

Material Science and Building Services

Lighting layout

Factory Area = $60\text{m} \times 24\text{m} \times 8\text{m (h)}$
Floor Area = 1440m^2
Benches = 1m above floor level

Reflectance - Ceiling = 0.3
Walls = 0.5

lights - Fluorescent lamps - $1200\text{mm} \times 200\text{mm}$
- Recessed louvre
- DLOR = 50%
Output = 18000 lumens

Illumination required = 200 lux (at working plane)
light loss factor = 0.75

1) ★ room Index

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

$$L = 60\text{m}$$

$$W = 24\text{m}$$

$$H_m = (8-1) = 7\text{m}$$

$$RI = \frac{(60 \times 24)}{(7(60+24))}$$

$$RI = \frac{1440}{7(84)}$$

$$RI = \frac{1440}{588}$$

$$RI = 2.4489795918367$$

$$RI = 2.45$$

2) ★ Utilisation Factor = 0.45

3) ★ Number of lamps required

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

$$E = 200$$

$$A = 1440$$

$$F = 18000$$

$$UF = 0.45$$

$$LLF = 0.75$$

$$N = \frac{200 \times 1440}{18000 \times 0.45 \times 0.75}$$

$$N = \frac{288000}{6075}$$

$$N = 47.407$$

$$N = 48$$

48 lamps

4)★ Value of S

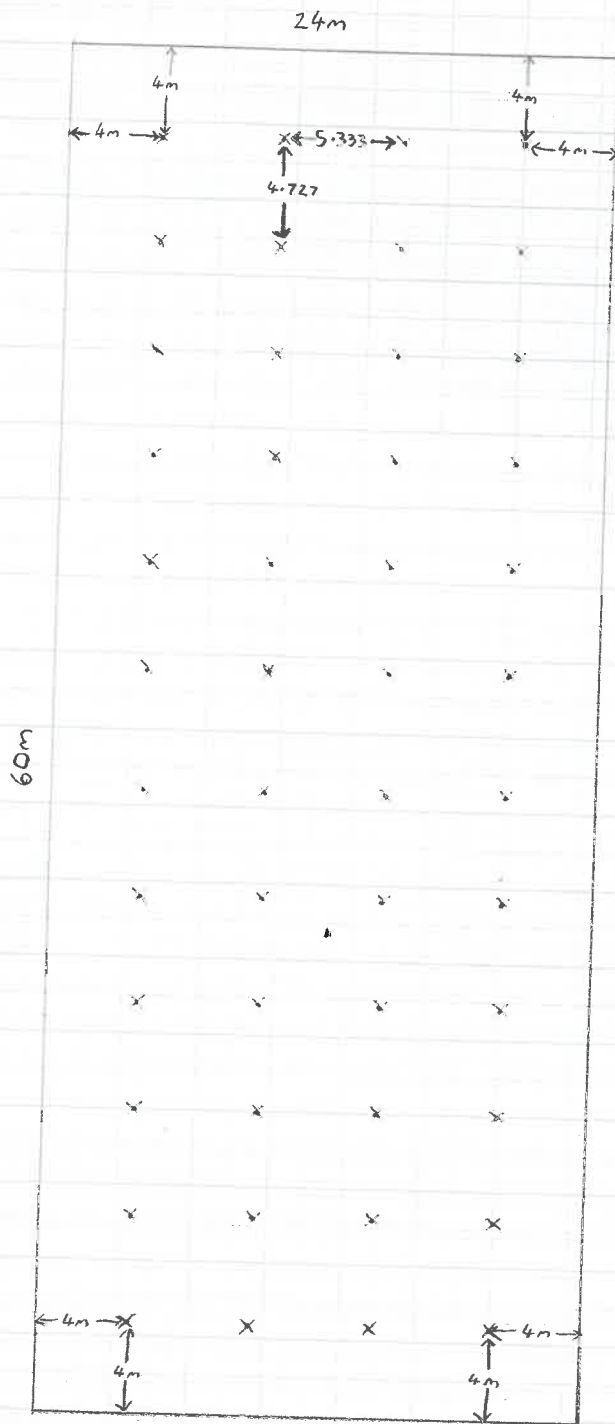
$$S_{\max} = 1.5 \times H_m$$

$$= 1.5 \times 7$$

$$= 10.5$$

maximum gap between lights = 10.5m

lighting plan



either 3 rows of 16 lamps
or
4 rows of 12 lamps

I chose 4x12 as it
gives more uniform coverage

4m gap around all
edges.

room width 24m

$$24 - (4 + 4) = 16m$$

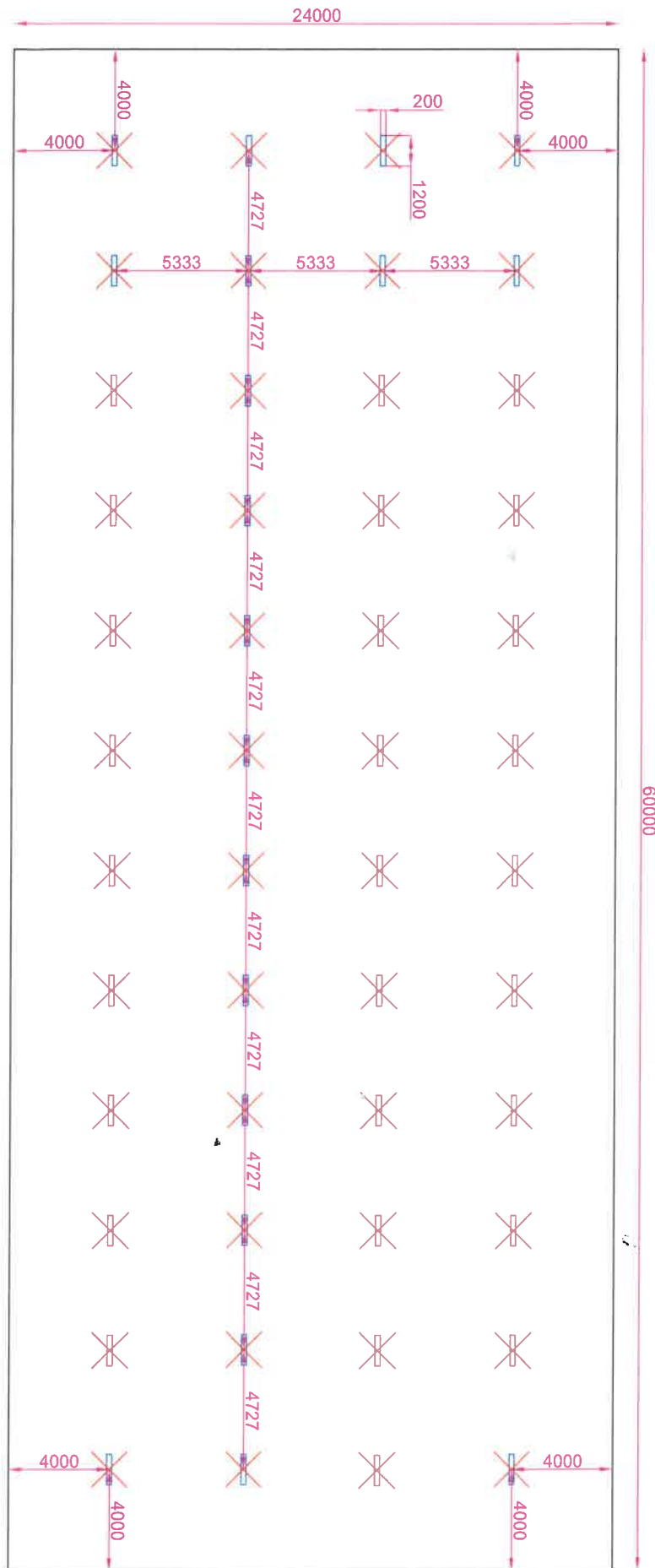
$$16 \div 3 = 5.333m$$

room length 60m

$$60 - (4 + 4) = 52m$$

$$52 \div 11 = 4.727m$$

3mm : 1m



1:250 @ A4

Transmission Coefficient and Sound reduction index

$$\text{Wall} = 20 \text{ m}^2$$

$$\text{Window} = 4 \text{ m}^2$$

$$\text{SRI window} = 10 \text{ dB}$$

$$\text{SRI Brick} = 50 \text{ dB}$$

Calculate overall sound reduction index.

$$\text{SRI} = 10 \times (\log_{10}(1/T))$$

T = Transmission Coefficient

Brickwork (T_1)

$$\text{SRI} = 10 \times (\log_{10}(1/T))$$

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

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

$$1/T_1 = 10^5$$

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

$$T_1 = 0.000010$$

Window (T_2)

$$\text{SRI} = 10 \times (\log_{10}(1/T))$$

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

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

$$1/T_2 = 10^1$$

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

$$T_2 = 0.10$$

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

T_0 = Overall transmission Coefficient

= ?

T_1 = Brickwork transmission Coefficient

= 0.000010

A_1 = Brickwork area ($20 \text{ m}^2 - 4 \text{ m}^2 = 16 \text{ m}^2$)

= 16 m^2

T_2 = window transmission Coefficient

= 0.10

A_2 = window area

= 4 m^2

$$T_0 = \frac{(10^{-5} \times 16) + (10^{-1} \times 4)}{16 + 4}$$

$$T_0 = \frac{1.6 \times 10^{-4} + 0.4}{20}$$

$$T_0 = 0.0200005$$

$$\begin{aligned} \text{SRI} &= 10 \times (\log_{10}(1/T)) \\ &= 10 \times (\log_{10}(1/0.0200005)) \\ &= 10 \times (\log_{10}(49.99875003)) \\ &= 10 \times 1.698959147 \\ &= 16.98959147 \\ &= 16.99 \text{ dB} \end{aligned}$$

The implications of frequency and wavelength

The implications of the factors of frequency and wavelength in internal sound management

To avoid acoustic issues when designing buildings we must understand frequency and wavelength and what sound is likely to be created within the space.

'The wavelength of a wave is the distance between a point on one wave and the same point on the next wave.'

'The frequency of a wave is the number of waves produced by a source each second.'
(BBC Bitesize, 2020)

The lower the frequency means that there will be fewer waves, as a result each of these waves must be longer (longer wavelength). A barrier to sound such as a wall must be thicker than the wavelength in order to absorb the sound effectively. In the case of high frequency sounds such as human speech this can be done quite easily but for low frequency sounds such as the lowest note on a piano where the wavelength can be over 12m long (Liutaio Mottola, 2020) this becomes impossible to do with wall thickness alone.

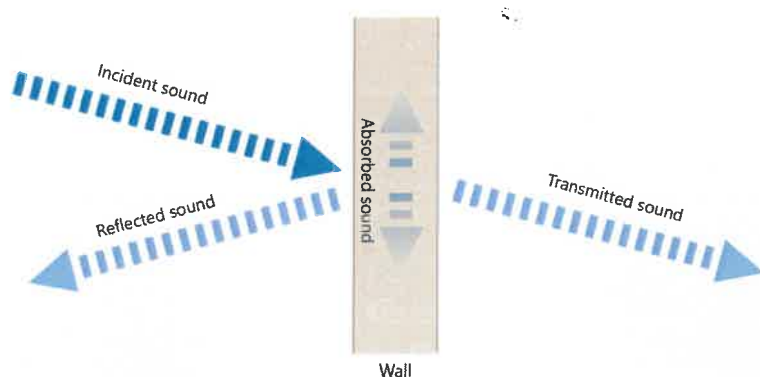
The type of sound transmission must also be taken into account, sound from a piano will be airborne sound created from a point in the room. Will there also be impact noise that will need to be insulated against? Impact noise is the sound that's transferred through the solid structural elements themselves, footsteps and doors closing are typical example of this but if the building is used as for example a dance studio then the impact noise will be more significant.

It's also important to understand that impact noise can also be from a vibrating source such as machinery, this sound will be transferred through the structure in the same way as footsteps. (Designing Buildings Wiki, 2021 a)

The implications of the factors of frequency and wavelength in partition wall construction technique

In partition wall construction we cannot use wall thickness alone in order to reduce noise, we must keep the partition wall as thin as possible to maximise floor space while maintaining acoustic insulation to Building Regulations Part E. To maximise the acoustic insulation properties we must layer different materials and air gaps (Designing Buildings Wiki, 2021 b).

When sound hits a wall a portion of that sound is absorbed by the material, a portion is reflected off the surface and the remainder is transmitted through. By using designed materials we can maximise the amount that is absorbed and lower the reflected sound and transmitted sound. When

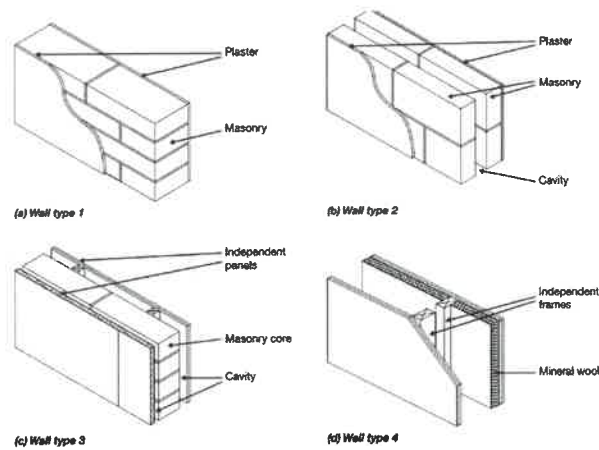


Good Science (n.y) Transmission, reflection and absorption of sound. Available at: <https://www.goodscience.com.au/year-9-physics/sound-waves/8-transmission-reflection-and-absorption-of-sound/> (Accessed: 08 April 2021).

designing acoustic insulation for areas with high noise levels we lower the amount of reflected sound by having an open porous surface such as foam, timber slats or fibre.

These materials wouldn't be suitable for a standard party wall due to their porous surface, instead a painted acoustic plasterboard or a layer of double plasterboard would be used, the surface of these boards would be non-porous and highly reflective to sound but is standard for this use.

Opposite we have various types of party wall construction; each would have different properties of sound absorption for impact and airborne sounds at different wavelengths and frequencies.



Welsh Government (2010) Approved Document Part E. Available at: <https://gov.wales/sites/default/files/publications/2019-05/building-regulations-guidance-part-e-resistance-to-the-passage-of-sound.pdf> (Accessed: 08 April 2021).

The implications of the factors of frequency and wavelength in the Insulation material choice.

We should look to acoustically insulate all areas of the build appropriately. In order to decide on the insulating material we must look at the most appropriate insulation for the sound created, how much space we have and the cost implications. A balance must be struck between these three factors when deciding on a noise reduction strategy. Often the source of the noise if possible is best tackled at source, for example vibration dampening on mechanical systems so that they create less sound to begin with means that less sound insulation will have to be applied to the structure.

Cost is the defining feature for most construction projects, the thinnest and most effective insulators such as aerogel (Material District, 2016) have a premium cost that is orders of magnitude more than less effective thicker materials such as rockwool.

Glazing is a key area when it comes to acoustic insulation as it tends to be the thinnest part of the structure. Preventing unwanted levels of noise in this area is key as the wavelength is almost always going to be wider than the thickness of the glass. Historically we would have just increased the thickness of the glass but new technologies such as acoustic PVB laminated glass (Dual Seal Glass, n.y.) allow us to have the thinner lighter panes of glass while maintaining a level of acoustic performance.

References

BBC Bitesize, 2020. *Amplitude, wavelength and frequency - CCEA*. [Online]

Available at: <https://www.bbc.co.uk/bitesize/guides/znjcscw/revision/1>

[Accessed 08 April 2021].

Designing Buildings Wiki, 2021 a. *Impact Sound*. [Online]

Available at: https://www.designingbuildings.co.uk/wiki/Impact_sound

[Accessed 08 April 2021].

Designing Buildings Wiki, 2021 b. *Sound absorption*. [Online]

Available at: https://www.designingbuildings.co.uk/wiki/Sound_absorption

[Accessed 08 April 2021].

Dual Seal Glass, n.y.. *Glass And Acoustic Insulation*. [Online]

Available at: <https://dualsealglass.co.uk/glass-technology/glass-and-acoustic-insulation/>

[Accessed 14 April 2021].

Liutaio Mottola, 2020. *Table of Musical Notes and Their Frequencies and Wavelengths*. [Online]

Available at: <https://www.liutaiomottola.com/formulae/freqtab.htm>

[Accessed 08 April 2021].

Material District, 2016. *New Aerogel insulation material more soundproof and heat resistant*.

[Online]

Available at: <https://materialdistrict.com/article/new-aerogel-insulation-material-soundproof-heat-resistant/>

[Accessed 14 April 2021].