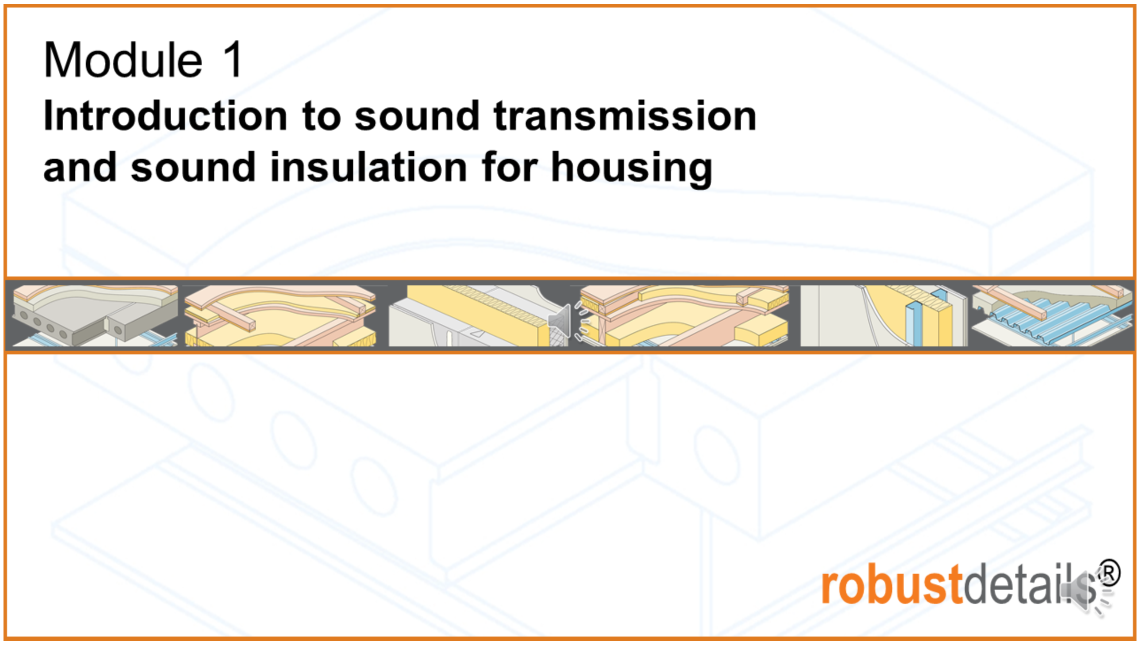
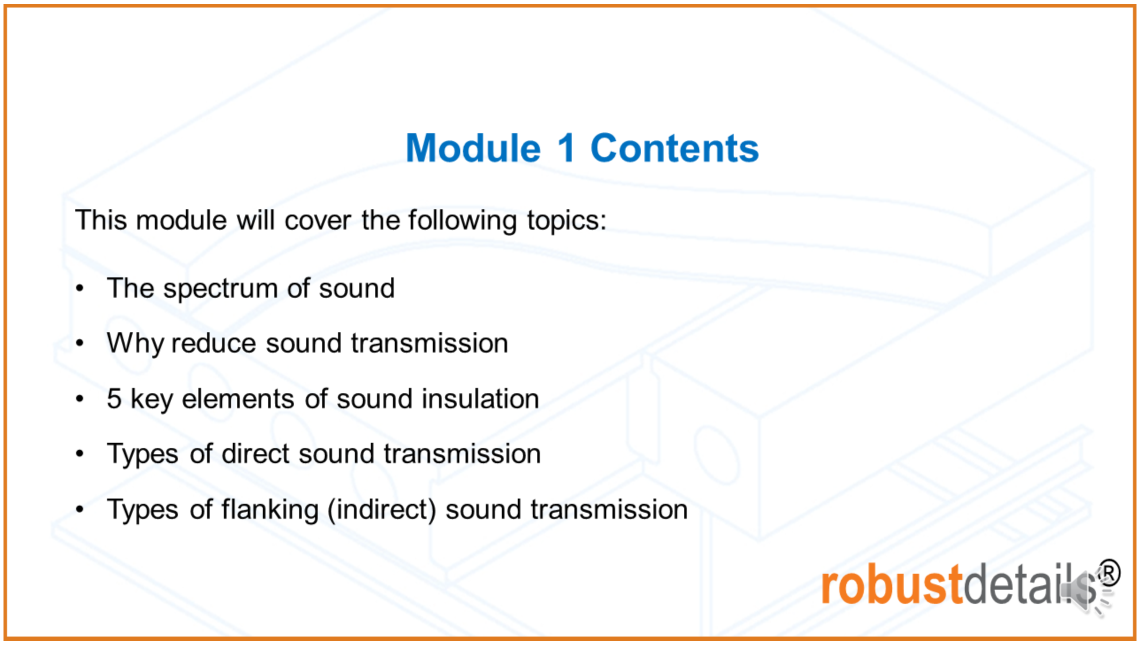
**Slide 1**




Welcome to Module 1 – Introduction to sound transmission and sound insulation for housing. This is the first module of this short course.

Additional notes:

**Slide 2**




This Module will cover the following topics:

- The spectrum of sound
- Why reduce sound transmission
- 5 key elements of sound insulation
- Types of direct sound transmission
- Types of flanking (indirect) sound transmission

Additional notes:

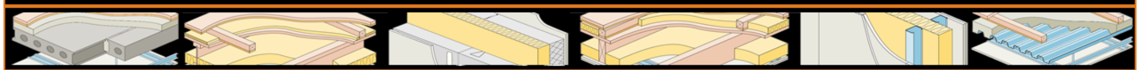
**Slide 3**


Firstly, lets explain some of the features related to hearing and the acoustic spectrum of sounds and noise.

Additional notes:

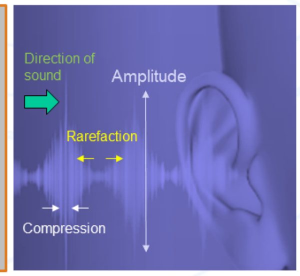
**Slide 4**

# The Spectrum of Audible Sound



**Sound pressure** or acoustic pressure is the local pressure deviation from the ambient atmospheric pressure, caused by a sound wave.

The compression and rarefaction (stretching) of the air particles causes pressure fluctuations.




In the outer-ear, our ear drum (the tympanic membrane) flexes due to these air pressure waves (fluctuations). This then drives dynamic movement of the 3 ear bones (in the middle ear). The bones movement then dynamically interacts with the inner-ear (cochlear) resulting in the inner-ear nerves releasing neuron transmitters to the brain, through the 8th cranial nerve.

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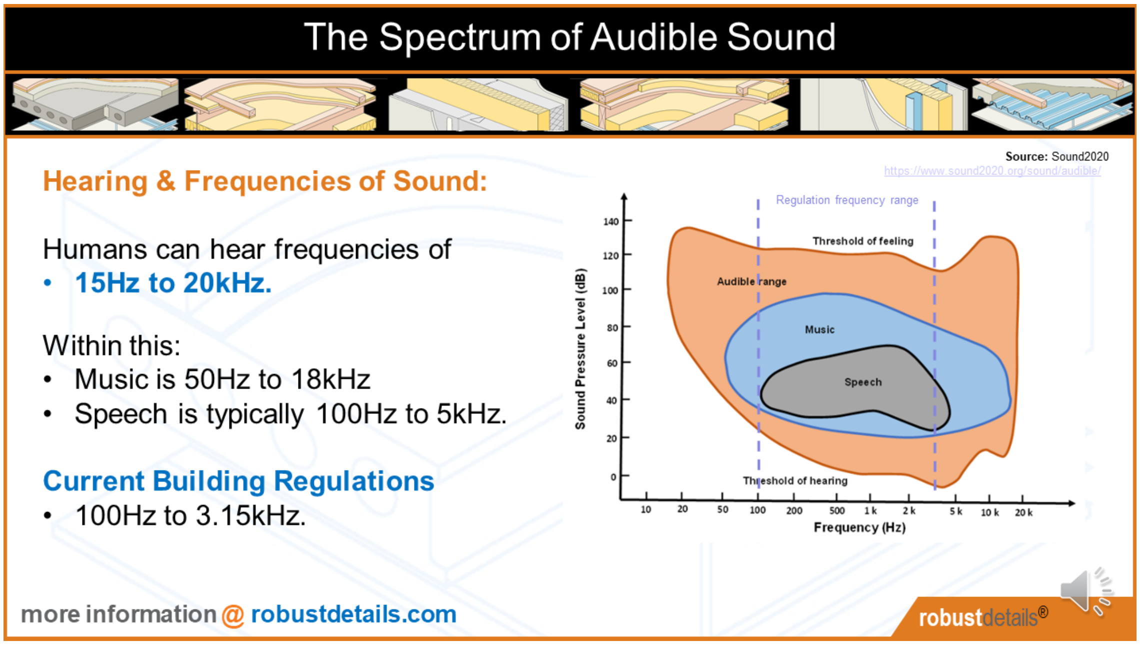
Read slide

Additional notes:

**Slide 5**



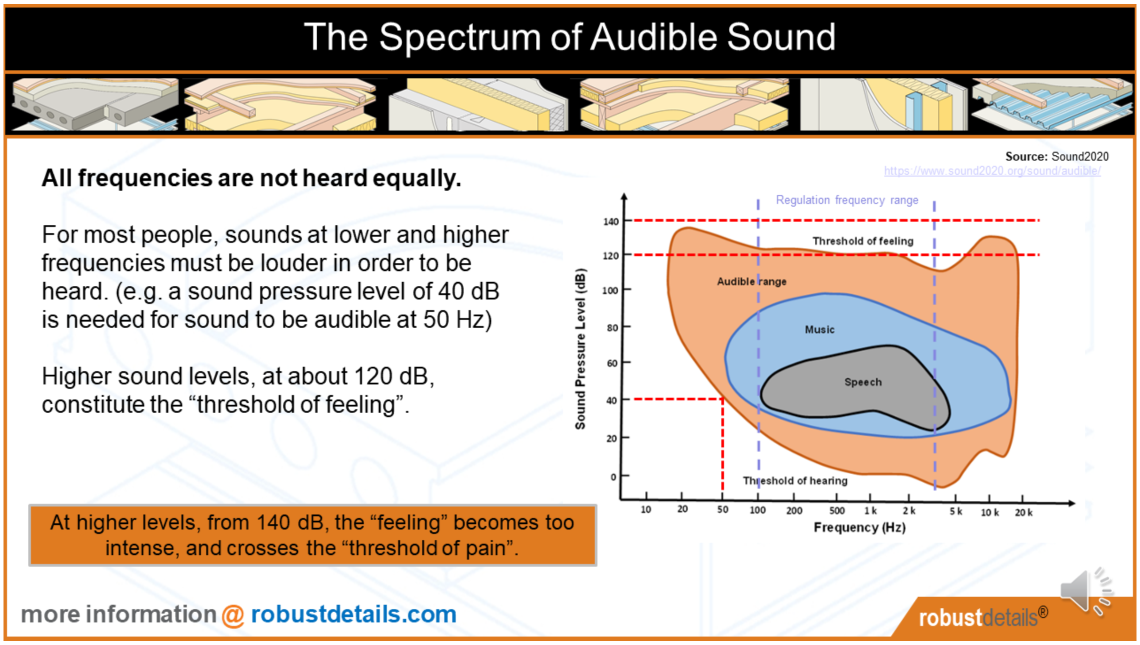

The audible frequency range of humans typically ranges from 15Hz to 20kHz. With aging process as early as 30 years our frequency range can decrease.

The music range extends from 50Hz to 18kHz and the speech range is typically 100Hz to 5kHz.

Current building regulations across the UK are 100Hz to 3.15kHz as shown here.

Additional notes:

**Slide 6**

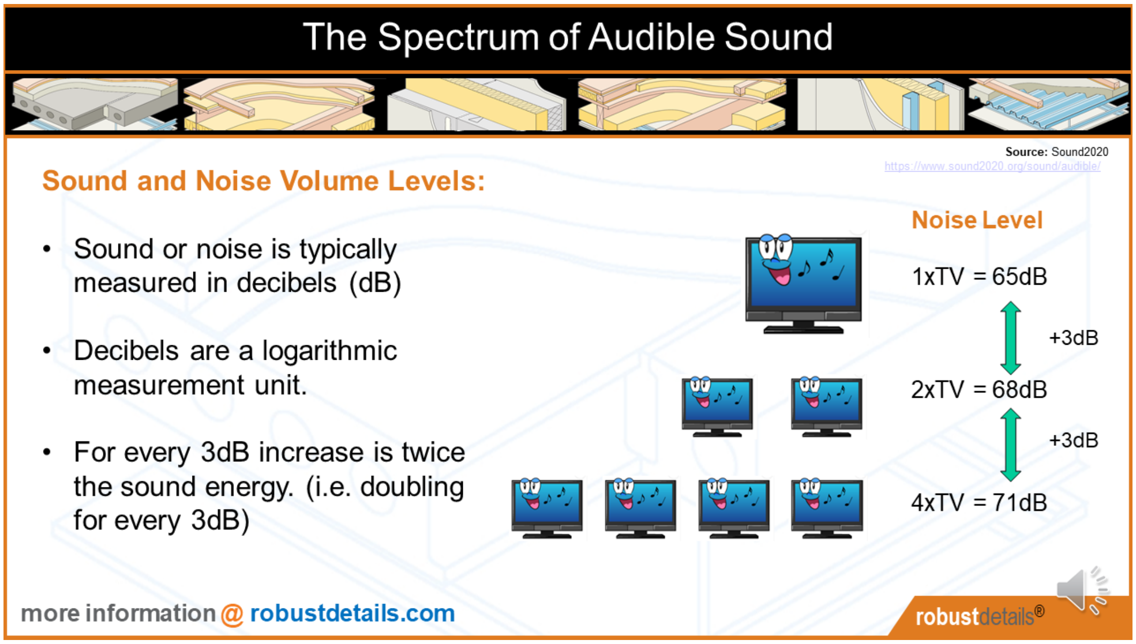



In the frequency band, (500 Hz to 5 kHz), sounds at very low sound pressure levels of about 10 dB are audible to young, healthy ears. For most people at lower and higher frequencies, sounds must be louder to be audible. (e.g. a sound pressure level of 40 dB is needed for sound to be audible at 50 Hz)

At much higher sound pressure levels, at about 120 dB, sound is not so much heard as felt. These levels constitute the threshold of feeling. At even higher levels, say 140 dB, the "feeling" becomes quite uncomfortable and we reach the threshold of pain.

Additional notes:

## Slide 7



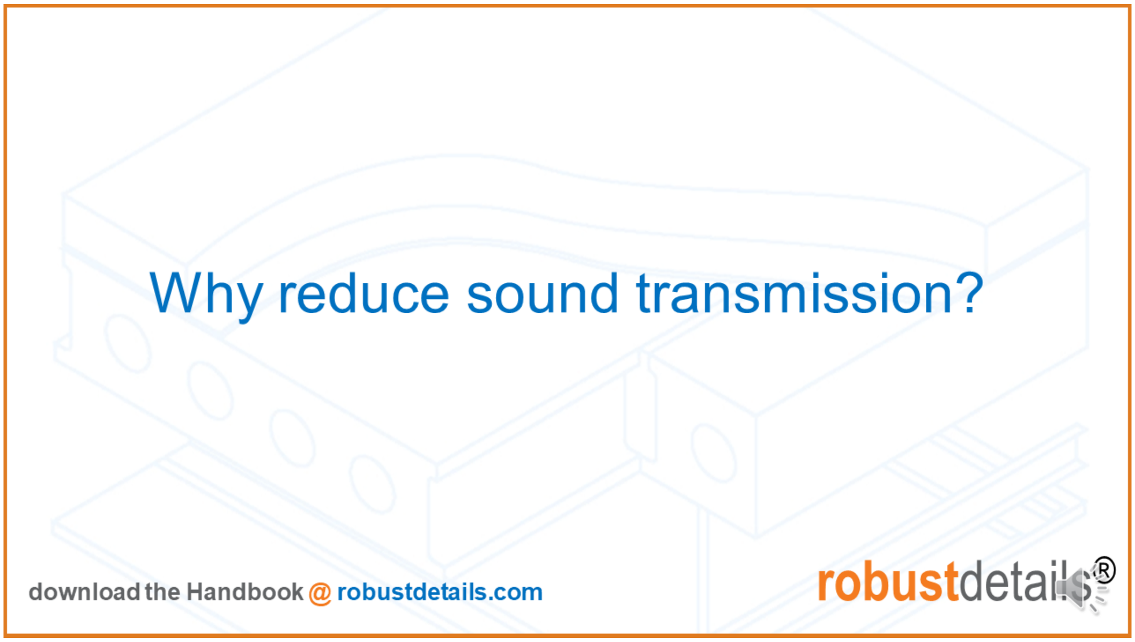

Let's now discuss sound and noise volume levels

Read slide

If one TV emits 65dB of sound – adding a second TV with the same volume level as the first TV now adds 3dB = 68dB and so on for every doubling of the sound source volumes - so 4 TVs at the same volume would be 71dB

Additional notes:

**Slide 8**

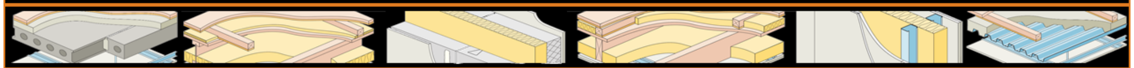



So why is sound insulation important and why reduce sound transmission between attached houses and flats?

Additional notes:

**Slide 9**

## Living with Sound and Noise



- Insufficient sound insulation can lead to **disturbance, annoyance and also affect people's health** through stress and anxiety.
- Types of sound and noise can vary in volume level (decibels, dB) and the pitch of sound (frequency, Hz)
- Noise from normal 'living behaviour' can also vary throughout a **24hr period,** depending on work shift patterns and activities of neighbouring occupants.
- Hence, designing in for sufficient sound insulation is important.

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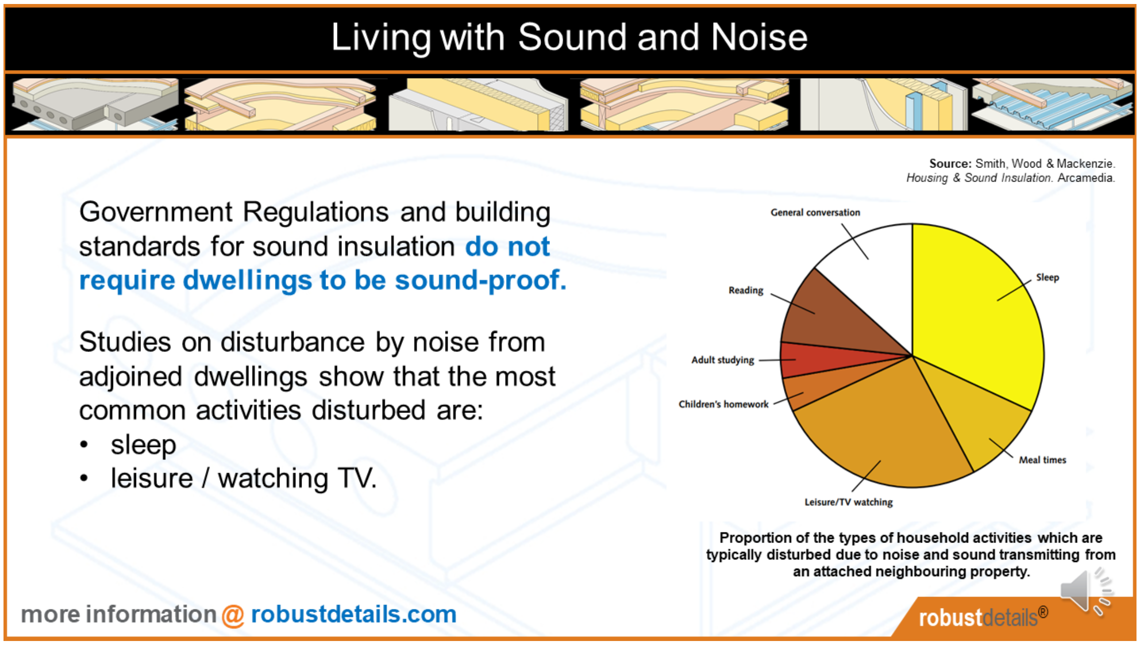
Read slide

Additional notes:

**Slide 10**




Government Regulations and building standards for sound insulation in attached housing aims to address the most common sound and noise sources by providing a reasonable level of insulation to address typical normal levels of living sound/noise. Attached housing includes attached houses and flats.

Noise is generally defined as unwanted sound. Noise and sound within housing can involve a wide range of sources such as TVs, conversations, kitchen appliances and other appliances, sound systems and footsteps. Studies on disturbance by noise often show similar patterns of the types of home activities which can be affected by neighbor noise (as shown on the right). The most common activities disturbed are sleep and leisure / watching TV.

**Continued Overleaf**

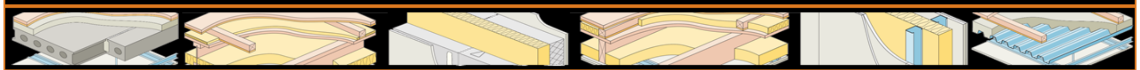
Additional notes:

In the diagram on the right, we can see that disturbance to sleep and leisure / tv watching can be the most affected.
Other activities affected include reading, conversations, meal times and adults studying or children doing homework.

Additional notes:

**Slide 11**

## Living with Sound and Noise



| Potential noise sources from adjoining dwellings | Airborne Noise | Impact Noise | Noise frequencies influenced |
|---|---|---|---|
| Teenagers or adult voices | ■ | | mid–high |
| TV | ■ | | mid–high |
| Doors closing | | ■ | low–mid |
| Radio/Music | ■ | | all* |
| Domestic equipment (e.g. vacuum cleaners) | ■ | | all |
| Plugs being inserted into sockets | | ■ | low–mid |
| Switches being turned on or off | | ■ | mid |
| Cupboard doors closing | | ■ | low–mid |
| Services noise (e.g. downpipes, water pumps) | ■ | | all |
| Footsteps | | ■ | low–mid |
| Children playing | ■ | ■ | all |
| DIY | ■ | ■ | all |
| Dogs barking | ■ | | low–mid |

** Amplified modern music often has a high level of bass frequency output*

| FREQUENCIES: | | | |
|---|---|---|---|
| Low | Mid | High | All |
| 40Hz–200Hz | 250Hz–1KHz | 1.25Kz–5KHz | wide range of frequencies |

Sound transmission within attached housing is normally grouped into two main areas:

1) **Airborne sound, and**
2) **Impact sound.**

Airborne sound includes that from speech, TV and general living noise.

Impact sound is generally from footfall. *It **does not include horizontal impact sound** through walls.*

Source: Smith, Wood & Mackenzie. *Housing & Sound Insulation..*

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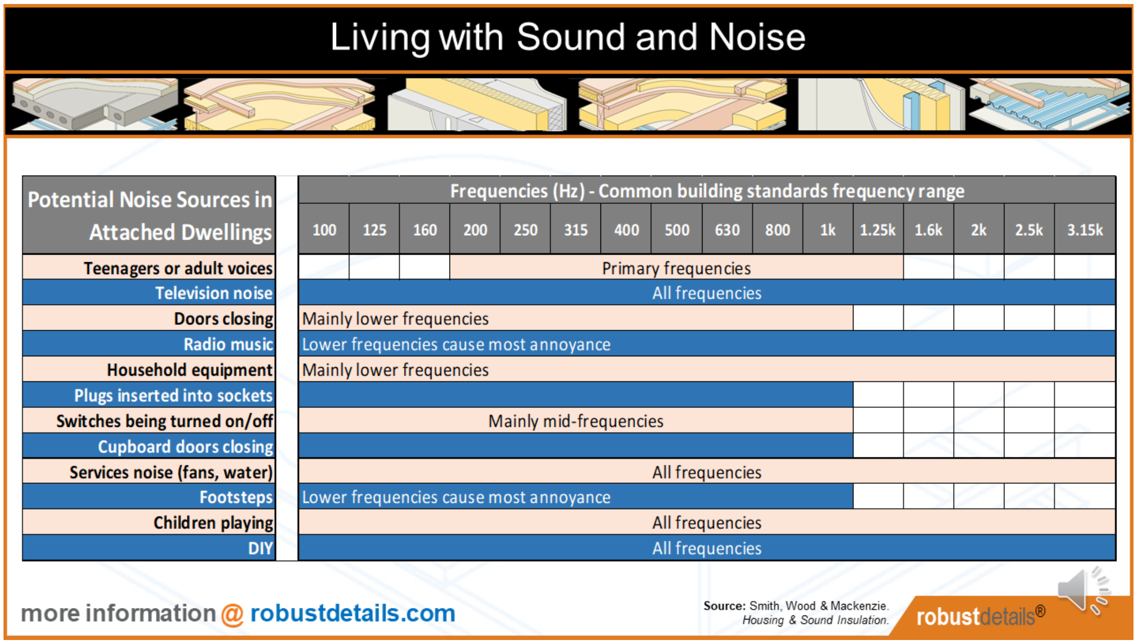
This table provides an indication of the types of everyday household noise sources, their categorisation for airborne and impact as sound sources and the range of frequencies low, mid or high they are likely to include.

Noise and sound sources within housing can cover a wide range of frequencies. Sound transmission within attached housing is normally grouped into two main areas: **Airborne sound,** and **Impact sound.**

Airborne sound insulation focuses on addressing airborne noise from speech, TV and general living noise. Impact sound insulation focuses on impact noise from footfall. NOTE: regulations in the UK do not include horizontal impact sound through walls such as cupboard doors closing, wall switches or door closing noise.

Additional notes:

**Slide 12**

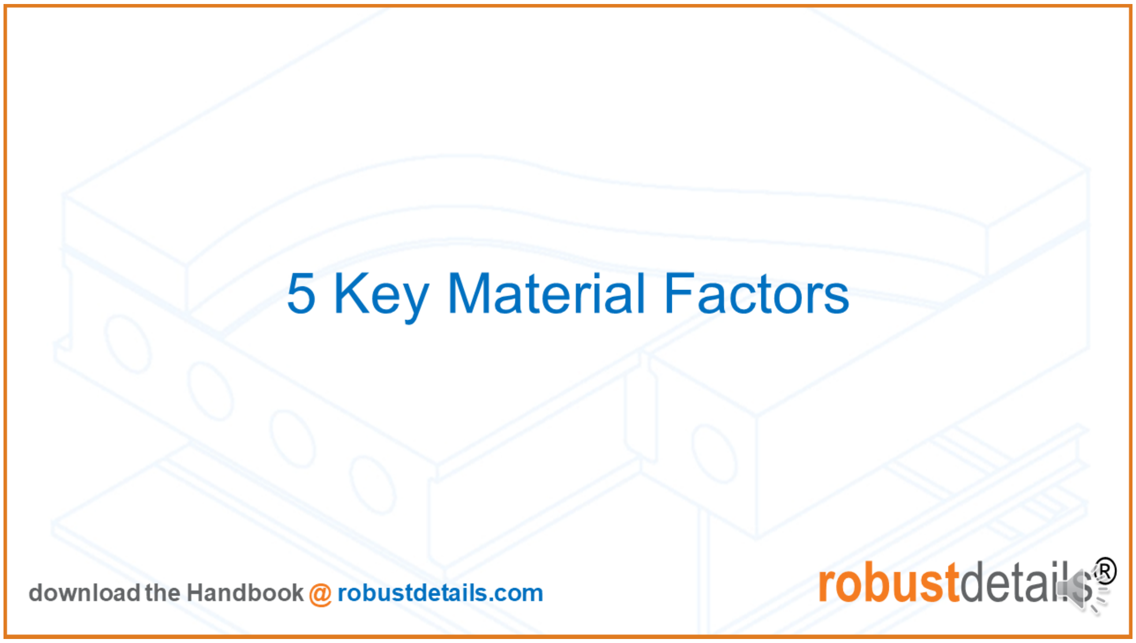



| Potential Noise Sources in Attached Dwellings | Frequencies (Hz) - Common building standards frequency range | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 125 | 160 | 200 | 250 | 315 | 400 | 500 | 630 | 800 | 1k | 1.25k | 1.6k | 2k | 2.5k | 3.15k |
| Teenagers or adult voices | | | | Primary frequencies | | | | | | | | | | | | |
| Television noise | All frequencies | | | | | | | | | | | | | | | |
| Doors closing | Mainly lower frequencies | | | | | | | | | | | | | | | |
| Radio music | Lower frequencies cause most annoyance | | | | | | | | | | | | | | | |
| Household equipment | Mainly lower frequencies | | | | | | | | | | | | | | | |
| Plugs inserted into sockets | | | | | | | | | | | | | | | | |
| Switches being turned on/off | Mainly mid-frequencies | | | | | | | | | | | | | | | |
| Cupboard doors closing | | | | | | | | | | | | | | | | |
| Services noise (fans, water) | All frequencies | | | | | | | | | | | | | | | |
| Footsteps | Lower frequencies cause most annoyance | | | | | | | | | | | | | | | |
| Children playing | All frequencies | | | | | | | | | | | | | | | |
| DIY | All frequencies | | | | | | | | | | | | | | | |

This table gives another format for comparing the types of noise sources and the frequency ranges they commonly include.

Additional notes:

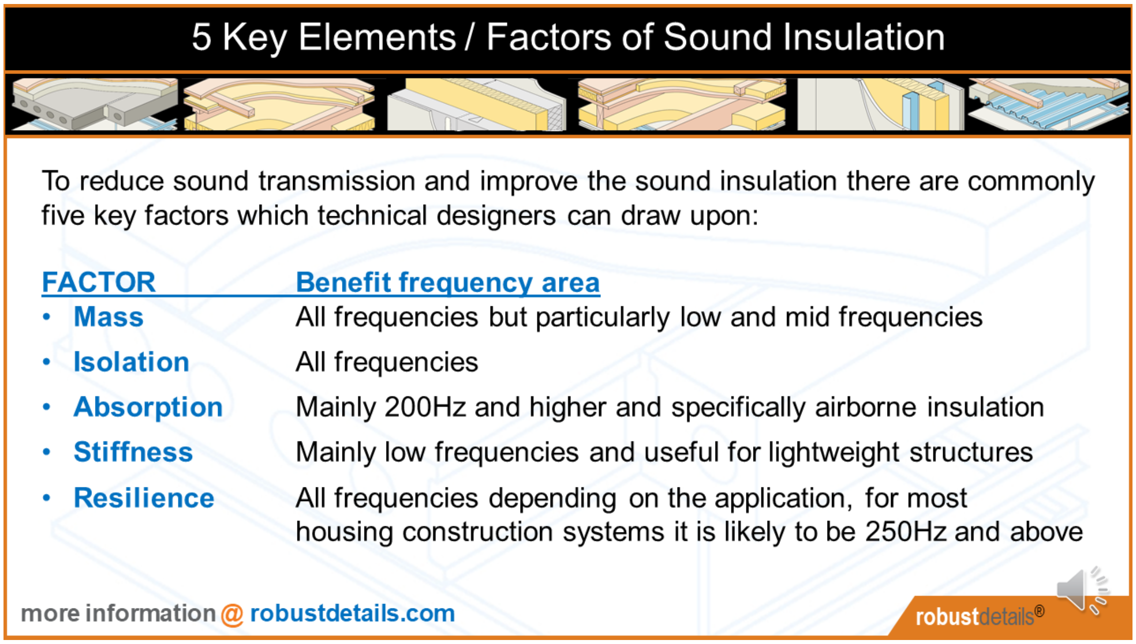
**Slide 13**




There are 5 KEY material factors or elements when designing for sound insulation.

Additional notes:

**Slide 14**

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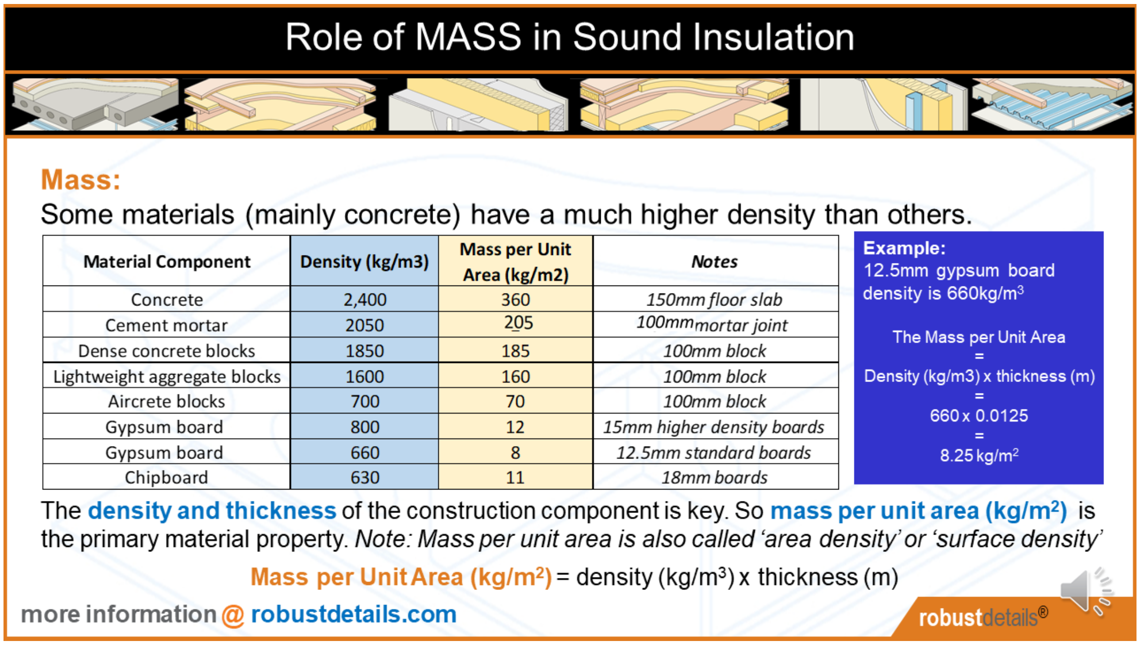
Additional notes:

**Slide 15**




| Material Component | Density (kg/m3) | Mass per Unit Area (kg/m2) | *Notes* |
|---|---|---|---|
| Concrete | 2,400 | 360 | *150mm floor slab* |
| Cement mortar | 2050 | 205 | *100mm mortar joint* |
| Dense concrete blocks | 1850 | 185 | *100mm block* |
| Lightweight aggregate blocks | 1600 | 160 | *100mm block* |
| Aircrete blocks | 700 | 70 | *100mm block* |
| Gypsum board | 800 | 12 | *15mm higher density boards* |
| Gypsum board | 660 | 8 | *12.5mm standard boards* |
| Chipboard | 630 | 11 | *18mm boards* |

Mass: Material components such as concrete slabs, dense concrete blocks and cement mortar are generally high density materials. Whereas aircrete blocks, gypsum board and chipboard are lower density materials.

For sound insulation purposes, the density and thickness of the construction component is key. Therefore, the mass per unit area (kg/m2) is the primary material property of interest.

**Mass per Unit Area** (kg/m2) = **density** (kg/m3) x **thickness** (m)

**Continued Overleaf**

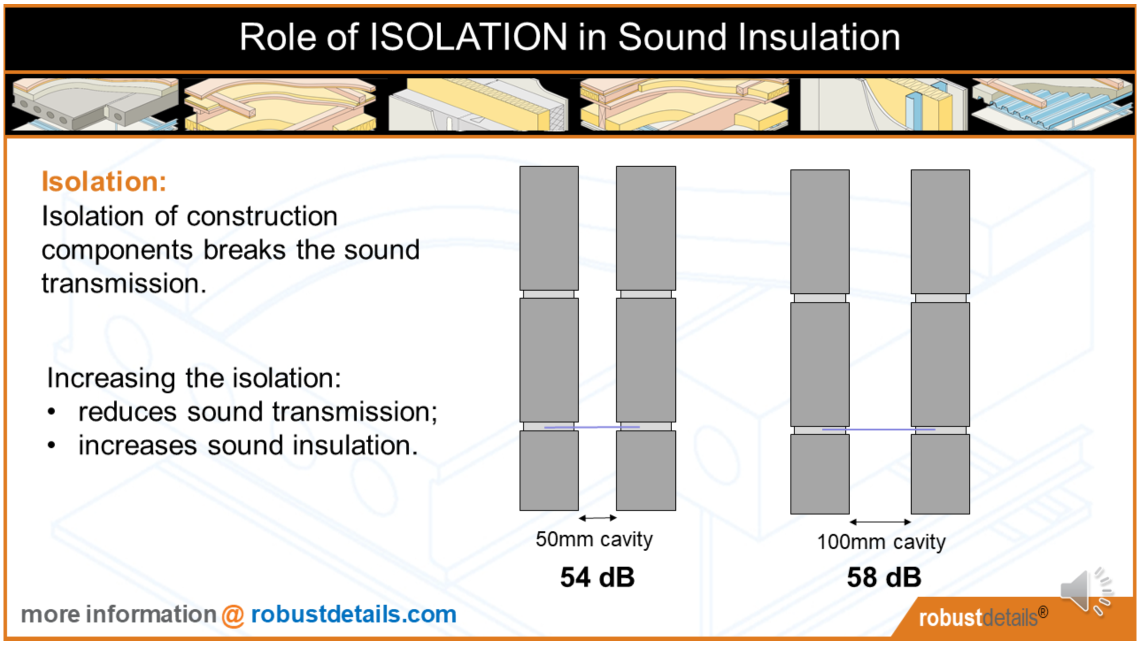
Additional notes:

The table shows a variety of different construction product materials, their density and typical mass per unit area.

Also, an example for calculating mass per unit area for a 12.5mm gypsum board of density 660kg/m3 is shown resulting in a mass per unit area of 8.25kg/m2
Always remember to use the same science-based units for kg and metres in your calculations (e.g. a 12.5mm board is written as 0.0125m)

Additional notes:

**Slide 16**

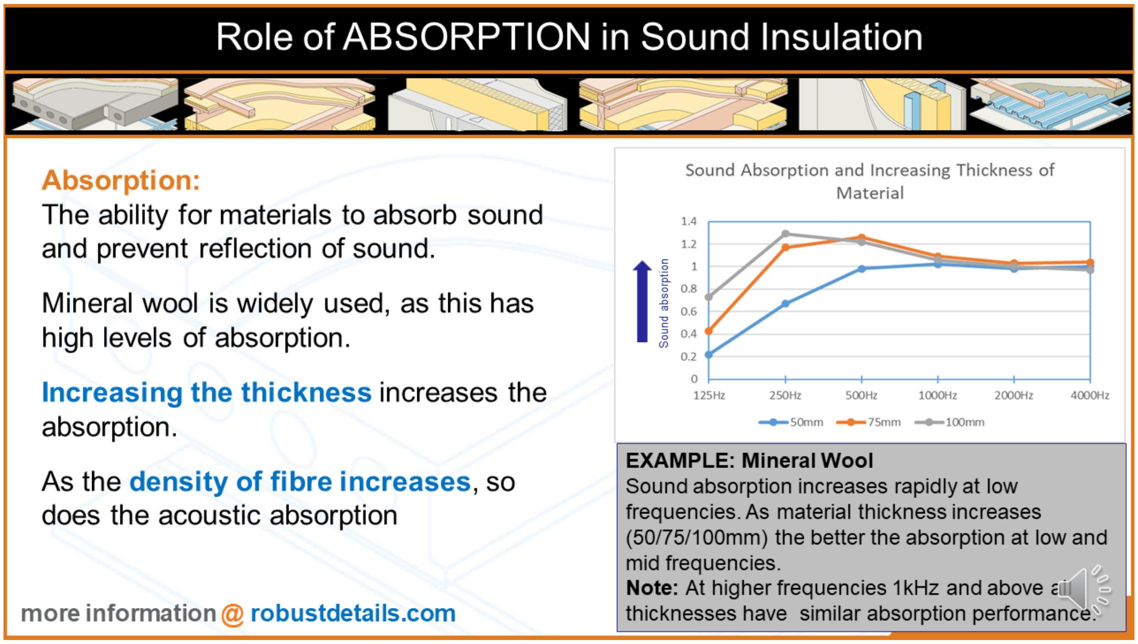



Isolation: The isolation of construction components can break the transmission of sound.

Taking the same twin leaf cavity block wall and increasing the cavity width, increases the isolation: reducing sound transmission; and increasing sound insulation.

Additional notes:

**Slide 17**




Absorption: Is the ability for materials to absorb sound and prevent reflection of sound. This is commonly used to improve airborne sound insulation. Materials such as mineral wool have high acoustic absorption.

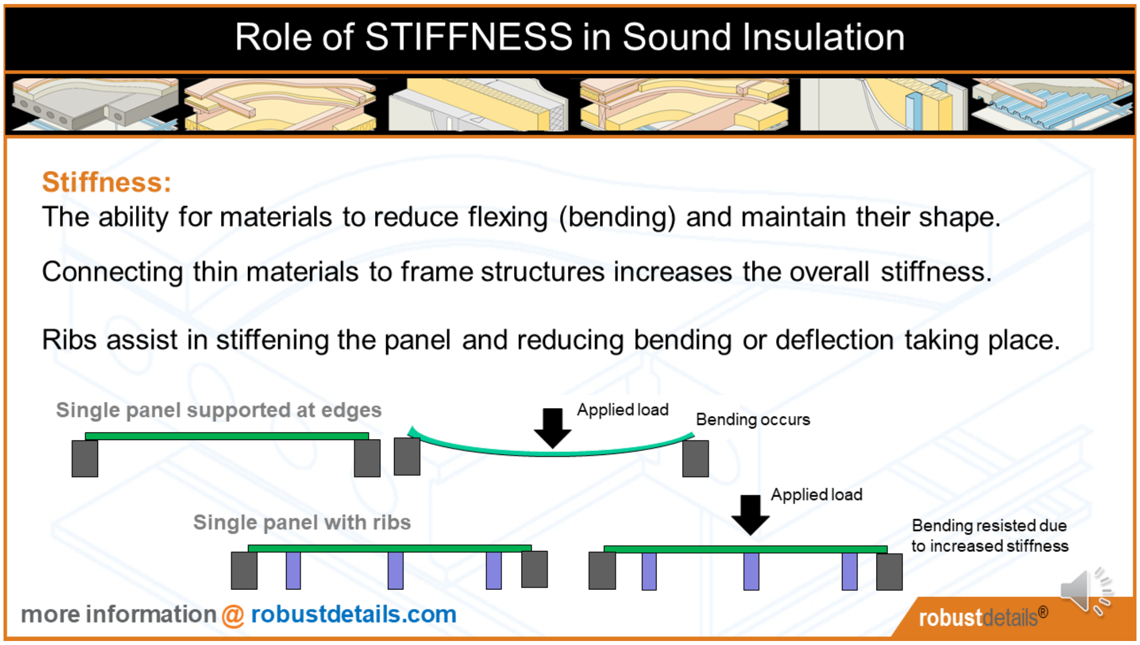
Other soft materials can also provide acoustic absorption but always check that the product is certified and approved for the specific intended application.

Generally, effective absorption can occur from frequencies of 200Hz and above. Increasing the thickness of the material increases the absorption.

As the density of fibre increases, this also increases the acoustic absorption performance.

Additional notes:

**Slide 18**




Stiffness: Is the ability for materials to reduce flexing (bending) and maintain their shape. If a construction material is too thin or the structure of the materials allows bending to occur, then this leads to flexural movement. Thin panels such as gypsum board or plywood will more easily flex. Connecting such materials to frame structures such as timber studs or joists reduces the flexibility and increases the overall stiffness. Double linings (e.g. gypsum) increase wall panel stiffness.

**Continued Overleaf**

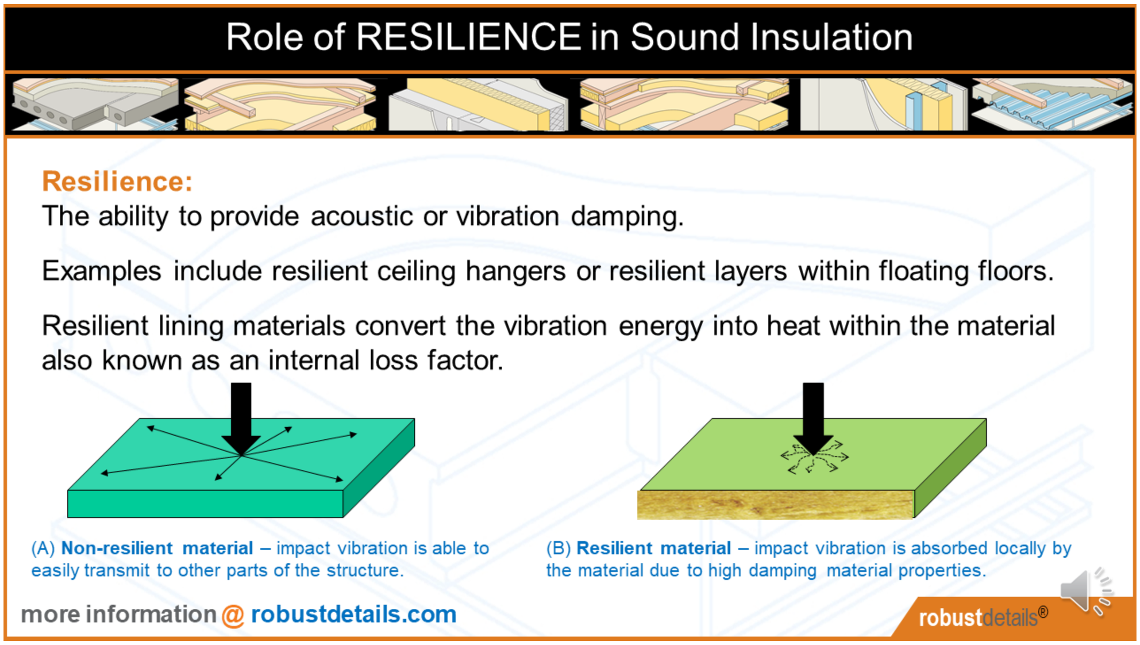
Additional notes:

For example, for floors, if they are able to flex and bend this can couple with the sound waves more easily leading to a dynamic motion and strong coupling between the sound pressure waves in the air and the vibration of the floor, resulting in sound transmission due to 'forced motion'.

The diagrams below show flexibility of a simple panel; and a panel with ribs. The ribs assist in stiffening the panel and reducing bending or deflection taking place.

Additional notes:

**Slide 19**



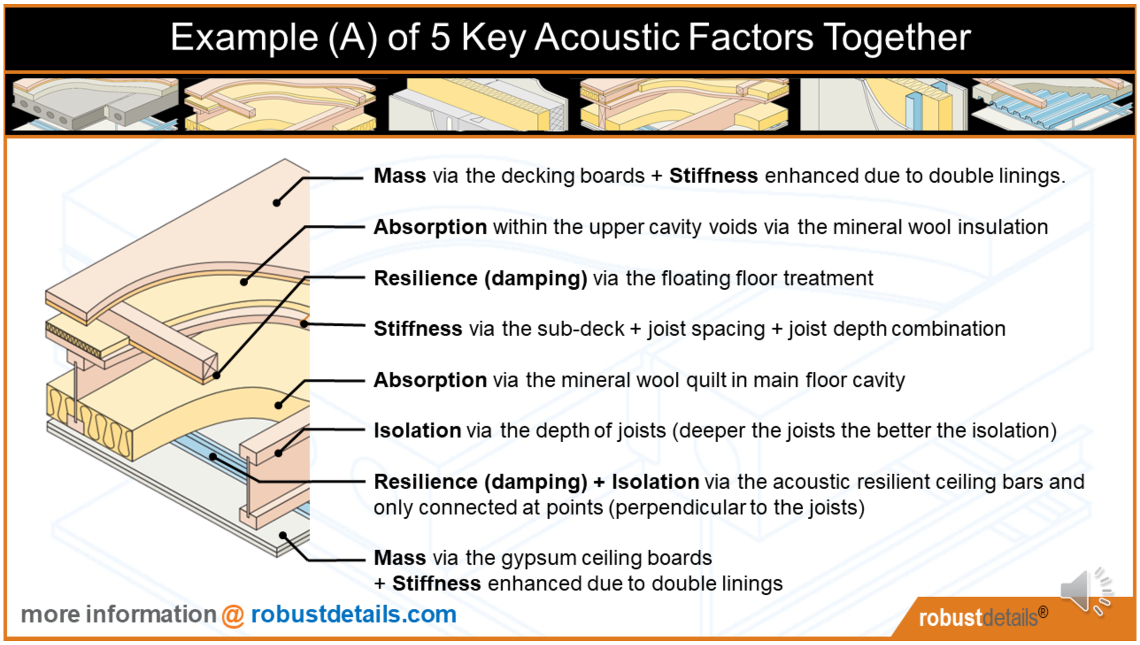

Resilience: Is the ability for materials or products to provide an effective acoustic or vibration damping. Often involving a combination of acoustic factors such as absorption and the ability to retain their shape and form, but also to dynamically absorb displacement forces. Examples include resilient ceiling hangers or resilient layers within floating floors, under-screed layers and bonded soft floor coverings, which absorb impact vibration from footfall.

Resilient lining materials convert the vibration energy into heat within the material also known as an internal loss factor. The higher the internal loss factor of a material the better the acoustic / vibration damping factor and the better vibration reduction performance.

Explanation of… diagram (A) and (B)

Additional notes:

## Slide 20

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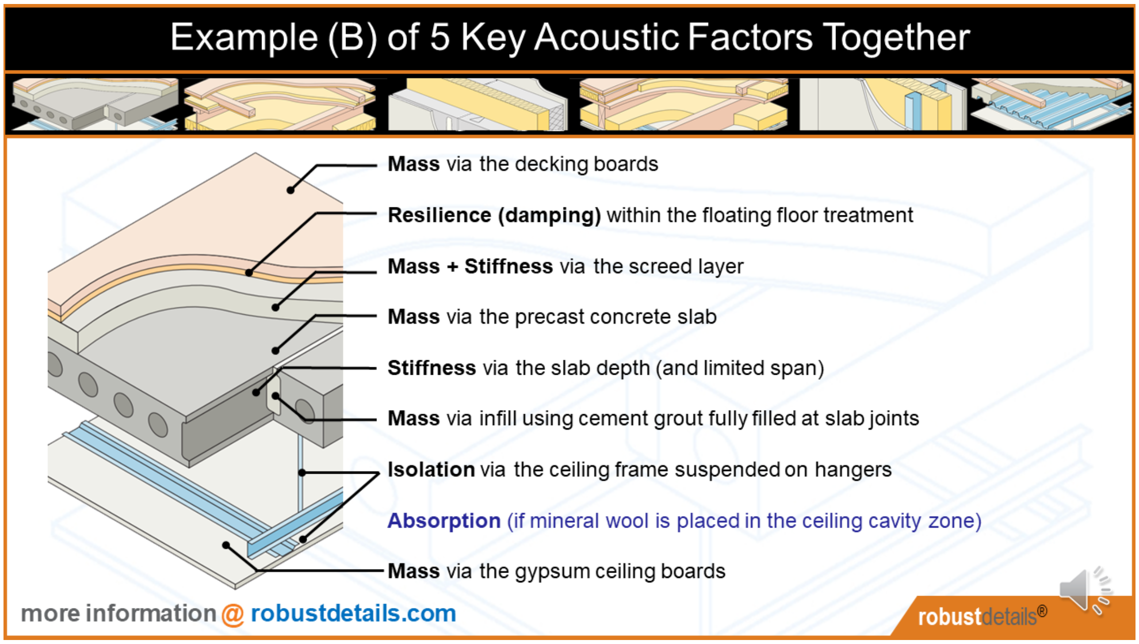
Additional notes:

**Slide 21**

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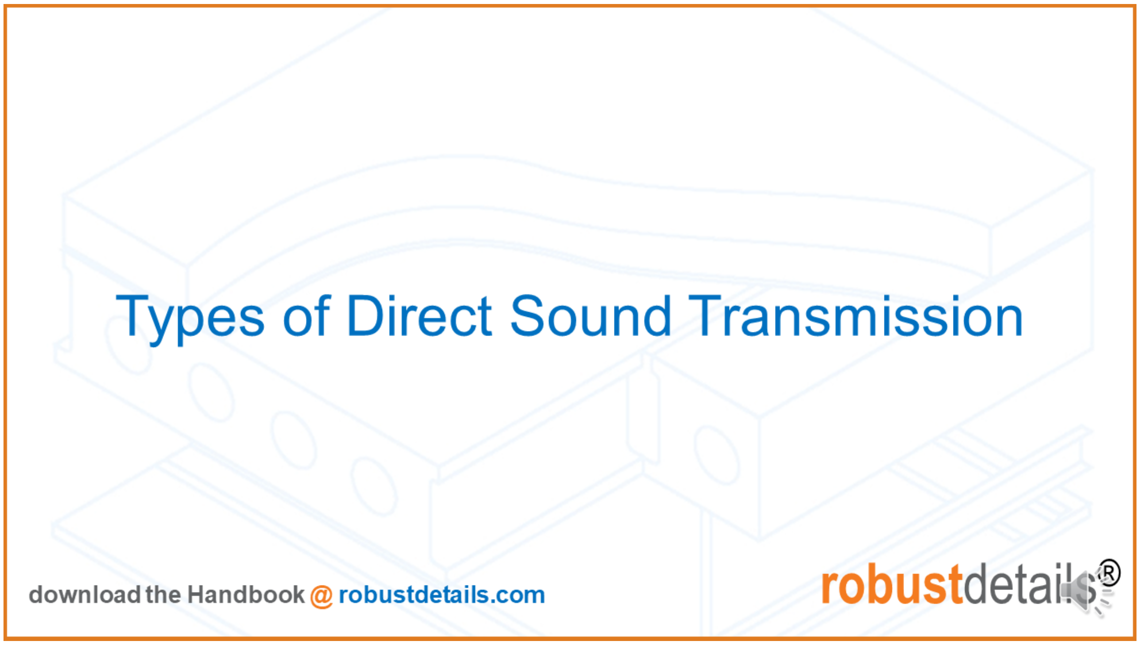
Additional notes:

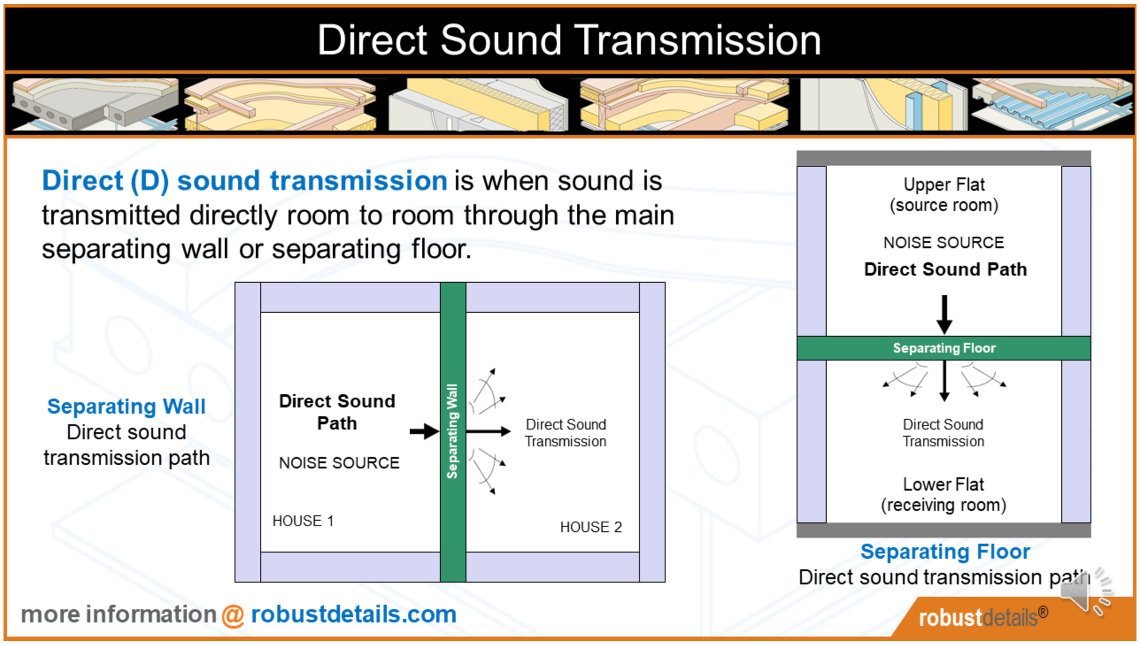
**Slide 22**




Let's now look at the types of sound transmission

Additional notes:

**Slide 23**

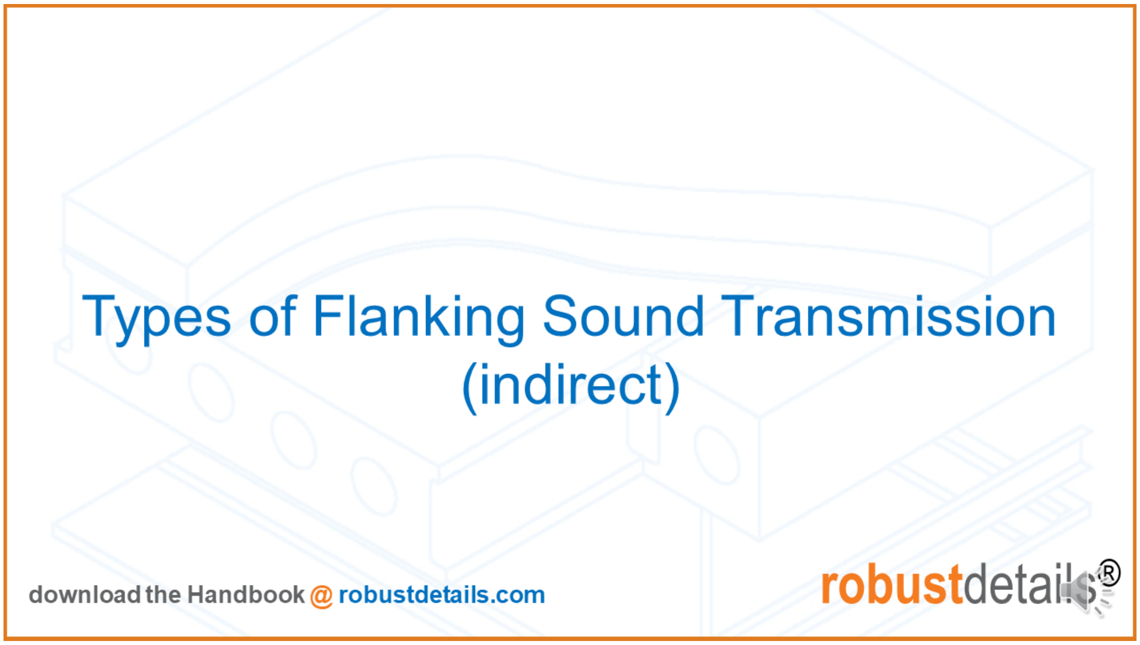



Direct (D) sound transmission is when sound is transmitted directly room to room through the main separating floor.

The diagrams shown here, for separating wall and separating floor, illustrate the direct paths.

Additional notes:

**Slide 24**

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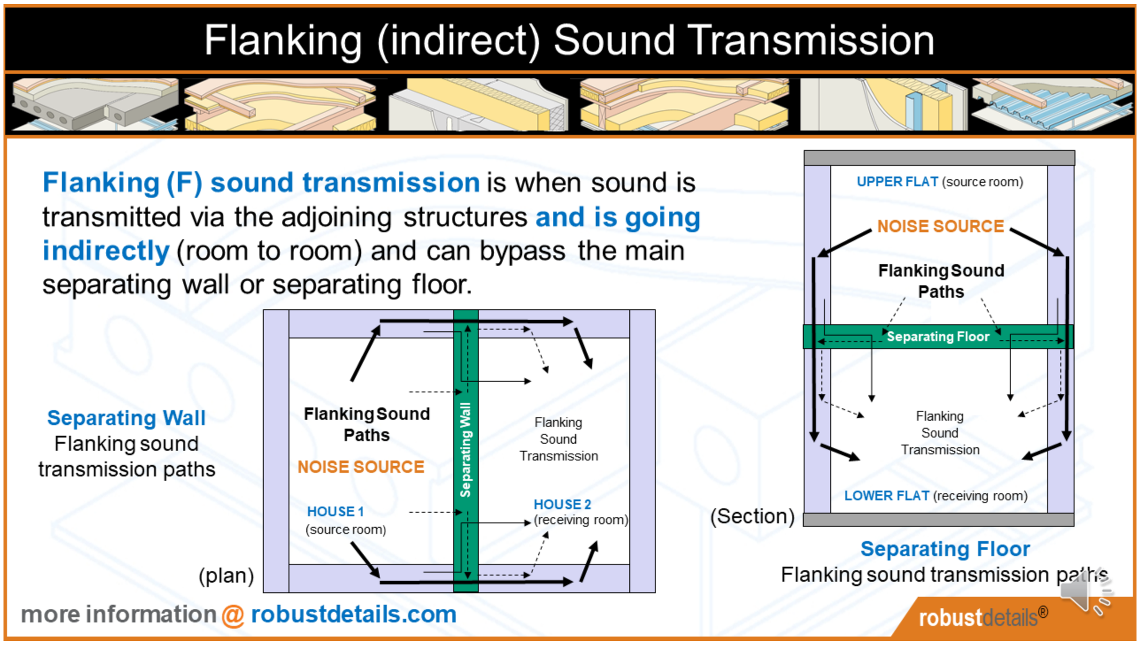
Additional notes:

**Slide 25**

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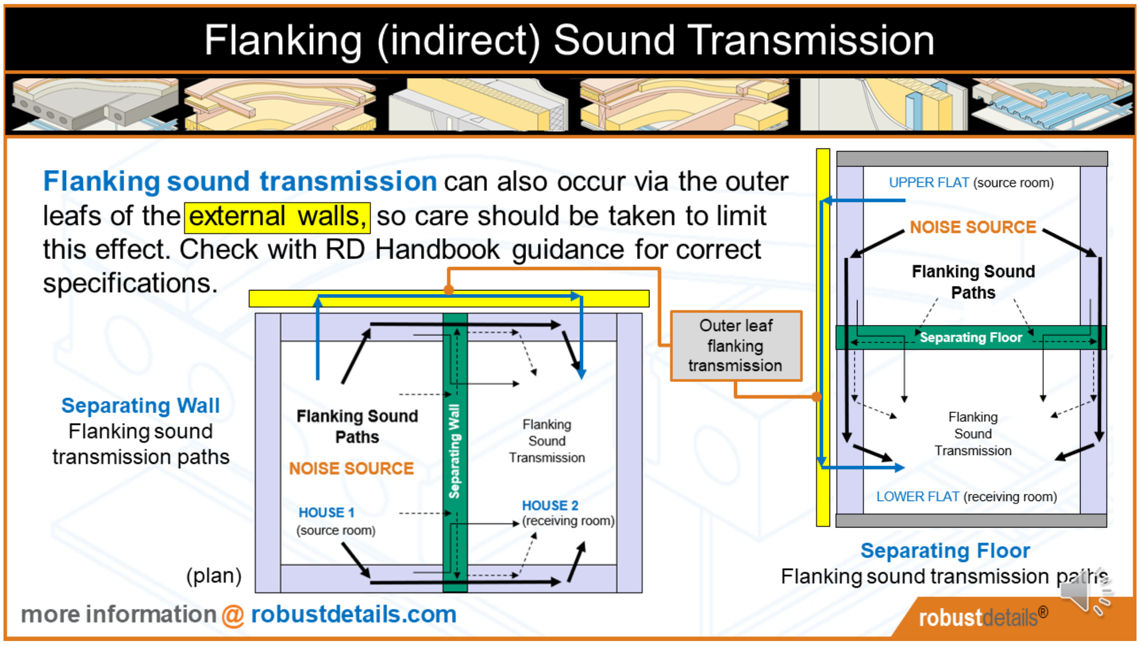
Note how many flanking sound transmission paths can occur past just one separating wall or floor.

Even for a very high performing core separating wall or floor – the flanking sound transmission can be the weak point and can be a controlling factor to achieve sufficient sound insulation.

Additional notes:

**Slide 26**

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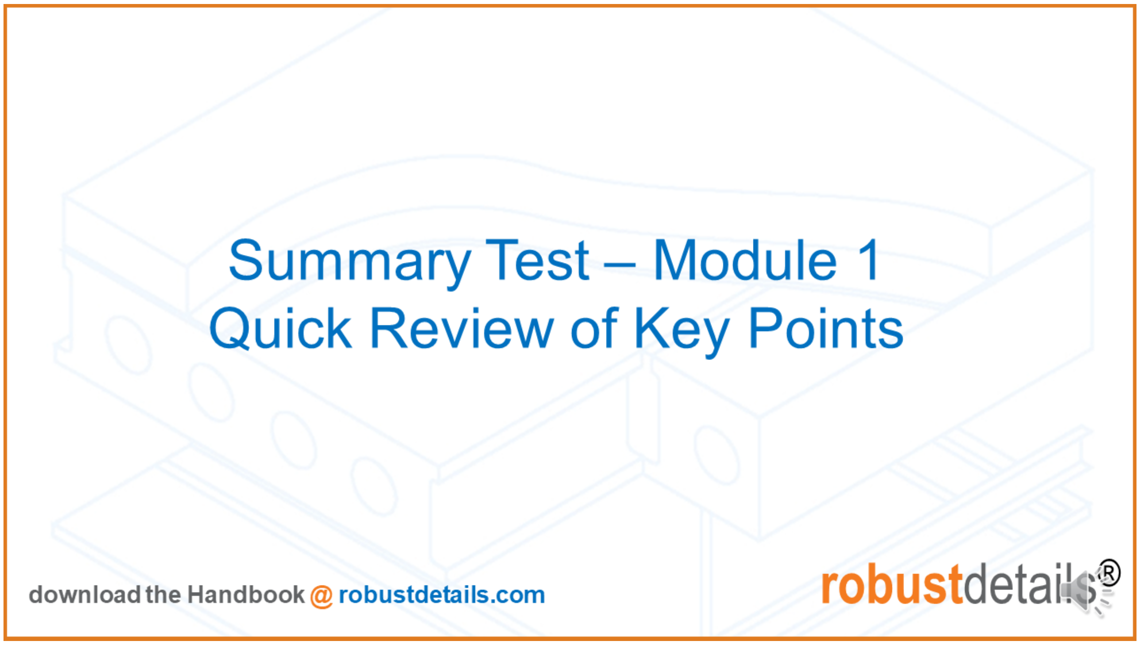
Additional notes:

**Slide 27**




Now for a quick TEST to recap on Module 1

Additional notes:

**Slide 28**

## Summary Test – Module 1

| No. | Question |
|---|---|
| 1 | What is the measurement unit for sound insulation? |
| 2 | What is the typical frequency range used across UK sound insulation building standards? |
| 3 | What is the change in sound energy for a 3dB increase? |
| 4 | When designing attached housing, should designers consider a 12hr, 18hr or 24hr household living period? |
| 5 | What are the most common home living issues affected by poor sound insulation? |
| 6 | Sound transmission is normally grouped into two main areas, linked to sound sources, what are they? |
| 7 | Do building regulations in the UK include horizontal impact sound through separating walls? |
| 8 | What are the 5 main key factors to consider when designing for sound insulation? |
| 9 | When considering the mass of a solid product, what is a key material property? |
| 10 | If the insulation thickness increases what happens to the acoustic absorption performance? |
| 11 | If the insulation product density is increased what happens to acoustic absorption performance? |
| 12 | What is the terminology used to describe sound transmission which passes only through the main separating wall or floor? |
| 13 | What is the terminology used to describe sound transmission which transmits indirectly? |
| 14 | Why are outer leaf walls important when designing for sound insulation? |

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Here are 14 questions – you may wish to PAUSE the recording and test yourself against these questions.

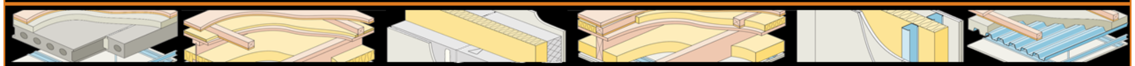
Once you have answered all of them – the next slide provides the answers.
In 10 seconds, the slide will change so press pause now if you want to test yourself first.

Thank you for following Module 1.

Additional notes:

**Slide 29**

## Summary Test – Answers



| No. | Answer |
|---|---|
| 1 | decibels (db) |
| 2 | 100Hz to 3150Hz |
| 3 | double the sound energy |
| 4 | 24hr |
| 5 | Sleep, Leisure / Watching TV |
| 6 | AIBORNE sound transmission and IMPACT sound transmission |
| 7 | No |
| 8 | Mass, Isolation, Absorption, Resilience, Stiffness |
| 9 | Mass per unit area |
| 10 | Increases |
| 11 | Increases |
| 12 | Direct sound transmission |
| 13 | Flanking sound transmission |
| 14 | They may provide sound flanking paths and reduce sound insulation performance |

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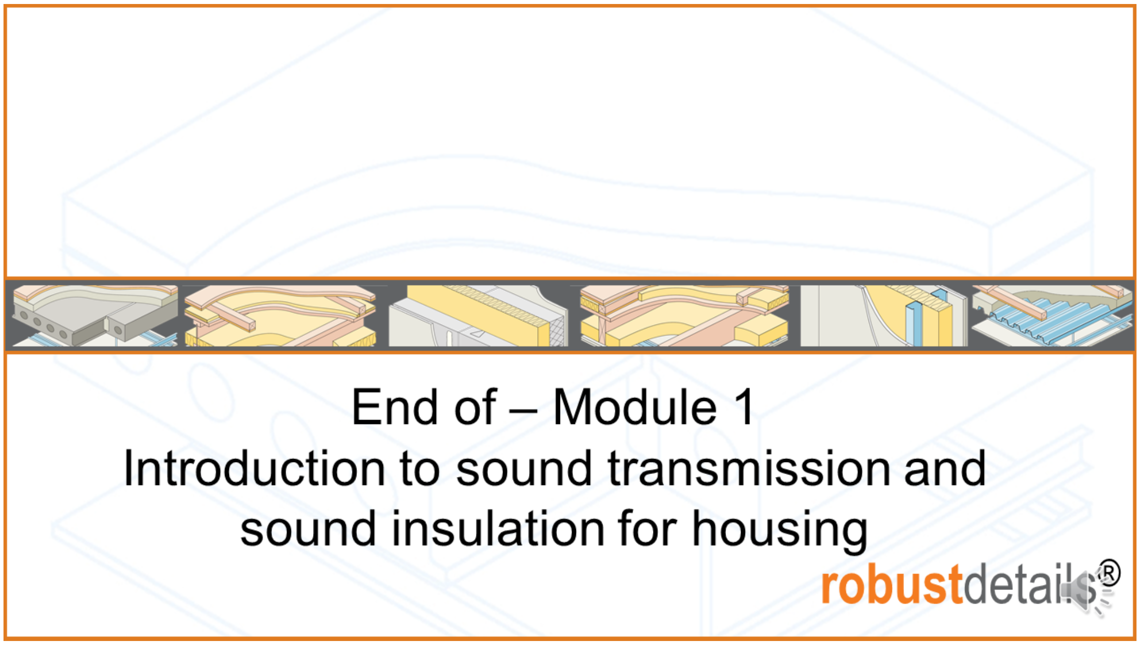
Here are the answer to Module 1's quick test.
How did you do?

Thank you for following Module 1

Additional notes:

**Slide 30**

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Additional notes:

**Slide 31**


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