Embodied energy and other qualities of natural materials in Passivhaus construction

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for the Passivhaus Conference 2017

working with volunteers

ecohub, lordship park

straw works


starting points -strawbale
summer fesitval 2012
ecohub, lordship park


The Timber Fram
www.TheTi
Telephone & Fa

local materials / passivhaus

Wedge shaped building element
still air spaces -> Secondary calculation

Heat transfer resistance [m²K/W] interior R_{si} 0.13
exterior R_{se} 0.04

	Area section 1	λ [W/mK]	Area section 2 (optional)	λ [W/mK]	Area section 3 (optional)	λ [W/mK]	Thickness [mm]
1.	Internal Clay Plaster	0.660					30
2.	Straw Bales	0.052					450
3.	External Lime Render	0.063					30
4.							
5.							
6.							
7.							
8.							

Percentage of Sec. 2 Percentage of Sec. 3 Total 51.0

U-Value: 0.107 [W/(m²K)]

Assembly No. Building assembly description
2 roof

Heat transfer resistance [m²K/W] interior R_{si}
exterior R_{se}

	Area section 1	λ [W/mK]	Area section 2 (optional)	λ [W/mK]	Area section 3 (optional)	λ [W/mK]
1.	reed thatch	0.090				
2.	battens	0.130				
3.	wood fibre board	0.070				

at

embodied energy

Material	Embodied energy EE MJ/kg	embodied carbon EC kgCO2/kg
polystyrene	88.6	2.55
concrete	0.7	0.97
steel reinforcement	17.4	1.31
timber softwood	7.4	0.19 - +0.39
foam glass	27	
straw/thatch	0.24	0.1
lime	5.3	0.76
cellulose insulation	0.94 - 3.3	
plasterboard	6.75	0.38

where do we have significant choices?

figures from the ICE, Inventory of Carbon and Energy summary

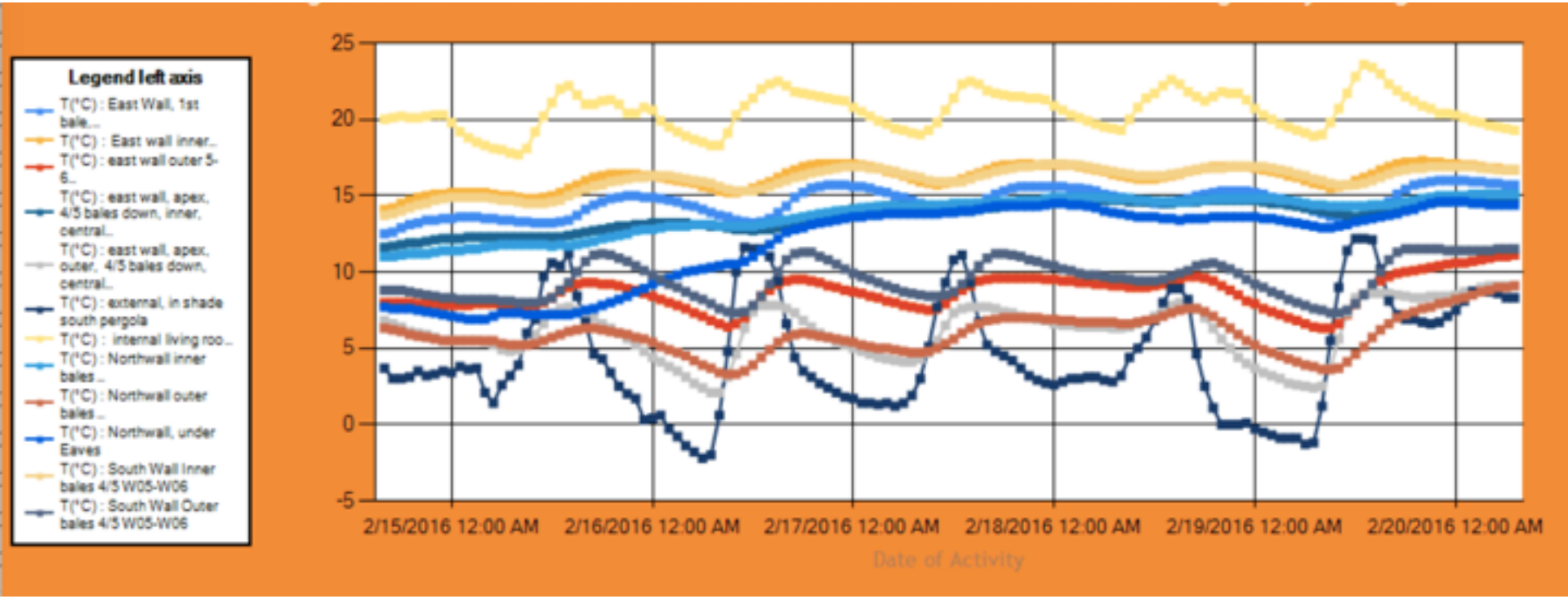
at

consider also toxicity, in manufacturing and use

Health	non-toxic production / disposal
	no off-gassing
	minimise allergies
Low embodied energy	carbon sequestering
	bio-degradable
	renewable materials
Better indoor air quality	naturally balances humidity
Protect existing fabric	hygroscopic
	vapour permeable
	prevents trapped moisture

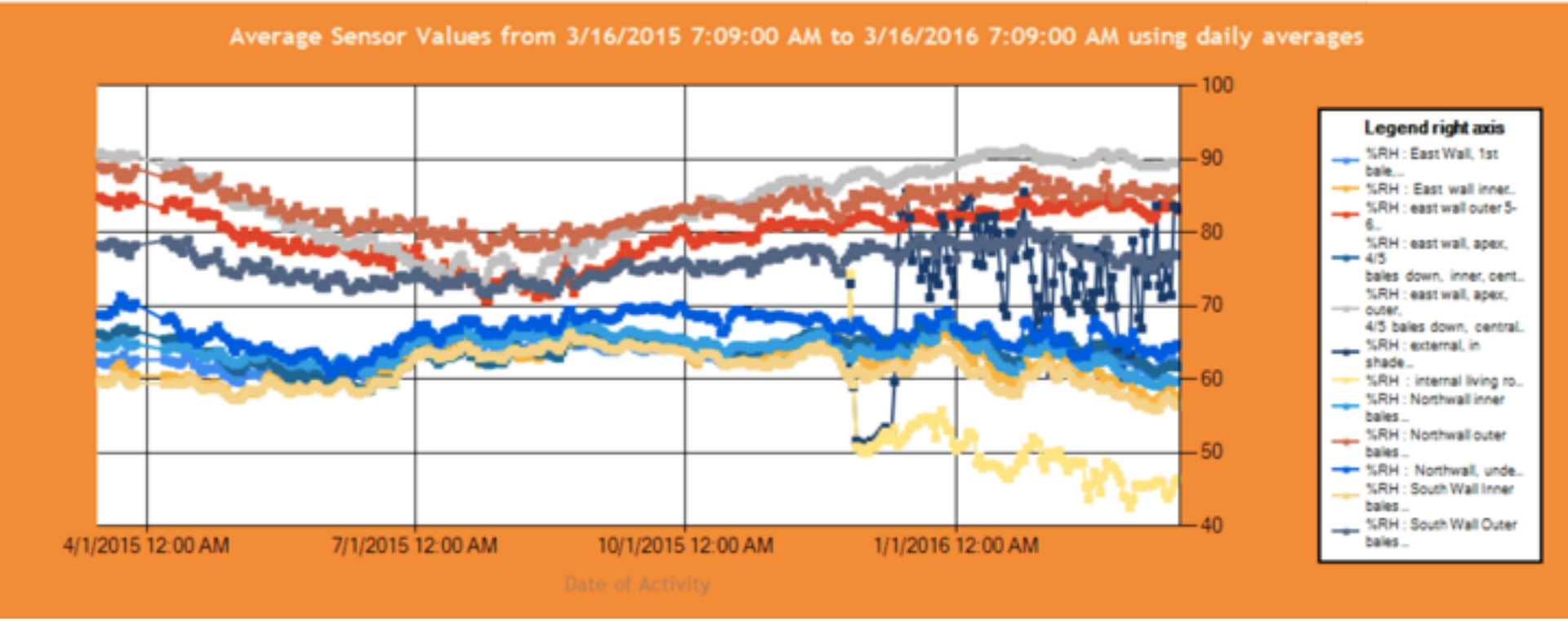
AECB hygrotrac monitoring

AECB hygrotrac monitoring



very even temperatures - a cold week in february
top line shows internal room temperature, the upper lines show sensors near the inside of the wall, the lower ones towards the outside and the black line the external temperature

AECB hygrotrac monitoring



relative humidity 2015-6
the internal and external sensors
move further apart during the winter,
(the later spiked line is external temp)

acoustic, light & air quality

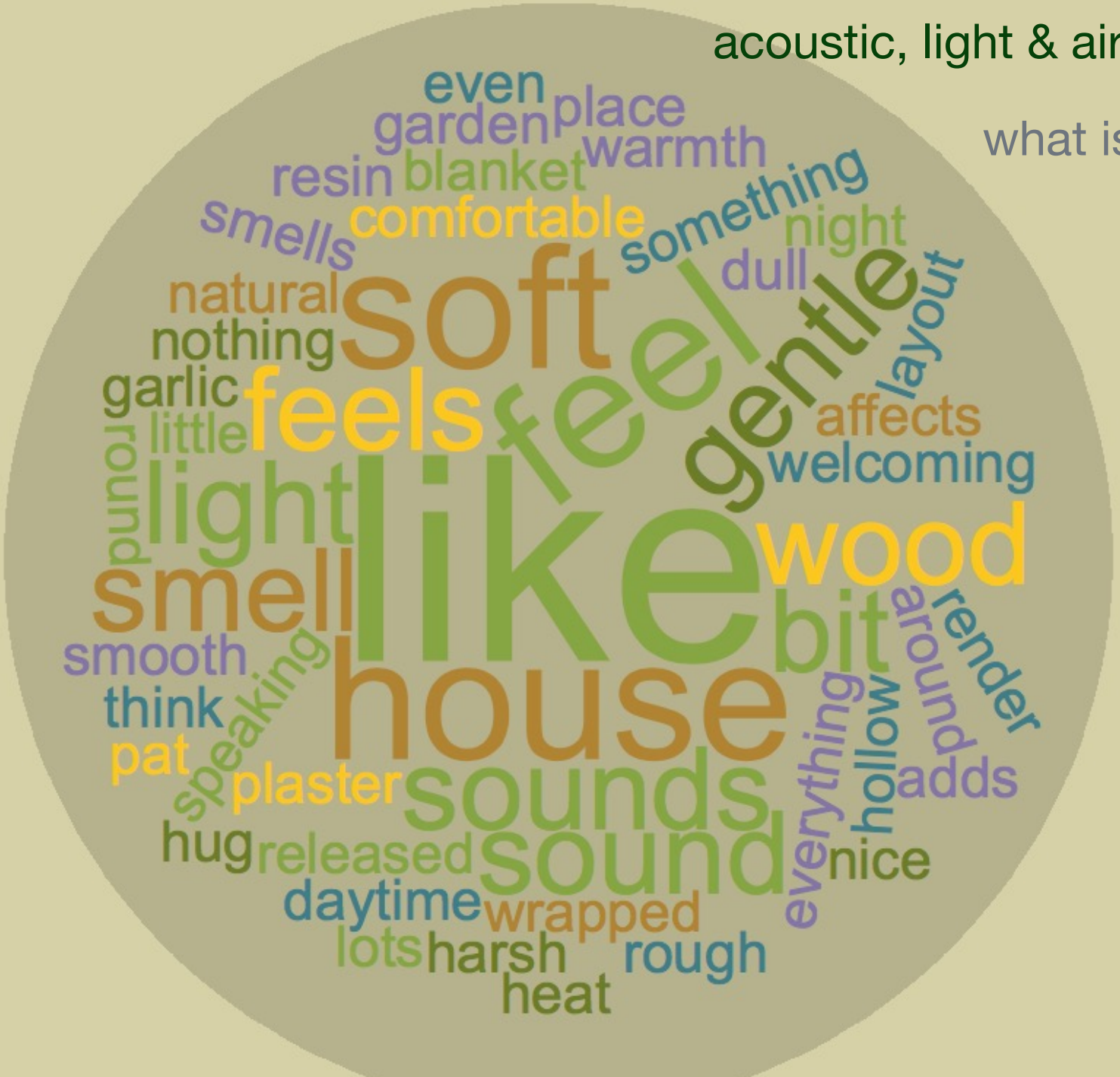
what is it like?

smell

touch

light

sound



qualities of light and sunshine

glare contrast

absorption radiance

warm soft harsh

at

The US LEED accredition for schools, looks at acoustic performance of classrooms, with emphasis on speech intelligibility. Aims are:-

(A classroom is a good equivalent to a community room or large domestic space).

- To provide classrooms that facilitate better teacher-to-student /student-to-teacher communication through effective acoustical design.

- To provide building occupants with an indoor healing environment free of intrusive or disruptive levels of sound.

- Provide classrooms that are quiet and in which teachers can speak to the class without straining their voices and students can effectively communicate with each other and the teacher.

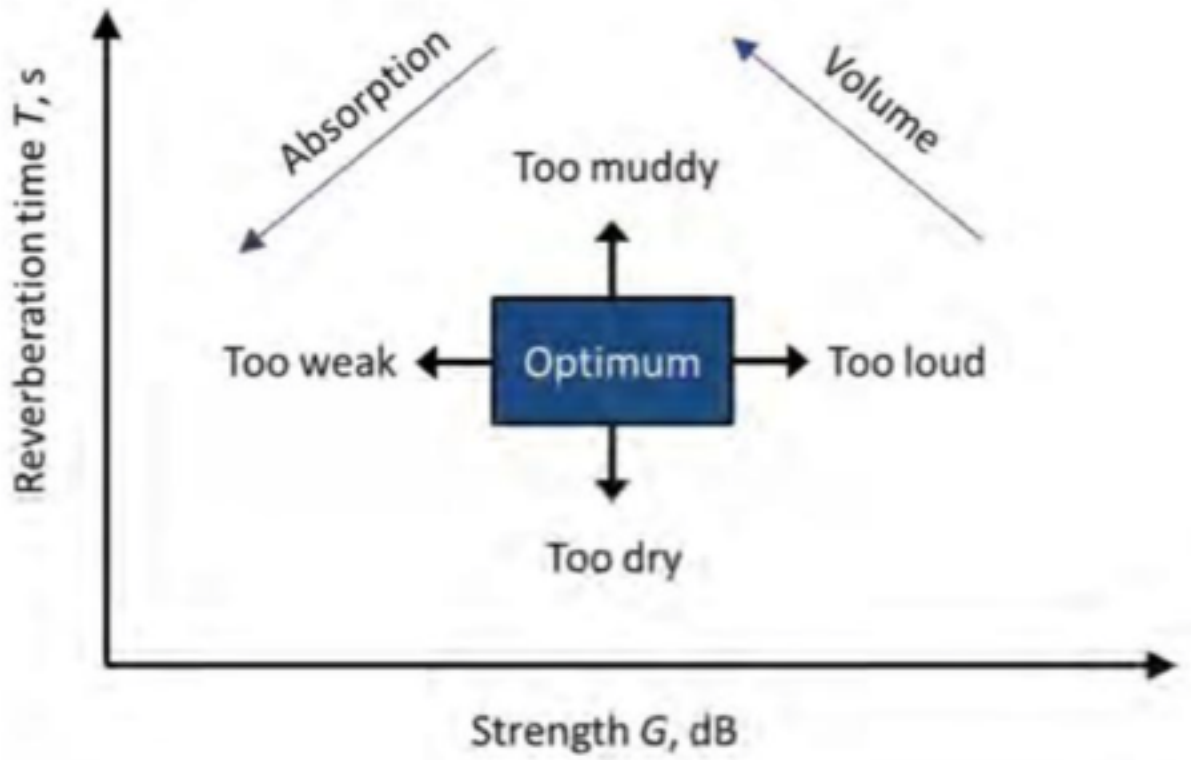


Figure 12: Principle influence of reverberation and strength in perceived music

Source: Rindel, 2014, p. 126

Musical Term	Acoustical Factor
Clarity	Reverberation time Early-to-late energy ratio Speed of the music
Intimacy	Initial delay gap Proximity to the musicians
Spaciousness	Apparent source width of early sound Listener envelopment by the reverberant sound
Timbre and Tone Color	Frequency balance in reflection and absorption
Color	Richness of treble Tonal distortion Texture Balance Blend Diffusion Focusing
Envelopment	Lateral reflections Reverberant sound
Ensemble	Musicians' ability to hear each other
Dynamic Range	Level of the fortissimo minus the background noise level
Warmth	Low-frequency reverberation

Figure 1: Musical terms and their related acoustical factors Source: Long, 2006, p. 655

Unlike speech comprehension which is typically measured one-dimensionally, music appreciation is multi-dimensional

I. Reverberation
reverberation time is the amount of time it takes for the reverberant sound to decay by 60dB (T_{60}). The reverberant fields below 500Hz should increase as the frequency gets lower; this results in a musical warmth

2. Envelopment
All concert halls and musical spaces should provide strong lateral reflections to achieve a sense of envelopment, where a "significant fraction of the energy [arrives] from the side"

3. Loudness
A space's volume has notable affects on reverberation and room gain, whereby a high volume per seat per person, ranging from range from $7m^3p^{-1}$ to 12 m^3 p^{-1}, is suitable for smaller capacities to control excessive loudness

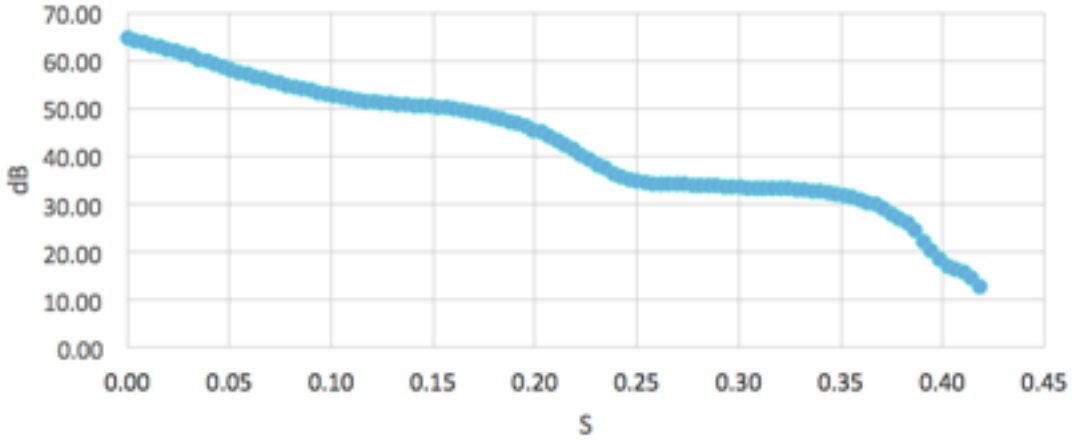
4 Clarity and Intimacy
Musical scores with rapid passages need clarity in order to be fully appreciated by the audience. Surfaces should facilitate this by creating reflections as near to the source of music or the receiver, creating shorter reverberation times and initial time delay gaps. This also creates a sense of intimacy.

I. Since instruments generate sounds from frequencies as low as 30Hz and high as 12,000Hz, the acoustic performance of the space should support such a broad bandwidth. The room should not colour the natural spectrum of the generated sounds.

II. The ensemble of the space should be maintained; the musicians must be able to hear each other play, with a "reverberant return that is close to that experienced by the audience”

While all the above criteria are all highly important Long (2006, p. 674) identifies reverberation as the "most recognisable parameter associated" with acoustic performance of music spaces.

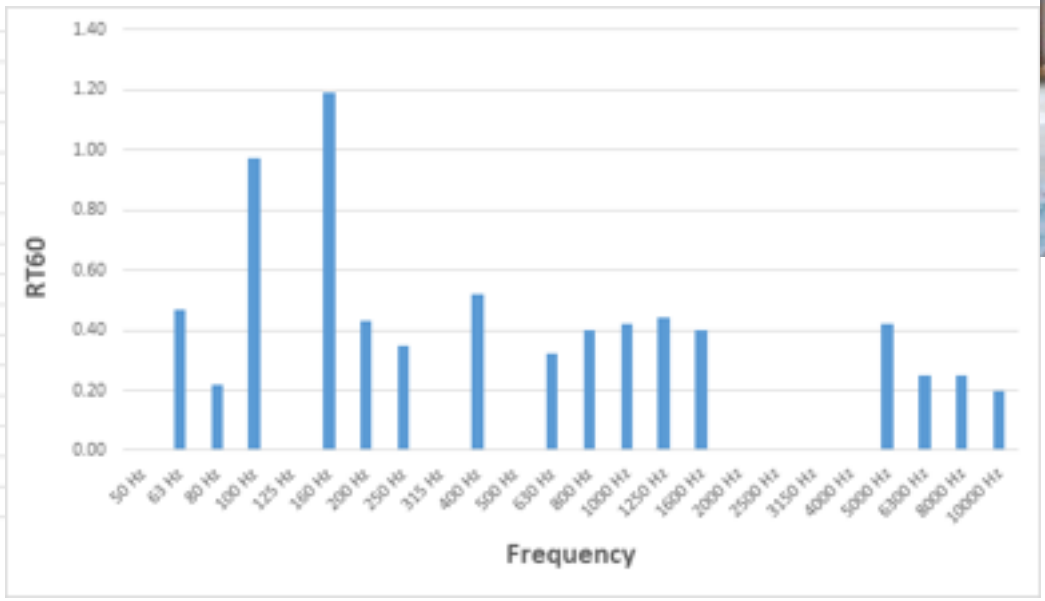
reverberation time decay chart



measured reverberation time at
Hickling house ground floor
0.453 seconds

reverberation over frequencies

50 Hz	
63 Hz	0.47
80 Hz	0.22
100 Hz	0.97
125 Hz	
160 Hz	1.19
200 Hz	0.43
250 Hz	0.35
315 Hz	
400 Hz	0.52
500 Hz	
630 Hz	0.32
800 Hz	0.40
1000 Hz	0.42
1250 Hz	0.44
1600 Hz	0.40
2000 Hz	
2500 Hz	
3150 Hz	
4000 Hz	
5000 Hz	0.42
6300 Hz	0.25
8000 Hz	0.25
10000 Hz	0.20



Location	Volume	Critical Distance D_c	Recommended RT60
Recording Studio	< 50 m^3	1.5 m	0.3 s
Classroom	< 200 m^3	2 m	0.4 - 0.6 s
Office	< 1'000 m^3	3.5 m	0.5 - 1.1 s
Lecture Hall	< 5'000 m^3	6 m	1.0 - 1.5 s
Concert Hall, Opera	< 20'000 m^3	11 m	1.4 - 2.0 s
Church			2 - 10 s

RT60 Reverberation Time

The ISO 3382 standards list a number of location types for which the reverberation time should be optimised, and recommends the following RT60 values:

A room with an RT60 of < 0.3 s is called acoustically "dead" (e.g. anechoic chamber), whereas sounds in rooms with reverberation times > 2 s are "echoic".

wellbeing - beyond comfort

'our sensations are fundamentally physical - human bodies are deeply affected by sensual cues, and our architecture is the most material of all art forms. Their bringing together takes us to the world of affect, where we look for language to articulate the richness of our material experience……'