Traffic Noise Control Using Acoustic Screens

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ABSTRACT

New residential development was recently established in Coomera at the Gold Coast to Brisbane urban corridor. The development has an extensive frontage to a sub-arterial road with an ultimate capacity of 14,000 vehicles per day (Annual Average Daily Traffic - AADT). The houses in the first row along the road were affected by traffic noise exceeding the free-field traffic noise criterion of 60dB(A)$L_{10(18\ Hour)}$. The design of the dwellings (all low-set houses) includes large patios with pergolas facing the traffic noise source. Considering that the elevation of the dwellings was at least 2 metres higher than the elevation of the road it was considered impractical to construct a noise barrier fence along the property boundary. Instead, acoustic screens (1.8m high) were recommended along the perimeter of the patios. Post construction investigation of the efficiency of one of the acoustic screens was carried out. The aim was to determine the noise reduction achieved as well as to determine the compliance with the relevant free-field traffic noise criterion for formal open space of 60dB(A)$L_{10(18\ Hour)}$ considering ultimate traffic flow of 14,000 vehicles AADT. The investigated 1.8m high acoustic screen has attenuated the traffic noise to below the free-field criterion of 60dB(A)$L_{10(18\ Hour)}$. The noise reduction achieved for the L_{10} parameter is 6dB(A), as expected from similar noise barrier fence. It is considered that an acoustic screen, not higher than 1.8m, can be viable alternative to standard noise barrier fences to provide noise protection for the formal open spaces of dwellings along sub-arterial roads with a maximum design traffic flow of not more than 15,000 vehicles AADT.

INTRODUCTION

New residential development was recently established in Coomera at the Gold Coast to Brisbane urban corridor. The development has an extensive frontage to a sub-arterial road with an ultimate capacity of 14,000 vehicles per day (Annual Average Daily Traffic - AADT). In recognition of the potential traffic noise impact the local authority (Gold Coast City Council) imposed statutory covenants on the title of five allotments in the first row along the road. The covenants stipulate that any future dwellings to be constructed on the traffic noise affected allotments have to be designed and constructed as per the requirement of AS3671-1989 to meet internal criteria of AS2107-2000. In addition the local authority requested noise protection for the formal open spaces of the traffic noise affected dwellings. For individual dwellings the formal open space is an area accessible from the living room that can be used for "outdoor living".

The design of the dwellings (all low-set houses) included formal open spaces (patios with pergolas) facing the traffic noise source. The view from the patios to the road is presented in Figure 1.

Figure 1. View to the Road from the Backyard Patio

To ensure compliance with the internal criteria of 2107-2000, the two windows on the most exposed façade were retrofitted with thicker glazing (6.78mm laminated glass). The traffic noise attenuation calculations (AS3671-1989) showed that the brick veneer construction and the insulated tiled roof, provide sufficient sound transmission loss to ensure compliance with the internal criteria. Based on experience from acoustic design on similar houses, located in a similar traffic noise environment, high level of internal noise amenity is expected. No further investigations were carried out.

To protect the noise amenity at the backyard patios, acoustic screens were designed as per the following specifications:

- Height of 1.8 metres;
- Setback of 2 metres from the edge of the patios;
- Returns of minimum 2 metres at both ends of the screens;
- Constructed with no gaps of a suitable material with a minimum density of 12.5 kg/m^2; and
- Embedded in the ground so that no gaps are left underneath.

The acoustic screens, shielding only the noise sensitive outdoors area, were considered due to the constraints encountered on site, as follows:

- The Local Authority does not support noise barrier fences along sub-arterial roads due to visual impacts;
- The elevation of the houses is at least 2 metres higher than the elevation of the road, requiring noise barrier fence of substantive height;
- The investigated houses were already built;

- There was a limited budget available for implementation of post-construction noise control measures.

The typical location of the acoustic screen is presented in Figure 2.

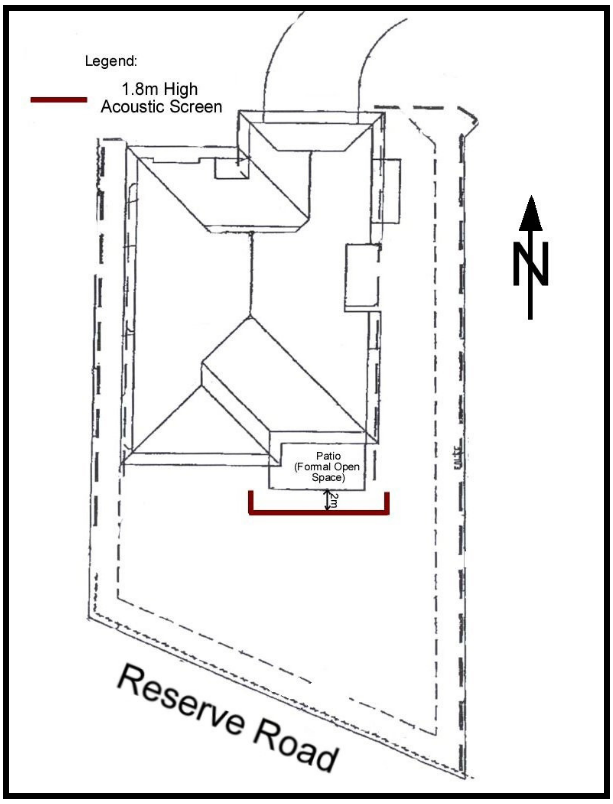

Figure 2. Typical Location of an Acoustic Screen

Post construction investigation of the efficiency of one of the acoustic screens was carried out. The aim was to determine the noise reduction achieved as well as the compliance with the relevant traffic noise criterion for formal open space of 60dB(A)$L_{10(18\ Hour)}$ (free-field) considering ultimate traffic flow of 14,000 vehicles AADT.

POST-CONSTRUCTION NOISE MEASUREMENTS

Traffic noise measurements, in front and behind the acoustic screen, were carried out simultaneously over 24-hour period on a normal weekday. The noise measurements were carried out with calibrated noise loggers (EL215 and El315) in free-field conditions. The measurements were undertaken in general accordance with AS 1055 – 1997 and AS 2702 – 1984.

The weather conditions were fine throughout the noise measurement period with light wind.

The locations of the noise loggers during measurements are presented in Figures 3 and 4.

Figure 3. Noise Logger In-front of the Screen

Figure 4. Noise Logger Behind the Screen

The results of the traffic noise $L_{10(18\ hour)}$ measurements are presented in Table 1.

Table 1. Traffic Noise Measurement Results

In-front of Screen	Behind Screen	Criterion
$L_{10(18\ Hour)}$ (Free field) dB(A)	$L_{10(18\ Hour)}$ (Free field) dB(A)	$L_{10(18\ Hour)}$ (Free field) dB(A)
64	58	60

Without noise control, the traffic noise criterion is currently exceeded by 4dB(A) in the backyard of the investigated house. The acoustic screen has attenuated the traffic noise to below the free-field criterion of 60dB(A)$L_{10(18\ Hour)}$ at the patio.

The noise measurements were carried out as post-construction compliance measurements and the measured noise parameters were the parameters stipulated in the traffic noise criteria applicable in Queensland. No sound pressure level measurements in different frequency bands were carried out.

The noise reduction achieved for the L_{10} parameter is 6dB(A) as illustrated in Figure 5.

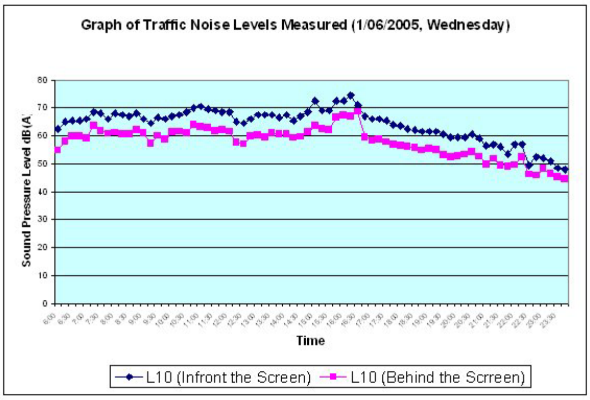

Figure 5. Graph of the Noise Measurement Results

COMPLIANCE WITH ULTIMATE CRITERION

The noise criterion for formal open space as per Queensland Legislation is 60dB(A)$L_{10(18\ Hour)}$ (free-field). The planning horizon is 10 years from the time of establishment of the development or the ultimate design traffic flow on the road of interest.

In this case GCCC specified requirement for acoustic design considering the ultimate design capacity of 14,000 vehicles (annual average daily traffic – AADT). The traffic noise levels were calculated using the traffic noise prediction module of SoundPLAN[3]. Calculations were based on the procedures developed by the U.K. Department of Transport, Welsh Office, issued as *"Calculation of Road Traffic Noise"* in 1988 (CoRTN'88).

The SoundPLAN model was validated based on the measured traffic noise levels ($L_{10\ (18\ hour)}$) in-front and behind the acoustic screen. Digital Terrain Model (DTM) was developed from the survey data of the development. The results of SoundPLAN validation are presented in Table 2 below.

Table 2. SoundPLAN Validation Results

In-front of Screen	Behind Screen	Validation Factor	
$L_{10(18\ Hour)}$ (Free field) dB(A)	$L_{10(18\ Hour)}$ (Free field) dB(A)	In-front of Screen	Behind Screen
64	57	N/A	+1

The model overestimates the efficiency of the acoustic screen by 1dB(A) implying that the noise reduction expected is 7dB(A). In reality, as shown by the noise measurements, the noise reduction achieved with the acoustic screen is 6dB(A). Validation factor of +1dB(A) was added to the calculated ultimate noise levels behind the acoustic screen.

Whilst the above SoundPLAN validation procedure is not statistically rigorous, it is an adopted procedure utilisised by acoustic engineers when assessing traffic noise. It is based on initial establishment of the model parameters (eg. traffic flows, road surface, topography, location and height of buildings) to closely reproduce the measured noise levels. The established model is used to calculate the change in the traffic noise levels (normally within a 10-year planning horizon) considering increased traffic flows and any noise ameliorative treatments.

In this case the impact of the ultimate road design traffic flow capacity of 14,000 vehicles AADT was considered. The ultimate traffic flow was scaled down by a factor of 0.95, to represent the 95[th] percentile traffic flow in an 18-hour period between 6:00a.m. and 12:00midnight. The zoned speed limit in the area is 60km/hr. "User Road Surface Correction" option was selected to address the characteristics of the road surface and its influence on traffic noise. Considering that dense graded asphalt is used on the investigated road, no correction was applied.

The results of the traffic noise propagation modelling are presented in Table 3.

Table 3. Traffic Noise Modelling Results

In-front of Screen	Behind Screen	Criterion
$L_{10(18\ Hour)}$ (Free field) dB(A)	$L_{10(18\ Hour)}$ (Free field) dB(A)	$L_{10(18\ Hour)}$ (Free field) dB(A)
66	60	60

The results obtained indicate that the acoustic screen as designed and constructed will provide sufficient noise attenuation to ensure compliance with the ultimate traffic noise criterion considering traffic flow of 14,000 vehicles AADT.

It is believed that the traffic noise reduction achieved by the acoustic screen at the investigated is a result of multiple factors including attenuation by the elevated terrain and the reduced angle of view due to partial screening by the adjoining houses. Irrespective of this, by far the dominant reduction of the traffic noise levels is due to the acoustic screen.

Noise contours overlaid over the terrain at the investigated site are presented in Figure 6.

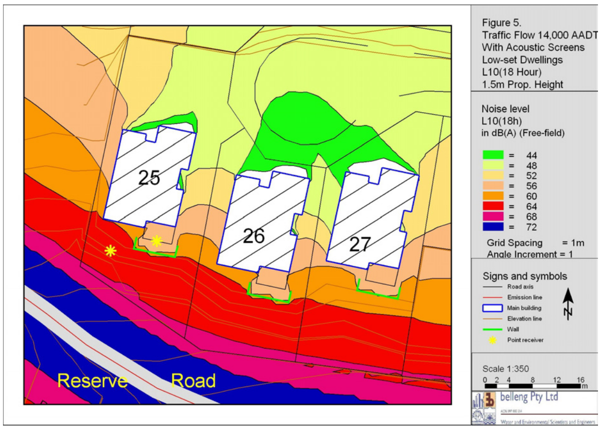

Figure 6. SoundPLAN Noise Contours

The efficiency of the acoustic screen was investigated further to determine the highest traffic flow that it can protect from. When 16,000 vehicles AADT, were considered in the model, the free-field criterion of 60dB(A)$L_{10(18\ Hour)}$ was exceeded by 0.6dB(A). This is considered a break point where the 1.8m high acoustic screen is no longer efficient.

To maintain the efficiency, the height of the acoustic screen needs to be increased above 1.8 metres. This is considered unacceptable due to shading effect. The 1.8m high screen already generates shading in the protected area that was considered acceptable by the house occupants. With an increase in elevation the shading effect can be unacceptable.

It is considered that 1.8m high acoustic screens can be used to provide noise protection for formal open spaces on dwellings along local sub-arterial roads with a maximum design traffic flow of not more than 15,000 vehicles AADT.

COST/BENEFIT ANALYSIS

The term "acoustic screen" was used instead of noise barrier fence in order to emphasise the distinct features of the system. Whilst the investigated acoustic screen reduces traffic noise by the same mechanism as noise barrier fence (reflecting and increasing the travel path of the sound wave), it has distinctive characteristics, as follows:

- It is designed to isolate the receiver from the surrounding noise using the principles of industrial noise control; and
- Its size and location is specific to the relatively limited noise sensitive area that requires protection.

The above characteristics of the acoustic screen make it a viable alternative to standard noise barrier fence within the limits of its applicability.

At the investigated site, noise protection in compliance with the formal open space criterion, is achieved by 1.8m high acoustic screen that is approximately 12 metres long (including the returns). Comparative noise propagation modelling, indicate that same level of noise attenuation can be achieved with 2.4m high boundary noise barrier fence with a total length (including returns) of 36 metres.

The construction costs of the two noise control systems are presented in Table 4.

Table 4. Construction Costs

Noise Control System	Area (m^2)	Cost* ($\$/m^2$)	Total Cost ($)
Noise Barrier Fence	86.4	120.00	10,368.00
Acoustic Screen	21.6	120.00	2,592.00

*Source: Quotation (GST Exclusive) by *FENCO Noise Barrier Pty Ltd*

Based on the overall cost of the two systems a cot analysis was carried out on the basis of cost ($) per area ($m^2$) protected. The comparative cost are presented in Table 5.

Table 5. Comparative Costs

Noise Control System	Total Cost ($)	Area Protected (m^2)	Cost/Area Protected ($\$/m^2$)
Noise Barrier Fence	10,368.00	260	39.8
Acoustic Screen	2,592.00	25	103.6

In relative terms (cost per area protected) the acoustic screen is more expensive than the noise barrier fence.

In situations where there is a requirement for protection of large areas (all of the outdoor area around a dwelling), the noise barrier fence will have obvious advantages. But the legislative requirements in Queensland distinguish formal external open spaces as places for "outdoor living" that require protection from traffic noise. The legislation is silent when it comes to protection of the total outdoor area. In this case, as mentioned earlier, the Local Authority has generally negative attitude towards noise barrier fences due to visual impacts. In practice, as long as the dwelling affected by traffic noise is designed to prevent traffic noise intrusion in compliance with the internal noise criteria, and has protected "outdoor living area", there are no further requirements.

Under the above regulatory conditions, the acoustic screen has important financial advantages to the full noise barrier fence. Even considering the costs of retro-fitting the two windows on the most exposed façade with thicker glazing (6.78mm laminated glass), the acoustic screen is three times more affordable alternative to boundary noise fence.

VISUAL IMPACT CONSIDERATION

In terms of visual impact the investigated acoustic screen has disadvantages compared to fully landscaped noise barrier fence. Viewed from the road the acoustic screen, the way it was constructed, is visually intrusive. The as constructed acoustic screen is presented in Figure 7.

Figure 7. Acoustic Screen (As Constructed)

Whilst currently visually intrusive, some softening of the visual impact can be achieved with dense landscaping. The cost of landscaping for the acoustic screen is lower than the equivalent landscaping for a noise barrier fence.

The comparative landscaping costs, assuming landscaping only along the front of the screen or equivalent noise fence, are presented in Table 6.

Table 6. Landscaping Cost Comparison

Noise Control System	Area (m^2)	Cost* ($\$/m^2$)	Total Cost ($)
Noise Barrier Fence	18	50.00	900.00
Acoustic Screen	8	50.00	400.00

* Source: *Standard Landscape Industry Rates based on Supply and Install Contract.*

The visual impact of the acoustic screen can be reduced at half of the cost for the landscaping of an equivalent noise barrier fence.

Although, landscaping can provide softening of the visual impact, and alternative construction was considered for an acoustic screen on a new house in the same area. To address the visual impacts, it is recommended to construct an acoustic screen of rendered brick in character with the house façade. To break-up the plain appearance, glass-brick features will be incorporated into the design of the new acoustic screen.

CONCLUSIONS

The investigated 1.8m high acoustic screen, designed to protect the noise amenity at the backyard patio of a traffic noise affected house, has attenuated the traffic noise to below the free-field criterion of 60dB(A)$L_{10(18\ Hour)}$. The noise reduction achieved for the L_{10} parameter is 6dB(A), as expected from similar noise barrier fence.

Whilst the investigated acoustic screen reduces traffic noise by the same mechanism as a noise barrier fence (reflecting and increasing the travel path of the sound wave), it has distinctive characteristics, as follows:

- It is designed to isolate the receiver from the surrounding noise using the principles of industrial noise control; and
- Its size and location is specific to the relatively limited noise sensitive area that requires protection.

In relative terms (cost per area protected) the acoustic screen is more expensive than the noise barrier fence. But, considering that the legislative requirements in Queensland place higher value on the formal external open spaces as places for "outdoor living" than the total outdoor area, the acoustic screen has important financial advantages to the full noise barrier fence.

Even considering the costs of retro-fitting the two windows on the most exposed façade with thicker glazing (6.78mm laminated glass), the acoustic screen is three times more affordable alternative to boundary noise fence.

The external visual impacts as well as the shading effects are important consideration in the design of the acoustic screens. Softening of the visual impact can be achieved with dense landscaping. The cost of landscaping for the acoustic screen is twice lower than the equivalent landscaping for a noise barrier fence.

The 1.8m high screen already generates shading in the protected area that was considered acceptable by the house occupants. With an increase in elevation the shading effect can be unacceptable.

It is considered that an acoustic screen, not higher than 1.8m, can be used to provide noise protection for the formal open spaces of dwellings along sub-arterial roads with a maximum design traffic flow of not more than 15,000 vehicles AADT.

REFERENCES

Standards Australia. 1997, *AS 1055 – 1997 (Acoustics - Description and measurement of environmental noise)*

Standards Australia. 1984, *AS 2702 - 1984 (Acoustics – Methods for the measurement of road traffic noise).*

Braunstein + Berndt Gmbh, SoundPLAN LLC. 2004, *SoundPLAN User's Manual*

U.K. Department of Transport, Welsh Office. 1988, *Calculation of Road Traffic Noise,* Her Majesty's Stationery Office, London, UK