

Australian/New Zealand Standard™

Lighting for roads and public spaces

Part 5: Tunnels and underpasses



AS/NZS 1158.5:2014

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Australian/New Zealand Standard™

Lighting for roads and public spaces

Part 5: Tunnels and underpasses

Originated as AS/NZS 1158.5:2007.
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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee LG-002, Lighting for Roads and Public Spaces, to supersede AS/NZS 1158.5:2007, and provide performance and design requirements for lighting schemes for tunnels and underpasses.

This Standard is for the use of designers, consultants, owners and operators of lighting schemes for tunnels and underpasses. The design of tunnel lighting schemes is complex and involves the use of specialist computer software and should be undertaken only by experienced designers.

This revision provides more explanatory information. It also recognizes that in some situations daylight penetration into an underpass can be significant and that software is readily available to determine the daylight luminance contribution, which may be used to offset some or all of the electric lighting requirements.

Requirements for the tunnel interior lighting are now based on operating speed and in very long tunnels, interior sub zones have been introduced.

A flow diagram has been introduced in Appendix L detailing lighting design steps.

The terms 'normative' and 'informative' have been used in this Standard to define the application of the appendix to which they apply. A 'normative' appendix is an integral part of a Standard, whereas an 'informative' appendix is only for information and guidance.

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FOREWORD

Tunnels and underpasses, including underbridges, are road elements where simple accidents can have a serious effect on the smooth operation of the associated road network. Lighting design for these elements is essentially to overcome the daylight problems of the 'black hole' seen on the approach to a tunnel portal on the one hand and on the other, shadowing of objects within an underpass. These potential effects result from the, often, high light adaptation of the motorist's vision and then may only be overcome by the application of very high levels of lighting in the relevant zones of the structures.

Since the structures in question are mainly located on heavily trafficked urban roads, the specific lighting categories are based on the structural design details, i.e. length for tunnels and the degree of 'see-through' for underpasses, and not on traffic characteristics.

For the design of lighting schemes for tunnels, reference was made to CIE 88, *Guide for the lighting of road tunnels and underpasses*, and is also based on considerable national experience. However, the method of determining the light adaptation level of the motorist approaching the tunnel portal (L20) is retained from the first edition (1990) rather than the method of the second edition (2004). This is because the 2004 method is complex, whereas the more simple method of the first edition has given very satisfactory results in practice.

The day lighting for much of the tunnel is predicated on the L20 value in the particular situation. Therefore, the luminances of the various elements, in particular that of the sky, making up the relevant field of view of the motorist must be known with accuracy. The Standard contains indicative values based on a program of sky measurements and more abbreviated measurements of other structural elements taken in Australia, together with those in CIE 88.

For the design of lighting schemes for underpasses, reference was made to BS 5489-2 (2003), *Code of practice for the design of road lighting, Part 2: Lighting of tunnels*. The method of determining the degree of 'see-through' is based on national experience.

The compliance values of the light technical parameters are the minimum to be maintained through the life of the installation; an effective maintenance regime for the lighting scheme is essential, particularly in the case of tunnels. The values given are the minimum necessary to ensure sufficient safety and comfort.

In general, the light technical parameters for the various zones in the structures are based on the following:

- (a) The luminance level of the road and walls.
- (b) The uniformity of luminance of the road and walls.
- (c) Limitation of glare from the luminaires.
- (d) Limitation of the flicker effect from luminaires.

Other requirements, such as luminaire IP ratings and maximum acceptable maintenance factor (MF) need to be considered.

Information is given on how motorist's perceptions are influenced by tunnel design and operation, on mains failure lighting, tunnel signage, tunnel lighting maintenance and on the design brief and compliance documentation.

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Australian/New Zealand Standard
Lighting for roads and public spaces**Part 5: Tunnels and underpasses**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies performance and design requirements for lighting schemes for tunnels and underpasses. It also specifies the luminaire data and other design data that is needed to facilitate the lighting design and the assessment of compliance with the requirements of this Standard.

NOTE: The basic steps of the design process are set out in a flow diagram in Appendix L.

This Standard does not deal with lighting schemes for underpasses catering solely for pedestrians/cyclists, which are covered by AS/NZS 1158.3.1. Underpasses and shorter tunnels are often designed to carry a mixture of motorized traffic, cyclists and pedestrians but long tunnels typically exclude all but motorized traffic. Current practice for underpasses within roads designated Category P is not to provide daytime lighting, and no recommendations are offered.

This Standard is intended to be read in conjunction with AS/NZS 1158.0, AS/NZS 1158.1.1, AS/NZS 1158.2, AS/NZS 1158.1.2 and AS/NZS 1158.6.

NOTE: Computer based design calculation procedures are given in AS/NZS 1158.0, AS/NZS 1158.2 and Appendices E and H of this Standard. Guidance on the design, installation, operation and maintenance of lighting schemes is given in AS/NZS 1158.1.2.

1.2 APPLICATION

Subject to the requirements of applicable laws, the choice of whether to install a lighting scheme in compliance with this Standard, and if so which category of lighting is appropriate, rests with the client (usually the applicable road controlling authority). In the application of this particular Standard, the decision is based solely on the structural characteristics of the road element.

1.3 REFERENCED DOCUMENTS

A list of the Standards and other documents referred to in this Standard is given in Appendix A.

NOTE: A number of additional documents, which are considered useful sources of information, are listed in Appendix B.

1.4 DEFINITIONS

For the purpose of this Standard the definitions given in AS/NZS 1158.0 plus those in the supplementary list below apply.

1.4.1 Access zone

Part of the road immediately outside (in front of) an entrance portal, covering the distance over which an approaching driver should be able to see into a tunnel.

1.4.2 Access zone length

Distance between the stopping sight distance point ahead of an entrance portal, and the entrance portal itself.

1.4.3 Access zone luminance (L_{20})

Average luminance contained in a conical field of view, subtending an angle of 20° with the apex at the position of the eye of an approaching driver and aimed at the centre of the entrance portal.

NOTE: Access zone luminance is assessed from a point at a distance equal to the stopping sight distance from the entrance portal at the middle of the relevant carriageway.

1.4.4 Counterbeam lighting

Lighting comprising luminaires the luminous intensity distribution of which is asymmetrical in a plane parallel to the tunnel axis and the main beam of which is directed towards oncoming traffic in a tunnel.

1.4.5 Daylight screen/louvres

Device that transmits (part of) the ambient daylight.

NOTE: Daylight screens may be applied for the lighting of the threshold zone of a tunnel in order to reduce the requirements for artificial lighting.

1.4.6 Design speed

Speed adopted for a particular stated purpose in designing a road.

1.4.7 Emergency lane

Lane parallel to the traffic lane(s) not intended for normal traffic, but for emergency vehicles, or broken-down vehicles, or both.

1.4.8 Escape lighting

Lighting that is maintained under emergency conditions (e.g. failures in the electricity mains supply).

1.4.9 Entrance portal

Part of the tunnel construction that corresponds to the beginning of the covered part of a tunnel or, when open daylight screens are used, to the beginning of the daylight screens.

1.4.10 Entrance zone

The combination of threshold zone and transition zone.

1.4.11 Exit portal

End of the covered part of a tunnel or, when open daylight screens are used, the end of the daylight screens.

1.4.12 Exit zone

Part of a tunnel where, during daytime, the vision of a driver approaching the exit is influenced predominantly by the brightness outside the tunnel and is normally equal to $20\text{ m} + \text{SSD}$ from the exit portal.

1.4.13 Interior zone

Part of a tunnel following directly after the transition zone to the beginning of the exit zone.

1.4.14 Interior zone luminance

Average road surface luminance of the calculation field at a given location in the interior zone of a tunnel.

1.4.15 Mixed traffic

Traffic that consists of motor vehicles, cyclists, pedestrians etc.

1.4.16 Parting zone

First part of the road directly after the exit portal of a tunnel.

NOTE: The parting zone is not a part of the tunnel, but it is closely related to the tunnel lighting. The parting zone begins at the exit portal.

1.4.17 Safety barrier

A roadside device that provides a physical restriction to penetration of a vehicle in a way that reduces the risk to vehicle occupants and other traffic. Its purpose is to contain or redirect an errant vehicle. It is used to shield roadside obstacles or non-traversable terrain features. Occasionally, it may be used to protect people from vehicular traffic.

1.4.18 See-through percentage (STP)

Area of the apparent exit portal of a tunnel, as a percentage of the area of the apparent entrance portal, when viewed in perspective from the stopping sight distance from the entrance portal.

1.4.19 Stopping sight distance (SSD)

The distance required by a driver, travelling at a given speed, to react and stop.

1.4.20 Sun tight screens

Screens that are constructed in such a fashion that direct sunlight can never reach the road or wall surface under the screen.

1.4.21 Symmetrical lighting

Lighting comprising luminaires the luminous intensity distribution of which is symmetrical in a plane parallel to the tunnel axis.

1.4.22 Threshold zone

First part of a tunnel, directly after the entrance portal.

NOTE: The threshold zone begins at the entrance portal.

1.4.23 Threshold zone lighting

Lighting of the threshold zone of a tunnel, which allows drivers to see into the tunnel stopping sight distance *SSD*.

1.4.24 Threshold zone luminance (L_{th})

Average road surface luminance of the calculation field specified for the first part of the threshold zone.

1.4.25 Threshold zone luminance ratio (*k* factor)

Ratio between the target threshold zone luminance of the first part of the threshold zone and the access zone luminance.

1.4.26 Traffic flow

Number of vehicles passing a specific point in a stated time in a stated direction.

1.4.27 Transition zone

Part of a tunnel following directly after the threshold zone and finishing when the luminance is twice that of the interior zone and luminance follows the curve in Figure 3.2.

1.4.28 Transition zone luminance (L_{tr})

Average road surface luminance of the calculation field at a given location in the transition zone of a tunnel.

1.4.29 Uninterruptible power system (UPS)

Combination of converters, switches and energy storage devices (for example, batteries), constituting a power system for maintaining continuity of load power in case of input power failure.

1.4.30 Visual guidance

Optical and geometrical means of providing drivers with information on the course of the carriageway in a tunnel.

1.5 SYMBOLS AND ABBREVIATIONS

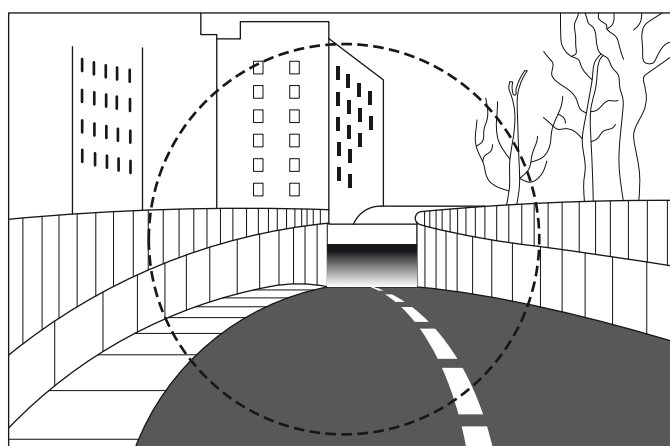
For the purposes of this Standard, symbols and abbreviations from AS/NZS 1158.0 apply along with the following symbols:

A	area of a segment on a perspective view of a tunnel entrance (m^2)
F	flicker effect
H	height of tunnel entrance portal, in metres (m)
k	ratio of threshold zone luminance to access zone luminance
L	luminance, in candelas per square metre (cd/m^2)
$\bar{L}$	average carriageway luminance (cd/m^2)
L_{20}	access zone luminance, in candelas per square metre (cd/m^2)
L_{in}	interior zone luminance, in candelas per square metre (cd/m^2)
L_{th}	threshold zone luminance, in candelas per square metre (cd/m^2)
L_{tr}	transition zone luminance, in candelas per square metre (cd/m^2)
$\bar{L}_{WL}$	average wall luminance (left) (cd/m^2)
$\bar{L}_{WR}$	average wall luminance (right) (cd/m^2)
SSD	stopping sight distance, in metres (m)
STP	see-through percentage (%)
t	time, in seconds (s)
TI	threshold increment, as a percentage (%)
U_L	longitudinal uniformity of road surface luminance
U_O	overall uniformity of road surface luminance
U_W	wall luminance uniformity
α_i	visual angle for an apparent entrance portal in the vertical plane, in degrees ($^\circ$)
α_u	visual angle for an apparent exit portal in the vertical plane, in degrees ($^\circ$)
β_i	visual angle for an apparent entrance portal in the horizontal plane, in degrees ($^\circ$)
β_u	visual angle for an apparent exit portal in the horizontal plane, in degrees ($^\circ$)
θ_H	angle subtended by tunnel height, in degrees ($^\circ$)

SECTION 2 OBJECTIVES AND LIGHT TECHNICAL PARAMETERS

2.1 ROAD ELEMENT CLASSIFICATION

Road elements are classified as either tunnels or underpasses. Tunnels will, in general, be relatively long and the exit will not be seen on entry; motorized traffic volumes will be high, and pedestrians and cyclists excluded. Underpasses, on the other hand, will be relatively short and the exit will generally be seen on entry, either wholly or in part; traffic may include pedestrians and cyclists, as well as motorized vehicles. Figure 2.1 shows an example of the motorist's view on the approach to a tunnel portal.



NOTES:

- 1 This schematic represents the motorist's view of the portal from 90 m distance.
- 2 The circle (subtending 20°) encompasses the field of view used in the determination of the motorists daylight adaptation level—the access zone luminance L_{20} .

FIGURE 2.1 EXAMPLE OF THE VIEW ON APPROACH TO A TUNNEL

The appropriate lighting scheme will not depend just on the simple dichotomy of tunnel or underpass but for a given situation will depend on the particular structural characteristics of that road element (e.g. its length); whether there is any direct see-through and the extent of it. Table 2.1 gives representative road element traffic and structural characteristics and the applicable lighting category, as specified in Clause 2.4.

TABLE 2.1
TUNNEL AND UNDERPASS CHARACTERISTICS AND LIGHTING CATEGORY

Typical applications		Lighting category
Structural characteristic	Traffic characteristics	
Tunnel of length which requires full tunnel lighting treatment	Part of urban, high traffic volume road network for motor vehicle traffic only	TU1 Daytime/night-time use
Tunnel of a length which requires an abbreviated tunnel lighting treatment after the threshold zone	Part of urban, high traffic volume road network for motor vehicle traffic only	TU2 Daytime/night-time use
Underpass of overhead road, building or other structure with see-through possible; see-through <i>very restricted</i> (i.e. $STP < 20\%$)	(a) Part of urban, high traffic volume road network with possibility of traffic mix, or (b) Access way into a facility with the possibility of traffic mix	TU3 Daytime/night-time use
Underpass of overhead road, building or other structure with see-through possible; see-through <i>restricted</i> (i.e. $20\% \leq STP \leq 80\%$)	(a) Part of urban, high traffic volume road network with possibility of traffic mix, or (b) Access way into a facility with the possibility of traffic mix	TU4 Daytime/night-time use
Underpass of overhead road, building or other structure with see-through possible; see-through <i>nearly or completely unrestricted</i> (i.e. $STP > 80\%$)	(a) Part of urban, high traffic volume road network with possibility of traffic mix, or (b) Access way into a facility with the possibility of traffic mix	TU5 Daytime/night-time use

NOTE: Underpass includes underbridge.

2.2 GENERAL OBJECTIVE

The objective of the lighting of all road elements is to provide a lighted environment that is conducive to the safe and comfortable movement of traffic, in this case both by day and by night, and the discouragement of illegal acts, while protecting the integrity of the environment through the control of spill light and glare and minimizing energy consumption. When designing the lighting of tunnels and underpasses the visual requirements of motorists predominate except in some explicitly stated situations occurring in underpasses.

To accomplish these objectives the lighting must reveal necessary visual information. Generally this consists of the road itself and the way ahead, its boundaries, footpaths, road furniture and surface imperfections, together with other road users and any inanimate objects on the carriageway.

That the lighting of tunnels and underpasses requires separate treatment arises from the daylight conditions and the confined enclosed nature of these structures; for night-time the lighting scheme will be, essentially, an extension of that on the connecting road.

By day the motorist's vision will be adapted to the general ambient light level, which can be very high dependent on the amount of sky in the field of view, cloud, sun position and the reflection of surfaces in the surrounds. On approach to the entrance of a tunnel, if it is not lit or poorly lit, the motorist will not be able to see into the tunnel, 'the black hole effect' and their lack of confidence may result in slowing and subsequent disruption to the smooth flow of traffic. Poor visibility into the tunnel (or underpass), increases the risk of rear-end collision with stopped or slow moving vehicles.

Since tunnels can be important links, catering generally for large traffic flows, it is imperative that they operate at maximum efficiency without such potential disruption. Therefore the lighting in the tunnel entrance must be at least sufficient that a motorist can see into the tunnel at a distance from which they can stop in time to avoid a potential collision. The initial, relatively high, light level necessary in the tunnel entrance can then be reduced as the motorist proceeds and becomes progressively adapted a much lower but adequate light level.

As well as having the correct lighting level, the total visual environment within the confines of the tunnel is important. The reflectivity and brightness of the walls, from the carriageway to luminaire level, influences visual performance and comfort.

NOTE: Refer to Appendix C for other information on driver perceptions and visibility enhancement factors.

The lighting requirements of underpasses and underbridges depend on the degree to which the approaching motorist can see through the exit portal. If this is severely restricted it will require a lighting design similar to that of a tunnel. Even if there is see-through, albeit restricted, significant shadowing of another road user within the underpass may occur which will need to be rectified; these concepts are explained in Appendix D.

The external daylight levels can be very high and these determine the entrance and transition lighting levels required inside the tunnel. It is therefore imperative that a tunnel or underpass is planned from the outset, to minimize the ambient brightnesses as seen by the approaching driver. Not only will this minimize equipment capital installation costs but also the energy consumption and associated greenhouse gas emissions.

2.3 DESIGN OBJECTIVES

2.3.1 Principal objectives

The principal design objectives for the lighting of tunnels and underpasses are to provide, as is relevant to the particular road element, the following:

- (a) Average luminance and luminance uniformity of the carriageway, wall linings and other structures, as relevant, to a specified level.
- (b) Glare control to a specified level.
- (c) Flicker limitation to within specified limits.
- (d) A lighting scheme control system in order that the lighting provided is commensurate with the ambient light level.
- (e) Mains failure lighting.
- (f) Traffic management and emergency signage to a specified standard.
- (g) Minimization of energy use.
- (h) A maintenance regime such that the lighting scheme complies at all times during each maintenance cycle of the lighting scheme.
- (i) To integrate the lighting systems with other tunnel services (e.g. signage, fans, sprinklers, communications, tolling equipment, etc.).
- (j) Where there may be a significant daylight penetration into underpasses, utilize the daylight contribution to offset the amount of daytime electric lighting required.

The specified levels of luminance depend on the particular road element category involved (see Table 2.1).

These objectives are realized by a combination of the choice of relevant road element category and the associated design procedure, leading to luminaire light output distribution and lighting scheme geometry and other associated hardware appropriate to the configuration and dimensions of the road element to be lit. The realization of the objective luminance values will depend on the reflection properties of the road surface and wall linings.

2.3.2 Other considerations

Other aspects of the lighting scheme will affect the initial and long-term viability and performance quality of the scheme. These include the following:

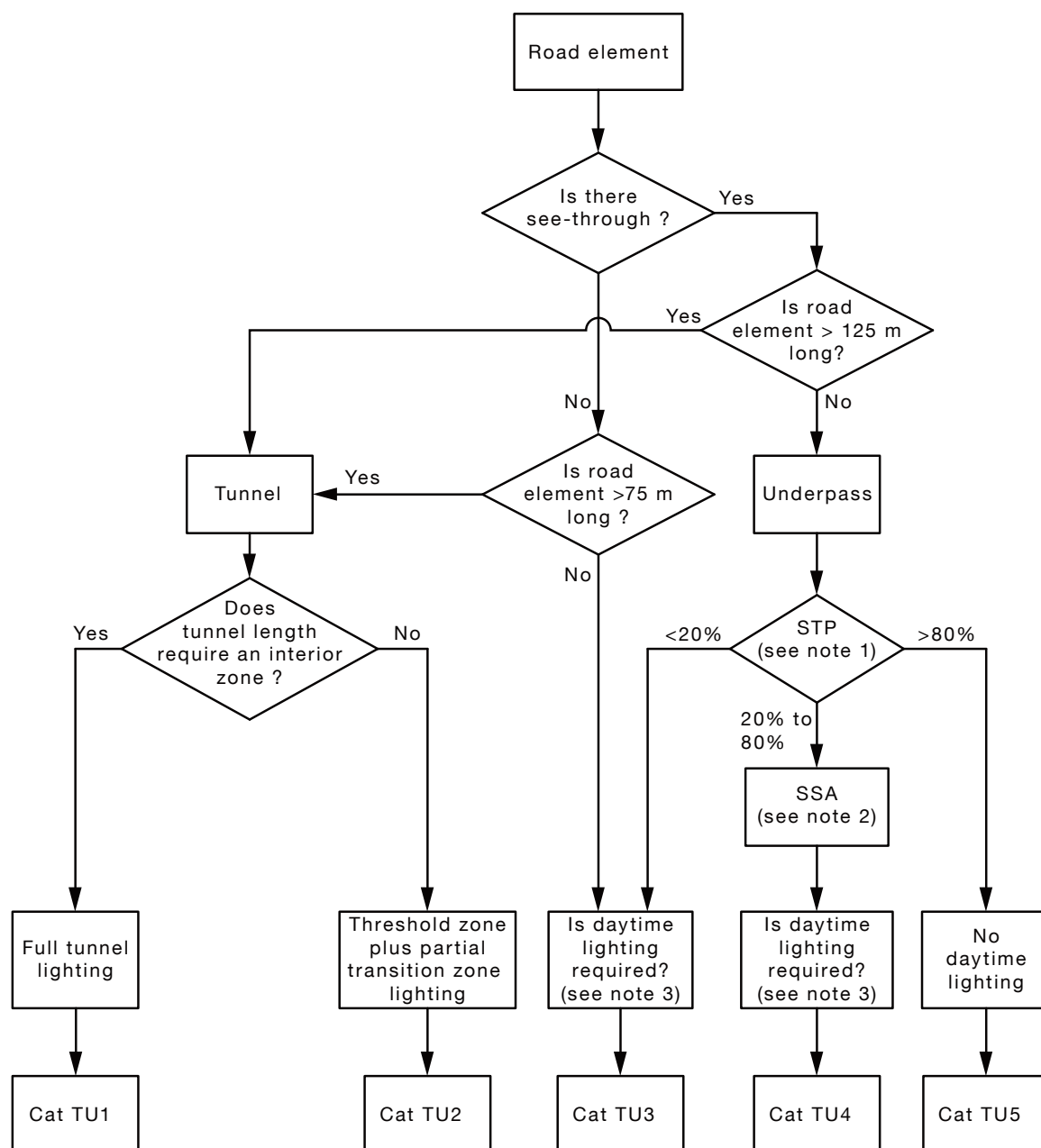
- (a) Lifetime, reliability and maintainability over the service life of the selected hardware components.
- (b) Life cycle costs of the scheme.
- (c) Ability to complement or enhance the visual amenity of the road element by the aesthetics of the lighting scheme and its environment (e.g. the use of white light or wall decoration).

2.4 LIGHTING CATEGORIES AND THEIR APPLICATION

For the purpose of this Standard, the lighting categories set out in Table 2.1 shall apply. The lighting category and design method appropriate for the specific situation shall be determined from the structural characteristics of that road element using the flow diagram in Figure 2.2. The lighting of tunnels and underpasses traffic volume and road user mix are not factors in the determination of the lighting category.

The appropriate lighting category for a particular road element should be a matter for determination in consultation with the client (usually the applicable road controlling authority). In the case that more than one authority is involved then the authorities need to jointly confirm the category, which is to be specified for the lighting scheme.

NOTE: Refer to Appendix I for a sample design brief.



NOTES:

- 1 STP (see-through percentage): the percentage of the exit portal that can be seen by a motorist at the stopping sight distance from the entrance portal (see Clause 1.4.19 and Appendix D).
- 2 SSA (specific situation analysis): for the need and extent of lighting for the specific situation (see Paragraph D2, Appendix D).
- 3 There may be sufficient daylight penetration to supplement or avoid the installation of daytime lighting. Further guidance is provided in Paragraph D2.3, Appendix D.

FIGURE 2.2 DETERMINATION OF THE LIGHTING SCHEME REQUIREMENTS OF THE TUNNEL OR UNDERPASS

2.5 LIGHT TECHNICAL PARAMETERS

2.5.1 General

The principal design objectives outlined in Clause 2.3.1 are formally specified in terms of various light technical parameters (LTPs). These parameters are divided as follows:

- (a) Parameters that relate to the attainment of the required level of lighting performance.
- (b) Parameters that limit the adverse effects of the lighting on users of the lit space, vehicle drivers (e.g. by the control of glare).

NOTE: These are often referred to as 'environmental' parameters.

Details of the applicable parameters are set out in Clause 2.5.2 (the mathematical definitions of the first four LTPs are located in AS/NZS 1158.2 and the definitions for the other LTPs are set out in this Standard).

The required values for these parameters for each lighting category are specified in the relevant clauses of Sections 3 and 4. These requirements are to be met throughout each maintenance cycle over the life of the installation.

The design calculation procedures necessary to determine compliance with the required values of the light technical parameters shall be as specified in Appendix E.

2.5.2 Applicable parameters

The following LTPs apply to the lighting scheme during both daytime and night-time:

Average carriageway luminance	$\bar{L}$
Overall uniformity	U_O
Longitudinal uniformity	U_L
Threshold increment	TI
Average wall luminance (right)	$\bar{L}_{WR}$
Average wall luminance (left)	$\bar{L}_{WL}$
Wall luminance uniformity	U_W
Flicker effect	F

2.6 DESIGN LAMP LUMEN VALUE

The initial lamp lumens, as conventionally evaluated using the CIE 1924 standard observer (i.e. V_λ function), shall be used in calculations. No de-rating lumen multipliers, such as those based on either the changing sensitivity of the eye at low light levels, or the enhanced receptiveness of the eye to 'white' light shall be used in tunnel or underpass lighting.

NOTE: See Appendix B for further reading on the topic.

2.7 COLOUR RENDERING

The choice of light source should be based on an analysis of all the factors relevant to the particular application including aesthetics, environmental, lamp mortality and lumen depreciation, lamp cost, energy use, etc.

Compatible with the operational and economical requirements of the lighting scheme, in general the type of light source used should have the highest Colour Rendering Index (CRI) practicable.

2.8 ENERGY AUDIT

An inherent part of the design of any lighting scheme is the minimization of life cycle energy consumption. To this end it is recommended that the documentation of a scheme contain an energy audit.

The purpose of this audit is to demonstrate that the designer of the lighting scheme has minimized the life cycle energy of the scheme, commensurate with reliability and cost.

Where the lighting is being refurbished the audit should contain a comparison of the energy consumption of both the existing and proposed schemes and their relative compliance with the current lighting Standard.

The audit is in three parts—

- (a) hardware used (with a view to minimizing the use of capital equipment that requires high energy inputs during manufacture);
- (b) electricity use in the lamp and control gear; and
- (c) energy (electricity and other) used in the maintenance of the installation commensurate with ensuring reliability and the efficiency of the scheme.

Should an energy audit be requested, the required documentation is given in Paragraph J2, Appendix J.

Poorly specified schemes are often unreliable and consequently require proportionally higher maintenance. Maintenance operations are a significant consumer of energy as bulk and spot replacement of lamps in public lighting installations consumes large amounts of fuel. A good public lighting scheme is one that is reliable, energy efficient and cost effective.

2.9 MAINTENANCE OF LIGHT TECHNICAL PARAMETERS

2.9.1 General

Significant reductions from the initial values of the LTPs will occur in service, primarily as a result of a gradual depreciation in lamp lumen output, an accumulation of dirt on the transmitting or reflecting surfaces of the luminaires and tunnel wall linings, and ageing of those surfaces. In general, long tunnels are environments with relatively high air dirtiness, and the dirtiness levels can vary greatly depending on the length and grade of a tunnel, the proportion of heavy vehicle traffic and the design of the tunnel ventilation system. Underpasses, short tunnels and areas of long tunnels that are near sources of fresh air supply will be relatively clean, whereas steep uphill graded sections near tunnel ventilation exhaust points can be extremely dirty especially if the motor traffic is dominated by heavy diesel-hauled vehicles.

Recognizing that this depreciation occurs requires compliance with the stated maintained values of the average luminance of the carriageway and wall linings as set in Sections 3 and 4. It is therefore essential that a realistic maintenance regime be determined in conjunction with the client (usually the applicable road controlling authority) as part of the lighting design and applied throughout the life of the installation so that the installation continues to comply with this Standard for the full duration of each maintenance period.

Lighting maintenance procedures specific to tunnels are set out in Appendix F.

2.9.2 Maintenance factor

The maintenance factor, used in the calculation of the specified maintained values of luminance, will be the product of several sub factors; the luminaire maintenance factor, the lamp lumen maintenance factor and, where the contribution of the wall lining is involved, the wall lining reflectance maintenance factor.

2.10 BASIS OF COMPLIANCE

2.10.1 Compliance of the design

At the design stage, the design of the lighting scheme shall be deemed to comply with this Standard if, when created in accordance with the relevant procedures of Section 3 or Section 4, it satisfies the values of the relevant LTPs when considered together with the included maintenance scheme and the documentation listed in Appendix J.

2.10.2 Compliance of the installation

After installation of a lighting design complying with Section 3 or Section 4, the installation shall be deemed to comply or continue to comply with this Standard if—

- (a) at the commissioning stage, following the commissioning testing procedures described in Appendix K, the measured values satisfy the relevant initial LTPs;
- (b) the installation accurately implements the final design documentation (i.e. ‘as built’ verification);
- (c) the final design documentation includes any changes to the original design made or agreed to by the designer in response to circumstances arising during installation and these changes do not cause non-compliance of the design with the requirements of Sections 3 and 4;
- (d) either the maintenance regime specified in Appendix F is carried out or alternative maintenance regime is implemented that can be demonstrated to provide a maintenance factor equal to or better than the design value; and
- (e) reference measurements on the carriageway and walls are conducted to validate that the maintenance regime ensures compliance, and to base modification if required, as described in Item (g) of Paragraph F5, Appendix F.

NOTE: If measurements are required for the purposes of commissioning, the lighting scheme should be in accordance with Appendix K.

2.11 DETERMINATION OF STOPPING SIGHT DISTANCE (SSD)

The SSDs involved in the design of lighting schemes shall be as advised by the client (usually the applicable road controlling authority) but in no case be less than that in Table 2.2.