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ADELAIDE AIRPORT NOISE INSULATION PROGRAM

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1. INTRODUCTION

The Department of Transport and Regional Services is overseeing a $63 million federally funded sound insulation program for residential and public buildings surrounding the Adelaide Airport. VIPAC was engaged by the project manager (Clifton Coney Stevens) as the Acoustic Consultant to design the treatments for the buildings, to oversee the installation of the treatment and verify the performance.

The project involves implementation of noise insulation treatments to about 600 residential dwellings within the 30 and 35 Australian Noise Exposure Concept (ANEC) noise contours and selected public buildings within the 25 ANEC noise contour. It is based on aircraft noise level contour data provided by the Federal Airports Corporation and amelioration treatment guidelines developed from the Sydney Airport Noise Insulation Program (SANIP).

2. HOUSING TYPES WITHIN THE NOISE INSULATION ZONE

Most of the residential buildings eligible for noise insulation treatment are single dwellings built between 1920 and 1970. There is a number of multi dwelling units (medium density houses) constructed between 1960 and 1970. The existing housing stock in the noise insulation zone was determined during a survey and divided into the following types (Table 1).

3. DETERMINATION OF THE ACHIEVABLE NOISE REDUCTION

The achievable noise reduction and the internal noise level in the houses (before and after treatment) within the insulation zone were determined using a model representing a typical house (bungalow with overall dimensions 18m x 14m) comprising three bedrooms, living area (kitchen and family/dining), sunroom and bathroom. The results from modelling were calibrated against noise measurements before and after treatment of the AANIP Display House.

3.1. Description of the Model

The type of the house was chosen based on the following criteria:

1. The model had to represent a dominant housing group within the insulation zone,

and

2. The model had to be of the same or similar housing type as the display house (70 years old bungalow situated in 30-35 ANEF contour on 13 Turner St, Cowandilla), which would help with the verification of the predicted noise reduction.

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	Building area, m^2	Walls construction	Glazing area	Windows	Roof	Fireplaces	Additions
Austerity (1930 – 1950)	80 - 200	Brick (solid or cavity)	10%	Double hung, timber frame	Pitched, tiles	No	Lightweight
Bungalow (1920 – 1930)	80 - 200	Brick (solid or cavity)	10%	Double hung or casement, timber frame	Pitched, sheet metal	1 - 2	Lightweight
Medium density (1960 – 1970)	50 - 100	Brick veneer, brick	16%	Sliding, aluminium frame	Pitched, gable or skillion	No	No
Conventional (1950 – 1960)	72 - 260	Brick (solid or cavity)	18%	Awning & sliding, timber or steel frame	Pitched, tiles	No	Brick veneer
Modern (1970 – onwards)	65 - 300	Brick veneer, solid brick	21%	Sliding, aluminium frame	Pitched, tiles or steel	No	No
Vila (prior 1920)	90 - 250	Solid brick	10%	Double hung, timber frame	Pitched, steel	1 –2	Lightweight
Dutch gable (around 1930)	80 - 200	Double brick	10%	Double hung or casement, timber frame	Pitched, tiles or steel	No	Lightweight

Table 1: Housing groups in the insulation zone

3.1.1. Building Elements

The model consisted of the following elements:

- External walls – according to the construction of the display house, the construction of the external walls of the model were as follows:
  1. Bedrooms – double brick walls. Wall and floor vents were modelled in the double brick walls reflecting the existing wall and floor vents of the display house.
  2. Family/Dining and Sunroom – plasterboard and fibre cement.
- Roof – corrugated iron with no sarking or insulation. Gaps between the roof and the external walls were modelled.
- Ceiling – plasterboard with insulation.
- Front and back gables – fibre cement.
- Internal walls – single leaf brick wall plastered both sides.
- Partition between the living area and the bathroom and between the bathroom and Bedroom 3 – fibre cement lining on both sides of timber studs with no insulation.
- Windows – 3mm thick float glass pane in timber frame.
- Front door – hollow core plywood door, no seals.
- French doors – 3mm thick float glass.
- Skylights – 3mm float glass.

3.1.2. External Design Level (EDL)

AS 2021-2000 provides a method for predicting the sound pressure level (in dBA) at a building site resulting from aircraft landings and take offs based on the distances in meters from the runway centreline and both runway ends.

Based on coordinate information for the display house, as provided by the Department of the Environment and Heritage, the calculated L_{Amax} for BOEING 737-300 (the aircraft considered as predominant for the Adelaide Airport) using AS 2021-2000 was 91dBA (the calculated L_{Amax} for BOEING 737-300 throughout the noise insulation zone was 81-98dBA).

Measurements of noise resulting from flyovers of different types of aircraft taken in the backyard of the display house showed external noise levels L_{Amax} in the range of 91dBA – 97dBA, average 94.5dBA.

3.2. Criteria

AS 2021-2000 "Acoustics – Aircraft Noise Intrusion – Building Siting and Construction" sets the recommended indoor design sound levels for determination of aircraft noise reduction for houses, home units and flats as follows:

- *Sleeping areas* *50dBA*
- *Other habitable spaces* *55dBA*
- *Bathrooms, toilets etc.* *60dBA*

3.3. Noise Reduction and Internal Noise Levels

The performance of each building element was analysed in the following cases:

- Untreated – used to determine the accuracy of the model based on the measurements carried out in the display house.
- Optimally treated – used to determine the maximum achievable noise reduction.
- Non-optimally treated – used to determine the likely noise reduction with some deficiencies remaining.

3.3.1. Untreated

Table 2 shows the sound pressure levels in the different rooms of the house predicted with the model and measured during aircraft flyovers. The impact of the directivity effects from the flight path has not been accounted for in the model (AS 2021-2000 also notes that a shielding effect can be applied). The sound pressure levels measured in the display home were within 4dBA of the predicted levels, which shows good agreement.

Room	Model (predicted)		Display house (measured), dBA	
	SPL, dBA	Overall reduction, dBA	SPL, dBA	Overall reduction, dBA
Bedroom 1	70	24	67	27
Bedroom 2	68	26	67	28
Bedroom 3	70	24	66	28
Family/Dining	77	18	76	18
Sunroom	84	9	78	16

Table 2: Predicted and measured sound pressure levels before treatment

3.3.2. Optimally Treated

The optimal treatment applied to the model is detailed below:

- Sealing the gaps between the roof and the external walls.
- Replacement of the existing window glazing with 6mm thick laminated glass.

- New secondary 6mm thick laminated glass windows offset from the existing windows by 100mm air gap.
- New 10mm thick laminated glazing to the French door in the Family/Dining room.
- Treatment of the lightweight external walls.
- Laying the ceiling with 85mm, 20kg/m^3 fibreglass batts and 4kg/m^2 flexible vinyl loaded acoustic barrier (Wavebar).
- Lined exhaust fan ducts.
- Sealing of the wall and subfloor vents.
- Treatment of the skylight in the Family/Dining room.
- Replacement of the external door with solid core timber door fitted with seals.
- Sealing of the fireplaces and chimneys.

Table 3 shows a comparison between the predicted sound pressure levels in the different rooms of the house with the optimal treatment applied to the model and measured during aircraft flyovers after the optimal treatment was applied to the display house.

Room	Model (predicted)		Display house (measured)	
	SPL, dBA	Overall reduction, dBA	SPL, dBA	Overall reduction, dBA
Bedroom 1	51	43	59	35
Bedroom 2	51	43	60	34
Bedroom 3	51	43		
Family/Dining	62	32	63	31
Sunroom	67	27	65	29

Table 3: Predicted and measured noise levels after optimal treatment and overall noise reduction gained

Inspection of the display house following the noise survey after the completion of the insulation work revealed that the following omissions in the noise control work carried out that explain the discrepancy between the noise reduction predicted with the model and the values measured on site:

- Cushion heads were not installed on the diffusers.
- The chimney in Bedroom 2 was fitted with a damper, but without any seal.
- The fireplace in Bedroom 1 was treated with a plywood cover instead of the recommended sealing of the fireplace within the chimney.
- There were drain holes in the glazed sliding door.

3.3.3. Non-Optimally Treated

We considered not applying treatments to the following elements:

- Gaps in the roof structure.
- Subfloor vents.
- Lightweight cladding (windows only).

- Replacement of the existing windows glazing with 10mm laminated glass instead of upgrading to double-glazing.

The predicted sound pressure levels in the different areas in the display house are shown in Table 4. Theses results are within 3-5dBA of those measured.

Room	Model (predicted)		Display house (measured)	
	SPL, dBA	Overall reduction, dBA	SPL, dBA	Overall reduction, dBA
Bedroom 1	57	38	59	35
Bedroom 2	55	39	60	34
Bedroom 3	57	38		
Family/Dining	71	24	63	31
Sunroom	74	21	65	29

Table 4: Predicted sound pressure and overall noise reduction levels after non-optimal treatment

3.4. Assessment

The analysis of the sound pressure levels and noise reduction predicted using the model and measured in the display house revealed the following:

- If a house is treated optimally, AS 2021-2000 criteria could be achieved in the areas with solid external walls (solid or double brick and brick veneer) and not achieved in rooms with lightweight external walls.
- An average noise reduction improvement higher than 10dBA throughout a residence could be achieved applying optimal treatment menu.
- Even an average noise reduction of about 10dBA throughout a residence could be achieved if a house is treated with deficiencies, the AS 2021-2000 criteria could not be achieved.
- The difference in terms of overall noise reduction between optimal and non-optimal treatment menus was estimated to be between 4 and 6dBA.
- The analysis of the predicted and measured internal sound pressure levels showed that shielding and directivity factors should be accounted for during development of a model.

4. ASSESSMENT OF THE NOISE REDUCTION GAINED

4.1. Measurement Procedure

To assess the effect of the noise insulation treatments, noise measurements are carried out in the residences before any acoustic treatment is applied and after the work on the residence is completed. The maximum A-weighted sound pressure levels are measured simultaneously outside and inside the residence. A Larson Davis LD2900 dual channel analyser is used in the measurements with the microphone reading the external noise levels positioned approximately in the middle of the front/backyard. The internal sound pressure levels are measured in the main bedroom and the living room (approximately in the centre of the rooms) during five flyovers of representative aircraft (BOEING 737, 747, 767, A320 and A340), assuming that if the AS 2021-2000 criteria are achieved in these noise sensitive areas, they will be achieved in the rest of the residence.

4.2. Results

Pre and post construction measurements have been carried out in 36 residences of different types (17 houses Austerity style, 11 houses Bungalow style, 3 Conventional house and 5 Medium density residences). The results of the treatment are summarised below:

- The highest average improvement in noise reduction so far has been gained among the Medium density residences (11dBA) with average improvement in noise reduction of 11dBA in the living rooms and 12dBA in the bedrooms. The selected criterion of 50dBA has been met in all medium density bedrooms, while the criterion of 55dBA has been exceeded in one living room.
- The average noise reduction improvement in the residences of Conventional type was calculated at 11dBA. However, only three houses of this type have been investigated after implementation of the proposed treatments and a generalisation would not be correct. The average improvement in noise reduction was 10dBA in the living rooms and 11dBA in the bedrooms. The recommended criteria of 50dBA in the bedrooms and 55dBA in the living rooms were marginally exceeded after noise insulation treatment in two of the houses.
- The average improvement in noise reduction gained in the Austerity style houses treated so far has been 10dBA with an improvement of 11dBA in the living rooms and 10dBA in the bedrooms. The results show that the criteria of 50dBA in the bedrooms and 55dBA in the living room were exceeded after the treatment in two houses.
- The average improvement in noise reduction that has been achieved so far is lowest in the houses of bungalow style (9dBA) with an average improvement of 10dBA in the living rooms and 9dBA in the bedrooms. The noise reduction gained in these residences is the lowest as most of them had been partially insulated (mainly ceiling insulation) before the treatment. The post-construction noise survey showed that the criterion of 50dBA is exceeded in the display home (it was discussed earlier) and marginally exceeded in one residence. The criterion of 55dBA in the living room is exceeded in the display house and again marginally exceeded in one residence.

4.3. Conclusions

An analysis of the adopted criteria, noise reduction prediction and noise reduction gained during the Sydney Airport Noise Insulation Project (SANIP) and Adelaide Airport Noise Insulation Project (AANIP) revealed the following:

- The constructions of the houses included in the noise insulation area during AANIP differ from the construction of the residential buildings in the SANIP areas eligible for noise insulation by construction, architecture and building area.
- The criteria for internal sound pressure levels after treatment adopted during SANIP were 50dBA (sleeping and relaxing areas) and 60dBA (other areas), while the criteria adopted during AANIP are 50dBA (sleeping areas), 55dBA (other habitable spaces) and 60dBA (corridors, laundries etc). A noise reduction of 10dBA before and after treatment was the design criterion defined by the Department of Transport and regional Services.
- Our experience confirmed that in the areas where the EDL's are higher than 90dBA it is unlikely the 50dBA criterion in the sleeping areas will be achieved with conventional noise controls (ie upgrading the existing roof/ceiling structure installing secondary

glazing within the normal domestic constructions) even in the residences with solid/cavity brick walls.

- The criterion of 50dBA is unlikely to be achieved in houses with lightweight construction even if the EDL is less than 90dBA.
- The average improvement in noise reduction gained so far in AANIP is slightly higher than the average improvement in noise reduction gained during the treatment of the initially selected 17 houses in the SANIP (Figures 1 and 2).

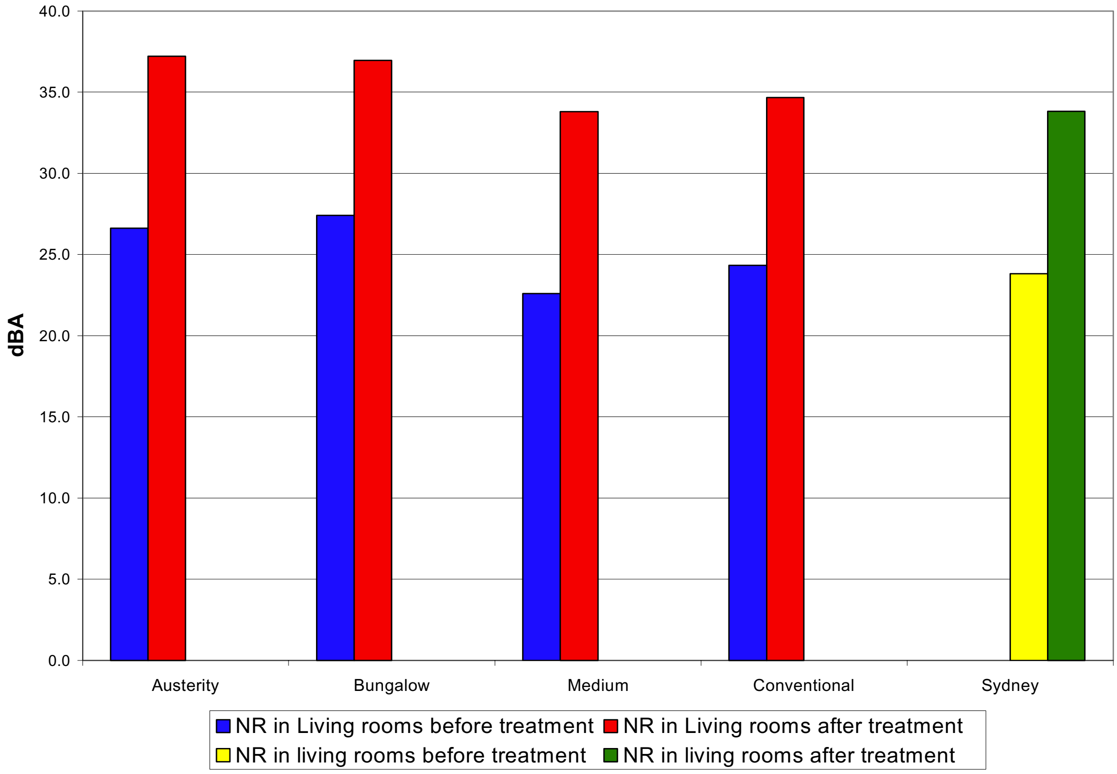

Figure 1: Comparison between the average improvement in noise reduction in the living rooms of the treated residences gained during AANIP and SANIP

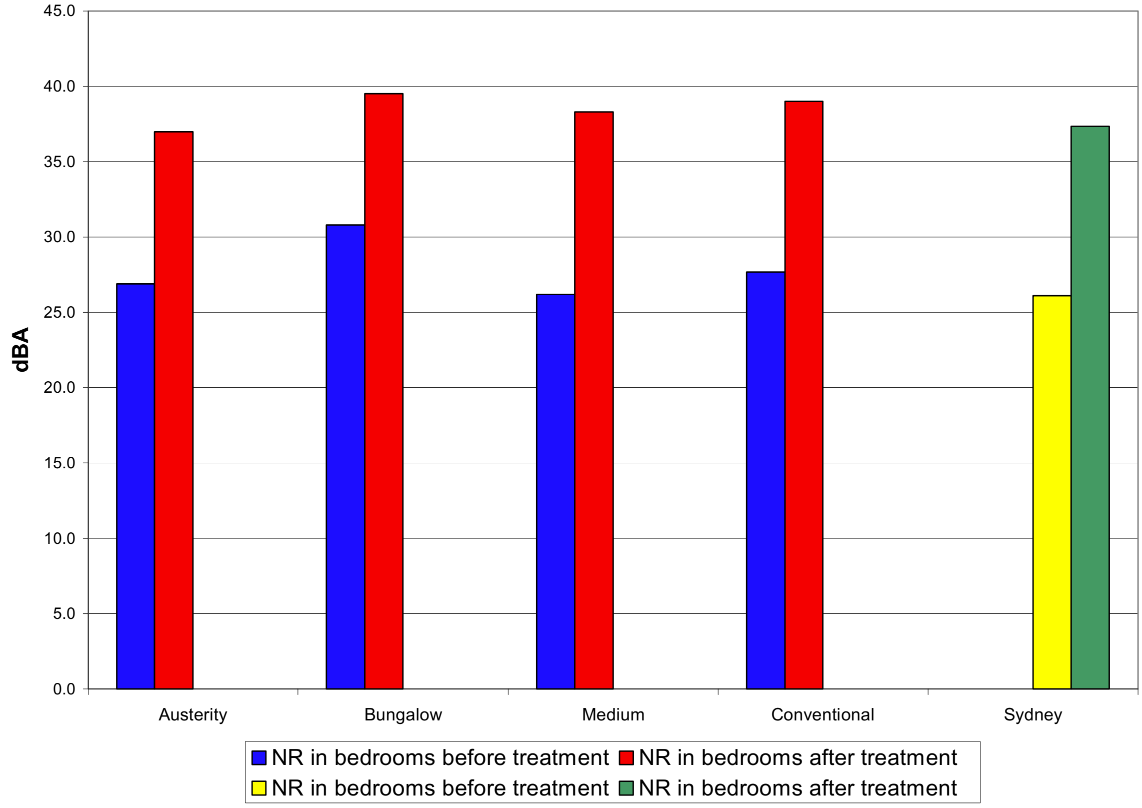

Figure 2: Comparison between the average improvement in noise reduction in the bedrooms of the treated residences gained during AANIP and SANIP

REFERENCES

1. AS 2021-2000 “Acoustics – Aircraft Noise Intrusion – Building Siting and construction”.
2. VIPAC Document No 504397-TRP-11882-00 “Review of treatment menu”, November 2000.