An examination of the relationship between the nature of the traffic noise source and the resultant internal noise levels determined under QDC MP 4.4

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ABSTRACT
Queensland Development Code Mandatory Part MP4.4 *Buildings in a Transport Noise Corridor* (QDC MP4.4) was gazetted by the Queensland Government in September 2010. The stated purpose of QDC MP 4.4 is to ensure habitable rooms of Class 1, 2, 3 and 4 buildings (ie residential dwellings) located in a Transport Noise Corridor are designed and constructed to reduce transport noise. The extent of building upgrade may be determined by reference to deemed-to-comply building constructions or to the results of a site-specific acoustical design review. For sites adjacent to major roads, the deemed-to-comply building constructions and the building upgrade performance requirements set by the Code tend to overstate the degree of attenuation required. For sites adjacent to rail lines trafficked by electric passenger trains only, the deemed-to-comply building upgrade performance requirements are generally quite comparable to the actual upgrades determined using the site-specific method. By contrast, in situations where residences are to be constructed adjacent to rail lines trafficked by diesel trains, the deemed-to-comply building upgrades are often not sufficient to adequately control rail noise intrusion. This paper attempts to quantify the degree to which the building upgrade performance requirements fall short of the mark as well as provide suggestions on methods for addressing this shortfall.

1. INTRODUCTION

The stated purpose of Queensland Development Code Mandatory Part 4.4 *Buildings in a Transport Noise Corridor* (QDC MP4.4) is to ensure habitable rooms of residential dwellings located close to major roads and rail lines are designed and constructed to reduce transport noise.

The extent of building upgrade may be determined by reference to two methods: (i) the building upgrade performance requirements and corresponding deemed-to-comply building constructions contained within the Code, or (ii) from the results of a site-specific acoustical design review.

In almost all instances, it has been found that, where the building site is located adjacent or close to a major road, the application of the first method (ie adopting the performance requirements and deemed-to-comply building constructions of the Code) results in a much higher degree of building upgrade and, consequently, more costly building construction than is warranted if the second method were to be adopted (ie the site-specific acoustical design review method).

For sites adjacent or close to rail lines, however, the differences shrink and, in many cases, are reversed. More specifically, where a dwelling is affected by electric passenger train noise only, the deemed-to-comply building upgrade performance requirements are generally quite comparable to the actual upgrades determined using the site-specific method. By contrast, in situations where the residence is affected by noise from both electric passenger trains and diesel-hauled trains, the deemed-to-comply building upgrades are often not sufficient to adequately control rail noise intrusion.

This paper presents the results of an acoustical analysis of a typical detached dwelling to quantify the degree to which the first method falls short of the mark. In addition, it provides guidance on adjustments that may be made to the assessment procedure to deal with this shortfall. It is noted that this paper does not attempt to examine the methods for designing buildings to control rail noise intrusion that have been developed by other regulatory bodies, either interstate or overseas. Nor does it delve into standards – either in force or in draft – to achieve the same outcomes that have been prepared by standards authorities. Rather, its focus is deliberately narrow, concerned as it is with an examination of the apparent shortcoming with the methodologies of QDC MP4.4.

2. QUEENSLAND DEVELOPMENT CODE MANDATORY PART 4.4

In Queensland, all residential allotments located within a Transport Noise Corridor (TNC) are required to be acoustically designed in accordance with the requirements of the Code having regard to the relevant noise categories. The TNC's can be determined by reference to the State Government State Planning Policy (SPP) Interactive Mapping System Website. In addition, the SPP Website can also be used to determine the specific the noise category/s applying to any particular lot within a TNC. Alternatively, a more accurate determination of the actual noise category/s applying to the particular lot can be made in accordance with the alternative site-specific noise level assessment method.

Five noise categories have been designated under QDC MP 4.4, ie Noise Categories 0, 1, 2, 3 and 4. Noise Category 0 is the least stringent noise category. No additional acoustical treatment is required to be applied to a residence in the Noise Category 0 band. Standard building construction will suffice. Noise Category 4 is the most stringent category. It requires that very high performance acoustical upgrades be implemented into the design of the affected residence.

The lower and upper noise level bounds, ie class intervals, of the noise categories of the Code are set by reference to the external noise level generated by passing trains. These class intervals (both stated and resolved) are presented in Table 1 together with the corresponding minimum transport noise reduction stated in the Code.

Table 1: Noise category class intervals and minimum transport noise reduction

Noise Category	External Single Event Maximum Noise Level for Lots Adjoining Railway Land, $L_{Amax\ passby}$ (dBA)		Minimum Transport Noise Reduction (dBA) Required for Habitable Rooms
	As Stated in Code	Corrected to Resolve Discontinuities	
Category 4	≥ 85 dBA	≥ 85 dBA	40
Category 3	80 - 84 dBA	80-85 dBA	35
Category 2	75 - 79 dBA	75-80 dBA	30
Category 1	70 - 74 dBA	70-75 dBA	25
Category 0	≤ 69 dBA	≤ 70 dBA	NA

The Single Event Maximum Noise Level, $L_{Amax\ passby}$, is defined as the arithmetic average of the 15 highest noise level passbys of trains over a typical 24 hour period.

From an examination of the data presented in Table 1, it is evident that, by subtracting the minimum transport noise reduction from the corresponding class interval bounds, the range of acceptable maximum internal noise levels for habitable spaces, notably bedrooms and living spaces, is 45-50dBA $L_{Amax\ passby}$.

Consequently, it can be concluded that the Code attempts to achieve compliance with a $L_{Amax\ passby}$ internal noise level target of 45-50dBA.

QDC MP4.4 also presents (i) building upgrade performance requirements set in terms of the minimum weighted sound reduction index (R_w) requirement for each component of the building envelope together with (ii) corresponding acceptable forms of construction (ie deemed-to-comply building constructions) in Schedules 1 and 2 of the Code. If the deemed-to-comply building constructions, or other constructions of equivalent acoustical performance, are implemented throughout the residence, compliance with 45-50dBA $L_{Amax\ passby}$ internal noise level target is deemed to have been to have been achieved.

3. COMPARISON OF ASSESSMENT METHODS

An evaluation of the acoustical adequacy of the minimum R_w requirement for the components of the building envelope set out in Schedule 1 of the Code was undertaken.

This assessment was conducted on two bases: (i) control of noise from electric trains only and (ii) control of noise from diesel trains. Source data for electric train passbys and diesel train passbys was gathered from actual noise level measurements conducted at a number of sites adjacent to rail lines trafficked by electric trains only, as well as at lines trafficked by both electric trains and diesel trains. In each case, the source data included the noise from a specific type of train only without contribution from the other type and without material contribution from extraneous noise sources.

As is well-known and as was evident in the source data, diesel trains generate significantly higher levels of low frequency sound energy than is the case for electric trains. Figure 1 below shows the typical measured free field sound pressure levels generated by electric and diesel train passbys normalised to an overall level of 75dBA.

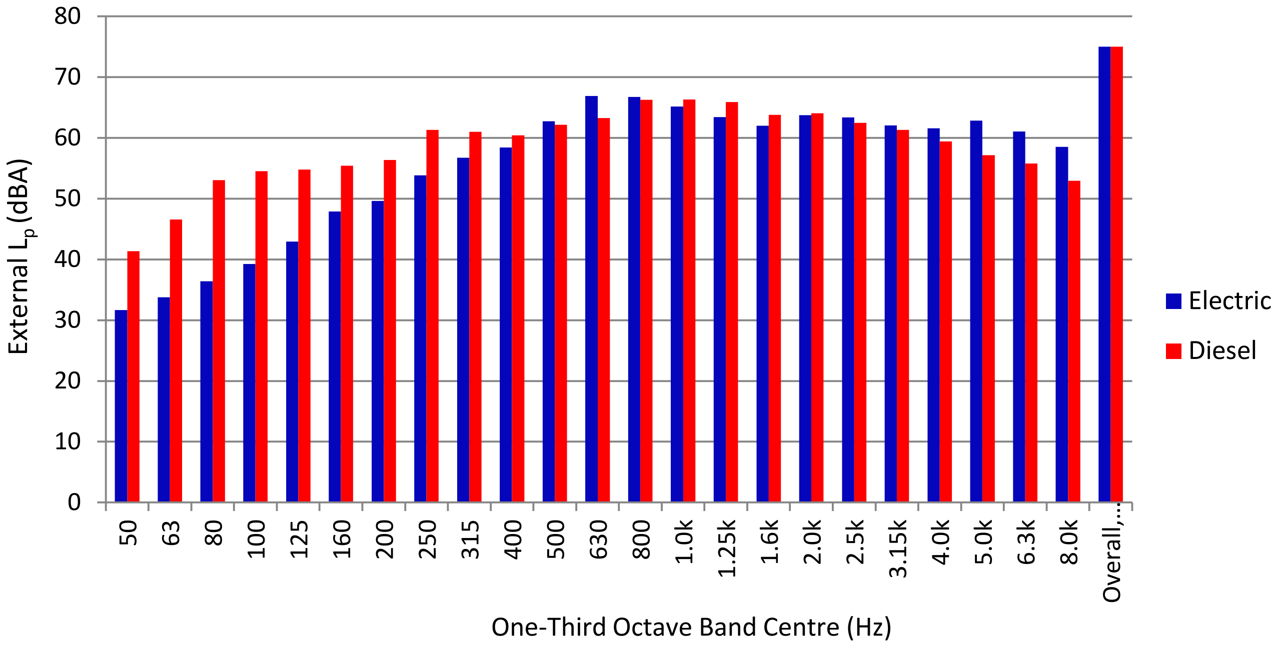

Figure 1: Comparison of Sound Pressure Levels Generated by Electric and Diesel Trains

For the purposes of this assessment exercise, a determination was made of the expected extent of rail noise intrusion into an average bedroom within a typical four-bedroom slab-on-ground residence. The typical four-bedroom residence was chosen by examining the floor plans for 12 contemporary four-bedroom residences. From these floor plans, the floor area of an average bedroom was determined to be 10.7m². Correspondingly, the average total wall area of the average bedroom was found to be 9.8m² and the average total window area was measured to be 2.3 m². The typical pitch of the roof was determined to be 22.5°.

One third octave band room constants for the typical bedroom were determined from reverberation time test data and by calculation having regard to documented sound absorption performance of bedroom furnishings. Thereafter, R_w test data on actual building component constructions together with, where necessary, predicted R_w test data generated using the INSUL V8.0.9 sound transmission loss prediction program developed by Marshall Day Acoustics were used to select typical building constructions which accorded with the minimum R_w requirement for each component of the building envelope set out in Schedule 1 of the Code.

The extent of noise intrusion into the typical bedroom space was calculated in one-third octave bands by applying standard acoustical theory to the external $L_{Amax\ passby}$ for electric trains and then for diesel trains for each class internal to determine the reverberant field sound pressure level in the typical bedroom. It is noted that (i) steady conditions were assumed and (ii) no account was taken of any specific frequency modal response effect other than that already embodied in the reverberation time data.

4. RESULTS

The results are summarised in Table 2 below.

Table 2: Resultant internal sound pressure levels due to train passbys using actual building constructions selected to meet minimum R_w requirement of QDC MP 4.4

Noise Category	External Single Event Maximum Noise Level, $L_{Amax\ passby}$ (dBA)	Type of Train	$L_{Amax\ passby}$ (dBA) in Typical Bedroom (Reverberant Field)
1	75	Electric	47
1	75	Diesel	57
2	80	Electric	48
2	80	Diesel	53
3	85	Electric	49
3	85	Diesel	55
4	90	Electric	49
4	90	Diesel	57

5. DISCUSSION, MODERATING FACTOR AND SUGGESTION

From the results presented in Table 2 above, it can be seen that, if the maximum value of the $L_{Amax\ passby}$ applicable to each QDC MP 4.4 noise category is adopted, the internal reverberant field $L_{Amax\ passby}$ sound pressure levels due to electric train passbys were calculated to be in the range 47dBA to 49dBA. All were within the 45-50 dBA target range of the Code.

By contrast, and unsurprisingly given the higher level of low frequency sound energy in the diesel train spectrum, the internal reverberant field $L_{Amax\ passby}$ sound pressure levels due to diesel train passbys were calculated to be in the range 53dBA to 57dBA, ie some 5-10dBA higher than the internal levels due to electric train passbys at the same external sound pressure level and 3-7dBA higher than the 45-50dBA target range of the Code.

On the basis of these results, it could be reasonably concluded that if the rail line is trafficked exclusively by diesel trains, or if the noise of diesel traffic dominates over that of electric trains, application of the minimum R_w requirement for the components set out in the Code and the deemed-to-apply building constructions of the code may not be adequate to achieve compliance with the 45-50dBA internal noise level target of the Code.

In view of this, it would be prudent to assess the extent of rail noise intrusion by the alternative site-specific noise level assessment method, or as minimum, elevate the external $L_{Amax\ passby}$ to take account of the apparent shortfall in acoustical performance of the minimum R_w requirement for building components as set out in the Code.

It is noted however that, in Queensland at least, very few rail lines impacting on residential areas are exclusively trafficked by diesel trains. Rather, residential premises are subjected to either (i) electric train noise solely, or (ii) a combination of electric train and diesel train noise. Furthermore, based on the results of noise level measurements conducted at a representative number of residential locations subjected to noise from both train types, it has often been found that, contrary to intuitive expectations, the highest noise levels have been generated by electric train passbys, rather than by diesel passbys.

Consequently, it is important to have regard to the definition of the Single Event Maximum Noise Level, ie $L_{Amax\ passby}$, to determine whether it is the electric train passbys or the diesel train passbys which will set the maximum the resultant internal noise level within the habitable spaces. As noted above, the external $L_{Amax\ passby}$ to be used for the assessment is the arithmetic average of the 15 highest noise level passbys of trains over a typical 24 hour period.

Having regard to the results presented above in Table 2, it can be reasonably concluded that (i) if the data set of the maximum noise levels generated by the electric trains is partitioned from the corresponding data set generated by the diesel trains and (ii) if $L_{Amax\ passby}$ noise level generated by the electric trains alone is at least 10dBA higher than the $L_{Amax\ passby}$ noise level generated by the diesel trains alone, it would be sufficient to adopt the resultant $L_{Amax\ passby}$ noise level generated by all trains as the external source level. Thereafter, the extent of rail noise intrusion could be calculated by adopting the minimum R_w ratings of the Code and using these ratings by application of appropriate and validated acoustical procedures to determine the degree of compliance with the resultant 45-50dBA internal noise level target of the Code.

By contrast, if the $L_{Amax\ passby}$ noise level generated by the electric trains alone is not more than 10dBA higher than the $L_{Amax\ passby}$ noise level generated by diesel trains alone, it may be appropriate to adopt the $L_{Amax\ passby}$ noise level generated by diesel trains as the external source level. Thereafter, it is suggested that the extent of rail noise intrusion could be calculated by, firstly, raising the $L_{Amax\ passby}$ noise level generated by diesel trains by 10dBA to take account of the poorer acoustical performance of building component when controlling diesel train noise intrusion and then, secondly, by applying appropriate and validated acoustical procedures to these elevated $L_{Amax\ passby}$ noise levels to determine the R_w ratings to be achieved by the various facade elements to in order that compliance with the resultant 45-50dBA internal noise level target of the Code may be attained.

For example, if the $L_{Amax\ passby}$ noise level generated by the electric trains alone is 83dBA and the $L_{Amax\ passby}$ noise level generated by the diesel trains alone is 6dBA lower, ie 77dBA, the assessment of the extent of rail noise intrusion could assessed by adopting an 87dBA external $L_{Amax\ passby}$ noise level which is assumed to be generated solely by electric trains.

Final note:

The results and analysis presented above have been based on a theoretical examination of the relative acoustical performance outcomes of typical building constructions when subjected to noise generated by electric train passbys and by diesel train passbys. The purpose of this exercise was to compare the outcomes resulting from the two sources of external noise under equivalent conditions and subject to a number of assumptions.

The suggestions that are provided above have been based on the results of this analysis combined with practical experience. The suggestions are provided simply for consideration by practitioners. They are not meant to be the definitive answer to resolving any inconsistencies between outcomes resulting from internal noise levels generated by electric trains and those generated by diesel trains. Importantly, the suggestions should not replace good professional practice and appropriate professional judgement.

Rather, it is hoped that by sharing this information, further work – both theoretical and practical – will be undertaken by others as a means of further refining the assessment and control of rail noise intrusion under the methods of QDC MP4.4 to the greater benefit of the community as a whole.

REFERENCE

Queensland Development Code Mandatory Part 4.4 *Buildings in a Transport Noise Corridor* (QDC MP4.4)
http://www.hpw.qld.gov.au/SiteCollectionDocuments/mp-4-4-buildings-in-transport-noise-corridors.pdf