BUILDING ACOUSTICS AND SUSTAINABILITY – SOME REAL WORLD EXAMPLES

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1 INTRODUCTION

Since the recent production of the Institute of Acoustics Building Acoustics Group's White Paper on Sustainability in Building Acoustics (and it's subsequent circulation amongst the IOA's membership as part of public consultation), various positive feedback has been received by the authors.

This paper seeks to illuminate some case studies in which the approaches proposed within the White Paper have been adopted in practice by the Building Acoustics community.

The purpose of the paper (and associated presentation at the conference) is not to demonstrate any particularly new or innovative examples of engineering – but rather to illustrate how some simple changes in mindset can generate quite remarkable outcomes in terms of producing climate conscious designs.

1.1 Aims of White Paper

From the introduction of the White Paper itself:

"The purpose of this paper is to provide some practical and pragmatic means by which acoustics professionals can contribute through research, practical implementation, or the provision of materials with the right information to producing multi-faceted and regenerative acoustic designs, solutions, and strategies for the built environment fit to tackle the climate crisis and deliver sustainable design in practice"

The emphasis here is on the aim to support acoustics professionals in immediately being able to adopt certain strategies in their designs which can have an impact, without them needing to undertake extensive upskilling.

In 2022 the UK's built environment is responsible for 25% of the UK's greenhouse gas emissions[1], compared with UN figures released at COP27 indicating 37% globally[2]. Whilst it is reasonable to suggest that all persons working in built environment design have a responsibility to educate themselves around planet-first design initiatives, it is accepted that the pressures of deadlines, cost and client demands can push professional development lower on an individual's to-do-list, particularly with regards to new areas of study.

The hope of the authors of the White Paper was to lower the barrier to entry with regards engaging with sustainable design principles. Some real-world examples of case studies in which small, thoughtful steps in design process result in notable increases in project sustainability credentials are given below, in the hope of inspiring more engineers, consultants, academics and manufacturers to follow suit.

2 BRIEF SUMMARY OF WHITE PAPER APPROACH

2.1 Strategies

The paper suggests a number of basic strategies that can be applied to a professional's mindset when engaging with project design issues. These are:

2.1.1 Enabling / blocking

Building acoustics professionals are far from being the only members of a design team interested in carbon and planet friendly engineering. Therefore, one of the first and most significant steps a practitioner can take is to remove obstacles to the delivery of sustainable design, and to think pragmatically beyond regulatory or code compliance and avoid being over-prescriptive. To achieve this it is important to be able to recognise sustainable design when it is happening, and that acoustics can often create conflicts to it (e.g. noise ingress verses natural ventilation strategies or lightweight structures and sound insulation).

2.1.2 Over-specification / reduction of materials

Traditionally, engineering consultancy designs-in some margin of safety in the design work associated with a project. This is often driven by the desire for comfort that best endeavours have been used to meet the target acoustic performance, with potential insurance claims in mind. The climate crisis and the need to focus significantly on the quantity of embodied carbon in design work brings this approach into question, and the Building Acoustics Group's stance is that specifications should aim to provide the appropriate level of acoustic performance, balanced against the minimum quantity of material required to see this achieved in practice.

2.1.3 Asking manufacturers for Environmental Product Declarations

By choosing products with EPDs (and by preferentially opting to specify products with, for example, low kgCO2eq values) acoustics professionals can report this information on the materials they are specifying and in turn influence the manufacturing industry. Both by encouraging established and emerging products within the industry to gain accreditation of their products, which allows calculation of the impact of design decisions; and by providing commercial motivation for innovation around reducing carbon in products.

2.1.4 Considering layout / design alternatives

Providing that acoustics professionals are engaged at a sufficiently early stage in the design, many carbon-costly options could be designed-out, rather than engineered-in by a traditional approach to acoustic design. Common examples include careful examination of orientations and layouts – avoiding problematic adjacencies where noise pollution increases the protection needed or where spaces which generate high levels of noise or vibration are situated next to areas with a low tolerance to intrusive noise and so need greater levels of acoustic protection and hence material.

2.2 Areas of impact

Generally, it is considered that the work undertaken by acoustics professionals can have the biggest impact in the following aspects of sustainable design:

2.2.1 Embodied carbon

Embodied carbon (CO2e) means all the CO2 emitted in producing materials. It's estimated from the energy used to extract and transport raw materials as well as emissions from manufacturing processes. The embodied carbon of a building also includes all the emissions from the construction materials, the building process, all the fixtures and fittings inside as well as from deconstructing and disposing of it at the end of its lifetime[3].

2.2.2 Embodied carbon

The amount of GHC carbon equivalents emitted during the operational or in-use phase of a building. This includes the use, management, and maintenance of a product or structure[4].

2.2.3 Circular economy

An economic system based on the reuse and regeneration of materials or products, especially as a means of continuing production in a sustainable or environmentally friendly way[5].

2.2.4 Health, wellbeing and social value

Sustainable wellbeing is achieved when improvements to individual wellbeing are correlated with improving the wellbeing of other members of society and the natural environment[6].

2.2.5 Design for Manufacturing and/or Modern Methods of Construction

DfMA and MMC are both processes intended to streamline construction, particularly through offsite and modularised manufacturing.

2.3 Bringing it together

Generally, the ‘strategies’ represent changes in mindset which can affect design decisions. The ‘areas of impact’ refer to the specific areas of sustainable design that those decisions can modulate. By considering both when approaching a project, many common-sense solutions can present themselves which can have a relatively large impact on the project’s sustainability credentials.

3 CASE STUDY 1 - REDUCING EMBODIED CARBON THROUGH ALTERNATIVE DESIGN

3.1 Overview & strategy

One of the Building Acoustic Group (BAG) members was leading the acoustic design of a new opera house in Saudi Arabia. The scheme included 2 large theatre spaces, with the client aspiration being to hold concurrent performances with little to no restriction on noise levels (so that an amplified music performance could occur in one space at the same time as a theatrical performance in the other).

The typical design approach is to create structurally isolated box-in-box systems in each, to control the transmission (particularly of low frequency sound, with it's long wavelengths and correspondingly high peak amplitude and energy) through connected items of building fabric.

This well-known strategy involves introducing air gaps around 5 sides of the internal box. At the base, where an air gap is physically impossible to achieve, an array of elastomers or springs is provided. These deflect sympathetically with the forcing frequencies, meaning much energy of the transmitted is dissipated as heat.

This is illustrated conceptually below:

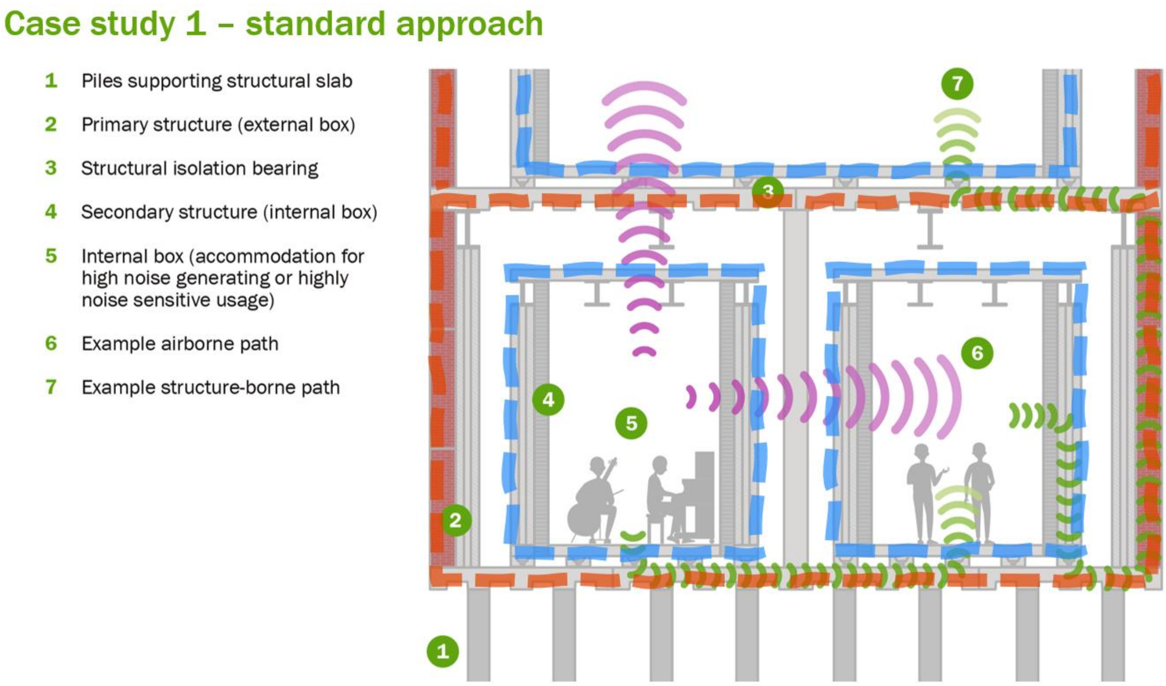


Figure 1 - Traditional box in box design - with external primary structural box highlighted red, and internal isolated boxes highlighted blue

Whilst being very effective and well-understood as a design solution, the approach is inherently wasteful in terms of material, requiring more than double the structural elements as a non-box-in-box design. The fact that these elements are typically concrete and steel (materials both high in embodied carbon) means that the carbon burden of such an approach is extremely high.

An alternative approach is to essentially treat each performance space as a separate building. By expressing the already-present structural expansion joint lines as continuous and truly separating gaps which run around the entire perimeter of the structure (slabs, walls, roof and foundations where relevant) it is possible to introduce a break in the path of vibration transmissibility without doubling up the structure. This is shown, again conceptually, below:

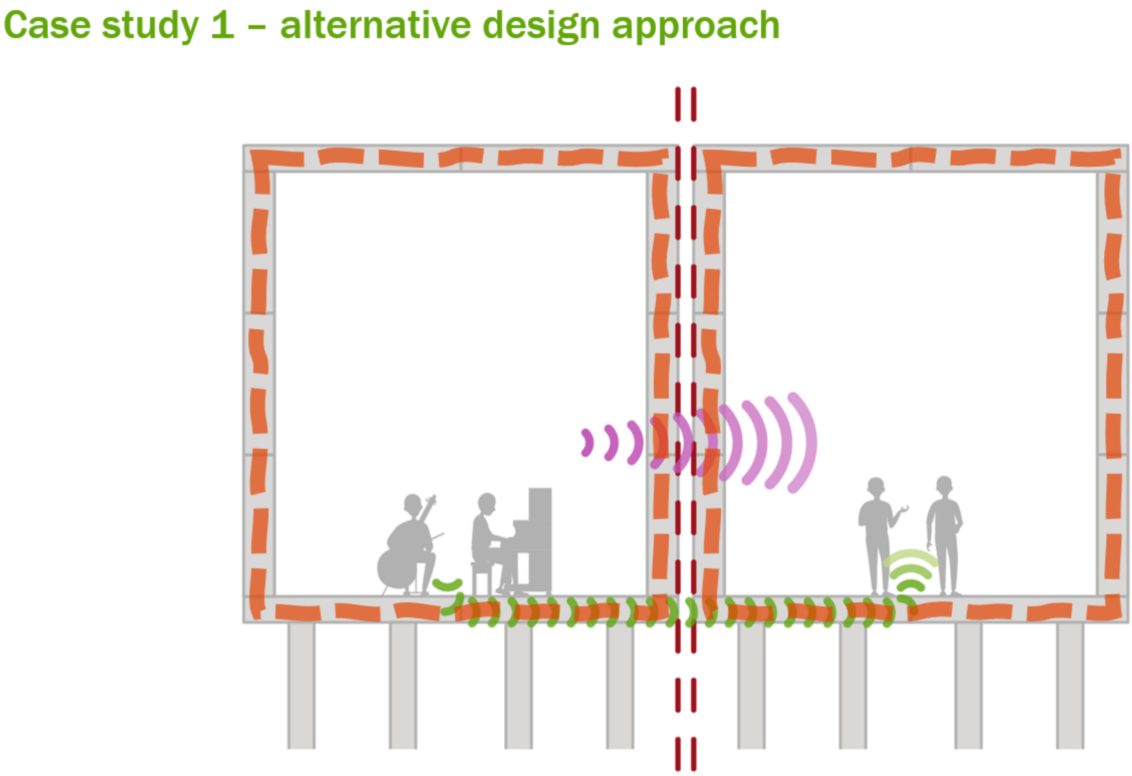
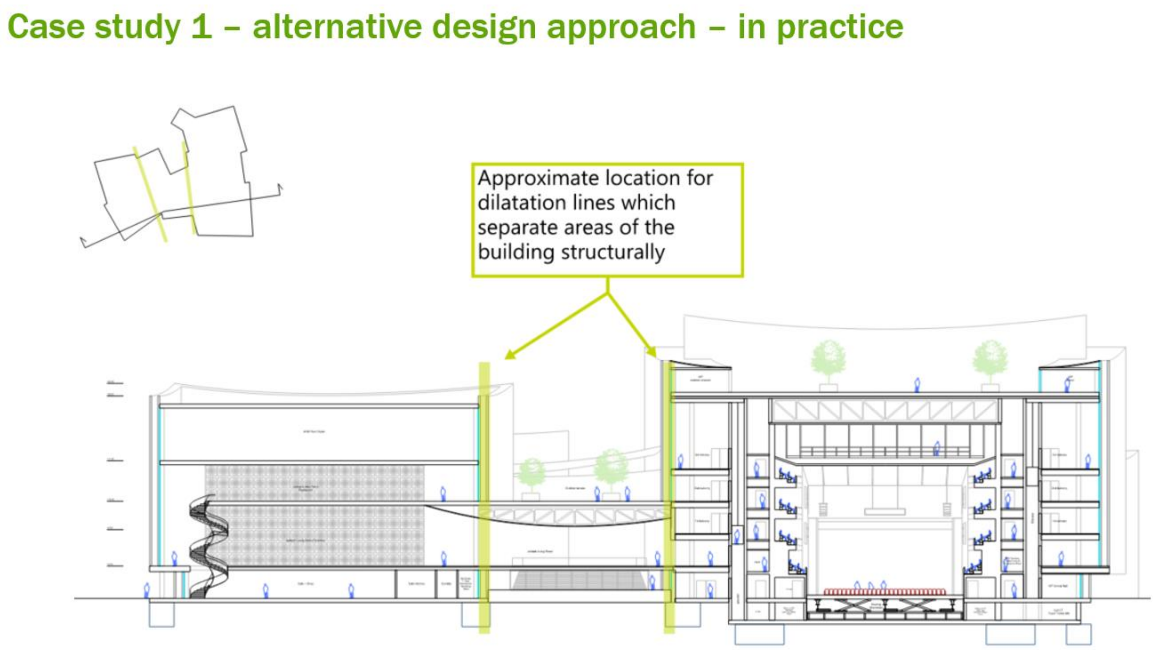


Figure 2 - alternative "structural expansion joint line" approach

The implications of such an approach should be obvious – and generate enormous losses in the quantity of steel and concrete (and hence embodied carbon) required in the design.

3.2 Design details

In the particular case study presented, the expansion joint lines ran either side of each performance space, as shown schematically below.



3.3 Areas of impact

Clearly – the primary area of impact is on the quantity of embodied carbon within the development as a whole. A very basic calculation by the project’s acoustic engineer suggested that a reduction in CO2e of 1.7 million kg was achieved – when considering conservative estimates of carbon in the materials saved alone (i.e. excluding considerations around transport, disposal and other lifecycle elements).

3.4 Conclusion

This is a very tangible example of how adopting an alternative design strategy (a suggestion in the White Paper) significantly impacted embodied carbon on a project (an area of focus highlighted in the White Paper).

4 CASE STUDY 2 - ENABLING A LOW OPERATIONAL CARBON APPROACH

4.1 Overview & strategy

Two members of BAG collaborated on this project in which a new residential development was exposed to moderately high noise levels due to it’s proximity to nearby road and rail networks. This is illustrated below.

Figure 3 Case Study 2 - site location

The design team were keen to pursue an open-windows strategy to control overheating in line with Building Regulations Part O, however had been prevented by doing this based on the design assumptions that the site would be subject to excessive noise levels, leading to an exceedance of the internal ambient noise level (IANL) targets within dwellings.

The BAG members sought to overcome this by enabling the natural cooling strategy.

4.2 Design details

The design to date had assumed a fixed and nominal degree of attenuation from a façade with an open window. The facilitated approach by the BAG members was to fully integrate the time of window opening and the angle of window opening, creating a more nuanced picture of potential noise ingress which could be interrogated with the TM59 thermal modeler.

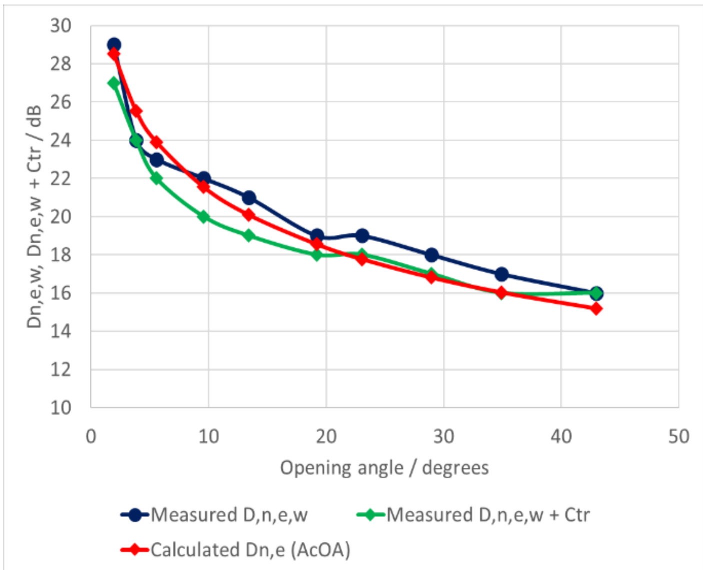


Figure 4 - Graph showing how attenuation varies with window opening angle

The steps were then threefold –

1. The overheating modeller defined an extent of window opening that ‘worked’ spatially (i.e. provided sufficient airflow to control overheating), and gave the corresponding time this opening was required for

2. The acoustic engineer then examined the external noise levels at that precise time, and determined the maximum open area that is possible (to allow average IANLs to be compliant)

3. Equivalent Area was used for both sound insulation and the thermal model. The overheating modeller checked if their TM59 model was still compliant with acoustic engineer’s suggested open area requirement in place

4. AVO and Approved Doc O assessments were carried out – showing that this balanced approach met regulatory requirements

4.3 Areas of impact

Avoiding the provision of mechanical cooling (via proving that passive cooling from open windows was possible), an enormous saving on operational carbon was generated, as well as some saving on the units and associated infrastructure that would be required for any mechanical cooling units and pipework.

4.4 Conclusion

A clear tangible example of enabling (rather than blocking) a particular sustainable design strategy (a suggestion in the White Paper) significantly impacted operational carbon on a project (an area of focus highlighted in the White Paper).

5 CASE STUDY 3 - REDUCING EMBODIED CARBON AND INCREASING CIRCULARITY THROUGH RE-USE OF MATERIAL

5.1 Overview & strategy

A BAG member was involved in the design of a remodel and extension of an existing higher education development. As part of this, an area of the existing building was subject to partial demolition. However, in this process it was found that the existing beam and block floors which were contained within the demolished wing remained in good condition. The design team had an aspiration to re-use these elements and the BAG member sought to enable (rather than block) this strategy.

5.2 Design details

The area of remodel is shown below:

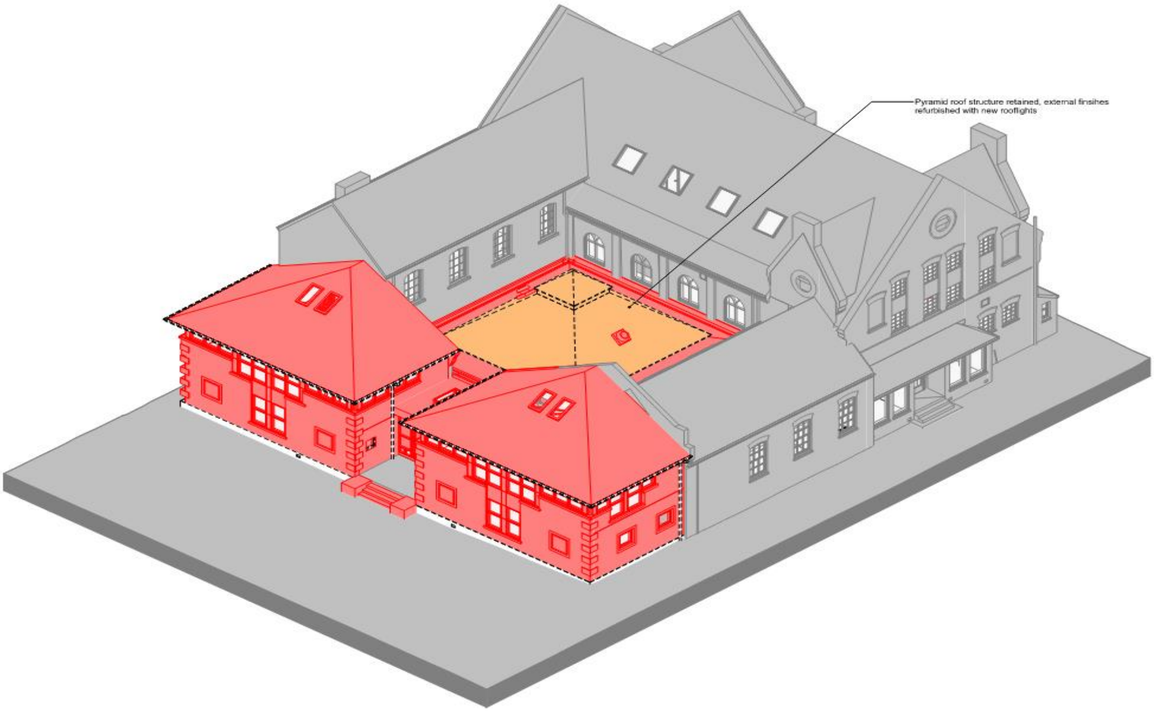


Figure 5 Case Study 3 - remodeled area

Indicatively, an image showing typical beam-and-block floors is given below. The primary structure is reinforced concrete, which is relatively high in embodied carbon due to it's content, which includes steel rebar, a material very high in embodied carbon.

Figure 6 Typical beam and block floor

It was not possible to benchmark the existing floor constructions before their disassembly. Therefore in order to support the aspiration for re-use of materials, the BAG member had to rely on predictions and previous experience of similar floor build ups in order to satisfy the design criteria between the future teaching spaces.

Whilst it would have been simpler to specify new constructions, a diligent and brave approach towards managing risk of non-compliance permitted an enabling of the design teams sustainability strategy. The decision was taken that the calculation tolerance of predicting performance (perhaps 2-3 dB) was well worth the enormous environmental benefits of re-using the structure.

5.3 Areas of impact

An all-new dividing primary structure and associated floor slab would have been a steel-and-concrete construction, therefore pushing the quantity of embodied carbon ‘spent’ on the project significantly higher. Instead, the approach was to embrace the circular economy strategy proposed by the design team.

5.4 Conclusion

This is a very tangible example of how enabling a sustainable design approach (a suggestion in the White Paper) promoted circular economy and significantly impacted embodied carbon on a project (both areas of focus highlighted in the White Paper).

6 CASE STUDY 4 - CHALLENGING THE BRIEF TO REDUCE MATERIAL

6.1 Overview & strategy

A BAG member was retained by a client to assist them in the acoustic design of a new entertainment development centered around offering karaoke. The scheme included dozens of new-build karaoke rooms within the same complex, as shown indicatively below.

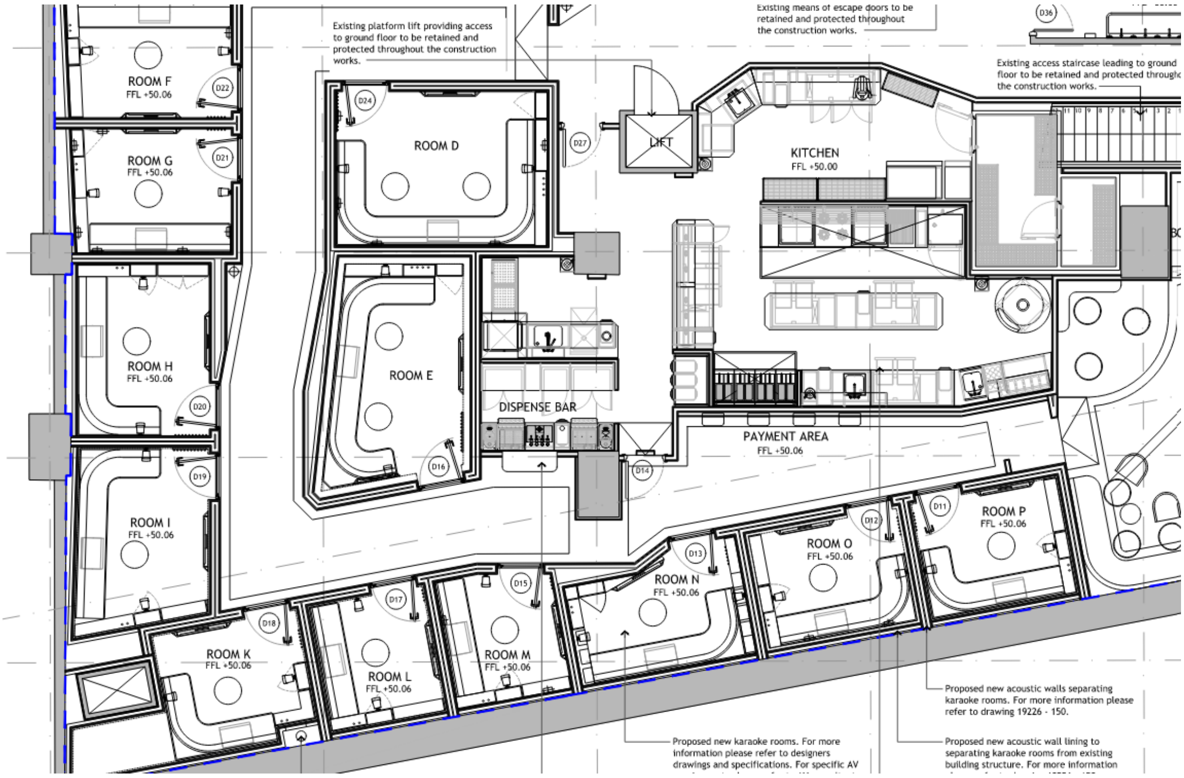


Figure 7 Overview of proposed scheme

Of course a key requirement for the project was controlling sound transmission between the karaoke suites so that patrons could enjoy their booking without disturbance from adjacent rooms.

The client (through iterative trial and error) had developed a set of criteria and solutions in their previous venues which included a very onerous low-frequency target (D45 dB @63Hz) necessitating both in-situ concrete floating floors, and masonry walls between each space.

The BAG member hoped to reduce the quantity of material required (particularly the high-embodied-carbon masonry and concrete elements) and therefore suggested that the brief could be revised, reducing the low frequency target (to D35 dB @63Hz) and allowing the rooms' mechanical ventilation systems to run at a higher NR level to provide some masking of any unwanted sound transmission.

6.2 Design details

The client's typical design solutions are illustrated conceptually below:

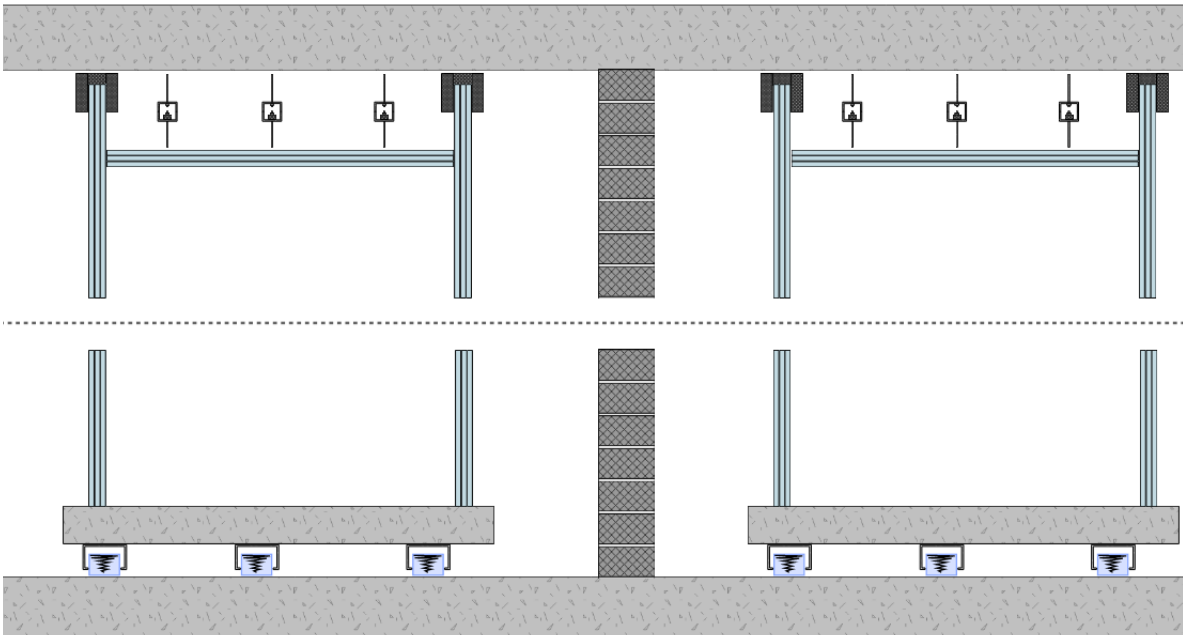


Figure 8 Concept for karaoke rooms, showing in-situ concrete floating floors and heavyweight masonry walls

Through working with the client to carefully examine the true need for such a high performance at lower frequencies, the BAG member was ultimately able to massively reduce the specification of the box-in-box rooms, requiring simple lightweight stud-and-plasterboard walls, and a composite lightweight timber floating floor, as shown below:

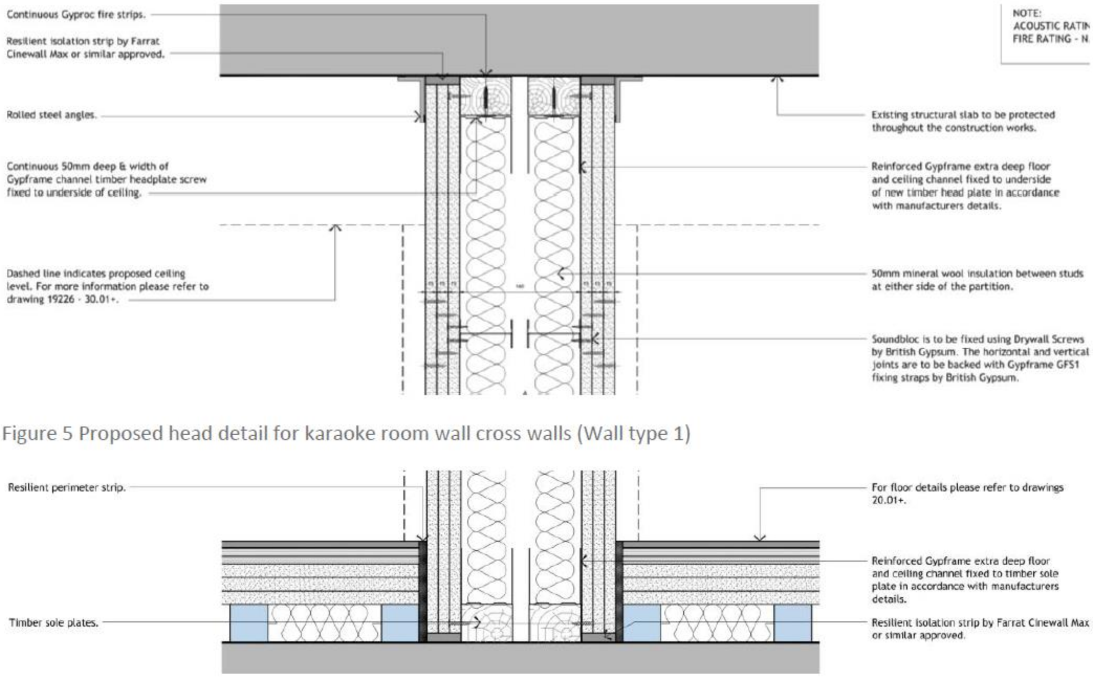


Figure 9 Final design drawings (tender issue) showing timber floating floors and lightweight partitioning

6.3 Areas of impact

By switching out all of the concrete and masonry elements for lightweight versions, the BAG member enormously reduced the overall quantity of embodied carbon on the project (particularly considering the number of iterations of design that would be repeated over the ~20 karaoke rooms on the scheme).

6.4 Conclusion

A clear tangible example of reduction of materials (a suggestion in the White Paper) significantly reducing the embodied carbon on a project (an area of focus highlighted in the White Paper).

7 SUMMARY

It is hoped that many readers of this paper will recognise common design situations to which many acoustic professionals find themselves contributing. None are considered to be highly unusual, and none of the approaches adopted by the BAG members in question are revolutionary.

Rather, what unites them is a concerted and mindful effort to consider sustainability aspirations to sit at least equally alongside the need for high performance acoustic design, and to adopt some of the subtle changes in mindset proposed by the White Paper in addressing the balance between a client’s aspirations, project performance and the need to consider planet-first outcomes to design.

BAG encourage all acoustics professionals to engage with this thought process and contribute to a reduction in greenhouse gas emissions associated with the built environment.

8 REFERENCES

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