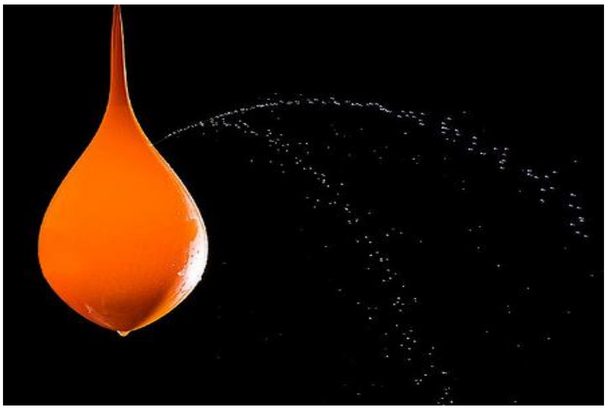
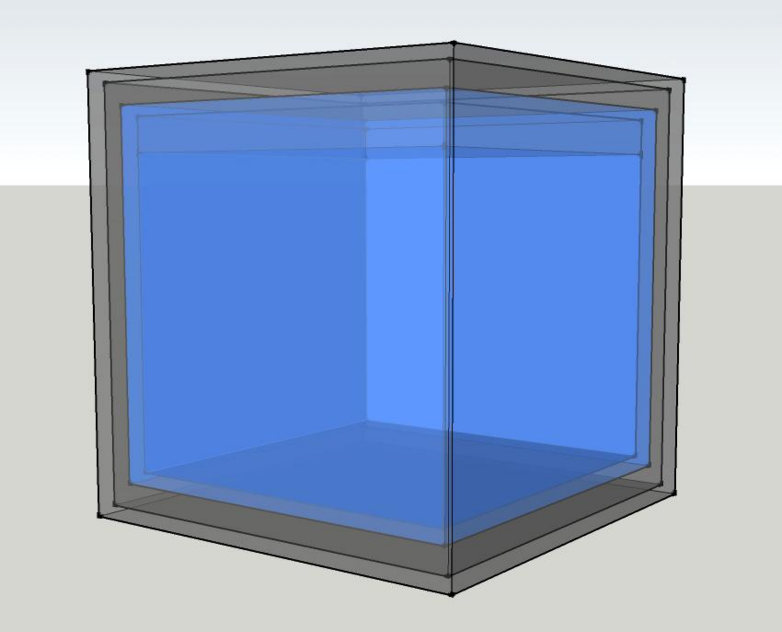
# SOUNDPROOFING

Soundproofing is the inhibiting of the passage of sound through the boundaries of a given three-dimensional enclosed space, in that acoustic energy is not able to either enter or leave the given enclosure. This treatment has nothing to do with the final quality of sound within the enclosure in terms of echoes, reverberations, equalisation or excess volume.

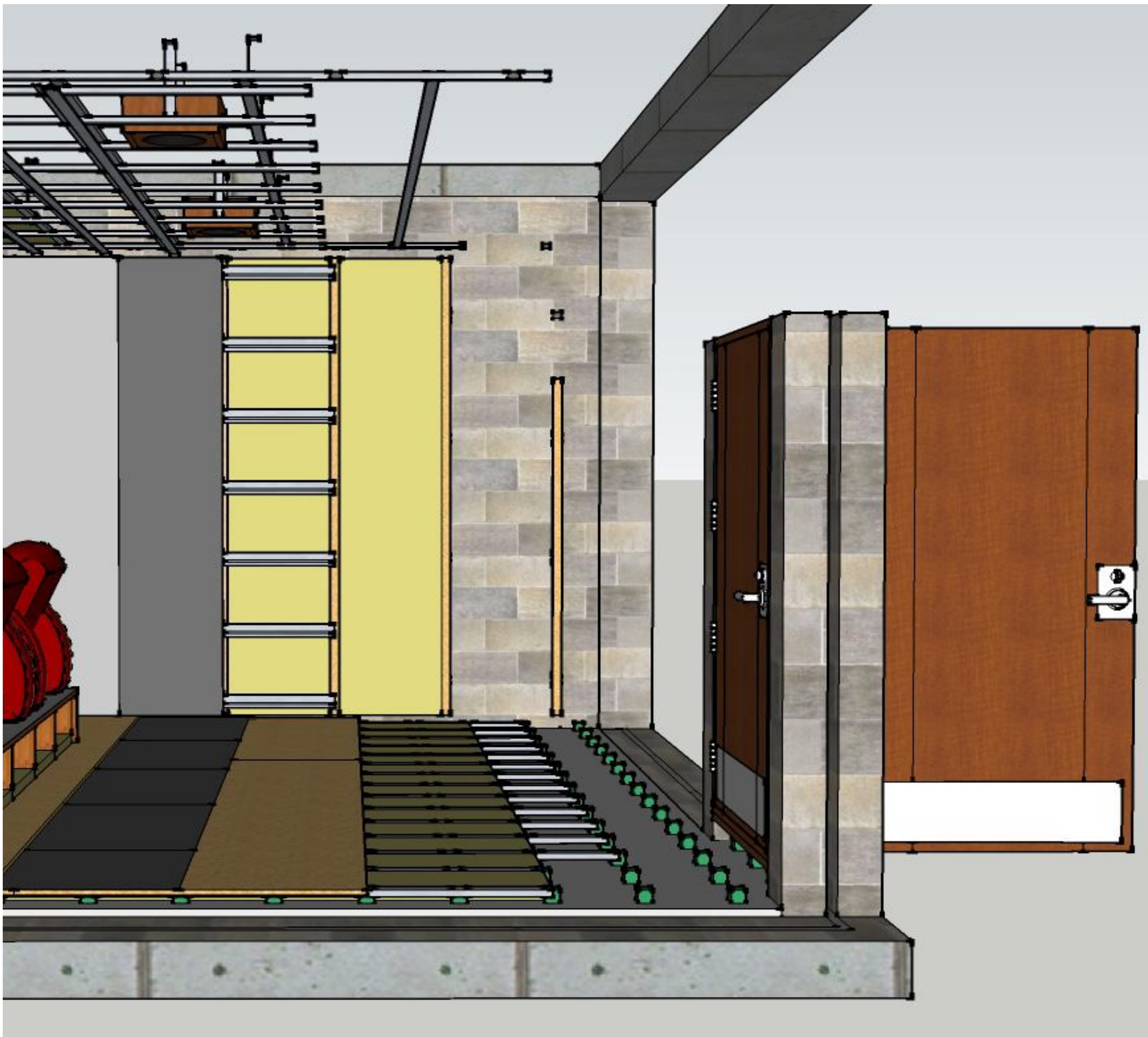


Soundproofing is an area of engineering which does not allow half-measures because it must provide a physical hermetic seal. A potentially soundproof enclosure is like a balloon filled with water - one pinhole is enough for the water to leak from the balloon. Analogically, any one part of a dividing sound barrier (window, door, floor, wall or ceiling) remaining un-treated within a given enclosure will cause global improvements to be much smaller than expected, and the end result to be un-satisfactory in terms of justification of the suffered expense.

Full scale soundproofing is attained by building a hermetically sealed three-dimensional twin enclosure within another enclosure. The inner enclosure must also be fully isolated from the outer enclosure in terms of the passage of mechanical vibrations, and should it theoretically be entirely filled to the brim with water, there should be no leakage whatsoever - not even a drop.



In situations where both soundproofing and acoustic treatment are required, soundproofing is implemented first as a sub-layer, followed by the required layer of acoustic treatment.



Example of collective soundproofing

## Noise Barrier Design

The grade of soundproofing required depends on the level of noise which needs to be blocked out. This noise level needs to be measured (in dB) with appropriate instruments. Consequently, the required soundproof barrier needs to be designed and constructed using select methods that take into account existing offending noise frequencies. Thus, for example, a partition designed to block music will carry a different design from one designed to block speech, irrelevant of dB rating.

### Misconceptions

One of the most popular misconceptions for an effective soundproof barrier is a simple rockwool-clad frame with gypsum board fixed on both sides. Think again – in most cases barring very quiet circumstances, this is not adequately soundproof, and more importantly, is not able to block low frequencies (bass)!

# Types of noise

## Airborne Noise

Airborne noise is sound travelling through air. It can be blocked by installing an adequate sound barrier between the offending sound source and the area requiring protection.

Typical airborne noise includes vehicle noise, car horns, human noise (shouting, laughing, singing etc..) sound from TV sets and other loudspeakers, sound made by small office and domestic machinery and small electric motors, fireworks, gun-shots and aircraft fly-by. The louder the noise, the higher the specification of the sound barrier must be in order to blank that noise out completely.

## Impact Noise

Impact noise is the mechanical transmission of vibration caused by an offending object impacting or directly vibrating another surface. The vibrations travel through a connecting solid and up or down walls and ceilings until they reach your domain, where they can be heard.

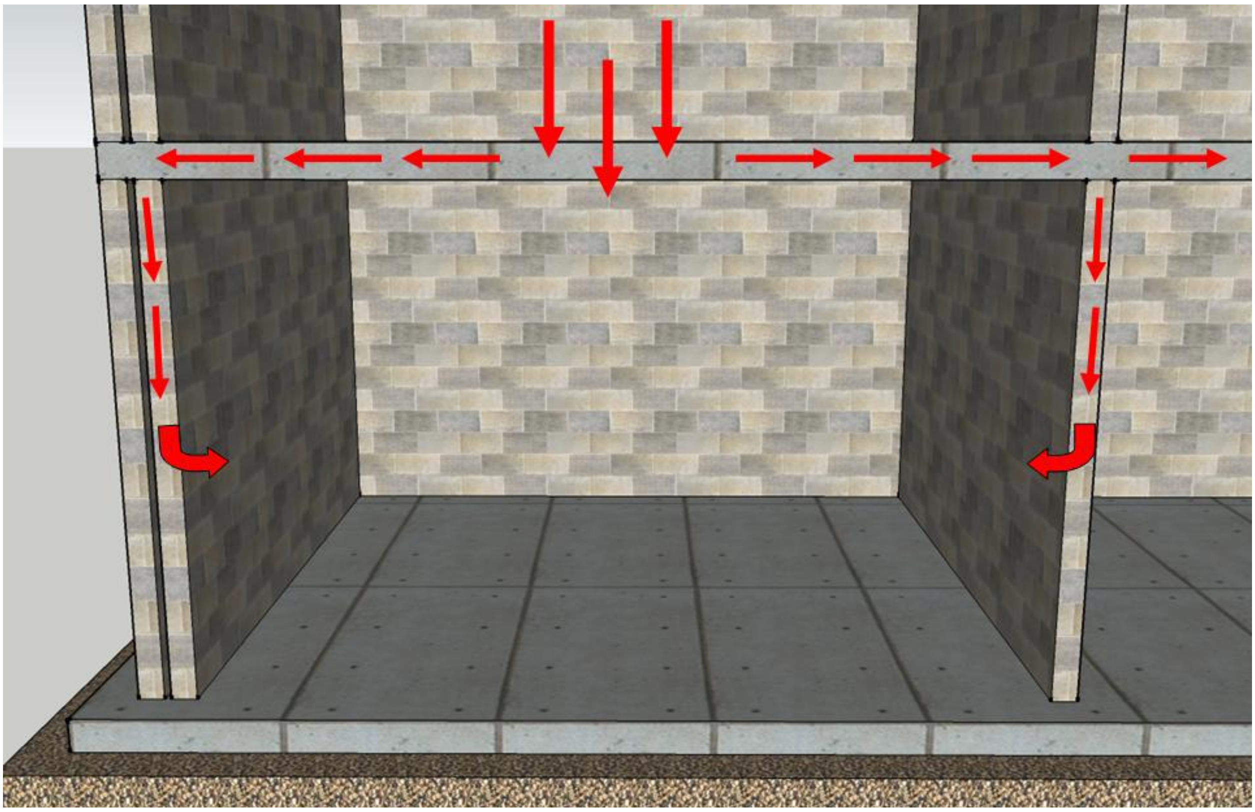
Impact noise also generates sound in air (airborne noise) because the vibrating surfaces in contact with air cause the air to vibrate in sympathy and transmit sound. This is how the sound is heard on the assumption that one's ears are not in physical contact with the vibrating surface(s), apart from the possibility of actually feeling the vibrations should the impact noise be extensive.

Impact noise is ideally addressed by architecturally designing a building which stops the transmission of vibrations. If the building shell is not designed accordingly, it is almost impossible to eliminate this kind of noise completely, though varying improvements can be made depending on the gravity of the situation.

Typical impact noise includes nearby passage of heavy vehicles (large trucks, trailers, trains etc..) , jumping or walking on a floor with heels, moving of heavy furniture, use of hand tools impacting a surface (hammers, drills etc..), percussive instruments (bass drums, toms etc..), nearby heavy construction machinery (jack-hammers, jiggers etc..) service units (pumps, generators, chillers, power transformers, etc..) and other heavy industrial machinery installed directly to a surface with improper shock absorbtion.

Very loud, low frequency soundwaves (bass) can also cause floors and walls to vibrate, causing audible impact noise.

## How impact noise travels in a non-noise-protected building



## The Golden Questions

Q. Am I going to eliminate impact noise completely by just soundproofing one wall or ceiling from where I think the sound is originating?

A. No. There will be an improvement, but you will not eliminate impact noise completely. The noise travels as a mechanical vibration through all unprotected connections between all walls, ceilings and floors. These other (untreated) surfaces vibrate and transmit sound to air.

Q. I can't live with it! Is the only radical solution to soundproof the whole room and fit soundproof doors and windows?

A. Yes – in an un-protected building this will give you a 90% solution

Q. It's too expensive – what can I do?

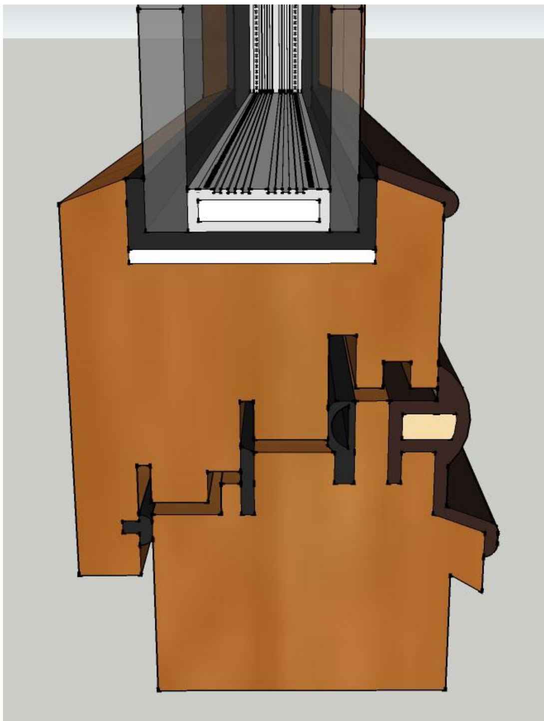
A. Impact noise eventually translates into airborne noise at some point. Work on the airborne noise first. This usually means your apertures (doors, windows and ventilation outlets), especially those overlooking a shaft.

## Common causes of inadequate noise-control

### Windows

Poorly fitted windows and windows unable to provide an air-tight seal on closure are subject to air leakage and are therefore poor soundproofing peformers. Also, lack of proper glazing using the proper glass considerations, improper gaps between glazing, and most commonly, inadequately manufactured frames all cause considerable degradation to soundproofing specifications.

** More information about soundproof windows can be obtained from the soundproof windows product page.



Example of soundproof window 46dB, triple seal, 20 Argon

As soundproofing and energy efficiency techniques with regards to window design have a lot in common, soundproof windows are also energy efficient.

### Doors

Doors which are unable to provide a proper seal (that includes the gap between the bottom of the door and the floor), and which do not contain the required mass to stop soundwaves travelling right through them are poor soundproofing performers, irrelative of the material used within the door shell..

Soundproof door single leaf with mass-loaded impact elastometer sheet

Double drop seal in type III single leaf soundproof door

** More information about soundproof doors can be obtained from the soundproof doors product page.

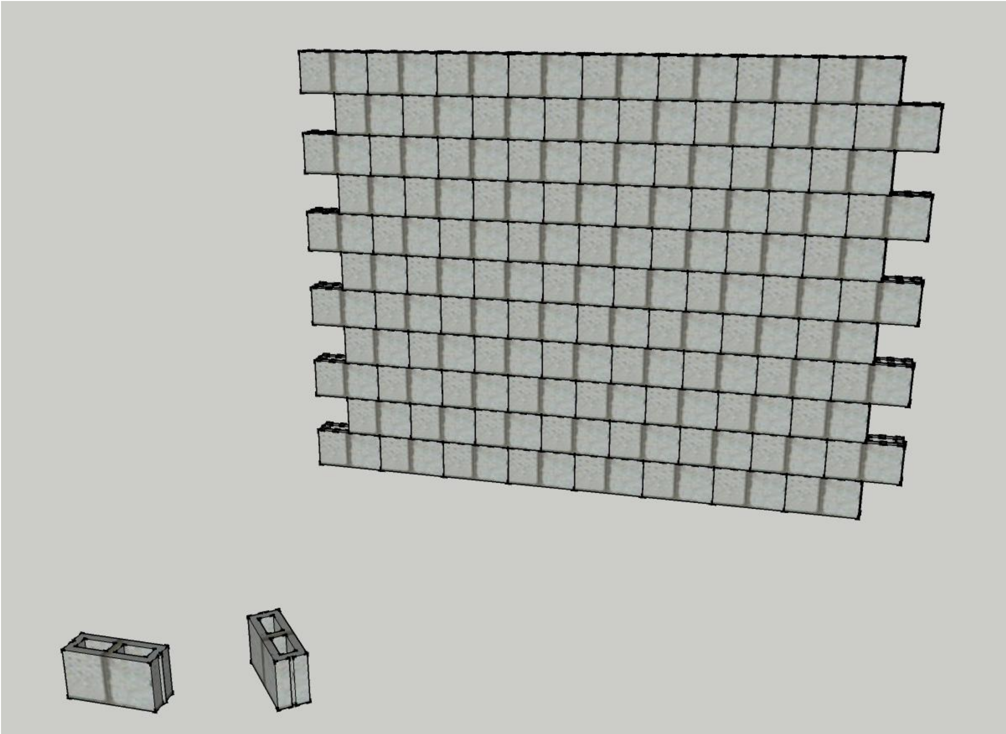
## Partitions

Partitions using materials which are inadequate on their own, single gypsum layers, lack of de-coupling, un-damped mechanical connections between opposite faces or the wrong type of framework for the job are poor soundproofing performers. Also, partitions which only come up to the soffit ceiling and not to the real ceiling will not work as the sound will travel across rooms through the soffit ceiling - (this is called flanking noise). In addition, the workmanship and installation in this case carry the greatest weight over the final result, irrelevant of the materials used.

** Mineral fibre cladding (sometimes referred to as Rockwool) is not a great performer in soundproofing applications because it lacks substantial mass. It must work alongside other key-player materials such as shock absorbers and de-coupling spring mounts. Correct choice of cladding is also a key issue in view of increasing variations of specifications exhibited by similar products, some of which are more tuned to address thermal performance rather than sound absorbtion.

## Walls

Inadequately constructed walls also exhibit a relatively much poorer soundproofing performance than expected. The amount of sound attenuation provided by a wall varies immensely according to factors below:



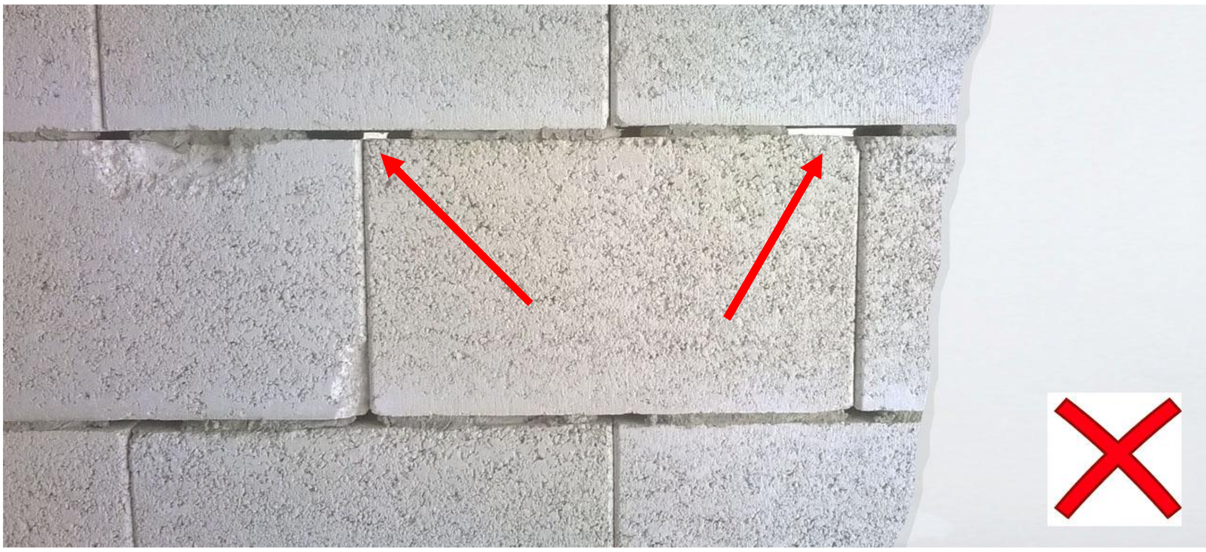
- What is the wall made of? Concrete bricks, stone blocks or a combination of both?
- Is it a single or a double wall?
- What is the width of the concrete brick or stone block used in this wall?
- What is the type of stone used, or the grade of concrete or aggregate used to constitute the brick?
- If it’s a double wall, then what is the width of the air-gap between the two walls?
- If it’s a double wall, has the gap between walls been left clean or has any excess material been spilt into the gap? It’s no use having a double wall if mechanical vibrations can still travel through the central air-gap via the debris in between the two single walls.
- If it’s a double wall, are there any connecting cross-over bricks or stone blocks between the two walls or are the two walls un-connected and mechanically isolated from eachother?
- How large or small are the hollow sections within the concrete bricks and what is their layout?

- Are the hollow sections within the concrete bricks filled in or left empty?

- If the brick hollow sections are filled in, what is the material used for filling and how densely has it been packed?

**And below is the most serious issue of all:**

- Have all seams between adjacent bricks been carefully filled in with the correct material BEFORE final plastering of the wall, or has the final plastering been applied directly over existing open seams between bricks? Hand-mixed (un-compressed) plaster has no soundproofing propeties whatsoever. In the latter case you will most probably hear your neighbour's TV and their baby crying!



Plaster applied directly over brick wall with open seams

Plaster applied over brick wall with carefully sealed-off seams

- What kind of material has been used for final plastering? Plain cement tends to crack over time. Once there’s a crack, you have a problem.

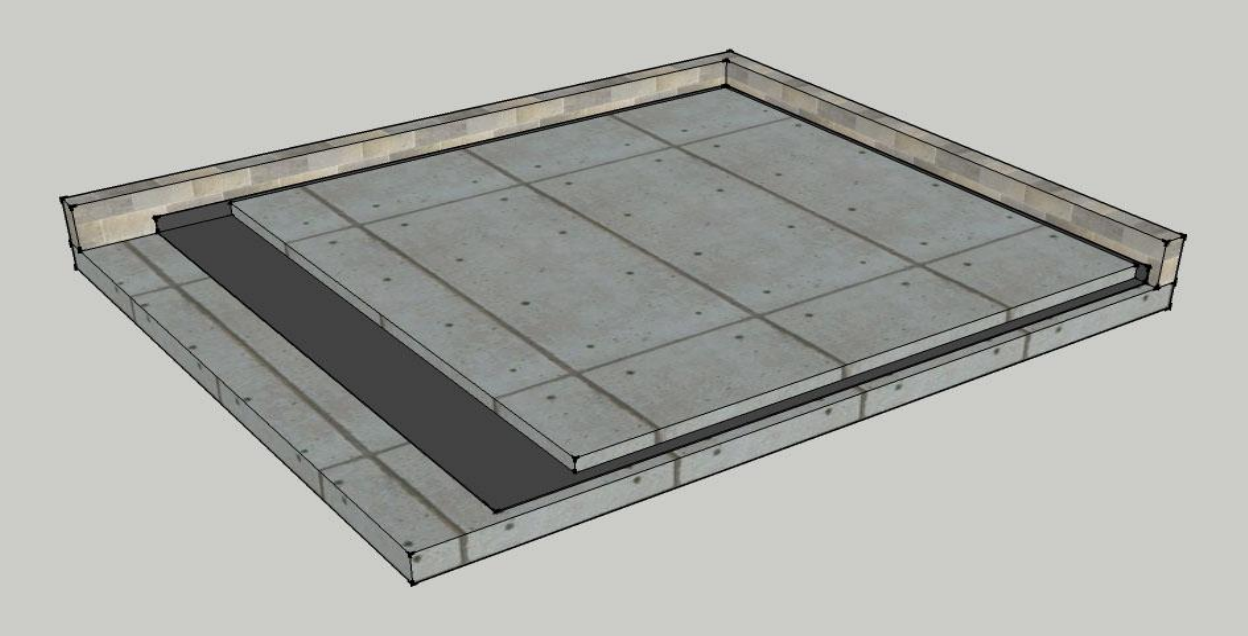
- Within what frequency bandwidth is the primary sound attenuation required?

Many websites tend to quote c45dB for a single concrete brick wall and c55dB for a double wall. These values are unsubstantiated as they take too many factors for granted. It is also worth noting that most of the available tests producing such results are carried out with brick widths which are larger than the ones available and used locally. In reality, the sound attenuation of a “concrete brick wall” can vary between 30 and 60 dB, depending on all of the above variables. 60dB is roughly 32 times more sound attenuation as compared to 30dB. All these factors will determine whether and what kind of additional soundproofing framework is required to be added to an existing wall structure depending on the specification to be attained, this being defined by the specific use of the room and the maximum noise levels within it and / or outside it.

**Floors**

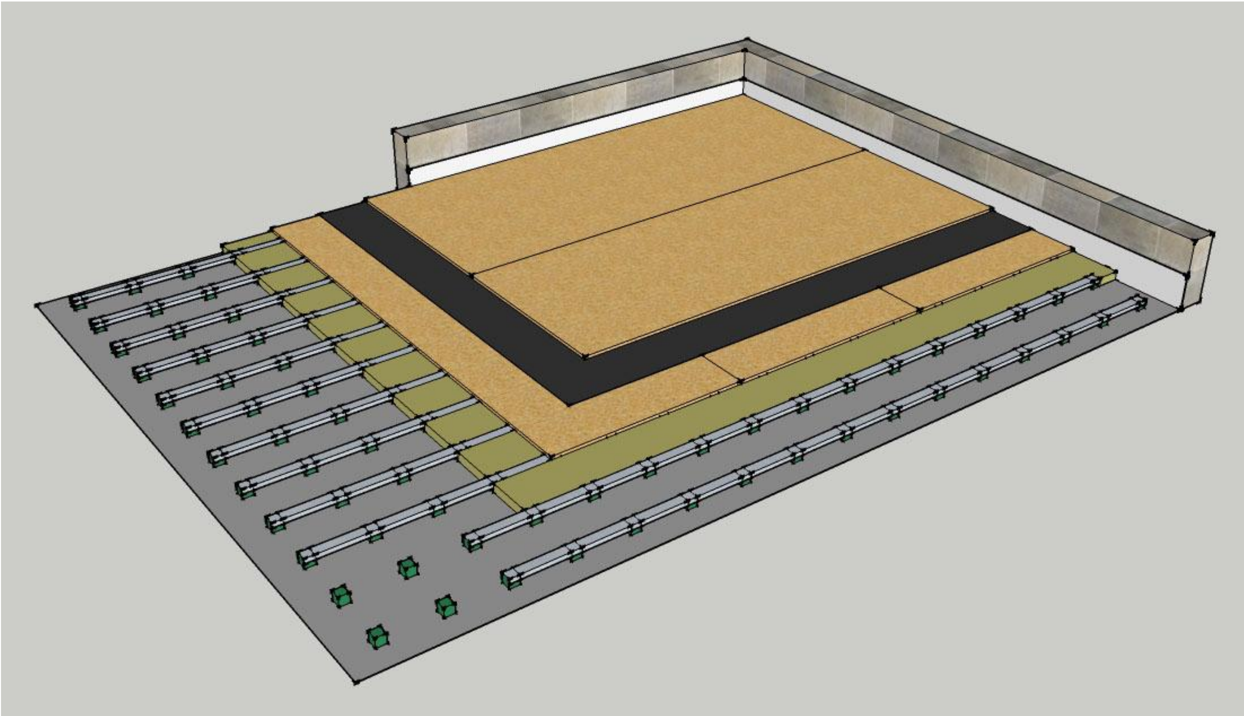
Un-treated floors are often susceptible to impact noise especially if they are above the ground-floor (or basement). In most cases this issue can be treated acceptably, though one must keep in mind that nothing beats a floor in a well pre-designed building such as (a) below.

a) Structural soundproof floors - (sub-concrete elastometer barrier)



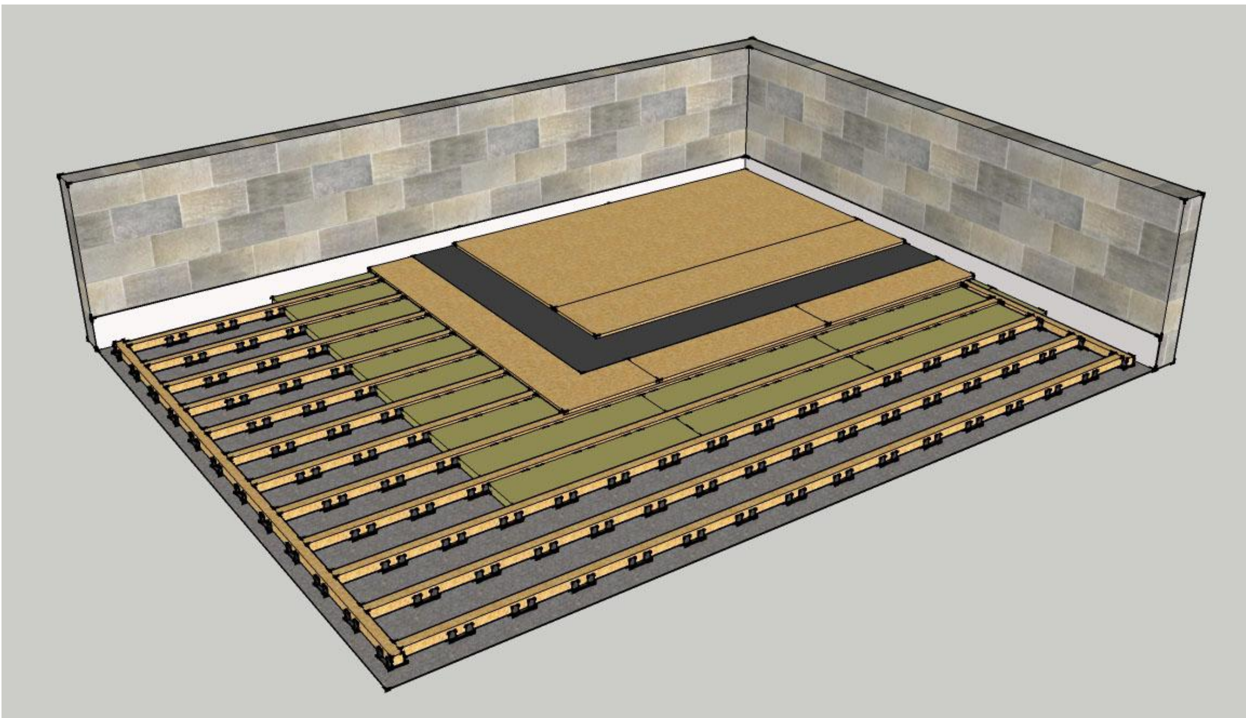
Structural soundproof floor

b) Suspended (floating) floors – high impact



Example of suspended floor (high impact)

c) Suspended (floating) floors – low impact

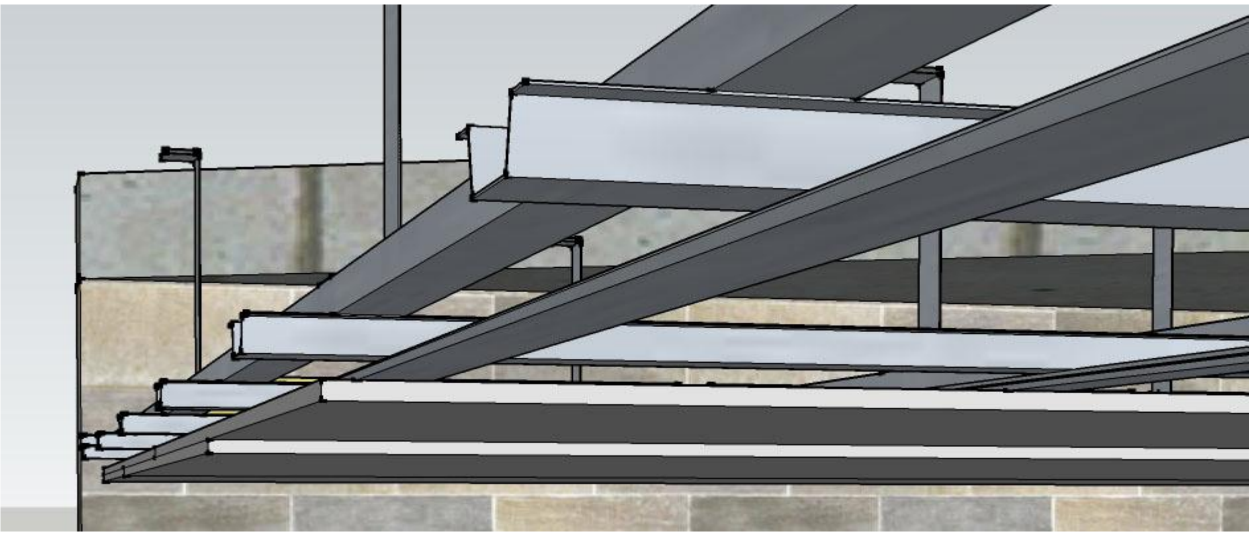


Example of suspended floor (low impact)

Suspended floors are able to absorb a lot more impact noise than acoustic floors, but they are more costly.

**Ceilings**

Ceilings are commonly candidates for acoustic treatment, however in cases where loud sound dominates the room, soundproofing will be required. Soundproof ceilings also help to fend off impact noise originating from floors above.



Soundproof ceiling showing gapping springs below furing and shock-mounted ceiling support

Interaction of soundproofing assemblies

The way individual soundproofing assemblies (floors, walls and ceilings) interact with eachother at points of intersection or joining make a big difference to the final result, and this is highly dependent on the workmanship of the installer.

**What you need to know**

Soundproofing is achieved by means of the following techniques:

1. **Mass – (Sound Barrier Contribution – 30%)**

Any solid object that is thicker and heavier will block more sound. Drywall (gypsum) and heavier soundboard and mass-loaded vinyl are examples of good soundproofing materials that use this property. This approach is mostly effective against airborne sound such as voices and TV’s, and not so useful for impact noise such as banging or footsteps, which are transmitted primarily through the building structure.

## 2. Damping – (Sound Barrier Contribution – 20%)

Tap a wine glass with a fork, and it will ring. Clamp it with your fingers, and the sound abruptly stops — that's the effect of damping. In soundproofing, damping is accomplished with damping compounds such as viscoelastic mastics, vulcanised rubber sheets and sponge-rubber waffles. The special property of damping compounds is their ability to convert sound energy into heat, so that the sound abruptly stops, as with the damped wine glass.

For a damping compound to work, it mostly needs to be applied between two stiff structures (drywall, plywood, or concrete screeds, for instance), which are then together forming a Constrained Layer Damping system. When sound hits the system, it causes shearing forces between the stiff panels which create friction in the damping layer, thus converting the sound energy into heat.

Damping is the most effective of the four elements against low-frequency noise, such as the booming bass beats of music or noise from construction machinery.

## 3. Decoupling - (Sound Barrier Contribution – 45%)

Sound is always transmitted mechanically through the building structure. With decoupling, gaps are introduced into parts of the structure, preventing the sound vibration from continuing along on its path. Decoupling is most easily accomplished during a building's construction, for example by staggering stud beams so that the two wall panels are supported by two different sets of studs, rather than having both walls use the same studs and thus being connected by them.

Decoupling can also be incorporated later, using gapping springs and de-coupling shock-mounts, allowing the outer spring-loaded visible surface to vibrate and absorb the sound by converting audible energy into kinetic energy (motion) and heat. Lack of de-coupling is the most common reason for failure of soundproof barriers.

## 4. Absorption - (Sound Barrier Contribution – 5%)

Absorption does have a role to play in soundproofing, but it has the least effect of all of the four elements. Acoustical ceiling tile and loosely packed acoustic insulation (such as Rockwool) are examples of good sound absorbers, and they provide a very small measure of additional soundproofing within a sound barrier.

**For best results, a soundproof structure needs to incorporate all four principles**

Soundproofing needs space, which will result in some trade-off on existing room length, width and height. Architects and designers should consult with soundproofing specialists to determine the space required by the necessary soundproofing (and/or acoustic treatment), prior to construction of a new enclosure and/or internal design of an existing enclosure. Best results are obtained when soundproofing is carried out at the construction stage. Once the building is ready to move into, options are available, but fewer, more limited and more costly unless you consider making changes to the structure.

There is no such thing as a standard soundproof barrier. The sound reduction of a given barrier needs to be rated accordingly in excess of the offending noise source to be blocked. It is quite normal, for example, to have localised partitions of different ratings in the same building, according to the particular noise levels exhibited by different rooms.

Unlike issues with visual interiors where you can probably find an acceptable work-around if a designer presents you with an expensive solution, a calculated dB rating required to provide a soundproof barrier for a particular scenario is what it is and cannot be bypassed. If you need “x” dB of soundproofing, budgeting for a cheaper “y” dB sound barrier where y is less than x means you will reduce the noise but not block it out completely.

Soundproof barriers must provide a full hermetic seal between the noise source and protected area. If there is as much as a crack or a pinhole anywhere, sound will leak through.

Every difference of 6dB in soundproofing specification effectively means double the soundproof barrier. Therefore for example,  a 42dB partition provides double the soundproofing capability that a 36dB partition provides. Conversely, a difference of 12 dB (6 + 6) is four times the soundproofing capability (2 x 2), a difference of 18 dB (6 + 6 +6) is eight times the soundproofing capability (2 x 2 x 2), and so on…

Mounting of an x dB soundproofing structure to an existing y dB wall, ceiling or floor, does NOT achieve x + y dB, but a lot less, reason being that the trapped air in the (relatively small) gap between one structure and another tends to compress and transmit some of the sound. In order to be able to happily add the separate ratings to produce a result of x + y, you need to have at least between 1 and 1.5 metres spacing between the two structures. In all but a few cases this is not practical.

The performance of a soundproofing structure deteriorates as audio frequency gets lower. That’s why when you walk outside by a poorly treated night-club, all you can hear is bass.

The actual installation of soundproofing is a very delicate issue and is responsible for the larger part of the final performance of any soundproof barrier. Meticulous workmanship, good training and knowledge of how individual soundproofing materials are assembled into the required structure are critical to the final result. It goes all the way from what is in contact with what, correct spacings between adjacent materials and spring mounts according to the particular application, right down to which screw lengths are used, where to use them, what they should and should not hold together and proper sealing of each individual layer before the next layer is applied.