Experiences in Acoustics 1980 to 2016

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ABSTRACT

This paper gives an overview of the experiences gained in 35 years whilst working as a professional acoustic engineer in New Zealand and Australia with major projects from Australia to the Middle East. Noise as unwanted sound is a subjective issue that varies significantly from project to project and country to country. Hence the controls applied in one building are not necessarily applicable to other buildings. Codes and standards only go part-way to resolving this dilemma. Coupled with this are changes in instrumentation, testing methods and building materials. As acoustic engineers we are dealing with an industry that is changing with the professionals working with greater responsibility to adapt and change with the times. Codes and Standards are being challenged to more accurately reflect a variety of community expectations which means that there are needs for recognition of capable acoustic engineers, review processes, regulations to be more flexible, and for more building acoustics research to be commissioned.

1. INTRODUCTION

After completing a mechanical engineering degree at the University of Canterbury (NZ) with a focus on acoustic papers, I returned to become unsettled in my position as an aircraft engineer and resigned that position to take on a sales engineering role selling noise-control products. This was my introduction to HVAC acoustic products and procedures. Those were the days of the telex machine and mark-sense cards to program computers. We had the typing pool and documents were delivered by mail and courier. Clients did not expect fast response and there was always the excuse that the documents were “in the mail”. Photocopy machines, mobile phones and desk-top computers did not exist. This sales engineering position lasted 12 months after which I resigned to set myself up as a consultant. I saw the opportunity to provide a wide range of options to clients and to work in more areas of acoustics. This, for me, was the beginning of an evolution, much of which was self-taught (without, until recently, assistance from Google). I will attempt to present a view on how changes have (or have not) occurred in our profession and give a perspective of where we might be going.

2. STANDARDS AND INSTRUMENTATION

Much of acoustics background and terminology goes back over 100 years, with many of our current standards changing little over the last 50 years. Much of this has been a product of English research and development. We still work with dB(A), with many consultants not understanding its history and limitations. We use L_{Aeq}, slow, fast, impulse and peak responses. The standards used 35 year ago are not too dissimilar to the current standards and were based upon developed technologies in sound level meters using high-quality condenser microphones. Predominantly Bruel and Kjaer had the market although Rion was developing very competitive in-roads. The meters at that time used 1:1 octave band filters, although more detailed analysis was carried out with the then new 1:1/3 octave band meters. These instruments based upon IEC 61672, *Electroacoustics — Sound level meters,* were expensive, bulky, heavy, limited battery life, were easily damaged and had limited functionality.

It was only in the late 70s that the first statistical analysers hit the market (B&K 4216). This meter could take only one set of samples with the data recorded manually, then re-set and started again. This meter opened up the concept of background noise and the idea that cities could be mapped, and that a rise above background could be a measure of intrusiveness. This research found that background levels were not constant and were very much a product of time of day, environmental conditions, traffic conditions, road conditions, vehicle types and speeds, thus requiring more research and the development of computer models. Then with better measurement tools, such models could be better calibrated.

No commentary on standard and instrumentation would be complete without comment with regards to the changes in acoustic devices which have occurred in recent years through the introduction of “smartphones” with 3/4G, MEMS microphones and accelerometers.

These MEMS devices are really only a product of the last 10 years and are game-changers in the way in which measure noise and vibration are measured. MEMS microphones are low cost (as low as $10), light weight, surprisingly accurate, rugged and small. MEMS noise loggers can be purchased for under $500 with a battery life of 1 week and a size which can fit into the palm of a hand. We now will express post loggers to a client already pre-programmed; they can stay on site for 6 days and then be express posted back to our office. With appropriate wind shields they are water resistant and can be dropped without (in most cases) damage. The limitation is that some of these devices do not allow calibration under current Australian Standard procedures. Currently we at Palmer Acoustics are working with an Indian company to develop our own range of such loggers.

(a)

(b)

Figure 1: Then and now; (a) Bruel & Kjaer 4426; (b) Mems Noise Logger

3. COMPUTERS AND THE INTERNET

The introduction of computers followed by access to the internet has transformed all facets of the way we do business. We no longer use typists, couriers have limited use, much of our work now uses colour, and much faster response times are expected from clients. Paperless offices are a trend with most offices now using electronic rather than paper filing. Digital photographs are expected a part of a projects records. Social media is now being used to communicate to clients and to design team members. Noise and vibration data can now be streamed back to our office using mobile phone 3 / 4 G technology. Solar powered systems are available to power equipment. Much of the equipment used in setting up such systems can be readily purchased on line using the likes of EBay, Amazon, Alibaba, etc. In effect we now spend most of our office time on a computer.

In this work we have been required to carry out design reviews, inspections and testing and to assist design teams to ensure that clients expectation are achieved at the end of a project. Previously design work was carried out on A0 drawings issued at design meetings, with hand drawn mark-ups provided in return. Today this has changed to emailed documents with reviews being PDF mark-up (usually to A3 scale). Today we are required to attend less formal meetings and more information is passed across the internet. However, in contrast, business development has facilitated easier communication between consultants and clients, but we do not have a replacement for face to face contact. Video conference calls do not meet the need to read body language, make personal connections and hence build trust. As a result I have found the need to travel frequently over the last 20 years.

A further advent of computers is that, as consultants we are expected to produce more. It does not mean that because we are more efficient and effective that we will have more time for leisure. A simplistic view widely presented in the 1980’s with the introduction of computers, was that we would have more leisure. This has not eventuated.

4. BUILDING ACOUSTICS

Over my 35 years in acoustics my focus has been noise in buildings from New Zealand, Australia, South East Asia and the Middle East. This had been concerned with HVAC system design, duct silencers, duct linings, noise sources, vibration isolation and duct design. Much of the technology applied in the calculations and principles of design is a product of the British Standards, American ASTM and SMACNA codes. Although going back to over 50 years these are still the foundation of much of the acoustic design for HVAC silencers and systems. The technology of splitter and circular silencers and acoustic louvers currently used goes back more than 50 years, with little overall change.

A real difference in the management of noise in buildings has been the accuracy with which noise can be predicted and the tools to confirm compliance. The use of 1:1/3 octave band meters means that it is now easier to carry out field tests. Further to this we are seeing more manufacturers providing detailed test data: CSR, BORAL, HEBAL, Lafarge, Raven, L'orient etc. Competition has meant that such companies must produce more data and in a much more visual format. Additionally, there is now more awareness of the tools available to manage noise (standards, procedures, equipment etc) and hence we find more detailed specifications and client expectations. Legislation is being now being more accurately defined and policed. Overall, we are getting better and more is expected of us. However we still have a long way to go.

5. PARTICULAR EXPERIENCES

To highlight some of the works that we have carried out, I have chosen to show the following as being different and challenging.

5.1 Building Expansion Joints

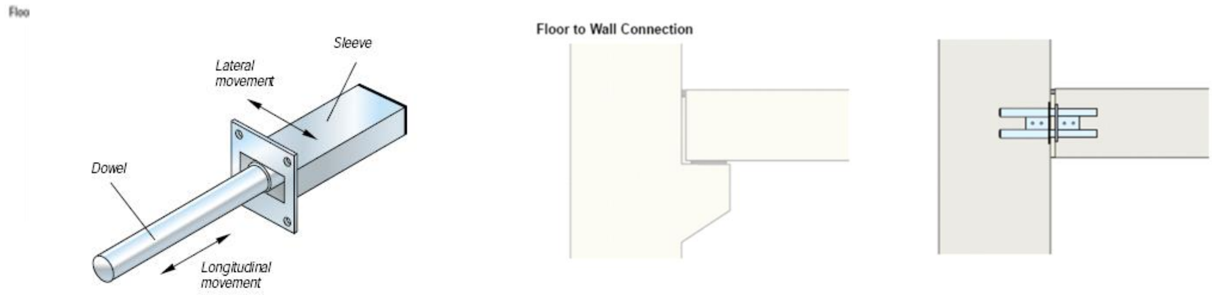


Figure 2: Shear Force Connectors: the noise (described as "like a gunshot") was particularly intrusive.

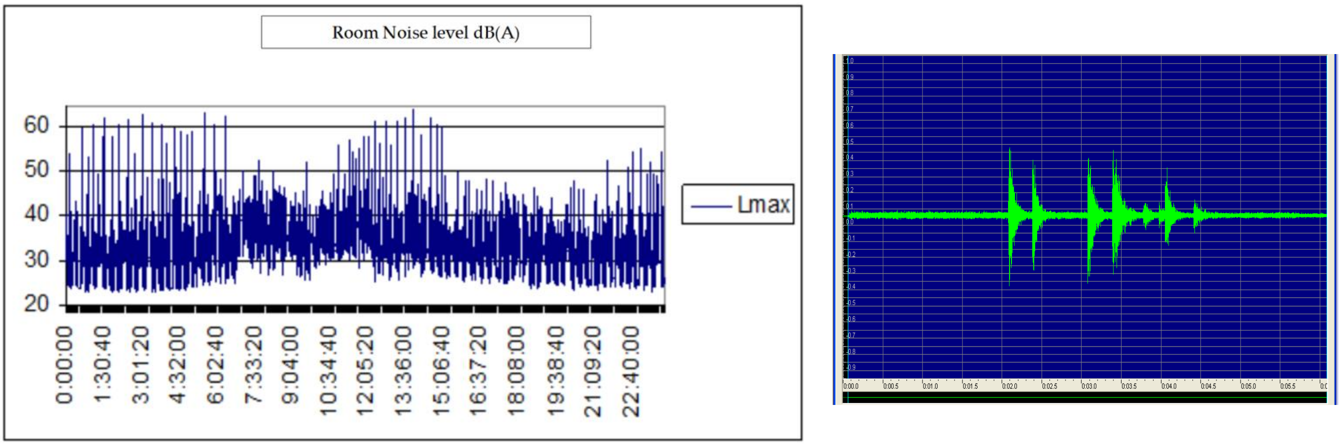


Figure 3: The measured sound: the matter was settled in court.

5.2 Wind on buildings overlooking the sea

Severe buffeting on the roof – thump thump thump.

Figure 4: Site photograph and roof profile

5.3 Pool noise in high rise buildings

This was a very intrusive low frequency noise.

Figure 5: Pool Photograph

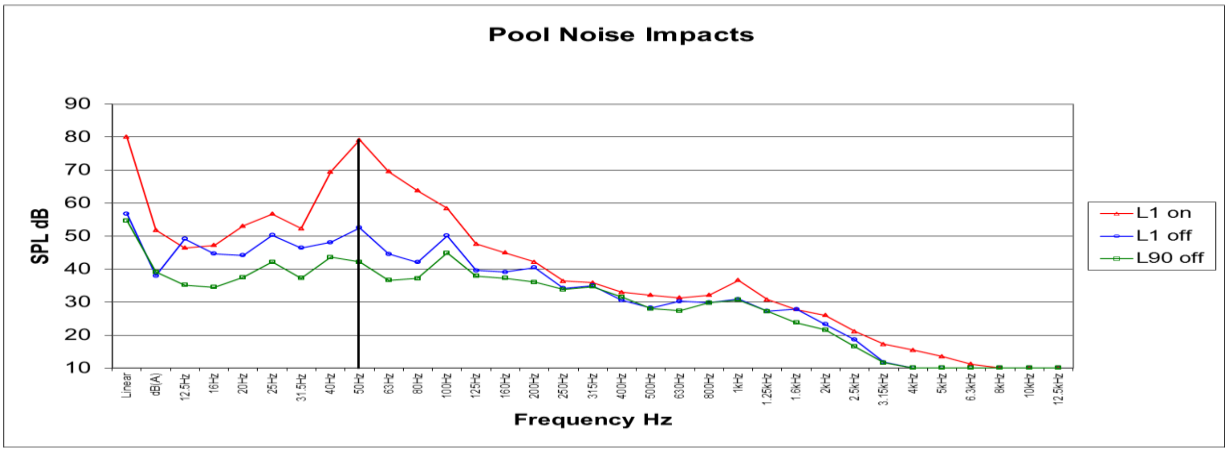


Figure 6: Measured noise levels in the lower apartment

5.4 Measurement of noise in the stomach of a three headed, 10 storey high elephant

(a): The elephant

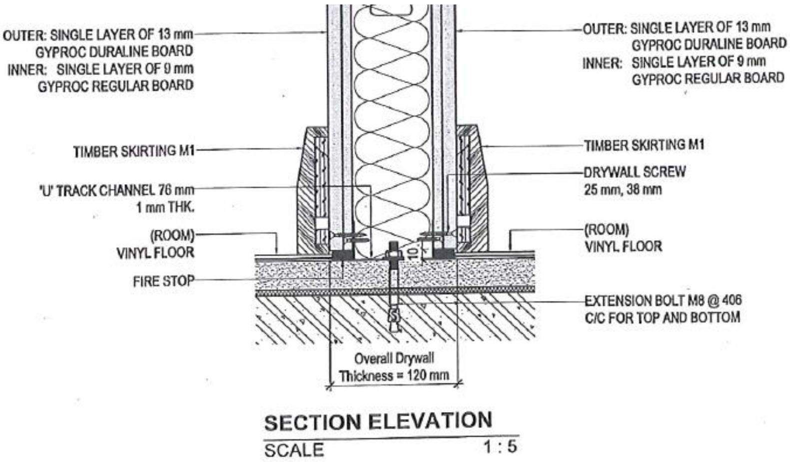
(a): The stomach

Figure 7: A three headed, 10 storey high elephant

The stomach (a museum), Rt_{60} = 7 seconds at 500 Hz.

5.5 Failures in party wall acoustic isolation

The wall was specified as STC 50 and was modelled at STC 55 +/-3. The measured sound transmission loss coefficient was STC 44. With this wall, noise from a television in one room at medium volume was intelligible in an adjacent room. Reasons for failure: steel studs located at 300mm centres (compared to 600mm centres) and the stud, sheet metal thickness changed from 0.55 to 1.0mm. The contractor thought that the changes would improve the performance.



(a) Detail

(a) Photograph

Figure 8: Party wall

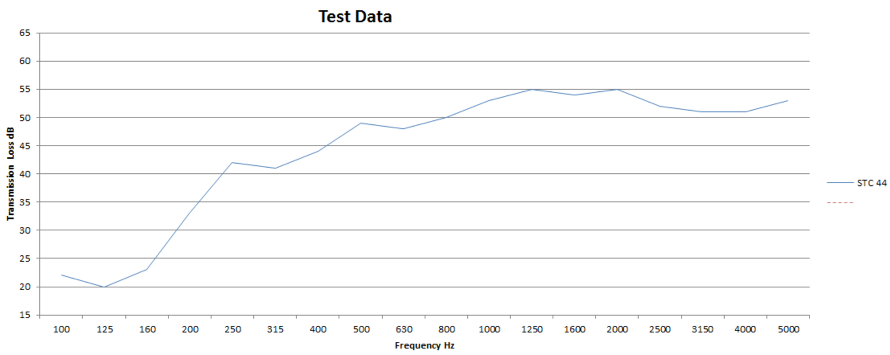


Figure 9: Wall sound reduction STC 44 (laboratory test)

5.6 The fallacy that dB(A) predicts human response.

New Age Festival (5,000 people), in a rural area (background < 30 dB(A), with residents 1,750 m away.

Figure 10: Site photograph

Table 1: Stage, noise levels at 30 m, 93 dB(C)

Time	Measured Noise Level 1/3 Octave Band Frequency L_{10}																	
	dB(C)	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500
Sunday 14th																			
22:20	96.7	91.6	89.5	90.6	84.1	78.8	75.5	75.5	65	69.8	62	79.9	74.9	74.7	75.3	75.5	70.9	67.2	91.6

Note: The dB(C) level is close to the 63 Hz octave band level (96 dB). Low frequency sound dominant.

Table 2: Residents, noise levels at 1750 m, 57.8 dB(C) and 40.6 dB(A).

Time	dB(C)	dB(A)	63	125	250	500	1000	2000	4000	8000
				Sunday	14th	L10				
21.00	57.4	40.6	51.2	38.7	26.7	28.0	26.6	20.1	39.3	29.1
A-weighted levels			*25.2*	*22.7*	*17.7*	*25.0*	*26.6*	*21.1*	*40.3*	*28.1*
Background level L_{90} (some insects) 0100		31.2	37.9	35.2	22.4	18	15.8	13.8	27.1	15.6

Notes

- Source dominant at 63 Hz (hence C – weighted level could be used to manage the 63 Hz octave band levels at 30m);background levels at receivers dominated by 4,000 Hz octave band (insect noise), 40.6 dB(A) overall;
- Receiving levels at 63 Hz, 51.2 dB; above a background level of 37.9 – quite audible;
- The A-weighted component of the source noise at 63 dB was 25.2 dB, where as the source was measured at 40.6 dB(A). The residents would not accept that their meters were measuring insect noise and not clearly audible music.

The human ear responds to a rise above the background levels and when there is dominant low frequency noise (10 to 200 hz sounds) this can be easily audible and intrusive. This noise is often not picked up by an A-weighted measurement alone.

These same issues apply to wind farms and pool noise where the intrusive noise cannot reliably be measured in dB(A) yet the standards used to manage this noise rely only upon tonal and impulse corrected dB(A) sound level measurements.

This exercise highlighted how sound systems are becoming much more effective at transmitting high level low frequency 63 Hz octave band sound. This is also an issue with wall mounted speakers for TV's in high rise buildings, causing higher levels to be transmitted to adjacent rooms.

6. WHERE TO FROM HERE

As the rate of change in technology and automation is rapidly increasing we are, as an industry, under threat. The use of internet search engines allows access to knowledge that was previously the privilege of the "professionals". Instrumentation is in the hand of more and more people. Many "Smart Phones" have apps which will measure noise and vibration, with the accuracy improving. Apps can be used for noise impact prediction.

Communication systems and travel mean that sites and projects are much more accessible. Travel is less expensive than previously and easier to arrange. Electronic based office system mean that offices can now be more focused with less administration and support staff. These changes mean that more work can be carried out by fewer professionals with a client expectation of higher outputs at lower fees. This is particularly obvious in my dealings throughout SE Asia and the Middle East. Much of the consultancy work in these regions is carried out by consultants at rates which are probably 50% of what is expected here in Australia. Globalisation also means that such services will in time be available to be drawn upon from other countries.

Australia with its high costs is vulnerable to international trends and is progressively becoming less competitive as the quality of work rises from other foreign countries (China and India in particular). These countries are producing large numbers of engineering professionals, who will provide serious competition to Australia's professionals, both in products and services. Our only choice is to maintain high standards and yet provide services at overall lower costs. We have to be more productive.

Another area of big change is the processes of automation and computer modelling. There are now real options to outsource work to international teams at much lower rates than the local Australian rates. Much of the building drafting work is a product of outsourcing to such countries as the Philippines, Indonesia, and India. Similarly data analysis from noise logging stations can be carried out in these countries with this data streamed directly to their offices. The combination of solar power and 3/4 G networks means that data can easily be streamed internationally if required at low cost. These systems are easy to set up from a combination of standard off the shelf components using either 12V or 5V power supplies. All the components are easily available from EBay and similar web sites.

As a profession we still have a long way to go to accurately connect between noise levels and the human response to noise. The issue is psychoacoustics and involves issues of not only sound measurements (level and spectrum) but also an understanding of human anatomy as to how sounds affect the human auditory system and the human body. This applies particularly with regards to low frequency sound. Our legislation, standards and codes must also be upgraded to keep up with new technologies, measurements systems and research findings in psychoacoustics.

As a consultant I am excited by the changes but realise the necessity of keeping up with the times. We have to work with new tools of communication, social media, and apps on mobile phone. We have to recognise how instrumentation is being transformed by solar power, MEMS sensors and high speed low cost communication systems. In the process of running an office I am constantly being challenged to adapt to new systems and procedures, marketing, web pages, email, blogs, internet sites etc. Automation and robotic systems will eventually take over a lot of our work dramatically changing our work environment. In many areas of our society this is starting to happen already. To survive as an industry we must all adapt, and change. We must be up with the processes of research and development and implement the newer technologies or simply be left behind. These changes are happening at a faster rate than many people realise.