MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Room modelling software comparisons

Raymond, Desmond[1]
Rodney Stevens Acoustics Pty Ltd
1 Majura Close, St. Ives NSW Australia

ABSTRACT

Acoustic treatment of internal spaces is vital in controlling the acoustic energy within the room. Precise location of the materials, selection of the materials and the layout of the room is important in controlling the acoustic environment. This paper investigates 3 different room acoustic models (EASE, I-Simpa and Basic Excel Model) and compares the results with measured on site data. Room modelling includes predicting the performance of the empty space and predicting the performance and location of the acoustic materials. The paper will summarise the limitations of each of the modelling method against the measured data. The scenario to be modelled consists of a large reflective room with a volume greater than 10,000m^3.

Keywords: Noise, Modelling, Simulation
I-INCE Classification of Subject Number: 76

1. INTRODUCTION

This paper presents a comparison of 3 room modelling tools with the on site measured data. 3 modelling tools for this scenario selected includes EASE, I-Simpa and Excel based calculator. The room to be modelled includes a public indoor swimming pool with a volume greater than 10,000m^3.

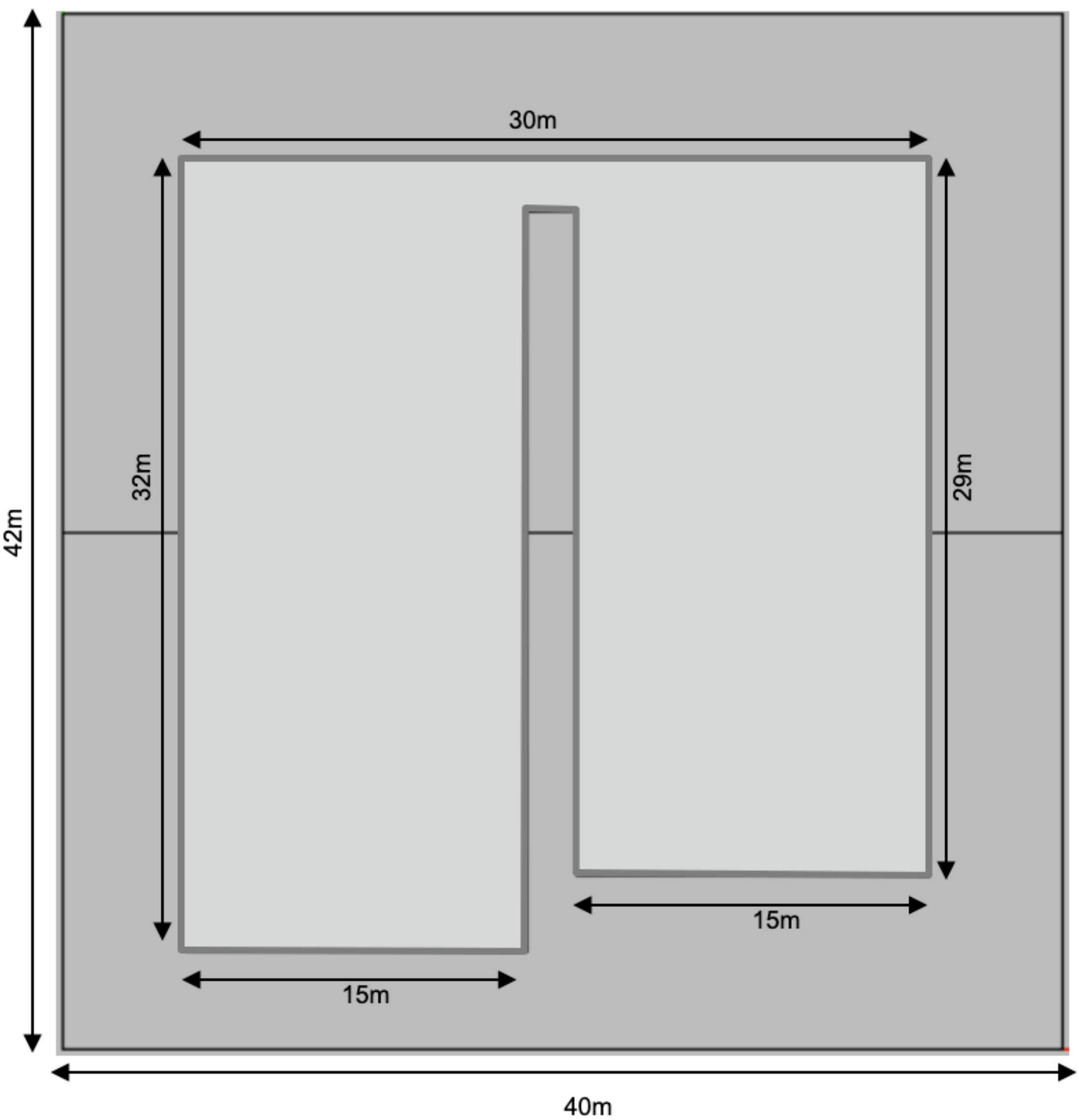
The specific acoustic treatment of the swimming and the subsequent acoustic treatment has been previously covered in the acoustic paper titled *Predicting the performance of hanging baffles in large swimming pools* presented in Acoustics 2017 Conference. The 2017 paper presented the challenges of modelling hanging baffles.

This paper looks into comparing the most accessible room modelling tools with the results of the actual measured data. For the purposes of the comparison, reverberation time (RT60) was modelled and measured. Project specific results, modelling limitations and use of modelling tools will be discussed in this paper.

2. PROJECT SITE

The Swimming Pool is located at Wollongdilly Leisure Centre in New South Wales. The Swimming Pool is the larger internal swimming pool. The dimensions of the swimming pool complex present as 40m x 42m with a height varying from 12-16m and consisting of 2 pools with surface areas of 480m^2 and 435m^2.

[1] des@rodneystevensacoustics.com.au



EASE Floorplan (RSA, 2017)
Figure 1: EASE Floorplan

3. MODELLING TOOLS

3.1 EASE

EASE (Enhanced Acoustic Simulator for Engineers) is considered one of the most used room modelling software available. Rooms can be defined using a CAD module, absorption coefficients can be assigned to surfaces, and sound sources as well as listener positions can easily be added to the model. These data can then be used to generate an exact simulation of reverberation times, speech intelligibility and other acoustical parameters even before the room itself is built. EASE was selected for this paper as this is popular software and already in use by RSA.

3.2 I-Simpa

I-Simpa is an open source software designed to assist professionals in the evaluation of sound in complex 3D domains. The software works with pre-designed 3D models, can calculate reverberation times, produce sound maps and work on ray tracing. I-Simpa was selected for this paper as a number of acoustic consultants use this frequently. I-Simpa is a free licensed software and is easily accessible and not resource heavy. I-Simpa can also be modified to suit the requirement of the specific project needs.

3.3 Excel

Possibly considered the most used modelling tool available. Excel based modelling tool used in this paper is based on the Sabine equation. Sabine's equation for RT60 in a room can be expressed as:

$$RT_{60} = \frac{0.161V}{A}$$

Equation 1

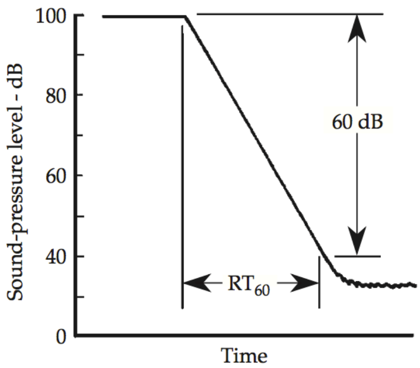
Where RT_{60} = reverberation time (s)
V = volume of room (m^3)
A = total absorption of room (sabins)

The same principle will be applied to the EASE model and the I-Simpa model.

4. MEASURING EMPTY SPACE

Reverb testing was conducted while the swimming pool was empty. The purpose of the reverb testing was to measure the Reverberation Time (RT) of the swimming pool, determine the decay rate and use the data to identify the acoustic characteristic of the swimming pool.

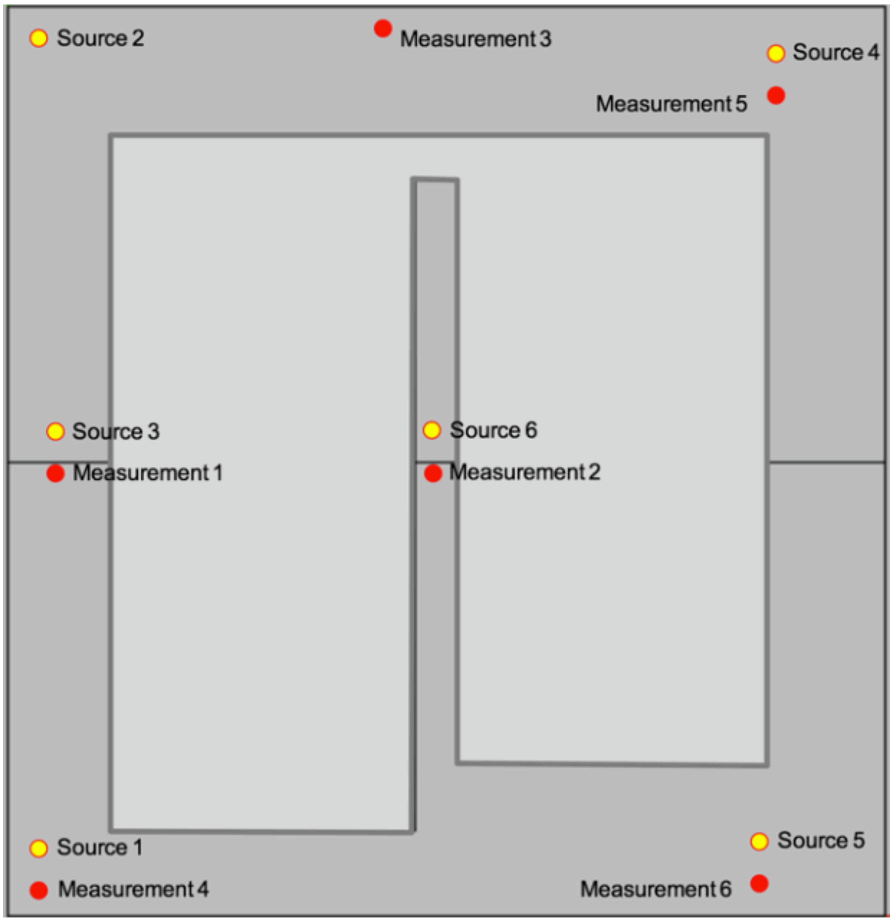
Reverberation Time (RT) is defined as the measure of the decay time from the direct sound and the time it takes for the sound intensity to decay by 60dB. 60dB has been used as this correlate to a loud sound decaying to inaudibility.



Master Handbook of Acoustics (F.Alton Everest & Ken C. Pohlmann, 2009)
Figure 2: Measuring Reverberation Time

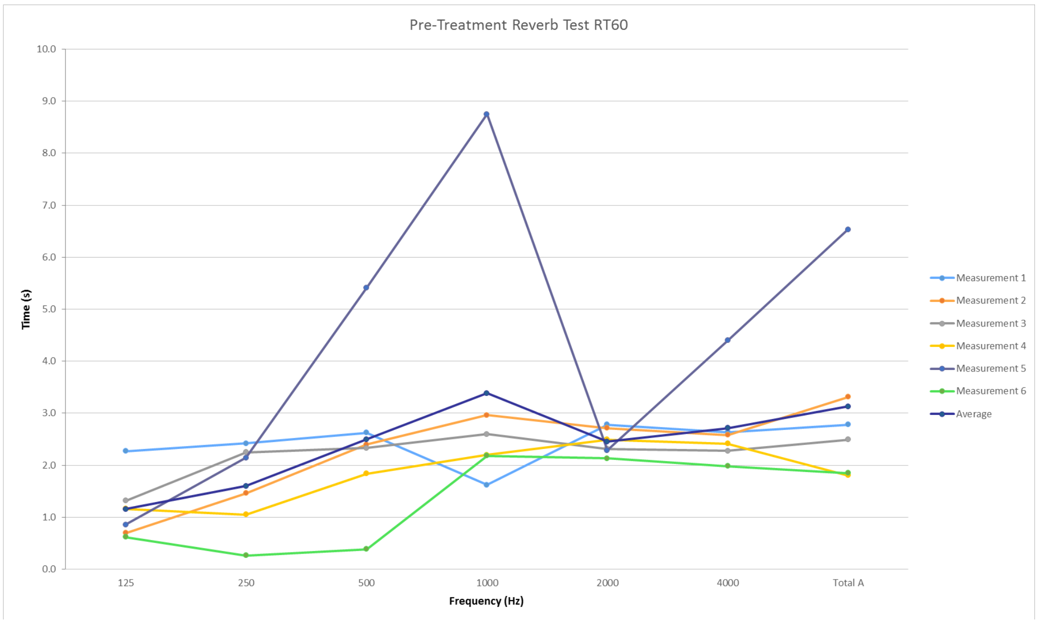
Figure 2 above illustrates the decay time for a sound source by 60dB. Factors influencing the measurement of reverberation time can include the sound source, the room dimensions and the background noise levels.

The reverberation time measurements were conducted inside the swimming pool after the pool was closed. The noise included impulse noise in the form of balloon pop and the data was measured using a Svantek Model 979 Type I Sound Level Meter.



Floorplan (RSA, 2017)
Figure 3: Pre-treatment reverb testing

The process for the included creating an impulse noise and measuring the decay at various locations as illustrated in Figure 3.



Measured RT60 - Pre-treatment (RSA, 2018)
Figure 4: Pre-treatment reverb testing

The graph above shows the results of the measured RT60 data in seconds. The overall average was calculated to be 3.1 seconds. Measured reverberation time at location "Measurement 5" shows a large decay time of 8.7 seconds at the 1kHz and 5.5seconds at the 500Hz Octave bands. This was due to the glass windows, doors and water being the reflective surfaces

5. MODELLING

To provide appropriate modelling for the 3 different tools, the parameters of the modelling will need to be established. Most of the surfaces had data available, for example, the tested data for concrete, glass and plasterboard. Absorptive coefficient for the water in the swimming was difficult to obtain as there is limited resources and the difficulty to accurately measure the absorptive coefficient of water in swimming pools which includes the varying depth of water and temperature. National Association of Broadcasters Engineering Handbook: NAB Engineering by Graham A. Jones, David H. Layer, Thomas G. Osenkowsky Section 3 page 430 provides tested data for Swimming Pools as tested to ASTM C 423.

Materials along with the absorptive coefficients used for the purposes of modelling are presented in table below.

Material	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Swimming Pool	0.01	0.01	0.01	0.01	0.02	0.02
Exposed Brickwork	0.05	0.04	0.02	0.04	0.05	0.05
Concrete	0.02	0.02	0.02	0.03	0.04	0.04
6mm Glass	0.10	0.08	0.04	0.03	0.02	0.02

Table 1: Absorptive Coefficient of materials

Using the data in Table 1 and the physical dimensions of the swimming pool, the 3 different was able to simulate the swimming pool when empty using the Sabine calculation method. EASE and I-Simpa requires additional data to condition the room. The room specifications used for modelling purposes are presented in the table below:

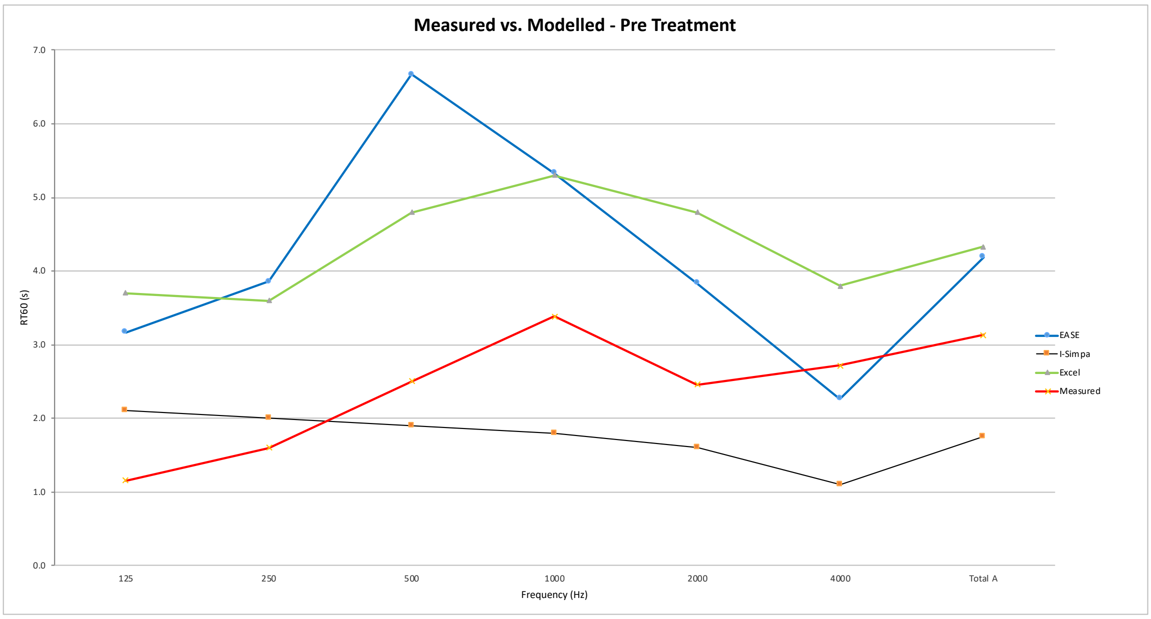
Parameters		
Humidity	60	%
Temperature	20	°C
Pressure	1013	hPa
Volume	15998	m^3
Effective Surface	5507	m^2
Total Surface	7404	m^2

Table 2: Room Parameters

The results of the measured and modelled Reverberation Times (RT60) in seconds are presented in Table 3 and graphically in Figure below:

Frequency (Hz)	EASE (s)	I-Simpa (s)	Excel (s)	Measured (s)
125	3.2	2.1	3.7	1.2
250	3.9	2.0	3.6	1.6
500	6.7	1.9	4.8	2.5
1000	5.3	1.8	5.3	3.4
2000	3.8	1.6	4.8	2.5
4000	2.3	1.1	3.8	2.7
Total A	4.2	1.8	4.3	3.1

Table 3: Modelled and Measured Results



Modelled and Measured Comparison - Pre-treatment (RSA, 2018)
Figure 4: Comparative Graph Pre-Treatment

There is a large difference in the measured data and the modelling. The spectrum of the reverberation time is significantly different to the measured data. There are considerable differences in the 500Hz between the 3 models. RT60 times differs by up to 6.7 seconds using EASE model and 4.8 seconds using Excel. I-Simpa is the closed to the measured RT60 time in the 500Hz with a RT60 time of 1.9 seconds.

Overall RT60 times differs significantly as well with 4.2 seconds using EASE, 1.8 seconds using I-Simpa and 4.3 seconds using Excel. These times are higher (in the case of EASE and Excel) by at least 1second and lower (in the case of I-Simpa) by 1.3 seconds.

The measured data is preferred and a more accurate method of establishing the baseline reverberation time for the swimming pool. Modelling the acoustic treatment into the swimming pool would need to be considerate of the measured data.

6. SELECTION OF MATERIAL

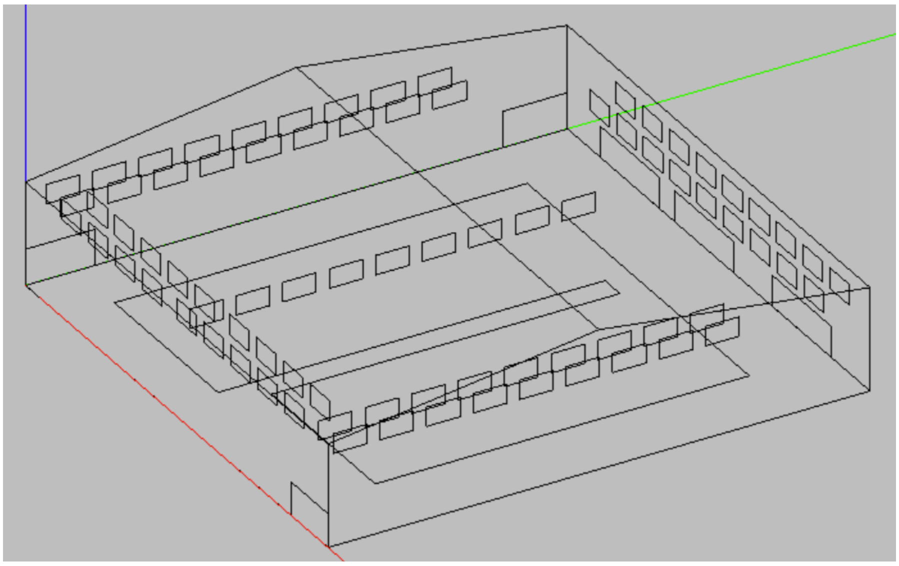
From the measured data and observations on site, significant acoustic treatment would be required for the swimming pool to reduce the reverberation time to acceptable levels. *AS/NZS2107: 2016 Recommended design sound levels and reverberation times for building interiors* provides a recommended RT of <2 seconds.

The material for the hanging baffle would need to be durable, susceptible to high levels of chlorine, easy to install and have a high acoustic absorptive property. The material for choice in this situation was closed cell foam panels. Manufacturer tested data claims the product has an NRC of 1.0.

7. ACOUSTIC TREATMENT

The decision to install the panels as hanging baffles was made in order to allow for both sides of the panels to be used as acoustic absorbers rather than installing it on the wall. The swimming pool was modelled in EASE with the hanging baffles placed in locations where it would be easier to install. For the modelling of the baffles in I-Simpa and Excel, absorption coefficients of the walls and ceiling were adjusted to account for the surface area of the baffles.

Figure below illustrates the 3D modelling of the swimming pool with hanging baffles.



Floorplan (RSA, 2017)
Figure 5: Hanging Baffle EASE modelling

A total of 45 baffles were modelled in EASE. The properties for the hanging baffles were defined as having 2 baffles at each location rather than 1. This provided the modelling with the parameters that we required for hanging baffles. Each of the surfaces had the following absorption coefficient:

Material	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Swimming Pool	0.01	0.01	0.01	0.01	0.02	0.02
Exposed Brickwork	0.05	0.04	0.02	0.04	0.05	0.05
Concrete	0.02	0.02	0.02	0.03	0.04	0.04
6mm Glass	0.10	0.08	0.04	0.03	0.02	0.02
Hanging Baffles	0.48	0.85	1.00	1.00	0.96	0.89

Table 4: Absorptive Coefficient of Hanging Baffles

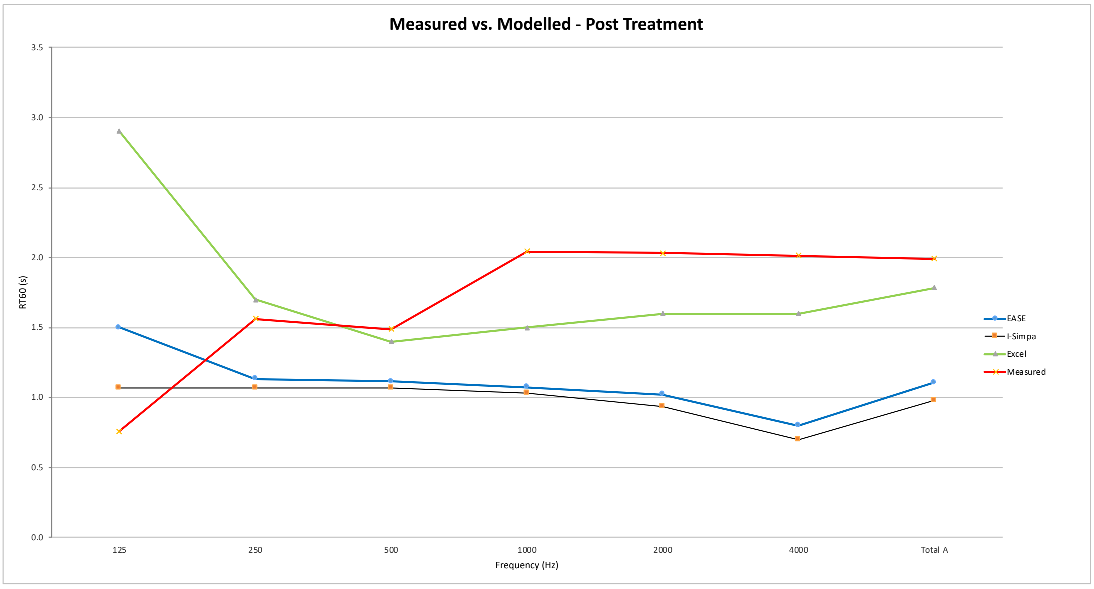
The data for the absorption coefficient of *Whisper* was provided by the manufacturer *Stratocell*. The primary areas of concern were identified with the initial reverb testing being the eastern corner and the centre.

The hanging baffles were installed in the swimming pool as per the modelling conducted in EASE. Once installation was completed, RSA staff was on site to measure the reverberation time (RT60). Measurements were conducted using similar methodology as pre-treatment measurements.

The results of the measured and modelled Reverberation Times (RT60) are presented in Table 5 and graphically in Figure below:

Frequency (Hz)	EASE (s)	I-Simpa (s)	Excel (s)	Measured (s)
125	1.5	1.1	2.9	0.8
250	1.1	1.1	1.7	1.6
500	1.1	1.1	1.4	1.5
1000	1.1	1.0	1.5	2.0
2000	1.0	0.9	1.6	2.0
4000	0.8	0.7	1.6	2.0
Total A	1.1	1.0	1.8	2.0

Table 5: Modelled and Measured Results



Modelled and Measured Comparison - Pre-treatment (RSA, 2018)
Figure 6: Comparative Graph Post-Treatment

8. CONCLUSION AND DISCUSSION

The purpose of this paper was to compare three different modelling tools with the measured data and to comment on the functionality of each of the tools. The comparison for the tools was based on the project specific analysis being the indoor swimming pool.

The three modelling tools included EASE, I-Simpa and Excel. Section 3 of this paper provides a brief description of each of the modelling tools. Acoustic modelling of the project area using the modelling tools provided a comparative view of each of the tools.

EASE provided a comprehensive modelling of the project area. The software enabled us to draw the swimming pool including the pool areas, specify the acoustic properties of each of the materials and calculate the reverberation times for the swimming pool. EASE also enabled us to position the hanging baffles at the locations we wanted. All the calculations and drawing were done within the program. When the calculated result was compared to the measured results, there were large discrepancies. The RT60 of the swimming pool prior to the acoustic treatment was calculated as 4.2 seconds with a standing wave at 500Hz at 6.7 seconds. The measured data resulted in an overall value of 3.1 seconds with 500Hz at 2.5 seconds. This is a significant difference in modelling and measured data. Modelled acoustic treatment resulted in an overall RT60 time of 1.1seconds with a flat reverb response. Measured RT60 resulted in an overall time of 2.0 seconds with a flat response. Difference in the overall timing is 0.9 seconds. For a space such as a swimming, this is within the <2.0 second project goal. During the EASE modelling, there are parameters that are assumed such as doors being closed, change rooms being unoccupied and no absorption by people this could lead to the inaccuracies in the data.

I-Simpa modelling provided a quicker calculation turn around and user-friendly interface when compared with EASE modelling. One of the biggest disadvantages of using I-Simpa was the lack of a drawing function. I-Simpa does provide provisions of modelling a simple cube or a rectangular prism. In order to model a complex room, the interior would need to be modelled using a drawing suite such as AutoCAD. For the purposes of this exercise, we used FreeCad and MeshLab. As we were able to draw the room using EASE, we were able to export the 3D shape as dxf file and import it to FreeCad. From here, the 3D mesh model was edited using MeshLab and imported to I-Simpa ready to be modelled. Where a project site has already been drawn, the above steps can be avoided however for projects such as the swimming pool, a drawing was not available. I-Simpa is an open source software and with further research (and development) drawing could potentially be incorporated within its operation. With the current version of I-Simpa, the modelling of hanging baffles could not be done. To model the acoustic treatment of the swimming pool, the NRC of the walls were adjusted to increase the acoustic absorption. We were also unable to input the NRC of the water in the swimming pool and had to adjust the absorption percentage of the floor to compensate for the water. The RT60 of the swimming pool prior to the acoustic treatment was calculated as 1.8 seconds with a flat acoustic response. The measured data resulted in an overall value of 3.1 seconds. This is a significant difference in modelling and measured data. Modelled acoustic treatment resulted in an overall RT60 time of 1.0 seconds with a flat reverb response. Measured RT60 resulted in an overall time of 2.0 seconds with a flat response. Difference in the overall timing is 1.0 seconds. The difference in the measured data and modelled data could be attributed to the limited definition of spaces (water and hanging baffles) and potential loss of room design.

Excel modelling was based on the Sabine theory of the calculation of reverberation time. As the indoor swimming pool is not a cube or rectangular prism, the manual calculation of room surfaces (including windows) was considered difficult. The acoustic treatment of the swimming pool was decided to be hanging baffles. This added another potential issue of introducing additional absorptive surface areas to the room. The complexity arose with the manual calculation of additional surface area to the existing area which could potentially lead to inaccurate results. The RT60 of the swimming pool prior to the acoustic treatment was calculated as 4.3 seconds with a flat response. The measured data resulted in an overall value of 3.1 seconds with 500Hz at 2.5 seconds. This is a significant difference in modelling and measured data. Modelled acoustic treatment resulted in an overall RT60 time of 1.8seconds with a flat reverb response. Measured RT60 resulted in an overall time of 2.0 seconds with a generally flat response. Difference in the overall timing is 0.2 seconds. The Excel model is the closest predicted modelling for post treatment.

In conclusion, we found that EASE was easy to use and contained all the necessary tools for calculation located within the software. EASE had the functionality of drawing the room to scale and can include the acoustic treatment of the room as well. Apart from RT60 calculations, EASE has other functionalities such as STi, room mapping with reflections and Auralisation. EASE can cost thousands of dollars however it is in our opinion that this might be the better modelling tools.

I-Simpa was easier to use than EASE for calculating the reverberation times. One of the major drawbacks with I-Simpa was the inability to draw the room within the software. Being an open source program, there is a potential for further research into incorporating this within the operational parameters. For the purposes of this paper, we used free software FreeCAD and MeshLab to complete the 3D room model. I-Simpa is a free software, however, unless the drawings are available, it is difficult to draw the room for I-Simpa.

For a large space as the swimming pool, calculations within Excel proved to be difficult particularly defining the acoustic treatment for the space. For small to medium size rooms, simple treatments and quick calculations, Excel based modelling might be suitable. For a project such as the swimming pool, Excel based modelling was difficult to use.