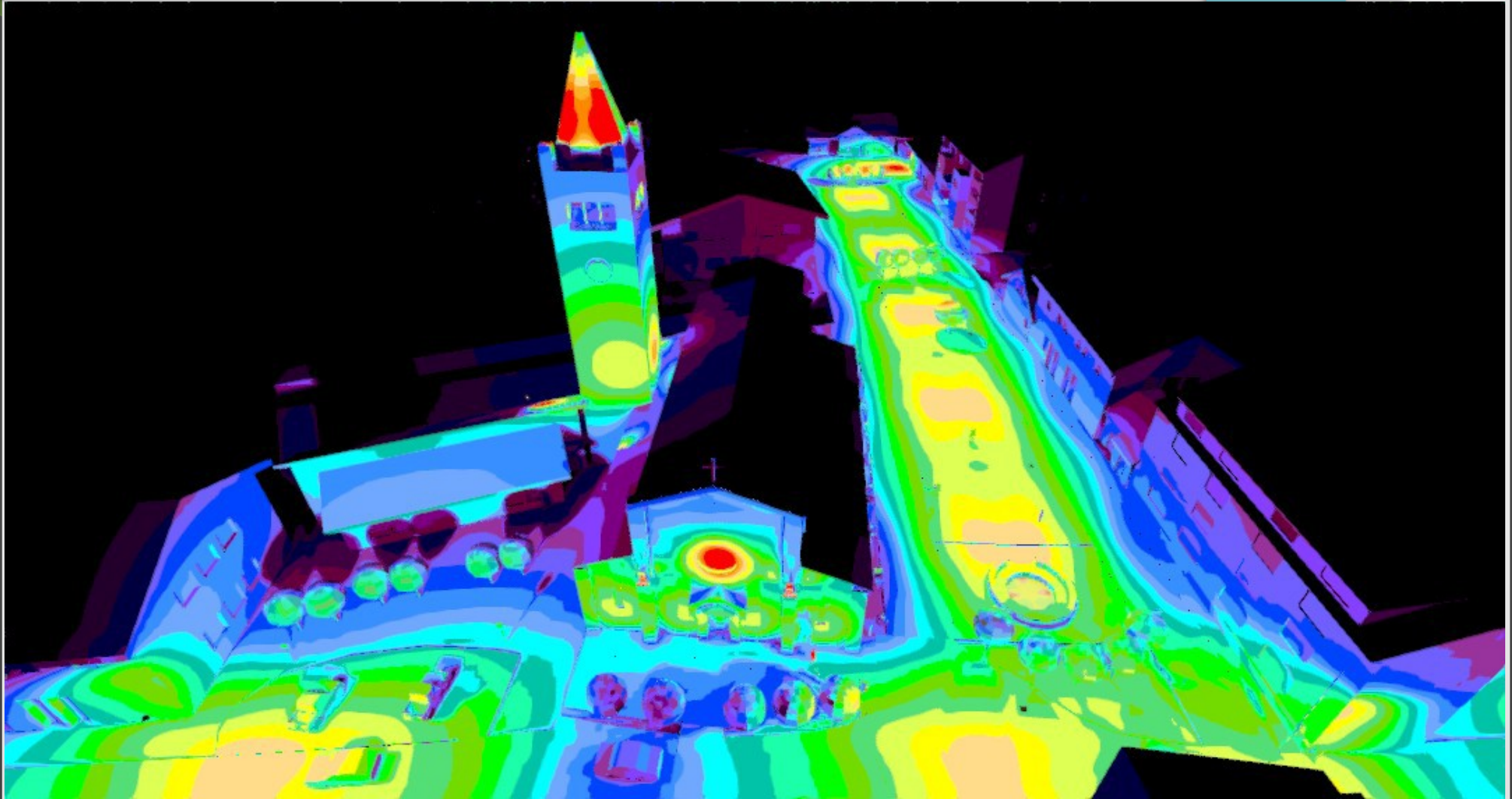


# Curso de Iluminación LED – Clase 7, Diseño y proyecto Facultad de Ingeniería - Universidad de la República



# Requisitos de diseño

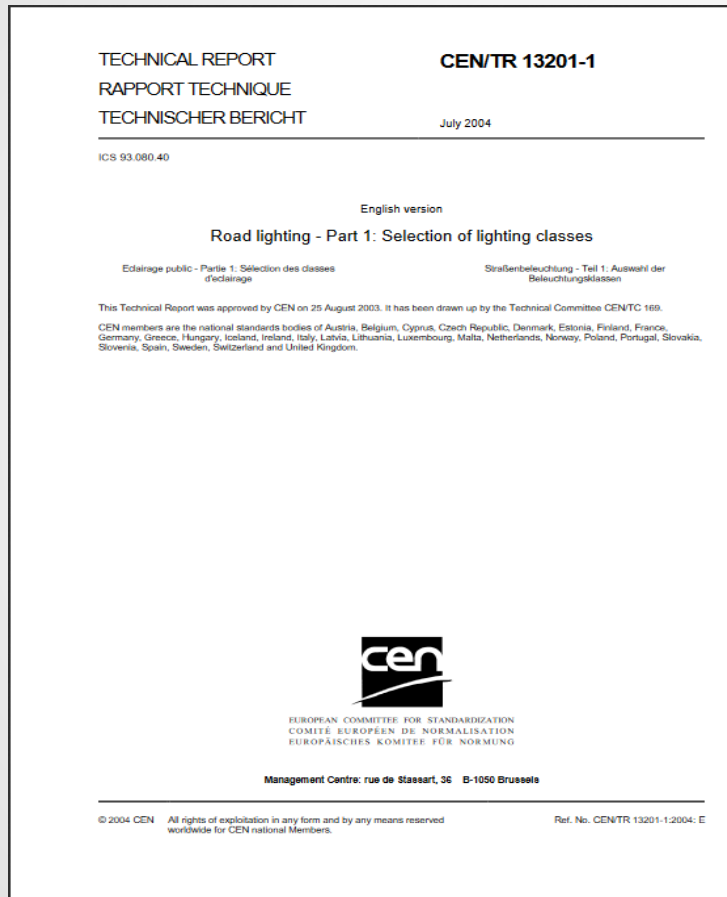


- Un proyecto lumínico debe contemplar:
- Requisitos lumínicos
- Requisitos de eficiencia
- Aspectos Tecnológicos y exigencias de servicio
- Requisitos económicos
- Requisitos estéticos



# Requisitos lumínicos

- La normativa de referencia para los proyectos de iluminación vial es la familia de normas EN-13201.
- Esta normativa establece una clasificación para los diferentes escenarios, los requisitos lumínicos del proyecto para cada uno y los métodos de medición.



# Clasificación de escenarios

Typical speed of main user km/h	User types in the same relevant area			Sets of lighting situations
	Main user	Other allowed user	Excluded user	
> 60	Motorised traffic		Slow moving vehicles Cyclists Pedestrians	A1
		Slow moving vehicles	Cyclists Pedestrians	A2
		Slow moving vehicles Cyclists Pedestrians		A3
> 30 and ≤ 60	Motorised traffic Slow moving vehicles	Cyclists Pedestrians		B1
	Motorised traffic Slow moving vehicles Cyclists	Pedestrians		B2
	Cyclists	Pedestrians	Motorised traffic Slow moving vehicles	C1
> 5 and ≤ 30	Motorised traffic Pedestrian		Slow moving vehicles Cyclists	D1
		Slow moving vehicles Cyclists		D2
	Motorised traffic Cyclists	Slow moving vehicles Pedestrians		D3
	Motorised traffic Slow moving vehicles			D4
Walking speed	Cyclists Pedestrians			
	Pedestrians		Motorised traffic Slow moving vehicles Cyclists	E1
		Motorised traffic Slow moving vehicles Cyclists		E2

- La parte 1 de esta norma establece en su tabla 1 una clasificación de las situaciones según la velocidad del usuario principal
- Luego los subdivide según los demás usuarios
- Los casos típicos de trabajo vial son los A y B y para aceras los E



# Clasificación de escenarios viales

Typical speed of main user km/h	User types in the same relevant area			Sets of lighting situations
	Main user	Other allowed user	Excluded user	
> 60	Motorised traffic		Slow moving vehicles Cyclists Pedestrians	A1
		Slow moving vehicles	Cyclists Pedestrians	A2
		Slow moving vehicles Cyclists Pedestrians		A3
> 30 and ≤ 60	Motorised traffic Slow moving vehicles	Cyclists Pedestrians		B1
	Motorised traffic Slow moving vehicles Cyclists	Pedestrians		B2
	Cyclists	Pedestrians	Motorised traffic	C1
> 5 and ≤ 30			Slow moving vehicles	



# Equivalencia de situaciones

- La tabla 3 de la EN 13201-1, muestra la equivalencia de las diferentes situaciones de iluminación anteriormente seleccionadas.
- Observando la tabla se puede concluir que las clases ME y CE coinciden
- Destaca además que las situaciones adyacentes no deben diferir entre si en más de dos clases. Por ejemplo si una avenida es CE 1, la calle secundaria que la cruza debe ser al menos CE3.

	ME 1	ME 2	ME 3	ME 4	ME 5	ME 6		
	MEW 1	MEW 2	MEW 3	MEW 4	MEW 5			
CE 0	CE 1	CE 2	CE 3	CE 4	CE 5			
			S 1	S 2	S 3	S 4	S 5	S 6

<sup>1)</sup> For ME / MEW classes: CIE road surface reflectance of CIE publication 66:1984, Table C.2.



# Clasificación de las situaciones - A1

## A.1 Lighting situations — set A1

Table A.1 — Recommended range of lighting classes

Main weather type	Separation of carriageways	Type of junctions		Traffic flow vehicles per day								
		Interchanges spacing, distance between bridges km	Intersections density intersections/km	< 15 000			15 000 to 25 000			> 25 000		
				←	o	→	←	o	→	←	o	→
Dry	Yes	> 3		ME5	ME4a	ME3a	ME4a	ME3a	ME2	ME4a	ME3a	ME2
		≤ 3		ME4a	ME3a	ME2	ME4a	ME3a	ME2	ME3a	ME2	ME1
			< 3	ME5	ME4a	ME3a	ME5	ME4a	ME3a	ME4a	ME3a	ME2
			≥ 3	ME4a	ME4a	ME3a	ME4a	ME3a	ME2	ME3a	ME2	ME1
	No	> 3		ME4a	ME3a	ME2	ME3a	ME2	ME1	ME3a	ME2	ME1
		≤ 3		ME3a	ME2	ME1	ME3a	ME2	ME1	ME2	ME2	ME1
			< 3	ME4a	ME4a	ME3a	ME4a	ME3a	ME2	ME3a	ME2	ME1
			≥ 3	ME4a	ME3a	ME2	ME3a	ME2	ME1	ME2	ME2	ME1
Wet			Choice as above, but select MEW classes									



# Clasificación de las situaciones – A1

- Finalmente según demás parámetros, indica como aumentar o disminuir la clasificación previamente seleccionada.
- La situación A1 implica un mínimo de velocidad.

Table A.2 — Recommended selection from range

Conflict area	Complexity of visual field	Difficulty of navigational task	Ambient luminance		
			low	medium	high
No	Normal	Normal	←	←	○
		Higher than normal	○	○	→
	High	Normal	←	○	○
		Higher than normal	○	→	→
Yes			→ <sup>a</sup>		

<sup>a</sup> For conflict areas, luminance is the recommended design criterion. However, where viewing distances are short and other factors prevent the use of luminance criteria, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.





# Clasificación de las situaciones – A2

## A.2 Lighting situations — set A2

Table A.3 — Recommended range of lighting classes

Main weather type	Intersection density Intersections/km	Traffic flow vehicles					
		< 7 000			≥ 7 000		
		←	0	→	←	0	→
Dry	< 3	ME5	ME5	ME4a	ME4a	ME3a	ME3a
	≥ 3	ME5	ME4a	ME3a	ME4a	ME3a	ME2
Wet		Choice as above, but select MEW classes.					

Table A.4 — Recommended selection from range

Conflict area	Complexity of visual field	Difficulty of navigational task	Ambient luminance		
			Low	Medium	High
No	Normal	Normal	←	←	0
		Higher than normal	0	0	→
	High	Normal	←	0	0
		Higher than normal	0	→	→
Yes			→ <sup>a</sup>		

<sup>a</sup> For conflict areas, luminance is the recommended design criterion. However, where viewing distances are short and other factors prevent the use of luminance criteria, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.



# Clasificación de las situaciones – A3

## A.3 Lighting situations — set A3

Table A.5 — Recommended range of lighting classes

Main weather type	Separation of carriageways	Intersection density Intersections/km	Traffic flow vehicles											
			< 7 000			≥ 7 000 and < 15 000			≥ 15 000 and < 25 000			≥ 25 000		
			←	0	→	←	0	→	←	0	→	←	0	→
Dry	Yes	< 3	ME5	ME5	ME4a	ME5	ME5	ME4a	ME5	ME4a	ME3b	ME4a	ME3b	ME3b
		≥ 3	ME5	ME4a	ME3b	ME5	ME4a	ME3b	ME4a	ME3b	ME2	ME3b	ME2	ME2
	No	< 3	ME5	ME4a	ME3b	ME5	ME4a	ME3b	ME4a	ME3b	ME2	ME3b	ME2	ME2
		≥ 3	ME4a	ME3b	ME3b	ME4a	ME3b	ME 2	ME3b	ME2	ME2	ME3b	ME2	ME1
Wet			Choice as above, but select MEW classes											

Conflict area	Complexity of visual field	Parked vehicles	Difficulty of navigational task	Ambient luminance		
				Low	Medium	High
No	Normal	Not present	Normal	←	←	0
			Higher than normal	0	0	→
		Present	Normal	←	0	→
			Higher than normal	0	→	→
	High	Not present	Normal	←	0	0
			Higher than normal	0	→	→
		Present	Normal	0	0	→
			Higher than normal	→	→	→
Yes				→ <sup>a</sup>		

<sup>a</sup> For conflict areas, luminance is the recommended design criterion. However, where viewing distances are short and other factors prevent the use of luminance criteria, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.



# Clasificación de las situaciones – B1

## A.4 Lighting situations — set B1

Table A.7 — Recommended range of lighting classes

Main weather type	Geometric measures for traffic calming	Intersection density Intersections/km	Difficulty of navigational task	Traffic flow vehicles					
				< 7 000			≥ 7 000		
				←	o	→	←	o	→
Dry	No	< 3	Normal	ME6	ME5	ME4b	ME5	ME4b	ME3c
			Higher than normal	ME5	ME4b	ME3c	ME5	ME4b	ME3c
		≥ 3	Normal	ME5	ME4b	ME3c	ME4b	ME4b	ME3c
			Higher than normal	ME4b	ME3c	ME2	ME3c	ME3c	ME2
	Yes	Choice as above, but select –1 only at area of traffic calming <sup>a</sup>							
Wet	Choice as above but select MEW classes								

<sup>a</sup> When the use of luminance criteria is impractical, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.

Table A.8 — Recommended selection from range

Conflict area	Complexity of visual field	Parked vehicles	Ambient luminance					
			Low		Medium		High	
			Traffic flow cyclists		Traffic flow cyclists		Traffic flow cyclists	
			Normal	High	Normal	High	Normal	High
No	Normal	Not present	←	o	←	o	o	o
		Present	o	→	o	→	→	→
	High	Not present	o	o	o	o	o	o
		Present	o	o	→	→	→	→
Yes	→ <sup>a</sup>							

<sup>a</sup> For conflict areas, luminance is the recommended design criterion. However, where viewing distances are short and other factors prevent the use of luminance criteria, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.



# Clasificación de las situaciones – B2

## A.5 Lighting situations — set B2

Table A.9 — Recommended range of lighting classes

Main weather type	Geometric measures for traffic calming	Intersection density Intersections/km	Difficulty of navigational task	Traffic flow vehicles					
				< 7 000			≥ 7 000		
				←	o	→	←	o	→
Dry	No	< 3	Normal	ME5	ME5	ME4b	ME4b	ME4b	ME3c
			Higher than normal	ME4b	ME4b	ME3c	ME4b	ME4b	ME3c
		≥ 3	Normal	ME4b	ME3c	ME2	ME3c	ME3c	ME2
			Higher than normal	ME3c	ME3c	ME2	ME3c	ME3c	ME2
Yes	Choice as above, but select -1 only at area of traffic calming <sup>a</sup>								
Wet	Choice as above but select MEW classes								

<sup>a</sup> When the use of luminance criteria is impractical, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.

Table A.10 — Recommended selection from range

Conflict area	Complexity of visual field	Parked vehicles	Ambient luminance					
			Low		Medium		High	
			Traffic flow cyclists		Traffic flow cyclists		Traffic flow cyclists	
			Normal	High	Normal	High	Normal	High
No	Normal	Not present	←	o	←	o	o	o
		Present	o	→	o	→	→	→
	High	Not present	o	o	o	o	o	o
		Present	o	o	→	→	→	→
Yes	→ <sup>a</sup>							

<sup>a</sup> For conflict areas, luminance is the recommended design criterion. However, where viewing distances are short and other factors prevent the use of luminance criteria, illuminance may be used. Comparable CE classes to recommended ME classes can be found in Table 3.



# Clasificación de las situaciones – C1

## A.6 Lighting situations — set C1

Table A.11 — Recommended lighting classes

Geometric measures for traffic calming	Crime risk	Facial recognition	Traffic flow cyclists					
			Normal			High		
			←	0	→	←	0	→
No	Normal	Unnecessary	S6	S5	S4	S5	S4	S3
		Necessary	S5	S4	S3	S4	S3	S2
	Higher than normal	S4	S3	S2	S3	S2	S1	
Yes			S3	S2	S1	S3	S2	S1

Alternative A classes of comparable lighting level to recommended S classes can be found in Table 4. Additional ES and EV classes to recommended S classes can be found in Table 5.

Table A.12 Recommended selection from range

Ambient luminance		
Low	Medium	High
←	0	→



# Clasificación de las situaciones – E1

## A.9 Lighting situations — set E1

Table A.17 — Recommended lighting classes

Crime risk	Facial recognition	Traffic flow pedestrians					
		Normal			High		
		←	0	→	←	0	→
Normal	Unnecessary	S6	S5	S4 <sup>a</sup>	S5	S4	S3 <sup>a</sup>
	Necessary	S5	S4	S3 <sup>b</sup>	S4	S3	S2 <sup>b</sup>
Higher than normal		S3	S2	S1 <sup>b</sup>	S2	S1	CE2 <sup>b</sup>

<sup>a</sup> Alternative A classes of comparable lighting level to recommended S classes can be found in Table 4.

<sup>b</sup> Additional ES and EV classes to recommended S and CE classes can be found in Table 5.

Table A.18 — Recommended selection from range

Ambient luminance		
Low	Medium	High
←	0	→



# Clasificación de las situaciones – E1

## A.10 Lighting situations — set E2

Table A.19 — Recommended lighting classes

Crime risk	Facial recognition	Traffic flow pedestrians					
		Normal			High		
		←	0	→	←	0	→
Normal	Unnecessary	S5	S4	S3 <sup>a</sup>	S4	S3	S2 <sup>a</sup>
	Necessary	S3	S2	S1 <sup>b</sup>	S3	S2	S1 <sup>b</sup>
Higher than normal		S2	S1	CE2 <sup>b</sup>	S2	S1	CE2 <sup>b</sup>

<sup>a</sup> Alternative A classes of comparable lighting level to recommended S classes can be found in Table 4.

<sup>b</sup> Additional ES and EV classes to recommended S and CE classes can be found in Table 5.

Table A.20 — Recommended selection from range

Ambient luminance		
Low	Medium	High
←	0	→



# Requisitos por clase

Table 1a — ME-series of lighting classes

Class	Luminance of the road surface of the carriageway for the dry road surface condition			Disability glare	Lighting of surroundings
	$\bar{L}$ in $\text{cd/m}^2$ [minimum maintained]	$U_0$ [minimum]	$U_1$ [minimum]	$Tl$ in % <sup>a</sup> [maximum]	$SR^{2b}$ [minimum]
ME1	2,0	0,4	0,7	10	0,5
ME2	1,5	0,4	0,7	10	0,5
ME3a	1,0	0,4	0,7	15	0,5
ME3b	1,0	0,4	0,6	15	0,5
ME3c	1,0	0,4	0,5	15	0,5
ME4a	0,75	0,4	0,6	15	0,5
ME4b	0,75	0,4	0,5	15	0,5
ME5	0,5	0,35	0,4	15	0,5
ME6	0,3	0,35	0,4	15	no requirement

<sup>a</sup> An increase of 5 percentage points in  $Tl$  can be permitted where low luminance light sources are used. (see note 6)

<sup>b</sup> This criterion can be applied only where there are no traffic areas with their own requirements adjacent to the carriageway.





# Requisitos de las clases ME y MEW

Table 1a — ME-series of lighting classes

Class	Luminance of the road surface of the carriageway for the dry road surface condition		
	$\bar{L}$ in $\text{cd/m}^2$ [minimum maintained]	$U_0$ [minimum]	$U_1$ [minimum]
ME1	2,0	0,4	0,7
ME2	1,5	0,4	0,7
ME3a	1,0	0,4	0,7
ME3b	1,0	0,4	0,6
ME3c	1,0	0,4	0,5
ME4a	0,75	0,4	0,6
ME4b	0,75	0,4	0,5
ME5	0,5	0,35	0,4
ME6	0,3	0,35	0,4

<sup>a</sup> An increase of 5 percentage points in  $T_l$  can be permitted where low luminance

<sup>b</sup> This criterion can be applied only where there are no traffic areas with their own carriageway.

- Las clases ME y MEW (wet/mojado) presentan requisitos de luminancia  $L$  y uniformidad en luminancia  $U_L$
- Los valores de luminancia son dependientes de la posición del observador, la dirección de observación y de la superficie emisora o pavimento en este caso



# Requisitos de las clases ME y MEW

Table 1a — ME-series of lighting classes

Class	Luminance of the road surface of the carriageway for the dry road surface condition		
	$\bar{L}$ in $\text{cd/m}^2$ [minimum maintained]	$U_0$ [minimum]	$U_1$ [minimum]
ME1	2,0	0,4	0,7
ME2	1,5	0,4	0,7
ME3a	1,0	0,4	0,7
ME3b	1,0	0,4	0,6
ME3c	1,0	0,4	0,5
ME4a	0,75	0,4	0,6
ME4b	0,75	0,4	0,5
ME5	0,5	0,35	0,4
ME6	0,3	0,35	0,4

<sup>a</sup> An increase of 5 percentage points in  $T_l$  can be permitted where low luminance

<sup>b</sup> This criterion can be applied only where there are no traffic areas with their own carriageway.

- Debido a esto, sumado a que los instrumentos para medir luminancia (L) tienen costos del orden de 10 veces mayor a instrumentos que miden iluminancia (E)
- Se recomienda trabajar con su clase CE equivalente según la tabla 3 de la EN13201-1



# Requisitos de las clases CE

Table 2 — CE-series of lighting classes

Class	Horizontal illuminance	
	$\bar{E}$ in lx [minimum maintained]	$U_o$ [minimum]
CE0	50	0,4
CE1	30	0,4
CE2	20	0,4
CE3	15	0,4
CE4	10	0,4
CE5	7,5	0,4

Si bien la clase CE no indica requerimientos de TI (deslumbramiento), Indica que cuando es aplicable se pueden tomar los requerimientos de TI de la tabla anterior para la clase ME equivalente.



# Requisitos de las clases S

Table 3 — S-series of lighting classes

Class	Horizontal illuminance	
	$\bar{E}$ in lx <sup>a</sup> [minimum maintained]	$E_{min}$ in lx [maintained]
S1	15	5
S2	10	3
S3	7,5	1,5
S4	5	1
S5	3	0,6
S6	2	0,6
S7	performance not determined	performance not determined

<sup>a</sup> To provide for uniformity, the actual value of the maintained average illuminance may not exceed 1,5 times the minimum  $\bar{E}$  value indicated for the class.



# Resumiendo requerimientos viales

- Para una calle interna, transitada a 45 km/h
- Transitada por automóviles, ciclomotores y bicicletas
- Se tiene una situación **B2**
- Considerándola mayormente seca, recta y con al menos 9 intersecciones por km y con un tráfico diario de 5000 vehiculos.
- Se obtiene una clasificación **M3c** equivalente a la **CE3**
- Esta tiene requerimientos de:
  - $E_m = 15 \text{ lx}$
  - $U_o = 0,4$
  - $TI < 15$



# Resumiendo requerimientos viales

- Para sus aceras
- **No** transitadas por automóviles, ciclomotores y bicicletas
- Se tiene una situación **E1**
- Considerándola de delincuencia normal, con necesidad de reconocimiento facial y tráfico normal de personas
- Se obtiene una clasificación **S2**, esta difiera de la clase adyacente CE3 en una clase, por lo cual se considera correcto.
- Esta tiene requerimientos de:
  - $E_m = 10 \text{ lx}$
  - $E_{min} = 3 \text{ lx}$



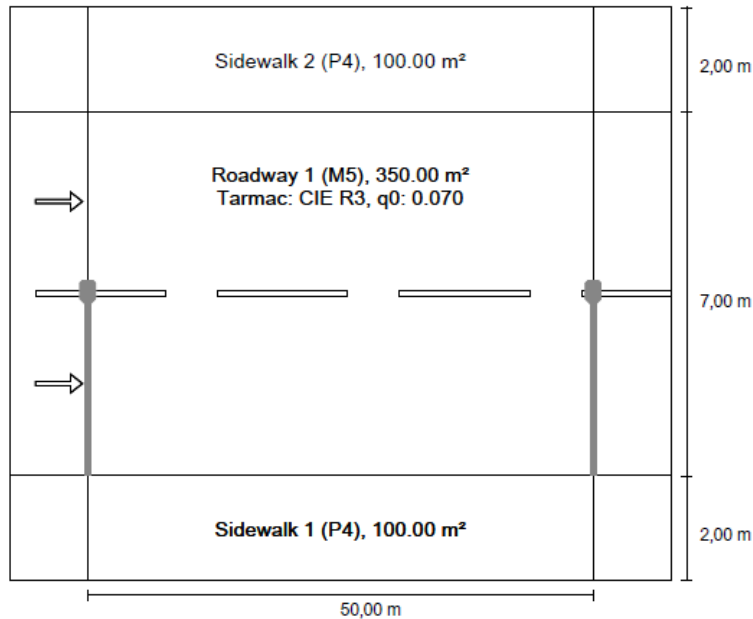
# Diseño en DIALux

Grezzana square: Multitasking Lighting Design 09/09/2017



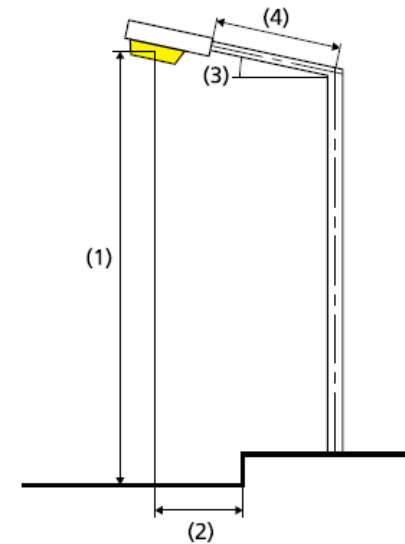
Street 1: Alternative 1 / Planning results

Street 1 according to EN 13201:2015



Results for valuation fields  
Light loss factor: 0.67

Disano Illuminazione 1784 Astro LED centre road  
Disano 1784 12 led CLD CELL graphite



Lamp:	1xLux_mv_1784_12
Luminous flux (luminaire):	10406.88 lm
Luminous flux (lamp):	10407.00 lm



# Requisitos de servicio

- Se deben poder construir los elementos previstos de la instalación e instalar. Por ejemplo cuidando no modificar ningún monumento.
- El mantenimiento debe garantizar la continuidad de las prestaciones del servicio. Por ejemplo la altura de los puntos de luz puede dificultar las tareas de mantenimiento
- Se debe prever un plan de gestión de los residuos generados tanto en el caso de la desinstalación como al final de la vida útil de la instalación
- Se debe sobre todo garantizar la seguridad de los usuarios



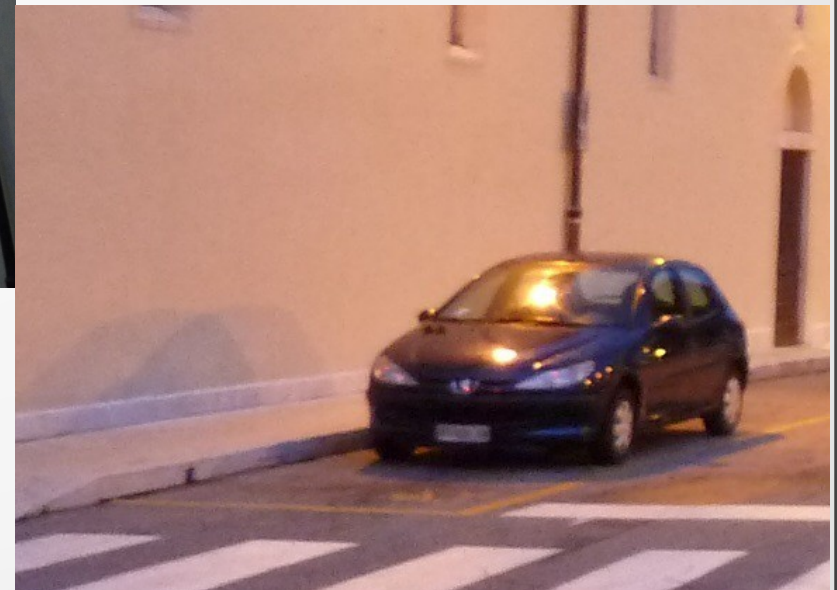


# Requisitos económicos

- El coste de un proyecto de alumbrado está basado en 3 costos
  - Costo de instalación
  - Costo de mantenimiento
  - Consumo energético de la instalación necesaria para su funcionamiento



# Requisitos estéticos



¿Preguntas?

# Muchas Gracias

