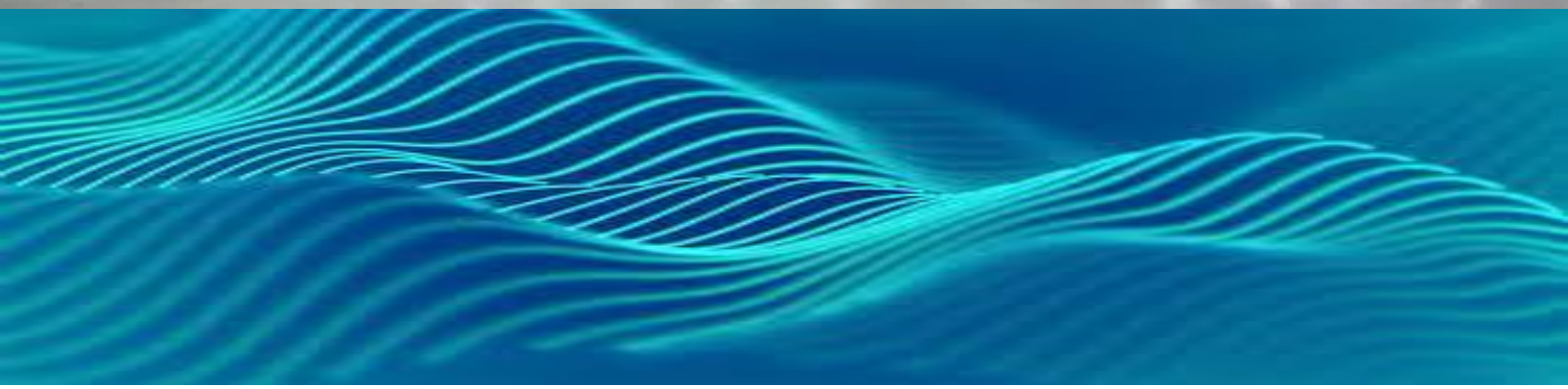




Elliott Lewis 20th April 2021



Lighting Layout and Sound Index Calculation



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Introduction

This report contains two separate elements:

1. Lighting calculations and lighting layout
2. Sound reduction index calculation and discuss the implications of the factors of frequency and wavelength in internal sound management, partition wall construction technique and the insulation material choice.

Element 1 – Lighting Calculations and Lighting Layout

Firstly, demonstrates the calculations and steps needed to work out the RI (room index) of a production area in a factory. Secondly, how the Utilization factor value can be achieved and finally, how to determine the number of lamps required and illustrate this by providing a scaled drawing showing of a suitable layout for the lamps.

Specification and dimensions

- The area in the factory measures 60 meters x 24 metres x 8 metres in height and the work benches are 1 meter above the floor level.
- The areas reflectance's are 0.3 for the ceiling and 0.5 for the floors.
- The lighting design specifies Fluorescent lamps in recessed louvre with DLOR (downward light output ratio) of 50%
- The size of the luminaires is 1200mm in length and 200mm wide
- LDL (lighting design lumen) output of 18,000 lumens illumination required for the factory area is 200 lux at the working plane
- LLF (light loss factor) is 0.75

The RI (Room Index)

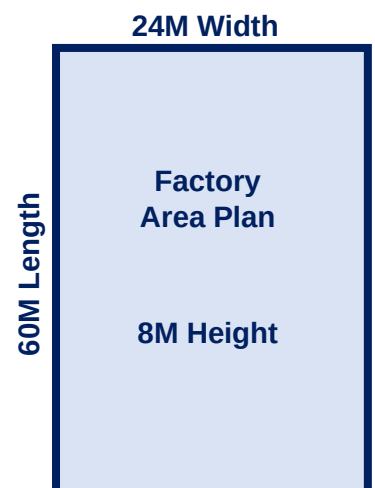
The room index is the number that describes the ratios of the room's length, width, and height.

$$\text{Formula } RI = \frac{(L \times W)}{(H_m (L + W))} =$$

Where L = Length of room

W = Width of the room

H_m = Height of the luminaire

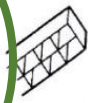


Values	Step 1	Step 2	Step 3
$L = 60M$ $W = 24M$ $Hm = 8 - 1 = 7M$	$RI = \frac{(60 \times 24)}{(7 (60 + 24))}$	$RI = \frac{1440}{7 \times 84}$	$RI = \frac{1440}{588}$
$RI = 2.4489795918367....$ $RI = \mathbf{2.45}$ (2 decimal places)			

Utilisation Factor

The Utilisation factor is the ratio of total flux reaching the working plane compared to the total flux output of the lamps. The utilisation factor brings together the reflectance of both walls and ceilings, the room index and type of luminaire into one single value.

Utilisation Factor Table

Description of fitting	Typical outline LOR	Basic downward LOR%	Ceiling	0.7			Reflectances 0.5			0.3		
			Walls	0.5	0.3	0.1	0.5	0.3	0.1	0.5	0.3	0.1
			Room index									
Aluminium industrial reflector, aluminium or enamel high-bay reflector		70	0.6	0.39	0.36	0.33	0.39	0.36	0.33	0.39	0.35	0.33
			0.8	0.48	0.43	0.40	0.46	0.43	0.40	0.46	0.43	0.40
			1.0	0.52	0.46	0.45	0.52	0.48	0.45	0.52	0.48	0.45
			1.25	0.56	0.52	0.50	0.56	0.53	0.49	0.56	0.52	0.42
			1.5	0.60	0.57	0.54	0.59	0.57	0.53	0.59	0.57	0.53
			2.0	0.65	0.62	0.59	0.63	0.60	0.58	0.63	0.59	0.57
			2.5	0.67	0.64	0.62	0.65	0.62	0.61	0.65	0.62	0.60
			3.0	0.69	0.66	0.64	0.67	0.64	0.63	0.67	0.64	0.62
			4.0	0.71	0.68	0.67	0.69	0.67	0.65	0.69	0.66	0.64
			5.0	0.72	0.70	0.69	0.71	0.69	0.67	0.71	0.67	0.66
Near-spherical diffuser, open beneath		50	0.6	0.28	0.22	0.18	0.25	0.20	0.17	0.22	0.18	0.16
			0.8	0.39	0.30	0.26	0.33	0.28	0.23	0.27	0.25	0.22
			1.0	0.43	0.36	0.32	0.38	0.34	0.29	0.31	0.29	0.26
			1.25	0.48	0.41	0.37	0.42	0.38	0.33	0.34	0.32	0.29
			1.5	0.52	0.46	0.41	0.46	0.41	0.37	0.37	0.35	0.32
			2.0	0.58	0.52	0.47	0.50	0.48	0.43	0.42	0.39	0.36
			2.5	0.62	0.56	0.52	0.54	0.50	0.47	0.45	0.42	0.40
			3.0	0.65	0.60	0.56	0.57	0.53	0.50	0.48	0.45	0.43
			4.0	0.68	0.64	0.61	0.60	0.56	0.54	0.51	0.48	0.46
			5.0	0.71	0.60	0.65	0.62	0.59	0.57	0.53	0.50	0.48
Recessed louvre trough with optically designed reflecting surfaces		50	0.6	0.28	0.25	0.25	0.23	0.28	0.25	0.23	0.28	0.25
			0.8	0.34	0.31	0.28	0.33	0.30	0.28	0.33	0.30	0.28
			1.0	0.37	0.36	0.32	0.37	0.34	0.32	0.37	0.34	0.32
			1.25	0.40	0.38	0.35	0.40	0.37	0.35	0.40	0.37	0.35
			1.5	0.43	0.41	0.38	0.42	0.40	0.38	0.42	0.39	0.38
			2.0	0.46	0.44	0.42	0.45	0.43	0.41	0.45	0.42	0.41
			2.5	0.48	0.46	0.44	0.47	0.45	0.43	0.47	0.44	0.43
			3.0	0.49	0.47	0.46	0.48	0.46	0.45	0.48	0.45	0.44
			4.0	0.50	0.49	0.48	0.49	0.48	0.47	0.48	0.47	0.46
			5.0	0.51	0.50	0.49	0.50	0.49	0.48	0.49	0.48	0.47

Reflectances:

Ceiling = 0.3

Walls = 0.5

RI = 2.45

DLOR = 50%

Fitting = Recessed
Louvre

Utilisation

Factor = 0.46

Number of Lamps Required

The Number of lamps required is given by the formula:

$$N = \frac{E \times A}{F \times UF \times LLF}$$

N = number of lamps required

E = illuminance level required (lux)

A = area at working plane height (m²)

F = average luminous flux from each lamp (lm)

UF = utilisation factor, an allowance for the light distribution of the luminaire and the room surfaces

LLF = light loss factor, an allowance for a reduction in light output caused by lamp deterioration and dirt.

Values	Step 1	Step 2
E = 200lux A= 60m x 24m = 1440m ² F = 18,000 lumens UF = 0.46 LLF = 0.75	$N = \frac{200 \times 1440}{18000 \times 0.46 \times 0.75}$	$N = \frac{288000}{6210}$
$N = 46.37681159...$ Number of lamps = 48		

Layout for lamp fittings

The minimum illumination level of the production area is taken as the illumination level at the working plane which is 200 lux. The maximum level in other parts of the area should not be higher than 285 lumens (200/0.7) This is best practice for ensuring a reasonable level of uniformity is achieved.

To maximum space between the centre of each light fitting should be no greater than 10.5m (1.5 x 7).

$$S_{\max} = 1.5 \times H_m$$

Where $S_{\max}$ = maximum spacing

Where H_m = Height of the luminaire from the work benches

Best Fit Layout Plan

See appendix 1 for scaled drawing of lighting layout.

Element 2 - Sound reduction index calculation and discuss the implications of the factors of frequency and wavelength in

Firstly, this section of the report will explain the steps needed to calculate the overall sound reduction index for an entire wall before finally discussing the implications of the factors of frequency and wavelength in internal sound management, partition wall construction technique and the insulation material choice.

Specifications and Dimensions

The brick wall of area 20m² contains a window of area 4m². The values of sound reduction indexes are 50dB for the brick wall and 10dB for the window,

Overall Sound reduction Index

The SRI (sound reduction index) is a measure of the reduction in the intensity of sound when it passes through the wall.

Transmission coefficient for each component using formula:
 $SRI = 10 \times (\log_{10} (1/T))$

Brick wall

$$50 = 10 \times \log_{10} (1/T_1)$$

$$5 = \log_{10} (1/T_1)$$

$$1/T_1 = 10^5$$

$$T_1 = 10^{-5}$$

**Transmission coefficient
for brick = 0.000010**

Window

$$10 = 10 \times \log_{10} (1/T_2)$$

$$1 = \log_{10} (1/T_2)$$

$$1/T_2 = 10^1$$

$$T_2 = 10^{-1}$$

**Transmission coefficient
for window = 0.10**

$$T_0 = (T_1 \times A_1) + (T_2 \times A_2)$$

Formula

$$A_1 + A_2$$

Where T_0 = overall (averaged) transmission coefficient

Where T_1 = transmission coefficient of one component

Where A_1 = area of component

Values	Step 1	Step 2
$T_1 = 10^{-5}$ $T_2 = 10^{-1}$ $A_1 = 16$ $A_2 = 4$	$T_0 = \frac{(10^{-5} \times 16) + (10^{-1} \times 4)}{16 + 4}$	$T_0 = \frac{0.00016 + 0.4}{20}$ Average transmission coefficient = 0.020008
Using SRI formula		
$SRI = 10 \times \log_{10} (1/T)$		
$= 10 \times (\log_{10} (1/0.020008))$		
$= 10 \times (\log_{10} (49.980007))$		
$= 10 \times 1.69$		
Overall SRI = 17 dB		

Frequency and wavelength

Sound is created by a vibrating object which therefore makes tiny particles of air around it to move in unison. These displaced air particles collide with adjacent air particles setting them in motion and in unison with the vibration object. This continuous chain reaction creates a sound wave which travels through the air until at some distance where the air particles movement is so small that it cannot be heard (Chudley and Greeno, 2016).

Internal management

There are two types of sound one being airborne sound and the other being impact sound. Impact sound is when an object impacts on another object causing the transmission of sound. The structural vibration caused by the impact results in sound being radiated from an adjacent vibrating surface. Differently to this airborne sound only sets the structural fabric vibrating in unison when the emitted sound wave reaches the structural fabric. A good example of how impact sound effects internal management of enclosed spaces is the impact of footsteps resulting in for instance the present occupants in the level below being disturbed by the noise of footsteps. Impact sound can travel through solid structures and through cavities (Design Building Wiki, 2021) Impact noise can be harmful to health through causing noise nuisance and therefore is something that always need to be considered in regard to internal spaces and how these wavelengths can be interrupted and prevented from causing issues to present occupants. In regards to preventatives to help with controlling noise nuisance inside things like carpets which always can help reduce high frequency sound are good to limit the transmission. There are also option like suspended floors and ceiling to help reduce impact noise and with regards to airborne sound, sound proofing is a good preventative as it can dissipate the vibrations and be used to reduce sound at all frequencies.

Partition wall

Partition walls usually are timber studs with gaps in-between, these gaps if left empty would be a easy route for sound waves to travel from room to room and therefore need to be filled in or addressed. A typical timber frame partition detail in compliance with building regulations part E is 2 layers of 12.5mm plastered each side with a min mass of 10kg/m² or another option is a single layer of the same plastered board but with minimum 25mm mineral wool in between the studs. (Building regs, Part E)

Insulation material

There are many different types of sound insulation options depending on the specific requirement and needs of that specific structure. Foam, fiberglass, rock wool are common materials used to insulate against sound waves and frequencies.

Conclusion

The first part showed in detail how to achieve the RI, Uf and number of lights required and a suitable layout for the lamps. The second element looked at the different types of sound and how the wavelengths can be mitigated in internal spaces to limit the impact to residence or occupants as noise nuisance can cause many things such as anxiety and other health issues.

Appendix

Appendix 1 see page 10.

References

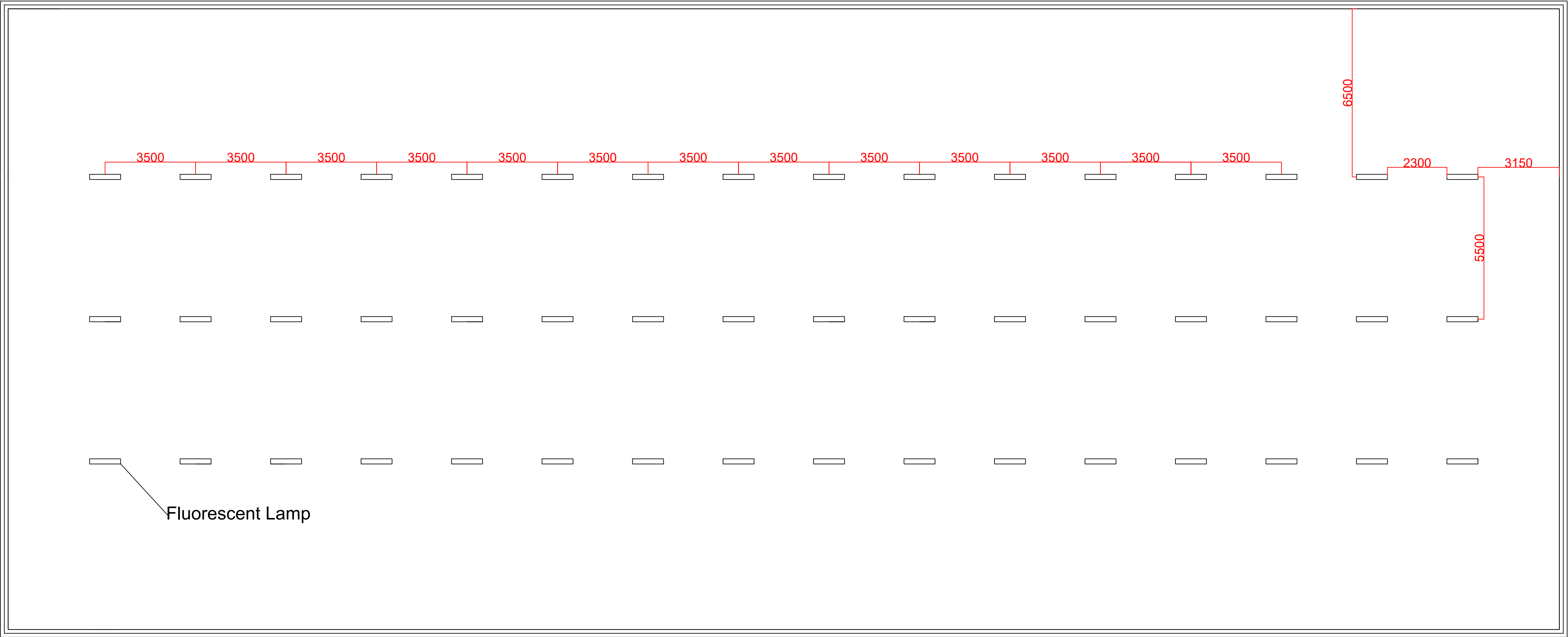
Chudley, R. and Greeno, R. (2016) Building Construction Handbook 11th Ed: Routledge

Approved Document E (2021) Available at: <https://www.gov.uk/government/publications/resistance-to-sound-approved-document-e> (Accessed 12th April 2021)

Designing Buildings Wiki (2021) Available at: https://www.designingbuildings.co.uk/wiki/Impact_sound (Accessed 12th April 2021)

FACTORY LIGHTING LAYOUT PLAN

SCALE: 1:100 @ A1



General Notes

No.	Revision/Issue	Date

Firm Name and Address

Project Name and Address

Elliott Lewis
Lighting Layout Drawing
1:100 @ A1
NOT FOR CONSTRUCTION

Project

SK003

Date

12/04/21

Scale

As Noted

Sheet

1