

TATA STEEL



Colorcoat® Technical Paper

Acoustic performance of pre-finished steel cladding systems



ACOUSTIC DESIGN

Tata Steel has been developing and manufacturing the Colorcoat® range of pre-finished steel for metal building envelope systems, for nearly five decades. Whilst much of this advice focuses on low-energy design, the building envelope also plays a vital role in providing the acoustic performance of a building.

Pre-finished steel cladding systems can form the basis of an acoustically high-performing building envelope. The actual requirements will be building-specific, but where improvements are needed over the standard systems there are some simple guidelines that can be followed. The guidance given here will help building designers to achieve the optimum acoustic performance from their building envelopes.

Working together to provide guidance

For nearly 50 years, Tata Steel have developed close strategic relationships with some of the leading roof and wall cladding system manufacturers. In developing the guidance included in this Colorcoat® technical paper, Tata Steel worked together with CA Group, Eurobond and Euroclad.

This close involvement with some of the leading suppliers of cladding systems ensures that the guidance given here represents the industry best practice and that any one of these supply chain partners are in a position to provide bespoke assistance with specialist acoustic requirements.

Contents

Overview	3
Sound and noise	4
Principles of acoustic performance	7
Laboratory testing	9
Effect of construction on acoustic performance	12
Single skin systems	12
Built-up systems	13
Factory insulated composite panel systems	19
Summary and conclusions	21
References	22
The Colorcoat® brand	23

Overview

Many buildings need some form of acoustic control to meet specific customer and building regulatory requirements. Pre-finished steel cladding systems offer acoustic solutions which can be designed to provide a building that:

- Gives a high level of sound insulation to stop noise break-in or break-out of a building.
- Provides sound absorption to control the level and quality of noise within the space using perforated liners and sound absorbing insulation.
- Provides effective control from the impact of noise on the roof from rain.

Tata Steel has worked closely with CA group, Eurobond and Euroclad to assess the performance of pre-finished steel cladding systems and how their performance can be enhanced to meet specific acoustic requirements. This Colorcoat® technical paper contains the results of an extensive acoustic testing programme carried out in collaboration with these supply chain partners.

This guide has been prepared to give advice to architects, designers and other construction professionals on the wide range of acoustic

solutions available when using a pre-finished steel building envelope and demonstrates the steps that can be taken to improve the acoustic performance of buildings. Whilst guidance is given, the actual performance of a specific construction on a specific building will be very individual.

It is important to consider acoustic performance at an early stage in the design process and more detailed advice about a particular project can be sought from any one of the supply chain partners listed above.

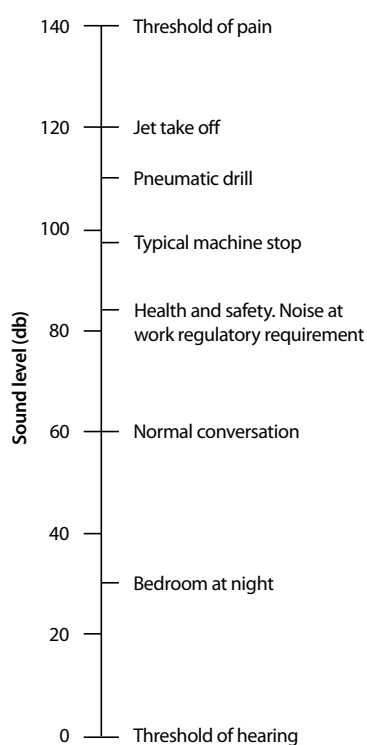
Sound and Noise

Sound is created when objects vibrate in air. The vibrations generate a pressure disturbance, which propagates through air as a wave.

The range of pressure disturbance is extremely large ranging from the threshold of audibility to sounds which are painful and can cause permanent damage to hearing. Due to this very large range, sound is measured using a logarithmic scale. The manner in which humans perceive sound governs the way it is measured and described. Two important characteristics of sound, which humans can detect, are:

- The level or loudness.
- The pitch or frequency.

Figure 1. Typical sound levels for different activities



Sound levels or loudness are expressed in decibels (dB). The decibel rating is a representation of the intensity or volume of the sound. The intensity of the sound depends on the pressure level and can be accurately quantified by a sound level meter. It should be noted that the decibel scale is logarithmic. The addition of two 100 dB sound sources, will generate approximately 103 dB.

Pitch or frequency is expressed in Hertz (Hz). The human ear can detect sounds within the frequency range 100 Hz to 3150Hz.

Noise can generally be described as unwanted sound, which can be annoying, can interfere with normal activities, and can sometimes be harmful.

Sound insulation is the ability of a material to resist the passage of airborne and impact sound. Effective sound insulation is an essential requirement for modern life styles. Excessive noise can increase stress, hinder speech and cause its own form of pollution.

Control of Noise at Work Regulations 2005¹ require that for processes where the noise level is:

Above 80 dB hearing protection should be available to all employees.

Above 85 dB hearing protection is mandatory for all employees.

Sound and well being

The aural environment can have a profound effect upon how people react and perform in a space. Noise, or unwanted sound, can of course have physiological effects if exposure is above a certain level and/or is prolonged, causing hearing damage such as full or partial deafness.

However in buildings, poor 'aural comfort', analogous to thermal comfort, relates much more to presence of sounds perceived to be a nuisance, as well as to the quality of sound in the room. Nuisance sounds can have psychological effects, such as stress, upon the occupant as well as make tasks that rely upon hearing more difficult to perform. Stress can affect concentration and productivity at work, can impair relaxation in the home, and can have long-term health implications if severe.

The field of psycho-acoustics is complex and reliant upon subjective assessments. For example, the current limits for airborne and direct sound transmission in dwellings are the result of extensive social surveys. Aural comfort depends upon many factors, including the individual, the frequency and level of the sounds, the purpose of the building, the nature of the tasks being performed, interior and exterior background noise, and the time of day. Much depends upon the expectations of the individual as to the desirable aural environment for the activity undertaken, and the degree of control which the individual can exert over this. A sound level of 110dB may be acceptable in a machine shop, but an inconsiderate neighbour playing music late at night can prevent sleep and be a cause of stress.

Good acoustic design, appropriate for the purpose of the space, can mitigate many of the problems that might otherwise be experienced. In practice this involves use of sound barriers and absorbers to reduce noise transmission and reflection, and blocking of flanking sound paths between spaces. To promote good wellbeing for occupants the aural environment should be appropriate and in line with expectations for the use of the building.

Noise in buildings

When considering the acoustic performance requirements of a building, there are a number of criteria to consider.

1. Airborne noise.

Internal process noise break-out, e.g. a factory in a residential area; or external noise break-in, e.g. airport terminal buildings.

2. Impact noise.

Rain impact, mainly on roofs, e.g. schools and sports halls. The building designer may also consider the effects of driven rain on wall elements.

3. Internal noise reverberation.

The way sound waves are reflected and absorbed will affect the overall noise level in the building and the clarity of sound within the building.

4. Flanking.

Sound transmitted between two areas by indirect paths, particularly around adjoining walls.

The structure of the building walls and roof can be engineered to modify the level to which the sound energy will be:

- Reflected back into the building.
- Absorbed within the structure.
- Transmitted through the structure.
- Consideration should also be given to elements within the cladding such as glazing and rooflights, which may have a reduced performance.

Direct and flanking transmission

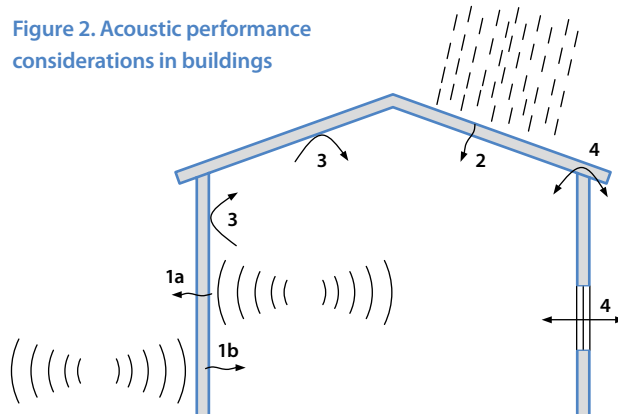
When two areas are separated from each other, sound can travel by two routes:

firstly directly through the separating structure called direct transmission; and secondly around the separating structure through adjacent building elements called flanking transmission.

Sound insulation for both routes is controlled by the following three characteristics:

- Mass
- Isolation
- Sealing

Figure 2. Acoustic performance considerations in buildings



Key

- 1a/1b: Airborne sound transmission
2: Rain impact noise transmission
3: Reflection/reverberation
4: Flanking

Figure 3. Acoustic performance factors

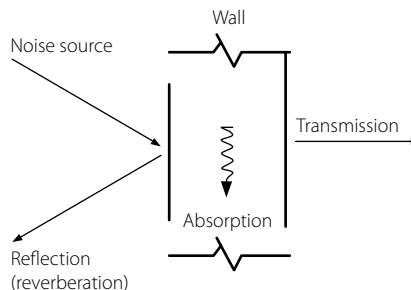
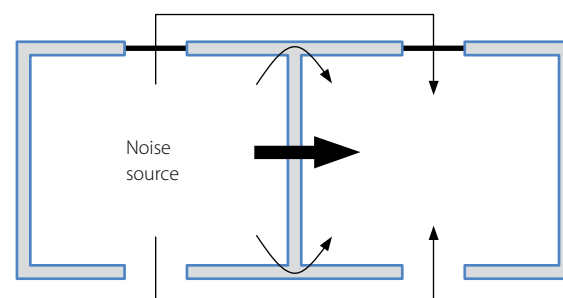


Figure 4. Direct and flanking transmission between areas



Key

- Direct transmission
→ Flanking transmission

Direct transmission depends upon the properties of the separating wall or floor and can be estimated from laboratory measurements. Flanking transmission is more difficult to predict because it is influenced by the details of the junctions between the building elements. It is notable that, in certain circumstances, such as where separating walls have a high standard of acoustic insulation, but side walls are constructed to lower standards and are continuous between rooms, flanking transmission can account for the passage of more sound than direct transmission. Therefore, it is important that the junctions between separating elements are detailed correctly to minimise flanking sound transmission.

When considering the acoustic requirements and noise levels within a building, there are a number of simple steps, which can be taken:

1. Internal equipment specification

The noise levels generated by the process should be included in the process equipment specification. The noise generated by different manufacturers equipment, may vary significantly.

2. Sound reduction at source

The use of sound deadened structures and acoustic cowling around noise sources such as machinery can significantly reduce the noise levels.

3. Separation of high and low noise areas

The location of noisy processes and quiet areas such as offices should be considered at the design stage. Noise levels decrease with distance from the source, so increasing separation between noisy and quiet areas will provide simple sound reduction.

4. Elimination of direct sound paths between areas

Penetrations through dividing structures and ducting will provide easy direct paths for the sound to travel. These need to be carefully considered.

Requirements of building regulations

Approved Document E² sets standards and provides guidance on how the regulations may be satisfied and sets acoustic performance standards for sound insulation in England and Wales.

The requirements apply mainly to residential buildings. Approved Document E describes two methods of demonstrating compliance with Part E of the Building Regulations, namely pre-completion testing (PCT) or by use of robust details.

PCT is carried out on-site and the onus is on the builder to demonstrate compliance. PCT should be carried out when the rooms either side of the separating element are essentially complete, except for decoration.

Client requirements

In many cases, the acoustic requirements will be specified by the client or local authority. These could be to reduce the overall noise levels within the building or to reduce noise break-out

from the building, if for example the building is sited adjacent to a residential area. Controlling the internal acoustics or reverberation of a building can be extremely complex and will

require the input of a specialist acoustic engineer. Reverberation is governed by the sound absorption of the surfaces and the geometry of the building.

Specifying construction details

The initial and most important stage in the specification process is to first define exactly the specific acoustic requirements of the building/building element. At this stage, it may be necessary to consult a specialist acoustic engineer. Computer modelling may be required to calculate internal noise levels and the effects of varying different elements.

Cladding system manufacturers will be able to provide acoustic performance data for different constructions and will be able to recommend a system which will meet the client specification. For special cases, the system may need to be modified and tested to demonstrate compliance.

Principles of Acoustic Performance

Sound insulation provides acoustic separation between separate areas and from noise breaking into or out of a building and is the ability of a material to resist the passage of airborne and impact sound. All materials have different sound insulation and absorption properties that are dependant on the mass, isolation between layers, use of sound absorbing insulation and sealing between layers and around the edge of the construction.

Here we consider these principles when applied to built-up and composite pre-finished steel cladding systems and the measures that can be taken to improve their acoustic performance.

There are a number of factors, which will affect the acoustic performance of a cladding system:

Stiffness

The stiffness of a construction will resist the sound pressure waves deflecting the panel. This will improve the sound reduction index for airborne noise transmission, particularly at low frequency and for rain impact noise transmission. Increasing the gauge or profile of steel cladding will increase the stiffness. Stiff single skin and factory insulated composite panel structures tend to resonate, reducing the mid frequency performances.

Mass

Sound transmission across a solid wall or a single skin partition will obey what is known as the mass law. In principle the law suggests that the sound insulation of a solid element will increase by approximately 5 dB per doubling of mass. Inclusion of dense acoustic mineral wool slab in the insulation cavity or dense board such as cement particle board or dense rubber matting will add significantly to the mass of the structure.

Isolation

Lightweight framed constructions and built-up wall or roof cladding systems, achieve far better standards of sound insulation than the mass law would suggest because of the presence of a cavity and therefore a degree of isolation between the various layers of the construction. It has been demonstrated that the sound insulations of individual elements within a double skin partition tend to combine together in a simple cumulative linear relationship. This is the basis of many lightweight partition and wall cladding systems. Use of a lightweight mineral wool insulation and spacer bar system will maintain a good level of isolation between the internal and external surfaces of a built-up cladding system.

Surface finish and perforation

The liner sheet may be perforated or in some cases embossed. This breaks up the sound waves, which are reflected back into the room. Perforations also allow the noise to more easily penetrate into and potentially through the wall or roof structure. For this reason, when perforated liner sheets are used, a dense acoustic mineral wool layer is often included in the construction to absorb the sound energy within the wall construction. In this case, a vapour control layer will also be required to generate air-tightness, for thermal performance.

Testing measurement and interpretation of results

The acoustic properties of wall and roof constructions can be measured according to British or ISO standards under laboratory conditions.

The most applicable tests are:

- Airborne noise transmission, sound reduction index.
- Airborne noise absorption.
- Rain impact noise transmission.

The acoustic performance of a wall or roof construction will vary significantly with the frequency of the sound source. Measurements are therefore normally taken at octave or one-third octave frequency bands. Increasing the number of measurements will give a more detailed understanding of the acoustic properties, allowing the performance across the full frequency spectrum to be analysed.

Test results are normally either quoted as a single figure result, which is derived from the performance at the different frequencies or presented graphically showing the performance across the frequency spectrum. The human ear responds differently to different sound frequencies, with a maximum sensitivity at around 2 to 3 kHz and much lower sensitivity at low frequencies. A commonly quoted figure is the A weighted result, dB(A), which is weighted according to the typical human ear response.

Test data can be used to show compliance with a building specification. Alternatively site testing on the completed building can be carried out to demonstrate performance and compliance with the specification.

Laboratory Testing

Airborne noise transmission

The procedure for determining the insulation of a construction against airborne sound is described in the standard BS EN ISO 140-3:1995³. The insulation of the test specimen against airborne sound is measured under reverberant sound conditions in which sound is incident on one side of the specimen from all directions.

The test specimen is constructed in an aperture approximately 9m² between the two reverberant chambers which have been constructed to suppress the transmission of sound by flanking paths. To improve the diffusion of the sound fields, both chambers are irregularly shaped and contain several reflecting diffuser panels.

A steady sound source with a continuous spectrum in the frequency bands of interest is used to drive an omni-directional loudspeaker, which is located sequentially in two positions in the source chamber. Measurements of the sound levels are made simultaneously in both chambers at the one-third octave frequency intervals from 100Hz to 5000Hz. Measurements are also made of the noise level in the receiving chamber in the absence of the noise source in order that corrections for any background noise may be made.

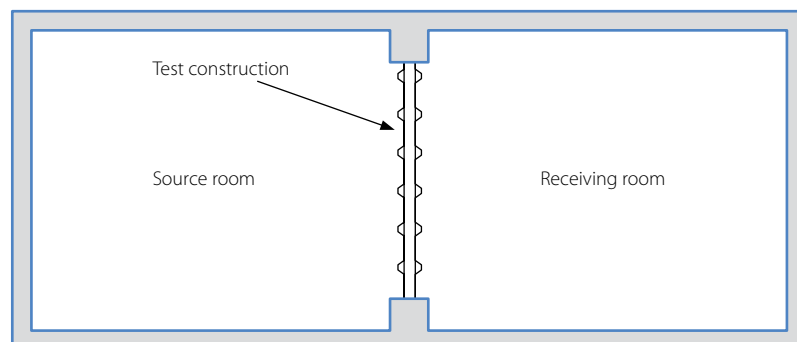
The sound reduction index (SRI) at different frequencies is plotted against the sound frequency. Generally, noise with lower frequency is more easily transmitted and the sound reduction index is lower.

The Weighted Sound Reduction Index (R_w) in decibels (dB) is calculated by comparing the sixteen values of Sound Reduction Index from 100 Hz to 3150 Hz with a defined reference curve which is incremented until the requirements of BS EN ISO 717-1:1997⁴ are met. The Weighted Sound Reduction Index is a single figure rating. The actual performance at different frequencies may vary significantly from this figure.

At a certain frequency, the construction will vibrate as if in resonance and there will be a large dip in performance. This is known as a coincidence dip.

A construction with a higher sound reduction index has a better acoustic performance.

Figure 5. Acoustic chamber test arrangement



Airborne noise absorption

The procedure for determining the sound absorption coefficient of a construction for airborne sound is described in the standard BS EN ISO 354:2003⁵.

The test specimen is installed in a purpose built acoustic reverberation chamber. A steady sound source with a continuous spectrum in the frequency bands of interest is used to drive an omni-directional loudspeaker, which is located in the chamber. The reverberation times of the chamber are measured for different microphone and loudspeaker positions. The results obtained with test sample installed are compared against the results for the chamber alone and the sound absorption coefficient (α_s) within the chamber due to the test sample is then calculated.

The greater the absorption coefficient, the more the sound is absorbed into the structure.

- An absorption coefficient of 0 means total reflection of sound.
- An absorption coefficient of 1.0 means total absorption of sound. Coefficients greater than 1.0 can be recorded due to surface area being greater than plan area. In these cases 1.0 is used.

The absorption class of a construction can be defined as laid down in EN ISO 11654⁶ where:

- Class A has the greatest level of absorption.
- Class E has the lowest level of absorption.

The calculated absorption coefficients for different frequencies can be plotted onto the graph and the absorption class calculated. In general, hard shiny surfaces such as steel and concrete will reflect most of the sound and will have very low absorption coefficients. Soft open textures such as rock and glass wool products make very good absorbers.

Figure 6. Absorption classifications according to EN ISO 11654

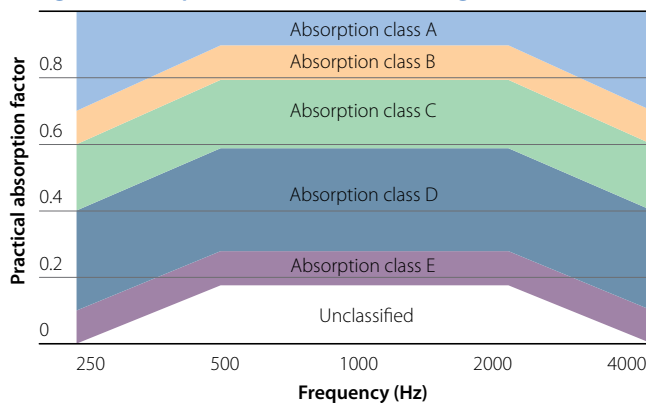
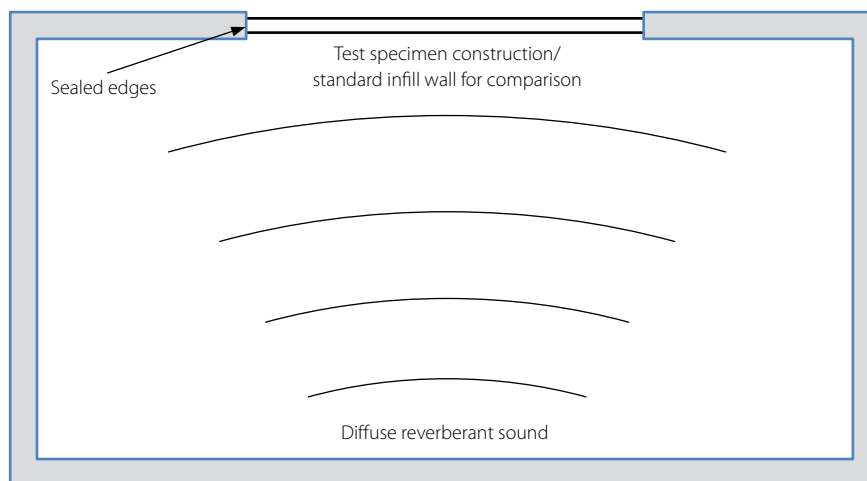


Figure 7. Acoustic chamber test arrangement



Rain impact noise transmission

The procedure for determining the sound insulation of roofs against rain impact noise is described in the standard EN ISO 140-18:2006⁷. This is a laboratory method of measurement of the impact sound insulation of roofs, roof/ceiling systems and skylights by artificial rainfall. The results obtained can be used for assessing the noise produced by rainfall on a building roof in the room or space below.

The results can also be used to compare rainfall sound insulation capabilities of different roof constructions and to design building elements with appropriate rainfall sound insulation properties.

This test method allows direct comparison of different constructions. Measurements using real rainfall are generally unrepeatable due to the

number of variables, however data from natural rainfall on actual buildings has been used to validate the procedure. Real rain can be classified in terms of rainfall rate, typical drop size, and fall velocities in accordance with IEC 60721-2-2⁸.

A construction with a lower impact noise transmission has a better acoustic performance.

Table 1. Classification of rainfall

Rainfall type	Rainfall rate mm/h	Typical drop diameter mm	Fall velocity m/s
Moderate	up to 4	0.5 – 1.0	1 – 2
Intense	up to 15	1.0 – 2.0	2 – 4
Heavy	up to 40	2.0 – 5.0	5 – 7
Cloudburst	>40	>3	>6

For laboratory testing, an artificial rainfall corresponding to the heavy type is used, unless a lower rate is required, in which case an intense type is recommended.

The size and fall height of the artificial raindrops are carefully controlled from a water tank which is positioned above the test panel.

The base of the tank is perforated and the water level in the tank is maintained at a constant level.

Table 2. Characteristic parameters of artificial raindrops

Rainfall type	Rainfall rate mm/h	Median drop diameter mm	Fall velocity m/s
Intense	15	2.0	4.0
Heavy	40	5.0	7.0

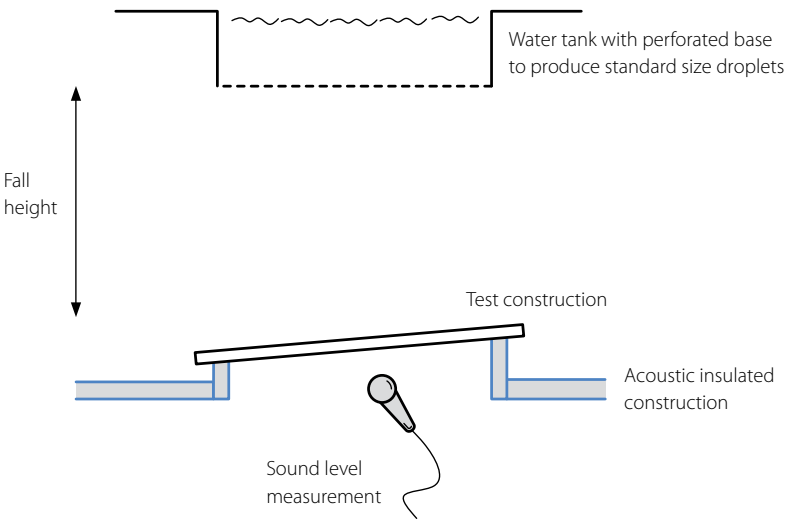
Test arrangement

The test specimen is set up underneath the perforated tank and the specified rainfall conditions are generated. Acoustic insulation is used to suppress flanking transmission. The noise level directly underneath the roof test section is measured at different frequency bands.

The impact of the raindrops, on the external surface causes the surface to vibrate and this energy is transmitted through the roof structure.

The performance at different frequencies is dependant on the exact construction details and properties of the materials used.

Figure 8. Rain impact noise test arrangement



Effect of construction on acoustic performance

Single skin systems

Figure 9. Sound reduction index for 0.7 mm single skin construction

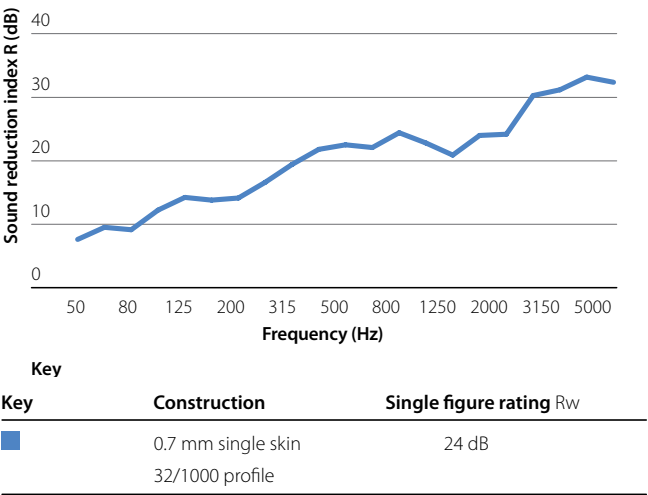


Figure 10. Cross section of single skin construction

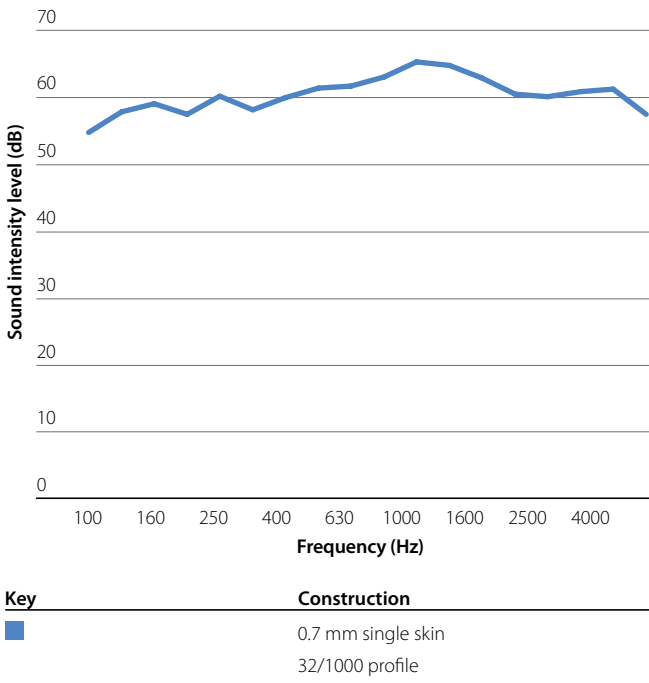


A single skin construction, has relatively low mass and the internal surface is effectively directly coupled with the external surface. For airborne noise, there will be very little energy absorption and the majority of sound reduction will be due to internal reflection.

Increasing the gauge of the cladding, the profile or the purlin spacing will slightly alter the stiffness and the resonant frequency of the panel, which will change the position of the coincident dip.

Rain impact noise will also be directly transmitted through the single skin and internal rain noise levels will be high.

Figure 11. Rain impact noise for a single skin construction



Built-up systems

Effect of insulation thickness in built-up systems

Figure 12. Effect of insulation thickness on the sound reduction index

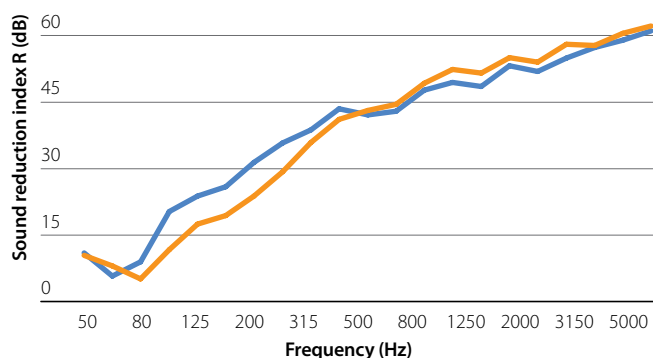
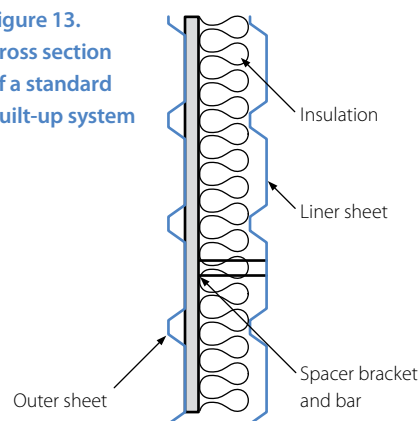


Figure 13.

Cross section of a standard built-up system



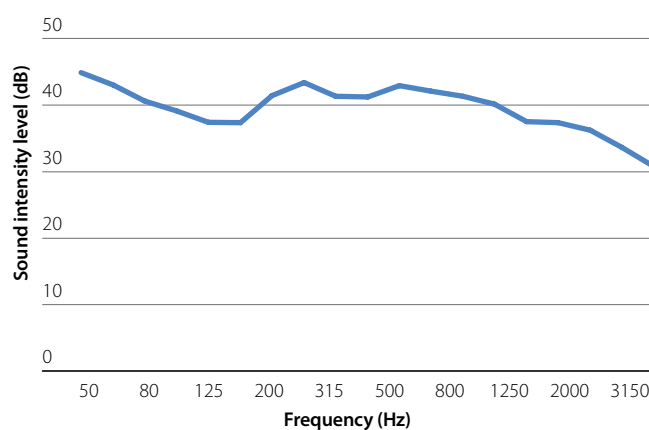
Key	Construction	Single figure rating R_w	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	45 dB	0.25
■	19/1000 liner 120 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	40 dB	0.35

A single skin construction, has relatively low mass and the internal surface is effectively directly coupled with the external surface. For airborne noise, there will be very little energy absorption and the majority of sound reduction will be due to internal reflection.

Increasing the gauge of the cladding, the profile or the purlin spacing will slightly alter the stiffness and the resonant frequency of the panel, which will change the position of the coincident dip.

Rain impact noise will also be directly transmitted through the single skin and internal rain noise levels will be high.

Figure 14. Rain impact noise for a built-up roof construction



Key	Construction	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	0.25

Effect of insulation density in built-up systems

Figure 15. Effect of insulation density on the sound reduction index

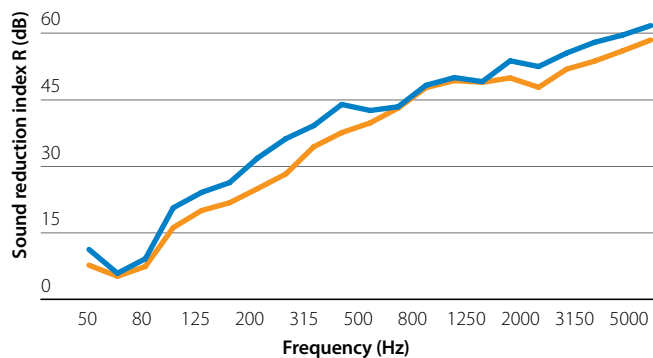
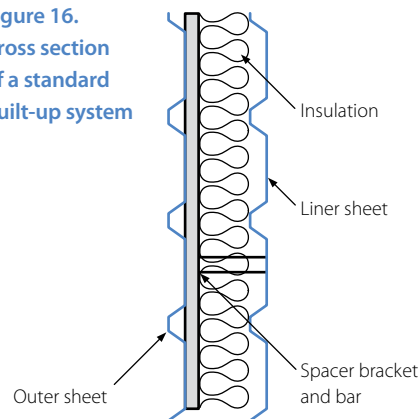


Figure 16. Cross section of a standard built-up system



Key	Construction	Single figure rating R_w	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	45 dB	0.25
■	19/1000 liner 120 mm rock mineral wool 15 Kg/m ³ 32/1000 outer	41 dB	0.25

Different types of mineral wool will have differing sound absorption qualities. Increasing the density of the mineral wool will generally increase the sound absorption properties, increasing the transmission sound reduction index and reducing the rain impact noise transmission, resulting in lower sound intensity levels inside the building.

Rock mineral wool insulation quilt has greater density than glass mineral wool insulation. This contributes additional mass to the construction and generally improves the sound absorption properties. This will increase the airborne sound reduction index and the rain impact sound intensity level. It will have negligible effect on the reverberation characteristics of the building, as this is generally dependant on the internal surface reflection.

Increasing the density of the insulation will be beneficial up to a point where the increased rigidity of the insulation increases the degree of coupling between the internal and external skins. This point is important when considering factory insulated mineral wool composite panels.

Effect of dense acoustic insulation slab in built-up systems

Figure 17. Effect of including dense acoustic slab insulation on the sound reduction index

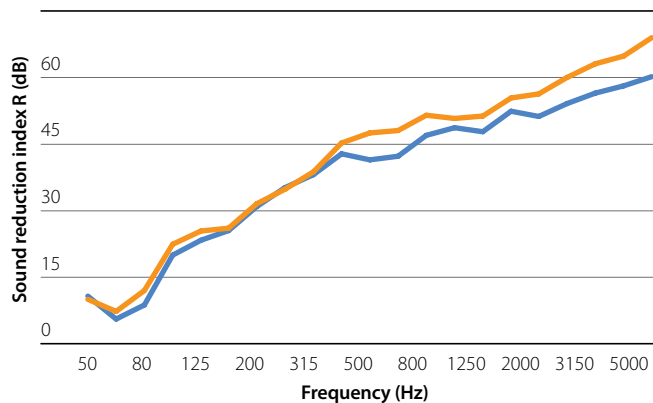
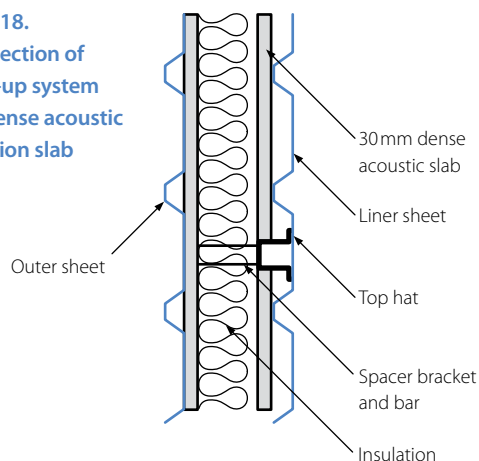


Figure 18. Cross section of a built-up system with dense acoustic insulation slab



Key	Construction	Single figure rating R_w	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	45 dB	0.25
■	19/1000 liner 30 mm dense acoustic insulation 120 mm rock mineral wool 15 Kg/m ³ 32/1000 outer	47 dB	0.25

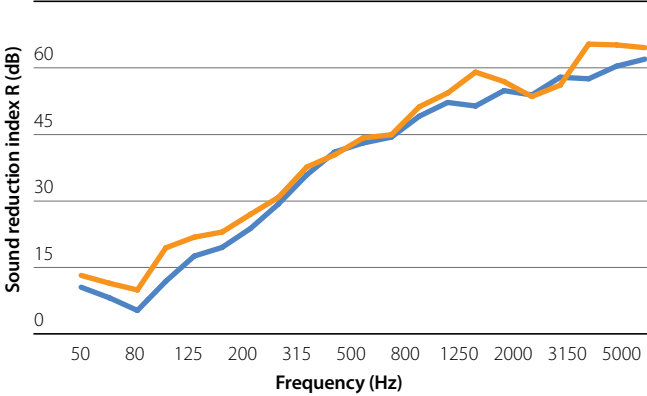
The most common approach to reduce the level of airborne noise transmission, is to include a layer of dense acoustic mineral wool slab. Dense acoustic mineral wool slab has very good sound absorption properties and also provides additional mass to the construction.

The additional mass and absorption properties of the acoustic mineral wool slab will also reduce the rain impact noise transmitted through the structure.

The acoustic slab is used in addition to the insulation quilt. This is to maintain the low level of coupling between the two skins and maintain the thermal performance of the construction. Mineral wool acoustic slab on its own is fairly rigid and would result in a high degree of coupling and so compromising acoustic performance.

Effect of dense particle board in built-up systems

Figure 19. Effect of dense particle board on the sound reduction index



Key	Construction	Single figure rating R_w	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 23 Kg/m ³ 32/1000 outer	40 dB	0.35
■	19/1000 liner 8 mm dense particle board 17/1000 liner 110 mm glass mineral wool 17 Kg/m ³ 32/1000 outer	44 dB	0.35

An alternative approach to increase the acoustic performance of a built-up system is to incorporate a dense board layer such as plasterboard or cement particle board into the construction. The exact position of this can vary as it can be included in the insulation cavity or installed on the internal face of the liner sheet.

The board layer adds mass to the construction and can also act to reduce the coupling between the internal and external surfaces. Increasing the thickness and/or density of the board layer will increase the sound absorption and reduce the overall level of sound transmission.

The additional mass of the dense board layer will also reduce the rain impact noise transmitted through the structure.

Figure 20. Cross section of a built-up system with a dense particle board layer

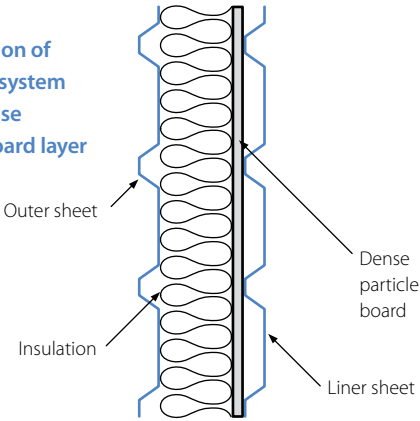
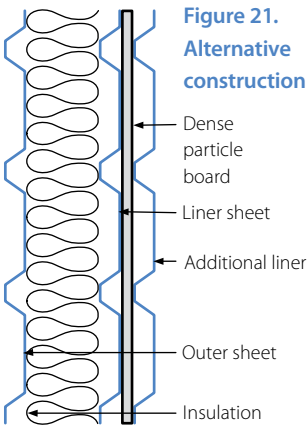


Figure 21. Alternative construction



Effect of a perforated liner sheet in built-up systems

Figure 22. Effect of a perforated liner sheet on the sound reduction index

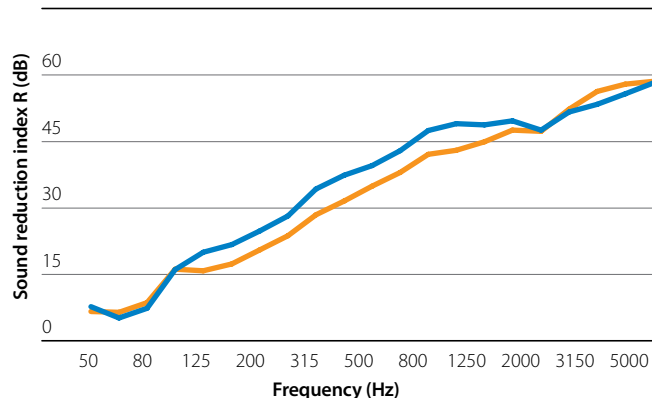
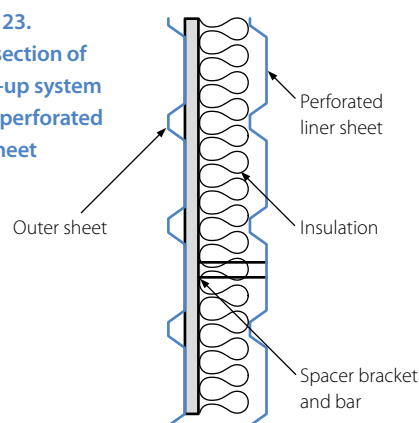


Figure 23. Cross section of a built-up system with a perforated liner sheet

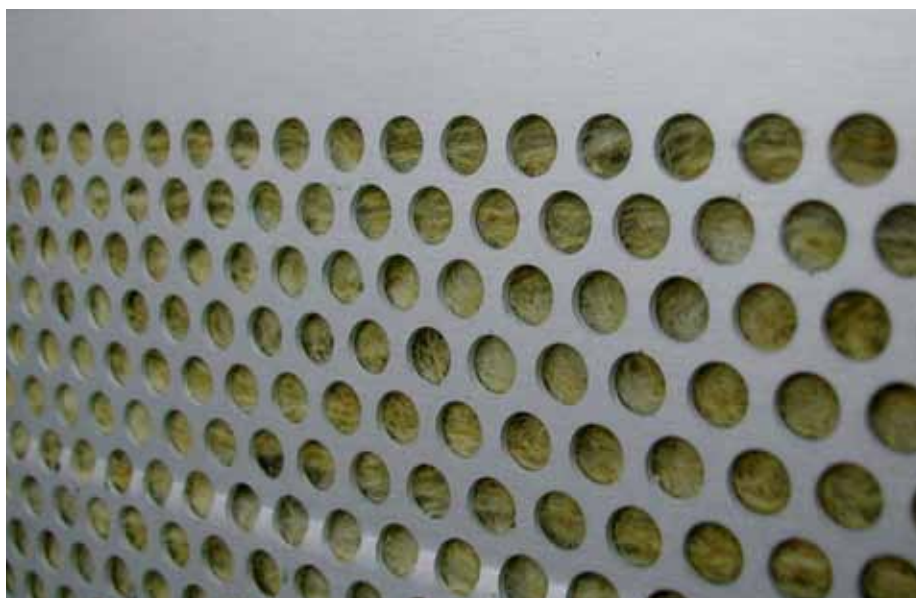


Key	Construction	Single figure rating R_w	Thermal performance U-value
■	19/1000 liner 180 mm glass mineral wool 15 Kg/m ³ 32/1000 outer	41 dB	0.25
■	19/1000 perforated liner 180 mm glass mineral wool 15 Kg/m ³ 32/1000 outer	37 dB	0.25

A perforated liner sheet is often specified when there is a requirement to reduce the levels of reflected sound inside the building. This will improve the sound quality and clarity inside the building and reduce the overall noise levels.

The perforations in the liner sheet allow the airborne noise to more easily penetrate the cladding. This effectively reduces the airborne sound reduction index. The liner sheet can be fully perforated or the perforated area can be limited to the profile troughs.

The size, pattern and total area of perforation will vary between different systems. Increasing the level of perforation will generally reduce the airborne sound reduction index and increase the sound absorption coefficient.



Example of a perforated liner sheet

Figure 24. Sound absorption for a built-up system with a perforated liner sheet

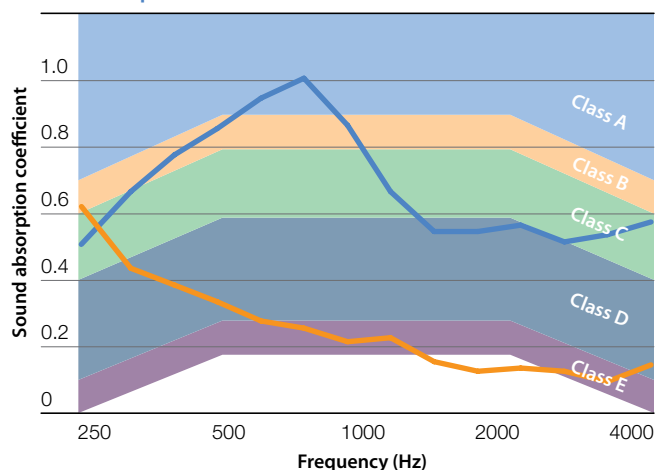
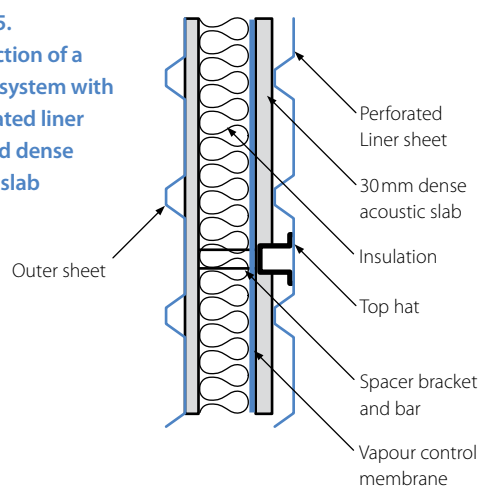


Figure 25. Cross section of a built-up system with a perforated liner sheet and dense acoustic slab



Key	Construction	Thermal performance U-value
■	19/1000 liner 180 mm rock mineral wool 15 Kg/m ³ 32/1000 outer	0.25
■	19/1000 perforated liner 180 mm glass mineral wool 15 Kg/m ³ 32/1000 outer	0.25

To counteract the reduction in airborne sound performance, a layer of dense acoustic mineral wool slab is usually installed in the cladding construction. This is installed next to the perforated liner sheet. Dense mineral wool has excellent sound absorption properties, due to its additional mass and soft open texture. To maintain air-tightness, which is normally generated at the liner sheet, a vapour control membrane is installed. This should be positioned between the dense acoustic slab and the thermal insulation quilt. The membrane will need to be fully taped and sealed.

The additional mass and absorption properties of the acoustic mineral wool slab will also reduce the rain impact noise transmitted through the structure. It should be noted that a built-up system with a perforated liner sheet used with standard mineral wool insulation, will have a lower airborne sound reduction index and higher impact noise transmission than a built-up system with a standard liner sheet. The purpose of the perforations are to reduce the level of reflected sound within the building and thus reduce the overall internal noise level.

The graph above demonstrates the improvement in sound absorption performance of a built-up system with perforated liner sheet over a built-up system with standard liner sheet when used in conjunction with 30 mm of dense acoustic mineral wool slab.

Factory insulated composite panel systems

Factory insulated foam filled composite panel systems

Figure 26. Effect of composite panel core thickness on the sound reduction index

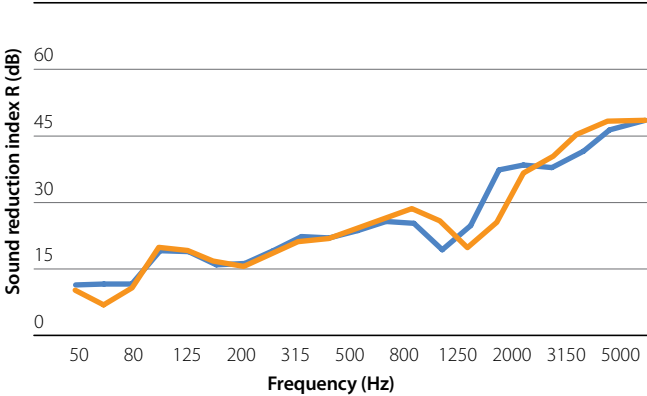
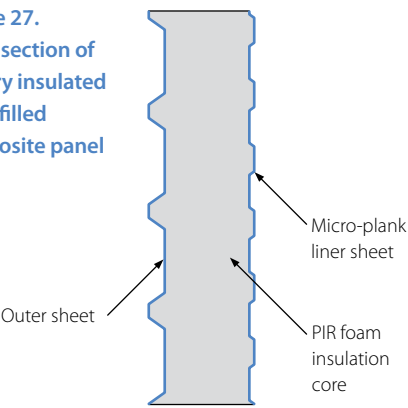


Figure 27. Cross section of factory insulated foam filled composite panel



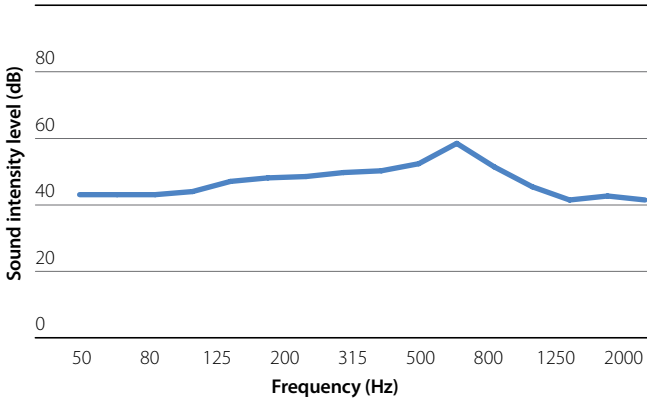
Key	Construction	Single figure rating R_w	Thermal performance U-value
■	Micro-plank liner 80 mm PIR foam core Trapezoidal outer	25 dB	0.25
■	Micro-plank liner 40 mm PIR foam core Trapezoidal outer	25 dB	0.45

The density and overall mass of the foam core is very low and has very little sound absorption properties. The inner skin is directly coupled to the outer skin by the rigid foam core.

Both airborne sound transmission and rain impact noise transmission performance are only marginally better than for a single skin construction.

Increasing the thickness of the foam core has virtually no effect on performance as it has minimal mass and absorption properties.

Figure 28. Rain impact noise for an 80 mm factory insulated foam filled composite panel



Key	Construction	Thermal performance U-value
■	Micro-plank liner 80 mm PIR foam core Trapezoidal outer	0.25

Factory insulated mineral wool composite panel systems

Figure 29. Effect of composite panel core density on the sound reduction index

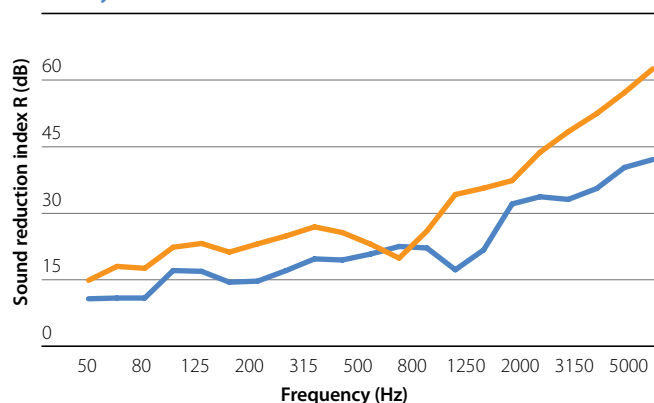
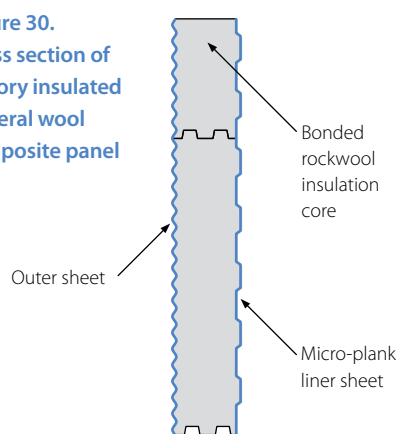


Figure 30. Cross section of factory insulated mineral wool composite panel



Key	Construction	Single figure rating R_w	Thermal performance U-value
■	Micro-plank liner 80 mm PIR foam core Trapezoidal outer	25 dB	0.25
■	Micro-plank liner 120 mm rock mineral wool core 110 Kg/m ³ Micro-rib outer	31 dB	0.35

The density and overall mass of the mineral wool core is quite high and has good sound absorption properties, however the inner skin and outer skin are directly coupled, albeit slightly less so than through the very rigid foam of factory insulated foam filled composite panels.

Both airborne sound transmission and rain impact noise transmission performance are significantly better than factory insulated foam filled composite panels but are considerably less than for built-up constructions.

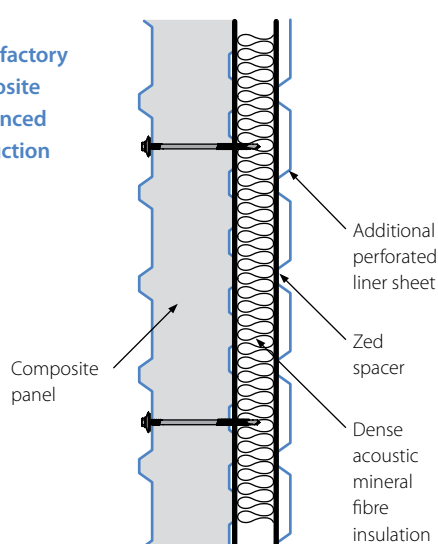
Increasing the thickness of the mineral wool core will increase the overall performance but it will still be considerably lower than for a built-up system.

Composite panel enhanced acoustic construction

When a composite panel is specified and there is an acoustic performance requirement, it is possible to increase the performance by using an additional internal liner of dense acoustic mineral wool slab or particle board. These add mass to the construction and reduce the level of coupling between the internal and external surfaces. This will increase the airborne sound reduction index and reduce the level of rain impact noise.

The additional liner may also be perforated to reduce the level of sound reflection, reducing the overall noise and improving sound clarity within the building.

Figure 31. Cross section of factory insulated composite panel with enhanced acoustic construction



Summary and Conclusions

Summary

The sound reduction indices for a range of typical pre-finished steel cladding systems are compared opposite. It can be clearly seen that built-up systems provide significantly better sound reduction performances and that this type of system can be enhanced by modifications within the construction.

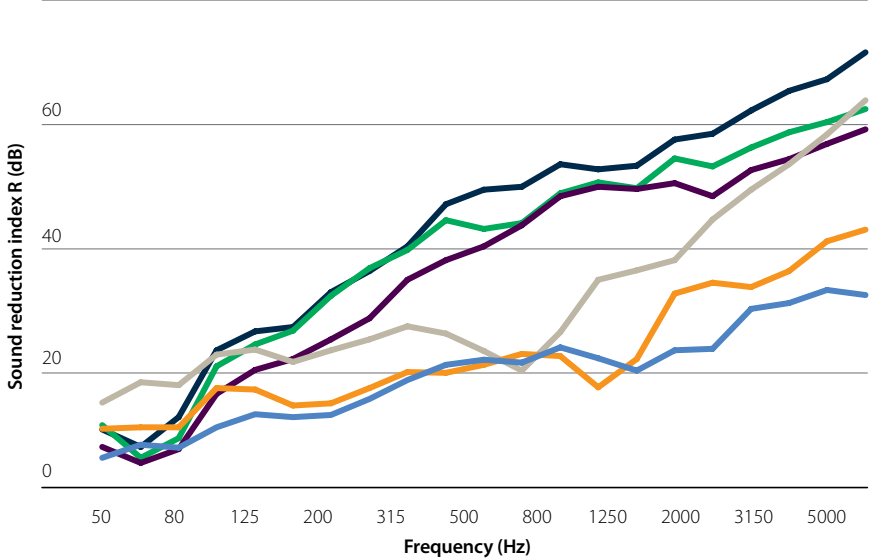
Factory insulated foam filled composite panel systems perform only marginally better than a single skin construction. Performance can be enhanced by additional internal acoustic layers and liner sheet.

The performance of factory insulated rock wool core composites sits between these two groups however these panels have much better performance at very low frequency noise due to their increased mass.

The rain impact noise levels for three different constructions are shown below. This again demonstrates the strong performance of a standard built-up system.

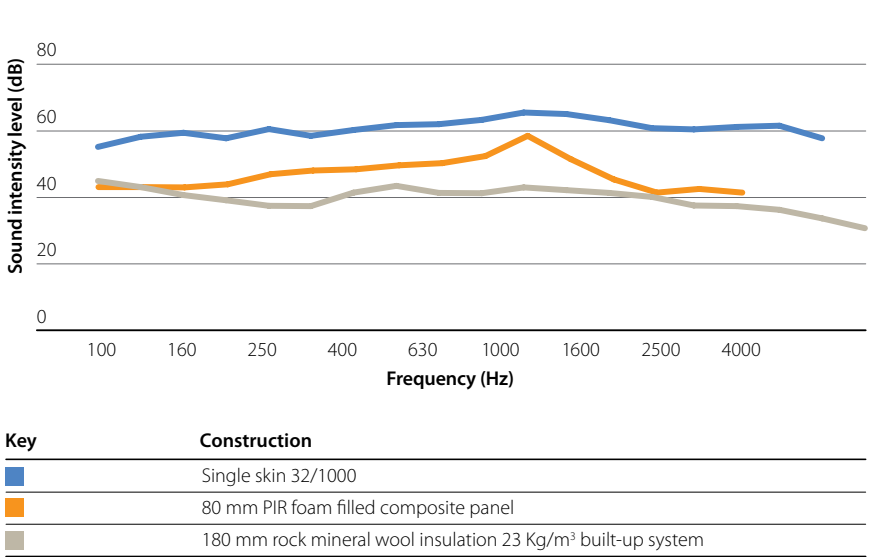
The rain impact noise performance of both built-up systems and factory insulated composite panels can be enhanced using similar principles to those used to increase the airborne sound reduction index.

Figure 32. Comparison of sound reduction index for different constructions



Key	Construction	Sound reduction index <i>R_w</i>
■	150 mm rock mineral wool 23 Kg/m³ + 30mm acoustic insulation built-up system	47
■	180 mm rock mineral wool insulation 23 Kg/m³ built-up system	45
■	180 mm glass mineral wool insulation 15 Kg/m³ built-up system	41
■	120 mm bonded rock mineral wool 110 Kg/m³ composite panel	31
■	80 mm PIR foam filled composite panel	25
■	Single skin 32/1000	24

Figure 33. Comparison of rain impact noise for different constructions



Conclusions

The field of acoustics is a very complex one with many factors at play in defining the acoustic performance of a building. A pre-finished steel cladding system can form the basis for an acoustically robust system and there are a small number of key rules to follow to specify a system which will meet most needs.

A standard built-up system comprising an inner and outer sheet of pre-finished steel with a mineral wool insulation between gives a good starting point for an acoustic system. This in itself can achieve over 40 dB of sound reduction, depending on thickness and density of insulation used. In order to upgrade this, more or denser insulation can be used or a dense acoustic slab, particle board or matting can be incorporated.

It should be noted that built-up cladding systems perform much better than their mass would indicate. This is a result of the low level of direct coupling between the liner and outer sheets, which makes sound transmission more difficult.

Factory insulated composite panels on their own do not perform as well as built-up systems, showing poorer performance against rain-noise, and a lower sound reduction index than built-up systems, except at very low frequency noise. Composite panels with a dense mineral wool core do perform slightly better than foam filled panels, but they are still acoustically inferior to built-up systems. Where a composite panel is specified the acoustic performance can be enhanced by using an additional liner sheet and dense acoustic insulation on the inner face of the panel.

Where the requirement is to reduce internal noise reverberation, to reduce overall internal noise levels, a perforated liner can be specified with a built-up steel cladding system. However, it is important to remember that this alone will be detrimental to the sound transmission performance of the system, so it is generally important to specify this with a dense acoustic slab within the cladding system.

The guidance given in this Colorcoat® technical paper is based on generic system performances. The actual performance of a specific construction on a specific building will vary dependant on numerous factors. Specifiers should refer to their system provider for detailed advice and performance figures for a given specification.

References

1. Control of noise at work regulations 2005.
2. The Building Regulations 2000, Approved Document E (2003 Edition).
3. Acoustics - Measurement of sound insulation in buildings and of building elements:
Part 3: Laboratory measurement of airborne sound insulation of building elements, BS EN ISO 140-3:1995.
4. Acoustics - Rating of sound insulation in buildings and of building elements:
Part 1: Airborne sound insulation, BS EN ISO 717-1:1997.
5. Acoustics - Measurement of sound absorption in a reverberation room, BS EN ISO 354:2003.
6. Acoustics - Sound absorbers for use in buildings: Rating of sound absorption, EN ISO 11654.
7. Acoustics - Measurement of sound insulation in buildings and of building elements:
Part 18: Laboratory measurement of sound generated by rainfall on building elements, EN ISO 140-18:2006.
8. International Electrotechnical Commission: Classification of environmental conditions:
Part 2: Environmental conditions appearing in nature. Precipitation and wind, IEC 60721-2-2:1988.

CPD accreditation

This paper has been assessed and approved as conforming to RIBA CPD guidelines. As such the content has been designated to fit under the following core curriculum headings:

General Headings

1. Professional context
2. Construction skills

Subjects

1. Architectural design
2. Statutory requirements
3. Technical innovations

Knowledge level

General awareness

To receive a CPD certificate for this paper, please go to www.colorcoat-online.com/cpd where you will be asked to correctly answer five short questions on the content of the paper before being issued with an electronic certificate.

The Colorcoat® brand

The Colorcoat® brand provides the recognised mark of quality and metal envelope expertise exclusively from Tata Steel. For nearly 50 years Tata Steel has developed a range of technically leading Colorcoat® products which have been comprehensively tested and are manufactured to the highest quality standards. These are supported by a range of services such as comprehensive guarantees, colour consistency and technical support and guidance.

Colorcoat® products are manufactured in the UK and are certified to independently verified international management system, ISO 14001 and are 100% recyclable, unlike most other construction products.

Colorcoat® BES 6001 approved

Colorcoat® products are certified to BES 6001 Responsible Sourcing standard, the first steel envelope products in the world to achieve this.

Colorcoat® products and services

Colorcoat® products offer the ultimate in durability and guaranteed performance reducing building life cycle costs and environmental impact.

We have detailed Life Cycle Costing and Life Cycle Assessment information that demonstrates the positive performance of Colorcoat® products when compared with other alternatives. This is available from www.colorcoat-online.com

Colorcoat HPS200 Ultra®

The latest generation product for roof and wall cladding, Colorcoat HPS200 Ultra® offers an exciting colour range and dramatically improved colour and gloss performance. Inspection and maintenance free, Colorcoat HPS200 Ultra® delivers twice the colour and gloss retention of standard plastisols, and is Confidex® guaranteed for up to 40 years, combining outstanding performance with unrivalled reliability.

Colorcoat Prisma®

The ideal choice to deliver eye-catching buildings that will stand the test of time. Technically and aesthetically superior to PVDF (PVF2), Colorcoat Prisma® is readily available in the most popular solid and metallic colours. All backed up by the comprehensive Confidex® Guarantee.

Confidex® Guarantee

Offers the most comprehensive guarantee for pre-finished steel products in Europe and provides peace of mind for up to 40 years. Unlike other guarantees, Confidex® covers cut edges for the entirety of the guarantee period and does not require mandatory annual inspections. Available only with Colorcoat HPS200 Ultra® and Colorcoat Prisma®.

Confidex Sustain®

Provides a combined guarantee which covers the durability of the Colorcoat® pre-finished steel product and makes the pre-finished steel building envelope CarbonNeutral® - the first in the world. Tata Steel and their Confidex Sustain® assessed supply chain partners endeavour to reduce the CO₂ emissions generated in the manufacture of pre-finished steel cladding systems but there will always be some unavoidable CO₂ emissions. These unavoidable CO₂ emissions are measured from cradle to cradle and the impact offset. Our aim is to encourage specification of the most sustainable pre-finished steel products and cladding systems. Available only with Colorcoat HPS200 Ultra® and Colorcoat Prisma®.

For further information on Colorcoat® products and services please contact the Colorcoat Connection® helpline on +44 (0)1244 892434 or email colorcoat.connection@tatasteel.com Alternatively visit www.colorcoat-online.com



www.colorcoat-online.com

Trademarks of Tata Steel UK Limited

(formerly Corus UK Limited)

Colorcoat, Colorcoat Connection, Colorcoat HPS200 Ultra, Confidex, Confidex Sustain, and Prisma are trademarks of Tata Steel UK Limited.

Care has been taken to ensure that the contents of this publication are accurate, but Tata Steel Europe Limited and its subsidiaries, (including Tata Steel UK Limited), do not accept responsibility or liability for errors or information that is found to be misleading. Suggestions for, or descriptions of, the end use or application of products or methods of working are for information only and Tata Steel Europe Limited and its subsidiaries accept no liability in respect thereof.

Before using products or services supplied or manufactured by Tata Steel Europe Limited and its subsidiaries, customers should satisfy themselves as to their suitability.

Printed with biodegradable vegetable inks on material sourced from responsible managed forests, certified in accordance with the FSC. Contains 10% recovered fibre, diverting waste from landfill.

Tata Steel

Colors

Shotton Works

Deeside

Flintshire

CH5 2NH

T: +44 (0) 1244 812345

F: +44 (0) 1244 892345

www.colorcoat-online.com

Colorcoat Connection® helpline

T: +44 (0)1244 892434

F: +44 (0)1244 892321

e-mail: colorcoat.connection@tatasteel.com

Copyright 2012 Tata Steel UK Limited, Registered Office: 30 Millbank London SW1P 4WY, Registered in England No. 2280000

Language English UK 0213