MACH ACOUSTICS

The Curve, Slough

ROOM ACOUSTICS OF THE OPEN PLAN LIBRARY

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Contents

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-	First issue		20/09/2013

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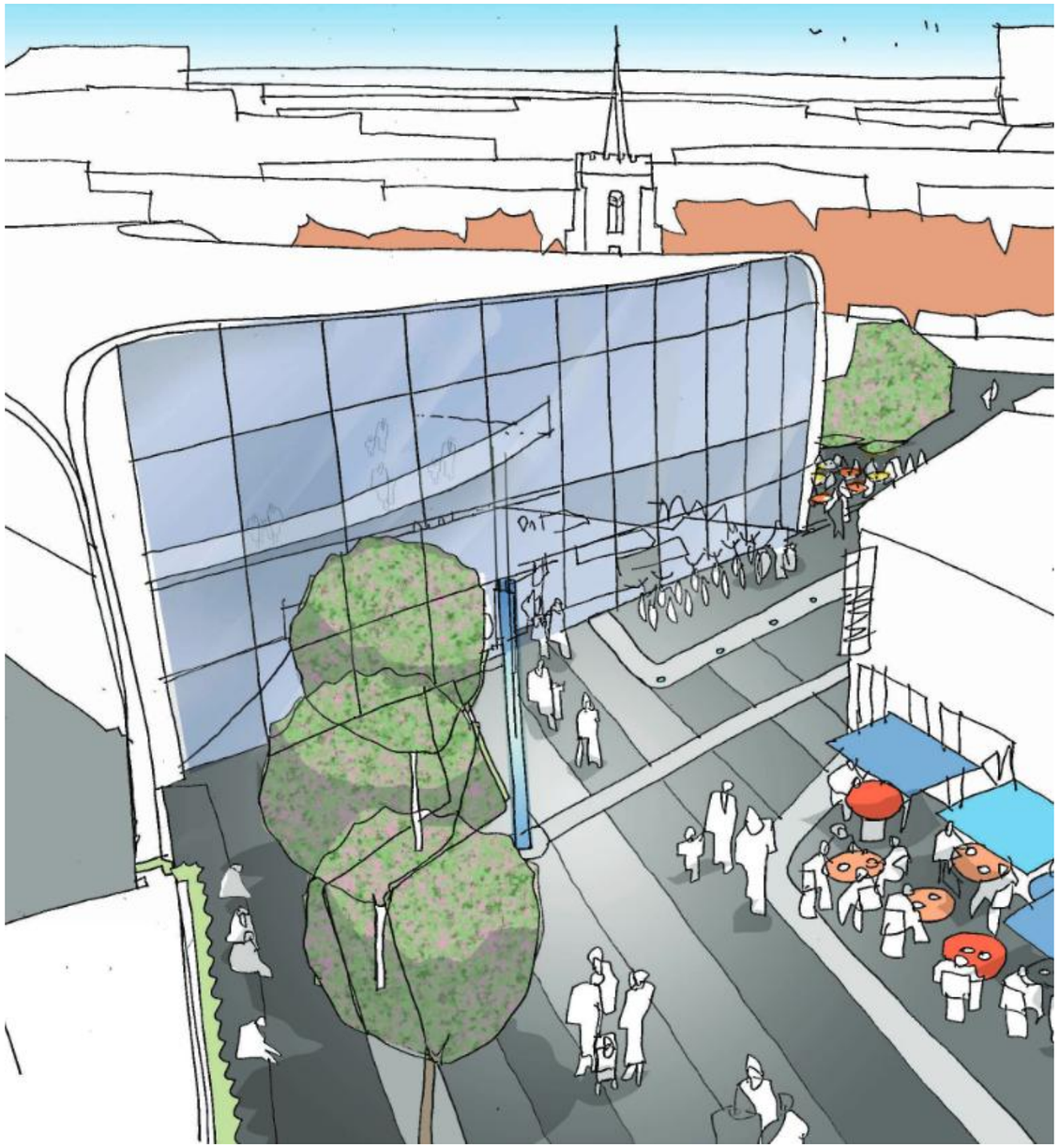
Introduction

MACH Acoustics are to provide the acoustic design for the new development of The Curve, Slough. This report will specifically present advice regarding the room acoustics of the large open plan spaces within the building.

There is currently no standard on which to base the acoustic design of libraries; therefore, MACH Acoustics have determined appropriate design targets through visits to a number of existing library spaces. This has been discussed in previous MACH Acoustics reports, please see ‘’Slough Library – Acoustics of Large Spaces – 11th May 2010’ for further details.

This document will outline the theory and methodology of predicting the room acoustics and noise propagation of the café space on the ground floor and main library space over the first and second floor.

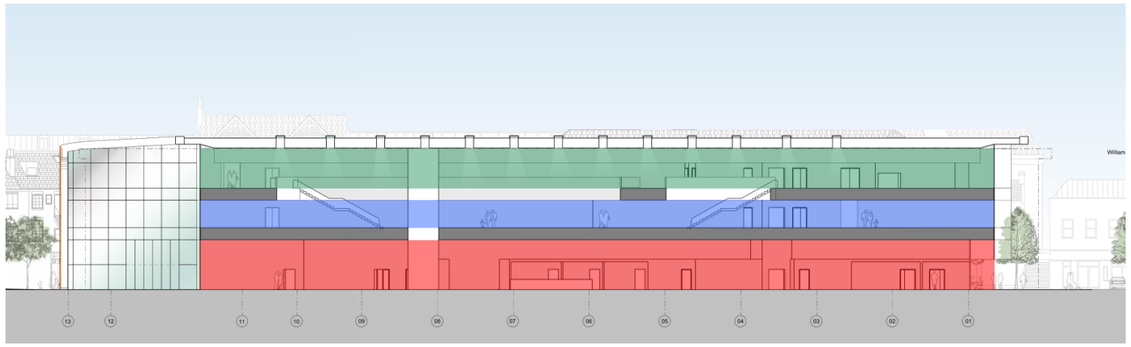
3D modelling has been carried out for both spaces, taking account of all proposed finishes so to predict the reverberation time and sound propagation within and between the two areas. It is found that due to the large amount of Class A absorption within both spaces, the target reverberation time should be achieved, and the possibility of unwanted noise leaking from the café to the library has been minimised.



Presentation of The Curve

The Curve spans over three storeys. The first and second floors include the library space and are interlinked by a large void which results in the two floors being acoustically interconnected. This layout brings a strong visual impact to the building but makes the acoustics of the building difficult to control, as large spaces can get considerably noisy due to reverberation, people traffic and the ease of sound bleeding from one space to another.

To a lesser extent, this also occurs between the ground floor Café and First Floor library space through open stairwells. Due to the high level of noise typically generated within a café and the low level of noise tolerance typical within libraries, it should be noted that sound transfer through these stairwells is an important aspect to consider within the design of the building.



The café on the ground floor (in red) with the first floor library (blue) are linked through two stairwells located against the northerly glazed façade.

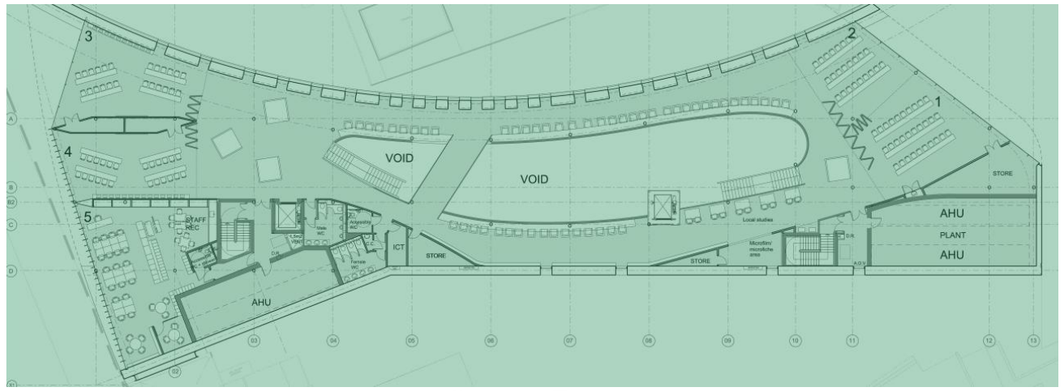
Cafes generally have a relatively long reverberation time due to hard floor and furniture finishes, and from the large ceiling height it is expected that the space will one of the most reverberant spaces in the building. The ground floor also includes a lobby to the building and is therefore considered to be the busiest and noisiest space within the development.

The Children's Library is also seen to be a source of noise within the building as children inherently create higher levels of noise in a library, while these spaces typically hold louder library activities such as reading sessions, as well .

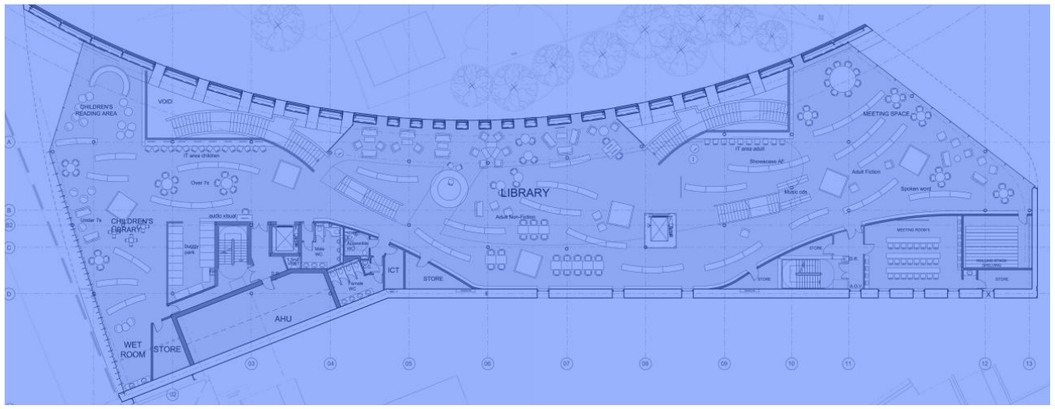
There are therefore two acoustic aspects of the building layout that require attention;

- Noise transfer from the Café to first floor Library;
- Noise transfer from the first floor Children's Library to first and second floor Library.

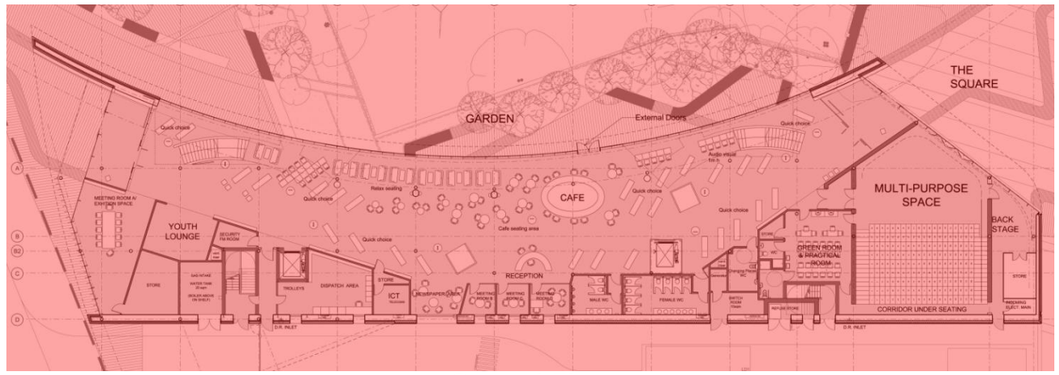
The purpose of this document is to assess the acoustic performance of these spaces and provide any mitigation measures, if required.



Second Floor



First Floor



Ground Floor

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Reverberation Time

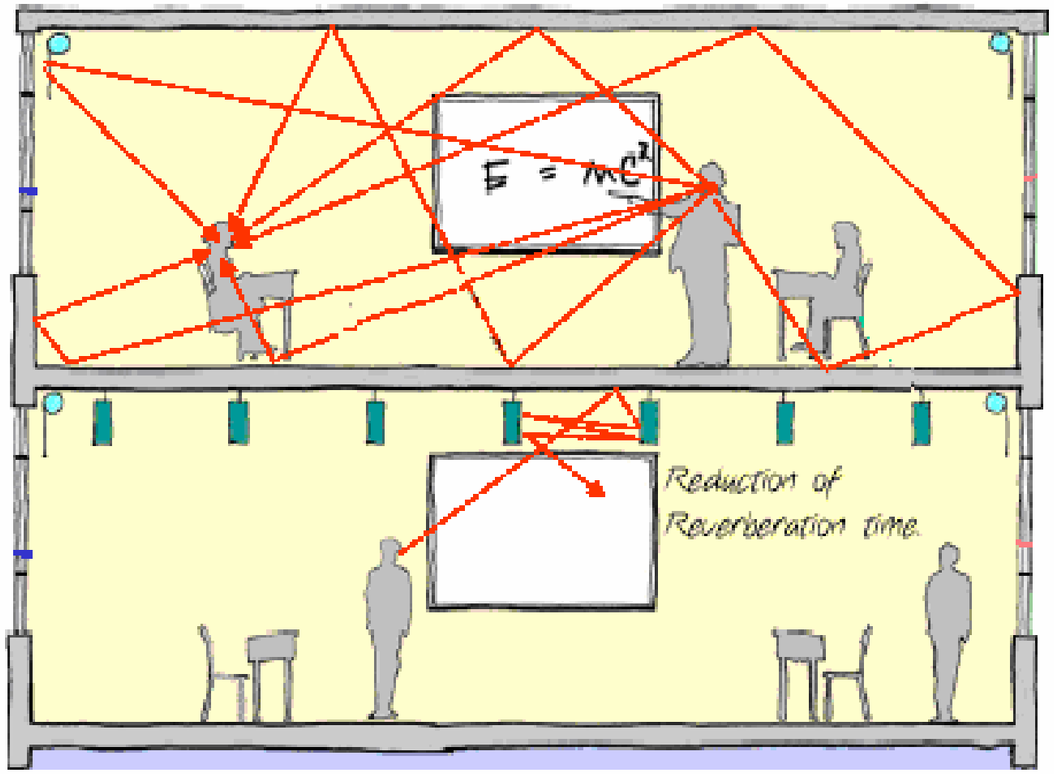
When sound, regardless of its nature, is generated within a space, the acoustic energy increases until equals the amount of energy absorbed by the boundaries of the room. The Reverberation Time is a measure of the time it takes for the acoustic energy to vanish when the sound source stops.

$$RT = \frac{\text{Volume} \times 0.161}{\text{Total Acoustic Absorption}}$$

As shown above, the Reverberation Time is directly dependent on the volume of the room and inversely dependent on the amount of absorption within the room. Hence, hard finishes on the room boundaries will lead to longer reverberation times which has the following consequences:

- the speech sounds become more difficult to hear as the long decay blurs successive syllables into each other, and ;
- a build-up of noise occurs as the sound takes longer to be absorbed. When this build-up of noise occurs, there is a snowball effect as voices are raised to be heard above the noise.

The purpose is then to control this two effects by putting the right amount of absorption.



What is an ideal Reverberation Time?

The first thing to take into account in order to specify a reverberation time target is the room's usage. According to BB93, the reverberation time for libraries is required to be 1.0 s or below. MACH Acoustics agree with this target in order to provide sufficient sound absorption to reduce the build-up of noise.

As discussed further in the report, the estimated reverberation time for the library spaces on the first and second floor, with the proposed finishes, is estimated to be 0.9 s which is just below the proposed suitable target.

Criteria	Reverberation Time (s)
BB93 Target	<1.0
Mach Acoustics' Target	1.0
Estimated value with proposed finishes	0.9

Proposed Acoustic Treatment – Ground Floor Layout

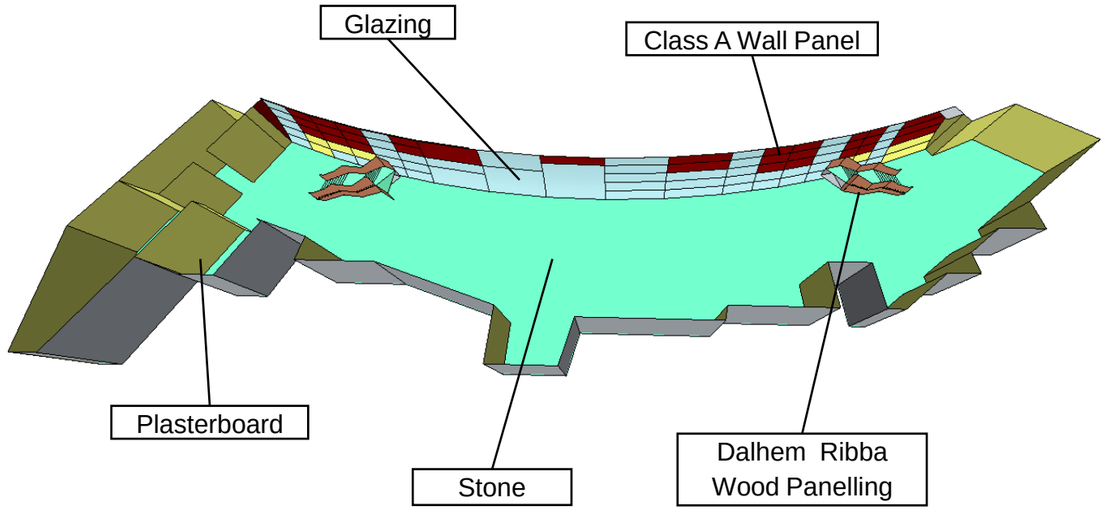
Previous input has been provided in to the acoustic design of the proposed development, and as a result the Café, first floor Library and second floor Library all have a significant amount of proposed acoustic treatment.

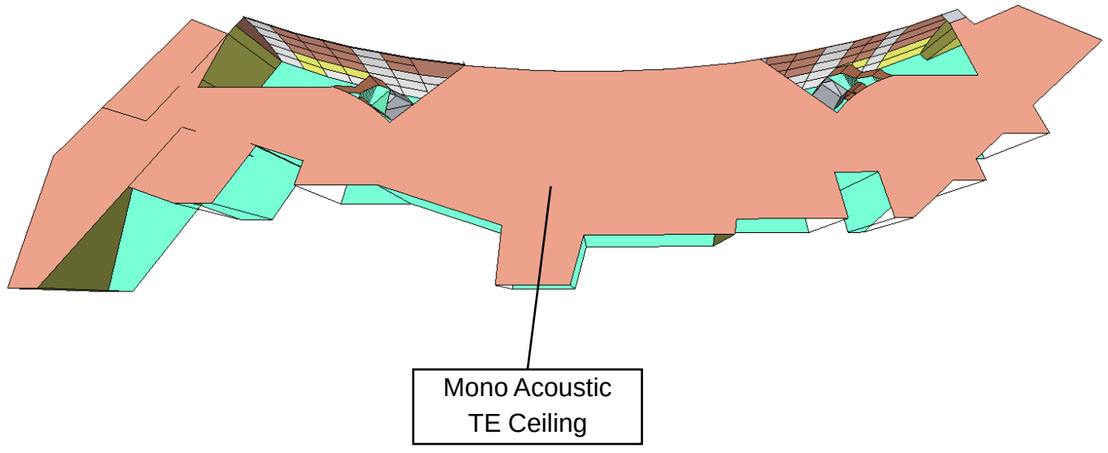
The figures opposite show the location and area of the proposed acoustic finishes for the ground floor. It is shown that stone and timber are used as the finishes for the floor. A plasterboard finish is proposed for all the walls apart from those on the northern façade, in which glazing will be alternated with lightweight walls with Class A wall panels. These walls are plasterboard up to 2m from floor height and Mono Acoustic TE Class A absorbent above.

The Class A wall panels are used to reduce the noise reflecting from the ground floor to the first floor and stop the build-up of noise. A similar outcome is achieved with Dalhem Ribba wood panels mounted on the balustrades of the stairs.

The ceiling is also the Class A, Mono Acoustic TE which provides a significantly important amount of absorption in order to reduce the reverberation time and reduce the build-up of noise.

A more detailed description of the proposed finishes are provided on page 10, in which acoustic properties are provided along with images.





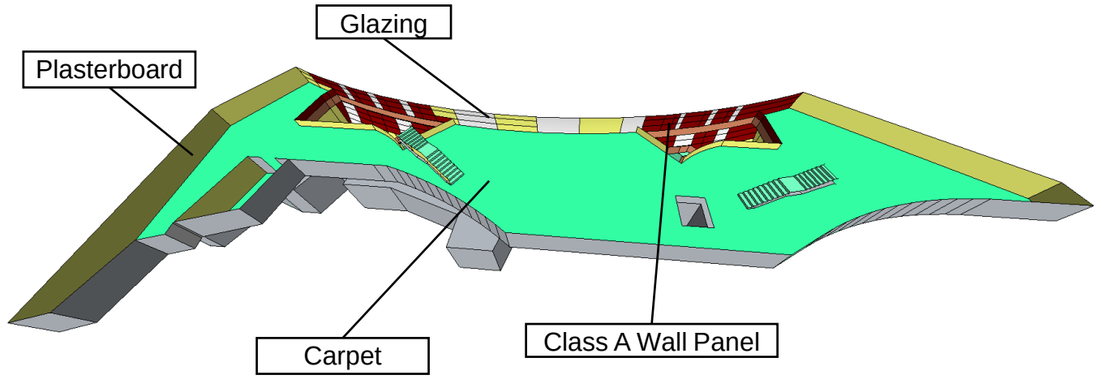
Proposed Acoustic Treatment – First & Second Floor Layout

First Floor

The figure to the top right illustrates that proposed finishes for the first floor level. It is shown that the floor finish is to be carpet throughout, and the ceiling is to be a class A Mono Acoustic TE, although this is not shown in the image.

Similar to the ground floor, all wall finishes are to be of a plasterboard finish with the exception of the north façade, which is to be a mixture of glazing, plasterboard and Mono Acoustic TE, so to prevent any strong reflections between the ground and first floor.

With these proposed finishes, it is predicted that the reverberation within the space is 0.9s, which is in accordance with the proposed library criteria.



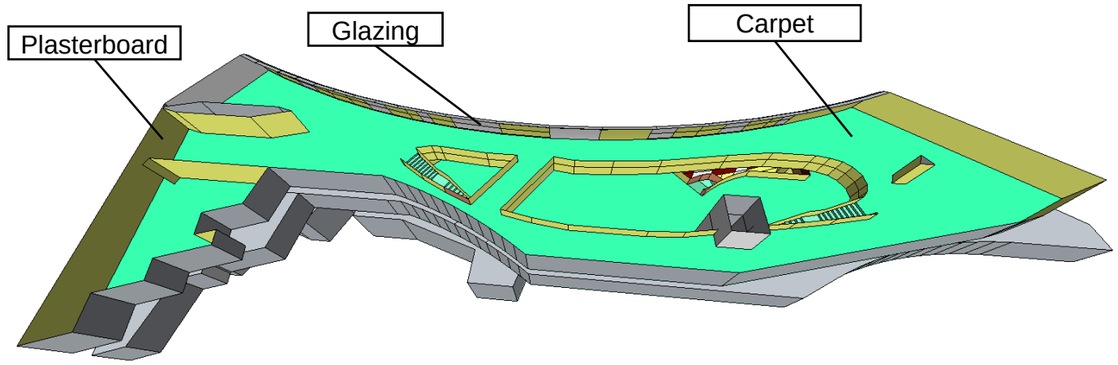
Second Floor

The figure to the bottom right illustrates that proposed finishes for the second floor level. As per the first floor, the floor finish is to be carpet throughout, and the ceiling is to be a class A Mono Acoustic TE, although this is not shown in the image.

The north facing wall is to include a mixture of glazing and plasterboard, while all other walls are to be either plasterboard or movable partitions to the meeting rooms.

As with the first floor Library, from the proposed finishes it is also predicted that the reverberation within the space is 0.9s, meeting the proposed library criteria.

Although not included in the images, both first and second floor library spaces are to include a large amount of furniture and book shelves, which provide both additional acoustic absorption and screening within the spaces. The furniture height and layout will determine the acoustic effect that the furniture will have, but it is anticipated that the reverberation time will be lowered further once the spaces are fully furnished.



Proposed Acoustic Treatment

There is a large amount of acoustic absorption proposed within all three floors. The finishes for all the boundaries of this space are outlined below ;

•Ground floor

- Floor: Stone and timber
- Walls: Plasterboard, Mono Acoustic TE Class A absorbent and glazing
- Ceiling: Mono Acoustic TE Class A absorption

•First and second floors

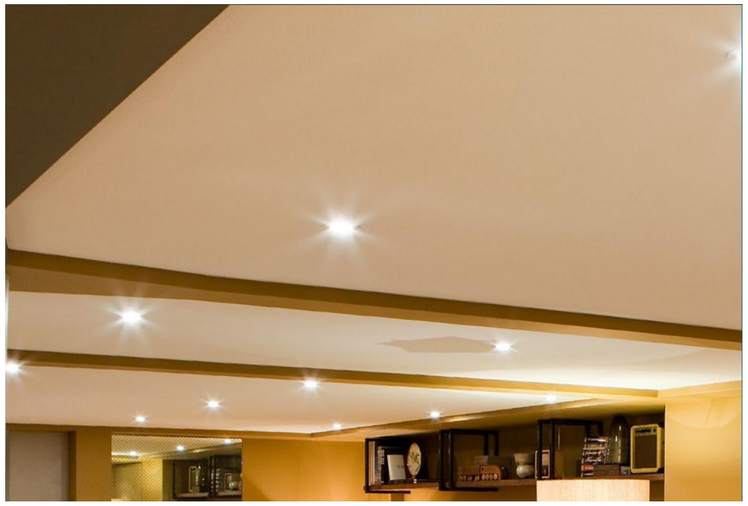
- Floor: Carpet
- Walls: Plasterboard, Mono Acoustic TE Class A absorbent and glazing
- Ceiling: Mono Acoustic TE Class A absorbent

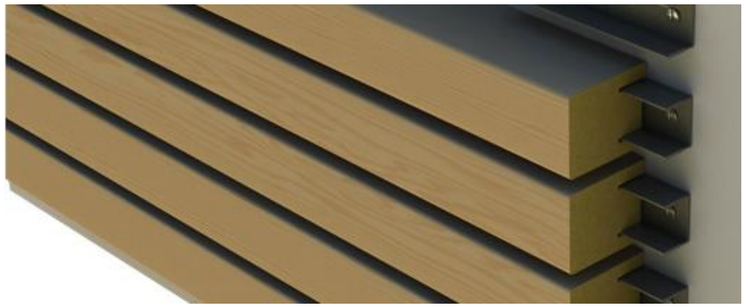
• Balustrades

- Dalhem Ribba wood panelling

In order to provide a sufficient amount of acoustic absorption, two acoustic products have been proposed. For the ceilings and the wall panels next to the stairwell void, the Mono Acoustic TE Class A absorbent will be used. The absorption coefficient is provided in the table below. Using a 200mm void from ceiling to soffit, the averaged absorption coefficient is 0.9.

For the balustrade of the stair on both the inside and the outside and on the balustrade around the void in which the stair rises, Dalhem Ribba wood panels are proposed . The absorption coefficient for this product with a 20mm mineral wool is shown below.





Product	Acoustic Absorption, Octave Band Frequency					
	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Mono Acoustic TE	0.35	0.60	0.90	1.00	1.00	1.00
Dalhem Ribba Wood Panel	0.50	0.90	0.70	0.55	0.30	0.30

Noise Activity – Ground Floor

Potential sources of noise

As discussed in the previous section, the ground floor is seen as the noisiest area within the library. In order to successfully prevent high levels of noise leaking into sensitive areas, it is important to identify which areas of the development need to be attenuated to a higher extent.

The image on the right shows the different open plan areas of the ground floor. The green areas are expected to be quiet, whereas the reddish areas are expected to be noisy. The type of noise disturbances expected are:

Different noise areas of the Ground Floor.

Noise from people:

- Footfall through the lobby;
- Large groups of people chatting within the café;
- People on mobile phones.

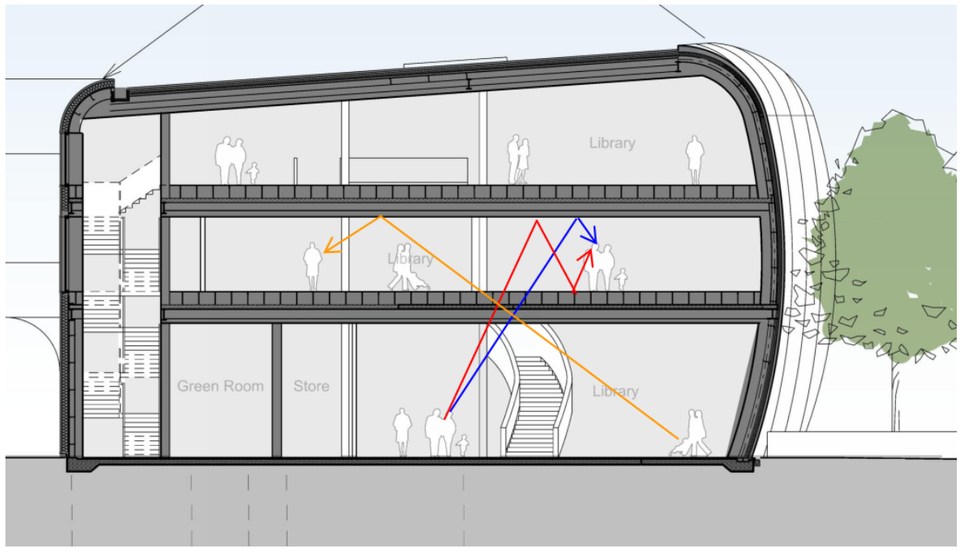
Noise from the building:

- General lift noise;
- Doors shutting;
- Catering trolley;
- WCs, air hand dryers ;
- Cafe noise - cutlery noise, coffee machines, music.

Transfer of noise from ground to first floor:

Noise at the source is controllable to a certain point. Therefore, it is also critical to limit the transfer of sound from the source to the receptor. In the case of The Curve, the source is the ground floor and the receptor the first floor.

The image on the right shows potential sound paths from the ground to the first floor.



Reflection of sound from Ground to First Floor

Noise Sensitivity – First and Second Floor

Areas of low noise tolerance

As well as identifying noisy areas, it is equally important to identify the most noise-sensitive spaces of the development so to determine which particular spaces require additional attention and thus evaluate what level of mitigation may be required.

The image on the right shows the various areas of the first and ground floor of the Curve, highlighted to indicate areas of high activity noise and low tolerance to noise.

The green areas are expected to be quiet areas which are most sensitive to high levels of noise, whereas the reddish areas highlight where noise from adjacent spaces is to propagate through. The Children's Library, highlighted in range is an area which has both low noise tolerance and occasional high activity noise.

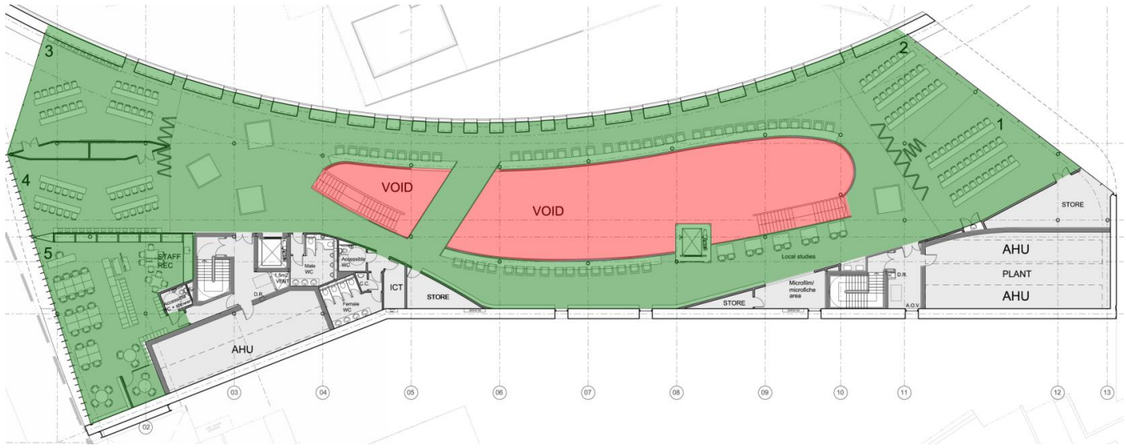
The most sensitive spaces have been identified as the main library areas on both floors, as well as the meeting rooms situated on the second floor. The main library spaces include areas intended for studying and quiet reading and therefore requires low levels of ambient noise so suitable levels of concentration can be achieved.

Different noise areas of the First Floor

Children's Library

It should also be noted that the Children's Library situated on the First floor has the potential to be a significant noise source within the development. Children's libraries typically put on readings and activities as well social sessions for both parents and children. It should also be noted that children typically generate higher levels of noise than other library occupants, with events such as crying babies being particularly noisy.

Therefore, noise transfer from the Children's Library to the rest of the library should also be considered as well as noise propagation from the Café.



Different noise areas of the Second Floor

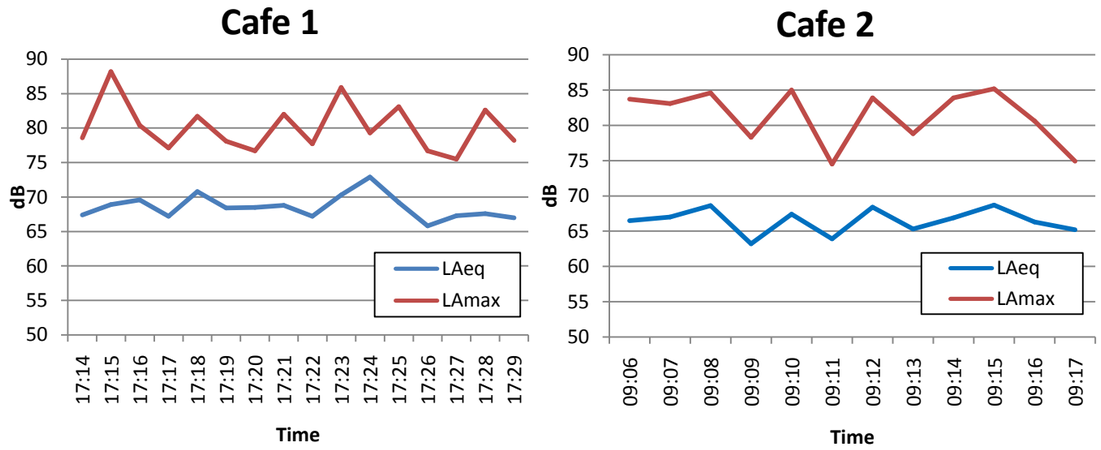
Noise Sources

Café

In order to determine the typical noise levels that will occur within the proposed Café area, MACH have carried out noise measurements in two typical café spaces to determine typical activity noise levels generated within such a space.

Both measurements were carried out a peak times in which cafes were considerably busy. This gives an indication of what the noise levels at the proposed café will be when it is at full capacity, which is the worst case scenario.

Similar results are shown for the two measurements, where it is considered that a typical café will produce ambient noise levels between the range of 65-70dBL$_{Aeq}$ and peak levels up to 85dBL$_{Amax}$.

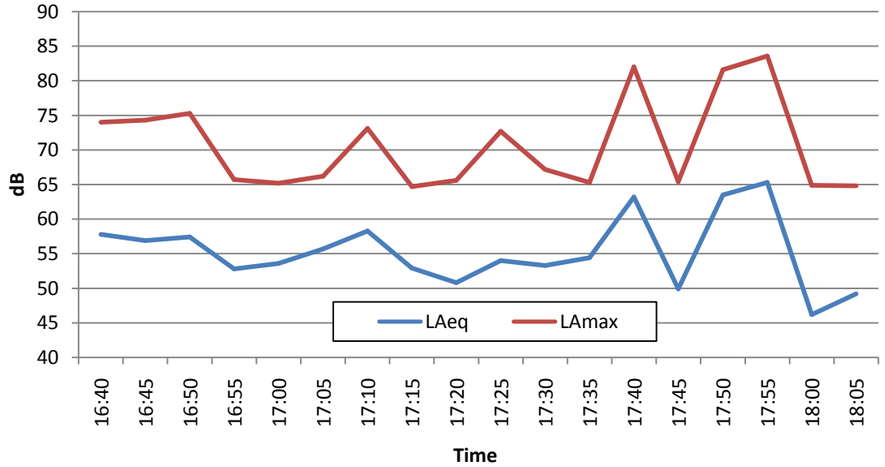


Children's Library

Noise level measurements were taken within an existing children's library during open hours, in which 5 minute measurements were taken consecutively over 90 minutes. These measurements fairly represent the general noise levels found within a children's library throughout the day.

It is considered that general activity with the children's library will produce ambient noise levels of 50-65dBL$_{Aeq}$, with peak levels up to 85dBL$_{Amax}$.

It should be noted that if the Children's Library is to include activities such as interactive story telling or reading/sing-along sessions, then these activities generally generate higher levels of noise and this will need to be modelled as a worst case scenario. From experience, it is considered that the ambient noise levels during these particular activities will be 5dB higher, with a maximum noise level of 70dBL$_{Aeq.}$



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Noise Propagation – Café

In order to ensure that the proposed acoustic treatment provides adequate sound absorption so that noise propagation within a space is adequately mitigated, a computer model (CATT model) of the library has been built up.

Within this model, MACH Acoustics have predicted the propagation of sound from noisy areas in to more sensitive spaces, thus allowing the assessment of level of disturbance throughout the library.

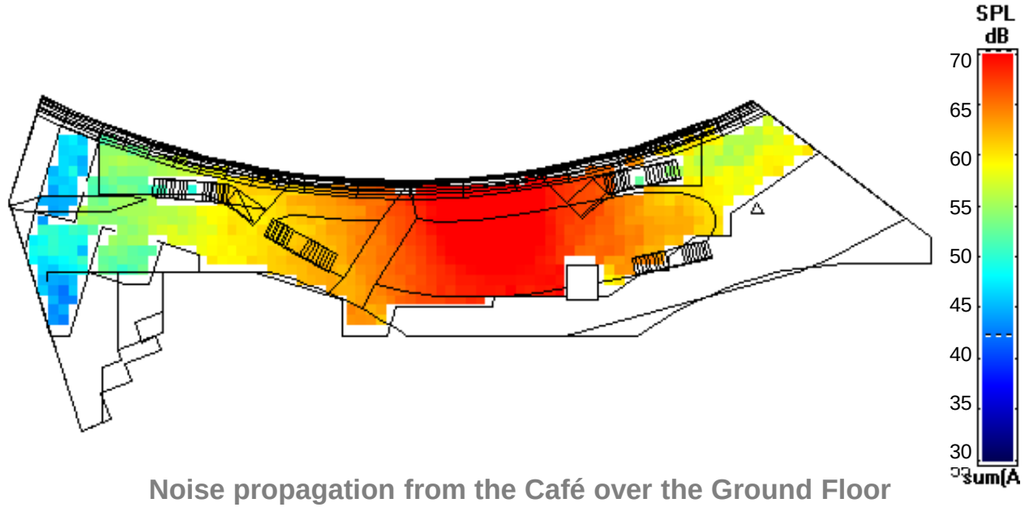
The first model predicts the spread of noise from the Café through the ground floor and into sensitive spaces such as the ground floor Meeting Room and first floor Library. The figures on the right show the decay of sound over distance with the proposed absorptive finishes, in which it is seen that a decay of between 20 - 35dB is achieved between the Café and first floor Library.

From using the predicted decay and typical noise levels stated on the previous page, we are able to predict the overall noise level in each sensitive space, shown in the table below.

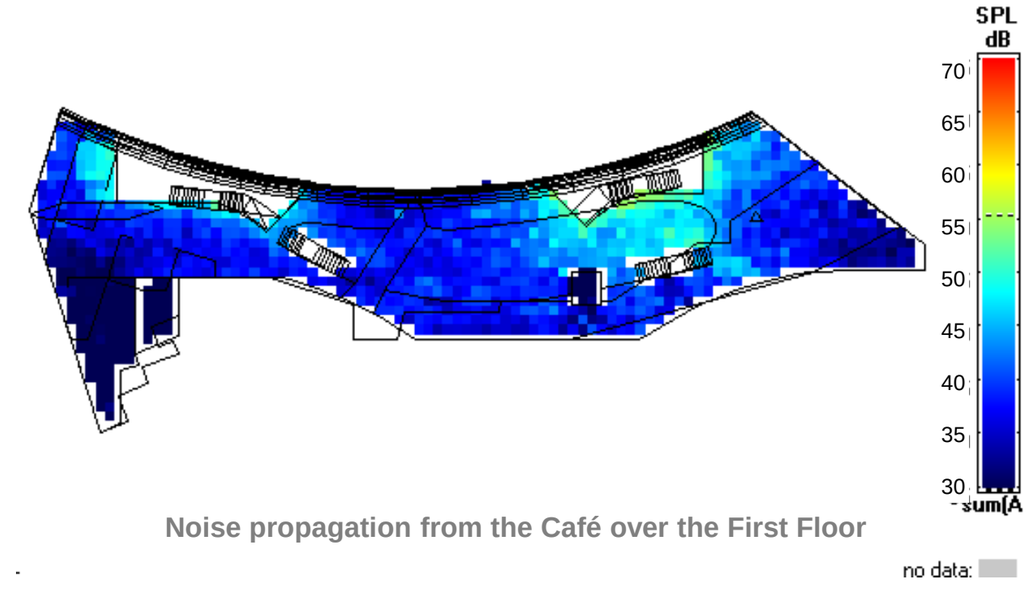
	Predicted Noise Level, L_{Aeq}	
Café Noise Level, L_{Aeq}	**Meeting Room**	**First Floor Library**
65 – 70 dB	45 – 50 dB	30 – 50 dB

Although the range of noise level on the first floor Library is between 30-50dBA, it is seen that the majority of the library spaces has an ambient level of 40dBA, which is seen as suitable for a large open plan library.

It is predicted that the ground floor Meeting room adjacent to the Entrance/Lobby room will have an ambient noise level of between 45-50dBA, which is approximately 10dB above suitable levels for a formal meeting room. If the space is to be used for more informal discussions and meetings the level of noise is suitable, however for a more formal environment it is recommended that a partition is installed, separating the meeting room from the rest of the Lobby.



Noise propagation from the Café over the Ground Floor



Noise propagation from the Café over the First Floor

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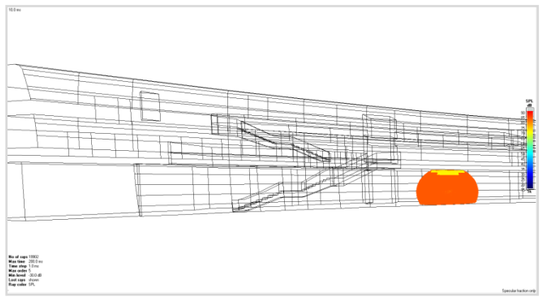
Noise Propagation – Café

The images below are time traces taken from the aforementioned 3D noise model of The Curve. These images represent how noise propagates within each floor and is helpful in determining if any surfaces may be problematic due to strong reflections as well as providing a strong visual presentation of noise propagation to adjacent floors.

It is shown that there is noise break through the stairwells from the ground floor to the first floor; however, this is not seen a problematic as the level of noise is low and the noise is spread quite evenly across the whole floor.



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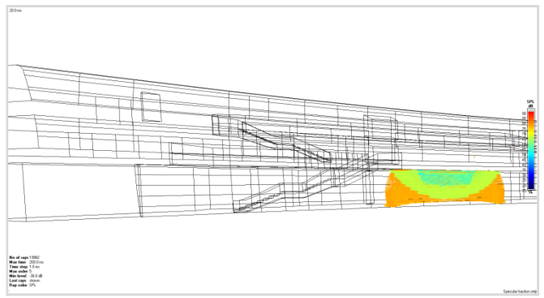

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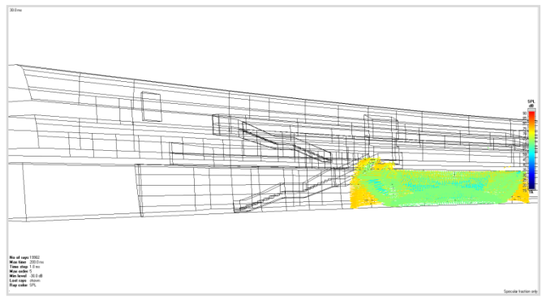

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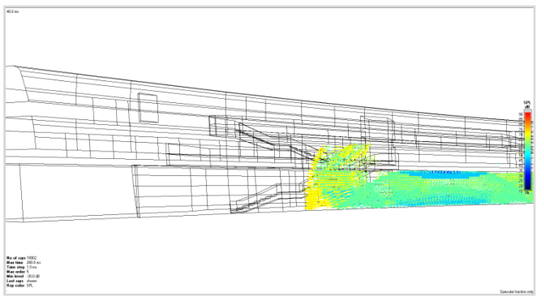

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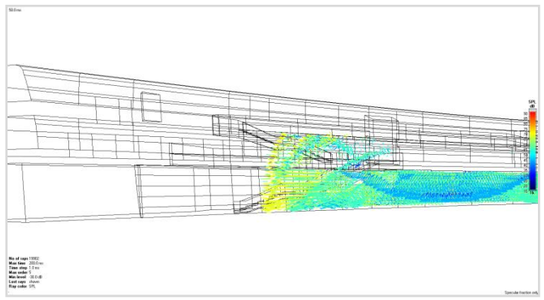

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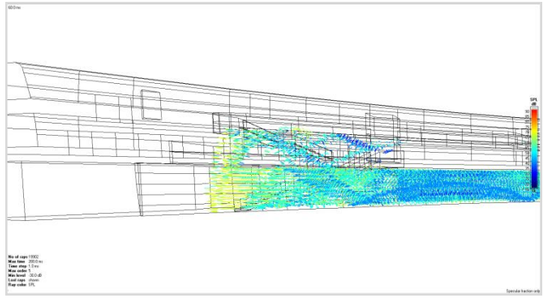

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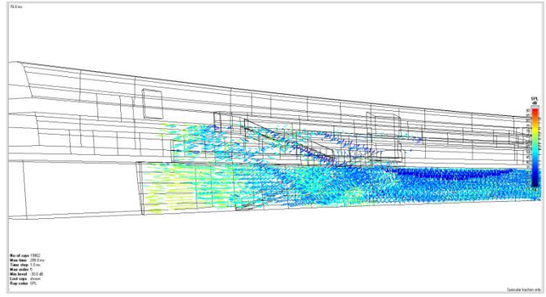

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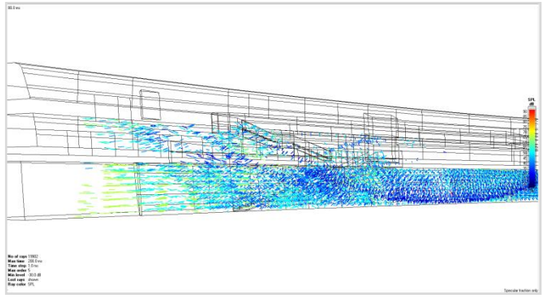

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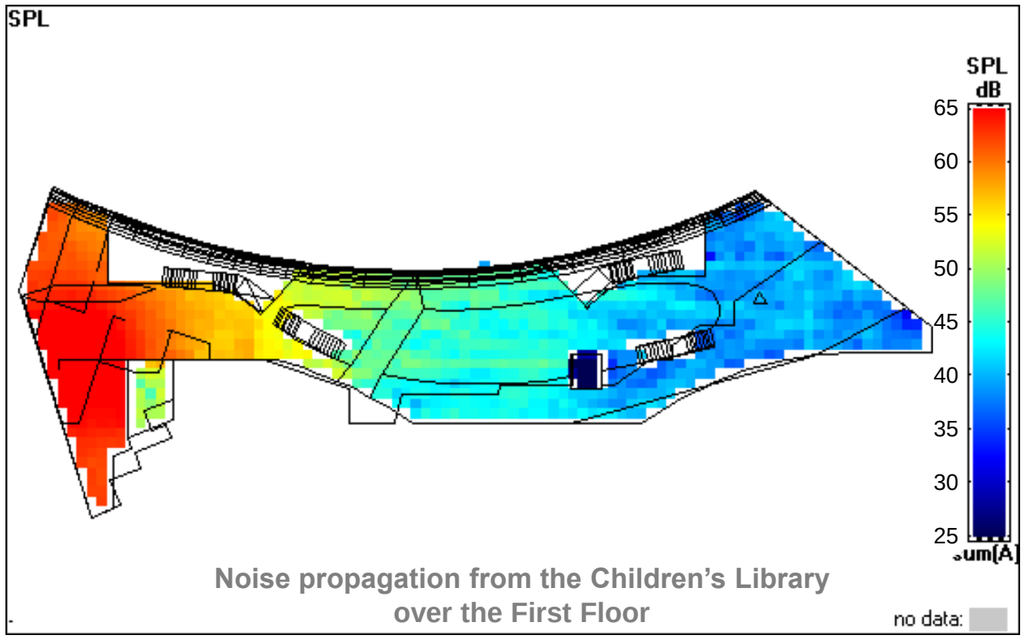
Noise Propagation – Children's Library

Noise propagation has also been predicted from the Children's Library space into the rest of the library on the first and second floors. The figures on the right show the decay of sound over distance with the proposed absorptive finishes, in which it is seen that a decay of between 10-25 dB is achieved between the Children's Library and the rest of first floor Library. While a level difference of over 40dB can be achieved from the Children's Library up to the second floor Library.

As per the previous page for Café noise, typical activity levels have been applied to the sound source to predict the overall level of noise at the sensitive space within the building. The results of these are shown in the table below.

Café Noise Level, L_{Aeq}	Predicted Noise Level, L_{Aeq}	
	First Floor Library	Second Floor Library
50 – 65 dB	35 – 50 dB	<25 dB

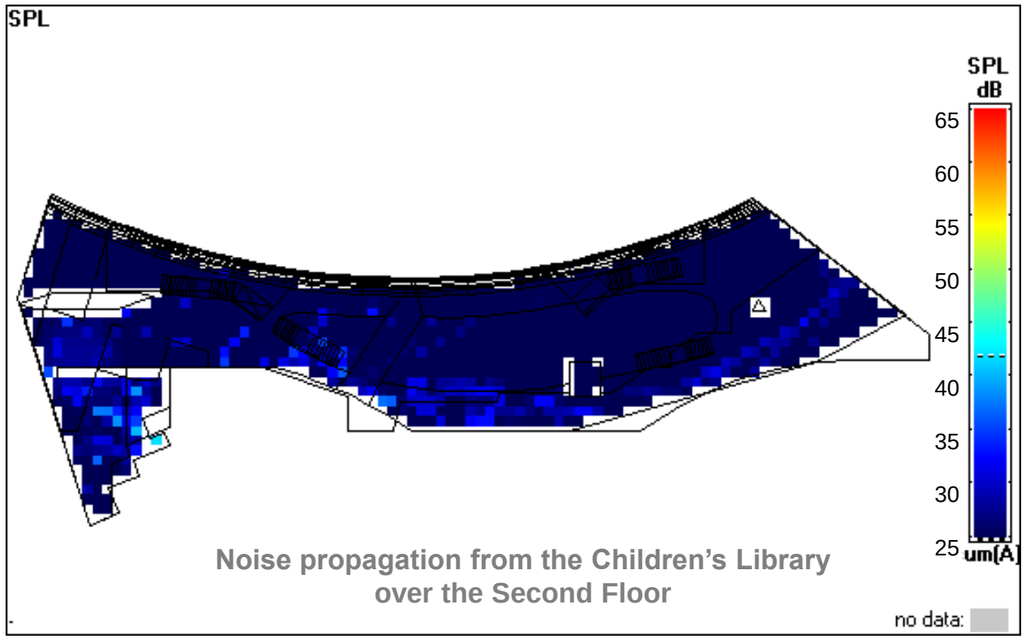


Noise propagation from the Children's Library over the First Floor

It is predicted that the first floor Library will achieve ambient noise levels of between 25 and 55 dBA, depending on proximity to the Children's Library. It is seen that the majority of the Library space falls below 40dBA, which is seen as a suitable level of ambient noise for such a space.

In regards to the second floor Library, it is predicted that noise from the Children's Library will be even lower than the first floor, at approximately 25-30dBA. This is therefore considered to be suitable for the use of the space.

From these results, it is shown that the acoustic treatment proposed within the space is effective in mitigating the propagation of noise within a space, and that no additional measures are required to ensure that the space works acoustically.



Noise propagation from the Children's Library over the Second Floor

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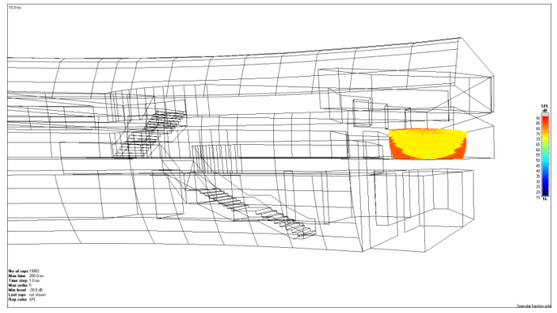
Noise Propagation – Children's Library

The images below are time traces taken from the 3D noise model of the Children's Library. These images represent the propagation of noise from the Children's Library across the first and second floor of the development.

It is shown that there very minimal noise propagation from the children's library to the second floor Library, which indicates that noise disturbance on that level will be at a minimum. It is seen that having both carpet flooring and absorptive ceiling is highly effective in reducing unwanted reflections.



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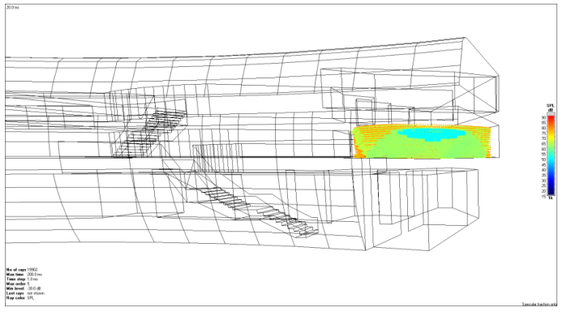

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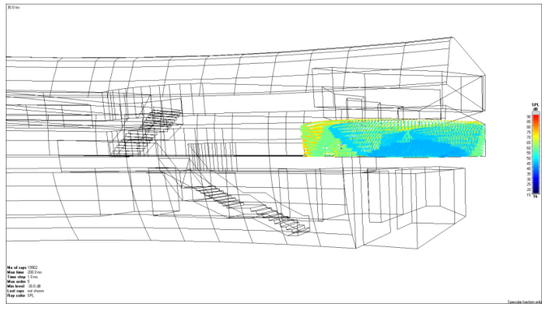

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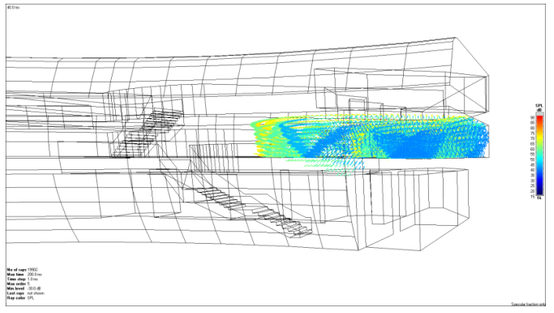

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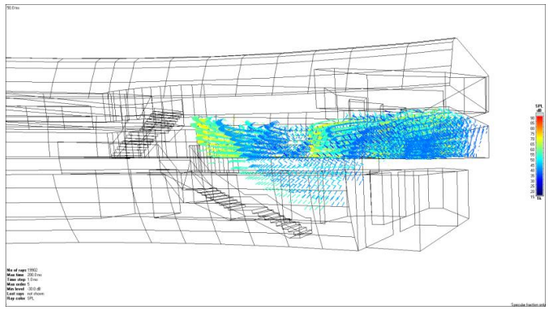

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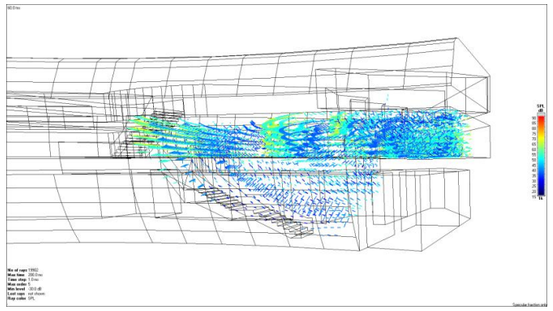

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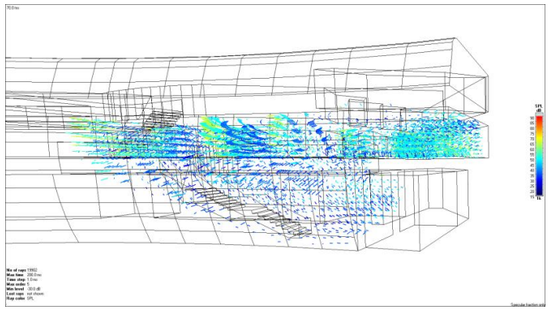

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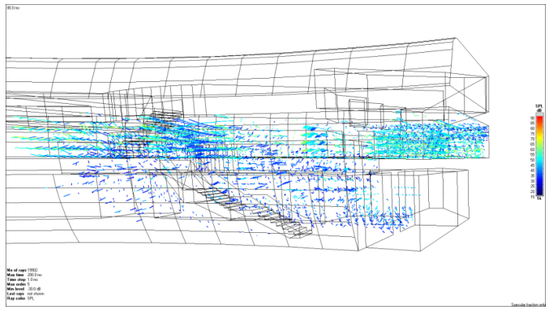

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Conclusion

In order to determine the levels of noise throughout the large open spaces within The Curve development, MACH Acoustics have created and processed a number of 3D acoustic models to determine the reverberation time and spread of noise throughout the building.

Models have been carried out for noise from the Café and Children's Library space, so to predict the level of noise propagation into the first and second floor library areas. In order to determine typical noise levels for the major noise sources within the building, noise measurements have been taken at existing Cafés and Children's Libraries to determine average ambient noise levels when in use.

The proposed spaces have a large amount of acoustic absorption proposed throughout, in which the Class A panels on the glazed façade provide an efficient method of mitigating noise reflecting between floors.

From the modelling carried out, it is predicted that noise propagation from the Café and Children's Library is of an acceptable level, and noise disturbances within the rest of the building is predicted to be minimum. It is also anticipated that when the space is fitted with furniture and book shelves, this will provide additional acoustic benefits to the space in regards to acoustic absorption as well as noise propagation, depending on the furniture layout.