NOISE IN HIGH RISE BUILDINGS

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Noise in high rise buildings has traditionally not been considered an issue, with people accepting the idea that they "had to live with noise". With the advent of higher expectations from purchasers, guests and tenants, noise has now become a significant issue with regard to acoustic amenity. Limits are now being established under many National and International Standards and local building codes. The outcome is more highly engineered buildings where external and internal noise is considered in detail and issues of privacy between adjacent areas is addressed through the detailing of high acoustic isolation façades, walls and floors. Requiring particular attention is: mechanical services, façade glazing types and details, wall types, floor impact isolation treatments. In addressing these issues there are basic principles that should be applied to ensure that noise does not become a major issue (eg do not locate noisy plant and activates adjacent to sensitive areas). This paper discusses these principles and how they apply in the "real world". Where these principles cannot be applied then the project acoustic engineer is challenged to come up with specific solutions.

1. Introduction

Noise is generally described as "unwanted sound", or alternatively "what your neighbour makes". In high rise buildings both definitions apply. The design of these buildings needs to concern both unwanted noise, ie noise from air conditioning plant, waste pipes and external road traffic, and also issues of privacy so that one does not hear one's neighbour. The management of these issues has become increasingly more important as the quality of such buildings and the purchaser expectations rise. The levels of acoustic amenity provided in a building directly affects the quality of the building and the re-sale value of such spaces. To this end there are now rating systems that allow the acoustics of buildings to be rated and to be used as a marketing tool (re www.aaac.org.au). It is also found that as market values rise, occupier expectations also rise with the expectation that they will be provided with a high level of acoustic amenity. This is not always the case and many projects that we have worked on have been developed as 3 star and sold as 5 star.

The achievement of high levels of acoustic amenity is in the design detail which must be addressed at the design development stage. It is very difficult once a building has been constructed to "upgrade" the acoustics. It also has to be understood that good acoustics come at a cost and that generally one "gets what one pays for".

Good acoustic design requires attention to detail. It can be often small failings (eg door seals that do not seal tightly) that mean a significant loss in performance.

2. Critical Acoustic Issues

From experience in over 30 high rise residential buildings over the last 20 years we have found that the following factors are important in defining the levels of acoustic amenity in high rise buildings:

2.1 Architectural Details

2.1.1 Façade acoustic isolation

In particular for the management of external road traffic and entertainment noise. In the design of curtain wall systems it is important to ensure that the façade provides effective isolation (privacy) both vertically and horizontally between adjacent residential areas.

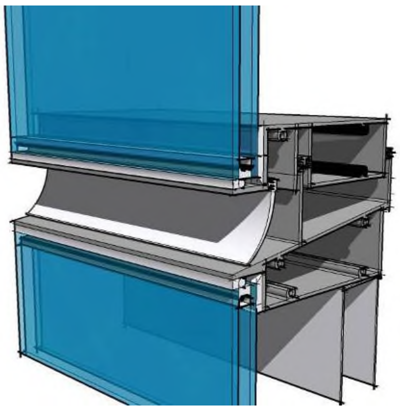

Figure 1. Curtain wall connection detail.

2.1.2 Floor impact isolation

For the management of impact noise from hard floor surface to protect lower noise sensitive areas.

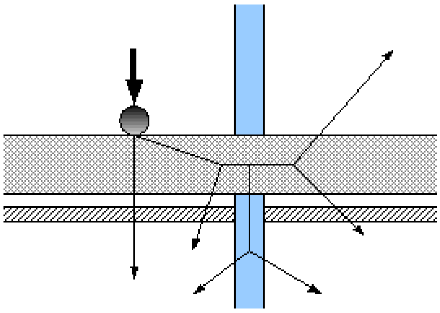

Figure 2. Floor impact noise transmission paths

Floor impact noise is one of the most common complaints about noise that we experience in Australia (even with impact treatments applied).

2.1.3 The design of party walls

To ensure that noise from one apartment does not impact into another adjacent apartment. To provide the levels of isolation expected within the Australian market many of these walls are now cavity construction walls rated to a minimum Rw 55.

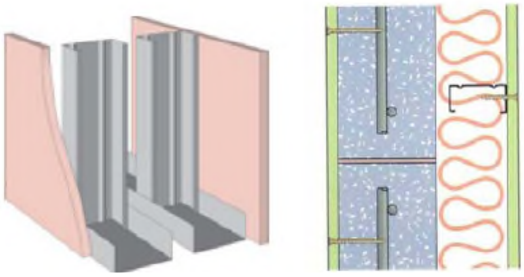

Figure 3. Cavity wall details.

2.1.4 Waste Pipes.

Waste pipes from one level often pass through a floor slab, set across in the lower ceiling void and drop down a riser shaft. This horizontal transfer in the ceiling void is often a source of noise for the lower area.

2.1.5 Entrance Doors.

These should have acoustic seals to provide a moderate level of privacy between lift lobbies and apartments.

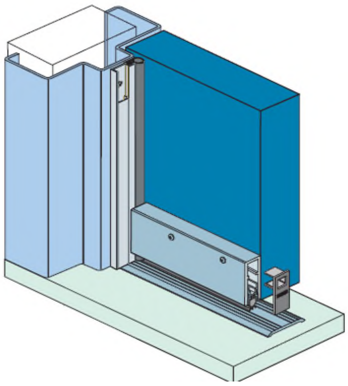

Figure 4. Typical sound rated door detail.

2.1.6 In sink garbage disposal units

These should never be installed in high rise buildings. These create high levels of structure borne acoustic energy that it clearly audible in adjacent areas.

2.1.7 Road Traffic and Aircraft Noise

Such noises are a significant impact into high rise buildings and when buildings are located near to major traffic routes or under aircraft flight paths it is appropriate to consider acoustic double glazing systems.

Figure 5. Acoustic double glazing system to manage aircraft noise.

2.1.8 Pools above sensitive areas.

Swimming pools can be subject to high impact loads from boisterous activity in the pool. This impact can easily be transmitted as low frequency sound to lower areas. To control this noise requires high levels of vibration isolation usually achieved with a minimum 45mm deflection springs (see below).

Figure 6. Swimming pool isolation system

2.1.9 Other Issues

- Entertainment noise
- Rain Noise
- Wind buffeting building facades

2.2 Services Details

Mechanical Plant. This, if not sufficiently acoustically treated, can have a significant impact onto the overall acoustic amenity of occupied areas. Key considerations are extract and supply fans, air conditioning fan coil units, chillers, cooling towers and external condensers as follows:

- **Duct regenerated noise**. Often mechanical duct systems are required to travel up the full height of the building. These ducts can also change location up the building and set across in the ceiling void of sensitive areas. Such ducts if sized at too high velocities or if the bulkhead around the duct does not provide sufficient acoustic isolation, can generate high levels of noise.

- **Heat exchange pump rooms.** These can be required for buildings over 50 floors where a mid level pump room is required to circulate condenser water in a condenser water loop. These pumps are high power flow and can easily impact noise into adjacent sensitive areas (above, below and each side).
- **Fan Assisted Variable Air Volume boxes (VAV).** These, when located in the ceiling void, can be noisy and should only be used as a last resort.
- **Pool filtration plant.** If not acoustically treated this can impact noise to outdoor amenity areas adjacent to the pool.
- **Condenser and chilled water pipe systems** can easily impact both pump, water flow and valve noise into sensitive areas adjacent to the riser shaft.
- **Lift motor rooms (particularly mid level).** Lift motors are relatively noisy. Noise and vibration from these rooms can easily affect adjacent apartments. Usually these will require cavity walls, sound rated doors and the lift motor to be well vibration isolated.
- **Lifts travelling in lift shafts.** Where lift shafts pass beside sensitive areas, the wall should be upgraded with an additional secondary plasterboard wall on the inside of the apartment.
- **Garbage Chutes.** These are noisy and should be supported from vibration isolation mounts and be made of fibrous cement and not steel. Ideally they should be located away from apartment separation walls.
- **Water supply pumps.** Experience has found these to be a common noise source in high rise buildings. They should be well vibration isolated with flexible connections between the pump and the pipe work. Photo 3 shows an installation where no consideration was given to these treatments.

Figure 7. Water supply pumps above penthouse suite

- **Standby power plant.** These can generate high noise and vibration levels and even though used for short lengths of time can be significantly annoying. Ideally they should be located away from sensitive areas in a sound rated enclosure. If located on the roof they must be very well vibration isolated and acoustically enclosed.
- **SPA Baths.** The pumps in these baths have the potential to create low level, tonal noise in lower areas. This noise can be such as to be significantly intrusive requiring that the pump or bath be vibration isolated from the building structure.

3. Noise Control Principles

The management of noise is often addressed by applying basic principles in the design of these buildings. Typically the following concepts will be applied to minimise having to apply detailed acoustic treatments:

3.1 Keeping noisy plant and activities away from quiet areas.

This is the most basic and yet most effective principle in managing noise:

- Locate noisy plant away from penthouse suites or executive offices;
- Do not locate air conditioning plant in occupied area ceiling voids;
- Do not locate night clubs and residential areas in the same building

3.2 Avoid mid-level plant rooms; Avoid high speed equipment (pumps, fans, lifts, etc).

Generally it is much better acoustically to select equipment at lower speeds and larger physical dimensions (ie larger fans running at slower speeds). Run equipment where possible at a lower speed for night time operation.

3.3 Design low velocity and pressure duct and piping systems.

Generally this will mean larger ducts but reduces the potential for these ducts to be a source of unwanted noise.

3.4 Design heavier systems.

Generally the greater the mass the greater potential to isolate noise and vibration.

3.5 Decouple where possible.

- Party walls with separated leaves provide considerably higher levels of acoustic isolation than solid walls of the same and even greater mass. We often find that plasterboard systems with separated studs will provide considerably better acoustic isolation than a much heavier masonry wall. Such plasterboard systems have become the main party wall in Australia. However we find a significant reluctance in the SE Asian and Middle East regions to accept plasterboard walls. These markets prefer to have “solid” feeling walls, even though they will be heavier and provide a lower level of acoustic isolation.

- Use double glazing systems where high levels of façade isolation are required. Good double glazed systems require air gaps in excess of 50mm. At this gap the system is not a good thermal insulating glass due to convective air and heat pumping in the void. Hence thermal and acoustic isolation design requirements can conflict. Another problem can occur with low air gap glass in that resonances can occur in the cavity meaning with the overall result that the glazing provides less isolation than a single glazed system with the same overall thickness of glass.

- Floating floors can be used for roof top chiller and cooling tower plant rooms to significantly reduce the levels of sound transmission to lower areas.

- Sound locks can be used for the doors of plant rooms and noisy places to minimise sound breakout through the entrance doors.

3.6 Vibration: isolate mechanical plant

Minimise the transfer of such vibration as noise into the building. Such treatments range from rubber pads under AHU cases to high deflection springs under chillers. All major plant (chillers, pumps, fans etc) will need to include spring mounts with spring hangers for the associated pipe work. In sensitive locations consideration should also be given to vibration isolating vertical pipe work risers. Cooling towers can either be supported on neoprene pads or springs depending upon the tower and the location.

3.7 Use carpet where possible instead of hard floor surfaces.

Where hard floor surfaces are used, consideration should be given to floor impact isolation and also in busy active areas the levels of reverberant sound.

3.8 Keep waste pipes above floor level.

Where possible do not allow waste pipes to penetrate the floor slab to lower sensitive areas.

3.9 Acoustically lag waste pipes in ceiling voids of sensitive areas and/or place them inside acoustically rated bulkheads.

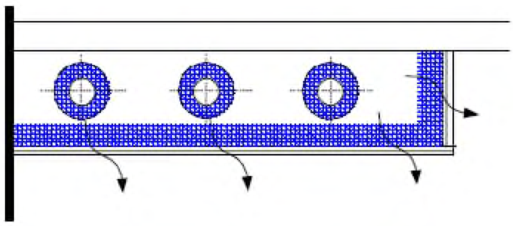

Figure 8. Waste pipe bulkhead and lagging detail

4. Acoustic Criteria

It is not difficult to define and quantify specific levels of acoustic performance. There are rating systems to define:

- Transmission loss (STC, Rw, DnTw)
- Impact isolation (IIC, Lnw, LnTw)
- Noise levels (dB(A))
- Reverberant noise (Rt 60 – the time taken for a sound in the space to drop 60 dB)

In many countries building codes and standards are written to define appropriate levels of performance. Such codes become law and set a minimum level of acoustic amenity. Beyond this there are standards which can be implemented as law or used as good codes of practice. Much of our work in the past had been in satisfying building code and local government requirements. However, we are finding in Australia that market forces are now starting to define the levels of acoustic amenity and that designs are now well in excess of minimum code requirements. All high rise projects in Australia will have an acoustic engineer; whereas in South East Asia, only the prestigious projects will consider these services.

It is important on any project to quantify the performance requirements. Recently we were called in to help resolve a dispute between a builder, owner and hotel operator. The owner told the builder that he wanted 5 star but did not quantify it further. The owner was very unhappy with the levels of noise. The builder's defence (which was finally accepted by the client) was that he built to specification (ie what was documented). The moral of the story - be sure that the acoustic performance criterion is clearly and accurately defined.

Under Australian regulations there is a standard (AS2107-2000) that establishes specific acoustic amenity criteria for the use in certain buildings. In addition, there are a whole series of standards describing how to assess and document particular noise characteristics. We have standards for measurement, testing (field and laboratory) and measurements equipment. These standards are now set around many of the ISO standards. These standards help set building requirements legally when written into the project specifications. Further to this we have building code criteria, and often the local government will also have its say as to what is required to maintain the quality of building acoustics. The Green Building Council of Australia released a green star rating system which applies points for high level of acoustic amenity. These points have become very valuable to building owners through being able to secure high class tenants. Hence more work for the acoustics consultant. There are similar rating systems in the UK, Singapore, and North America.

In Australia, the Association of Australian Acoustics Consultants has set up a star rating system for residential buildings. This rating system is gaining acceptance within Australia as a means to quantify the star rating and hence levels of acoustic amenity in high rise residential buildings.

5. The Real World

The above is what can be considered the acoustic engineers "design list". In reality we now have to deal with:

- High rise buildings located immediately adjacent to high traffic volume motorways, airports, railway lines and other high rise buildings. These sites can often be the last sites to develop.
- High rise buildings looking down to or over mechanical plant on other buildings.

Figure 9. View from penthouse balcony to adjacent high rise tower roof

- High rise buildings at such a height where there is minimal ambient noise and hence internal noise from plant and occupants can be more readily audible (penthouses in inner city areas can be very quiet internally).

- Spaces for plant rooms and acoustic treatments becoming smaller. Height restrictions and attempts to maximise the number of floors means that ceiling void spaces are being reduced.

- Budget costs are creating spaces where the ceiling is the concrete slab of the upper level floor. Such a construction has the potential for high levels of impact noise.

- Night clubs in and immediately adjacent to, high rise buildings.
- Hard floor surfaces as a market preference (stone, tile, timber).
- High sound volume plasma TVs mounted onto party walls with a bedroom on the other side. To minimise this noise some consultants are specifying walls between apartments as separated steel studs with 3 layers of 16mm fire rated plasterboard on each side with a fibreglass infill.
- In an attempt to maximise views and capitalize on the value of roof deck areas, top level penthouse apartments are being located adjacent to major items of mechanical plant (condensers, cooling towers, chillers, fans, pumps etc).
- Higher buildings with mid level plant rooms.
- Buildings built to a budget and yet expected to perform well acoustically.
- Higher speed fans pumps and lifts.
- Projects with unrealistic design development and construction programs. Hence due consideration is not being given to critical acoustic issues.

6. Conclusion

The management of noise in high rise buildings is a complex process requiring good planning, design, management, documentation and processes. When managed correctly the end result can be a significant increase in the internal amenity of the building and with not necessarily a significant increase in cost. By the application of many basic principles, many noise problems can be avoided without the need for engineered solutions. It has been our observation in Australia that as the levels of affluence increase, the expectations from owners/occupiers rise significantly requiring that issues of acoustic amenity be addressed in detail. A building with poor acoustics can easily gain a bad name and be difficult to either sell or lease.