G6 Airborne and impact sound

Purpose:

The purpose of this practice note is to provide guidance on the application of the building code clause G6 Airborne and impact sound in buildings containing household units.

Building code functional requirements:

- *G6.2 Building elements which are common between occupancies, shall be constructed to prevent undue noise transmission from other occupancies or common spaces, to the habitable spaces of household units.*

Definitions

Undue noise – means any noise that causes unreasonable distress, annoyance, or irritation to any person which can result in illness or loss of amenity.

Habitable spaces – includes bedrooms, kitchens, living rooms, dining rooms but does not include corridors, bathrooms, garages, and laundry rooms.

Abutting occupancies – includes household units, commercial or industrial occupancies but does not include corridors, lobbies, plantrooms or lift shafts.

Determination 2005/004 concluded that a corridor does not fall within the definition of an occupancy, the same as a plantroom or a stairway, and therefore the common building elements (the walls) between a household unit and a corridor is not required to satisfy the performance requirements of G6.3.1.

Although not a code requirement, acoustic engineers generally recommend the application of the national standard AS/NZS 2107:2016 that requires noise levels within habitable spaces to be within specific limits. This will result in quality buildings and safeguard people living in residential dwellings from loss of amenity from undue noise transmitted from abutting occupancies and common spaces such as service rooms, corridors, lobbies and lift shafts.

Legislative requirements

Performance requirements of G6

Airborne noise is associated with sound transmitted by air, e.g., human speech, music, tv, radio, telephone, etc.

Impact noise is associated with activities that cause vibrations of the structure. Impact noise typically occurs on floors, e.g., footfall (walking), moving furniture on hard surfaces, dropping of objects, etc.

G6.3.1 performance standards require a laboratory performance of Sound Transmission Class (STC) for walls of no less than 55 and in accordance with classification ASTM E 413.

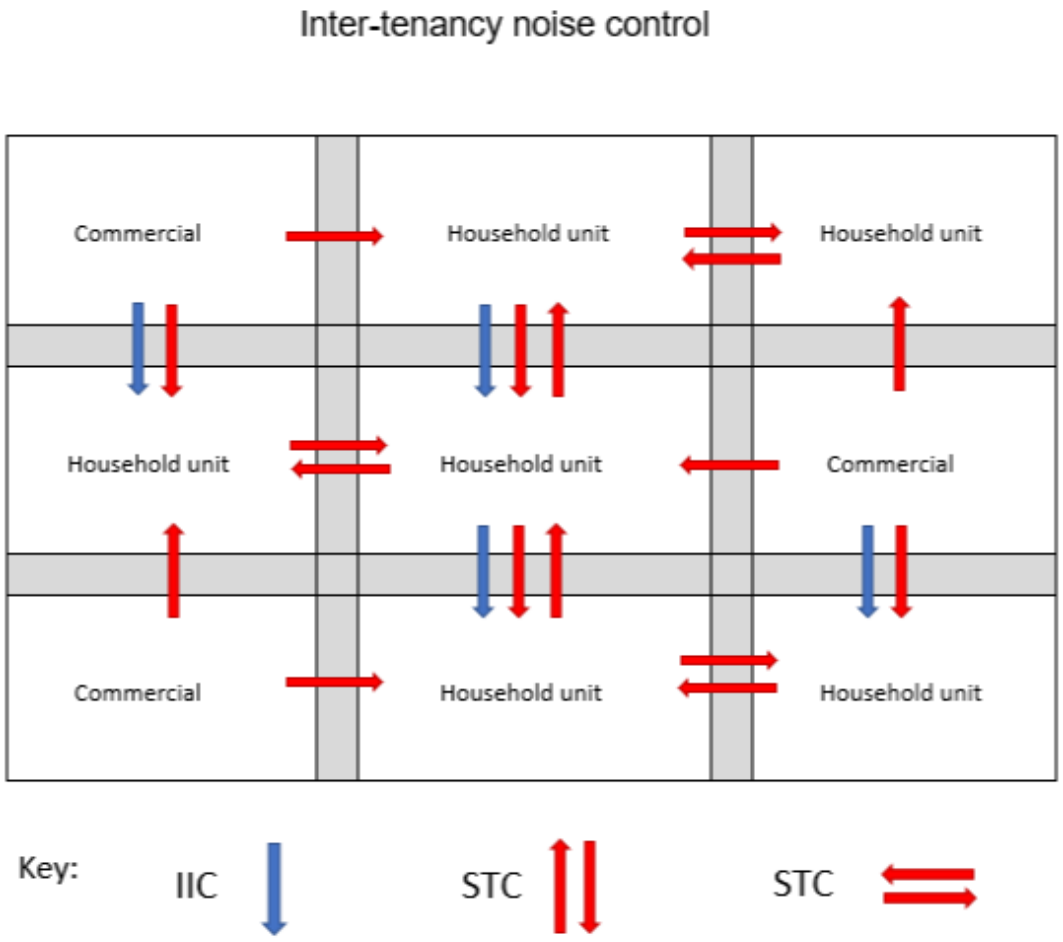
G6.3.2 performance standards require a laboratory performance of Impact Insulation Class (IIC) for floors or floor/ceiling assemblies of not less than 55 in accordance with classification ASTM E 492. The verification method allows a 5dB drop for site performance down to FSTC 50 minimum and FIIC 50 minimum.

STC represents a material or products ability to block sound from travelling through a wall, floor or floor/ceiling assembly. The higher the STC rating, the better the ability to reduce airborne sound transmission from one space to another.

IIC measures a floor assembly's ability to absorb impact sound, like footsteps. The higher the IIC rating the better the ability to block sound or reduce impact noise transfer from the space above to the space below.

An STC rating roughly equals the decibel (dB) reduction in sound once it passes through a wall or partition. For example, if an 80dB sound on one side of a wall is reduce to 50dB on the other side, that partition is estimated to have an STC of 30. However, this estimate does not take into account the performance of the wall at individual frequencies which govern the STC weighting curves. A field STC result by a qualified acoustic consultant verifies in situ performance, if required.

Decibel (dB) is a relative unit of measurement widely used in acoustics. The dB is a logarithmic unit used to describe a ratio between the measure level and a reference or threshold level of 0dB. The ratio may be Sound Power, Sound Pressure or Sound Intensity, etc. How loud is a decibel? Normal conversation is about 60dB. A smoke alarm is about 85dB at 3m.



Note: G6.2 requires that habitable spaces within household units are protected from undue noise transmission from abutting occupancies.

Flanking transmission

Any sound transmitted to the receiver not directly through the building element separating the occupancies is referred to as flanking transmission. These indirect or 'flanking' paths between source and receiver are harder to predict and can be the reason for not achieving the expected performance results.

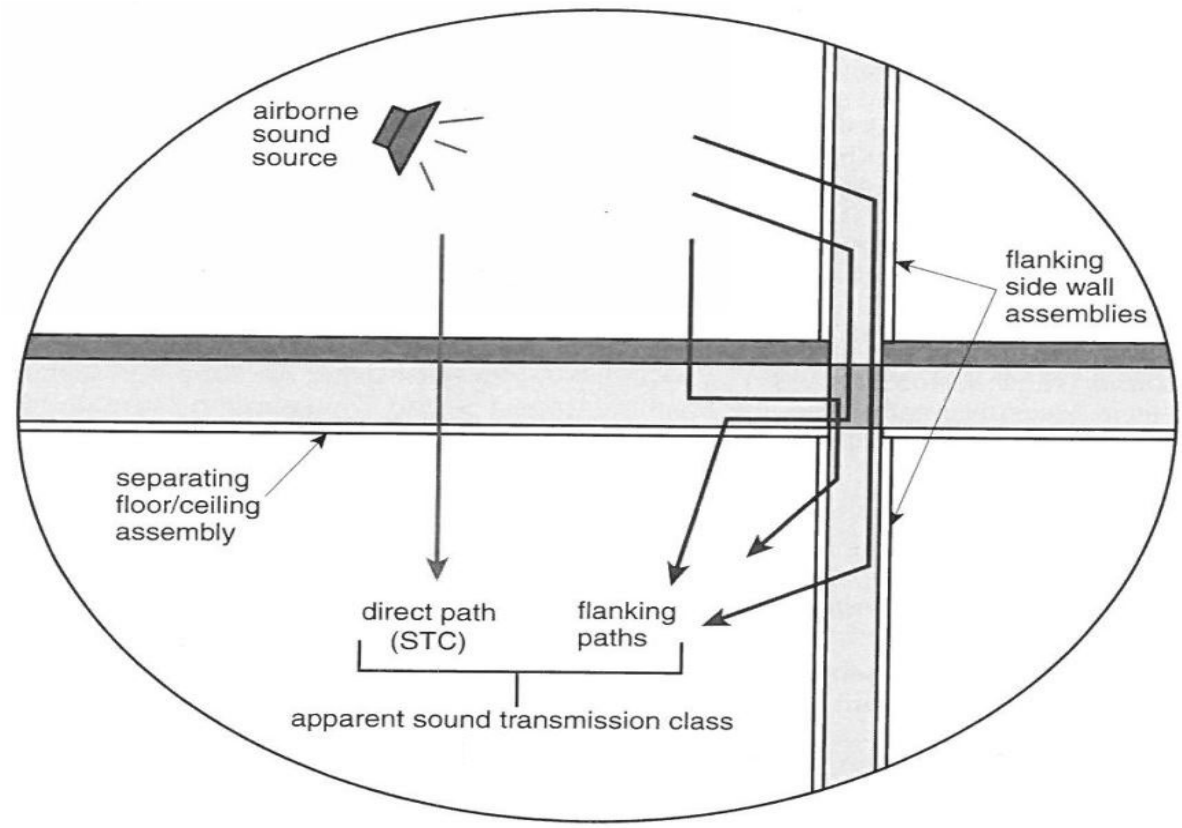
Sound flanking via the surrounding structure must be addressed to achieve the proposed building system performance – refer to the diagram below.

Flanking is addressed by the acoustic engineer at design stage for compliance with G6 performance requirements for STC and IIC sound transmission.

The acoustic engineer reviews the architectural, structural and services drawings to ensure they are co-ordinated and that flanking paths have been addressed.

Common building elements that must be considered to avoid flanking transmission include, but are not limited to:

- Shared structural building components such as floorboards, floor joists, continuous drywall partitions and continuous concrete floors
- Junction details, include floor façade junctions
- Services such as ductwork and pipework
- Corridors and other circulation spaces
- Windows and doors



Direct and flanking sound transmission

Sound insulation materials and products

The most effective sound insulation materials and products include, but are not limited to:

- mass loaded vinyl
- cork
- resilient channels
- sound proofing dry walls
- sound proofing insulation such as rockwool, mineral wool and fibreglass
- acoustic sealants and adhesives
- silicon caulk
- acoustic underlay
- acoustic foam
- isolation clips and mounts

There are four sound insulation principals based on physics of sound transmission:

1. **Sound blocking by mass**
   It takes more energy to vibrate more mass, heavy weight barriers will block more sound energy than lighter barriers

2. **Damping compounds**
   To dissipate energy as heat as vibrations move through solid building elements, e.g. adding damping compounds between layers of material.

3. **Isolation or decoupling**
   Physically separating solid components from one another, e.g. double stud walls and floating floor systems, resilient clips used to fasten wallboards to framing, acoustic underlays or battens on rubber supports separating hard flooring surfaces from the floor structure.

4. **Absorption**
   Adding fibrous material in cavities reduces sound build-up and dampens low frequency resonances.

New buildings

For newly constructed townhouses and apartment buildings, full compliance with the Building Code G6.3.1 and G6.3.2 performance requirements are mandatory under Section 17 of the Building Act 2004.

Alternations and refurbishment of existing buildings

Section 112(1)(b) 1 & 2 of the Building Act 2004 applies. The clause is interpreted to say:

- If the building complied with the Building Code for G6 before the alteration, it must continue to comply after the alteration.
- If the building did not comply with the Building Code before the alteration, it must comply after the alteration to the same extent it did before the alteration.

This means that the building should continue to comply with the Building Code clause G6 to the same extent as before the construction. Reducing the level of compliance is not allowed.

New building work must fully company with G6.

Note: An interconnecting door between two residential units should be selected to provide an STC rating of no less than 55. This may necessitate the installation of a pair of solid core doors hung in separate frames of a common frame to provide the required FRR and acoustic rating. A single solid core door can generally achieve up to STC 43.

Change of use to of existing buildings

Where the change involves building 1 or more household units where household units did not exist before, section 115(a) of the Building Act applies. Unless the territorial authority provides written notice that they are satisfied on reasonable grounds that the building, in its new use, will comply as nearly as is reasonably practicable (ANARP) with the building code.

New building work, as in new walls, must fully comply with G6.

ANARP applies to all existing walls, floors or floor/ceiling construction not being altered, that may not comply with the current performance requirements of G6.

The building consent applicant should justify why full compliance cannot be achieved by demonstrating the cost of full compliance outweighs the benefit gained. This will be assessed by Council before allowing the building in its new use to not fully comply with G6 performance requirements. Refer to Practice Note AC2226 Applying the term as near as is reasonably practicable

Acoustic field tests may be required to verify that the approved design requirements have been met. Access to the floors above and below to where the change of use is undertaken is required in order to carry out the acoustic testing. Refer to 'Acoustic Report' and "Field inspection and testing' sections below for more information.

Change of use and staged building consents

For change of use applications where an existing multi-storey office is converted in stages (floor by floor) from offices to apartments, the design must provide the necessary compliance with impact insulation class IIC. This applies to the floor undergoing the change of use and especially for hard surface areas or tiled areas where acoustic underlay would be applied. It is not possible to achieve IIC 55 by acoustically treating the floor/ceiling assembly of the floor below when the next stage of the change of use from office to apartment is applied for.

It is good practice to consider the same when receiving a one-off building consent application for change of use for one level in an existing multi-storey office building to apartments. It is likely that future building consents continue to change the use of other levels from office to apartments.

Auckland Unitary Plan

Managing noise in mixed use urban environments

Where adequate protection from external noise sources, such as outdoor activities or from other properties are considered. These are achieved through planning restrictions.

Noise amenity for apartments built in the CBD, mixed used and business zones

As well as the CBD, the AUP looks after residential developments within mixed use or business zone areas.

The consent holder must submit an acoustic report to Council for any multi-level apartment building in the CBD zone, mixed use or business zones prepared by a suitably qualified consultant. The report must consider any design requirements under the AUP. Please refer to AUP for information.

Achieving these internal noise levels is likely to require windows being closed and therefore the ventilation and cooling requirements prescribed in the AUP section 25.3.10 must be achieved by providing mechanical ventilation and / or air-conditioning.

Building services performance requirements

Reticulation of building services through intertenancy walls

In apartment buildings with central HVAC, ductwork may require special considerations to avoid noise transmission through the ducts.

Ductwork and pipework are not recommended to be supported off the acoustic walls and acoustic ceilings. Where this occurs, resilient hangers are required as opposed to rigid connections. All gaps should be acoustically sealed.

Light weight pipes shall be lagged with a mass loaded material for a least 1m on each side of the penetration on the IT wall or floor. All penetrations should be completed with an appropriate acoustic sealant.

Cable trays should be cut clear of IT walls and all penetrations completed with an acoustic sealant.

Service penetrations in acoustic walls or floors should include the necessary acoustic treatment to mitigate flanking, e.g., acoustic sealants, compressible rubber seals, etc.

Risers and service shafts

Although not a building code requirement, ductwork and pipework within the riser or service shaft may require acoustic insulation to meet the recommended internal levels, referencing AS/NZS 2107. Additionally, the risers will be acoustically rated to mitigate cross talk between apartments.

Risers that are part of the intertenancy wall need to comply with the performance requirement of G6 for STC55.

Electrical sockets and power outlets

Electrical sockets and power outlets can be located in the intertenancy wall provided the positions of the sockets are staggered and backed with an acoustically rated well sealed box. Where staggering the power outlet boxes is not practical, additional acoustic treatment is required.

Access hatches

Acoustic rating may also be required for access hatches in the acoustic ceilings and service risers.

Junctions

The acoustic walls and floors shall be complete with the necessary acoustic treatment at junctions with other building elements, such as, roofs, external walls and facades.

Acoustic report

For multi-storey buildings containing household units, an acoustic report by a qualified acoustic engineer, who is on Council's Producer Statement Author Register, is recommended. If a report is not provided, Auckland Council may engage a suitably qualified expert at the applicants cost.

For a one or two storey side-by-side household unit (townhouses) a field test of STC and IIC is not necessary where the proposed intertenancy building system is a tested and proven system Council will carry out an inspection during pre-line, post-line and final inspection construction stages. If the inspector is not satisfied with the quality of building work on-site, they may need to call for on-site acoustic testing to be carried out in designated areas.

When using a non-standard or a system that has not been tested by an accredited laboratory, an acoustic report and field testing will be required. Prediction and calculations of STC and IIC ratings is not as simple as adding the ratings of individual building elements together as computer modelling may be required.

The acoustic report should include, but is not limited to:

- Proposed development description
- Internal noise limits for resource consent purposes if applicable
- Acoustic performance standards
- Intertenancy walls design for compliance with G6
- Intertenancy floor/ceiling design for compliance with G6
- Toilets, kitchens and non-carpeted floor areas design for compliance with G6
- Balconies floor design for compliance with G6 and IIC performance requirement to the habitable space of the abutting occupancy below
- Apartment doors STC
- Riser/shafts and access hatches
- Acoustic treatment of building services through intertenancy walls
- A quality assurance plan for inspection and field testing during construction is highly recommended for new multi-storey and high risk buildings
- Recommend field test plan for completed units
- Agreement to provide producer statements on completion

Additionally, the follow will also be required:

- A PS1 is required from a qualified acoustic engineer that is on the Council Producer Statement Author Register in support of the acoustic design for the building
- A co-ordination statement is required from the acoustic engineer confirming the architect and structure have been reviewed for compliance with G6 performance requirements

Field inspection and testing

In multi-storey apartment buildings, selected wall and floor assemblies must be tested on each floor of the building. Tests of the sound insulation of the constructed building elements common between occupancies are measured in-situ. This requires access to both sides of the intertenancy wall or floor and is normally carried out after the building is constructed.

The process requires generating sound on one side of the building element being tested (wall or floor). For airborne sound, this involves the use of speakers emitting loud noise designed to contain a wide range of frequencies. For impact sound, this involves the use of tapping machines that repeatedly drop small, calibrated weights onto the floor creating both noise and vibrations. Background noise and reverberation is discounted to ensure the final test results are representative of the intertenancy walls or floor building elements sound reduction measurements.

The testing shall be as per ASTM as noted in G6. The ASTM standards refer to the ISO standard methods, so it is already implied. Acoustic engineers carry out the field test in accordance with ISO 140-4 for STC tests and ISO 140-7 for IIC tests. The testing must be carried out by the design engineer or an independent qualified engineer that is overseen by and acoustic engineer on the Council Producer Statement Author Register.

It is recommended that sample tests are conducted as early as possible during construction to find and address any construction issues. Fixing these issues in the early phases can save a lot of costs that would be incurred after the building is complete. A quality assurance field test plan submitted by the acoustic engineer at consenting stage is highly recommended.

It is recommended that 20% of household units in a multi-storey building apartment are tested and a field test report submitted to Council to demonstrate compliance with the approved design and the building code. This may be reduced to 10% for large apartment buildings with more than 30 apartments.

It is recommended that the location of the wall and floor assemblies to be tested are agreed with the acoustic engineer and Council before the tests are carried out and preferably before the consent is issued.

There is a need to test different arrangement of samples to include both the repeated elements (same wall across all floors) and the extremities, such as the wall on the top floor, to ensure no flanking through the ceiling cavity. This should also include abutting units in the middle of a building and abutting units at the ends of a building to test the junction of an IT wall with the building envelope.

If the first few tested walls or floors fail to achieve the requirement minimum FSTC/FIIC, consideration to increase the level of testing may be necessary. This may be an indication of construction issues that will result in more household units failing the tests.

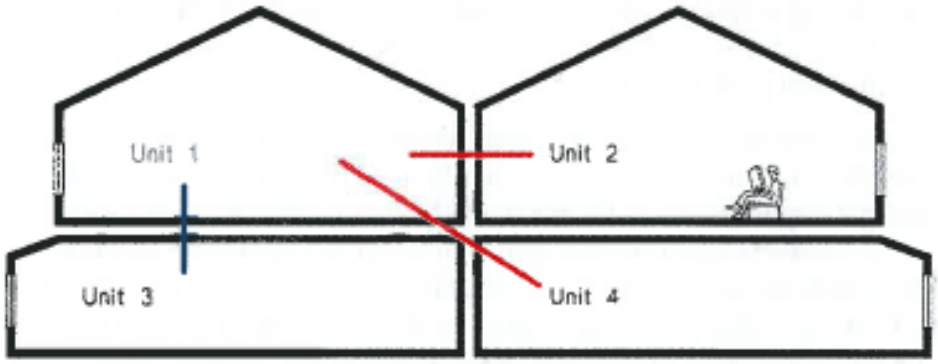
If the field test does not demonstrate compliance with the approved design, the acoustic engineer should be consulted by the applicant to identify the underlying causes of failure and advise the applicant and the Council of possible solutions. The intertenancy building elements that failed will need to be retested to demonstrate compliance with the approved design after the necessary remedial work has been completed.

If a design change is made, an amendment to the building consent must be applied for and approved, unless the work is considered minor. In any event, the design change must be approved by Council and appropriately documented.

Horizontal and diagonal IIC

The determination 2015/007 confirmed that horizontal and diagonal IIC do not apply to the performance requirement of G6.3.2.

G6.3.2 applies to vertical assemblies only, i.e., one unit above the other. Refer to the diagram below where IIC applies noise reduction from unit 1 to unit 3. Additionally, the definition of IIC refers to floor assemblies.



SCHEMATIC SECTION THROUGH FOUR UNITS

Amended from Figure 1 in G6/AS1 (not to scale)

References

- New Zealand Building Code clause G6 Airborne and impact sound
- Building Act 2004 sections 17, 112 and 115
- AS/NZS 2107:2016 Recommended design sound levels and reverberation times for building interiors
- ASTM E 413 Classification for rating sound insulation
- ASTM E 492 Test method for laboratory measurement of definitions impact sound transmission through floor-ceiling assemblies using the tapping machine
- ISO 140-4 Field measurements of airborne sound insulation between rooms
- ISO 140-7 Field measurements of impact sound insulation of floors
- Determination 2005/004
- Determination 2015/007
- Determination 2012/070