Dynamic Measurement of Tyre/Road Noise

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1 Background of Road Traffic Noise

Environmental noise is becoming an ever-increasing issue in many industrialised countries, such as Australia. "Surveys show that noise is the main environmental concern for most Australians. Many people complain that traffic noise has the greatest direct impact (Federal Department of Environmental Heritage, 2006)". The word 'noise' in the term 'environmental noise' is most commonly defined as unwanted sound. This means that noise is not a technical term but instead is a subjective term. The environmental noise source of concern for this paper is road traffic noise. Surveys have been conducted to determine what impacts noise has on the people of Australia. It has been estimated that more than 70% of environmental noise is due to road traffic (Australian State of the Environment, 2001). The Brisbane Noise Survey 1989 showed that people noted that they are 'seriously affected' by light and heavy vehicle traffic noise, ahead of aircraft noise and barking dogs. The issue of road traffic noise has been addressed in detail since then but is sure to remain an ongoing problem with continuing urbanisation.

The main contributing components of road traffic noise include noise from the tyre-road interaction; car transmission noise; engine noise; exhaust system noise; and intake system noise. Over the years considerable reductions in traffic noise have been achieved with respect to reducing engine and exhaust noise via Australian Design Rules.

Tyre-road interaction noise is the dominant traffic noise source for speeds above 40-50 km/h for cars and 60-70 km/h for trucks (Sandberg, 2001). Tyre-road noise under most conditions is the dominant contributing factor to road traffic noise and therefore has been the focus of many studies and ongoing design of 'quiet, hush, low-noise' pavements/road surface finishes.

The option of low noise generating road surfaces becomes important if for example it either obviates the need to erect noise barriers, or the effective height of noise barriers can be substantially reduced. This reduces visual impact as well as other amenity issues associated with light and airflow.

2 Tyre-road Noise Measurement Procedures

There are currently five major procedures for measuring tyre-road noise:

- Coast-By Method (CB)
- Trailer Coast-By Method (TCB)
- Laboratory Drum Method (DR)
- Statistical Pass-By Method (SPB)
- Close Proximity Method (CPX)

The Coast-By procedure involves a test vehicle coasting past a measurement location with minimal engine noise being emitted. The Coast-By procedure is normally performed on a specific test track and has been known to be time inefficient. The TCB procedure is similar to the Coast-By procedure except measures the noise emitted for a trailer being towed behind the test vehicle. Similar to the Coast-By procedure the Trailer Coast-By procedure is normally performed on a specific test track and has been known to be time inefficient. The Laboratory Drum procedure involves measuring noise emitted from a tyre rotating around a drum with representative road surfaces. The Drum method requires large and expensive test equipment.

The Statistical Pass-By method involves monitoring the maximum sound levels of vehicles in the 'normal traffic' as they pass-by a monitoring location on the side of the road. The Statistical Pass-By method is commonly known as a static form of noise measurement.

To date, the most widely used measurement procedure in Australia has been the Statistical Pass-By method. ASK explored and experienced some of the restrictions from the above test methods and chose to develop Australia's first Close Proximity (CPX) method test rig. Based on our review of the test methods, the CPX appeared to have a number of advantages, which ASK chose to investigate in detail.

3 Close Proximity (CPX) Procedure

The CPX procedure is a relatively new procedure for measuring tyre-road noise in Europe and the USA. It has not to date been used in Australia. The CPX procedure involves the dynamic measuring of tyre-road noise along stretches of road. The procedure emerged from the need for a tyre-road noise measurement procedure that had fewer variables present in comparison to other test methods. The CPX procedure achieves this by isolating the noise emitted from the interaction between a tyre and the surface of a road and excluding other noise sources. To achieve this isolation CPX trailers usually consist of a chamber surrounding a test wheel. This chamber is treated with various materials and designed to a stage where it replicates a free field environment around the test tyre and road surface noise source.
The Close Proximity (CPX) procedure is based on the committee draft ISO 11819:2 entitled Acoustics – Method for Measuring the Influence of Road Surfaces on Traffic Noise – Part 2: the Close Proximity Method and Sandberg, 2002.

One of the main variables controlled by the CPX procedure is the tyre type. The CPX procedure uses four reference tyres in its procedure. Each reference tyre has a different tread pattern and represents a different group of vehicles. These are detailed in **Table 1** and shown in **Figure 1**.

Table 1 Reference Tyre Summary

Reference Tyre	Tread Pattern	Represents
Tyre A	Summer A	Summer tyres used on new vehicles
Tyre B	Summer B	Summer tyres used on older vehicles produced in the time period 1990 – 1997
Tyre C	Winter	Tyres used in winter conditions
Tyre D	Block	Heavy vehicles

Figure 1 Reference Tyres

The CPX procedure was first developed in Europe with the majority of current CPX trailers being developed and used in that part of the world. In recent years road and transport authorities in America have accepted the CPX procedure. To date there are no other known developments of the CPX procedure and CPX trailers in Australia.

The advantages of the CPX procedure are summarised in **Table 2.**

Table 2 Advantages of CPX Tyre-Road Noise Measurement Procedure.

	CPX Method
Advantages	o Testing is efficient & cost effective
	o Enables continual assessment of long sections of road
	o Ideal for comparing noise emissions from various road surfaces
	o Test rig isolates tyre-road noise
	o Direct measurements – minimal operator interpretation

3.1 Close Proximity Index (CPXI)

The CPX procedure measures the noise emitted from road surfaces with the four different reference tyres. The reference noise levels obtained by the CPX procedure are developed into a Close Proximity Index (CPXI). The CPXI represents the measured noise levels for the subject section of road surface.

To correctly calculate a CPXI the following equations from committee draft ISO 11819:2 are applied:

Representing light vehicle traffic: $CPXL = 0.25\,L_A + 0.25\,L_B + 0.25\,L_C + 0.25\,L_D$ [dB]

Representing heavy vehicle traffic: $CPXH = 1.00\,L_D$ [dB]

Representing mixed traffic: $CPXI = 0.20\,L_A + 0.20\,L_B + 0.20\,L_C + 0.40\,L_D$ [dB]

Where: L_A, L_B, L_C and L_D are the averaged tyre sound levels calculated for each reference tyre A, B, C and D as per committee draft ISO 11819:2.

4 Development of the CPX Road Ear

After researching CPX test rigs overseas, ASK undertook the challenge to design and develop a CPX test rig. A CPX Test Rig was developed with the lengthy Australian road system and potential large travel distances as a design factor. The resulting trailer is called the ‘Road Ear’ and is shown in **Figure 2**.

The ‘Road Ear’ test rig achieved full compliance certification in accordance with the committee draft ISO 11819:2.and is now on an even standing with other international CPX test rigs.

Figure 2 ‘Road Ear’ Test Rig – for CPX Testing.

4.1 Certification of CPX Road Ear

The certification testing outlines influences the CPX 'Road Ear' may have on noise measurements.

4.1.1 Influence of Sound Absorption Within an Enclosure

The first of the three certification tests assessed the influence of sound absorption within an enclosure. The test involved comparing the noise emitted from an artificial noise source placed within the enclosure against the noise emitted from the same artificial noise source in a free field environment. ASK achieved full compliance with this test.

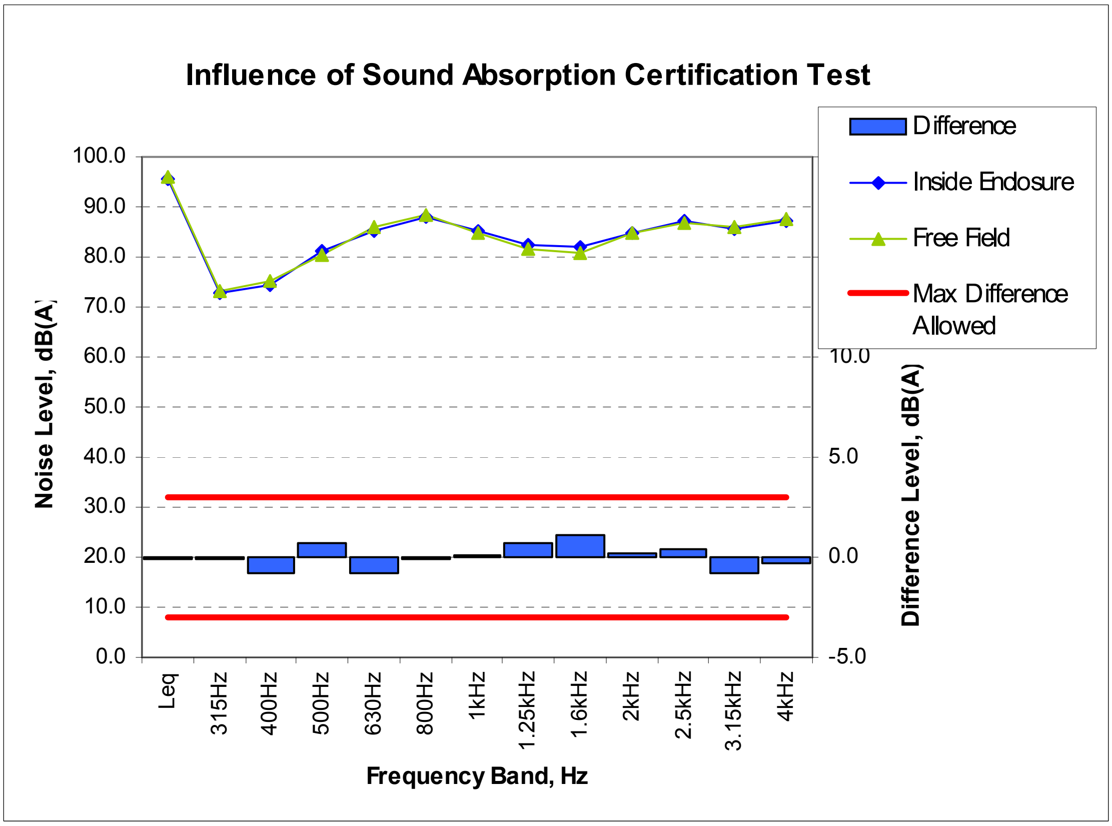


Figure 3 – Graphical Summary of Sound Absorption Certification Test.

4.1.2 Other Acoustical Reflections

The second certification test assessed the influence of any other reflective surfaces within the enclosure. ASK achieved full compliance with this test.

After some initial tests it was decided to cover all reflective surfaces with absorptive acoustic foam which eliminated the requirement for this test.

4.1.3 Background Noise

The third certification test assessed the performance of the enclosure to reduce the intrusion of outside noise sources into the enclosure. The CPX test rig achieved full compliance with this test.

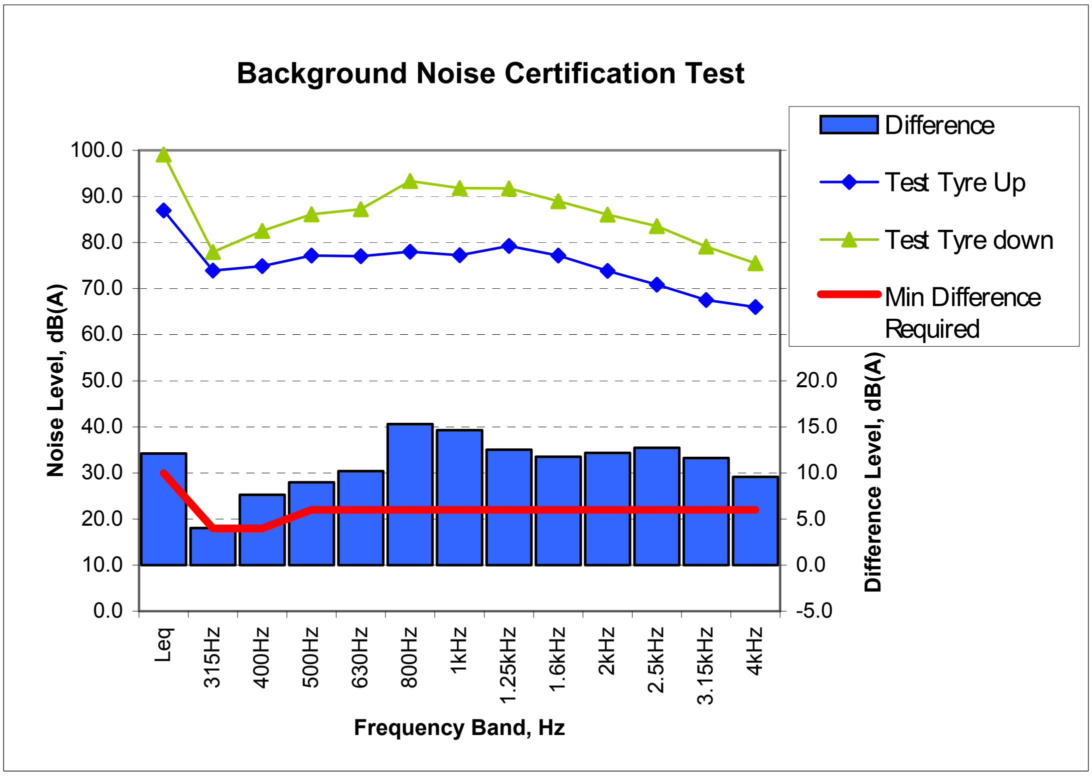


Figure 4 – Graphical Summary of Background Noise Certification Test.

4.2 Certification Summary

Full compliance with the certification tests means the CPX 'Road Ear' can be used to perform tyre-road noise measurements to international standards.

5 Preliminary CPX Testing

Preliminary results are encouraging with respect to reproducibility and integrity with other CPX test data.

The road surfaces chosen for testing were an Open Graded Asphalt (OGA) surface and a Portland Cement Concrete (PCC) surface. OGA is made up of a porous layer (usually 25mm to 45mm thick) laid over the top of a dense graded asphalt base. OGA surfaces generally have above average drainage and low noise generation. PCC surfaces are cement concrete. The surface is usually textured through various methods that increase drainage. The texture tends to increase the noise levels generated.

5.1 Preliminary CPX Results

The CPX ‘Road Ear’ can provide output data in many different forms.

Sound level traces are one form of data output. Sound level traces are useful in identifying sections of road that differ acoustically from the norm eg. expansion joints on bridges. A representative trace for both the OGA and PCC road surfaces are shown in **Figure 5** and **Figure 6** respectively. The PCC road surface shown in **Figure 6** indicates more variation across the length of the site than the OGA surface shown in **Figure 5.** This could be due to different texturing techniques along the PCC surface or due to aging of the PCC surface.

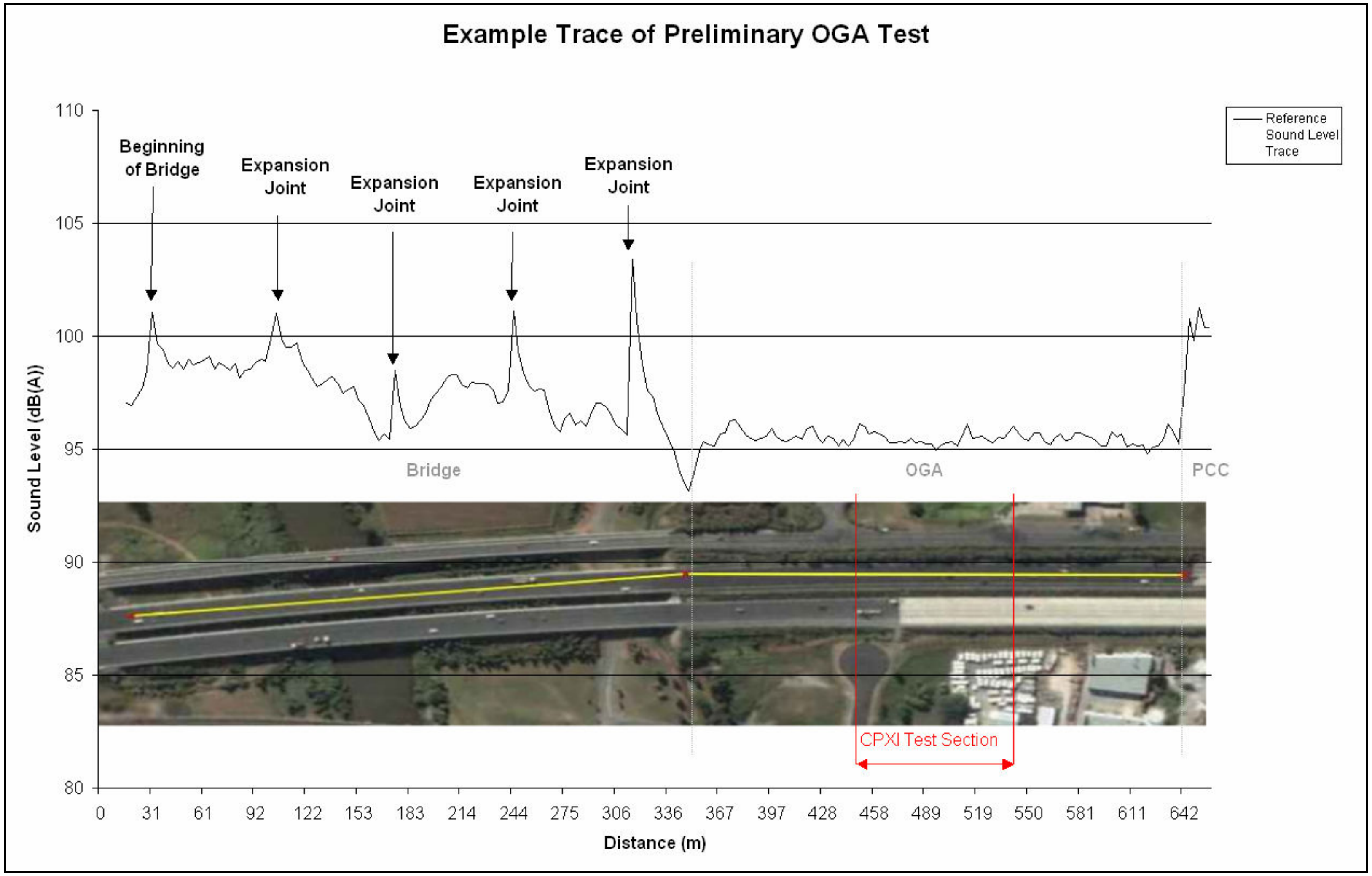


Figure 5 – Example Trace of Preliminary OGA Test

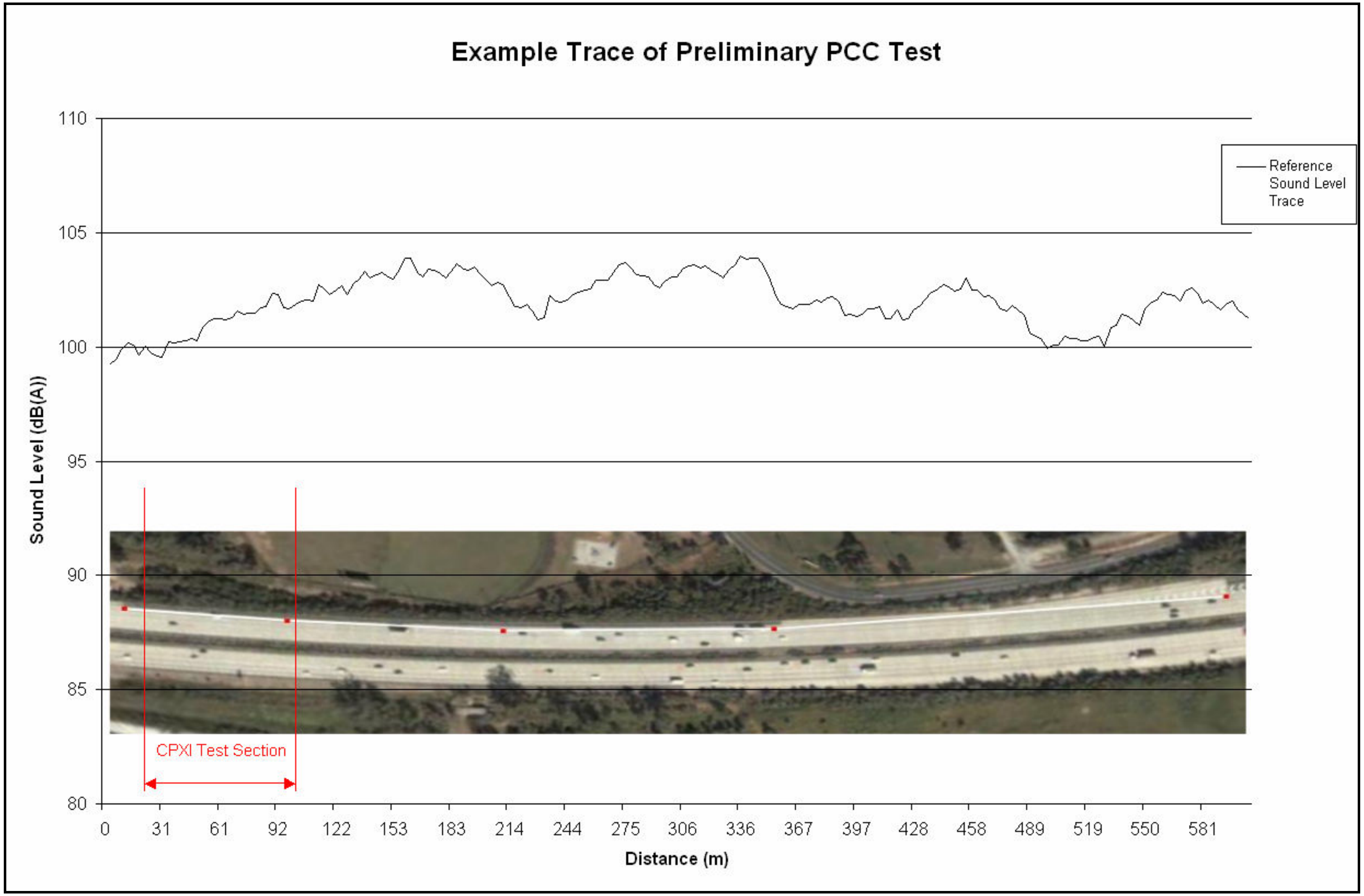


Figure 6 – Example Trace of Preliminary PCC Test

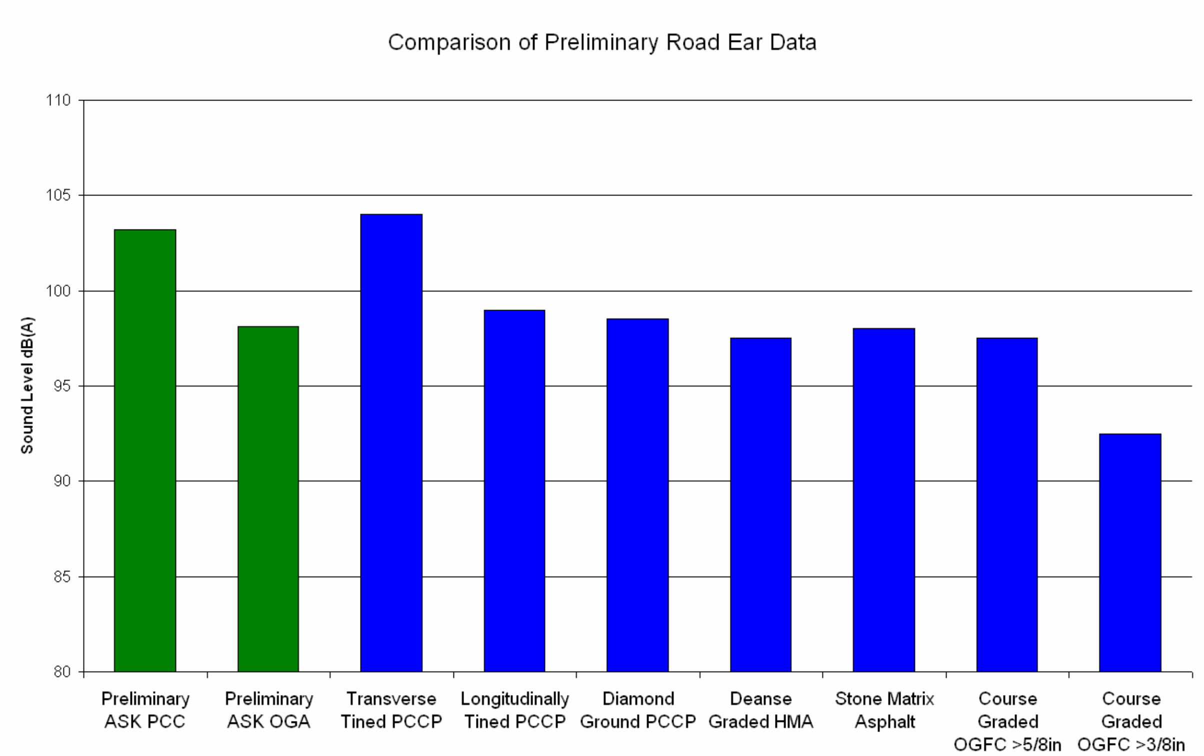
Another way to analyse data output from the CPX 'Road Ear' is to calculate the CPXI for the road surface. The averages for each reference tyre within a 100m CPXI test section are used to calculate a CPXI for each road surface, as shown in **Table 3.**

Table 3 – Preliminary CPXI's for OGA and PCC at 110 km/hr Reference Speed

Pavement Surface Type	Average CPXI (dB)
	110 km/hr Reference Speed
PCC	103.2
OGA	98.1
Difference PCC-OGA	5.1

The preliminary results shown in **Table 3** compare favourably with the general known differences between the PCC and OGA road surface types.

It can also be seen in **Figure 7** that the preliminary Road Ear data for OGA and PCC compare favourably with relevant international data for similar road surfaces.



Note: International data is an approximation of averages published in Jones (2005).

Figure 7 Comparison of Preliminary Road Ear Data

6 Conclusion

The CPX 'Road Ear' will assist in the following relevant environmental planning related activities:

- Lower noise emitting road surfaces would assist in reducing the height and extent of acoustic barriers, thereby reducing other adverse amenity issues such as visual, light and airflow amenity.
- Cataloguing road surfaces and their noise output
- Compliance testing of road pavement/surfaces after construction
- Ongoing assessment of road surface deterioration
- Design and development of new pavements and claims of noise reduction
- Noise mapping purposes
- Noise measurement data could be collected and fed directly into databases of road authorities

7 References

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