Disco Dreaming: Sound Insulation Between Bar and Hotel

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Non-refereed

A paper originally presented at the New Zealand Acoustics Conference, Wellington 2004

Abstract

This paper presents an increasingly common sound insulation problem in which an existing conference space, situated beneath noise sensitive hotel rooms has been converted into a bar and nightclub. The lack of sound insulation to hotel rooms had proven to be a problem in the past when amplified music was played in the conference space.

Noise reduction measurements between the conference space and overhead hotel rooms were carried out before and after the renovations. It was considered that the concrete slab, common to the hotel rooms and the conference space, was the primary medium for sound transmission between the two areas. As such, an acoustic ceiling was designed to control the level of sound energy affecting the concrete slab. The design required an understanding of what noise levels could be expected inside the new bar/night club facility and what are acceptable noise levels inside hotel rooms at night.

Several design challenges were addressed including build-ability issues, ventilation requirements and potential building element resonance conflicts. The sound insulation design was expected to deliver a 60 – 80% improvement on the existing situation. With this improvement it was anticipated that a small number of sensitive guests would find the noise level in hotel rooms unacceptable.

The bar/night club has now been operating successfully for several months. As predicted, occasional complaints are received by the hotel from guests staying in the most affected rooms above the bar. However the overall result is such that the acoustic ceiling design is considered to be successful.

Introduction

As part of a renovation of the Sky City Casino and Conference Centre in Auckland, an existing conference room was converted to a bar/nightclub. The conference room was one of several on Level 3 of the complex. Marshall Day Acoustics was engaged to design the sound insulation for the refitted bar. The objective of the design was to mitigate bar noise transmission to hotel suites located on Level 4, diagonally above the new bar location. The hotel had previously received noise complaints from occupants when the conference room was used as a ballroom.

Marshall Day Acoustics worked within the project design team which included Beca Carter Hollings and Ferner, ASPEC Construction and Skyring Design. The final acoustic solution is an isolated ceiling between the bar and the Level 4 floor slab. The ceiling is incorporated into the architectural ceiling and is trafficable within the ceiling cavity to allow access to services. The resulting performance of the ceiling is such that a small number of hotel suites are unusable during high noise levels in the bar. At the start of the project it was considered that a complete solution for all hotel suites would not be possible due to constraints of the existing structure. As such the objective of the design was to reduce the effects on the hotel as much as practically possible.

Problem

The objective of the acoustical design was to mitigate loud noise levels from the bar transmitting into hotel rooms on the upper levels. This had to be achieved with a build -able and affordable solution that accommodated interrelated services and architectural issues.

The existing structure of the building was remaining and as such there was no scope for structural changes. The hotel suites and the new bar are diagonally adjacent and share a common floor/ceiling slab. The immediately obvious problem was how to reduce the amount of sound energy entering the common floor/ceiling slab. From this stemmed the main focus of the design which was an acoustic ceiling between the bar and the slab.

The main design target of the ceiling was to achieve a high degree of transmission loss at low frequencies. All sound transmitted to the hotel rooms would be structure borne. Any mid-high frequency components of the music would be attenuated through the structure therefore it was essentially a low frequency problem (63 Hz - 125 Hz).

Some non acoustical issues associated with the ceiling design were:

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- Treatment of air-conditioning and other service penetrations in the ceiling;
- Ceiling location with regard to existing steel work, architectural ceiling and ceiling cavity services;
- The requirement for access to the ceiling cavity for services maintenance (trafficable ceiling).

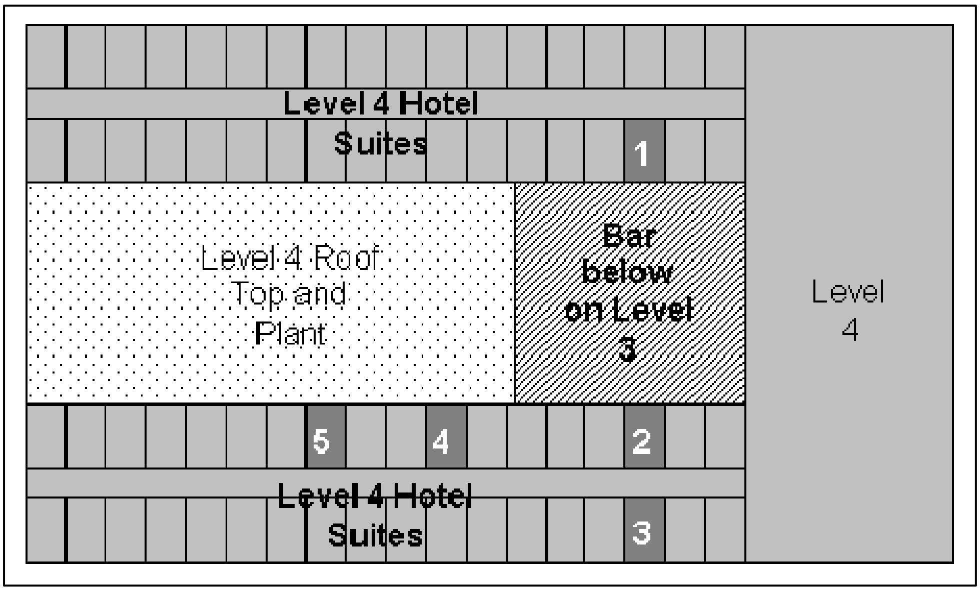

Figure 1: Hotel Layout

Methodology

The steps taken in designing and verifying the acoustic treatment for the project are as follows:

1. Pre-renovation measurements to determine sound insulation of existing structure;
2. Determine a suitable design standard for noise received in hotel rooms;
3. Establish the potential operating noise levels in the bar;
4. Consider possible treatment options and predict the effectiveness of each option for comparison;
5. Iteratively review options with other design team members to determine a workable solution;
6. Finalise design;
7. Construction observations;
8. Commissioning measurements;

Existing Construction

The hotel suites are located on the level above the converted conference room. While the rooms are not directly above the bar they do share the same floor/ ceiling slab. Figure 1 shows in plan view the relative locations of the bar and hotel suites.

The numbered suites are those where pre-renovation and commissioning measurements were carried out.

The shared floor/ceiling slab is 120 Hibond which gives an average concrete thickness of 90 mm. The ceiling in the conference rooms was a perforated acoustic ceiling. All walls on both the conference room and hotel levels were lightweight drywall construction. The perimeter walls of the conference room were full height and sealed to the underside of the hibond slab.

Pre-Renovation Measurements

Measurements were carried out in the conference room before the renovation to determine the sound insulation of the existing structure between the conference room and the hotel suites on the floor above. Sky City Entertainment Group provided audio equipment to generate the high noise levels required.

Independently, pink noise and a dance music sample were amplified to a reverberant level of L_{eq} 95-97 dBA in the conference room. The noise levels received in five hotel suites on Level 4 were measured with both the pink noise and dance music samples.

The reverberant levels of the pink noise generated in the conference room were: -

- L_{eq} 105 dB @ 63 Hz
- L_{eq} 101 dB @ 125 Hz

In Suite 5 (refer Figure 1), the pink noise was inaudible above the ambient noise levels. The bass beat of the dance music sample was barely detectable. Measurements in this room were abandoned.

The ambient background noise levels in each hotel room were also measured with the fan coil units running on a low setting. These

	Suite 1		Suite 2		Suite 3		Suite 4	
	63 Hz	125 Hz	63 Hz	125 Hz	63 Hz	125 Hz	63 Hz	125 Hz
Ambient	48	44	47	44	47	39	50	48
With Pink Noise in Bar	60	50	63	52	54	44	55	48
Increase above ambient	12	6	16	8	7	5	5	0

Table 1: Pre-Renovation Measured Noise Levels

measured ambient levels were slightly affected by distant traffic and construction noise.

Tables 1 summarises the measurement results.

The bottom row of the table shows that the ambient noise in hotel rooms was exceeded by up to 16 decibels (63 Hz).

Design Standard

The structure borne sound received from dance music and live bands typically consists of a low frequency rhythmic tone. If this noise is clearly distinguishable above the ambient noise levels in a bedroom then it is likely to cause annoyance. As such, the ambient noise levels in the hotel suites were used as a starting point for a design criterion.

It became clear from the pre-renovation measurements that an acceptable noise level for bedrooms would not be practically possible in all hotel suites.

The objective of the acoustic design was to mitigate the effects of music from the bar on the hotel as much as practically possible. For the purpose of comparing the effectiveness of different solutions, hotel suites were described as being unusable if the predicted 63 Hz and 125 Hz components from bar music were more than 2 dB above the ambient level in the hotel room (based on measured day time ambient levels).

Where the predicted levels were 0 - 2 decibels above the ambient level, these suites were considered to be marginal depending on the sensitivity of the occupant.

Design Noise Levels

In order to determine what the likely noise levels would be in the new bar, a series of measurements were carried out in operating bars around Auckland. Table 2 summarises these measurements.

Source	L_{10} 63 Hz	L_{10} 125 Hz	L_{10} A-weighted
Dance Music	115 dB	112 dB	100 dBA
Live Covers Band	107 dB	106 dB	100 dBA

Table 2: Average Measured Noise Levels in Auckland Bars

The intended use of the Sky City new bar is as a live jazz venue mid-week and a nightclub during weekends. Therefore noise levels in the bar could potentially be as high as those listed in Table 2. However, in order to control noise transmitted to hotel suites, Sky City could limit the output of audio equipment used in the bar.

Design Assumptions

The following assumptions were made as part of the design process: -

- The flanking path from the light weight perimeter walls of the bar into the concrete slab was not considered to be a major contributing path due to losses at the wall/slab junction. The path was also difficult to isolate therefore was left untreated. However, the junction between the perimeter wall and the new acoustic ceiling was isolated and sealed.
- The proposed acoustic ceiling was modelled as an infinite panel.
- The acoustical target was to improve low frequency transmission loss, therefore small fixing penetrations in the acoustic linings were not a major concern.
- A predicted improvement in transmission loss above the Hibond slab transmission loss would translate into the equivalent improvement in noise reduction (as measured) to hotel rooms less the effects of flanking paths.

Treatment Options and Predictions

Two main concepts for the acoustic ceiling were considered.

Option 1

Separate isolated ceiling consisting of 3 layers of 13 mm Gib Noiseline suspended on spring hangers approximately 360 mm from the bottom of the slab with cavity insulation.

Option 2

Incorporate the acoustic ceiling into the architectural ceiling which would be suspended at least 2 m below the bottom of the slab to avoid structural steelwork. 3 layers of 13 mm Gib Noiseline suspended on spring hangers 2 m from bottom of slab with cavity insulation.

Following discussion with the design team and initial costing, Option 2 was chosen. Option 1 was more expensive, restricted the space for services in the ceiling cavity and required complex detailing in order to seal the ceiling around the structural steelwork. By incorporating the acoustic ceiling with the architectural ceiling, the structural steelwork would be avoided.

The predicted improvement in performance of Option 2, above the measured performance of the existing construction, was 12 dB at 63 Hz.

The improvement was predicted by comparing the low frequency transmission loss of the existing construction (120 Hibond) to that of the proposed slab/ceiling combination.

It was assumed that this translates into an equivalent reduction of noise received in the hotel rooms (less the effects of flanking paths which were not assessed).

The suspended ceiling was required to be trafficable so that services in the ceiling space could be accessed. The construction contractor requested alternatives to plasterboard linings so that spring hangers could be easily fixed through the lining. In addition the trafficable surface needed to be more robust than plasterboard.

The alternatives to three layers of 13 mm Gib Noiseline were:

1. 1 layer 21 mm plywood and 2 layers 13 mm Gib Noiseline;
2. 1 layer 20 mm flooring grade particleboard and 2 layers 13 mm Gib Noiseline.

Final Treatment

The final solution evolved after working through the various technical and build-ability issues with the design team. The construction is as follows: -

- 120 mm Hibond slab;
- 2000 mm air gap accommodating structural steelwork and services;
- 3 layers of R1.8, 75 mm Pink Batts insulation
- Ceiling consisting of 1 layer 21 mm plywood and 2 layers 13 mm Gib Noiseline suspended on spring hangers

Joins in the ceiling linings are overlapped and joins on the bar side are stopped.

A 5 – 10 mm clearance gap was left around the perimeter of the ceiling. This gap is sealed to the perimeter walls with a backing rod and acoustic sealant and covered with an architrave backed with compressed closed cell foam.

Recessed light fittings are enclosed within the ceiling cavity by lighting boxes constructed from 3 layers 13 mm Gib Noiseline.

All supply and return air is fully ducted with rigid cylindrical ducting to reduce bar noise breaking through into the ceiling space. Diffusers are connected with a short length of flexible duct which is lagged with mass loaded vinyl.

The isolation hangers were selected so that the natural frequency of the hanger did not coincide with the natural frequency of the Hibond slab or the Mass-Air-Mass resonance of the slab/ceiling combination. BCHF structural engineers assisted with the specification of the hangers to meet the natural frequency requirements. The hangers were fitted with solid stops at the point of maximum deflection. The purpose of these was to support the live load of people walking on the ceiling while ensuring that the isolation of ceiling was not short circuited under normal static load.

Commissioning Measurements

Following completion of the bar refit, the sound insulation performance of the acoustic ceiling was measured in the same way as the pre-renovation measurements. Pink noise was generated in the new bar to a reverberant level of L_{eq} 95 – 97 dBA. The levels received in two hotel suites on Level 4 were measured and the ambient noise levels in the suites were re-measured. Table 3 summarises these measurements.

Noise from the bar caused a moderate increase in the low frequency noise level in hotel rooms however there was no change to the A-weighted noise levels in the rooms.

Dance music was played at high levels in the bar and a subjective assessment of noise received in the hotel suites was made. With the dance music playing, a moderately low level of low frequency transmission was detectable in the hotel suites, which is consistent with the results in Table 3. Another person participating in the subjective assessment could not hear the low frequency noise at all. It is probable that these noise levels would be more noticeable at night time when the ambient levels in the suites are likely to be lower.

A comparison of the before and after measurements gives an indication of the improved sound insulation achieved with the acoustic ceiling. For each of the measurements, the Noise Reduction between the source room (conference room/new bar) and the receiving rooms (hotel suites) has been calculated. In each case an adjustment has been made for the background noise in the receiving rooms.

The calculated noise reduction, at octave band centre frequencies, before and after the installation of the acoustic ceiling is shown in Figure 2. As illustrated, there is an improvement in Noise Reduction of approximately 6 — 8 decibels at 63 Hz, and approximately 2 — 4 decibels at 125 Hz.

	63 Hz (dB)	125 Hz (dB)	A-weighted (dBA)
Noise Level in Bar	98	95	96
Suite 6			
Background	49	41	38
With Noise from Bar	52	44	38
Suite 7			
Background	49	44	35
With Noise from Bar	51	46	35

Table 3: Commissioning Measured Noise Levels (L_{eq})

Discussion

The measured improvement in sound insulation performance resulting from the installation of the acoustic ceiling is not as great as predicted theoretically. This performance shortfall was expected and is likely to be due to the nature of field conditions, possible material variations in building products and also some flanking transmission through other paths.

While the noise level generated in the bar for the measurements was very loud, it is possible that greater low frequency noise could be generated during normal operation.

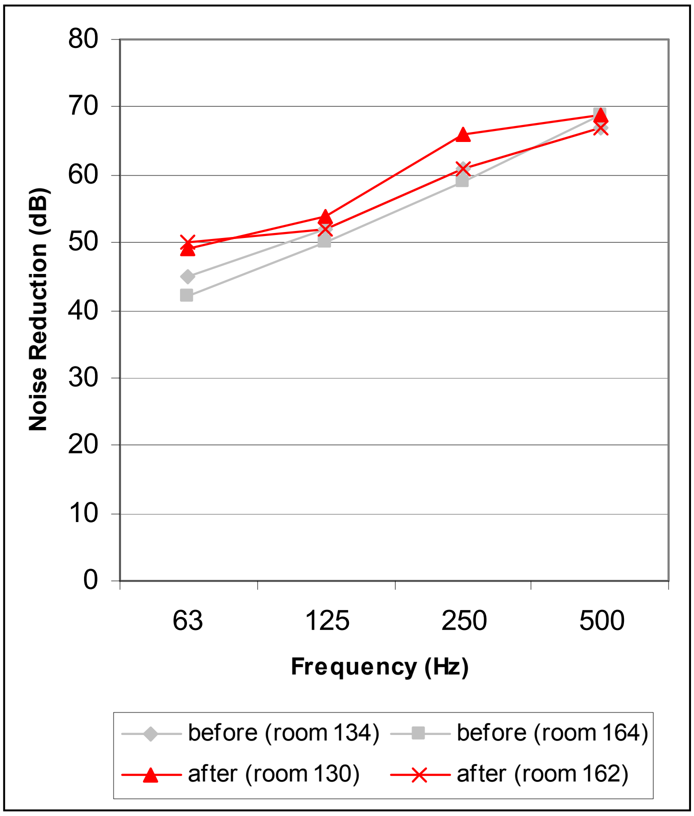

Figure 2: Measured Noise Reduction

Typical measurements of bar noise indicate that levels of up to 110-115 dB at 63 Hz and 125 Hz are possible in noisy bars and clubs.

The level of noise generated in the bar would need to be limited to approximately 95 dB at 63 Hz and 92 dB at 125 Hz in order to control the transmission of low frequency noise and so limit the number of complaints received. Where bar noise levels are similar to those measured on site, noise complaints from sensitive patrons may continue to occur.

It is understood that a small number of noise complaints have been made by patrons staying in hotel rooms closest to the bar since commissioning. This is generally consistent with bar noise being moderately detectable in these suites. ❑