In-field measurement of cylindrical illuminance and the impact of room surface reflectances on the visual environment

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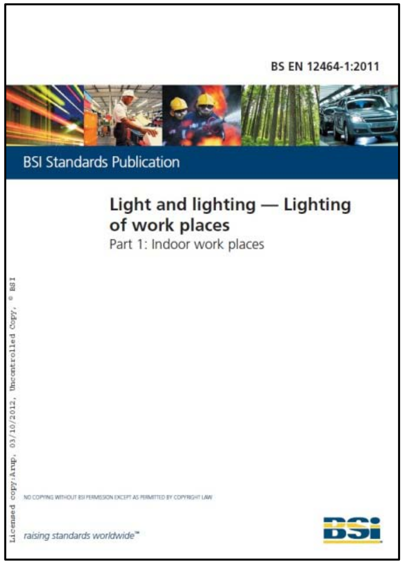
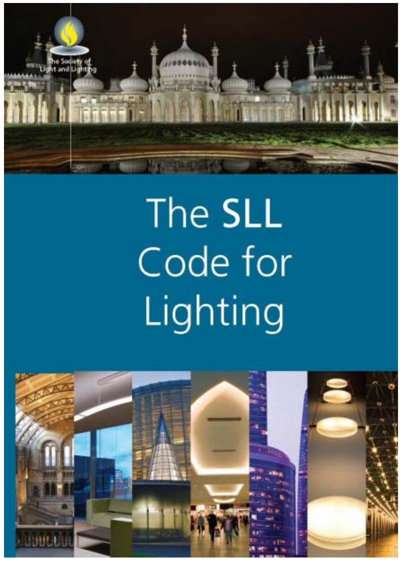
Background

- Changes to European (CEN) lighting standards
- Revision of EN 12464-1. Light and Lighting – Lighting of work places. Part 1: Indoor work places

- The impacts for illumination engineers?





Introduction & contents

1. Changes in the revised Society of Light and Lighting's Code for Lighting

2. Measuring cylindrical illuminance

3. Demonstration of the effect of increased room surface reflectances

1.1 Increased room surface reflectances

[2][3]

	2009 SLL Code (%)	2012 SLL Code (%)
Ceiling	60 – 90	70 – 90
Walls	30 – 80	50 – 80
Working Plane	20 – 60	Not specified
Floor	10 – 50	20 – 40

Usually a parameter that is outside the control of the designer/engineer, but…..

1.2 Requirement for minimum illuminance on room surfaces

[2][3]

Illuminance in enclosed spaces	
Walls	$E_m > 50$ lux with $U_o \geq 0.10$
Ceiling	$E_m > 30$ lux with $U_o \geq 0.10$

Illuminance in enclosed spaces where visual communication is important	
Walls	$E_m > 75$ lux with $U_o \geq 0.10$
Ceiling	$E_m > 50$ lux with $U_o \geq 0.10$

[2][3][5][7]

In 2009 Code, LG5 and LG7:

Ceiling 0.3 – 0.9

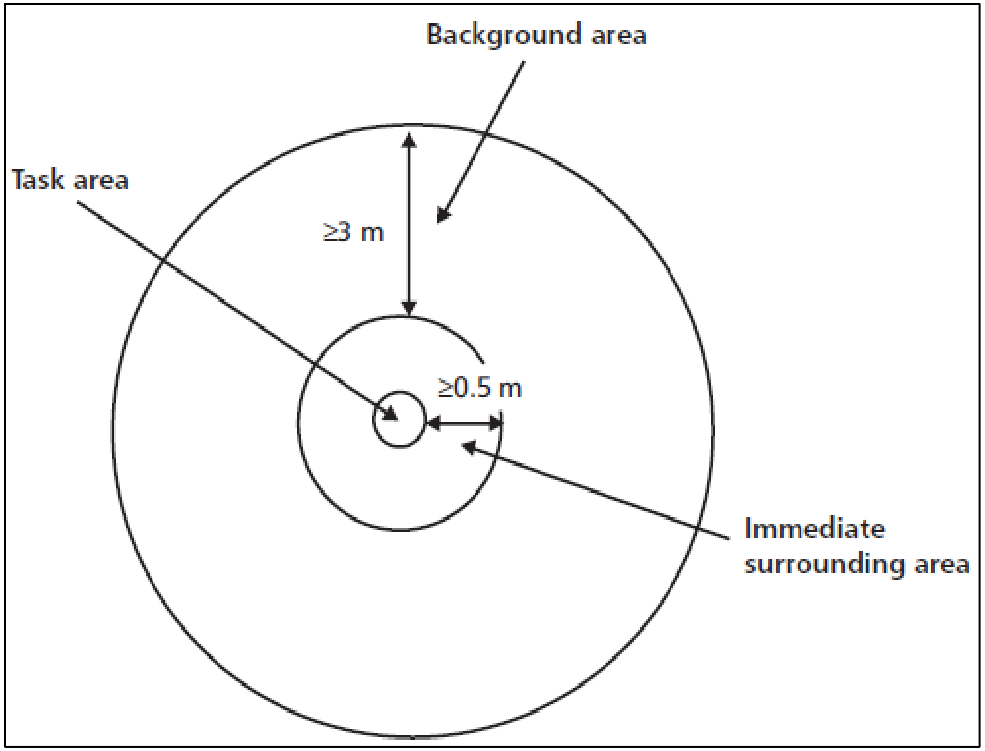
Walls 0.5 – 0.6

1.3 Task area, immediate surrounding area and background area

[3]

- No longer a reference to a working plane
- Instead, schedules of illuminance are given for the *task* area
- Illuminance in the *immediate surrounding* area and the *background* area are then derived from this

[3]



1.3 Task area, immediate surrounding area and background area

[2][3]

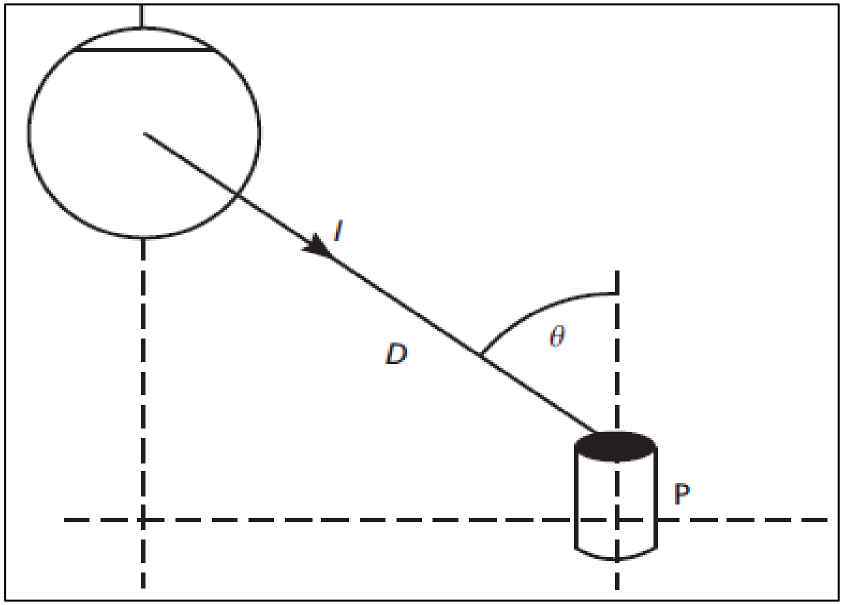
Ratio between illuminance on the task area, the illuminance in the immediate surround area and the background area		
Task area	Immediate surrounding area	Background area
>750	500	33% of the immediate surrounding area
500	300	
300	200	
200	E_{task}	
150	E_{task}	
100	E_{task}	
>50	E_{task}	

1.4 Cylindrical illuminance

[2][3]

- The luminous flux falling on the curved surface of a very small cylinder, divided by the curved surface area of the cylinder
- Required to highlight objects, reveal texture and improve the appearance of people within spaces

[3]



[2][3]

Standard areas	Areas where visual communication is very important
> 50 lux with $U_o \geq 0.10$	> 150 lux with $U_o \geq 0.10$

1.5 Modelling

[2][3]

- Modelling is the balance between direct light and diffuse light
- Modelling index provides an indicator of good modelling and is defined as the ratio of cylindrical illuminance to horizontal illuminance at a point
- Recommended to be between 0.3 – 0.6

[2]

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Possible impacts and opportunities for illumination engineers?

- Dealing with a new metric – cylindrical illuminance?

- Significant benefits from increased room surface reflectances?

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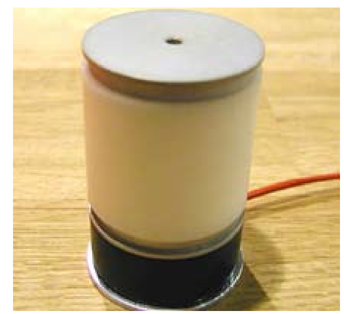
2. Measuring cylindrical illuminance

- A new challenge for illumination engineers?
- Dedicated meters are available, but costly



[9][10][19]

- An alternative method exists, but is yet to be validated - Engineers must understand illumination vectors and cubic illumination

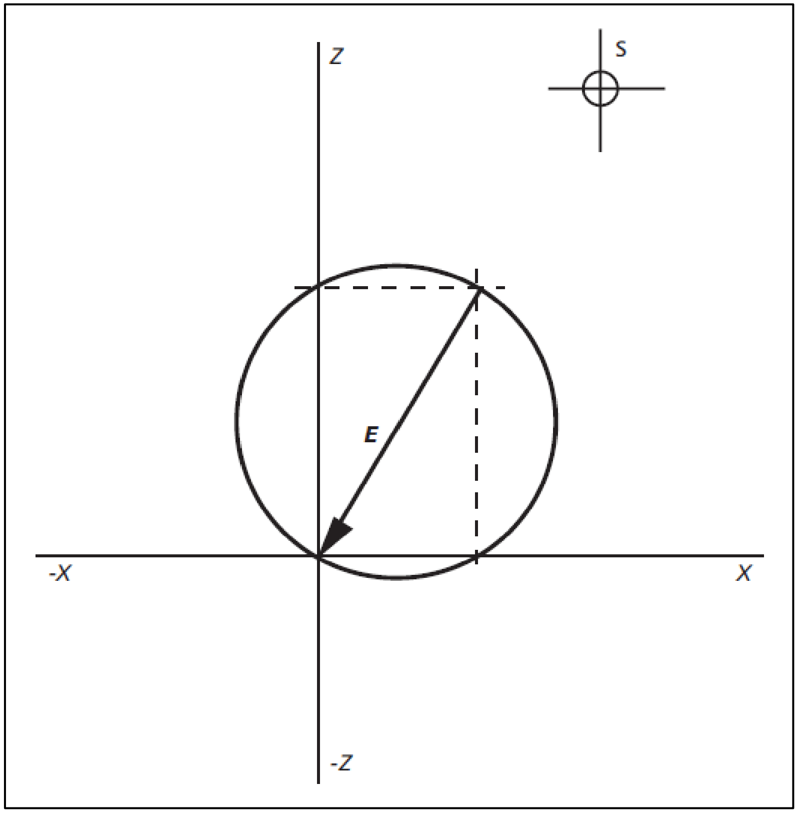
2.1 Illumination vectors

[10][19]

- Distance from the origin of the axes and the circle is the relative illumination falling on a plane, normal to the line joining the origin to the circle

- As a vector is the sum of more than one component, it is possible to analyse vectors into a series of components

[2]

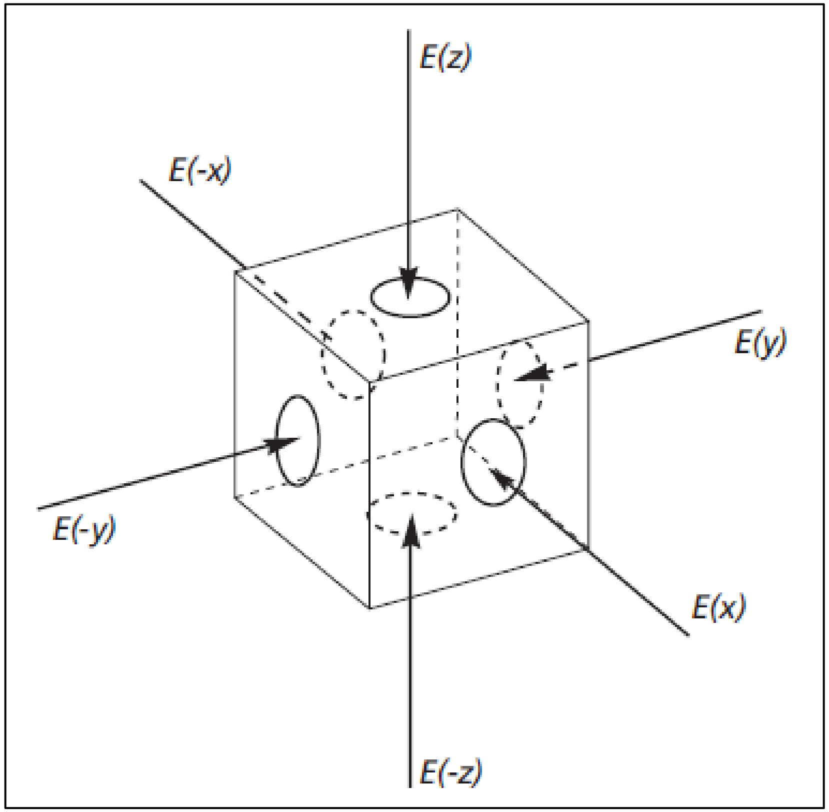


2.2 Cubic illuminance

[10][19]

- Illuminances falling on the six faces of an indefinitely small cube
- Using vector and symmetric components, cylindrical illuminance can be calculated

[2]



2.2 Math??

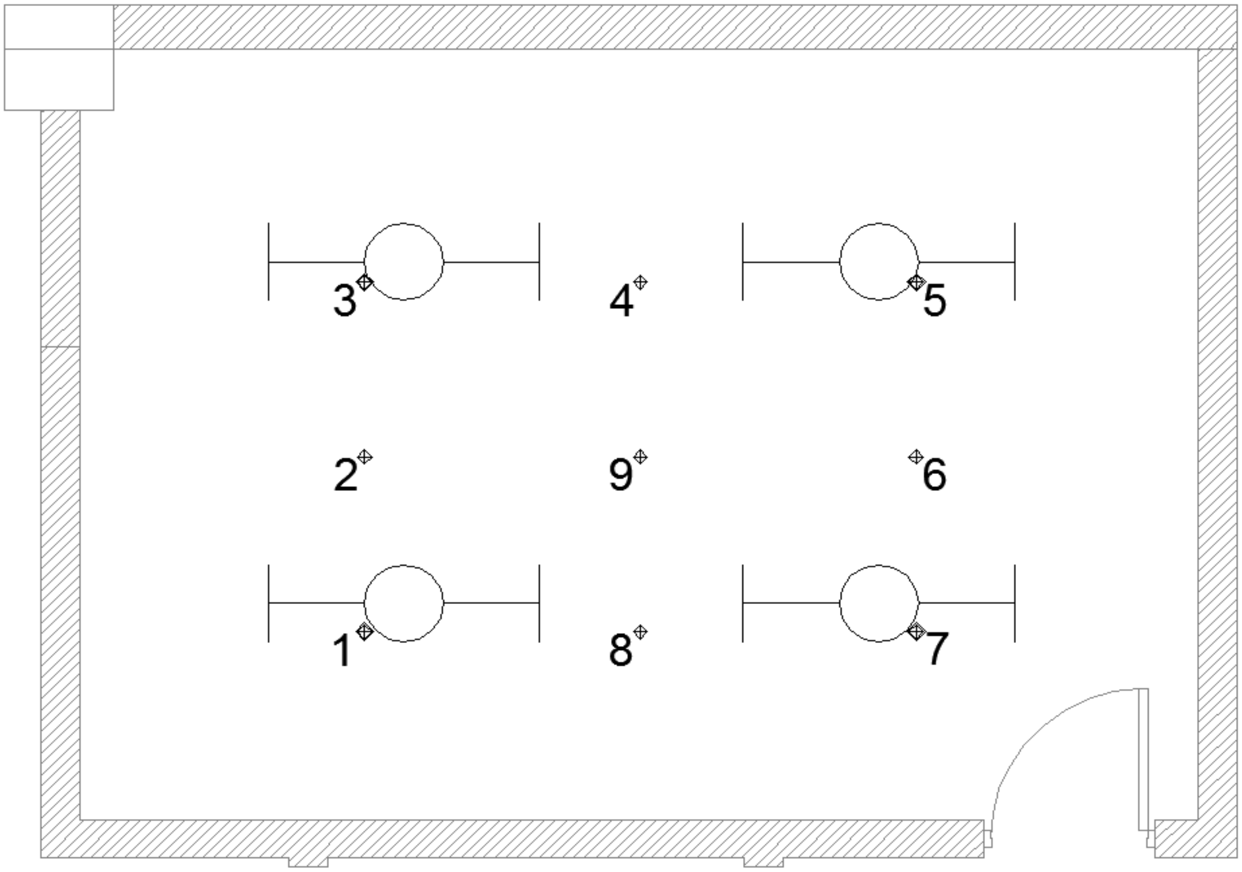
$$E_{(x)}, E_{(y)}, E_{(z)}, E_{(-x)}, E_{(-y)}, E_{(-z)}$$

Some vector algebra and a bunch of other boring stuff

[10][19]

$$E_{cyl} = \frac{|E|e.e_{(x,y)}}{\pi} + \frac{\left(\sim E_{(x)} + \sim E_{(y)}\right)}{2}$$

2.3 Test room & methodology



- 6.1m long, 4.5m wide, 3.2m high
- daylight excluded
- walls are painted concrete
- 4No. surface mounted linear fluorescents w/ T5 lamps

2.3 Test room & methodology

1. Room dimensions were measured
2. Reflectances obtained
3. New lamps
4. LLF in Radiance model set to best match the lumen output of the new lamps
5. Lamp optics, luminaire optics and LOR were verified by manufacturer
6. A grid of nine points was marked out on all room surfaces
7. Small cube was attached to 1.6m wooden pole
8. Cube was always positioned with its sides parallel to major room surfaces
9. Readings taken at designated points

[20]

Room Surface Reflectances (%)	Ceiling	Walls	Floor
	44	31	14

$$L = \frac{\rho E}{\pi}$$

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2.4 Results

Grid Point Number	E_{cyl} In-field	E_{cyl} Simulated
1	53	63
2	77	81
3	59	65
4	75	77
5	59	67
6	77	81
7	52	64
8	72	77
9	84	80
Average	**68**	**73**

2.4 Difficulties and nuances in measurement

- Bespoke, home-made apparatus
- Lengthy time for single point measurements – approx. 15 min/point
- Radiance defaults to 63 grid points – almost two days of measurements?

3. Increased room surface reflectances

- Room surface reflectances were increased through cleaning and painting
- Existing colours were dark yellow/brown and new colours were bright white for ceiling and yellow for walls

Before	Room Surface Reflectances (%)	Ceiling	Walls	Floor
		44	31	14

After	Room Surface Reflectances (%)	Ceiling	Walls	Floor
		81	64	14

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3.1 Results

	Reflectances at 44/31/14	Reflectances at 84/65/14	Percentage increase (%)
Average illuminance on walls (lx)	43	84	**95**
Average luminance from walls (cd/m^2)	8.5	26	**206**
Average horizontal illuminance (lx)	223	276	**24**
Average cylindrical Illuminance (lx)	68	115	**69**
Modelling Index	0.30	0.42	**37**

Conclusions

1. The SLL Code for Lighting has changed and the notation of the working plane is gone

Conclusions

2. Accurate in-field measurement of cylindrical illuminance is possible using the methodology described, but it is tedious and time consuming to implement correctly

Conclusions

3. Increasing room surface reflectances had a significant impact on the visual environment

	Percentage increase (%)
Average illuminance on walls (lx)	**95**
Average luminance from walls (cd/m^2)	**206**
Average horizontal illuminance (lx)	**24**
Average cylindrical Illuminance (lx)	**69**
Modelling Index	**37**

Final note

At a time when advances in technology are much publicised, don't forget the benefits of utilising appropriate design methods

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