain and surrounding the site	Compliance to be demonstrated by meeting the requirements of the Australian Standard as detailed in this report
The impacts of the proposed illumination/lighting on the light rail corridor	Details of this are shown above
The operational hours of the proposed lighting	The operation hours are proposed to be as follows: • Sunday to Thursday – dusk to 12.00am Monochromatic, gentle, subtle colour and movement. • Friday and Saturday – dusk to 12.00am Dynamic colour and movement • Operate to 1.00am during special events Special events may include Christmas Eve, Christmas Day, New Year's Eve, Australia Day, festival days or one-off or special events during the year.

It should be noted that the typical curfew hours as stated in the Australian Standard begin at 11.00pm. However, given the building location in Sydney's premier tourist and entertainment precinct, the curfew hours proposed above are considered reasonable.

It is also stated that curfew hours may be determined by the consent authority. Therefore on the basis that the proposed hours of operation as shown above are agreed, then the hours of operation can be deemed as compliant with the Australian Standards.

9 Compliance with Australian Standards and design requirements

9.1 Australian Standards

Based on the above product information and calculation assumptions, the illuminance calculation has been completed. The following table shows a comparison to the recommendations with the Standards.

As per 4.1 of this report, ICC Hotel falls within a commercial area or at the boundary of commercial and residential area and any analysis has been undertaken on this basis.

AS4282 Technical parameter	**AS4282 recommendation for commercial area or at the boundary of commercial and residential areas with light surrounds**	**Maximum theoretical illuminance at 100m from hotel**	**Compliance**
Illuminance on vertical plane pre-curfew	25 lux	22.2 lux	YES
Illuminance on vertical plane curfew hours	4 lx	0 lux	YES
Luminous intensity emitted by single luminaire pre-curfew	100,000 cd	301 cd	YES

It is important to note that the above figures assume the worst case scenario using the maximum illuminance produced and brightness possible from the system.

9.2 Threshold increment (Road/transport users)

The viewing angle of the proposed building is outside of that experienced by transport uses and therefore the proposals are compliant with this requirement. Furthermore the form and brightness of the façade is significantly different (the façade luminaires are 0.01% of the peak brightness of a highway luminaire) and as such the effect would not cause adverse glare to motorists.

9.3 CASA

The site location is outside of the 6km restriction radius around aerodrome and therefore the proposals comply with this restriction.

9.4 SEARs

The requirements as shown above have been addressed within this report. The visual impact has been addressed through compliance with the Australian Standard and the operating hours have been detailed.

9.5 Light rail

No specific standards apply for this. However given the infrequent use of signals within the light rail network, and the difference between the viewing distance, form and intensity of the façade lighting it is highly unlikely that the façade will negatively affect the view of signalling.

10 Conclusions

Whilst the ICC Hotel facade lighting is visible from a number of residential buildings, however the analysis detailed in this report demonstrates that the intensity from the fixtures and the resultant illuminance reaching these buildings is significantly lower than the recommended limits as stated within the relevant Australian Standard.

To put this in perspective, the illuminance reaching these buildings is considered less than a public street light. This conclusion therefore also addresses a number of the SEARs comments.

Appendix B

AS 4282 Control of the obtrusive effects of outdoor lighting - reference tables

Contents

B1 AS4282 Table 2.1

TABLE 2.1

RECOMMENDED MAXIMUM VALUES OF LIGHT TECHNICAL PARAMETERS FOR THE CONTROL OF OBTRUSIVE LIGHT

(See Clause 2.7)

1	2	3	4	5
Light technical parameter	Application or calculation conditions (see also Figure 2.1 and Section 5)	Recommended maximum values		
		In commercial areas or at boundary of commercial and residential areas*	Residential areas	
			Light surrounds†	Dark surrounds‡
Illuminance in vertical plane (E_v)	*Pre-curfew:* Limits apply at relevant boundaries of nearby residential properties, in a vertical plane parallel to the relevant boundary, to a height commensurate with the height of the potentially affected dwellings. Values given are for the direct component of illuminance	25 lx	10 lx	10 lx
	Curfewed hours: Limits apply in the plane of the windows of habitable rooms of dwellings on nearby residential properties. In the absence of development (i.e. vacant allotment), the limits apply on the potentially affected property, in a vertical plane parallel to the relevant boundary, at the minimum setback permitted for a dwelling, to a height commensurate with land use zoning provisions. Values given are for the direct component of illuminance	4 lx	2 lx	1 lx
Luminous intensity emitted by luminaires (I)	*Pre-curfew:* Limits apply to each luminaire (irrespective of the number on a head frame) in the principal plane, for all angles at and above the control direction, when aimed in accordance with the installation design	Limits as determined from Table 2.2. Alternatively, the limits and method of assessment associated with curfewed hours may be applied, at the discretion of the designer (see Clauses 2.7.1 and 2.7.2)		
	Curfewed hours: Limits apply in directions where views of bright surfaces of luminaires are likely to be troublesome to residents, from positions where such views are likely to be maintained, i.e. not where momentary or short-term viewing is involved	2 500 cd	1 000 cd	500 cd
Threshold increment (TI)	Limits apply at all times where users of transport systems are subject to a reduction in the ability to see essential information. Values given are for relevant positions and viewing directions in the path of travel	20% based on adaptation luminance ($\bar{L}$) of 10 cd/m²	20% based on adaptation luminance ($\bar{L}$) of 1 cd/m²	20% based on adaptation luminance ($\bar{L}$) of 0.1 cd/m²

* Applies to residential accommodation in commercial areas or at the boundary between commercial and residential areas. The term 'commercial' is used as a generic description for zoning which provides for urban uses other than residential.

† Where the affected property abuts roads that are lit to Category V5 or higher in accordance with AS/NZS 1158.1.1.

‡ Where the affected property abuts roads that are lit to Category B1 or lower in accordance with AS 1158.1, or where there is no lighting.

B2 AS4282 Table 2.2

TABLE 2.2

MAXIMUM LUMINOUS INTENSITY PER LUMINAIRE FOR PRE-CURFEW OPERATING TIMES
(See Table 2.1)

1	2	3	4
Area description		**Maximum luminous intensity from each luminaire***	
Size of area	**Controlling dimension (Figure 5.1)**	**Level 1 control (Note 1)**	**Level 2 control (Note 2)**
Large	>75 m	7 500 cd	100 000 cd
Medium	≥25 m ≤75 m	7 500 cd	50 000 cd
Small	<25 m	2 500 cd	25 000 cd

* Limits apply to each luminaire (irrespective of the number on a head frame) in the principle plane, for all angles at and above the control direction, when aimed in accordance with the installation design (see Clause 5.3.2.1).

NOTES:

1 Level 1 control is appropriate for development control of environmentally sensitive areas, i.e. where the existing environment is of high quality, where abutting properties are close to the installation, where they are residential in nature, where the existing ambient light levels are low and where the community requires the best available environmental safeguards to be applied.

As the use of Type C cut-off luminaires† is likely to be necessary for Level 1 control, the implementation of this level of control will normally be possible only for lighting applications that require relatively high illuminances over areas that are small to medium in size, e.g. lighting for tennis courts or hockey fields. However, Level 1 control may also be suitable for larger areas where lower illuminances are appropriate, e.g. for car parks and outdoor storage areas.

2 Level 2 control will permit the use of a wide range of currently used lighting techniques but will limit intensities in the control direction to what might reasonably be expected by careful attention to design and the selection and aiming of luminaires, especially for applications involving Type A luminaires†.

Appendix C

Lighting calculation summary

Contents

C1 Estimated LED linear lengths

Elevation	LED Continuous length (m)	Quantity of Lengths per Floor	Total	Quantity of floors	Total lengths
North East	35	1	35	16	560
	16.7	2	33.4	1	33.4
	15.9	2	31.8	1	31.8
	14	2	28	1	28
	12.5	2	25	1	25
	11	2	22	1	22
	9.5	2	19	1	19
	8	2	16	1	16
	5.4	2	10.8	1	10.8
				Total Elevation Length	746

Elevation	LED Continuous length (m)	Quantity of Lengths per Floor	Total	Quantity of floors	Total lengths
South East	8	1	8	21	168
	6.5	1	6.5	1	6.5
				Total Elevation Length	174.5

Elevation	LED Continuous length (m)	Quantity of Lengths per Floor	Total	Quantity of floors	Total lengths
North West	8	1	8	21	168
	6.5	1	6.5	1	6.5
				Total Elevation Length	174.5

Total Building Length	1095

C2 Illuminance summary

Illuminance from Whole Buidling		
Intensity	**Distance from Hotel**	**Illuminance (lux)**
62,780	100	6.3
62,780	200	1.6
62,780	300	0.7
62,780	400	0.4
62,780	500	0.3

Illuminance from South Eastern Elevation		
Intensity	**Distance from Hotel**	**Illuminance (lux)**
10,005	100	1.0
10,005	200	0.3
10,005	300	0.1
10,005	400	0.1
10,005	500	0.0

Illuminance from North Western Elevation		
Intensity	**Distance from Hotel**	**Illuminance (lux)**
10,005	100	1.0
10,005	200	0.3
10,005	300	0.1
10,005	400	0.1
10,005	500	0.0

Illuminance from North Elevation		
Intensity	**Distance from Hotel**	**Illuminance (lux)**
42,771	100	4.3
42,771	200	1.1
42,771	300	0.5
42,771	400	0.3
42,771	500	0.2

C3 Intensity calculations

North Eastern Elevation													
Light Colour	**Peak intensity (cd) per 600mm**	**Length mm**	**Peak intensity (cd) per 1000mm**	**Peak intensity (cd) per luminaire (1600mm)**	**Total peak intensity (cd) North Eastern elevation**	**Total peak intensity (cd) North Eastern elevation including maintenance factor 0.8**	**Maximum intensity (cd) as per AS 'pre-curfew'**	**Minimum intensity (cd) as per AS during 'curfew'**	**Maximum Recommend output % to meet 'pre-curfew' maximum**	**Whole elevation compliant 'pre-curfew'?**	**Whole elevation compliant during 'curfew'?**	**Individual luminaire compliant 'pre-curfew'?**	**Individual luminaire compliant during 'curfew'?**
Red	11	600	18	29	13,677	10,941	100,000	2,500	100	YES	NO	YES	YES
Green	28	600	47	75	34,813	27,851			100	YES	NO	YES	YES
Blue	6	600	10	16	7,460	5,968			100	YES	NO	YES	YES
Red Green Blue	43	600	72	115	53,463	42,771			100	YES	NO	YES	YES

South Eastern Elevation													
Light Colour	**Peak intensity (cd) per 600mm**	**Length mm**	**Peak intensity (cd) per 1000mm**	**Peak intensity (cd) per luminaire (1600mm)**	**Total peak intensity (cd) South Eastern elevation**	**Total peak intensity (cd) South Eastern elevation including maintenance factor 0.8**	**Maximum intensity (cd) as per AS 'pre-curfew'**	**Minimum intensity (cd) as per AS during 'curfew'**	**Maximum Recommend output % to meet 'pre-curfew' maximum**	**Whole elevation compliant 'pre-curfew'?**	**Whole elevation compliant during 'curfew'?**	**Individual luminaire compliant 'pre-curfew'?**	**Individual luminaire compliant during 'curfew'?**
Red	11	600	18	29	3,199	2,559	100,000	2,500	100	YES	NO	YES	YES
Green	28	600	47	75	8,143	6,515			100	YES	NO	YES	YES
Blue	6	600	10	16	1,745	1,396			100	YES	YES	YES	YES
Red Green Blue	43	600	72	115	12,506	10,005			100	YES	NO	YES	YES

North Western Elevation													
Light Colour	**Peak intensity (cd) per 600mm**	**Length mm**	**Peak intensity (cd) per 1000mm**	**Peak intensity (cd) per luminaire (1600mm)**	**Total peak intensity (cd) South Eastern elevation**	**Total peak intensity (cd) South Eastern elevation including maintenance factor 0.8**	**Maximum intensity (cd) as per AS 'pre-curfew'**	**Minimum intensity (cd) as per AS during 'curfew'**	**Maximum Recommend output % to meet 'pre-curfew' maximum**	**Whole elevation compliant 'pre-curfew'?**	**Whole elevation compliant during 'curfew'?**	**Individual luminaire compliant 'pre-curfew'?**	**Individual luminaire compliant during 'curfew'?**
Red	11	600	18	29	3,199	2,559	100,000	2,500	100	YES	NO	YES	YES
Green	28	600	47	75	8,143	6,515			100	YES	NO	YES	YES
Blue	6	600	10	16	1,745	1,396			100	YES	YES	YES	YES
Red Green Blue	43	600	72	115	12,506	10,005			100	YES	NO	YES	YES

Whole Building													
Light Colour	**Peak intensity (cd) per 600mm**	**Length mm**	**Peak intensity (cd) per 1000mm**	**Peak intensity (cd) per luminaire (1600mm)**	**Total peak intensity (cd) South Eastern elevation**	**Total peak intensity (cd) Whole Building elevation including maintenance factor 0.8**	**Maximum intensity (cd) as per AS 'pre-curfew'**	**Minimum intensity (cd) as per AS during 'curfew'**	**Maximum Recommend output % to meet 'pre-curfew' maximum**	**Whole building compliant 'pre-curfew'?**	**Whole building compliant during 'curfew'?**	**Individual luminaire compliant 'pre-curfew'?**	**Individual luminaire compliant during 'curfew'?**
Red	11	600	18	29	20,075	16,060	100,000	2,500	100	YES	NO	YES	YES
Green	28	600	47	75	51,100	40,880			100	YES	NO	YES	YES
Blue	6	600	10	16	10,950	8,760			100	YES	NO	YES	YES
Red Green Blue	43	600	72	115	78,475	62,780			100	YES	NO	YES	YES