

Shoe Box | *by John Mauvan*

Shoe Box | *An analysis of the concert hall and its adaption to small-scale music performance space*

By John Mauvan

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Abstract

In the first 150 years after 1600, western music was traditionally performed in palace ballrooms which were mostly rectangular in shape. In the following two centuries a change in social conditions led to the first halls especially built for public concerts. Although the audience capacity of these halls had increased exponentially, those that derived from the rectangular plans and dimensions of the ballrooms in the century before proved to have particularly favourable acoustics. The proportions of which are roughly that of a double cube, 1:1:2. Today this rectangular form is widely ascribed throughout acoustic literature as the shoebox.

Although the shoebox has proven a popular paradigm in all time periods, until the late nineteenth century little was known of the scientific reasoning for its acoustic success. Therefore much of the contemporary literature regarding the model has focused on the large-scale designs of the nineteenth and twentieth century. Comparatively, less is written about the adaption of these design concepts to smaller-scaled concert facilities with audience capacities up to 400 persons. This thesis analyses a number of highly celebrated large-scale concert halls, with audience capacities between 1,500-3,000, and tests the application of their design principles to small-scale concert spaces with capacities ranging between 100-350 persons.

The aims of this thesis are applied to a design project, which seeks to adapt the traditional shoebox archetype to a series of small-scale concert spaces, initiated by a design brief for the New Zealand School of Music (NZSM). The design project relocates the NZSM to an existing building on a disused site in central Wellington. Acknowledging the programmatic need for acoustic performance in conjunction with the social component inherent to the occupation of an urban territory, this thesis investigates two strands of design logic: technical and contextual. One strand investigates the acoustic performance of the concert hall; the other investigates its response to site context.

The findings from this thesis are substantiated through a method of proportionate variation whereby the acoustic principles of large-scale concert halls are adopted to small-scale music halls. In addition, the findings established from a site analysis of contemporary large-scale concert halls are then downscaled to inform the integration of the NZSM programme with the proposed inner city site.

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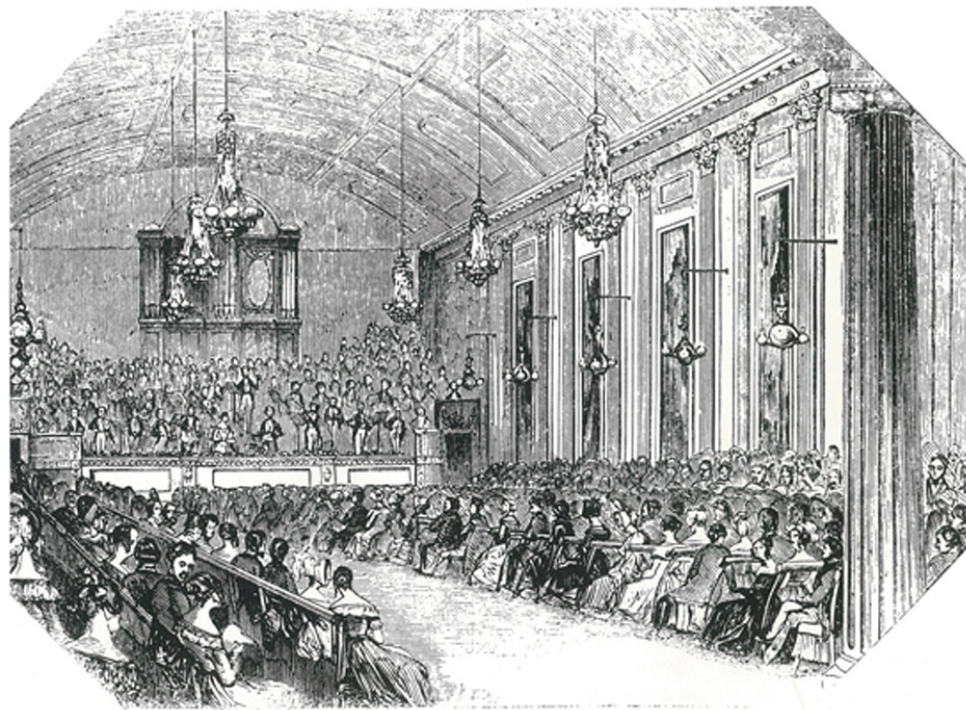
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From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 37), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.



Introduction

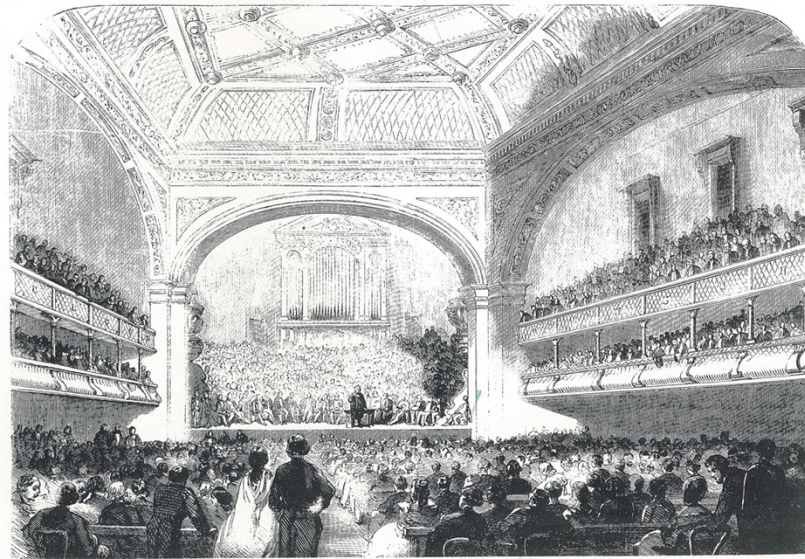
Historically concert halls are categorized in five primary room shapes: shoebox, fan- shape, horseshoe, arena/ semi-arena, and irregular style. In the first 150 years after 1600, western music was traditionally performed in palace ballrooms, which were mostly rectangular in shape. Subsequently, in the later years of the eighteenth century the first halls especially built for public concerts appeared in central Europe. These included the Hanover Square Rooms in London, built in 1775 and seating an audience of 800 [Fig i], and the Altes Gewandhaus in Leipzig built in 1780, and seating an audience of 400. Although the audience capacity had increased substantially, the construction of these halls mirrored that of the rectangular ballrooms from the century before. In these halls, along with others that soon followed, came the great symphonies and sonatas of Haydn, Mozart and Beethoven – the period of the eighteenth and early nineteenth centuries labelled as Classical (Beranek, 2011, p. 7).

During the nineteenth century, however, the expansion of the middle class led to the demand for even larger public concert halls. Although at the time it was not entirely clear why, those halls that derived from the rectangular plans and dimensions of the palace ballrooms and early concert rooms in the previous centuries proved to have particularly favourable acoustics. The proportions of these concert halls are roughly that of a double cube, 1:1:2. Today this rectangular form is widely ascribed throughout acoustic literature as the shoebox (Barron, 2010, p. 78).

In 1849 the (old) Liverpool Philharmonic hall seating 2100 people was built [Fig ii], and in 1863 the Boston Music Hall was opened, seating 2400 people [Fig iii]. These large-scale halls pointed the way for a change in musical style, the Romantic Period. This period extended through the early years of the twentieth century, and was characterised by the personal and emotional expression of composers starting with Schubert and Brahms and continuing through Prokofiev and Vaughan Williams. Boston and Liverpool halls, in combination with other early shoebox halls profoundly influenced the later design of three of the world's greatest concert halls – Grosser Musikvereinssaal in Vienna, Concertgebouw in Amsterdam and Symphony Hall in Boston (Beranek, 2011, p. 7).

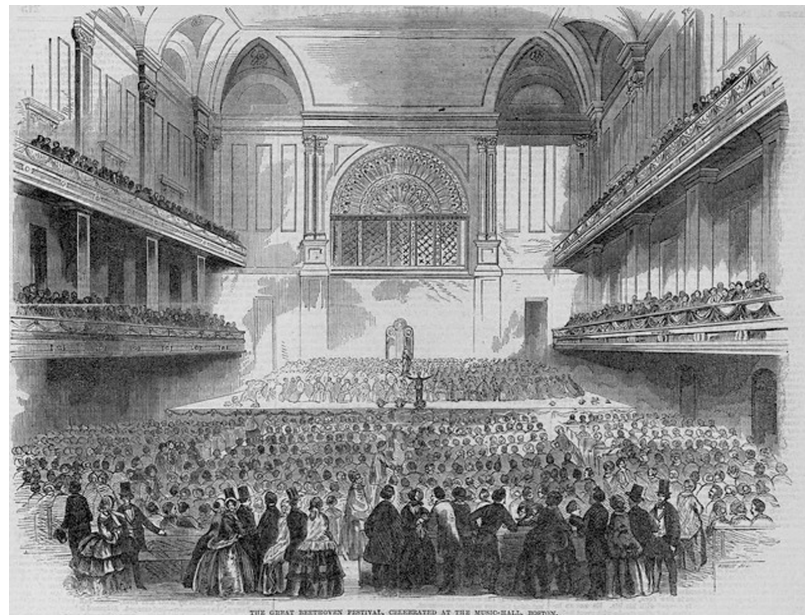
[Fig ii] The old Philharmonic Hall, Liverpool, by John Cunningham, 1849.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 202), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.



[Fig iii] Boston Hall, Boston, 1863.

From: Music Hall Rendezvous, 2009, Retrieved from <http://musichallrendezvous.wordpress.com/2009/12/16/history-of-the-music-hall/> (accessed 31/03/2011).



Although the shoebox has proven a popular paradigm in all time periods, until the late nineteenth century little was known of the scientific reasoning for its acoustic success. Therefore much of the contemporary literature regarding the model has focused on the large-scale designs of the nineteenth and twentieth century. Comparatively, less is written about the adaption of these design concepts to smaller-scaled concert facilities in music schools and community halls (Hidaka, 2004, p. 357). This thesis analyses a number of highly celebrated large-scale concert halls, with audience capacities between 1,500-3,000, and tests the application of their design principles to small-scale concert spaces with capacities ranging between 100-350 persons. This research focuses specifically on the shoebox model; selected for both its modest simplicity and acoustic superiority. The rectangular form of the shoebox means that it can be easily adapted to all music genres, while also adopting the appropriate acoustic requirements for speech.

The aims of this thesis are applied to a design project, which seeks to adapt the traditional shoebox archetype to a series of small-scale concert spaces, initiated by a design brief for the New Zealand School of Music (NZSM). The design project relocates the NZSM to an existing building on a disused site in central Wellington. Acknowledging the programmatic need for acoustic performance in conjunction with the social component inherent to the occupation of an urban territory, this thesis investigates two strands of design logic: technical and contextual. One strand investigates the acoustic performance of the concert hall; the other investigates its response to site context.

Research approach

Chapter 1 | *Proportionate Variation*

Chapter one develops a comparative study throughout the progression of the concert hall from the small-scale music rooms of the eighteenth century to the large-scale concert halls of present day. The findings from this study are developed into a theoretical framework of proportionate variability to substantiate these historic examples as precedents for the NZSM programme.

In a parallel study this chapter discusses the development of two contrasting musical periods, and the modern devices that have been developed to accommodate their contrasting acoustic requirements.

Chapter 2 | *Acoustic Design for Small-Scale Space*

Functional acoustics will be crucial to the success of the NZSM programme and are therefore a vital consideration for this design project. Chapter two focuses on the acoustic design principles of spatial types specific to the NZSM programme. In breaking down the basic science of acoustics, this chapter establishes a set of guidelines to inform acoustic treatments in the design solution. This chapter will also discuss construction methods that ensure acoustic isolation to and from the music performance space.

Chapter 3 | *Urban Territory & the Public Interface*

Chapter three discusses the social component of the concert hall, exploring the relationship between the internal contents and exterior container. Through an analysis of contemporary examples, this chapter discusses the integration of the concert hall programme with the urban territory, and the strategies used to develop a responsive interface between the acoustic programme and the public domain.

Chapter 4 | *Design Brief*

Chapter four defines the scale of the design scheme by developing a design brief. The design brief is constructed through a series of site meetings and semi-structured interviews with the NZSM and Victoria University Directors. Information gathered from these interviews is used to define the capacity of the school and set specific spatial criteria.

Chapter 5 | *Site Analysis*

The site analysis undertaken in Chapter five investigates the existing context including the existing building. Analytical maps are used to record current site conditions, while archival research is used to assess the interior structure and exterior aesthetic of the existing building.

Chapter 6 | *Design Solution*

Chapter six presents the proposed design solution. It discusses interior and exterior as separate design strands with alternative design logics. The exterior content discusses both the response of the envelope to the urban condition, and the adaptive reuse of the existing fabric. The interior content focuses on the performance spaces specific to the NZSM programme and discusses the acoustic logic used to substantiate design decisions.

Chapter 7 | *Conclusion*

The final chapter summarizes the main topics discussed in the thesis and re-outlines the primary focus. The chapter concludes with a statement of significant findings and establishes a point of departure for future research.

Chapter 1 | *Proportionate Variation*

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This chapter analyzes the scaled progression of the concert hall throughout history to determine which acoustic principles can be adapted to both large- and small-scale spaces dedicated to music. This chapter investigates the small-scale concert rooms used by pioneering Classical composers such as Haydn, Mozart, and Beethoven, as a precedent for the design of contemporary recital and chamber halls. Following this investigation a comparative analysis investigates the increasing scale of the concert hall throughout the nineteenth century, and the subsequent development of the Romantic genera. Expanding on this inquiry into large-scale concert halls, this chapter develops an observation of four proportionately different concert halls: the Neues Gewandhaus, Leipzig, - the Musikvereinssaal, Vienna, - the Concertgebouw, Amsterdam, and Symphony Hall, Boston, as a principle theory to demonstrate both the modular adaptability, and proportionate variability of the shoebox archetype. The final section of this chapter will discuss adjustable acoustics, and the use of modern acoustic devices to create a compromise between Classical and Romantic musical genres.

Optimal acoustics is a subjective term that largely depends on musical styles and cultural preferences (Barron, 2010, p. 78). Due to the fact that each style and type of music evolved in a particular acoustic ambience, and because taste of listeners naturally differs, there is no single optimal form for auditoria where a range of music is to be performed. Like a musician's technique, it is a means to a musical end, not an end in itself (Forsyth, 1985, p. 17). As Cremer and Müller say in their handbook *Principles and Applications of Room Acoustics*:

There exist particular solutions that have proved themselves. Nevertheless, for concert halls such standardization would be the end of architecture. Variability in these facilities is attractive to both the eyes and the ears. This variability is also justified by the reasonable assumption that the acoustic optima, if they exist at all, are at least rather broad so that it becomes most important simply to avoid exceeding certain limits (Cremer, 1982, p. 608).

Nevertheless, from the early seventeenth century the best composer's have had a strong understanding of the way their music was affected by space. Thus, the buildings of the period and the acoustic ambience were stylistically akin (Forsyth, 1985, p. 129). Historically, the success of a concert hall has been measured against its ability to create an appropriate acoustic ambience for either Classical or Romantic styles.

¹ Beranek's subjective terms are explained further in [Fig 1.01], and the scientific reasoning is explained further in Chapter two.

² Reverberation refers to the decay of sound after a note has stopped being played (Cox, 2003, p. 119). The science of reverberation is discussed further in Chapter two.

Intimacy:

A small room has visual intimacy – people in the room see the walls and other objects nearby. By the same token, a hall can have “acoustical intimacy” if sounds seem to originate from nearby surfaces (Beranek, 1996).

Note: Although acoustic intimacy is a subject term, the degree of musical intimacy in a space corresponds to how soon after the direct sound the first reflected sound reaches the listener's ears. The time difference between the direct sound and the first reflected sound within a hall can be used to scientifically substantiate the level of acoustic intimacy (Beranek, 1996).

Liveness:

A *live* hall has a long reverberation time, with a long a sustained sound; a hall with a short reverberation time is called a *dead* or *dry* hall. Concert halls with extreme *liveness* such as the Concertgebouw have a reverberation time in excess of 2 seconds (Beranek, 1996).

Warmth:

Warmth of music in a concert hall is directly related to whether the bass sounds are clearly audible when the full orchestra is playing. In technical terms, *warmth* in music is determined by the strength of the bass tones. Conversely, music will lack *warmth* if the internal surfaces of the hall soak up low-frequency sounds (Beranek, 1996).

[Fig 1.01] Chart of subjective acoustic terms.

Adapted from: Concert and Opera Halls: How They Sound (p. 38), L.L. Beranek, 1996, New York, Acoustical Society of America.

Although these two music styles remain an important measure for acoustic success, today contemporary concert spaces of both large- and small-scale are required to achieve an acoustic range for both (Barron, 2010, p. 385).

The first major review of concert hall acoustics was Beranek's *Music, acoustic and architecture* of 1962, which surveyed 47 world-famous concert halls. Beranek pioneered analysis of auditorium acoustics on the basis of several independent subjective qualities, such as *intimacy*, *liveness* and *warmth*¹ (Beranek, 1962). This subjective approach to acoustics design is reinforced by the American acoustician Theodore Schultz who refers to acoustics as, "an art, not a science," being a matter of musical judgment rather than simply a scientific process (Forsyth, 1985, p. 17). This is evident in the opposing demands of Classical and Romantic genres. For example, music from the Romantic period, encompassing the works of Berlioz, Liszt and Wagner is best heard in large-scale halls, such as the Concertgebouw, Amsterdam, and the Musikvereinssaal, Vienna, with reverberation² times between 1.8 – 2.0 seconds (s) (Beranek, 2011, p. 7). In comparison, the music of the Classical period, which includes the great symphonies and sonatas of Haydn, Mozart, and Beethoven, is better suited to smaller-scaled halls, such as the Hanover Square Rooms, London, and the Altes Gewandhaus Leipzig, with reverberation times between 1.2 – 1.5s (Beranek, 2011, p. 7).

The formally structured music of the Classical period has reason and clarity as its basis. The details such as ornamentation, and the subtler emotional characteristic of the Classical era were revealed best in small, often overcrowded concert rooms (Forsyth, 1985, p. 129). Three of the most prevalent music rooms at the time include the Hanover Square Rooms, London, Haydn-Saal, Eisenstadt, and the Altes Gewandhaus, Leipzig. These rooms were lined with thin wood, which prevented distortion and ensured acoustic clarity was gained by a short reverberation time and extreme acoustic intimacy (Hidaka, 2004, p. 362). The orchestras housed in these spaces were relatively small, but in the confined enclosure of the early concert room they could sound as loud as a twentieth century symphony orchestra does playing the same music in a large-scale concert hall (Forsyth, 1985, p. 129). In comparison the large-scale concert halls of the Romantic period are particularly well suited to Romantic music. The increase in volume extended the reverberation time and the use of plaster in place of wood for the internal walls help to produce a full, rich body of sound (Beranek, 2002, p. 13). Romantic music generally allows for a greater degree of acoustic distortion than does music of the Classical period (Beranek, 2002, p. 13). The increase in reverberation sustains the sound from one note to another, blending the music to create an overall tonal picture³ (Forsyth, 1985, p. 199).

³ (See Appendix 1 for a chart of interrelations between the musical and acoustical factors of concert halls.)

⁴ Chamber music is a form of classical music, written for a small group of instruments, traditionally accommodated in a palace chamber.



[Fig 1.02] Haydn-Saal, Eisenstadt, c1700.

From: Panoramio, 2010, Retrieved from <http://www.panoramio.com/photo/44027794> (accessed 20/04/2011).

1.1 | *Small-scale precedents*

Hanover Square Rooms, London, 1775:

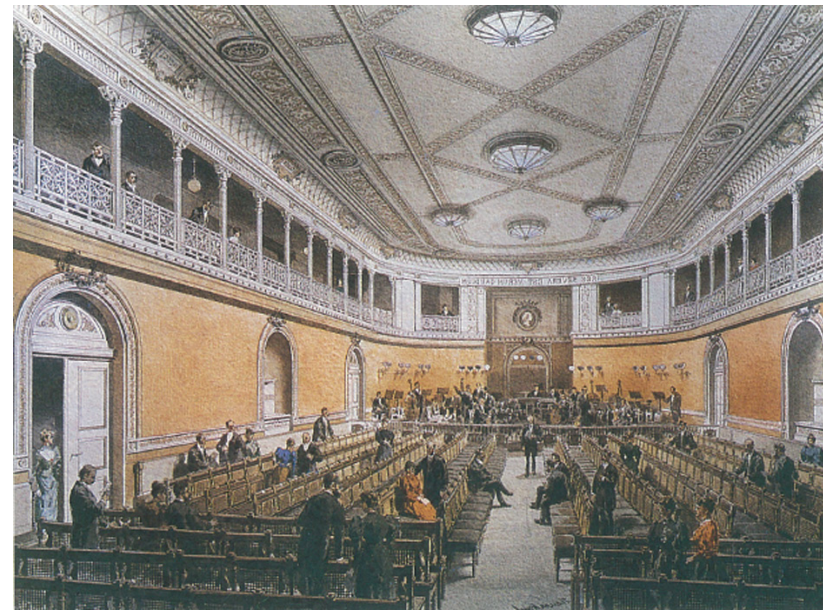
Around 1800 the first halls especially built for concerts appeared in central Europe. In 1775 two of the most influential composers at the time, Johann Christian Bach and Carl Friedrich Abel went into partnership to establish the Hanover Square Rooms, London. The hall is most famous for being the place in which Joseph Haydn conducted his London Symphonies nos. ₉₃ to ₁₀₁ (Barron, 2010, p. 78). The Symphonies were written especially for the Hanover concert hall, and it was the first time Haydn had written quarters for a concert hall rather than the Chamber⁴ (Long, 2006, p. 21). The concert hall itself was 24.1m long and 9.7m wide, with an approximate height of 8.5m (Long, 2006, p. 21). The room was extremely crowded with an intended audience of 800 seated within approximately 185.8 m² (Barron, 2010, p. 78). Although the cramped audience contributed to sound absorption in the hall, the small volume produced a significantly loud sound which was reinforced by the 35 strong orchestra, used by Haydn for his London Symphonies (Forsyth, 1985, p. 38).

Haydn-Saal, Eisenstadt, 1700:

Another famous hall favored by Haydn is the Haydn-Saal, in Eisenstadt [Fig 1.02]. Rectangular in shape, it is the largest of all the concert halls from which Haydn composed. Characterised by its narrow balconies supported on columns at either end, the hall accommodates an audience of 600 persons (Forsyth, 1985, p. 57). The dimensions of the hall are, 38.0m long, 14.7m wide, and 12.4m high (Forsyth, 1985, p. 57). Haydn demanded that a wooden floor be laid over the original stone, to reduce the *boomy* reverberation in the bass frequencies. The result is a *dry* clear sound, equivalent to present-day recital hall conditions (Forsyth, 1985, p. 57). However, considering its small-scale volume, the hall has a considerably long reverberation time of 1.7s (Forsyth, 1985, p. 57). The longer reverberation time for the size of the hall, combined with the reflection of sound from the narrow side walls provides an effective impression of the music filling the space. The resulting sound in combination with the visual proximity to the stage creates a supremely intimate setting for music (Forsyth, 1985, p. 57).

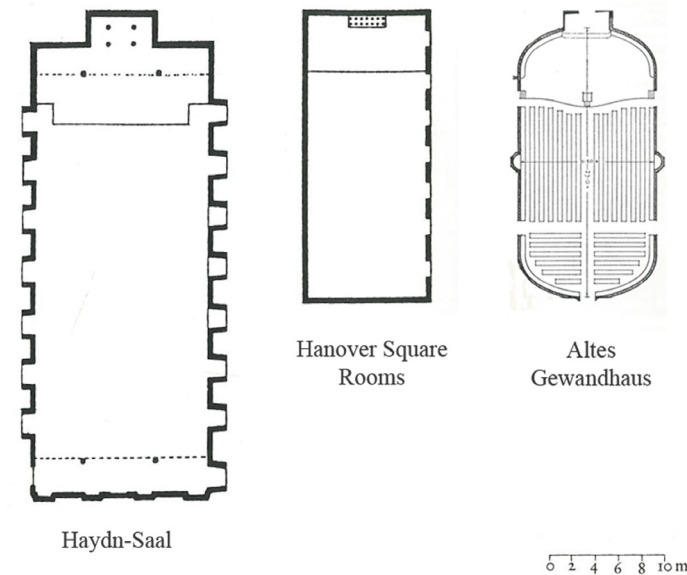
[Fig 1.03] Altes Gewandhaus Concert Hall, Leipzig, by Johann Friedrich Dauthe, 1780-1781: Converted from part of the existing Gewandhaus, or Drapers' Hall, the concert hall became particularly famous during the time of Mendelssohn's directorship, 1835-1847.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (preface), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.



[Fig 1.04] Comparative plans of small-scale shoebox halls.

Adapted from: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 38), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press.



Altes Gewandhaus Concert Hall, Leipzig, 1780:

The third and final example of the early small-scale concert halls is the Altes Gewandhaus, in Leipzig [Fig 1.03]. With an audience capacity of 400 persons, the shape of the hall continued the rectangular trend established by the early music rooms; however, it was distinguished by its curved ends [Fig 1.04] (Long, 2006, p. 21). The dimensions of the hall were 23.0m long, 11.5m wide, and 7.4m high (Barron, 2010, p. 78). An orchestra platform occupied over a quarter of the layout to accommodate 60 players (Forsyth, 1985, p. 64). The walls were lined entirely with thin wood paneling that, together with the wooden stage floor, had a favourable acoustic effect of absorbing low frequency sound, complementing the medium-to high-frequency absorption of the audience (Beranek, 1962, p. 47). At full capacity, this resulted in a reverberation time no more than 1.3s at middle frequencies (Beranek, 1962, p. 47). Such a short reverberation time in conjunction with the small volume ensured that the orchestra was heard with great clarity and, because of the small volume, considerable dynamic strength (Forsyth, 1985, p. 64).

Although at the time the exact science was not absolutely certain, the acoustic success of these three small-scaled concert halls proved the acoustic superiority of the shoebox model. The principles of these small-scale halls were later reapplied throughout Europe on a larger scale. The success of the design was attributed to its narrow width, which ensured every seat received powerful sound reflections from the side walls (Barron, 2010, p. 78). These sound reflections in combination with the close proximity of the direct sound created a powerful bright tone and a satisfying sense of intimacy for all members of the audience (Jaffe, 2010, p. 53).

As the popularity of concert going continued to increase, so did the size and scale of the concert hall. In the early nineteenth century, new halls commonly held 1,500 persons or more, and existing concert rooms were frequently adapted to accommodate larger audiences. However, in doing so, the sense of intimacy was somewhat lost in the larger volume (Forsyth, 1985, p. 199). The response from composers at the time was to increase the size of the orchestra proportionately. In addition, musical instruments were also modified to produce a louder strength and tone (Forsyth, 1985, p. 22). The number of string, brass, percussion and woodwind sections all increased proportionately (Forsyth, 1985, p. 199). Performers too became aware of the need to adjust their style of playing and their choice of piece to suit a particular concert hall



[Fig 1.05] Neues Gewandhaus, Leipzig, by Martin Gropius and Heinrich Schmieden, 1844.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (preface), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.

(Forsyth, 1985, p. 22). Johann Joachim Quantz, celebrated flautist at the court of Frederick the Great, gives the following advice in his book *On Playing the Flute*:

In a large place, where there is much resonance, and where the accompanying body is very numerous, great speed produces more confusion than pleasure. Thus on such occasions he must choose concertos that are written in a majestic style, and in which many passages are in unison. The echo that constantly arises in large places does not fade quickly, and only confuses the notes if they succeed one another too quickly, making both harmony and melody unintelligible.

Comparatively, in a small room, where few instruments are at hand for the accompaniment, the player may use the concertos that have gay and gallant melodies, and in which the harmony changes more quickly than at half or whole bars. These may be played more quickly than the former type (Quantz, 1966, p. 200).

The German acoustician Jürgen Meyer also advocates for a proportionate increase in orchestra size to respond to a change in scale. He argues that a closer impression of Haydn's original orchestral sound, in terms of loudness, instrumental balance, and spatial impression, is gained in a large-scale concert hall by carefully scaling up the size of the orchestra (Forsyth, 1985, p. 16). The composition and style of the orchestra can thus be adapted to come as near as possible to the original sound picture in the acoustical conditions of today's large-scale concert halls (Forsyth, 1985, p. 16). In addition to the increase in orchestra size, plaster and other heavyweight materials were used in place of wood to sustain reverberation and produce a fuller tone. This increase in the strength of sound made up for the sensation of intimacy lost on the larger scale.

By the late nineteenth century the most successful and repeated precedent in the design and construction of concert halls was the rectangular shaped shoebox (Forsyth, 1985, p. 205). These halls were built specifically for the performance of orchestral and choral concert music before an audience of about 1,500 to 2,000 people. Additional balconies were adapted around the perimeter of the halls to accommodate the increasing audience size, however they also proved useful in reflecting sound around the room. The combination of a large volume and reflective internal linings ensured the halls were resonant and had a rich, full tone, well suited to the Romantic music of the period (Forsyth, 1985, p. 205). Four of the most famous large-scale concert halls of this era are the Neues Gewandhaus, Leipzig, 1844 - The Musikvereinssaal, Vienna, 1869 - the Concertgebouw, Amsterdam, 1888 - and Boston Symphony Hall, Boston, 1900.



[Fig 1.06] Grosser Musikvereinssaal, Vienna, by Theophil Hansen, 1869.

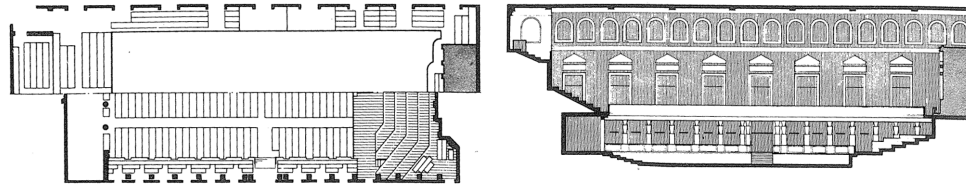
From: Musikverein, 2011, Retrieved from http://www.musikverein.at/dermusikverein/galerie/musikvereinssaal.asp?foto_id=GS_unten_7 (accessed 20/04/2011).



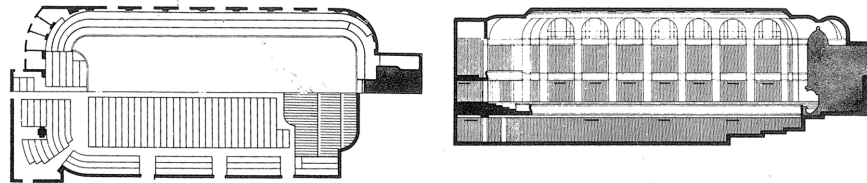
[Fig 1.07] Concertgebouw, Amsterdam, by Adolf Leonard van Gendt, 1888.

From: Het Concertgebouw, 2010, Retrieved from <http://www.concertgebouw.nl/het-concertgebouw/over-het-gebouw/beroemde-akoestiek> (accessed 20/04/2011).

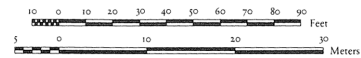
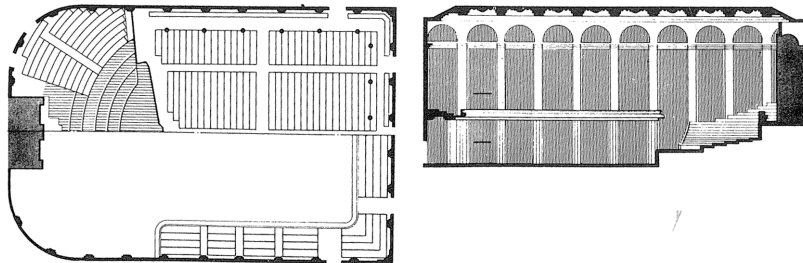
Grosser Musikvereinssaal, Vienna



Neues Gewandhaus, Leipzig



Concertgebouw, Amsterdam



[Fig 1.08] Comparative plans and sections of large-scale shoebox halls.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 218), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.

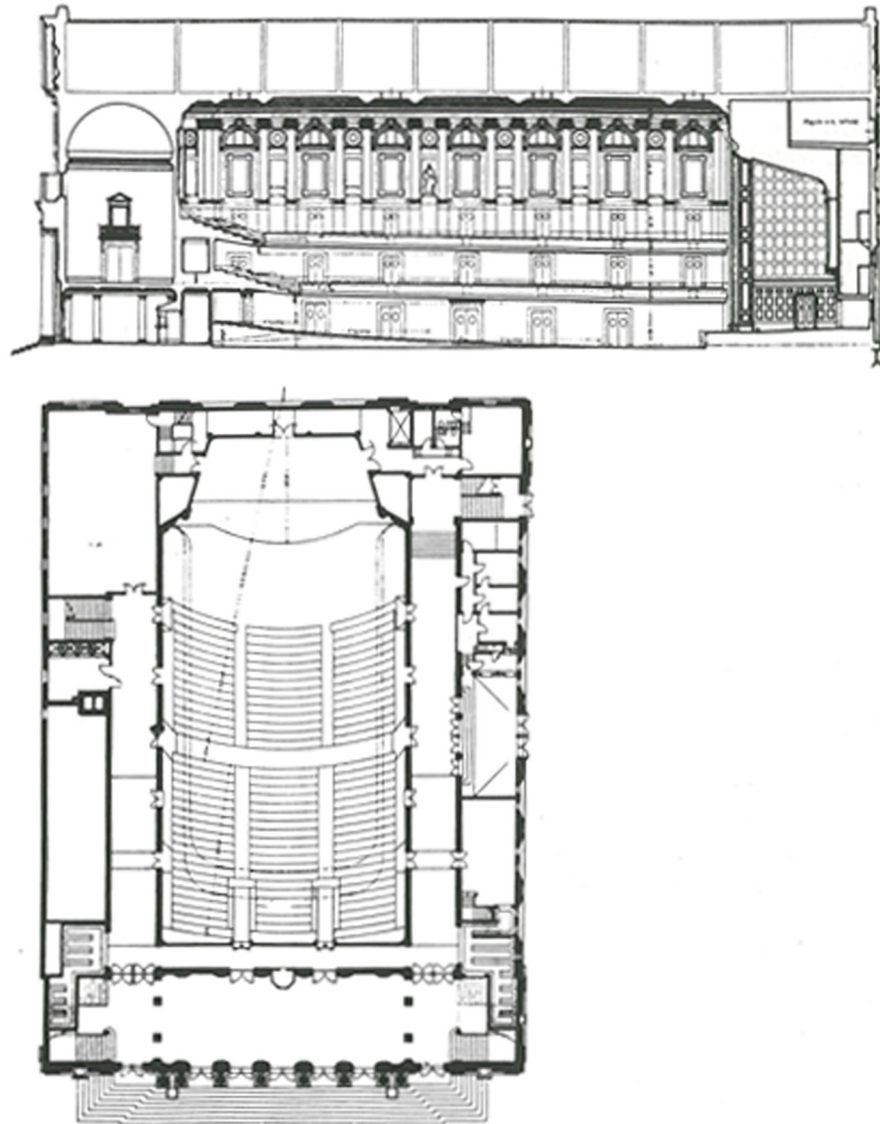
1.2 | *Large-scale precedents*

Neues Gewandhaus, Leipzig, 1844:

The rectangular main hall of the Neues Gewandhaus was in effect an enlarged version of the Altes Gewandhaus, except that the end walls were flat with curved corners [Fig 1.05]. The dimensions of the hall were 44.9m long, 19.2m wide and 15.1 m high, and contained 1,560 plush-upholstered seats (Barron, 2010, p. 78). The reputation of the Neues Gewandhaus became established at once, and the main hall was regarded from the outset as a model of acoustic excellence (Beranek, 2002, p. 13). Its stature was enhanced further still when, in 1895, it was used along with Vienna's Grosser Musikvereinssaal, as a model for the new and successful Boston Symphony Hall (Beranek, 2002, p. 13). The Neues Gewandhaus was a little less reverberant than the Musikvereinssaal, with a full audience it had a reverberation time of 1.55s at middle frequencies (Barron, 2010, p. 78). With such a reverberation time the hall managed to achieve a compromise in suitability for both large-scale Romantic and small-scale Classical music. Unfortunately, the hall was destroyed by an air raid in 1944 (Forsyth, 1985, p. 214).

Grosser Musikvereinssaal, Vienna, 1869:

The most venerable of all the old halls of Europe is the Grosser Musikvereinssaal in Vienna, which opened in 1870 [Fig 1.06] (Beranek, 2002, p. 13). Like its small-scale predecessors, the Musikvereinssaal is a long and narrow hall seating 1,680 persons. The audience is seated on wooden seats divided among a flat main floor, also constructed of wood. The internal dimensions of the hall measure 52.9m long and 19.8m wide, with a height of 17.8m (Barron, 2010, p. 78). A balcony extends around all four sides of the hall to help reflect sound and accommodate the remaining audience. Comprehensively ornamented, the gilder plaster-paneled walls and ceiling help to scatter the sound throughout the room (Forsyth, 1985, p. 208). With a full audience, the hall has a reverberation time of 2.2s at middle frequency (Long, 2006, p. 21). The volume, coupled with the hard plaster surfaces, gives a full, rich brass tone, while the narrow width and broken surfaces provide every seat with immediate sound reflections, giving the high strings a particularly fine, clear tone (Beranek, 2002, p. 13). Today the concert hall is still regarded as one of the worlds very best, and it continues to be exercised as a precedent for contemporary designs such as the Casa da Musica, Portugal (Castro, 2006, p. 56).



[Fig1.09] Boston Symphony Hall, Boston, by Charles McKim and Wallace Clement Sabine, 1900: Plan and section.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 253), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.

Concertgebouw, Amsterdam, 1888:

The Concertgebouw in Amsterdam, which opened in 1888, is the third principal European shoebox hall [Fig 1.07] (Beranek, 2002, p. 13). However, it is very different from the Neues Gewandhaus and the Musikvereinsaal in both its size and proportion; consequently it has quite different acoustics. The dimensions of the hall measure 43.0 long, 28.4 wide, and 17.4 high, to give an overall volume of 18,770 m³, nearly twice that of the Leipzig hall [Fig 1.08] (Beranek, 2002, p. 13). Plaster is used throughout the interior to give the hall its characteristic *boomy* sound (Forsyth, 1985, p. 8). Not only does this cause the hall to have a high reverberation time of 2.2s, but sound reflections from the broadly spaced side walls arrive relatively late in the centre of the main floor. This provides the music with a *warm*, blended, ringing tone, lacking in clarity but very *live* (Forsyth, 1985, p. 217). Although ill-suited to the intimate music of Mozart and Haydn, the hall is one of the best in Europe for large-scale works of the Romantic period (Forsyth, 1985, p. 217).

Boston Symphony Hall, Boston, 1900:

The latest of the historical shoebox principles came at the beginning of the twentieth century [Fig1.09]. Boston Symphony Hall was the first concert hall where the principles of reverberation were applied. These principles were developed in 1898 by Wallace Clement Sabine, who was the first person to apply modern scientific principles to room design and pioneered modern concert hall acoustics (Cox, 2003, p. 119). The Boston Symphony Hall, built in 1900, was based on the Gewandhaus, with a desired reverberation time of 2s at middle frequency. However, the Boston hall was adapted to accommodate an audience of 2,600, over a thousand more than the 1,560 at the Gewandhaus (Beranek, 2011, p. 6). The larger audience would require a greater volume, which would effect the desired reverberation time of 2s at middle frequency.

However, as Sabine, the pioneering American physicist and acoustic consultant for the project said, “An excellent hall can theoretically be copied exactly so as to give identical acoustics, but any variations must be compensated for” (Forsyth, 1985, p. 250). Expanding the width of the hall to accommodate the larger audience was an unsuitable alternative, as it would reduce the intensity of the side reflections. Instead, Sabine suggested an additional balcony be added, and the row-to-row spacing be reduced to accommodate the larger audience (Beranek, 2011, p. 6). He also suggested the ceiling be lowered to compensate for the increase in volume created by the extended length (Beranek, 2011, p. 6). The combination of these three changes meant the desired reverberation was achieved. Like its large-scale predecessors, the walls of the hall are lined with

plaster, to preserve the bass sounds. Niches in the side walls and coffers in the ceiling, help to create favourable irregularities and an even sound mix. Today the hall is still regarded as one of the best in the world and continues to be used as a model for acoustic excellence (Cox, 2003, p. 119).

Shoebox summary

A comparative study of shoebox halls by Hidaka and Nishihara in 2004 found that of the 15 halls surveyed, the aspect ratio, length over width ranged from 4:1 to 3:2 (Hidaka, 2004, p. 362). One feature now considered irrelevant is the detailed proportions of the shoebox. However, the width length and height are all significant in their various ways. What is certain is that their good acoustics are not due to a single feature (Müller, 1992). Nevertheless, the shoebox hall has several acoustically important characteristics. One is the relatively small seating area in proportion to the halls overall volume which contributes to its favourably long reverberation time (Beranek, 2011, p. 6). The sustained sound of these halls produces a full-tone, especially rich in the bass frequencies, where individual notes are smoothed out by background reverberation (Forsyth, 1985, p. 217). In addition, shoebox halls are especially good because of their narrow width, usually no more than 23m wide (Beranek, 2011, p. 6). This ensures no member of the audience is far from a side wall, so that each listener receives powerful lateral sound reflections soon after the direct sound. Strong reverberation also has the advantage that the overall sound energy of the orchestra is increased. All of which contributed to the desired sensation of intimacy in large-scale halls (Jaffe, 2010, p. 53). The combination of the direct sound with the reflected sound gives the music good definition, and makes it seem to fill the space when the orchestra plays at *forte* level (Forsyth, 1985, p. 217).

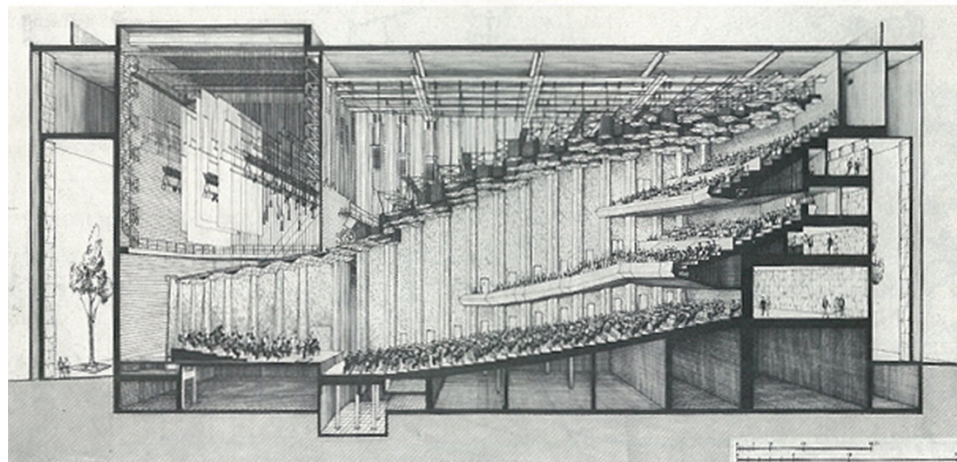
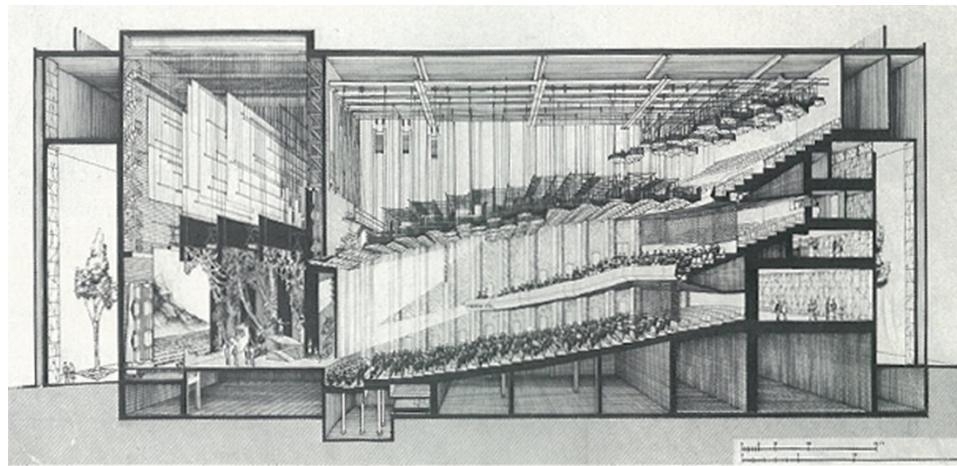
1.3 | *Twentieth century developments*

Since the early twentieth century, economic considerations have not only caused auditoria to become larger, but also demanded that they be used as often as possible. Their acoustics are therefore compromised by the need to serve a variety of purposes (Jaffe, 2010, p. 53). Today, one hall must accommodate speech and music of all kinds. These include symphony concerts, opera, chamber music, jazz and other amplified and pop performance. This issue is especially relevant to the design of new music schools where a wide variety of music is practiced daily.

Technological advancements throughout the twentieth century has enabled the users of contemporary auditorium to match the musical style and required acoustic ambience with far greater accuracy. From the late 1950s onwards, the approach taken by architects and acoustic associates has been in a number of cases to provide halls with variable acoustics (Jaffe, 2010, p. 53). This is often achieved by alternating absorbent and reflective surface materials. Alternatively, more complex mechanisms have given users the ability to adjust the volume of a room and, in turn, alter the reverberation time. The purpose of such variability is to establish an acoustic range from the small-scale concert hall of the seventeenth century with a reverberation time of little over 1s, to the large-scale symphony hall's of present day with a reverberation time of around 2s, all in one concert hall (Jaffe, 2010, p. 53).

One simple way of adjusting the reverberation time in a hall is to use retractable sound-absorbent curtains. The curtains can be opened or closed to cover or expose a reflective surface as desired. However, a more complex alternative is moveable walls and ceilings and reflective ceiling panels (Ando, 1997, p. 101). These elements can be mechanically adjusted to direct sound or adjust the volume of a space. The purpose of reflective ceiling panels is to increase the clarity of the music by reflecting sound directly toward the audience to reduce the blurred effect of sound reflecting off a lofty ceiling (Jaffe, 2010, p. 53).

Reflective ceiling panels are generally made of lightweight plywood that have the advantage of reflecting mid- to high-frequency sound, while at the same time being transparent to long-wave, low frequency sound (Ulrike, 2006, p. 1446). This means the sharp definition of the high-frequency is directed to the audience while the low frequency sounds are able to reverberate throughout the hall. This achieves both symphonic depth



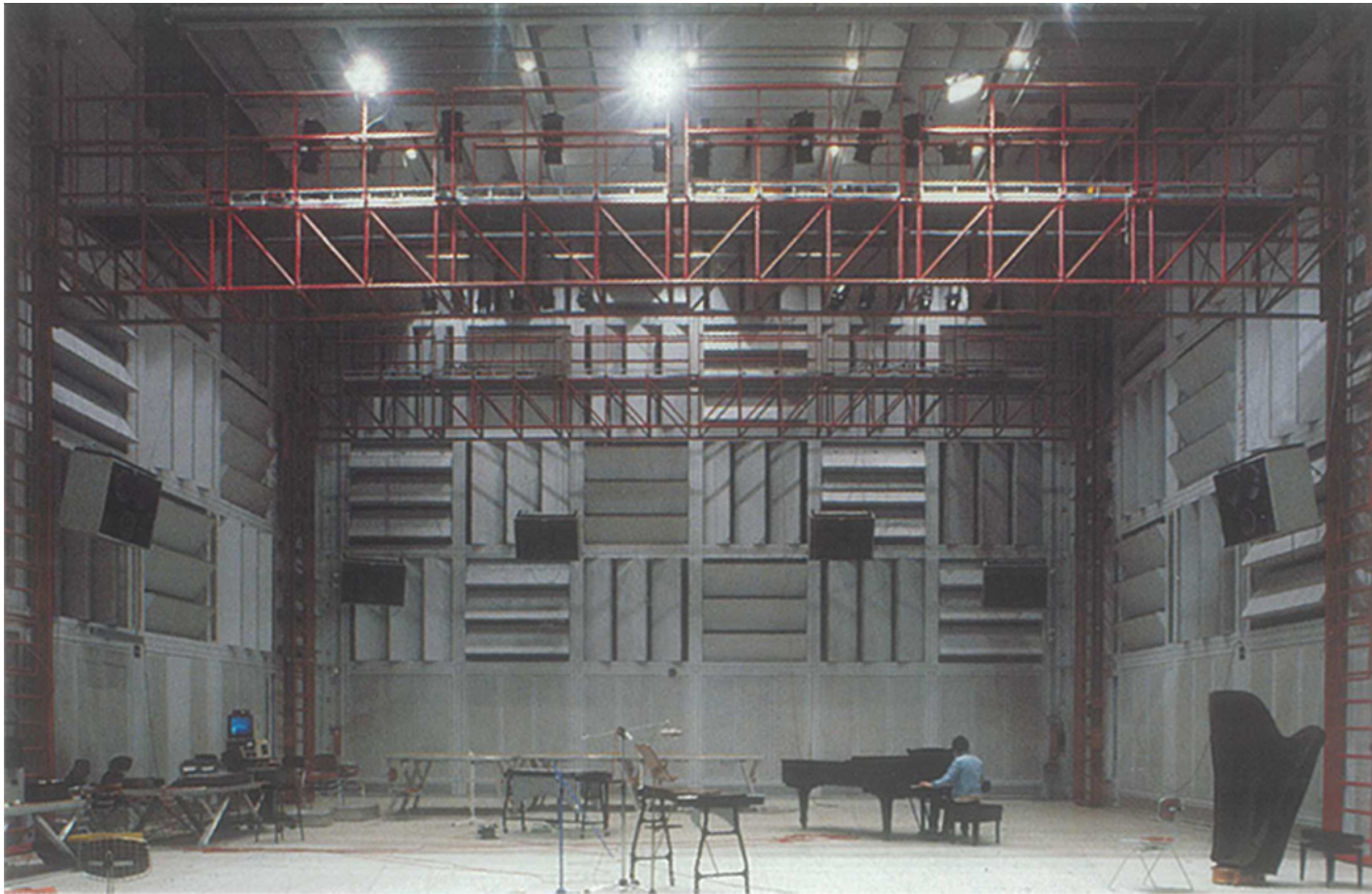
[Fig 1.10] Jesse H. Jones Hall for the Performing Arts, Houston, Texas, by Caudill, Rowlett, and Scott, with consultants Bolt, Beranek, and Newman and G. C. Izenour, 1966.

From: Buildings for music: The architect, the musician, and the listener from the seventeenth century to the present day (p. 291), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.

and extreme clarity at the same time (Ando, 1997, p. 101). Alternatively the ceiling panels can be re-tracked so that they maintain the overall volume of the hall. This avoids the problem of the sound being directly absorbed by the audience and results in a much longer reverberation time (Forsyth, 1985, p. 298). With this kind of acoustic adjustability one space can be adapted for both Classical and Romantic styles. Two of the most revolutionary examples of adjustable acoustics were established at the *Jesse H. Jones Hall* in Houston, Texas, and the experimental workshop *L'Espace de Projection*, at the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in the Centre Georges Pompidou, Paris (Forsyth, 1985, p. 16).

Jesse H. Jones Hall for the Performing Arts, Houston, Texas, 1966:

Built in 1966, The Houston Hall, designed by Caudill, Rowlett, and Scott, with Bolt, Beranek, and Newman and George C. Izenour as consultants, is one of the earliest examples of large-scale adjustable acoustics [Fig 1.10]. The basic auditorium shell forms a 3,000 seat symphony hall with a reverberation time of 2s, while a moveable ceiling of hexagonal steel panels can descend to seal off the upper balcony, to form a small-scale recital hall with a reverberation time of 1.6s (Forsyth, 1985, p. 290). This example illustrates the proportionate flexibility of any acoustic volume and the potential to adapt space for both large- and small-scaled purposes.



[Fig 1.11] IRCAM (Institut de Recherche et Coordination Acoustique/Musique), Paris, by Piano and Rogers, opened 1978: The Espace de Projection, a workshop for experimental music, designed to the requirements of its director, Pierre Boulez.

From: Architecture and music: Seven sites for music from the IRCAM in Paris to the Auditorium in Rome (p. 108), by R. Piano, 2002, Milano: Edizioni Lybra immagine.

The Espace, IRCAM Building, Paris, 1978:

In a comparatively smaller scale, the 400 seat Espace de Projection in the IRCAM building designed by Renzo Piano, which opened in 1978 has even greater acoustic variability [Fig 1.11]. A motorised system of adjustable walls and ceilings is used to vary acoustics in the space, virtually creating a musical instrument in itself (Piano, 2002, p. 105). The Espace is 25m long, 27 wide and 14m high. All six of the internal sides have variable surfaces to reflect or diffuse sound. The ceiling is in three sections and can be raised and lowered so as to be capable of a 4:1 change in volume. Similarly, the floor is modular and consists of panels with changeable finishes. The walls are built of 172 triangular panels capable of rotating to expose either reflective or diffusive surfaces. Consequently the room is capable of a 4:1 alteration in reverberation time (Forsyth, 1985, p. 316). This kind of proportionate variation means that the spaces can be adapted to suit almost any musical genera and is an exceptional solution to contemporary demands for acoustic multi-functionality. Although these final two examples operate at a scale and level of technical advancement beyond the requirements of the NZSM, there is potential to replicate their mechanical principles.

This chapter develops a historical analysis of small-scale concert spaces including: the Hanover Square Rooms, Haydn-Saal, Eisenstadt, and the Altes Gewandhaus Concert Hall. The fact that the pioneering father's of Classical music used these rooms to develop their now influential styles, establishes them as highly relevant paradigms for their contemporary counterparts. Furthermore, an additional finding of interest is that these small-scale spaces were fitted out under the instructions of the composer, to good effect. The information gathered from these historical spaces in regards to their dimensions, materials and reverberation times operates as a precedent for the small-scale spaces required by the NZSM programme.

The findings from this chapter establish that with the highly diffused nature of sound in Classical halls, reverberation time is less crucial than elsewhere. However, values of more than 1.8s are clearly preferred for the Romantic repertoire. A shorter reverberation time will enhance musical definition at the expense of *liveness*. Therefore a recommended reverb time for small-scale recital halls and chamber rooms is between 1.4 -1.8s.

Subsequently, this chapter also discusses the adaption of the Neues Gewandhaus, and the Musikvereinssaal, as a model for the Boston's Symphony Hall. The variations made in this process assert this example as a principle theory to demonstrate the adaptability of the shoebox model. The results from this study establish that an existing hall can be modified proportionately to give identical acoustics. However, any variations must be compensated for. In objective design terms, the favourable aspects appear to be that all seats are close to reflecting surfaces, that hall width is small, that parallel side walls produce a high reflection density, that the hall surfaces are highly scattering and that the balcony overhangs are shallow.

These findings further suggest that it is possible to proportionately downscale an existing large-scale concert hall for small-scale purposes. However, in doing so variations such as material choices, audience capacities and overall sound absorption must be compensated for. These compensations are discussed further in the following chapter, which narrows the focus of this acoustic investigation down to the small-scale spaces specific to the NZSM programme.

Chapter 2 | *Acoustic Design for Small-Scale Space*

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This chapter focuses on the acoustic design principles of spatial types specific to the NZSM programme. It begins by differentiating between the acoustic requirements for sound and those for speech. Subsequently, in breaking down the basic science of acoustics, this chapter investigates the way sound behaves in space and proposes acoustic treatments which can be used to control it. The final section discusses construction methods to ensure sound isolation and noise control between music performance spaces.

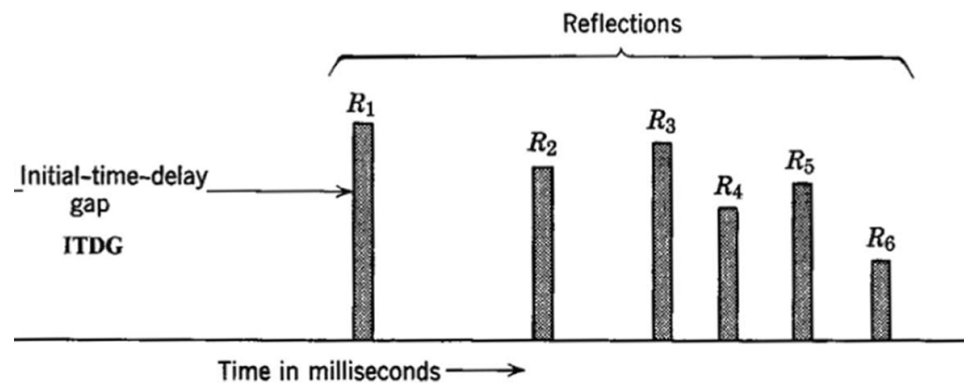
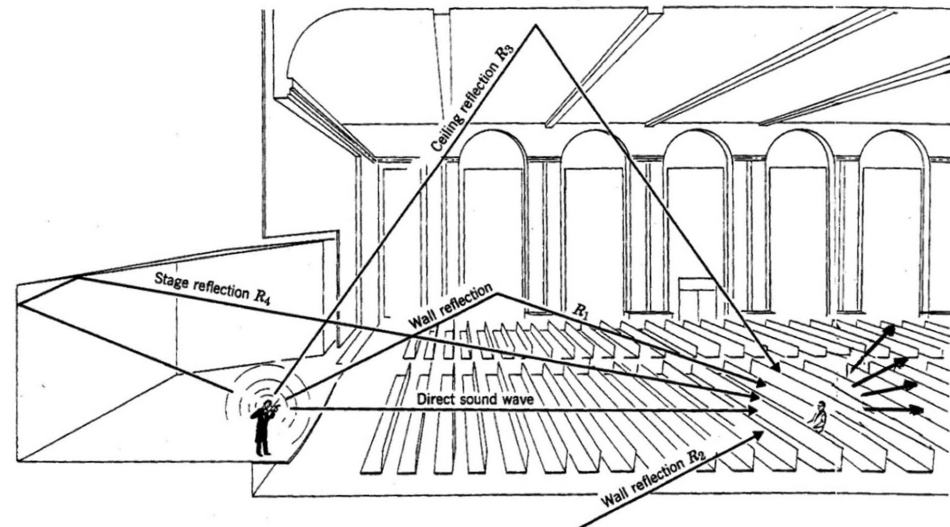
2.1 | *Basic Principles of Acoustic Design*

The English acoustician Hope Bagenal argued that all auditoria fall into two groups: those with the acoustics of the cave and those with the acoustics of the open air (Forsyth, 1985, p. 3). From the former, where music originated, grew the concert hall, and the latter, where the spoken voice belongs, grew the theatre (Forsyth, 1985, p. 3). Auditoria with the acoustics of the open air, have traditionally lent themselves to events where the intelligibility of speech is important, such as lecture theatres and seminar rooms. In these spaces clarity is necessary as opposed to fullness of tone (Forsyth, 1985, p. 8). This is because the open air is sound absorbing; consequently, the direct sound from the speaker is not masked by reverberation.

Early composers soon discovered that reverberation was the most significant attribution a space could have on sound (Beranek, 2011, p. 7). As identified in Chapter one, larger spaces increase reverberation, however, too much reverberation confuses rhythms. Therefore, the music created for larger-scale spaces is generally less rhythmic and more textural. In comparison smaller spaces have less reverberation, which means the music is generally more intricate, and the sound can change key without great dissonance (Byrne, 2010). This is evident in the forms used by Mozart and Haydn in their chamber and orchestral music. The forms are identical, however the details of style (counterpoint, ornamentation, rhythm, the layout of chords and the rate at which harmonies change) will vary according to whether they are writing room-music, concert music, or street music (Forsyth, 1985, p. 9).

[Fig 2.01] Sequence of sound reflection as heard by the listener.

From: Concert hall acoustics (p. 7), by L.L. Beranek, 2011, Architectural Science Review.



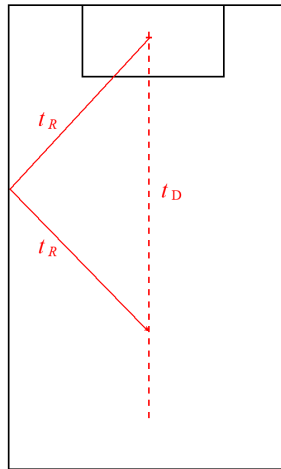
[Fig 2.02] Sequence of sound reflection as heard by the listener in [Fig 2.01].

From: Concert hall acoustics (p. 7), by L.L. Beranek, 2011, Architectural Science Review.

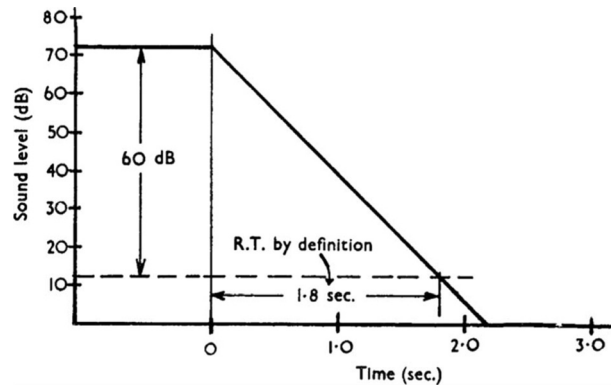
Although it is the sound source that determines acoustics, the room determines how the sound arrives at the listener. Sound works within a space much like light does (Cox, 2003, p. 119). If a room consists exclusively of hard, smooth surfaces, the listener's impression is comparable to the visual impression gained in a room full of mirrors (Mommertz, 2009, p.12). Sound bounces off hard surfaces, just like light is reflected by very bright surfaces. By contrast, surfaces capable of vibration and open porous surfaces absorb sound like darker colours absorb light (Mommertz, 2009, p.12).

The first sound to reach the listener is the direct sound because it has to cover the shortest distance. It is followed by reflections from the ceiling and side walls. Just like light, sound is reflected from flat surfaces such that the angle of incidence is equal to the angle of reflection (Beranek, 2002, p. 13). The paths determine the interaural time differences the sound waves have to travel in the room (Mommertz, 2009, p.12). When sound is created in a room, the signals are superimposed on each other in the same way and reach the ears of the listener thousands of times with corresponding time delays (Mommertz, 2009, p.12). The ear does not resolve the individual reflections. Instead, together with the direct sound they determine the aural impression of the sound as a whole (Mommertz, 2009, p.12).

Early sound reflections are those that arrive at a listener's position in the first 80 - 100 milliseconds (ms) after the arrival of the direct sound (Marshall, 2001, p. 92). In [Fig 2.01], the direct sound and four typical sound reflections in a hall are shown that arrive from the side walls, ceiling and rear of the stage (Beranek, 2011, p. 7). Sound is radiated by the instruments in all directions and is partially absorbed by the audience. As shown in [Fig 2.02], the portion of the sound that strikes a listener and is not absorbed is radiated out into the hall to again be reflected around the hall, striking the listener repeatedly, and dying out in the process (Beranek, 2011, p. 7). The combination of the direct sound with the reflected sound from the side walls enhances the three-dimensional acoustic impression of space. This feeling of being surrounded is an important quality criteria for concert halls in which symphony orchestras perform as it creates a feeling of intimacy (Mommertz, 2009, p.13). [Fig 2.02] shows the separation in milliseconds, at a seat in the middle of the main floor of a hall, between the arrival of the direct sound, t_D and that of the first reflection, t_{R1} . This is called the 'initial-time-delay gap (ITDG).' In [Fig 2.03] the ITDG equals the time $t_{R1} - t_D$, measured in milliseconds (Beranek, 2011, p. 8). Beranek argues that in the best halls, at the centre of the main-floor audience area, ITDG is less than 20ms (Beranek, 2011, p. 8). However, halls with ITDG greater than 40ms sound like arenas and are often acoustic disasters (Beranek, 2011, p. 8).

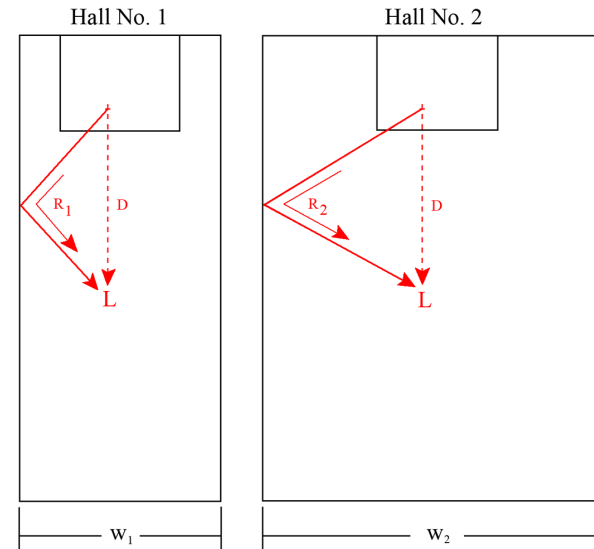


[Fig 2.03] Direct and reflected sound in a typical shoebox hall.
By author, 2011



[Fig 2.05] Decay of sound / Reverberation time $T_{60} = RT$.

From: Concert hall acoustics (p. 5), by L.L. Beranek, 2011,
Architectural Science Review.



[Fig 2.04] Effect of hall width W on the first reflection:

The distance $(R_2 - D)$ in Hall No. 2 is longer than $(R_1 - D)$ in Hall No. 1. Therefore hall No.1 is more intimate.

Adapted from: Concert halls: How they sound (p. 35), L.L. Beranek, 1996, New York, Acoustical Society of America.

The strength of sound G is also a major component in determining the acoustic success of a performance space (Beranek, 2011, p. 8). There are two terms that determine the strength of sound in a space. The first term is the distance r the direct sound, which decreases rapidly as distance increases from the source to the listener, must travel (Beranek, 2011, p. 8). The second term is the reverberation, which is nearly the same all over the hall, and is inversely proportional to the total sound absorption Sa in the room (Beranek, 2011, p. 8). The sound absorption in a hall is mostly dependent on the size of the audience. The orchestra can give out only so much sound energy and the amount for each listener depends on how many listeners there are (Beranek, 2011, p. 8). Part of the sound energy is absorbed by the walls and ceiling. Thickly upholstered seats and the materials chosen for internal linings also affect total Sa . In the best halls, at mid- frequencies, the strength of sound measures between 2 and 6.5 decibels (dB) (Beranek, 2011, p. 8).

Ensuring there are clear sightlines between all members of the audience and the stage is one simple way of achieving sound clarity. If there are obstructions between the listener and the sound source, the direct sound can be weakened to such an extent that localisation is impaired (Mommertz, 2009, p.13). Guaranteeing an unobstructed direct sound propagation is therefore always important when acoustic intelligibility and clarity are important (Mommertz, 2009, p.13).

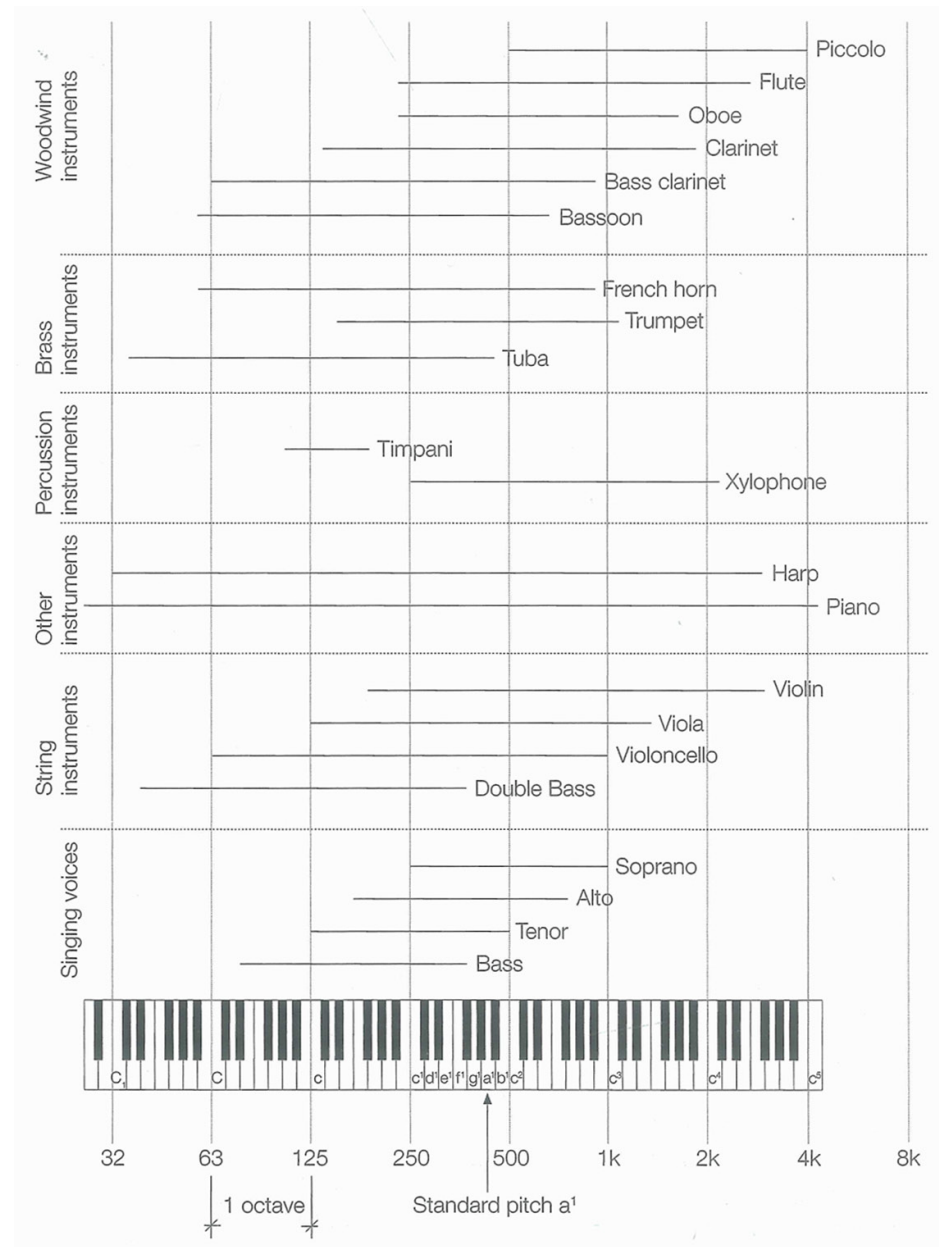
Reverberation:

Reverberation refers to the decay of sound after a note has stopped being played (Cox, 2003, p. 119). Reverberation time is the most important acoustic parameter because it is part of the composer's intention (Beranek, 2011, p. 5). In contrast to early reflections it is usually not dependent on the listeners position so it gives a good indication of the acoustic quality for the entire space (Mommertz, 2009, p.13). The reverberation time T_{60} is the length of time it takes for a loud sound to decay to inaudibility. Such a range of decay is equated to 60dB (Beranek, 2011, p. 5). The sloping line in [Fig 2.05] represents the decay of sound. It is seen that a decay of 60dB takes 1.8 seconds (s) (Beranek, 2011, p. 5).

The reverberation in a room influences the sound of music in several ways. During continuously flowing music, listeners hear the first 10dB of sound decay (Beranek, 2011, p. 5). Each note is prolonged and the music takes

[Fig 2.06] Frequency range for musical instruments.

From: Acoustics and sound insulation: Principles, planning, examples (p. 8), E. Mommertz, 2009, Boston, Detail.



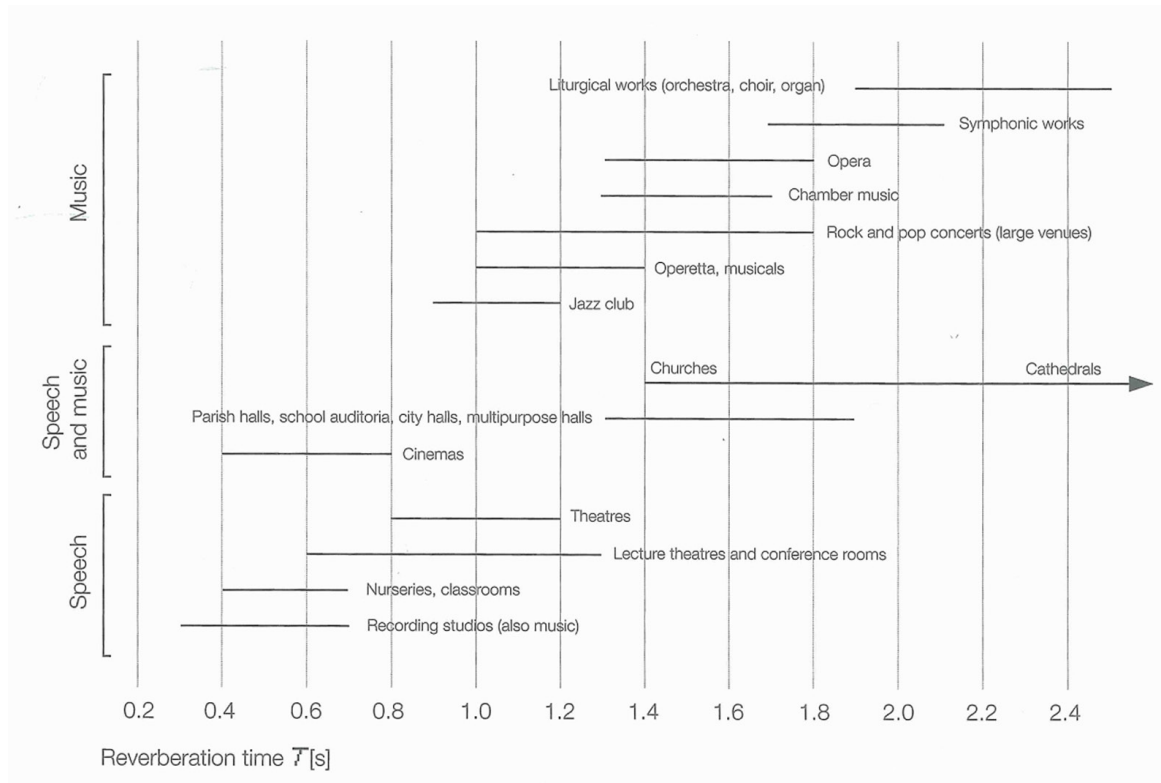
on a singing tone. When the music stops abruptly, listeners hear 35 or more decibels of the decay in the quiet interval (Beranek, 2011, p. 5). This longer reverberation adds both fullness of tone and loudness to the music and gives the listener a sense of being enveloped by the sound [Fig 2.04] (Beranek, 2011, p. 5).

Which reverberation time is desirable for which room depends entirely on the function of that room (Mommertz, 2009, p.13). In cathedrals and churches, for example, a long reverberation time reinforces the sacred character and provides organ and choral works with the proper acoustic environment (Mommertz, 2009, p.13). In contrast to this, the reverberation time in a lecture theatre should not be too long in order to avoid successive syllables being lost in the reverberations (Mommertz, 2009, p.13). For today's large-scale symphonic repertoire the optimum time, with full audience and at mid-frequencies, is 1.9 - 2.1s. Chamber music fares better in a hall with a reverberation time between 1.4 - 1.8s, while opera is best performed in a house with a reverberation time of 1.4 - 1.6s (Beranek, 2011, p. 5). Practices Rooms of up to 135m³ typically have reverberation times around 0.5s (Ulrike, 2006, p. 1446).

Reverberation is primarily effected by the volume of the space and the amount of total sound absorption within the space (Jaffe, 2010, p. 53). Therefore, an important initial step in the design of room acoustics is to specify the desired reverberation time depending on the use and volume of the room (Mommertz, 2009, p.14). The formula for calculating reverberation time is:

$$RT = 0.5 \times \text{volume of hall} / \text{sum of all the absorption in the hall} \text{ (Jaffe, 2010, p. 53).}$$

The reverberation time should not depend too much on frequency, especially for the octaves from 250 to 2000 Hertz (Hz). [Fig 2.06] shows the ideal frequency range for specific instruments (Mommertz, 2009, p.14). Deviations in the region of $\pm 20\%$ do not generally cause problems. However, if the reverberation time for low frequencies is considerably longer than that for medium and high frequencies, the room will sound *boomy* and muffled, whereas extra emphasis on the medium and high frequencies will lead to a bright to shrill aural impression (Mommertz, 2009, p.14). In a large concert hall, an increase in the reverberation time for low frequencies below the 250 Hz octaves is desirable if a *warm* sound is to be achieved (Mommertz, 2009, p.14). [Fig 2.07] gives an over view of reverberation time in relation to room function. Which reverberation time is ideal in each individual case also depends on room volume.



[Fig 2.07] Reverberation times for selected performance spaces.

From: Acoustics and sound insulation: Principles, planning, examples (p. 14), E. Mommertz, 2009, Boston, Detail.

Absorption:

In a concert space the audience accounts for the greatest amount of sound absorption. [Fig 2.08] shows a table, which lists the room volume per seat, which can be used as an elementary acoustic requirement (Mommertz, 2009, p.14). If a figure is much lower than given here, it is generally impossible to achieve very good objective acoustic characteristics for the type of use concerned (Mommertz, 2009, p.14). With higher values, more absorbent surfaces are required in order to reduce the reverberation time to a reasonable level (Mommertz, 2009, p.14). At the same time, this leads to a reduction in the loudness - normally an undesirable effect in rooms used for non-amplified music or speech (Mommertz, 2009, p.14).

<i>Room type/usage</i>	<i>Room volume per seat</i>
Lecture theatre	4-6m ³
Multipurpose venue	6-9m ³
Symphonic music	10-11m ³
Music rehearsal room	15-50m ³

[Fig 2.08] Acoustically favorable room volumes per seat.

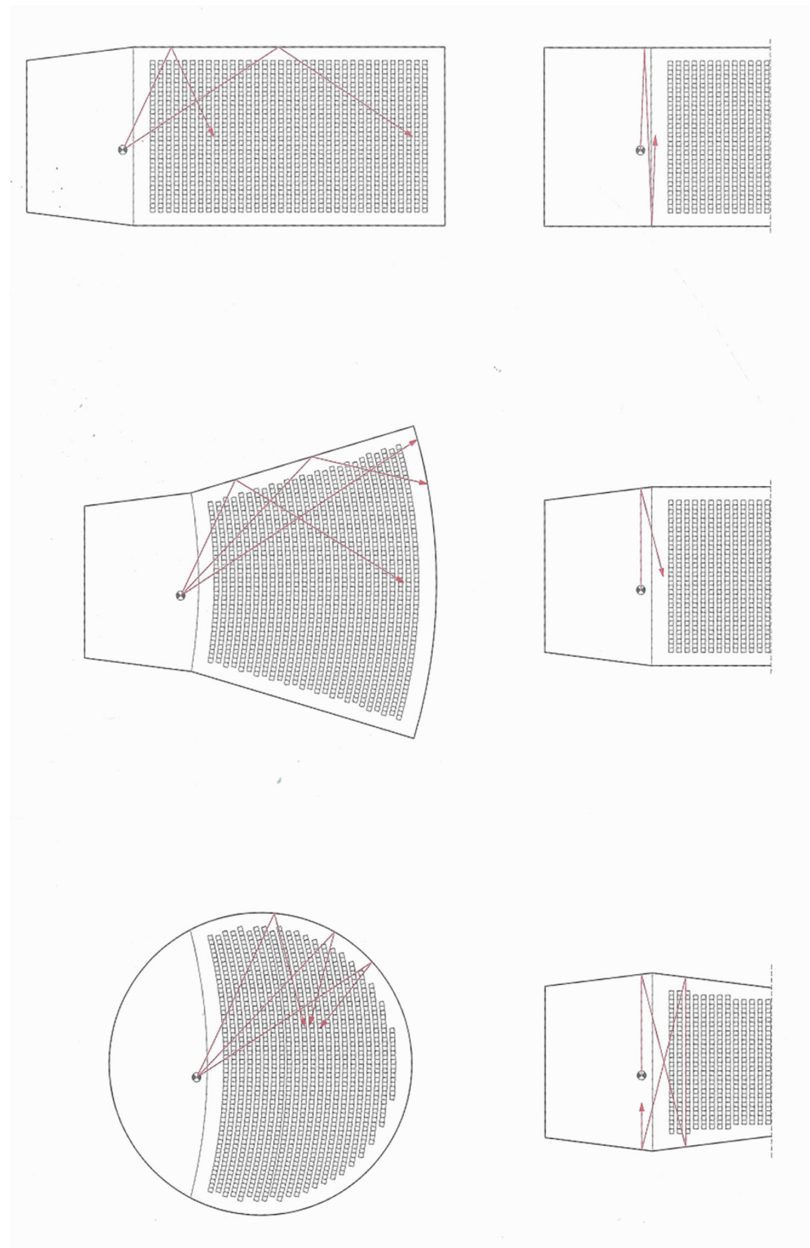
Figures much lower than those given here mean that it is very difficult to achieve optimum reverberation.

Adapted from: Acoustics and sound insulation: Principles, planning, examples (p. 14), E. Mommertz, 2009, Boston, Detail.

⁵In [Fig 2.09] the sound wave illustrates flutter echoes between parallel wall surfaces. This can be avoided by designing the stage to taper towards the rear. If the walls taper inwards the sound wave is reflected back, and unpleasant flutter echoes can be the result (Mommertz, 2009, p. 16).

[Fig 2.09] Plan shape and early reflections.

From: Acoustics and sound insulation: Principles, planning, examples (p. 16), E. Mommertz, 2009, Boston, Detail.



[Fig 2.10] (*Opposite*) Avoiding echoes from the rear of the space.

1. Reflections from the rear wall with a long delay increase the risk of echoes. Right-angles are particularly treacherous because the sound is reflected back parallel to its original direction. Disturbing reflections can be avoided by:

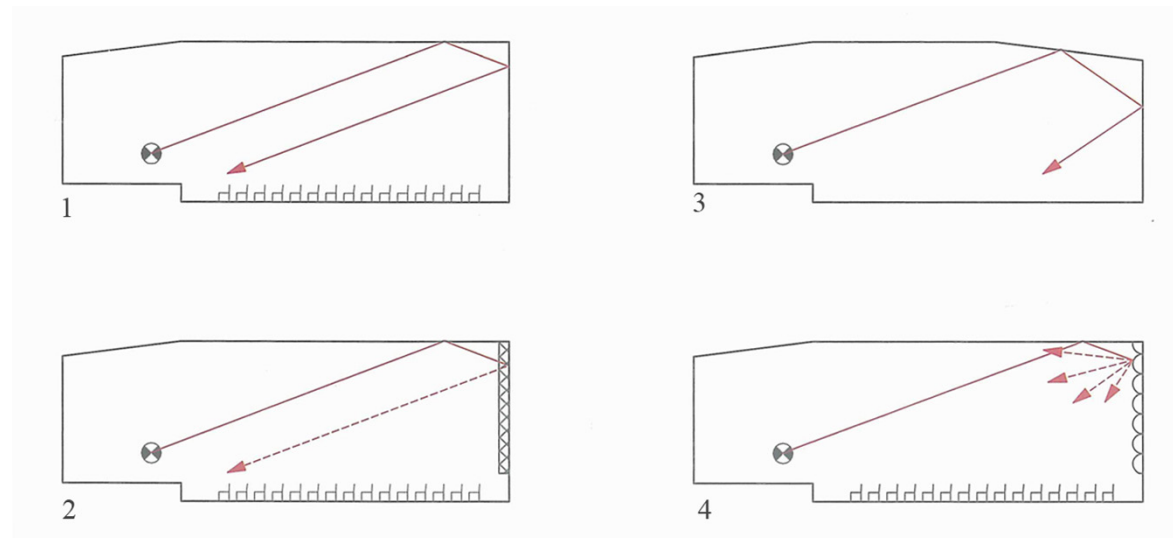
2. Including absorbent surfaces,
3. Positioning the rear part of the ceiling at an angle,
4. Including structured wall surfaces

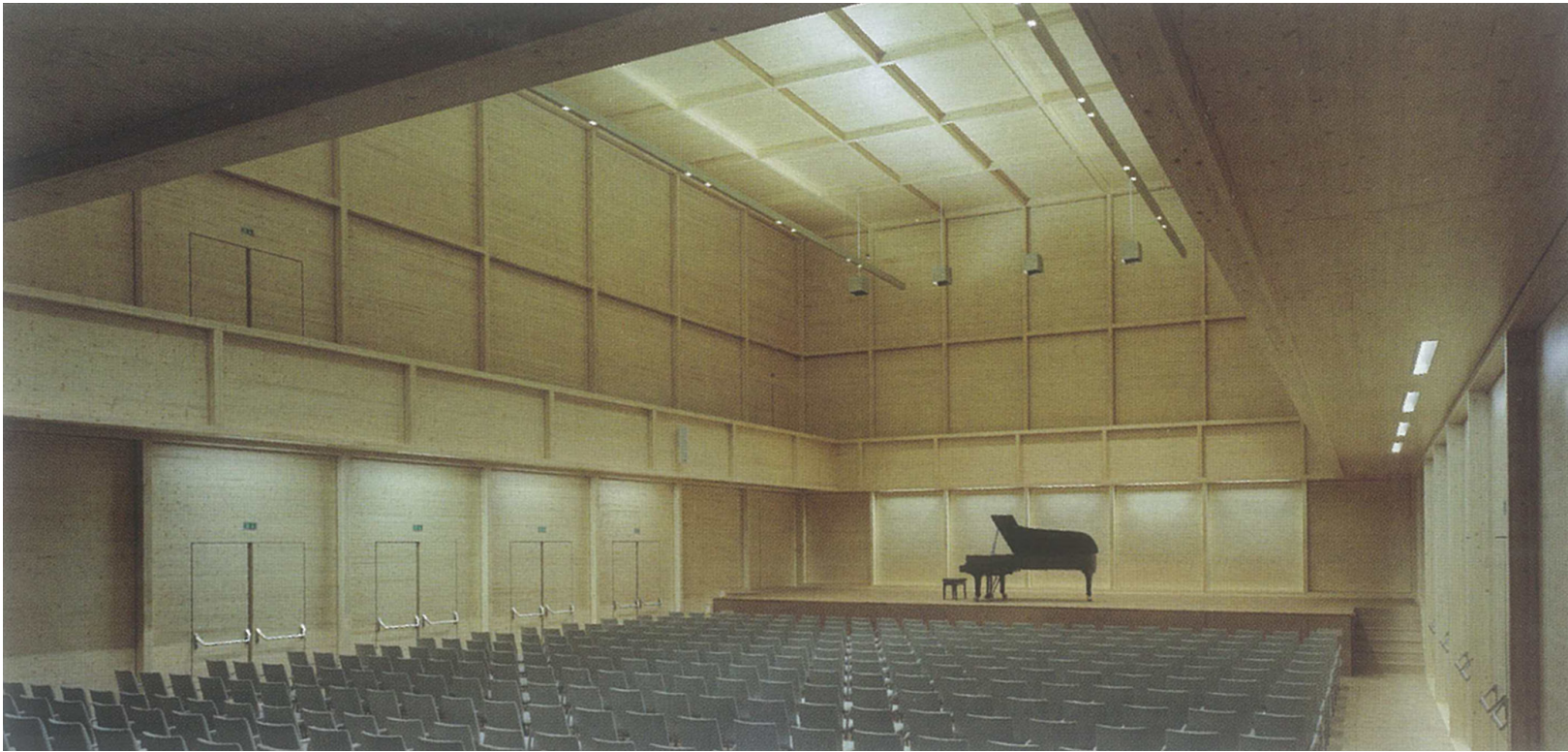
From: Acoustics and sound insulation: Principles, planning, examples (p. 17), E. Mommertz, 2009, Boston, Detail.

Interior Form:

The shape of a space has an enormous effect on how it functions acoustically. The best-liked concert spaces are shaped like shoeboxes, and are less than 23m wide [Fig 2.09] (Beranek, 2011, p. 7). The rectangular shape creates an even distribution of reflections, however, it is important to adapt a certain amount of irregularity within the space to prevent sound reflecting parallel to its original direction (Mommertz, 2009, p.13). If high-energy reflections occur in the reverberant sound, these may be perceived as echoes, where sound signals are heard twice (Mommertz, 2009, p.13). Flutter echoes are periodically recurring reflection sequences which build up between parallel wall surfaces (Mommertz, 2009, p.13). Such echo effects can disrupt music and speech quite considerably and should therefore be avoided⁵ (Mommertz, 2009, p.13).

Reflections from the rear wall with a long delay also increase the risk of echoes [Fig 2.10] (Cox, 2003, p. 119). Right angles are particularly treacherous because the sound is reflected back parallel to its original direction (Mommertz, 2009, p.17). Including absorbent surfaces or including structured wall surfaces such as balconies can avoid these disturbing reflections (Cox, 2003, p. 119). In addition, designing walls and ceilings at a minimum 7° angle, helps to avoid flutter echoes that distort the sound (Mommertz, 2009, p.17).





[Fig 2.11] Franz List Hall, Raiding, by Atelier Kempe Thill, 2006.

From: Acoustics and sound insulation: Principles, planning, examples (p. 93), E. Mommertz, 2009, Boston, Detail.

⁶ Franz List Hall is lined entirely with wooden finishes. The Concert hall seats an audience of up to 600. The volume of the hall and its heavyweight paneled ceiling and walls allow it excellent acoustics for chamber music, piano recitals and small orchestra works (Mommertz, 2009, p. 16).

Material Selection:

Appropriate material selection is a vital part of designing a performance space to create an even spread of volume and clarity. A performance space is generally divided by absorbent and reflective surfaces (Mommertz, 2009, p. 92). Apart from the seating upholstery, most of the surfaces in a performance space for music are reflective. As a rule, large sound absorbent surfaces are avoided in order to promote a longer reverberation time and ensure an exciting sound. However, the expansive use of flat, reflective surfaces can lead to distortion in the sound heard as a result of echoes (Cox, 2003, p. 119). This means that solid surfaces with high weight per unit area are required in order to achieve a good reflection of sound for medium and low frequencies (Mommertz, 2009, p. 92).

The properties on which the acoustical performance of a material depends are primarily its density, Young's modulus, and loss coefficient. These factors determine the speed of sound in material (Ulrike, 2006, p. 1446). Birch is a popular timber choice in concert halls because of its density and speed of sound (Ulrike, 2006, p. 1446). Wooden surfaces also absorb low-frequency bass sound, which is why heavyweight linings such as plaster and concrete are typically more popular in large-scale concert halls because their reflective properties help to amplify low-frequency sound. However, because of the reduced volume in small-scale space this amplification is unnecessary. Instead, timber-plated panels are generally more common in small-scale concert halls [Fig 2.11]. The low-frequency absorption of timber in combination with the medium-frequency absorption of the audience leads to a clear bright sound⁶ (Bucur, 2006, p. 31). In comparison to smooth reflective surfaces, good sound absorbers are open-pore structures such as fibrous insulating materials, open-cell plastic foams and textiles, granulate or aerated concrete (Mommertz, 2009, p.20). For the material to be effective, it is critical that the sound can infiltrate the pores, where the sound energy can be eliminated by friction (Mommertz, 2009, p.20). Perforated or slotted wood-based products are frequently used, with a backing of sound absorbent material in good effect [Fig 2.12] (Bucur, 2006, p. 31). The absorptive effect depends on the proportion of openings, but also the size of the openings and the thickness of the material (Mommertz, 2009, p.20).

Curtains or sheets of fabric can also contribute noticeably to the attenuation in a room, and are a popular way of varying the acoustics in rehearsal or multipurpose rooms (Mommertz, 2009, p. 23). Dividing the interior of the performance space with a combination of smooth and irregular surfaces creates a highly desirable acoustic effect by defocusing the reflections and creating an even sound mix⁷ (Mommertz, 2009, p.17).



[Fig 2.12] Parish Hall, Forstenried, by Cornelius Tafel, 2001.

⁷ Parish hall is a multipurpose hall used for both speech and orchestral performances. The 160m² floor area and 6m ceiling height of the Parish hall ensures a good volume for the acoustics. The lining of the ceiling is mainly reflective, but there is an absorbent backing along the sides and at the rear. This method prevents an excessively live acoustic without over attenuating the room (Mommertz, 2009, p. 98).

From: Acoustics and sound insulation: Principles, planning, examples (p. 98), E. Mommertz, 2009, Boston, Detail.



[Fig 2.13] Landshut Music School: Typical practice room

⁸ A typical practice room at the Landshut Music School, fitted with a perforated plasterboard suspended ceiling, and a absorbent backing covering 60% of the area to avoid disturbing reverberation. One wall in each room is fitted with absorbent curtains so that the room's acoustics can be regulated (Mommertz, 2009, p. 89).

From: Acoustics and sound insulation: Principles, planning, examples (p. 89), E. Mommertz, 2009, Boston, Detail.

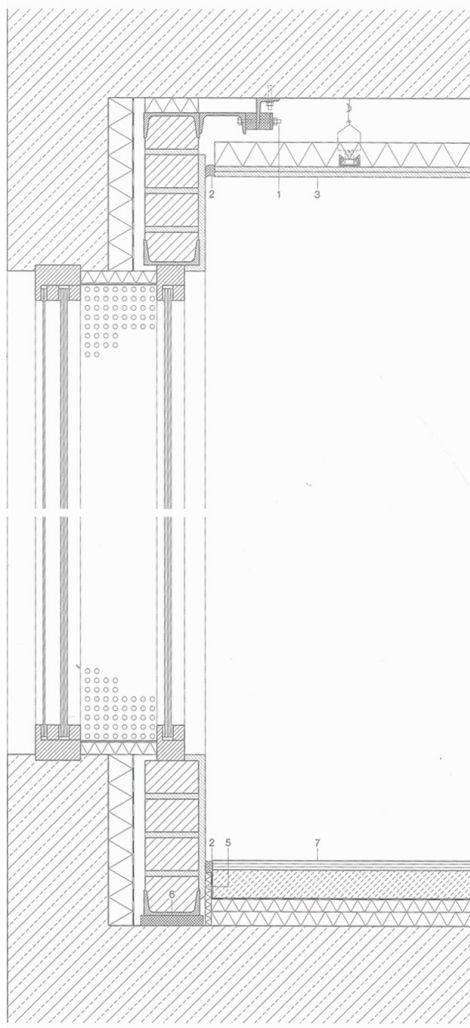
Classroom acoustics:

Classrooms within a music school usually range in size from very small practice rooms for one or two people, to larger practice rooms for percussion and brass ensembles. The size of a smaller room alone results in a totally different tonal relationship to those in large interior spaces intended for musical performances (Mommertz, 2009, p. 82). Therefore the assessment as to what constitutes *good acoustics* depends on the expectation of the listener and the desired ambience in relation to the instrument and the type of music being played (Mommertz, 2009, p. 90).

In rooms with too little damping, or in extreme cases no acoustic treatment at all, the loudness level is too high. Such rooms tend to encourage imprecise articulation and tone formation (Mommertz, 2009, p. 82). On the other hand, if the absorption surface area in the room is too large, the room is over-attenuated, which can sometimes curb the pleasure of playing and the motivation because correct intonation is made more difficult and the sonority of the instrument or voice is reduced (Mommertz, 2009, p. 82).

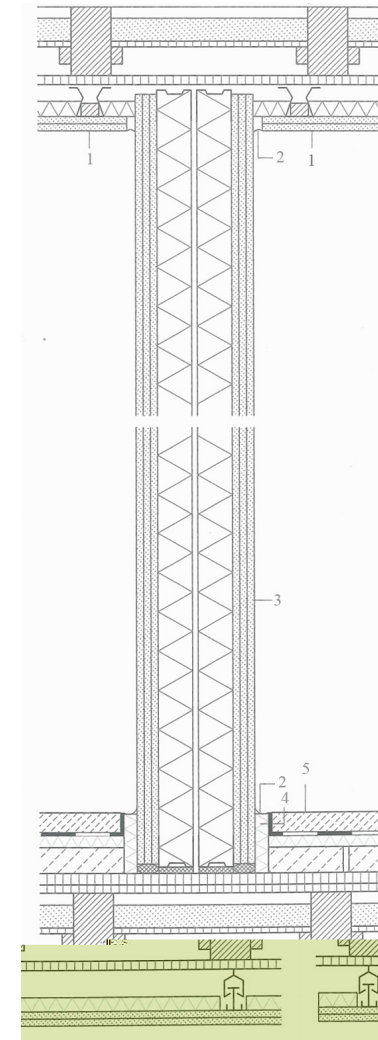
As discussed previously the loudness level of the room essentially depends on the volume of the room. Therefore the size of the room cannot be too small, especially for louder musical instruments. The loudness level in a room that is too small is frequently impossible to keep within a bearable limit (Mommertz, 2009, p. 83). The recommended minimal size for individual lessons on loud instruments is approximately 40m³, at least 6-8m² per person for ensemble or orchestra rehearsal rooms (Mommertz, 2009, p. 83). However, the larger the room, the more important it is to ensure an adequate ceiling height.

Applying the acoustic considerations discussed above such as sound scattering surfaces on the walls and ceiling also make a decisive contribution to achieving a balanced sound mix (Mommertz, 2009, p. 83). The extent of absorbent linings depends on the desired reverberation time and the use of the room⁸. Smaller spaces are generally designed to be more reflective. The recommended reverberation time for rooms for individual music tuition is about 0.6-0.8s (Mommertz, 2009, p. 83). However high attenuation and extensive absorbent surfaces on the ceiling and also the walls are indispensable in rooms used for band practices, drums and percussion ensembles. Adequate attenuation in the brass range is also important so that a rise in reverberation time for low frequencies is avoided [Fig 2.13] (Mommertz, 2009, p. 83).



1. Resilient fixing with rubber-metal elements
2. Permanently elastic seal
3. Suspended ceiling construction:
80mm Flexible hanger
60mm mineral-fibre insulation
2 No. 12.5mm plasterboard $m' \geq 20\text{kg/m}^2$
4. Coupled window:
Double glazing, 4mm + 16mm cavity + 6mm sound-absorbent reveal $\geq 200\text{m}$ single glazing,
8mm laminated glass.
5. Mineral-fibre perimeter insulation
6. Resilient bearing strip, 25mm polyurethane elastomer
7. Floor construction:
Wood-block floor finish
70mm screed, separating layer 30mm mineral-fibre impact sound insulation, dynamic
stiffness $\leq 20\text{ MN/m}^3$
35 mm wood-wool lightweight building boards
250 mm reinforced concrete.

1. Suspended ceiling construction:
 $\geq 60\text{mm}$ resilient bars fixed to battens, with 40mm mineral-fibre insulation in between
2 No. 12.5mm plasterboard, $m' \geq 20\text{kg/m}^2$
2. Permanently elastic seal
3. Wall construction:
3 No. 12.5mm plasterboard, $m' \geq 30\text{kg/m}^2$
75mm channel studs, with 60mm mineral-fibre insulation between 10mm cavity
3 No. 12.5mm plasterboard, $m' \geq 30\text{kg/m}^2$
4. Perimeter insulation
5. Floor construction:
 $\geq 25\text{mm}$ asphalt on separating sheeting 20mm impact sound insulation, concrete flags,
bonded, $m' \geq 120\text{kg/m}^2$, particleboard, screwed down, joints filled timber joist floor, with
plugging in between, $\geq 150\text{mm}$ flexible hanger, with 40mm mineral-fibre insulation between 2
No. 12.5mm plasterboard, $m' \geq 20\text{kg/m}^2$



[Fig 2.14] Detail section: Heavyweight room-in-room construction.

From: Acoustics and sound insulation: Principles, planning, examples (p. 84), E. Mommertz, 2009, Boston, Detail.

[Fig 2.15] Detail section: Double stud walls in dry construction.

From: Acoustics and sound insulation: Principles, planning, examples (p. 89), E. Mommertz, 2009, Boston, Detail.

6. *Noise isolation:*

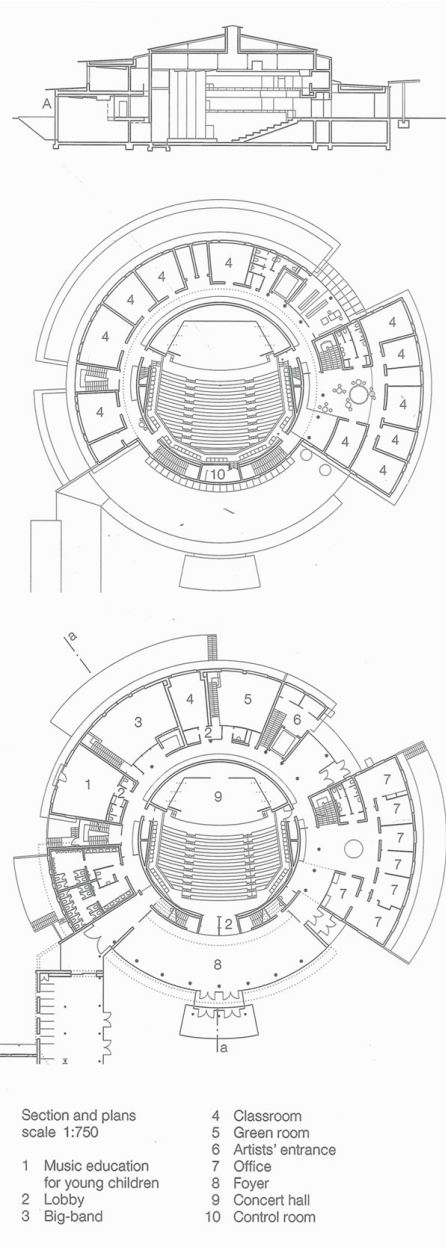
While thus far the discussion around the manipulation of sound has focused on the interior space, it is important to also consider the affect of exterior sound. In the case of a music school, especially one located in a dense urban environment, it is important to consider strategies for the isolation of sound so that the concert space is not effected by its exterior environment.

Sound requires a medium for its transmission and is categorised as either airborne or structure-born sound (Mommertz, 2009, p. 9). The speed of sound in solid bodies is about 5-15 times faster than that in air, depending on the material. Furthermore, it is far more complex because different wave forms ensue (Mommertz, 2009, p. 9). In rooms where sound insulation is paramount, separate rooms within the enclosing walls should be detailed. In this method acoustically decoupled walls, floors and ceilings are built inside the actual room itself. This is referred to as “room-in-room construction” [Fig 2.14] (Mommertz, 2009, p. 84). This method of construction can be performed using both dry and heavyweight construction methods [Fig 2.15] (Mommertz, 2009, p. 84).

Consideration with regards to the classroom layout should also be made to help isolate the noise between performance spaces. The Music School in Grunwald has been designed so that there are no loud rooms directly adjacent to the main hall [Fig 2.16]. Subsequently, all the practice rooms are of such a construction that all rooms can be used simultaneously, without causing disturbances in adjacent rooms. The radial plan of the building automatically results in walls that fan out, thus rendering unnecessary any wall linings to counteract the effect of parallel walls (Mommertz, 2009, p. 85).

[Fig 2.16] Grünwald Music School, Munich, by Biedermann & Rupprecht Biedermann, 2002.

From: Acoustics and sound insulation: Principles, planning, examples (p. 85), E. Mommertz, 2009, Boston, Detail.



This chapter establishes outlines for room sizes, audience capacities and corresponding reverberation times, typical of a school of music programme. In doing so, it has also distinguished between the acoustic requirements of rooms for speech along with those of music. The investigation into the basic science of acoustics establishes that reverberation time is the most significant acoustic variable in determining the desired effect or impression of acoustic space. The volume and the arrangement of reflective and absorbent materials is the primary determinant of reverberation. This investigation has illustrated how volumes may be designed and interiors adjusted to suit a specific instrument and the required acoustic ambience. However, to achieve the sensation of intimacy, which seems to be a vital aspect to all music genres, the concert space should be designed with an intended ITDG of less than 20ms. Finally, this chapter has provided practical solutions and tested construction methods that ensure acoustic isolation and the prevention of exterior noise. Through an analysis of large-scale concert hall precedents, the following chapter discusses the integration of a concert programme with the urban territory.

Chapter 3 | *Urban Territory & the Public Interface*

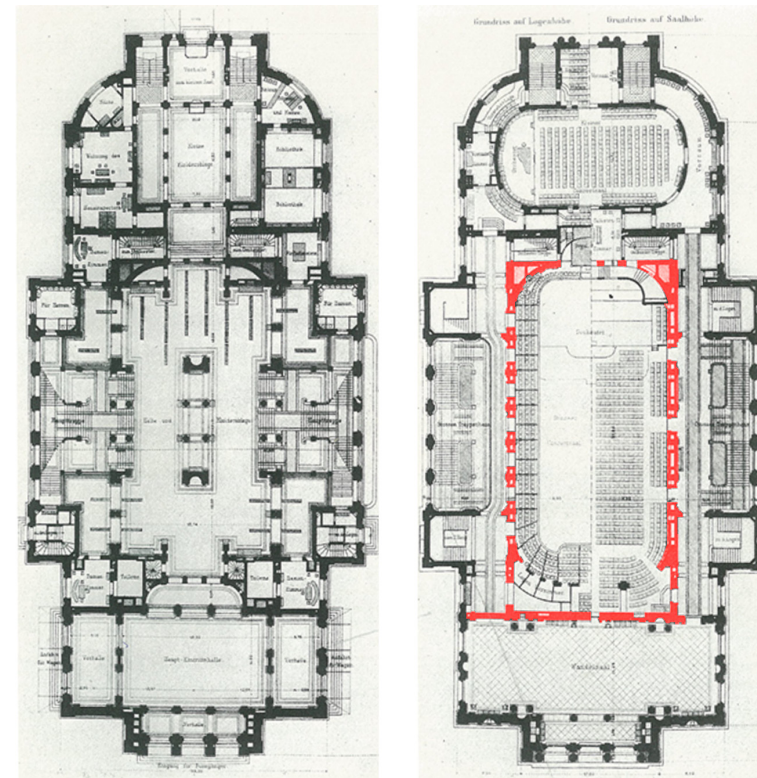
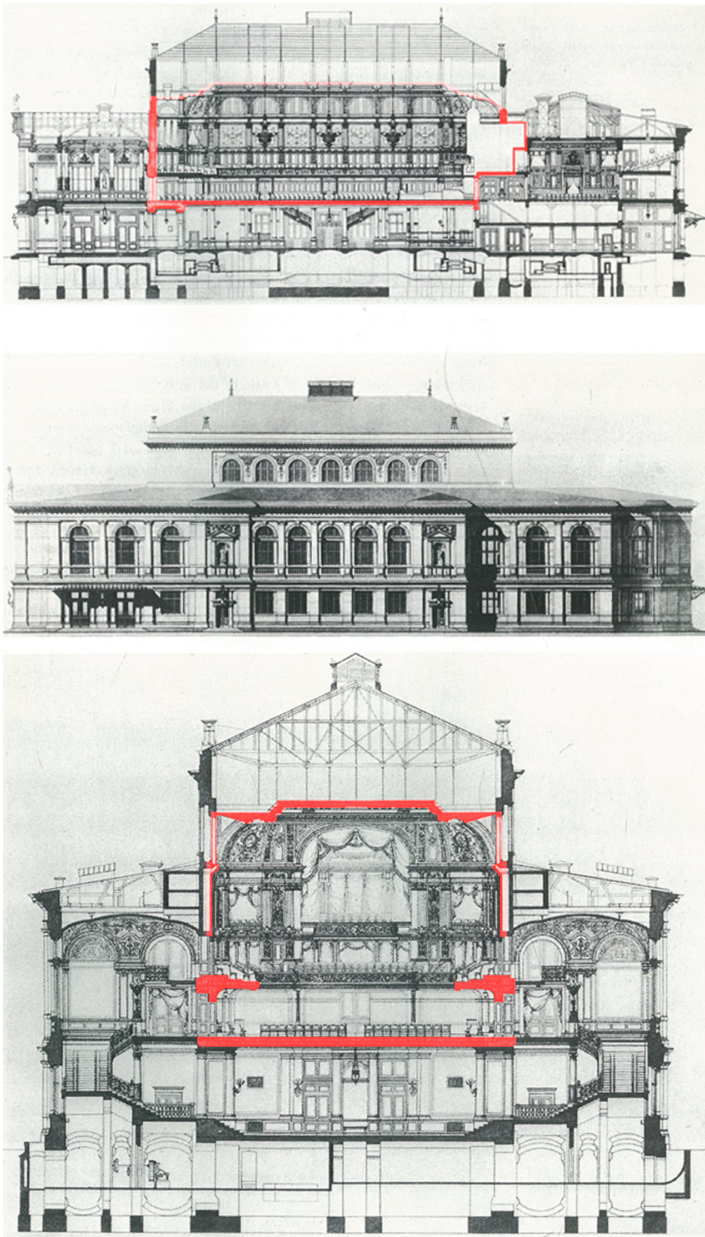
Chapter 3 | *Urban Territory & the Public Interface*

As discussed in Chapter one, the increase in audience size generated by the expanding middle class during the eighteenth and nineteenth centuries provoked the development of larger concert hall infrastructure. This trend continued throughout the twentieth century with the audience capacity of some present day concert halls exceeding 3000 persons. From the expansion of the early music rooms, concert halls soon established themselves as cultural institutions. Today these concert spaces often develop a distinct relationship with the city, occupying some of the most prominent urban sites.

Although these concert halls operate on a much larger scale in comparison to the performance spaces required by the NZSM, as spaces intended for public use, they are both required to operate a social function. Through an analysis of existing large-scale concert halls, this chapter investigates the social component of concert architecture. This chapter uses site analysis to discuss the integration of concert halls with their respective urban territory. It also explores the visual relationship between the internal contents and exterior container, and discusses the strategies used to develop a responsive interface between the acoustic programme and the public domain.

Much of the historical literature regarding architecture and music focuses on making abstract comparisons between the manifestation and construction of the two art forms (Waterhouse, 1921). However, many contemporary theorists approach the intersection between architecture and music with a large degree of incredulousness. As John Sands writes:

It is simply too difficult to ideate a concrete basis for such a comparison of architecture and music. The affective devices of architecture differ greatly from those of music, though historically each discipline has shown an astonishing capacity for appropriating convincingly and meaningfully the theoretical tropes of the other (Sands, 2007, p. 214).



[Fig 3.01] Neues Gewandhaus: *(Above)* Plans, at entry level (left) and concert hall level (right). *(Adjacent)* Sections and elevation.

⁹ Neseled inside the buildings exterior the Neues Gewandhaus Concert Hall illustrates the early demand for acoustic isolation. However, located on the second floor, the concert hall is removed from any strong physical or visual links to the exterior.

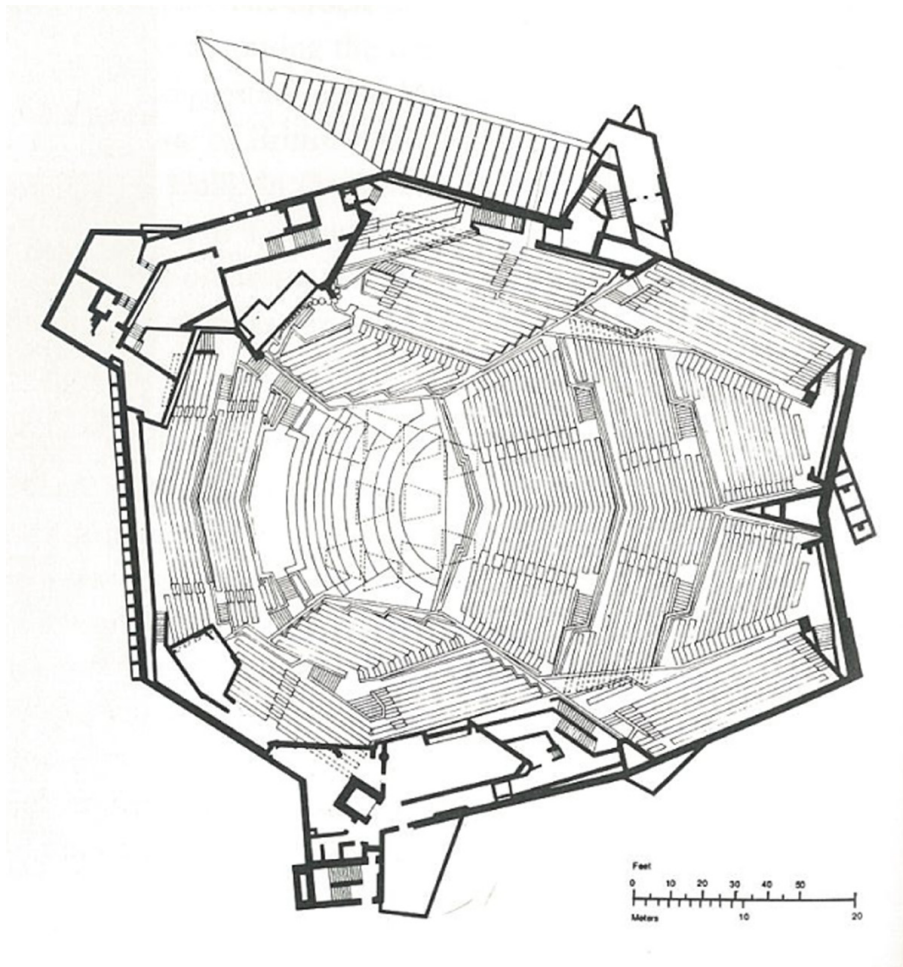
Adapted from: Buildings for music: The musician, and the listener from the seventeenth century to the present day (213), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.

Alternatively Sands argues, for the contemporary comparison to be fruitful we must examine *what* music and architecture do rather than *how* they do it (Sands, 2007, p. 214). He writes:

My proposition is that the common ground of music and architecture, beyond all topical elements-form, proportion, harmony, and so on- and beyond the more-than-occasional overlap in parlance, might be better and more convincingly assessed through a consideration of shared social and cultural functions (Sands, 2007, p. 214).

Antje Pieper reinforces this association of music and its social function in her book *Music and the Making of Middle-Class Culture*. Through a comparison of eighteenth century concert life in Leipzig and Birmingham, the book describes how the two revered concert institutions provided a focus for social and cultural life in the cities as a whole. The rise of Classical music canons in different musical genres by the 1840s, Pieper argues, provided “stability for the establishment and maintenance of middle-class cultural identity for much of the remaining decades of the nineteenth century” (Pieper, 2008, p. 196).

Although the eighteenth century expansion of the concert hall encouraged broader social groups, it remains today an event experienced by only a minority of the population. This is partly because of the concert halls traditionally obscured location within an acoustically independent container.⁹ While the concert hall unarguably serves a social function, historically it has lacked the visual transparency and accessibility between its acoustic layers to establish a comprehensive connection with the exterior public. Thus, the concert hall is caught in a conflict between the acoustic desire to create an intimate and secluded experience, and the social desire to make that experience accessible to all members of the public [Fig 3.01].



[Fig 3.02] The Berlin Philharmonie Concert Hall, Berlin, by Hans Scharoun, 1963: Plan.

From: Buildings for music: The musician, and the listener from the seventeenth century to the present day (p. 302), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.



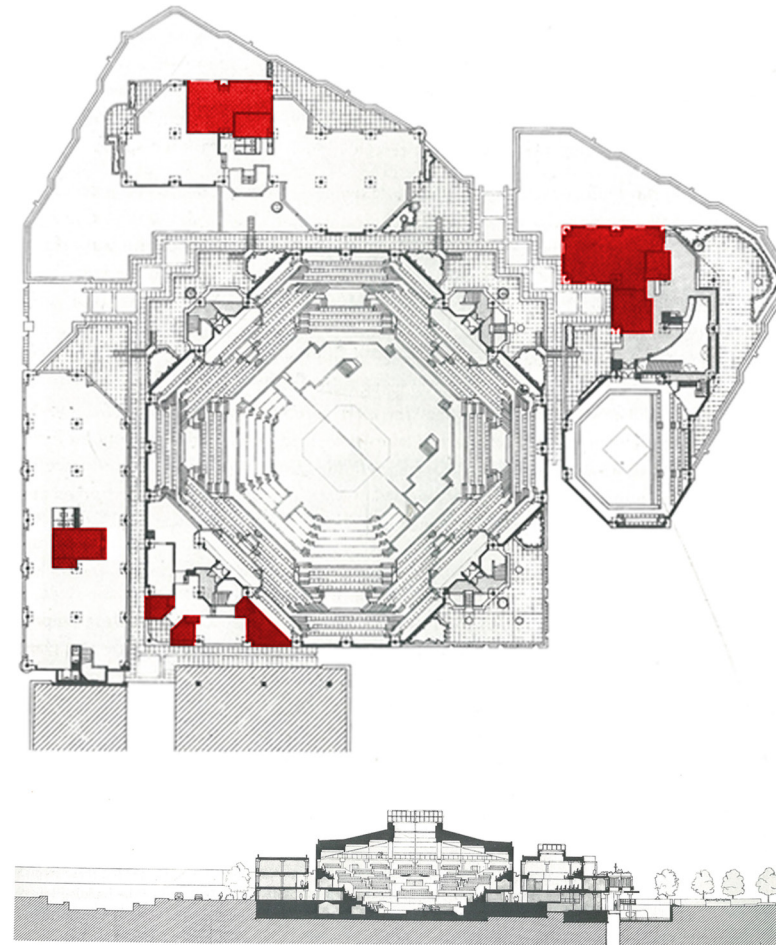
[Fig 3.03] Disney Concert Hall, Los Angeles, by Frank Gehry, 2003.

From: *Symphony: Frank Gehry's Walt Disney Concert Hall* (p. 154), by F. Gehry, 2003, New York, Harry N. Abrams.

[Fig 3.04] The Muziekcentrum Vredenburg, Utrecht, by Herman Hertzberger, 1977: Plan and section.

The foyers shaded red around the hall are bounded on two sides by enclosed shopping streets, seen at gallery level.

Adapted from: Buildings for music: The musician, and the listener from the seventeenth century to the present day (p. 305), by M. Forsyth, 1985, Cambridge, Massachusetts: MIT Press Cambridge.



Although beyond the specific scope of the shoebox, the vineyard or arena formation of the Berlin Philharmonie by Hans Scharoun had a significant influence on the social theories in regard to concert hall development in the late twentieth century [Fig 3.02] (Forsyth, 1985, p. 306). These principles have since been reapplied to more contemporary examples such as Frank Gehry's Disney Hall, 2003 and the Copenhagen Concert Hall, by Jean Nouvel in 2009 [Fig 3.03] (Hammond, 2009). Visually the vineyard formation breaks the monotony created by linear rows of seating found in traditional concert halls. However, this is often at the expense of an even sound distribution. In terms of equal sound proportions meeting every member of the audience, the shoebox model remains the most effective (Hammond, 2009). Nevertheless, the Berlin Philharmonie was an important principal for the later design of the Muziekcentrum Vredenburg, Utrecht, by the Dutch architect Herman Hertzberger, which opened in 1977 [Fig 3.04] (Forsyth, 1985, p. 306). Hertzberger took the social intentions pioneered by Scharoun and extended them into the context of the city. The aim of this was to integrate music making into the day-to-day community by making itself highly accessible and "non-elitist" (Forsyth, 1985, p. 306).

Hertzberger takes principles from an urban design scale and reduces them down to the building scale. Architecturally, this is achieved with the amalgamation of public foyers and intimate shopping galleries that surround the concert hall. He also introduces irregularities such as viewpoints, changes of level, and seating alcoves, in order to introduce the human scale and a sense of place to the large-scale complex (Forsyth, 1985, p. 306). The proximity of the hall to public activity stimulates interest in its obscure internal function. The circulation in between becomes an extension of the street life outside, providing clear access and helping to define the location of the internal concert hall.

Hertzberger's concert hall demonstrates an ability to see beyond the narrow confines of the specific problem. Ultimately, specialization can only work within the context of a comprehensive cultural understanding (Grueneisen, 2003, p. 16). The threshold between the building's envelope and its urban context has an enormous effect on the success of the buildings internal functionality. The following analysis determines the ways in which contemporary precedents of the large-scale concert halls have or have not acknowledged the cultural requirements of their context. The analysis focuses on urban design elements such as: edges, nodes, landmarks and the existing fabric, as reference points to help integrate the programme with the surrounding context (Lynch, 1960).

[Fig 3.05] Casa da Musica, Porto, by Rem Koolhaas and OMA, 2005.

From: OMA, by P. Ruault, 2005, Retrieved from http://www.oma.eu/index.php?option=com_projects&view=portal&id=48&Itemid=10 (accessed 20/04/2011).



[Fig 3.06] Casa da Musica.

From: OMA, by P. Ruault, 2005, Retrieved from http://www.oma.eu/index.php?option=com_projects&view=portal&id=48&Itemid=10 (accessed 20/04/2011)



3.1 | *Contemporary Examples*

Casa da Musica, Porto, 2005:

Located in a historic neighborhood of Porto, Portugal, the Casa da Musica, designed by Rem Koolhaas and OMA deals with the contextualization of old and new architectural fabric [Fig 3.05]. The site, although one of the strategic points on the city's topography, had never been the focus of true urban development (Gänshirt, 2005, p. 46). The Boavista plaza, a circular space from which the streets project radically, remained without a future (Gänshirt, 2005, p. 46). With the terminus of a disused suburban line, vacant tram depots, seedy department stores, an old cemetery and cafes and business in decline, the neighbourhood displayed all signs of decay (Gänshirt, 2005, p. 46). The architectural response was a stand-alone object in stark contrast to the existing fabric [Fig 3.07].

However, it is this contrast that clearly defines the boundaries between old and new. Pinpointed at the adjacent centre of a major traffic intersection, the solitary building sits on a travertine-paved plateau in front of the Rotunda's park. The streets surrounding the site isolate the building as an object in space. However, access is resolved with pedestrian crossings at three of the site's four main corners. Although the form and colouring of the building seem to disregard the existing fabric, the brown and gold Jordanian travertine covering the outdoor plaza creates a striking contrast to the dreary grey granite used all over the city (Castro, 2006, p. 56). This contrast helps to define the edge conditions of the plaza, which also functions as a spill out space for the public to gather before and after a performance. Gathering points such as this encourage public interaction with the building and enhance the sensation of an event.

Inside, two concert halls appropriating the traditional shoebox shape have been carved out from the monolithic volume (Gänshirt, 2005, p. 46). However, contrary to the traditional model, the main auditorium is lined with corrugated glass surfaces at both of its ends to articulate the location of the concert hall. These double corrugated-glass walls also activate the building at street level, by establishing a visual link between interior and exterior (Castro, 2006, p. 57).



[Fig 3.07] Casa da Musica: Site plan.

1. Casa da Musica

Adapted from: Google Maps, Retrieved from <http://maps.google.com>. (accessed 15/03/2011).



[Fig 3.08] Concert Hall Bruges, Bruges, by Robbrecht and Daem Architects, 2007: Site plan.

1. Concert Hall Bruges

Adapted from: Google Maps, Retrieved from <http://maps.google.com>. (accessed 15/03/2011).



[Fig 3.09] Concert Hall Bruges, Bruges, by Robbrecht and Daem Architects, 2007.

From: Architectural Design (p. 106), by J. Melvin, 2007.



[Fig 3.10] Concert Hall Bruges.

From: Architectural Design (p. 109), by J. Melvin, 2007.

An expansive staircase announces entry to the building [Fig 3.06]. Like Hertzberger's hall, pockets of public space are scattered throughout the building's interior to reduce its large-scale volume. A continuous public route connects the spaces around the main concert hall by means of stairs, platforms and escalators (OMA, 2005). The collaboration of these architectural strategies contributes to a lucid transition between interior and exterior, while also giving purpose to a previously under-determined site.

Bruges Concert Hall, Bruges, 2007:

Like the Casa da Musica, the Concert Hall in Bruges by Robbrecht and Daem Architects deals with the contextual issue of locating a large-scale contemporary building within an existing historical fabric [Fig 3.08]. In addition, it is an example of a disused and under defined site becoming functionalized with a responsive design solution.

The site itself is an opening within a complex and irregular network of traffic flows. The location of the concert hall was once the site of the city's main railway station, however it was moved south when Bruges became a through-route rather than a terminal (Melvin, 2007, p. 105). The railway was replaced by a motorway which tunnels beneath a large public square in front of the present concert hall [Fig 3.09] (Delbeke, 2006, p. 360). This motorway extends through the site dividing the park at the rear end of the recently located concert hall.

The incursion of the motorway created an opening for the concert hall to sit as a free-standing object in between the closed and neatly defined border of the historical city (Delbeke, 2006, p. 360). Locating the concert hall at the southern end of the square created an edge condition to the previously under defined zone (Delbeke, 2006, p. 360). Fringed on one side with a parade of cafes and restaurants, the remaining edges of the square are articulated with rows of trees that help to define the space as an entity (Melvin, 2007, p. 105). The entrance located at the south-eastern corner of the square connects with an intricate web of low-rise streets. Although these streets surround the square, pedestrian crossings are located at close intervals to provide easy access to the popular thoroughfare.

[Fig 3.11] Copenhagen Concert Hall, Copenhagen, by Jean Nouvel, 2009.

From: Architectural record, by R. Halbe, 2009, Retrieved from <http://archrecord.construction.com/projects/portfolio/archives/1002copenhagen-1.asp> (accessed 20/04/2011).



[Fig 3.12] Copenhagen Concert Hall.

From: Architectural record, by R. Halbe, 2009, Retrieved from <http://archrecord.construction.com/projects/portfolio/archives/1002copenhagen-1.asp> (accessed 20/04/2011).



Unlike the stark contrast between the Casa da Musica and its context, the Bruges Concert Hall develops a far more sensitive response to its surroundings. Firmly embedded into the existing fabric, the hall shares the skyline with the cities three iconic medieval towers. Without aping the towers, the subtly sculptured form of the hall, with vertical elements of its own, creates an echo of this historic context (Delbeke, 2006, p. 360). The variegated treatment of the envelope generates four distinct facades materialised in a shield of ceramic tiles whose red colour echo with the surrounding city's roofs. Clusters of small-scale windows arranged throughout the exterior create an intermediate scale of detail, which mimics the domestic scales surrounding the hall (Delbeke, 2006, p. 360). The monolithic sections of the facade enhances the variety within the existing fabric, while large sections of semi-transparent and transparent materials help to divide the volumes bulk (Delbeke, 2006, p. 360).

The main tower is made up of two transparent facades lined with exterior mullions. This visual transparency in conjunction with the clearly articulated slope above the public entrance enunciates the buildings public function [Fig 3.10] (Delbeke, 2006, p. 360). Furthermore a dialogue between interior and exterior is enhanced by the large window acting as a screen emerging from the facade, which at night during performances projects messages and images to the square. Although high tech and fully part of contemporary visual culture, this screen is first and foremost an architectural element connecting the semi-public programme of the interior to the public exterior (Delbeke, 2006, p. 360).

Copenhagen Concert Hall, Copenhagen, 2009:

This contemporary trend of digital projections and virtual facades is exasperated in the Copenhagen Concert Hall designed by Jean Nouvel [Fig 3.12]. The 45 metre high rectangular box is covered in a series of semi-transparent screens made of glass fibres and a PVC coating (Stephens, 2010, p. 72). At night a video montage of concert performers, fragmented forms and colours drifts across the building's exterior. These video projections continue into the building's interior creating a visual experience verging on the psychedelic (Ouroussoff, 2009). However, beneath these technological gimmicks used to seduce the observer, the building develops an interesting dialogue between the contents and its container [Fig 3.11] (Stephens, 2010, p. 72).

[Fig 3.13] Sage Music Centre. Gateshead, by Foster and Partners, 2004.

From: Foster and partners, Retrieved from http://www.fosterandpartners.com/Practice/1/Architecture_and_Planning.aspx (accessed 12/04/2011).



In a largely under developed site, the hall sits among monotonous residential and office blocks (Ouroussoff, 2009). The simplicity of the form in combination with its monumental scale clearly defines it in the skyline. Materialised with a translucent fabric stretched over a structural frame of steel beams and tension cables, the envelope operates a dialogue between the semi-transparent exterior and the density of the interior (Nouvel, 2009, p. 32). Embedded within the glass-fibre-and-steel cage, these masses within the interior are discretely revealed to the exterior.

The interior itself is a unity of varied voids and volumes. Three small scaled performance facilities are sunk 8ft below grade, while the main concert hall hovers in the upper reaches of its container (Stephens, 2010, p. 72). Public space at ground level such as the restaurant and bar help to articulate the circulation between the performance spaces. Although the main concert hall is located above the main hive of public activity, the towering proportions of the lobbies throughout the levels visually propel visitors towards it (Stephens, 2010, p. 72). Clad in wooden panels that resemble reptilian scales, the concert hall has a strong presence and is clearly defined within the internal space.

As cultural centres aimed at reviving part of their respective cities, these examples use their cultural function to help promote the development of their surrounding context. However, as Peter Hall points out, these cultural schemes rely heavily on the cities demand for cultural consumption (Hall, 2004, p. 257). This itself demands a certain kind of population, which in turn presupposes a certain kind of economy (Hall, 2004, p. 257). Alternatively, a longer-term strategy with a much deeper process is the development of a city of cultural production (Hall, 2004, p. 258). Glasgow for example, with the success of its art school and the works of Charles Rennie Mackintosh, has helped the city mature into one of cultural production (Hall, 2004, p. 258). Arts schools of this kind produce artists, and if enough stay in the city after they graduate they can begin to generate a network and an informal college (Hall, 2004, p. 258). Gateshead is a city clearly trying to achieve the same thing with the studios built into its new Baltic gallery, and with the next-door Sage Music Centre [Fig 3.13] (Hall, 2004, p. 258). Combining performance and education on a central city site locates the concert programme within a critical mass and is therefore more likely to contribute to further cultural production (Hall, 1999).

However, it is important to acknowledge that these examples operate at the large-scale end of the performance space spectrum. Their iconic forms and monumental scale lead them to be what Hal Foster describes as “spectacle architecture” (Allen, 2007, p. 116). By comparison the cultural status of the NZSM is far more modest. Nevertheless, the contextual responsiveness discussed in these examples has specific relevance to the integration of the NZSM programme with a disused urban site. Although the NZSM operates as a private institution, it also operates a social function in exhibiting New Zealand musicians to the general public. Therefore the analysis of these large-scale structures in regards to public integration, access and transparency remains relevant to the NZSM programme.

Performance spaces and educational institutions play a crucial role in the social and cultural development of a city. However, for the performance space to function effectively as a public amenity it must develop an informed response to its context. The findings from this analysis of large-scale concert halls establish that the most effective way to incorporate a concert programme within an urban territory is through clearly articulated pathways and the integration of public space. Furthermore, locating the concert programme within close proximity to similar cultural/performance programmes helps to develop a critical mass of cultural productivity. The following chapter sets specific spatial criteria for the NZSM programme with a design brief and a corresponding Space List.

Chapter 4 | *Design Brief*

¹⁰(See Appendix 3 for existing NZSM plans.)

Chapter 4 | *Design Brief*

This design brief has been developed through a series of site meetings and semi-structured interviews with representatives of the New Zealand School of Music (NZSM) faculty and planning authorities from Victoria University Wellington.

The NZSM is divided into two campuses. One is located at Victoria University's main campus in Kelburn and the other is located at Massey University in Mt Cook [Fig 4.01]. The school currently faces three major issues; a lack of space, a lack of public engagement and the obvious impracticality of having one school split in two, at opposite ends of the city.¹⁰ This design brief proposes to combine the two campuses into one, on a central city site (Wareham, 2004).

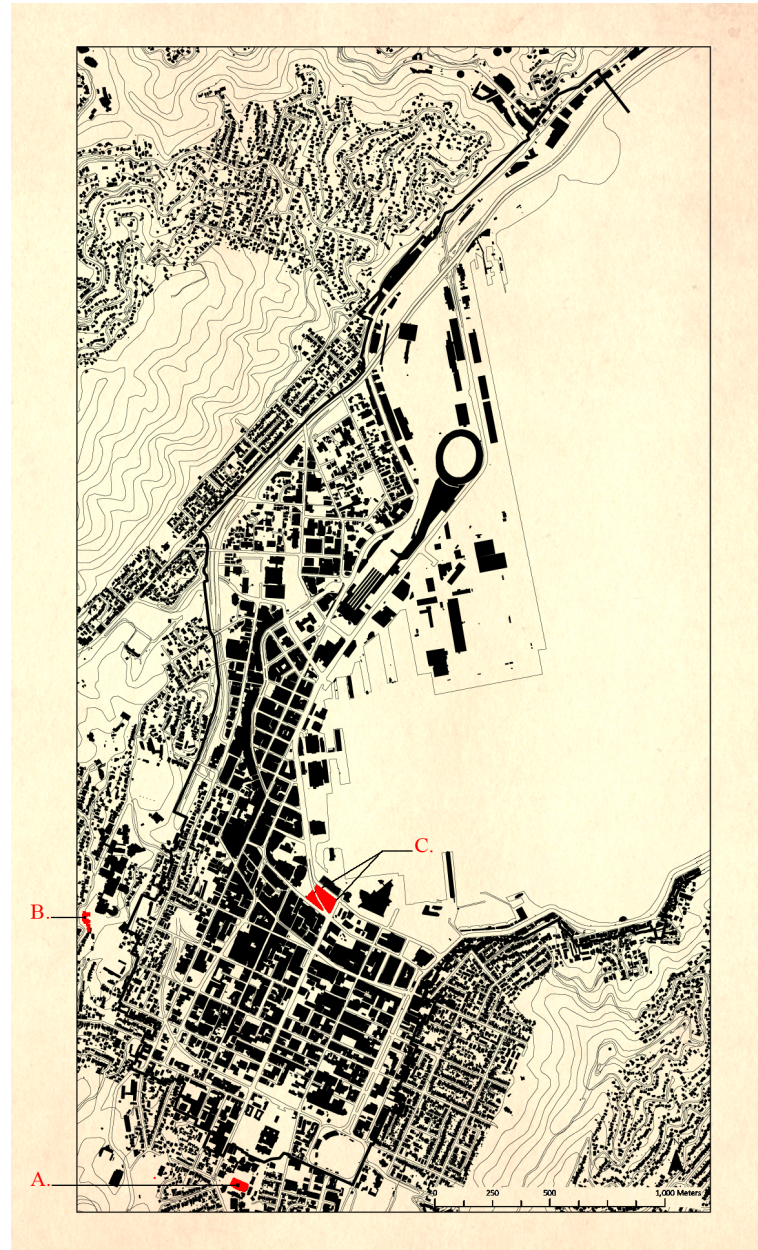
The proposed site is within walking distance of both Wellington's Central Business District (CBD) and the Waterfront [Fig 4.02]. The site consists of two parts, *A* and *B*. Currently the John Chambers Building (JCB) occupies site *A* intersecting Jervois Quay and Cable Street. Site *B* is a Public Park and Private Car Park on the opposite side of Jervois Quay bordered by Wakefield Street and Taranaki Street. The school will occupy both sites. However, the spaces designed to incorporate public use will be located on Site *A*, while Site *B* will be designed to function more specifically for NZSM tuition and administration.

[4.01] City Map, Wellington, 2011.

- A. Current Massey Campus
- B. Current Victoria Campus
- C. Proposed inner-city site

The map in [Fig 4.01] illustrates the physical disconnection between the two campuses. Located on the outskirts of the central city, neither campus has a strong link to the concert going public of the central city.

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.





[Fig 4.02] Site.

Adapted from: Google maps, Retrieved from <http://maps.google.com>. (accessed 05/06/2010).

4.1 | *Space List*

1. Concert Spaces:

Recital Hall:

The school's largest performance facility is the Recital Hall. This is the principal performance venue of the facility and is used for the presentation of public performances by students and faculty. The shoebox is chosen as an acoustic model for the Recital Hall, because of its ability to deliver appropriate acoustics for both Classical and Romantic periods. Seating an audience of 350, the hall should be a relatively narrow and relatively tall room, with a shallow main floor rake and a balcony extended on each side to create ledges at the sides and rear of the hall. The total volume of the hall is established in coordination with the audience capacity and the desired reverberation times for Classical and Romantic periods defined in Chapter one. The internal dimensions in conjunction with the material selection will be specified to ensure early sound reflections to all members of the audience. The primary goal of this design is to deliver the most visually and acoustically intimate space possible (Wareham, 2004).

Multipurpose Hall:

The Multipurpose Hall is to be designed for rehearsal use by large ensembles of the School. However, it will be used extensively for a wide range of activities ranging from other School of Music needs to small-scale public performances and community events. It will be designed as a flexible performance space, used primarily for multi-track recording and playback; electronic music composition; opera rehearsals; small-scale music ensembles; and activities involving movement.

The Multipurpose Hall is to be a rectilinear (shoebox) space with a flat floor. The material treatment of the interior is to be in accordance with the acoustic literature discussed in Chapter two. The hall is to be designed to accommodate a range of reverberation times for both amplified and non-amplified music types. Designed with loose seating, the audience capacity is to be adjusted as required. However, the space is to have a maximum capacity of 140 persons (Wareham, 2004).

Lecture Theatre:

The Lecture Theatre will be sized for an audience capacity of 150 persons, while the stage area will be sized to fit an ensemble of up to ten performers. The acoustics of the venue will be designed to accommodate both speech and music performance. The room will include a permanently installed sound system for reinforcement and playback. It will therefore require structural rigging to support the AV systems and production lighting (Wareham, 2004).

Gamelan Room:

The Gamelan Room will be located between the Main Lobby and the Recital Hall. It is expected that it will be placed in a primarily transparent container so that the Gamelan instruments can be observed as a museum artefact when not in use. The instruments will be able to be seen by the public entering the building through the Main Lobby and also those viewing the building from the exterior. When the instruments are in use the glass partitions walls will open out so that the space works as one acoustic volume in which the Gamelan instruments can be heard (Wareham, 2004).

Jazz Café:

The Jazz Café will be a publicly accessible commercial organisation and is intended to be a key area of interaction between students and visitors to the facility. This venue will therefore be connected to the public circulation within the building and should be located near the main entrance (Wareham, 2004).

2. Teaching and Rehearsal Spaces:

Teaching and rehearsal spaces in the facility fall into three categories: Seminar Rooms, large & small Practice Rooms and large & small Teaching Studios. Each of the rooms in this section will be constructed with a room-in-room configuration to minimise the noise between rooms (Wareham, 2004).

Seminar Rooms:

Seminar Rooms will primarily be used as teaching spaces, but may also be converted into practice rooms for small sized ensembles. These spaces will be a scaled down version of the shoebox model with a small stage and angled walls at one end. The spaces will require a flat floor and loose seating so that occupants may easily alternate the use of the space (Wareham, 2004).

Large and small Practice Rooms:

Practice Rooms will be designed for individual or small groups between 3-4 persons. Practice Rooms should be grouped together to promote community and camaraderie amongst students (Wareham, 2004).

Large and small Teaching Studios:

Studio spaces will function as individual Staff Offices, but also as spaces where staff teach individual lessons. These spaces are where the teachers will spend most of their time therefore they should be comfortable with adequate natural light. Large Teaching Studios are sized to hold a grand piano as well as a desk and teaching area (Wareham, 2004).

3. Specialized Spaces:

Ethnomusicology / Music Therapy Room:

This space is designed for musicians to practice breathing and muscle strengthening exercises. It will be designed with a Sprung Floor and have a high level of absorption to keep internal noise levels low. The space will also facilitate ethnomusicology classes, which involves the study of native instruments and dance rehearsals (Wareham, 2004).

Keyboard / Midi Labs:

Four rooms will accommodate 25 keyboard/computer workstations each for teaching and individual work. These rooms should be grouped together to encourage community and camaraderie amongst students (Wareham, 2004).

Electronic Music Studios:

These studios will be designed for use by the electronic music department as high quality recording and composition studios. They will be either attached to, or in close proximity to the major concert spaces (Wareham, 2004).

Percussion Rooms:

The Jazz and Classical Percussion departments will be allocated three spaces for ensemble rehearsal and teaching. Percussion instruments produce extremely loud sounds so it will be important to provide both an adequate room volume and sufficient sound isolation so that the use of these instruments does not disturb surrounding tuition spaces.

Library:

The Library will be designed as a quiet, naturally lit space. It will contain all the reference resources for the school as well as a multi-media listening station (music archive). The library should be located in such a way that it is easily accessible to the public without the public entering the main body of the school (Wareham, 2004).

Administration Spaces:

The Administration Space should not require an excess of 100m² and will be designed as an open plan office space (Wareham, 2004).

The spatial Matrix [Fig 4.02], on the following page outlines the recommended capacities and volumes for the spaces listed above.

	Public / Private	Quantity	Capacity (persons)	Ideal Floor Area	Ideal Volume per person	Ideal Reverberation time	Absorption	Natural Fenestration	Natural Light
<i>Performance venues:</i>									
Recital Hall	Public	1	350 seats	370m ²	10 - 12m ³	1.3 - 1.6 seconds	Low	No	No
Multipurpose Hall	Public	1	140 seats	180m ²	7m ³ min	1.3 - 1.5 seconds	Medium	No	Yes
Lecture Theatre	Public	1	150 persons	130m ²	4 - 6m ³	0.8 - 1 second	High	No	Yes
Jazz Café	Public	1	250 max	150m ²	7 - 10m ³	1 - 1.3 seconds	Medium	Yes	Yes
Gamelan Room	Public	1		150m ² 980m ²	12+ m ³	1.8 - 2 seconds	Very Low	Yes	Yes
<i>Teaching and rehearsal spaces:</i>									
Seminar Rooms	Private	2	50 +	80m ²	6m ³	1 second	High	Yes	Yes
Largé & Small Practice Rooms	Private	23	6 max	12m ² -30m ²	5 - 8m ³	0.8 - 1.3 seconds	Medium	No	Yes
Large & Small Teaching Studios	Private	7	6 max	12m ² -30m ²	5 - 8m ³	0.8 - 1.3 seconds	Medium	Yes	Yes
Percussion Room	Private	3	10 max	50m ² 890m ²	6 -10m ³	0.5 - 1 second	Very High	No	Yes
<i>Specialized Spaces:</i>									
Ethnomusicology/Music Therapy Room	Private	1	30 max	35m ²			High	Yes	Yes
Keyboard / Midi Labs	Private	4	25 max	60m ²			Medium	Yes	Yes
Electronic Music Studios	Private	4	10 max	40m ² 435m ²			Very High	No	No
<i>Library & Administration Offices:</i>									
Library	Public		70	900m ²			High	Yes	Yes
Administration Offices	Private		10+	100m ² 1000m ²			High	Yes	Yes
TOTAL				3305m ²					

[Fig 4.03] NZSM space matrix. By author, 2011

4.2 | *Design considerations*

Sites where performances take place have in fact a significant function in the structuring of cities and territories with which they irrigate culturally (Sebastian, 2010). As mentioned previously the site is chosen for its proximity to both the CBD and Waterfront. Locating the NZSM between two highly populated zones aims at promoting increased interaction between the NZSM and general public. It is intended that the proposed site will act as a stepping-stone for pedestrians between these two public zones. Way finding will therefore be essential to the success of the facility as the performance spaces must be easily accessible to the public. The following section develops an analysis of the proposed site, which includes plotting the surrounding performance infrastructure and addressing the current issues of access and circulation.

Chapter 5 | *Site Analysis*

Chapter 5 | *Site Analysis*

The Casa da Musica, Concert Hall Bruges, and the Copenhagen Concert Hall are three examples which demonstrate an aim to revive disused parts of their respective cities with cultural infrastructure. However, as mentioned in Chapter three, these cities and their corresponding cultural incentives operate on a scale much larger than the proposed scheme for the NZSM. Although the proposed site for the NZSM programme is currently disused, the wider urban periphery is well established with existing cultural infrastructure [Fig 5.01]. While applying a large-scale theoretical concept, whereby culture is used to stimulate growth, the integration of the NZSM with the proposed site is aimed at adding a secondary layer of culture to the existing cultural infrastructure in the wider urban context (Hall, 2004, p. 257).

This chapter develops a site analysis which investigates the existing site context including the existing building. In reference to Chapter three, this analysis investigates urban design principles to inform the integration of the NZSM with the urban territory. The final section of this chapter briefly discusses adaptive reuse and the architectural strategies used to treat the juxtaposition of old and new architectural fabric.

Strategic Location:

The site is located in-between the CBD and the Waterfront [Fig 5.02]. It has been strategically chosen for the purpose of this design project for both its prominent location and approximation to surrounding large-scale performance infrastructure - specifically the Michael Fowler Centre (capacity 2,210), Town Hall (capacity 1,600), and the Opera House (capacity 1,380). The aim of this design project is to locate the NZSM at the intersections of these existing large-scale structures to establish a performance precinct (TNS, 2004).

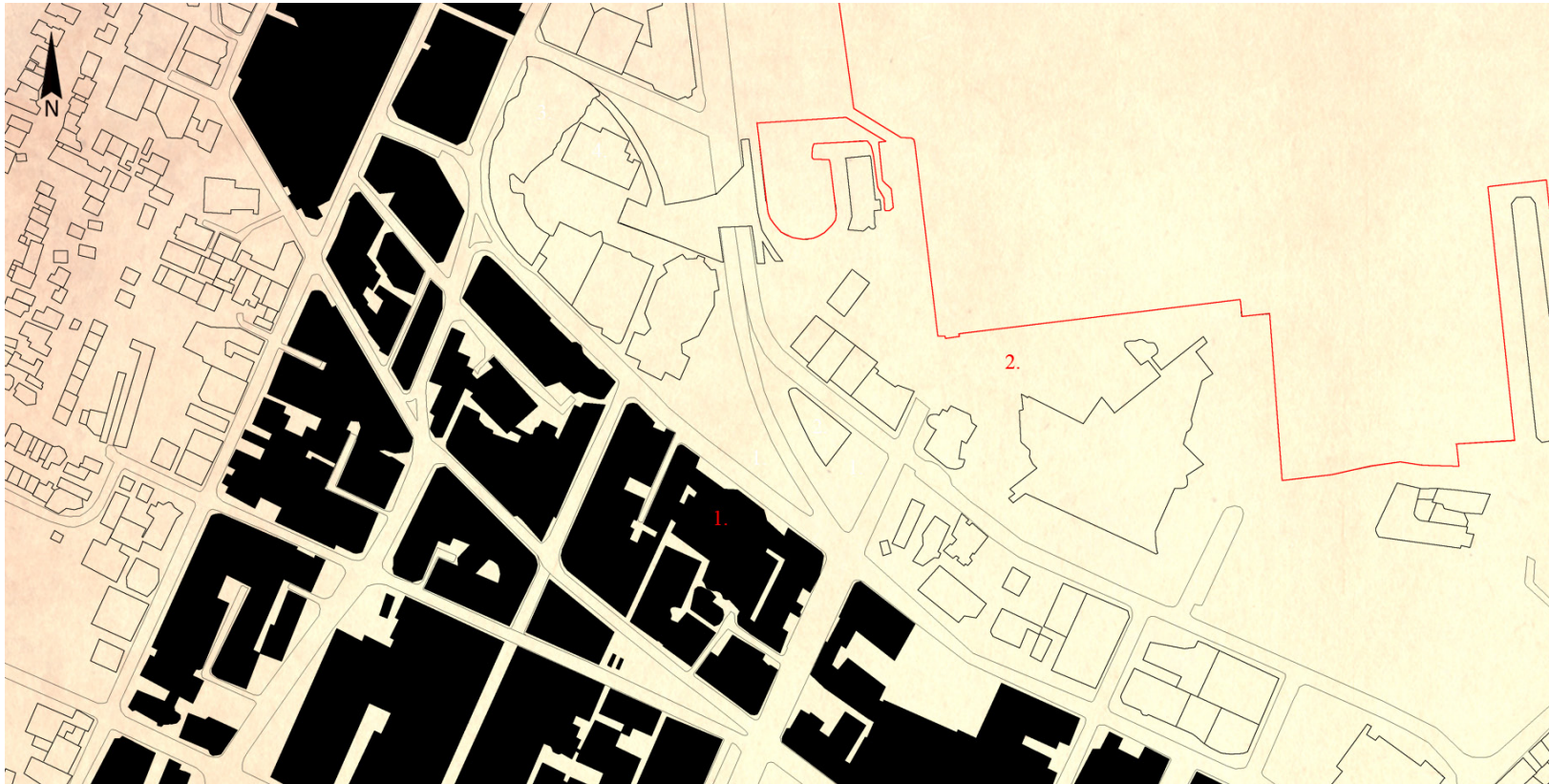
In conjunction with the existing performance spaces, the site is also within close proximity to broader public infrastructure such as the National Museum of Te Papa, The City Library, The City Art Gallery and Civic Square. Furthermore, the site also has a close relationship to smaller-scaled hospitality destinations such as Circa Theatre, the Wharewaka building, Mac's Brewery and the St John's Bar and Restaurant.



[Fig 5.01] Site key

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.

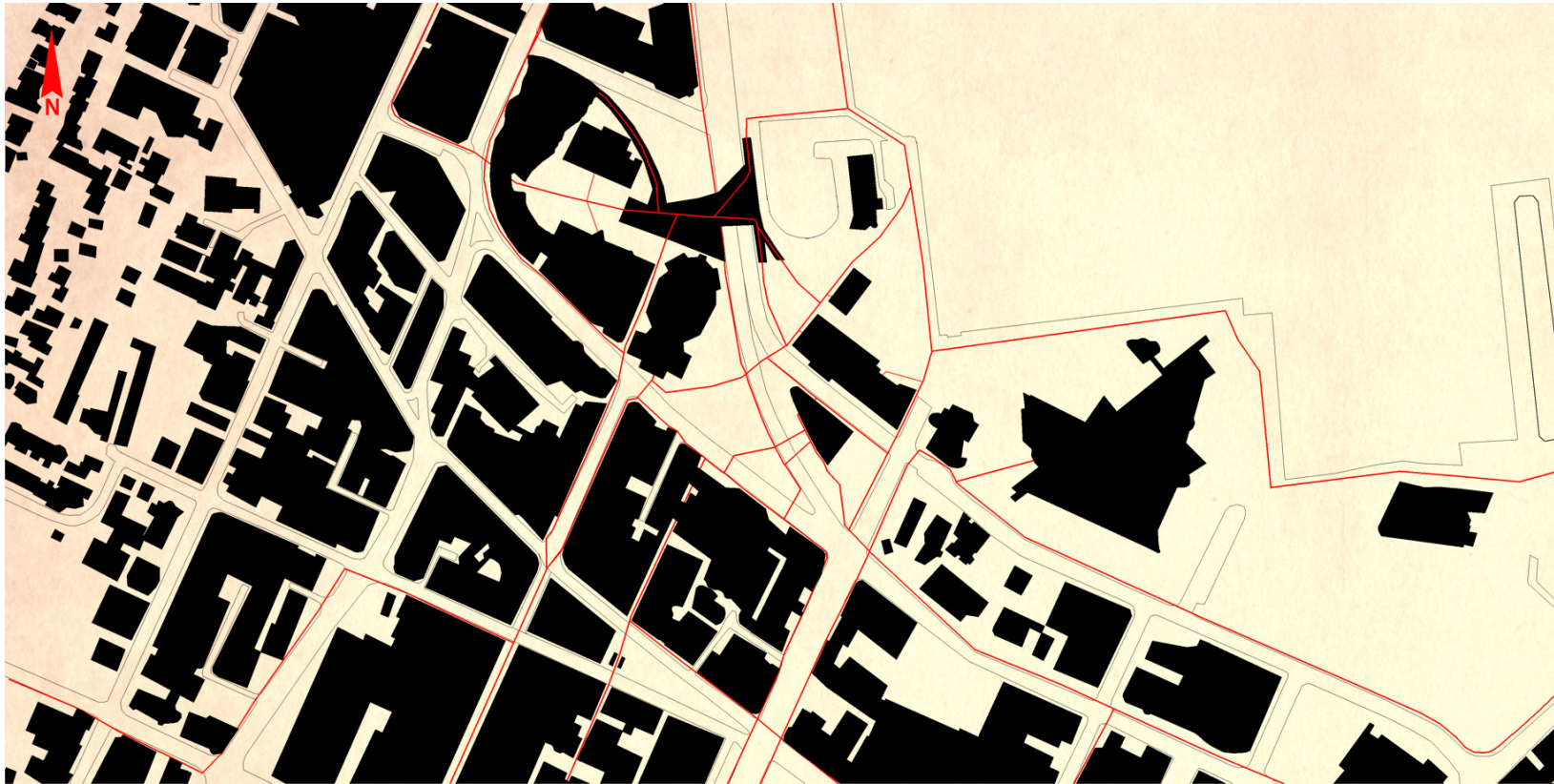
- | | |
|---------------------------|--------------------------------|
| 1. Site | 9. Duxton Hotel |
| 2. John Chambers Building | 10. St John's Bar & Restaurant |
| 3. City Library | 11. Te Wharewaka |
| 4. City Art Gallery | 12. Mac's Brewery |
| 5. City to Sea Bridge | 13. Circa Theatre |
| 6. Town Hall | 14. Te Papa, National Museum |
| 7. Michael Fowler Centre | 15. BP Service Station |
| 8. The Opera House | 16. Apartment developments |



[Fig 5.02] Site Map: City zones.

- 1. CBD
- 2. Waterfront

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.



[Fig 5.03] Site Map: Primary pedestrian arteries.

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.

Public Access:

The site intercepts pedestrians from three central city streets, Cuba Street, Taranaki Street and the Opera House Lane [Fig 5.03]. All three of which have a high amount of foot traffic throughout the day. Cuba Street has recently become semi-pedestrianised which has reduced the traffic flow and encouraged more pedestrians. The council has also made a commitment to develop Taranaki Street as a boulevard sometime in the near future, which will also increase the usage and flow of pedestrians towards the waterfront. Thirdly, the Opera House Lane has a high pedestrian usage during the day. However, it is a dark narrow space and can be unsafe in the evening. The solution to this issue is to activate the zone with increased use. People are the most effective form of surveillance. A continuous flow of public and NZSM students along this alleyway, in combination with additional street lighting, should help to reduce the issues associated with safety (Department of the Environment, 2000).

The junction of these three streets concentrates pedestrian flow towards the site to create an urban node, the strategic foci into which the observer can enter (Lynch, 1960, p. 79). The advantage of locating the NZSM at an urban junction is that the pedestrian is forced to make a decision. Pedestrians must heighten their attention at such places, and will therefore perceive nearby elements with more than normal clarity (Lynch, 1960, p. 79). This strategy is used to visually engage the pedestrian with the NZSM programme.

Although these streets direct a high amount of foot traffic toward the site, access to the site is problematic. Pedestrians approaching the site from Cuba Street have to walk an undefined pathway across the Michael Fowler Centre car park and cross two separate sets of lights no more than three metres apart to reach the Waterfront. Pedestrians approaching from Taranaki Street have to make up to four crossings at the Wakefield Street junction to reach site *A* or informally cross Wakefield Street to reach site *B*. Pedestrians who approach the site from the Opera House lane can either use the crossings at Cuba or Taranaki however are faced with the same problems as previously mentioned. Alternatively, pedestrians can choose to cross Wakefield Street informally; however it is a busy street and the current traffic conditions mean that it is an inappropriate crossing for the large numbers of people who could be visiting the school at any one time.



[Fig 5.04] Site Map: Traffic flow.

1. Cable Street
2. Jervois Quay
3. Wakefield Street
4. Taranaki Street
5. Service Lane

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.

Traffic flow:

All along the Jervois Quay Motorway the CBD is separated from the Waterfront by six lanes of traffic, making pedestrian access to and from the Waterfront difficult [Fig 5.04]. Site *A* is the point at which the motorway is split in two. Like the Casa da Musica, it is surrounded by dense traffic, creating an island site with a strong edge condition (Lynch, 1960, p. 79). Site *B* has a similar issue, with heavy traffic on two of its three sides. The traffic flow isolates the two sites from an otherwise pedestrian friendly city grid. The isolation of the site is intensified by the ill-defined pathways across the site and the fact that neither site currently functions as a destination.

Site lines:

The site is fortified by several large-scale landmarks including the Michael Fowler Centre, the Duxton Hotel and the row of historic buildings on the opposite side of Cable Street. These buildings have a major role in defining circulation and site lines across the site [Fig 5.05]. Over the past decade a band of high-rise apartments have been constructed in the city blocks between Cable Street and Wakefield Street. In future years there is a good chance that this private development will continue and the current BP service station will be developed as an apartment block. There is a risk that this will further affect Te Papa, which is already disconnected from any strong visual links to and from the CBD. In 2006, the building adjacent to the John Chamber (the Inglis Bros & Co Ltd building) was demolished for the proposed Watermark Apartment Complex. The apartment block was designed at a scale that dramatically exceeded the already large-scale buildings such as the Duxton Hotel and the Michael Fowler centre.¹¹ The result was a design proposal which dwarfed the historic townscape along Cable Street [Fig 5.06]. It is important to acknowledge this example to ensure that the design solution is sympathetic to the scale of the existing buildings.

As previously mentioned in the design brief, the aim of this design project is to link the publicly accessible spaces within the NZSM programme to the surrounding parks, bars and restaurants of the wider urban context. This site analysis has mapped the significant sight lines and access routes essential to way finding across the site. The most prominent connection across the site extends from the Opera House Lane to the exterior courtyard of the St John's Bar and Restaurant. This pathway has an unobstructed link between city and sea and is easily accessible to pedestrians approaching the site from Cuba Street and Taranaki Street. These findings will be used to locate the major concert spaces and define the external circulation of the proposed design solution.

¹¹ (See Appendix 4 for proposed Watermark development.)



[Fig 5.05] Site Map: View shafts at street level.

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.



[Fig 5.06] Site Map: Heritage building footprint

Adapted from: Wellington 2040: The future of our central city (p.11), by R. Leblanc, WCC, unpublished.

5.1 | *Building Analysis*

The John Chambers Building (JCB), 119 Jervois Quay, Wellington.

The John Chamber Building (JCB) [Fig 5.07], designed by Hoggard, Prouse and Gummer Architects, was constructed in 1918 as a warehouse, workshop and office space for the John Chambers and Son Company.¹² Since then, Fisher and Co. Ltd and the New Zealand Film Archive and Film Centre have occupied the building. Currently the building is un-occupied¹³ (Heritage Inventory, 2010).

The extensive use of glass in the building's exterior envelope creates a visual link between interior and exterior. This transparency helps to activate the building's exterior, especially at ground level [Fig 5.08]. Both the transparent exterior and predominantly hollow interior of the JCB make it an ideal shell for the insertion of small-scale performance spaces. The interior of the building is very basic and its industrial nature provides wide-open spaces. The interior structure is constructed with concrete moment resisting frames in each direction. The columns are arranged on a 5x5 m grid and the primary and secondary beams are exposed throughout [Fig 5.10].

Buildings such as the JCB are not only appreciated for their age but also the image of solidity, prestige, prosperity and prominence which they project (Highfield, 1987, p. 8). In addition, when these buildings occupy areas where they are in close proximity to other architecturally attractive older buildings, it adds further to their appeal and townscape value (Bullen, 2007, p. 26).

The JCB has both historical and cultural significance to Wellington. The building has become a landmark in Wellington's cityscape with its idiosyncratic bull-nose and unapologetic bulk, wedging itself between Cable Street and Jervois Quay [Fig 5.09]. The confrontational nature of the building's orientation makes it one of the first buildings motorist entering from Aotea Quay engage with¹⁴.



[Fig 5.07] John Chambers Building, Wellington, by Hoggard, Prouse and Gummer, 1918: Photograph showing windows broken by the Wairarapa earthquake of 24 June 1942.

¹² The John Chambers and Son Company occupied the building until the early 1940s. Fisher and Co. Ltd occupied the building thereafter until 1971. The building was later refurbished for the occupation of New Zealand Film Archive and Film Centre (Heritage Inventory, 2010).

From: Alexander Turnbull Library, Retrieved from <http://www.natlib.govt.nz/collections/digital-collections/timeframes>. (accessed 12/07/2010).



[Fig 5.08] John Chambers Building, Wellington, altered by Athfield Architects c1995.

From: Athfield Architects Ltd, 2010.

¹³ A series of adaptations has seen the building develop an eclectic aesthetic. The ground floor level has a faint classical structure particularly in the bracketed cornice and pilasters, as well as in the detailing of the Jervois Quay entrance. However, the first and second floors, at the time of their construction were stylistically advanced. Stripped clean of any embellishment they are dominated by strong horizontal bands of steel-framed windows that give an impression of the 'art deco' style of the 1930s. (Heritage Inventory, 2010)

[Fig 5.09] John Chambers Building: Photograph by author, 2010

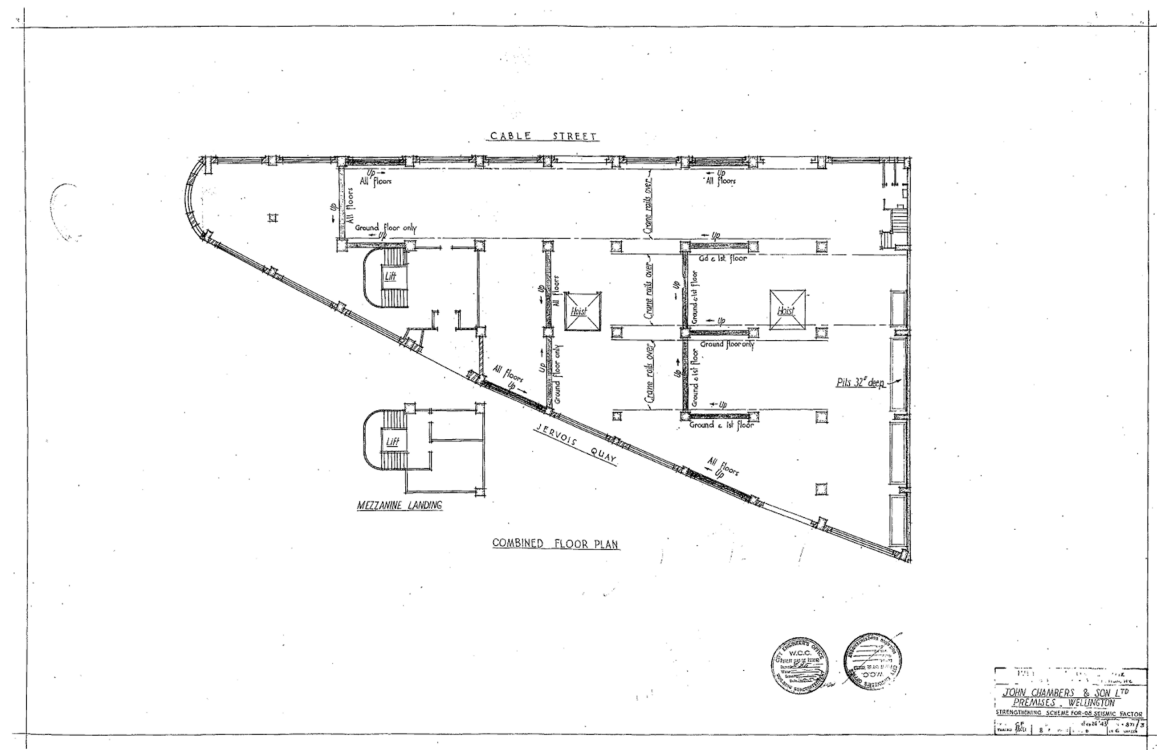
¹⁴ The curve of the facade around the nose of the building has been altered from its original state. The brick masonry has been plastered over and the original windows have been replaced with much larger ones forming a continuous band of transparency that wraps around the building's infamous bull-nose.



¹⁵ Since the adjacent building was demolished in 2006, all four of the JCB's elevations have been exposed. The building has developed a distinctive sense of place as one of the last remaining pieces of built fabric from its era. One of the most prominent views for pedestrians is from the City to Sea Bridge where the building stands abandoned on the island site.



Although the JCB stands alone as a heritage landmark, it is also one of a group of important period buildings, including the former Free Ambulance Building (St John's Bar & Restaurant), Odlin's and the Mac's Brewery. All three heritage buildings are located on the opposite side of Cable Street¹⁵. However, the JCB provides an anchoring role to this disparate heritage grouping, by helping to maintain the character of the surrounding townscape (Kernohan, 1994, p. 8). For the purpose of this design project the existing building will be retained, and reused. The following section briefly discusses adaptive reuse along with architectural strategies used to treat the juxtaposition of old and new building fabric.



[Fig 5.10] John Chambers Building: Existing plan.

From: Wellington City Archives.



[Fig 5.11] Tate Modern, London, by Herzog and Meuron, 2000.

From: Tate Modern: The handbook (p. 9), by A. Marr, 2006, London, Tate Enterprises Ltd.

5.2 | *Adaptive reuse*

Adaptive reuse describes the process through which the cultural and historical integrity of the existing building is prolonged through carefully planned interventions. Two examples discussed in this passage include the Tate Modern, by architects Herzog and Meuron, and The Circus: Caribbean Orange, by Gordon Matta-Clark.

The strategy of the Tate Modern project was to accept the physical power of the Bank side's massive mountain-like brick building and to enhance it rather than break it up [Fig 5.11] (Brooker, 2004, p. 83). Architects Herzog and Meuron describe this approach to design as a kind of “*Aikido* strategy, where you use your enemy's strategy for your own purpose. Instead of fighting it, you take all the energy and shape it in a new and unexpected way” (Brooker, 2004, p. 83). The architects decision to keep the shell of the existing building dictated the majority of the internal space. Although the intervention is quite subtle, the most obvious modification is the addition of the glazed roof, a huge body of light hovering above the bulk of the existing brick structure. This contrast of solid and transparent materials illustrates the counterpoint between old and new (Brooker, 2004, p. 83).

Similar to the Tate Modern, the approach taken in the Circus: Caribbean Orange was to retain the building's exterior [Fig 5.12]. However, the designer Gordon Matta-Clark had free rein on the interior (Walker, 2009, p. 13). Like much of his work, Matta-Clark applied a series of cuts and openings to the existing structure to re-open a new experience of the building, with the aim of re-invigorating it (Moure, 2007) Matta-Clark discussed this approach to intervention as a notion of *discrete violation*. He writes:

Usually the thing that interests me is to make a gesture that in a very simple way complicates the spaces I'm working in. Looking through the cut, looking at the edges of the cut, should create a clearly new sense of space. But the cut must also reveal a portion of the existing building system, simply as that which exists (Walker, 2009, p. 15).

The cuts impose a new mode of behaviour, and a new reaction to the spaces of the building. Familiar sequences of spaces and movements are replaced with new possibilities that simultaneously expand the visual space within and through the building (Walker, 2009, p. 15).



[Fig 5.12] The Circus: Caribbean orange, by Gordon Matta-Clark, 1978.

From: Gordon Matta-Clark (p. 127), by C. Diserens, 2003, London, Phaidon

These examples are supported by a large body of historic literature which examines the impact of new building onto existing important architecture. It argues that innovative, expressive design can enhance the older, original, and often historic structure to which it is appended (Byard, 1998). In his book *The Foundations of Architecture*, Viollet-le-Duc discusses a reuse approach, identifying adaption as, “a means to re-establish a building to a finished state, which may in fact never have existed at any given time” (Viollet-le-Duc, ([1854] 1990), p. 195) However, he makes the point that while structural elements might require renewal or outright replacement, decorative features should generally not be re-carved because it is impossible to reproduce their authentic character (Viollet-le-Duc, 1990).

The author Manfredo Tafuri also advocates for the adaptive approach because it seeks to create a new architectural narrative rather than recreating the original one. He argues that the architects role is to learn from history and to challenge it, rather than attempt to recreate it. He writes:

History can no longer promote solutions. The task of historians is to present the architects with the contradictions of history; so that an architect can get control of the historical sources and question them; and so the architect is not subconsciously guided by past aesthetic and symbolic systems; and to ensure the architect no longer makes choices out of habit (Tafuri, 1980, p. 275).

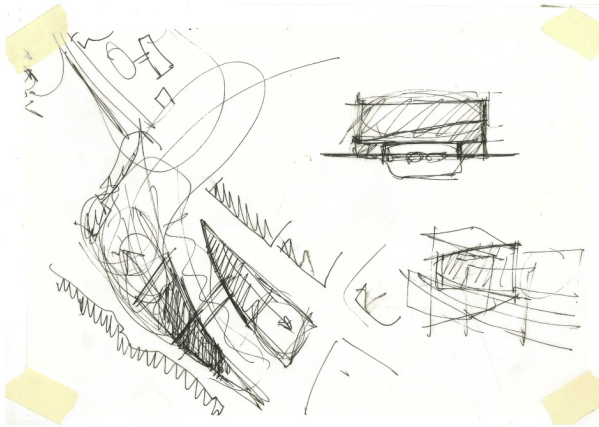
Adaptive reuse is a crucial design challenge for contemporary designers. This section argues that adaption is the most effective way to conserve otherwise redundant architectural heritage. By responding to the existing fabric with an informed analysis and contextual sensitivity, an intervention may successfully breathe new life into a disused architecture object. The following chapter presents the design solution, in which a discussion regarding the findings from the literature study and site analysis is re-applied to develop a design logic.

[Fig 5.13] Office Baroque, by Gordon Matta-Clark, 1977

From: Gordon Matta-Clark: works and collected writings
(p. 244), by G. Moure, 2007, Poligrafa.



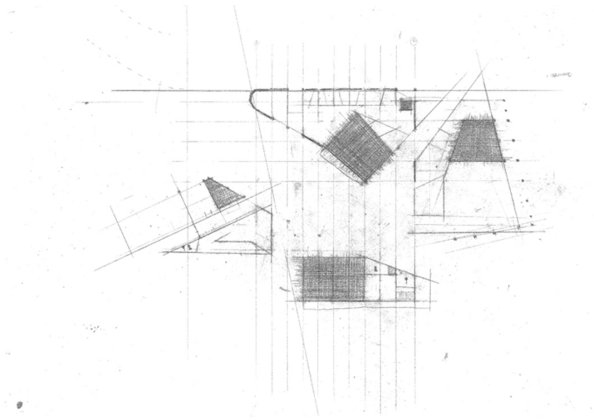
Chapter 6 | *Design Solution*



[Fig 6.01] Conceptual Sketch.
By author, 2011

Chapter 6 | *Design Solution*

The scope of the design scheme ranges from the public interface of the exterior to the acoustic technicalities of interior. The exterior design is governed by the site context, while the interior concert space is governed by acoustic design functionality. In acknowledgment of these separate functions, the design solution is discussed as two separate design logics, interior and exterior. The exterior content discusses the responsiveness of the envelope to the urban condition, in conjunction with the design strategy used to authorise the adaption of old and new. Subsequently, the interior content focuses on the performance spaces specific to the NZSM programme and discusses the acoustic logic used to inform the design solution.



[Fig 6.02] Conceptual Sketch.
By author, 2011

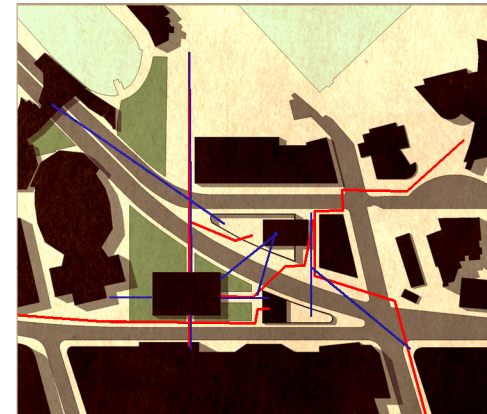
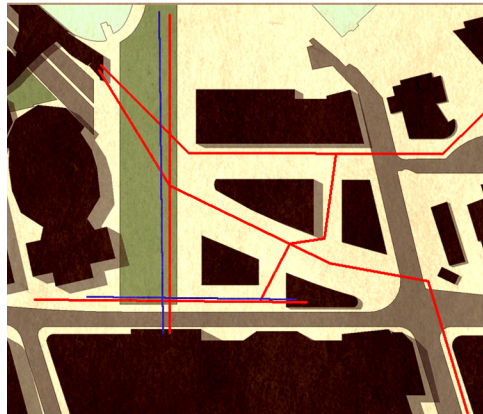
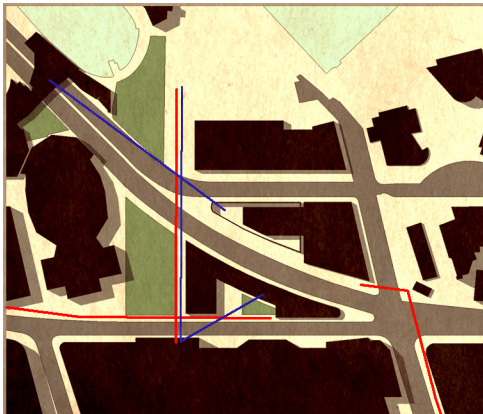
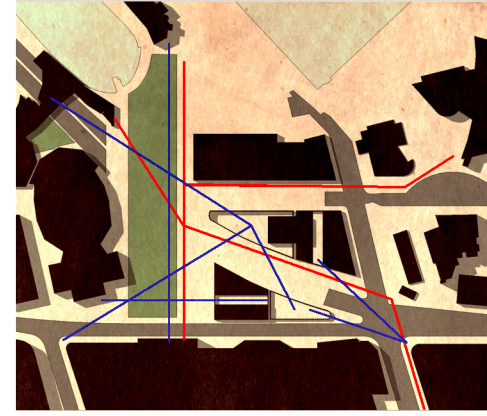
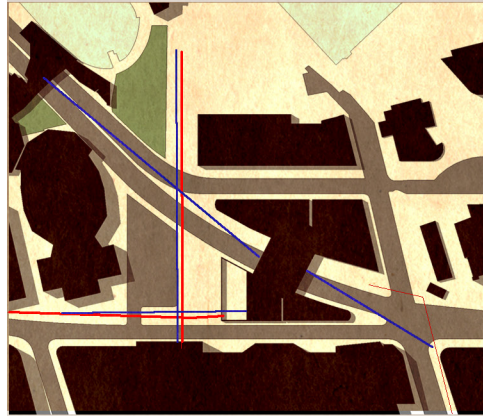
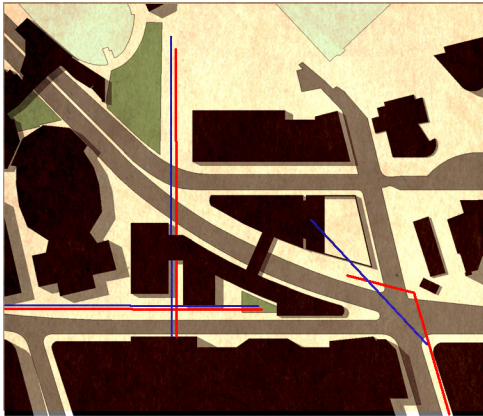
6.1 | *Exterior Design Logic*

Urban Design

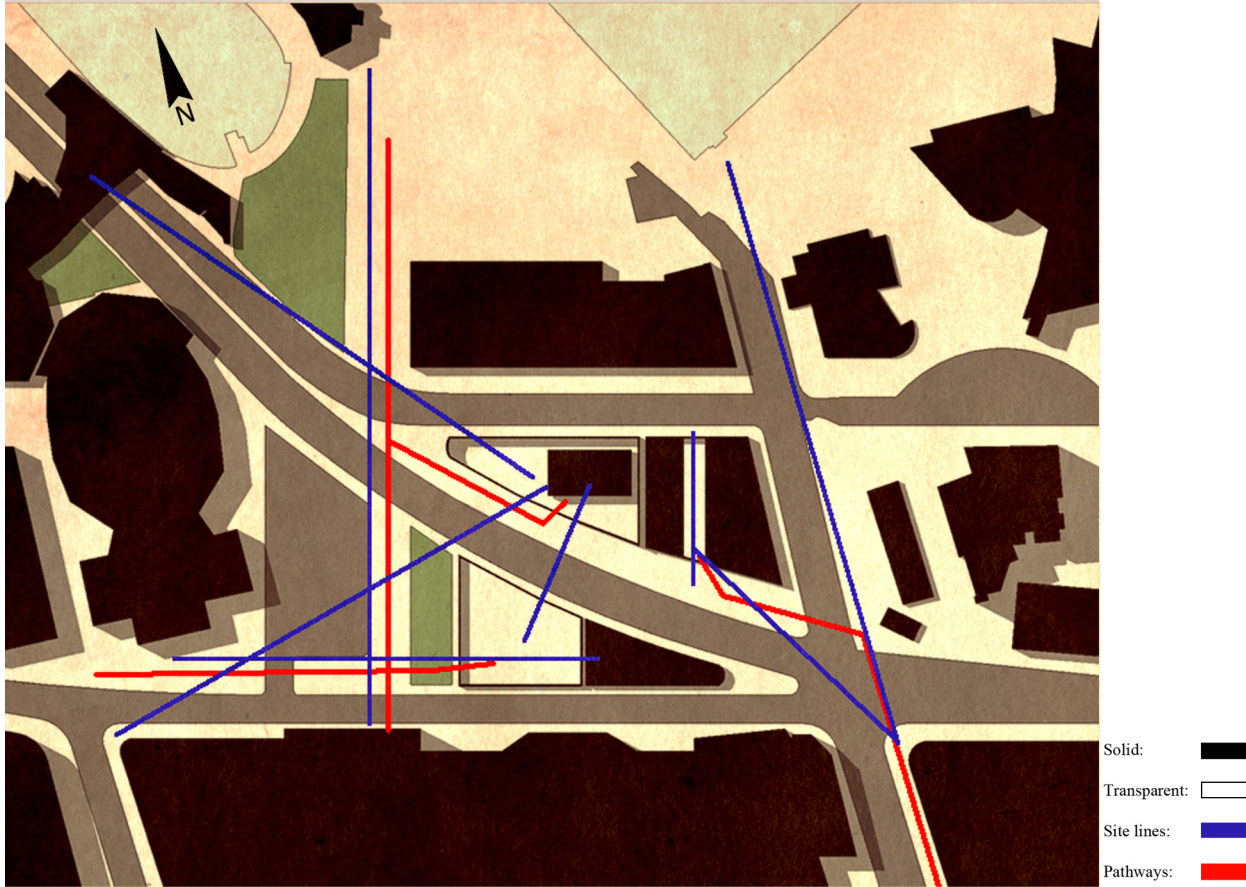
The design solution was initiated by first locating the publicly accessible spaces so that they intersect the most prominent pathways across the site. The major concert spaces were located first, followed by the Library and subsequent tuition and administrative spaces.

Historically, the solid envelope of the concert hall has obscured the location of the performance interior. However, as previously discussed in examples such as, the Casa da Musica and the Copenhagen Concert Hall, a contemporary alternative is to apply visual transparency to the envelope so that the performance interior can be located from the exterior. This desire to establish a visual relationship between interior and exterior began by crudely mapping solid and transparent volumes onto the site [Fig 6.03]. These volumes are located in relation to the significant site lines and view shafts established in the site analysis. This process also considered dissecting major chunks of the existing building to divide the bulk of the major volumes. However, these concepts were rejected because they diluted the density necessary for a central city space.

As the design developed, several alternatives were explored to address the issues of access to the site. One alternative was to submerge the motorway and landscape over the top of it to create an uninterrupted pathway across the site, similar to the public square located at the front of the Concert Hall in Bruges. A second alternative was to bridge between the two sites. However, the bridge complicated the internal circulation of both buildings, and submerging the motorway drastically exceeded the scale of the NZSM programme. Instead the proposed design solution resolved access to the site with a pedestrian crossing, extending from the Opera House lane to cross Wakefield Street [Fig 6.04]. This pathway continues in a direct line across both Jervios Quay and Cable Street to establish a connection between the CBD and the Waterfront. A secondary pathway branches off the primary footpath to connect with the park and courtyard at the rear of the library. Furthermore, the removal of the service lane along the southern end of the JCB creates a plaza space that, like the Casa da Musica and Bruges Concert Hall, identifies a place for the public to gather before and after concerts [Fig 6.05].



[Fig 6.03] Figure Ground Study. By author, 2011





[Fig 6.04] From City to Sea.
By author, 2011



[Fig 6.05] Proposed Site Plan.
By author, 2011.

1. Gamelan Room
2. Recital Hall
3. Multipurpose Hall
4. Lecture Theatre
5. Jazz Cafe
6. Music Therapy Room
7. Key board lab
8. Practice Rooms
9. Teaching Studio
10. Electronic Music Studio
11. Seminar Room
12. Percussion Room
13. Library
14. Reception / Administration
15. Storage Space
16. Outdoor Courtyard
17. Park
18. Carpark

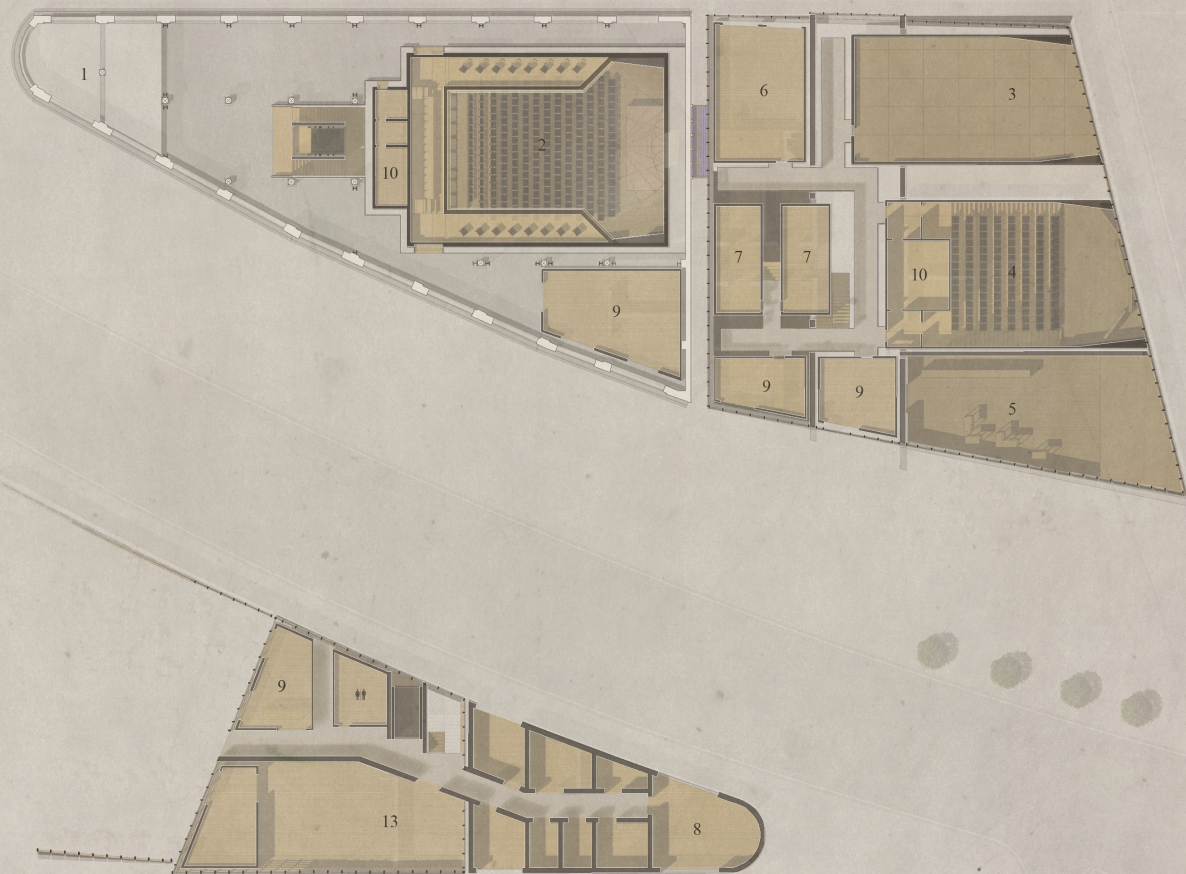


[Fig 6.06] Proposed Basement Plan: -5000.00
By author, 2011

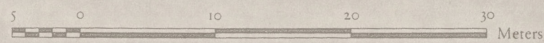
5 0 10 20 30 Meters



1. Gamelan Room
2. Recital Hall
3. Multipurpose Hall
4. Lecture Theatre
5. Jazz Cafe
6. Music Therapy Room
7. Key board lab
8. Practice Rooms
9. Teaching Studio
10. Electronic Music Studio
11. Seminar Room
12. Percussion Room
13. Library
14. Reception / Administration
15. Storage Space
16. Outdoor Courtyard
17. Park
18. Carpark



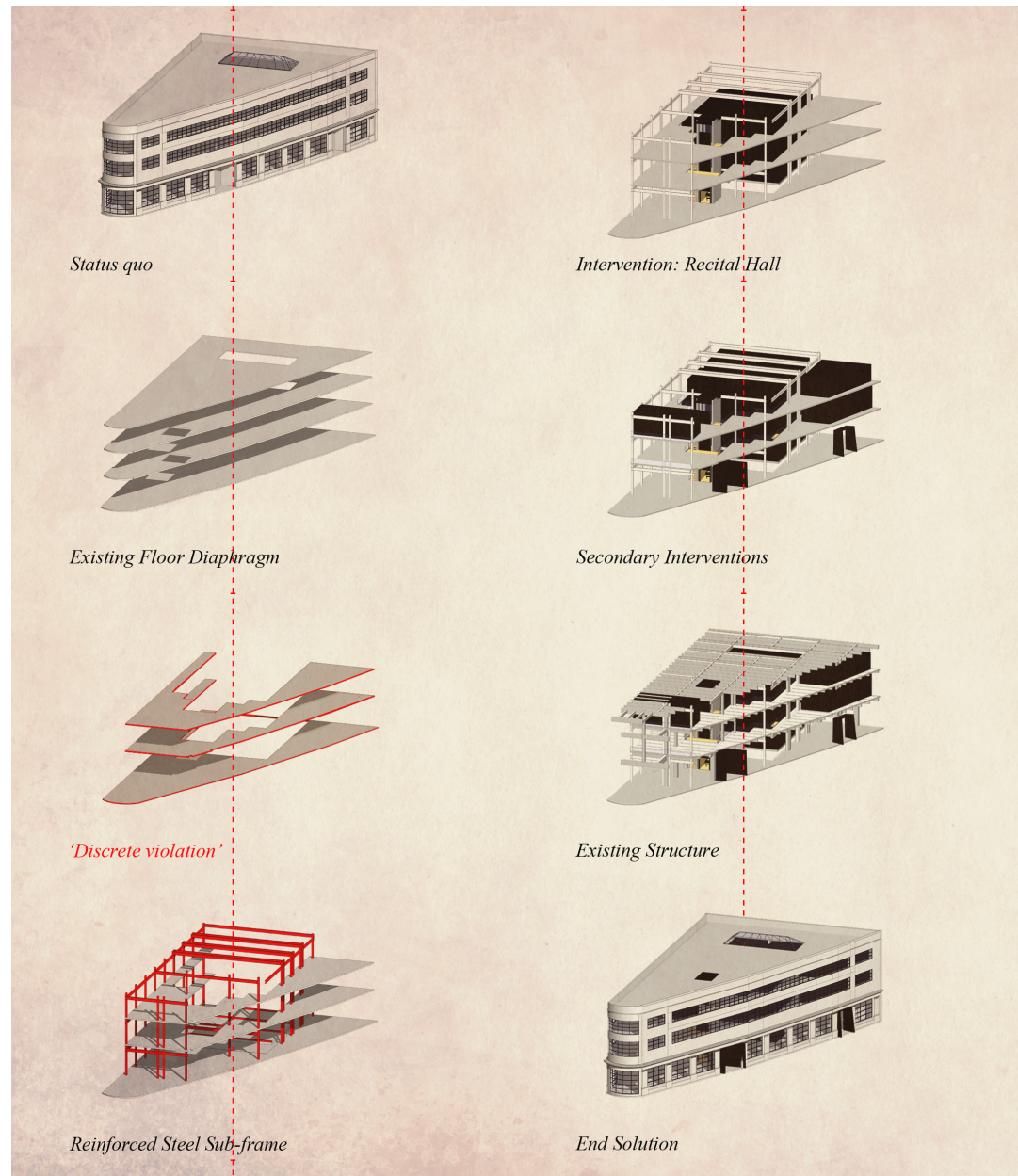
[Fig 6.08] Proposed First Floor Plan: 7000.00
By author, 2011





[Fig 6.09] Proposed Second Floor Plan: 12000.00
By Author, 2011

[Fig 6.10] Adaption Process.
By author, 2011



The Existing John Chambers Building

Once a relationship between the major concert spaces and the site circulation had been established, the design focus adjusted from the urban scale to the building scale. Thus, the existing JCB and the relationship between old and new became the primary focus of the proposed design (Adeyeye, 2010, p. 365).

Gordon Matta-Clark's notion of *discrete violation* in the context of the Circus: Caribbean Orange project became a key precedent at this stage of the design [Fig 6.10] (Walker, 2009, p. 15). Like the Circus: Caribbean Orange project, the exterior shell of the JCB is retained. However, a series of cuts through the building's interior structure dramatically open the space. While clearly creating a new sense of space, the raw ends of the cuts reveal a portion of the existing building system, "simply as that which exists" (Walker, 2009, p. 15).

The first step in the adaption process was to gut the interior of the existing building, removing all sub floor and secondary structure. The generous spacing between structural members means that smaller spaces within the new programme could be inserted into the existing building without compromising its structural integrity. However, major structural changes would be required to facilitate the insertion of the Recital Hall and Gamelan Room.

The Recital Hall is the heart of the NZSM programme. It is the school's biggest facility and is the primary discourse between the school and the general public. For this reason it is located at the core of the JCB where it is contained within the building's predominantly transparent exterior. This visual transparency activates the interior and defines the location of the Recital Hall. This visual connection is further reinforced with the location of the hall at street level.

The insertion of the Recital Hall is achieved without any alteration to the building's exterior envelope. The original entry points have been reused to respect the orientation of the original building and its relationship to the exterior circulation. However, the main stair has been relocated to suit the revised circulation of the building's interior. The new stairs are constructed with timber treads and glass balustrades to continue the visual transparency into the interior and contrast the abundance of concrete within the existing interior [Fig 6.11]. Contrast of this kind is a common strategy in adaptive reuse, it is used to establish a clear definition and counterpoint between old and new (Klanten, 2009).



[Fig 6.11] Lobby.
By author, 2011

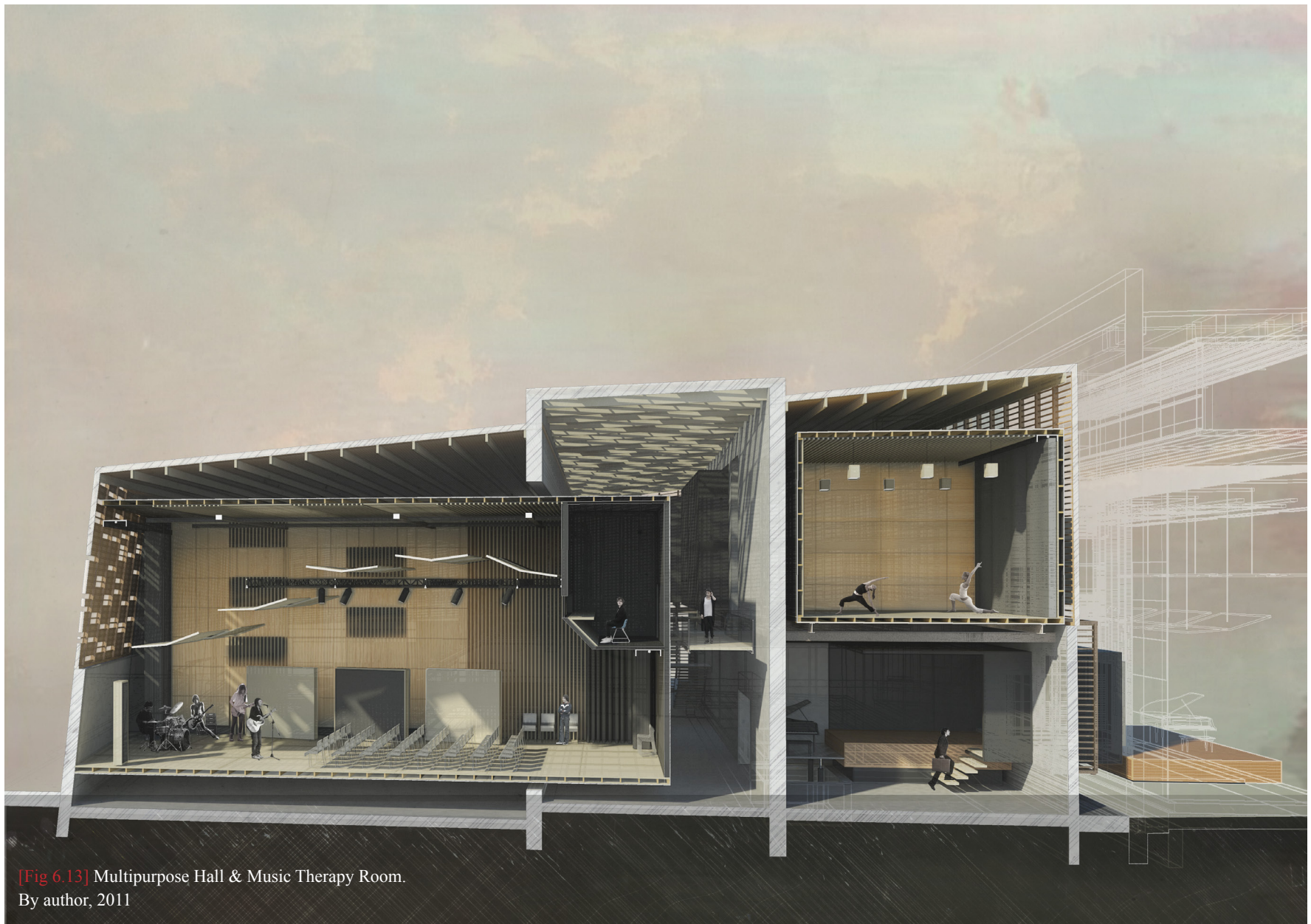
All three floors of the original building are cut-out to create an opening for the hall. An additional steel frame is erected inside the shell of the existing building to replace the original structure and supported the increased span of the interior. Structurally independent, the Recital Hall is erected as an autonomous object with the buildings interior. An air gap of 500mm surrounds the hall to create a threshold between acoustic layers. This distinction is reinforced by a podium, which elevates the hall, and clearly defines it as a new intervention (Brooker, 2004). Like the Music School in Grunwald, Munich, the structural separation also serves an acoustic purpose in that it isolates the hall from structure born noise vibrations (Mommertz, 2009, p. 85).

Located on the ground floor inside the bull-nose of the existing building, the adaption of the Gamelan Room would also require significant structural changes. Traditionally gamelan instruments are played in an outdoor pavilion setting where the air absorbs much of the ensembles sound (Spiller, 2004, p. 107). To simulate the acoustic conditions of the open air, the floors above the Gamelan Room and Lobby area are cut back to the first moment frame. This full-height space opens up the entire interior of the JCB, and the increased volume helps to absorb the strength of the gamelan sound (Spiller, 2004, p. 107). In addition, the cavernous ceiling and heavyweight surfaces of the JCB interior ensure a suitable sound mix for the gamelan ensemble (Spiller, 2004, p. 107). The glazing around the bull-nose of the JCB building allows the gamelan instruments to be viewed from the outside [Fig 6.12].



[Fig 6.12] Longitudinal Section A-A.
By author, 2011





[Fig 6.13] Multipurpose Hall & Music Therapy Room.
By author, 2011

The Annex ('A' Block)

Accepting that old and new will never meet perfectly, the contrasting fabric is separated by a gap creating a negative detail. However, the two volumes are tied together internally with a service bridge which extends from the Recital Hall stage into the Annex building [Fig 6.13]. The height and over-all size of the Annex building is kept below that of the JCB to respect the historic townscape of the surrounding buildings (Kernohan, 1994, p. 8).

The design strategy was to take the physical presence and general bulk of the existing JCB and balance those same characteristics in the Annex. It applied the *Aikido* theory discussed by architects Herzog and Meuron in their design of the Tate Modern. Instead of trying to dilute the bulk of the existing building, the intervention equals its mass, yet shapes itself in a new and contrasting way [Fig 6.14] (Brooker, 2004, p. 249).

From the exterior, the juxtaposition of old and new creates a synonymous dialogue. Each volume has both solid and transparent qualities. Although the Annex has a similar mass and volume to the existing building, its form and materiality have a contrasting elegance. This contrast in form and materiality establishes a counterpoint, where the tension created between the two objects gives definition to both [Fig 6.15] (Brooker, 2004).

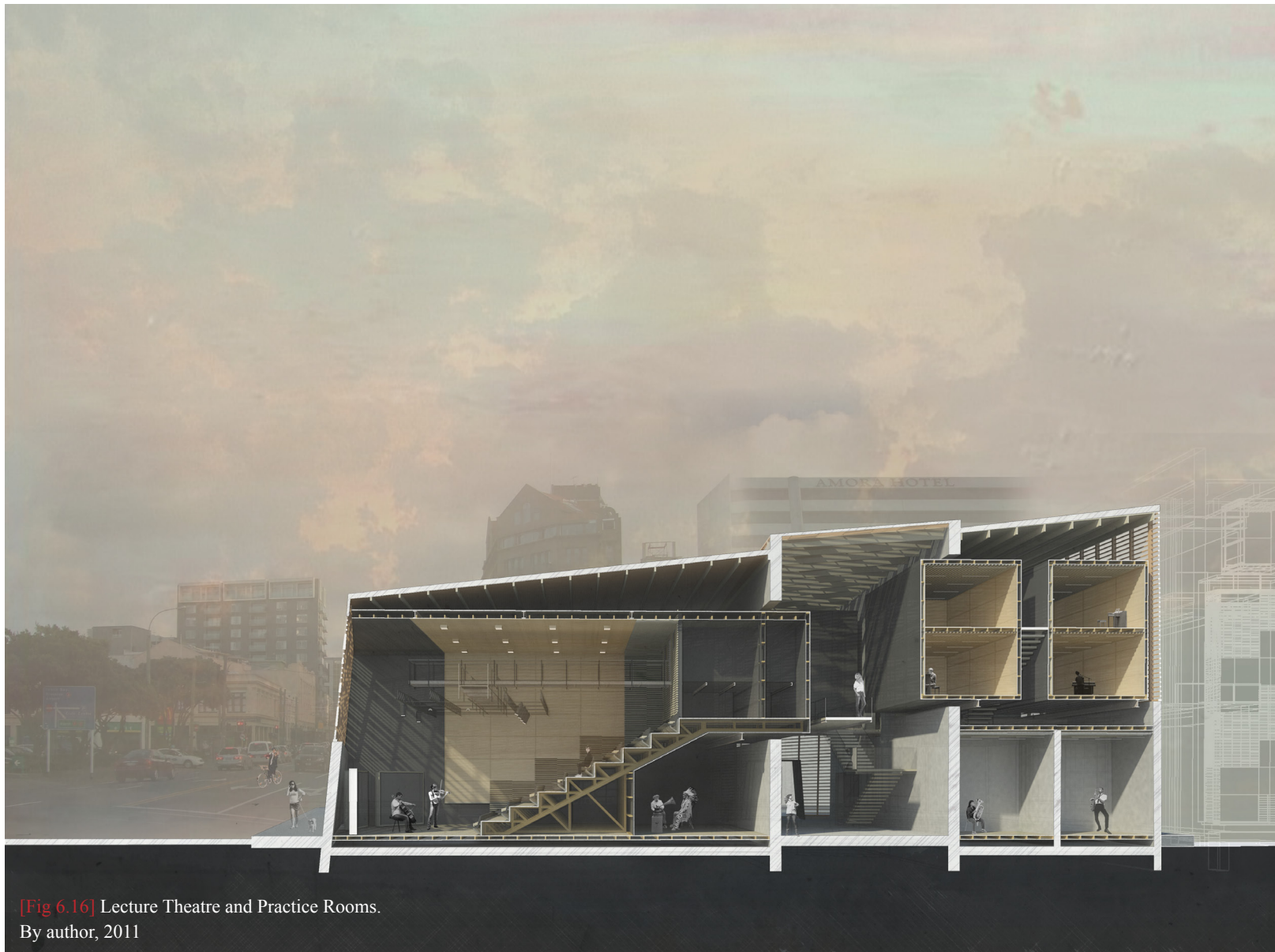
The Annex building explores the relationship between the contents and container in a similar way as Jean Nouvel does in the Copenhagen Concert Hall. The solid black performance spaces are discretely revealed to the exterior through a semitransparent facade. Timber is used extensively throughout the Annex to contrast the predominant use of concrete in the existing building. Like the mullions used on the Bruges Concert Hall, the timber slates create an intermediate scale of detail to mediate the scales of detail on the existing building. This detailing strategy is used to extend the range of visual interest between the two buildings so that different details can be viewed at different distances from the building [Fig 6.16].



[Fig 6.14] Front & Back.
By author, 2011



[Fig 6.15] Back to Front.
By author, 2011



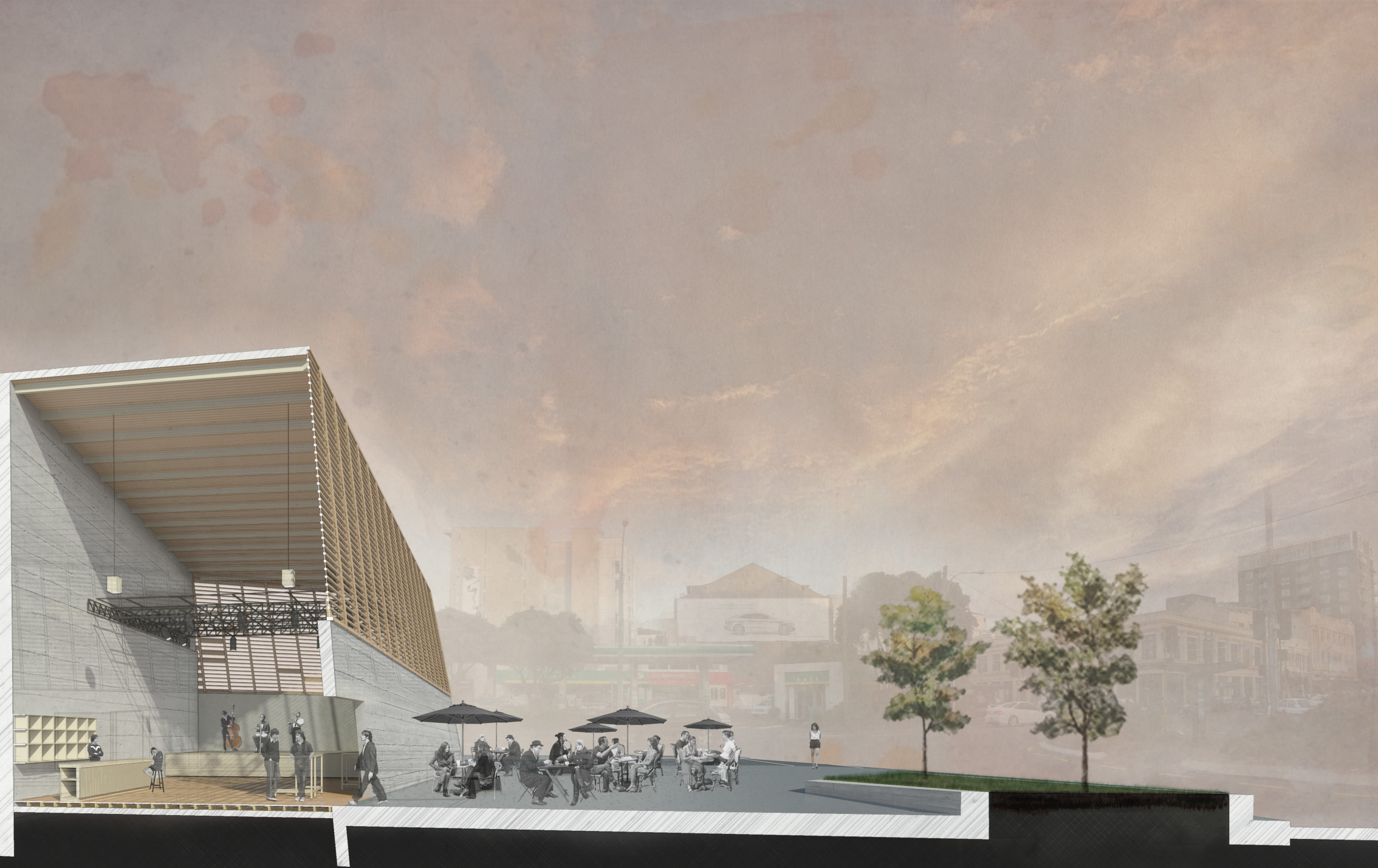
[Fig 6.16] Lecture Theatre and Practice Rooms.
By author, 2011

A ring of heavy-weight concrete construction wraps itself around the ground floor of the Annex building to prevent exterior traffic noise from disrupting the internal performance spaces (Mommertz, 2009, p. 84). It takes its reference height from the first floor of the existing building and slopes down to a less intimidating height for pedestrians at street level. The angled concrete face, in partnership with the irregular timber cladding, creates an exterior responsive to the human-scale [Fig 6.17].

The Annex building facilitates the remaining performance venues including the Jazz Café, Lecture Theatre, and Multipurpose Hall. It also facilitates the Music Therapy Room, four Practice Rooms, four Keyboard Labs and two Teaching Studios. The location of the Jazz Café on the ground floor promotes public integration at street level. What was previously a services lane and parking space is now an extended plaza. Appropriated from the Muziekcentrum Vredenburg, pockets of public space such as this one activated interest and create an atmosphere similar to that of a pedestrianised street [Fig 6.18].



[Fig 6.17] East Elevation.
By author, 2011



[Fig 6.18] Jazz Café.
By author, 2011

‘B’ Block

The final stage in the design of the exterior was the development of the new building on site ‘B’. The form of the new building is predominantly determined by the existing context, and mirrors the architectural language established on the neighbouring site. Currently the site is an ill-defined and under-utilised space. Therefore the intention of the new building was to clarify way finding across the site and give the site a sense of purpose.

An edge condition is established with a row of trees that help to establish a visual hierarchy, singling out the key channel across the site (Lynch, 1960, p. 79). This pathway from the Opera House Lane to the St John’s Bar and Restaurant anchors the two sites to the city grid by creating a strong line of motion, with clarity and direction [Fig 6.19] (Lynch, 1960). This pathway also creates an informal link between the NZSM and the Opera House, while acknowledging a connection to the Michael Fowler Centre and the Town Hall.

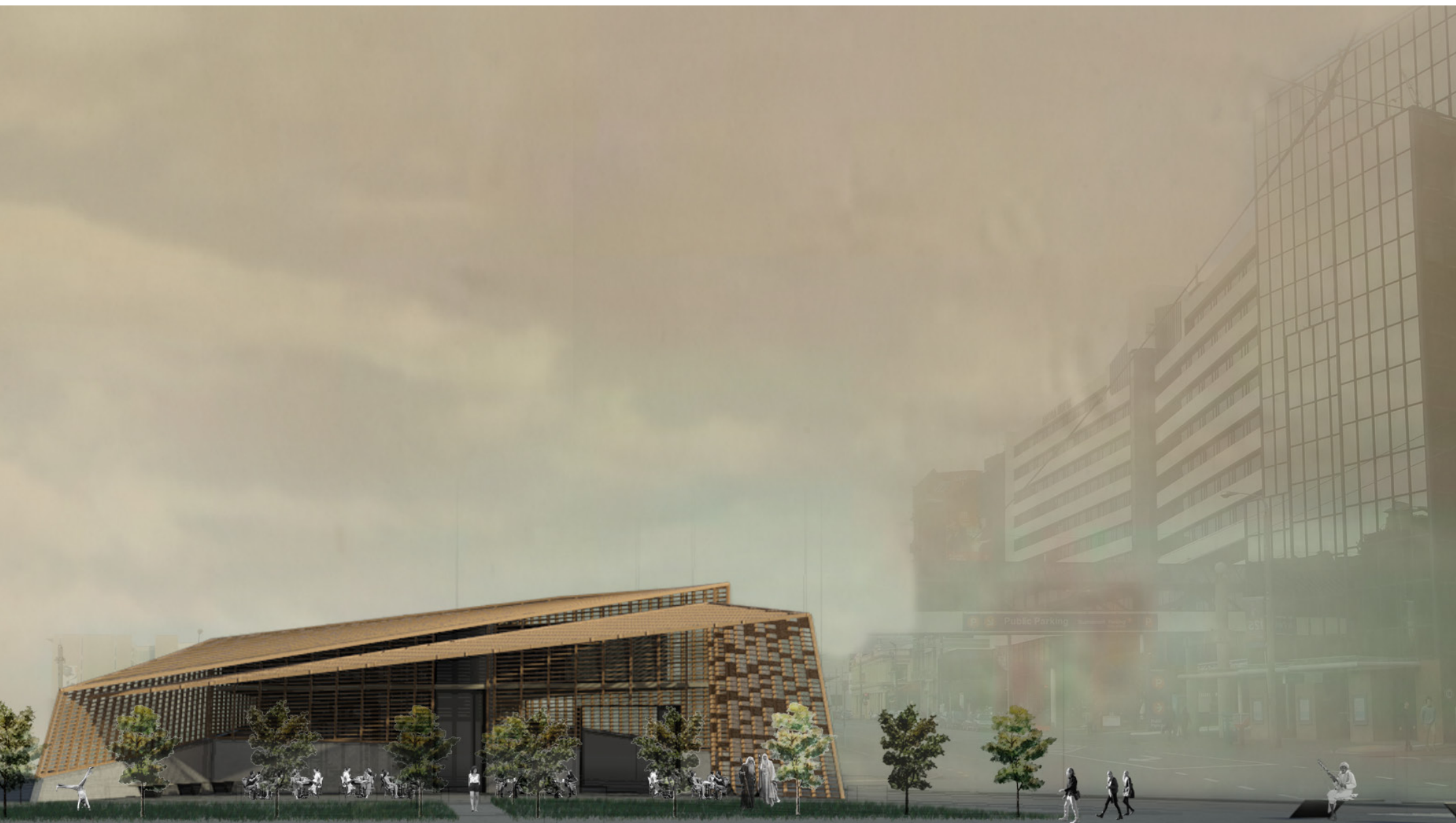
The new library opens out onto a courtyard extending into the park. The park and the exterior courtyard become another place for the public to integrate with the school. NZSM faculty members requiring parking space will be able to use the existing Michael Fowler Centre car park. In addition to the Library, the new building facilitates the main administration offices. It also hosts three levels of Practices Rooms and Teaching Studios. An additional level is submerged underground to facilitate three Percussion Rooms. Locating these rooms underground prevents the sound generated from their instruments from disrupting tuition in the Practice Rooms above (Mommertz, 2009, p.20). All of the Practice Rooms within this building are constructed with the room-in-room construction method discussed in Chapter two.

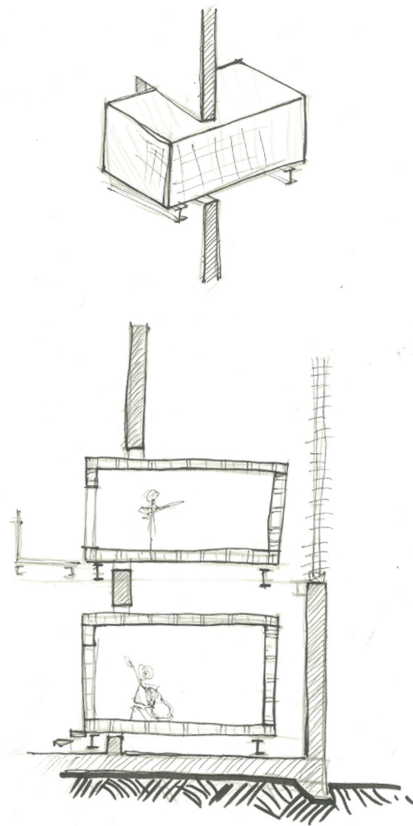
Exterior Summary

The development of the new buildings defines the boundaries of the site, to establish a functioning city block. A simple material pallet of timber, glass and concrete creates a coherent architectural language and produces a clear image of the overall scheme. Legibility is enhanced across the site with a hierarchy of primary and secondary pathways. Trees and other vegetation define the major public zones and clarify overall way finding by articulating the primary pathways (Lynch, 1960).



[Fig 6.19] West Elevation.
By author, 2011





[Fig 6.20] Conceptual Sketches.
By author, 2011

6.2 | *Interior Design Logic*

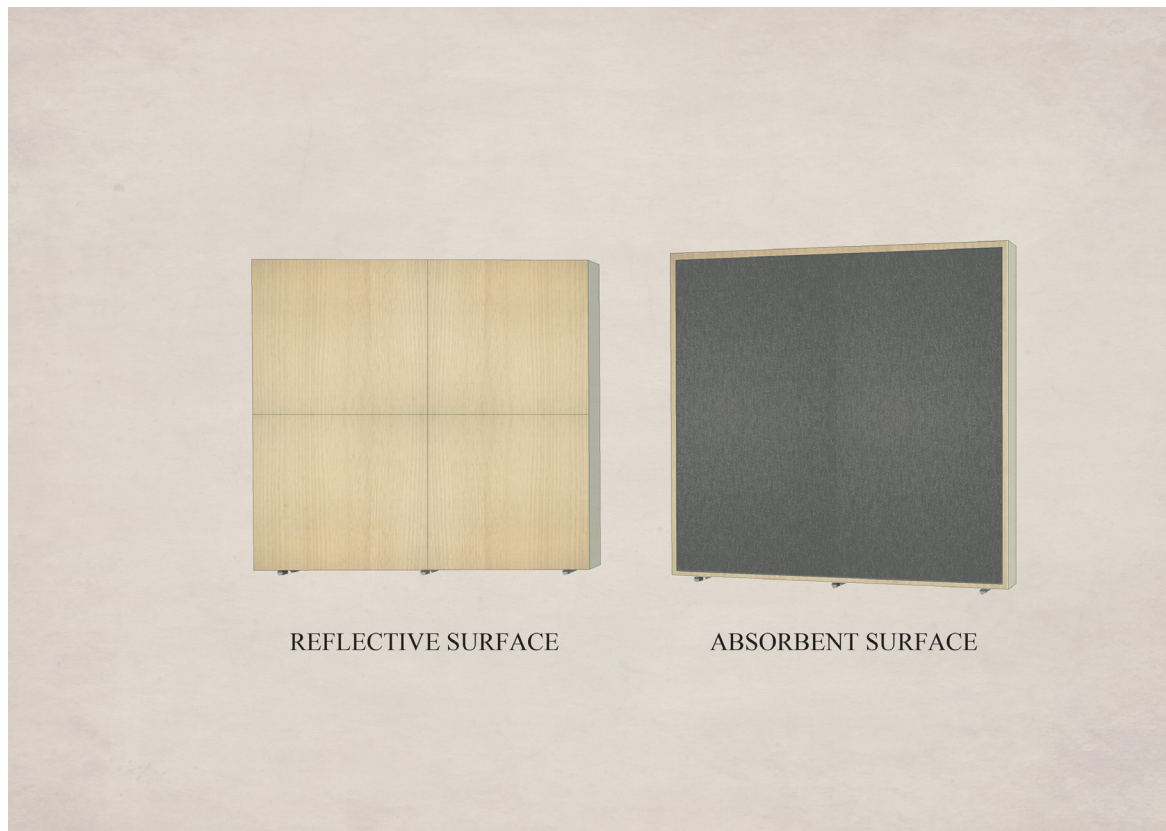
The interior logic focuses on the spatial types listed in the Space List of the NZSM design brief (See Chapter four [Fig 4.02]). This section discusses the acoustic logic used to determine the volume, shape and materiality of both the major concert spaces and smaller tuition rooms.

Practice Rooms, Teaching Studios and Tuition Spaces

The greatest acoustic concern to this design scheme is that of exterior traffic noise, which can target the building through both air and structure borne vibrations. The solution to air borne transmission is heavy weight concrete construction (Mommertz, 2009, p.20). Alternatively, the remedy for structural noise transmission is achieved with separate enclosures and structural isolation between the building's walls and floors (Mommertz, 2009, p. 101). Detailing connections with elastic foundation bearings and isolating joints ensures structure-borne noise vibrations are dissipated before they reach the interior space [Fig 6.22] (Mommertz, 2009, p. 101).

In these spaces, reverberation is secondary to attenuation. Therefore, rooms used for band practices, drums and percussion ensembles have extensive absorbent surfaces on the walls and ceilings. Attenuation in practices rooms for brass instruments is also applied so that a rise in reverberation time for low frequencies is avoided (Mommertz, 2009, p. 83). In Seminar rooms the necessary absorption or reflection can be adjusted with a curtain, which can be open or closed to expose or cover reflective surface. In addition, some of the larger spaces also have rotatable elements, which are absorbent on one side and reflective on the other [Fig 6.21] (Barron, 2010, p. 78).

[Fig 6.21] Rotatable Acoustic Element.
By author, 2011



1. Exterior Envelope
2. Room-in-Room construction:
60mm mineral fibre insulation inside
20mm plywood shell
3. Suspended ceiling:
Timber battens fixed to sound
absorbent backing with perimeter
sound insulation an elastic seal.
4. 40mm air cushion
5. Sound absorbent curtain
6. Wood-plated panels in front of air
cushion
7. 40mm timber flooring with 40mm air
cushion and 40mm mineral-fibre
impact sound insulation.
8. Isolated structural joint with elastic
foundation bearing
9. Suspended ceiling:
60mm mineral fibre insulation inside
20mm plywood layer
10. Air cushion with fibre glass
blanket
11. 2 layers of 12mm gypsum board
12. 250mm reinforced concrete
13. 40mm timber flooring on 40mm
air cushion
14. 40mm mineral fibre impact sound
insulation with perimeter
insulation and elastic seals
15. Structurally isolated 150mm rein
forced concrete slab
16. Coupled door:
40mm double glazed panel, 150mm
air space, 6mm sound absorbent
reveal, 8mm laminated glass



[Fig 6.22] Typical Practice Room.

By author, 2011

[Fig 6.24] (*Opposite*) Ideal distribution of absorbent surface in rooms for speech.

1. Reflective surface
2. Absorbent surface

From: Acoustics and sound insulation: Principles, planning, examples (p. 78), E. Mommertz, 2009, Boston, Detail.

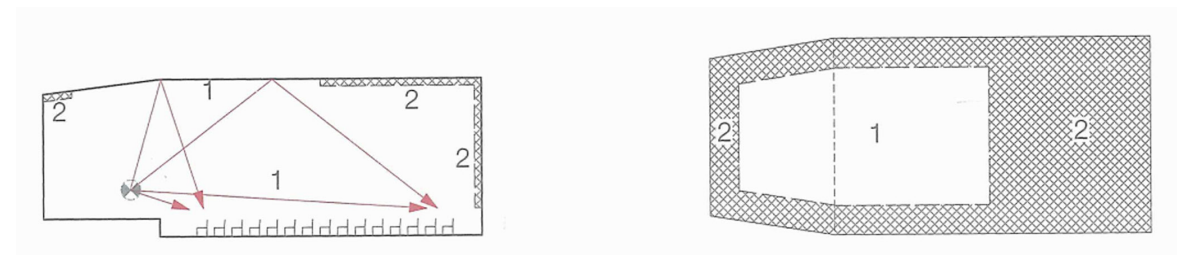


[Fig 6.23] Lecture Theatre: Isometric.
By author, 2011

Lecture Theatre

The Lecture Theatre is designed as the traditional shoebox shape with a steep seating rake to reduce the volume of the space [Fig 6.23]. This arrangement achieves both clear sightlines, but also direct sound transmission to each person in the audience (Mommertz, 2009, p. 78). The space is used for both music and speech. Good speech intelligibility requires a low reverberation time. Therefore the design of the space aims at a reverberation time between 0.8-1s with a full audience (Barron, 2010, p. 78). This is achieved with a low room volume of 4-6m³ per person, regarded as ideal in rooms for speech (Barron, 2010, p. 78). Two-thirds of the plan area is allocated to sound-absorbing measures, which should be sufficient in preventing echoes (Mommertz, 2009, p. 78). However, the audience seats are only lightly upholstered so that the space maintains some reverberation for musical performances. Alternatively the transportable devices around the stage can be rotated to increase absorption or reflection as desired.

To improve clarity the geometric and acoustic design of the ceiling is such that early reflections reach the audience from dense wooden surfaces (Ulrike, 2006, p. 1446). The central part of the ceiling is designed to reflect the frequency range significant for speech: octaves from 250 to 2000Hz (Mommertz, 2009, p. 78). Sound absorbent material is fixed beneath the wooden lining at the rear of the room to assist with attenuation [Fig 6.24] (Cox, 2003, p. 119). This absorption is designed to prevent delayed reflections, which hinder speech intelligibility from being reflected back to the podium (Mommertz, 2009, p. 78). Connected to the rear of the space is a sound isolated Electronic Music Studio for recordings and production.





[Fig 6.25] Multipurpose Hall: Isometric.
By author, 2011

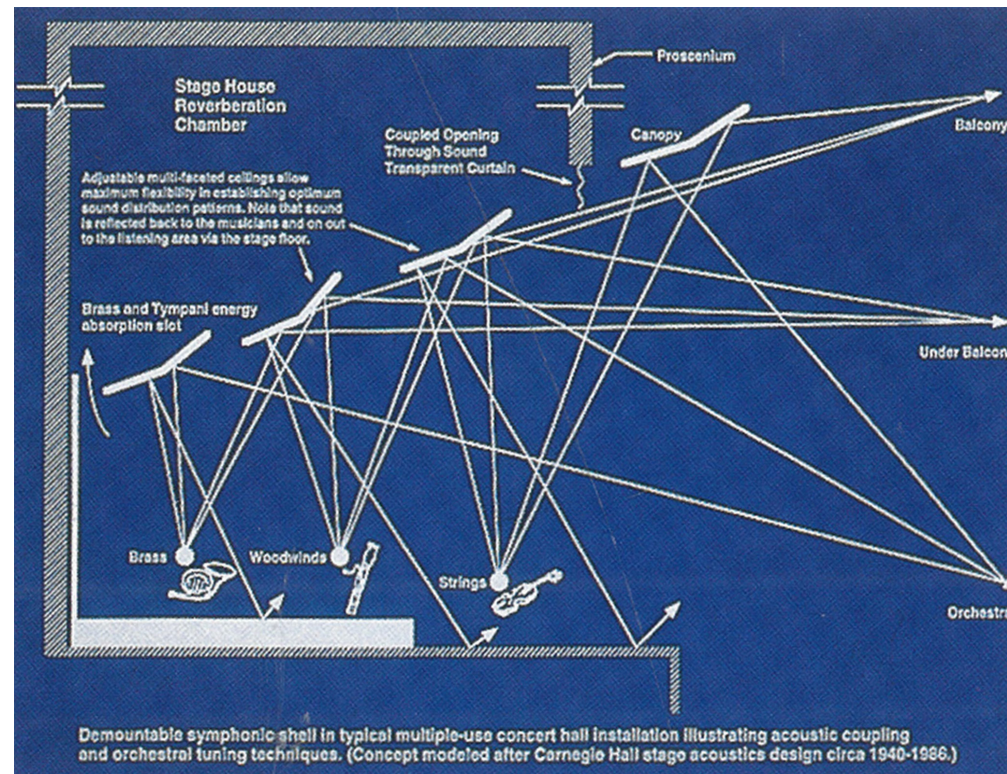
Multipurpose Hall

The Multipurpose Hall is the second primary adaption of the shoebox archetype [Fig 6.25]. The space appropriates the narrow width, long length and high ceilings of the Altes Gewandhaus and the Hanover Square Rooms, with comparatively similar dimensions. However, unlike its eighteenth century predecessors, it is designed without a stage or seating so that the stage size and audience capacities can be easily adjusted. The performance platform and volume of the space have been designed to achieve an average mid frequency reverberation time of 1.3 to 1.5s, which is ideal for a multi-use space of this kind (Jaffe, 2010, p. 77). Diffuser panels on the side and end walls of the hall help to balance high- and low-frequency reverberation and reduce harshness (Jaffe, 2010, p. 84). Removable curtains at the back of the stage as well as at the rear corners of the space reduce undesirable acoustic feedback and enable the space to be used for amplified performances (Hidaka, 2004, p. 362).

The space is designed to accommodate jazz, opera and amplified performances as well as small-scale orchestral performances. With such a wide range of acoustic requirements it is difficult to establish an acoustic optima for all. However, as discussed in Chapter two, the solution is to create a reverberation time that creates an acoustic range between music and speech. A reverberation time between 1.3 and 1.5s should be adequate for both the short reverberation time required for speech and the long reverberation time needed for Classical music (Mommertz, 2009, p. 98).

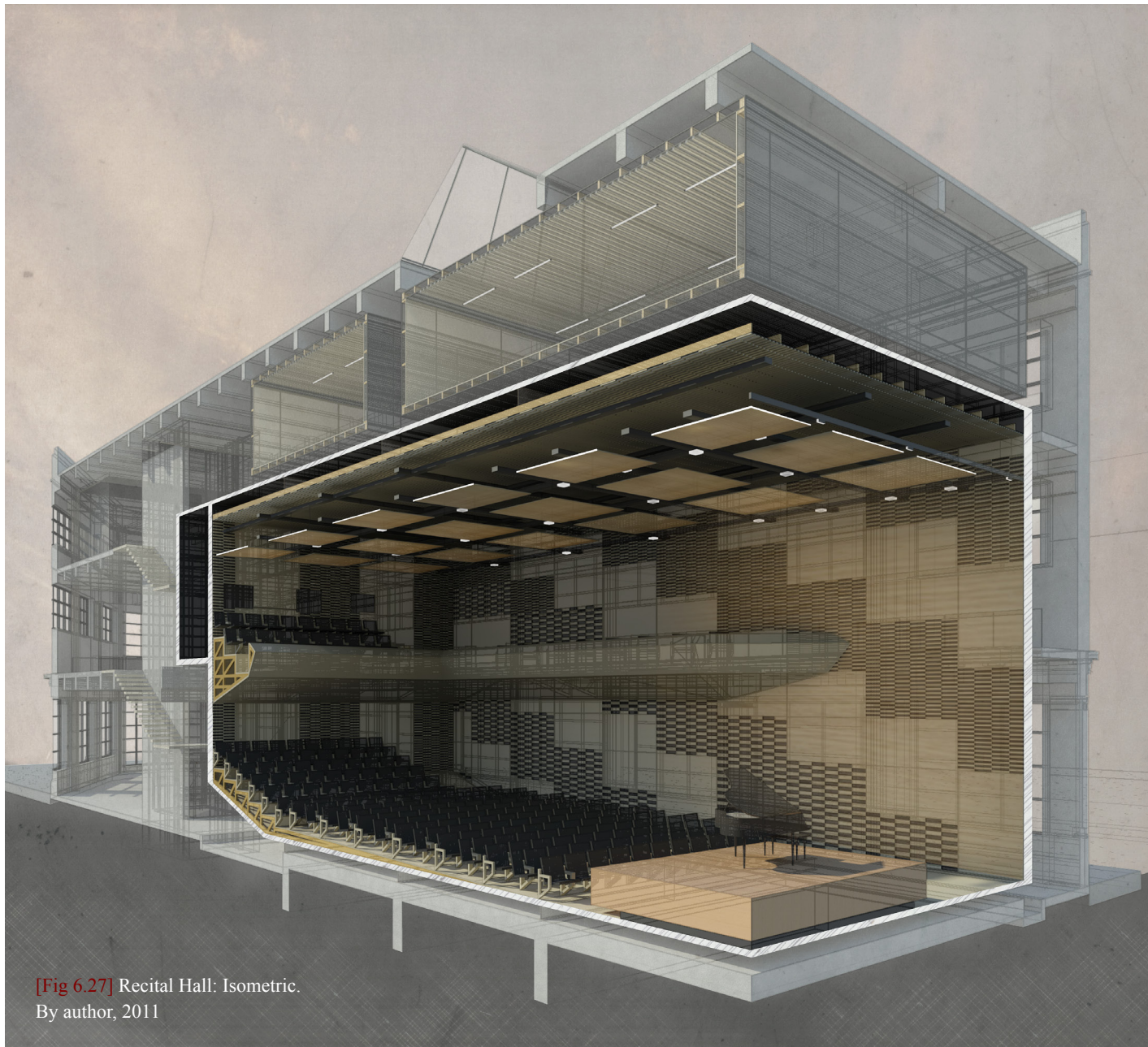
This acoustic range is achieved by employing a relatively high degree of acoustic attenuation within the interior (Mommertz, 2009, p. 98). The high interior attenuation also offers good acoustic conditions for amplified music. However, with such a hall design, the reduction in the acoustic quality for Classical music has to be accepted (Mommertz, 2009, p. 98). Lightly upholstered removable chairs will make up the audience seating as required. The music corresponding with the desired reverberation time will determine the size of the audience. If good acoustics for Classical music are important, it is essential to provide at least 7m³ per person (Mommertz, 2009, p. 98).

An important feature of the ceilings is the way the reflective panels are hinged along a centre line to create two different reflecting angles in each individual ceiling unit [Fig 6.26]. This enables the user to tune the shell so that a portion of the sound energy reflected from these surfaces is directed toward the audience and another portion is returned to the musicians on stage (Jaffe, 2010, p. 104). The reflective panels are controlled by an electromechanical winch system mounted on the upper surface of the ceiling.



[Fig 6.26] Adjustable acoustic panels.

From: The acoustics of performance halls: Space for music from Carnegie Hall to the Hollywood Bowl (p. 104), J.C. Jaffe, 2010, New York, W.W. Norton & Company, Inc.



[Fig 6.27] Recital Hall: Isometric.
By author, 2011

Recital Hall

The Recital Hall is designed primarily for symphonic programs; however, it has also been design to house chamber music, soloists and ensembles of up to 35 performers. Based on the small-scale concert halls of the eighteenth century, the hall is designed for a 350-seat audience and is intended to achieve a maximum reverberation time at mid frequency between 1.4 – 1.8s. The hall has been built as a completely separate space within the main building. This ensures that the interior of the hall is acoustically decoupled from the rest of the building (Mommertz, 2009, p. 101). The hall is also surrounded with corridors, circulation zones and foyer areas to create an effective buffer zone between itself and any exterior noise [Fig 6.27] (Mommertz, 2009, p. 101).

The scale of the Recital Hall is designed to ensure clarity, intimacy and the intelligibility of individual voices and instruments (Barron, 2010, p. 78). The shoebox has been chosen as an acoustic model for the Recital Hall for both its simplicity and ability to deliver a clear and intimate sound (Jaffe, 2010, p. 50). As discussed previously, the strongest feature of this shape is the uniformity of sound quality throughout the entire seating area (Beranek, 2011, p. 8). Sound quality is reinforced by lateral reflections designed to come from the parallel side walls. The side walls at the stage end are designed with a 7° angle to avoid flutter echoes (Mommertz, 2009, p.17). Extending the remaining walls high above the balcony helps to create a rich reverberation, especially for Romantic ensembles (Beranek, 2011, p. 8).

The main goal in the design of the Recital Hall was to develop a performance space which guarantees an even blending of musical tone, and produces a homogeneous orchestral sound. In large-scale concert halls, such as the Musikvereinssaal and Boston, reverberation times of 1.7- 2.0s are advantageous for medium frequencies (Jaffe, 2010, p. 53). However, the longer the reverberation in the hall, the more difficult it is to obtain clarity for small ensembles and soloists performing Bach fugues or Mozart quarters (Jaffe, 2010, p. 53). Instead, the proposed Recital Hall aims at a reverberation time between 1.4 -1.8s to establish an acoustic range between Classical and Romantic performances. In order to achieve the desired reverberation time the hall is designed with a volume of 11m³ per person¹⁶ (Barron, 2010, p. 78). Considering the small scale of the space and the need to facilitate soloists, a reverberation time extending any longer may lead to a diffused and undifferentiated overall sound (Mommertz, 2009, p. 90).

The audience capacity is limited to 350 people because anything larger would reduce loudness and require an enormous increase in volume to compensate for audience absorption (Jaffe, 2010, p. 52). Measuring 15.7m across, the proposed NZSM Recital Hall is much wider than its historic small-scale precedents, with a comparatively higher ceiling. In fact the hall is proportionately more similar to the Concertgebouw, Amsterdam.¹⁷ In theory, the widely spaced side walls in conjunction with the high ceiling should match the *live* acoustics of the large-scale concert hall and provide a suitable ambience for Romantic styled performances. Subsequently, the width of the hall will ensure an initial time delay gap of less than 15 milliseconds so that the hall can be easily adapted to create the clarity required for Classical performances (Jaffe, 2010, p. 52).

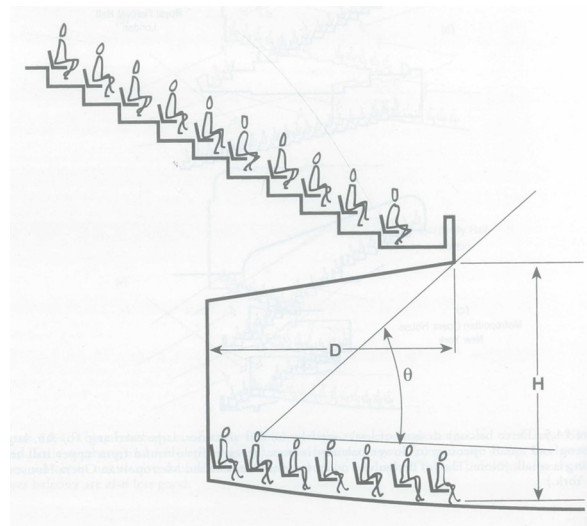
As discussed previously, air absorbs high frequencies, so the hall must have enough volume to cut down the highs and equalize the bass ratio (Jaffe, 2010, p. 75). The total volume of the hall should provide sufficient air volume to accommodate the power of a large orchestra and choir works so that the sound will not become shrill (Jaffe, 2010, p. 75).

The exterior walls of the hall are constructed with a plywood (painted black), in front of heavyweight concrete construction to contain low-frequency energy in the hall (Jaffe, 2010, p. 53). It will also provide the proper ratio of mid- to low-frequency reverberation needed for *warmth* (Bucur, 2006, p. 31). The floor of the hall is lined with 40mm parquet rigidly connected to the hall's foundation structure so as to gain additional low-frequency structural vibration that will further enhance *warmth* (Jaffe, 2010, p. 53). The interior side walls of the hall are lined with a reflective high-density wooden surface. The panel system is divided into clean and broken surfaces. These irregularities create surface diffusers which prevent distortion in the room. Like the coffered ceilings and extensive ornamentation found in large-scale halls, these diffuser panels remove the focusing effect from the sound while preserving the acoustic energy (Cox, 2003, p. 119). Sound absorbent material is fixed underneath various sections at the rear of the hall to reduce parallel sound reflections (Beranek, 2011, p. 6). The comprehensive use of timber throughout the hall will contribute to extreme clarity and supreme acoustic intimacy.

The stage is designed at a height of 1m above ground level to reach an optimal audience both visually and aurally (Mommertz, 2009, p. 93). The audience seating is staggered with a gradual rake to ensure both clear sightlines and also a direct sound link between performer and listener. A shallow seating rake was chosen to avoid reducing the volume of the room unnecessarily (Mommertz, 2009, p. 91). The audience is essential for the absorption in the hall, and hence affects the relationship between the volume and reverberation time.

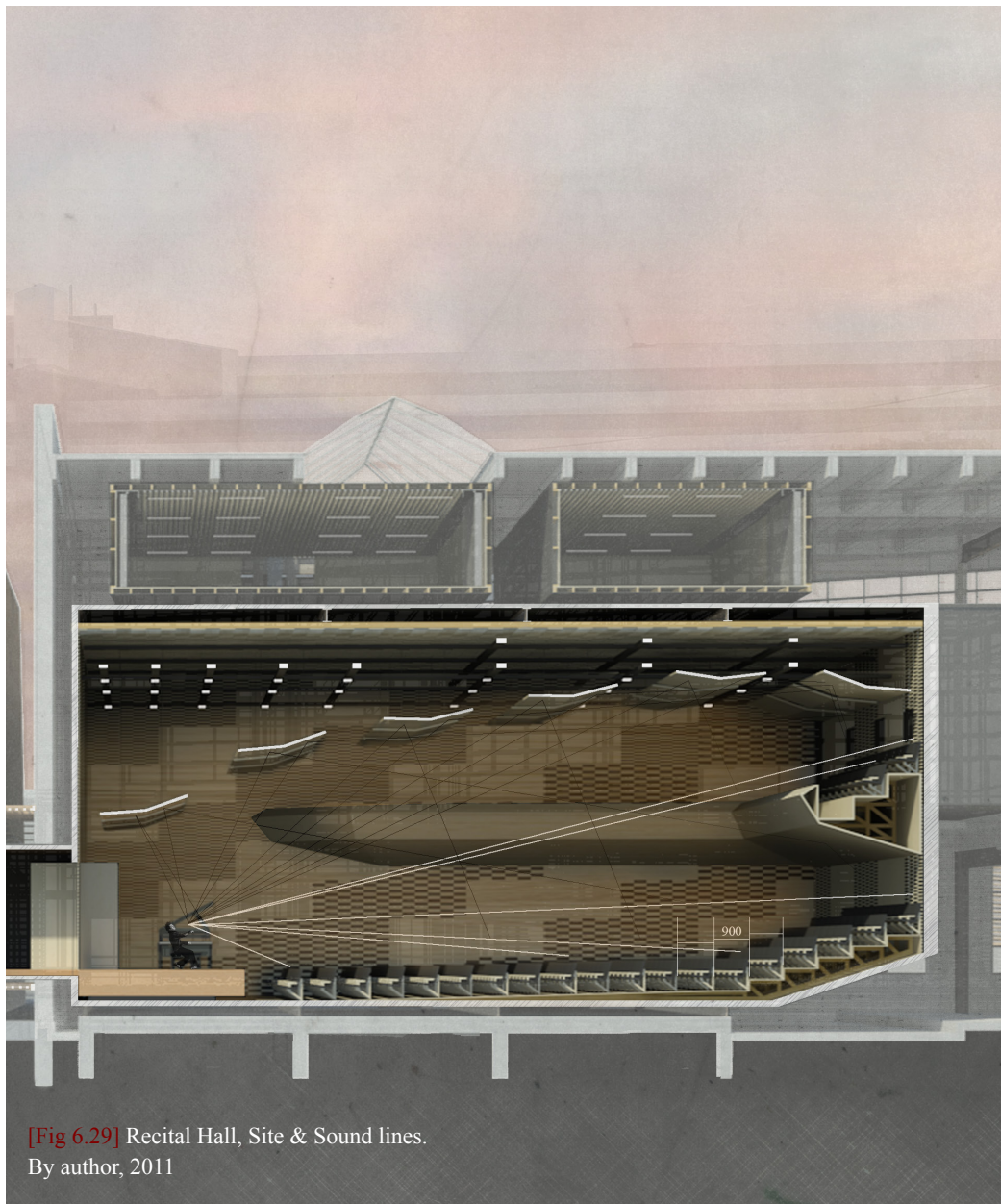
However, the sound absorption per person decreases with the distance between the rows and the width of the seats. To ensure the audience works effectively as an absorbent mass, the seating is designed with a distance of 900mm and a width of 550mm per seat [Fig 6.29] (Mommertz, 2009, p. 92).

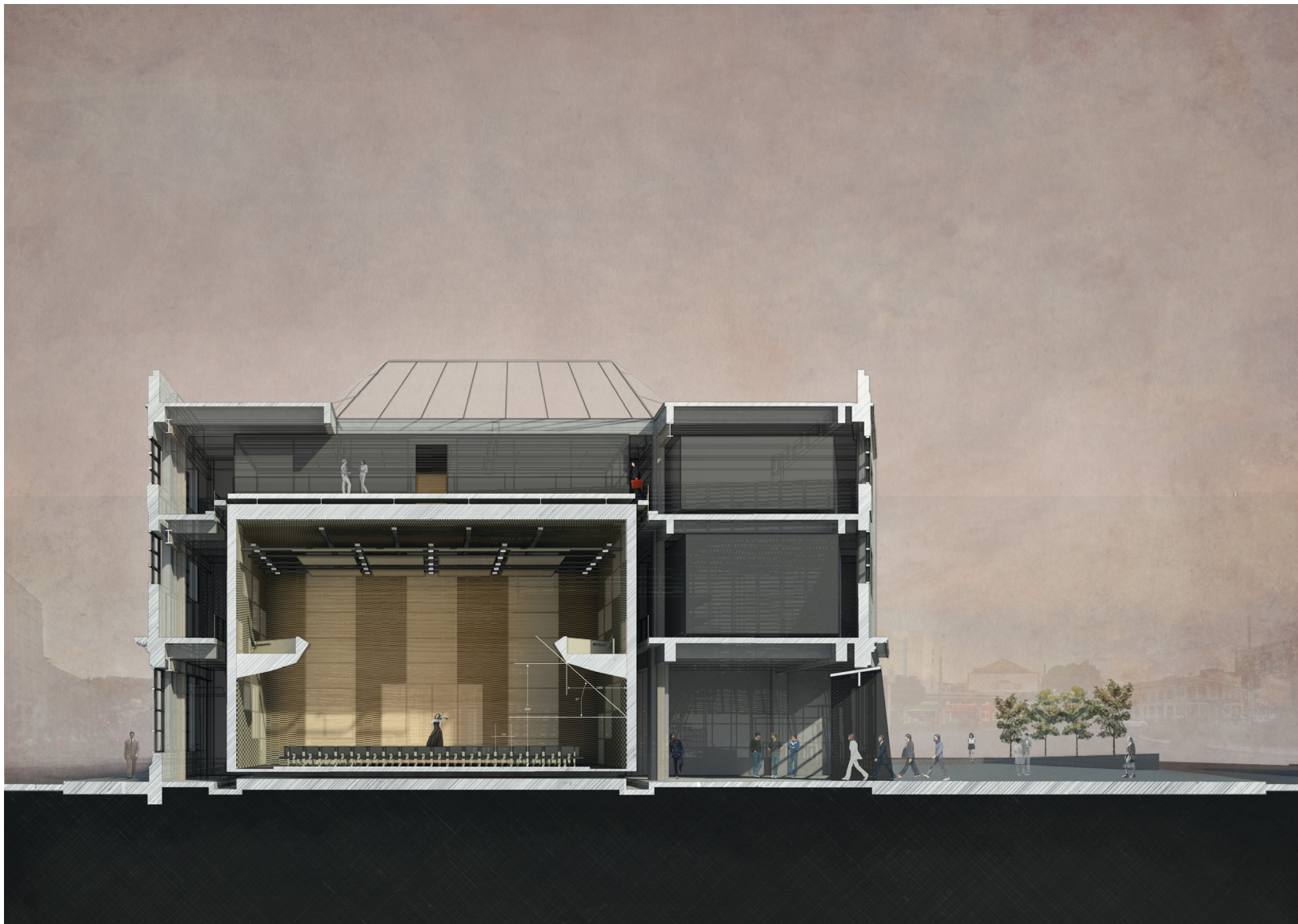
The balconies of the hall are designed to both increase the audience capacity and reduce parallel sound reflections [Fig 6.28]. The ratio of balcony height, h to balcony depth, i , is designed to be a maximum 1:2 with a minimum 25° angle to ensure an effective reflection (Mommertz, 2009, p. 95). The side balcony is designed as a single row to minimise the overhang factor and maintain a site line from the seats in the rear corner [Fig 6.30]. The rear balcony is designed to reduce the overhang factor for those members of the audience seated at the rear of the main floor (Beranek, 1996, p. 504).



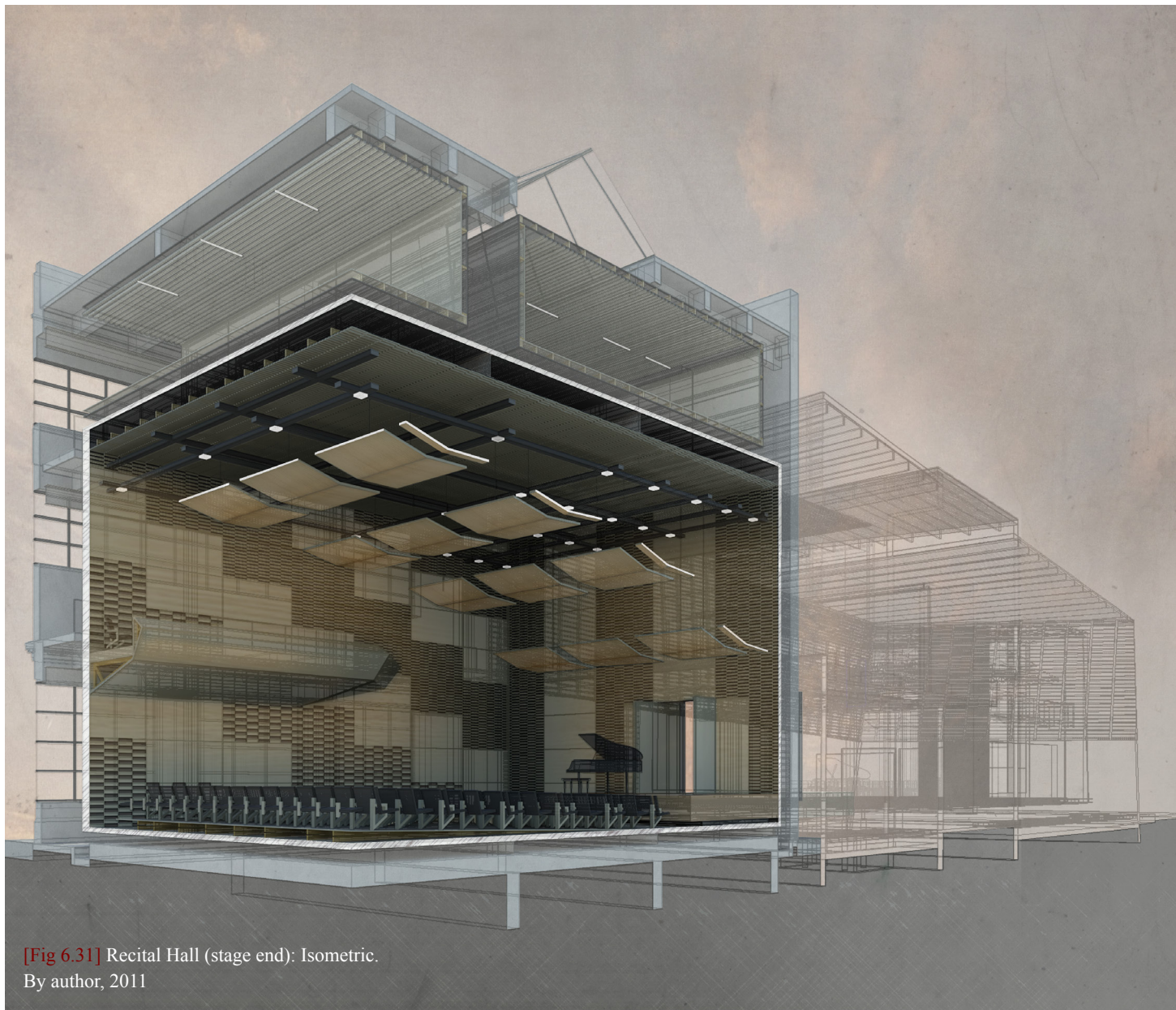
[Fig 6.28] Recommended design for overhang of balconies in Concert Halls: As a general principle D should not exceed H . The angle should not be less than 45° .

From: Concert and opera halls: How they sound (p. 35), L.L. Beranek, 1996, New York, Acoustical Society of America.





[Fig 6.30] Transverse Section A-B.
By author, 2011



[Fig 6.31] Recital Hall (stage end): Isometric.
By author, 2011

Appropriated from the adjustable ceiling panels in the Jesse H. Jones Hall for the Performing Arts, the hall has the ability to alter the scale of the space with mechanically operated adjustable ceiling panels. The panels help to compensate for the comparatively wide spacing between the side walls by lowering the overall volume and providing additional overhead reflections (Marshall, 2001, p. 92). These reflections improve the clarity within the hall by directing sound toward the audience (Mommertz, 2009, p. 93). In addition this will also assist in blending the orchestral sound into a unified whole (Jaffe, 2010, p. 55).

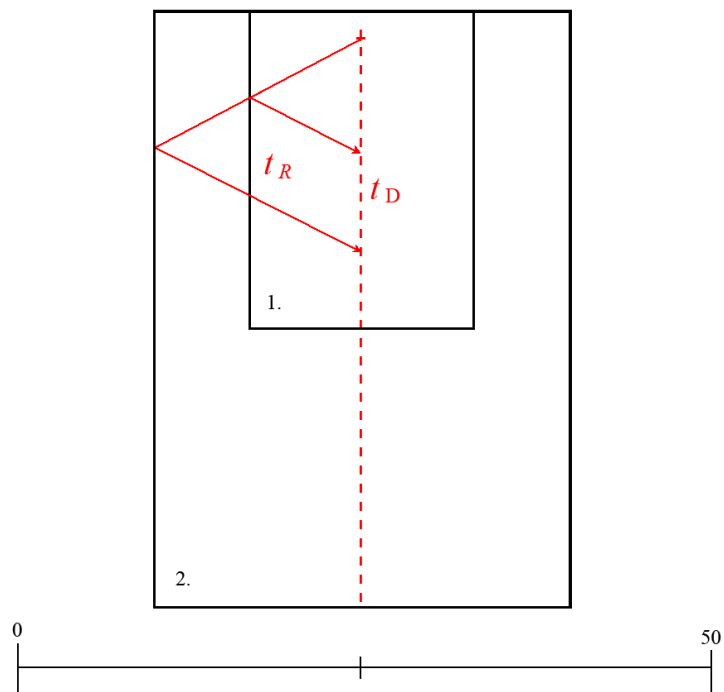
Like the Multipurpose Hall, the reflective panels are hinged along a centre line to create two different reflecting angles in each individual ceiling unit [Fig 6.31]. The panels are made of lightweight plywood that have the advantage of reflecting mid- to high-frequency sound, while at the same time being transparent to long-wave, low-frequency sound (Forsyth, 1985, p. 290). The sharp definition of the high-frequency sound directed toward the audience means that the hall's acoustics can be altered for Classical performances. Alternatively the ceiling panels can be re-tracked so that they maintain the full volume of the hall. This in turn increases the reverberation time, and the hall becomes suitable for Romantic performances. The acoustic range achieved by the reflective panel ensures the hall can produce an ambience suited to both Classical and Romantic performances (Forsyth, 1985, p. 289).

	Capacity	Dimensions $l \times w \times h$ (m)	Volume m^3	Volume (m^3) per person	Reverberation time (mf)	ITDG
<i>Performance venues:</i>						
<i>Small-scale precedents</i>						
Hanover Square Rooms	800	24.1 x 9.7 x 8.5	1,875	4 m^3	1.0 seconds	
Haydn-Saal	600	38 x 14.7 x 12.4	6,800	11.5 m^3	1.7 seconds	
Altes Gewandhaus	400	23.0 x 11.5 x 7.4	1,800	4.8 m^3	1.2 seconds	
<i>Large-scale precedents</i>						
Neues Gewandhaus	1560	44.9 x 19.2 x 15.1	10,600	6.7 m^3	1.55 seconds	
Grosse Musikvereinssaal	1680	52.9 x 19.8 x 17.8	15,000	8.9 m^3	2.2 seconds	12 msec
Concertgebouw	2037	43.0 x 28.4 x 17.4	18,770	9.2 m^3	2.2 seconds	21 msec
Boston Symphony Hall	2625	50.7 x 22.9 x 18.8	18750	7.1 m^3	1.85 seconds	15 msec
<i>NZSM proposal</i>						
Recital Hall	350	22.6 x 15.7 x 10.1	3538	11 m^3	1.4 - 1.8 seconds	10 msec
Multipurpose Hall	200	17.7 x 10.2 x 8.7	1,570	7.8 m^3	1.3 - 1.5 seconds	8 mses
Lecture Theatre	150	12.5 x 11.2 x 8.1	886	5.7 m^3	0.8 - 1 second	6 msec

[Fig 6.32] Table of comparison.

Adapted from: Auditorium acoustics and architectural design,
by M. Barron, 2010, London, Spon Press.

¹⁶ For traditional small-scale halls the room volume per person on average is 6.4 m^3 , however more modern halls average 9.1 m^3 (Hidaka, 2004, p. 362).

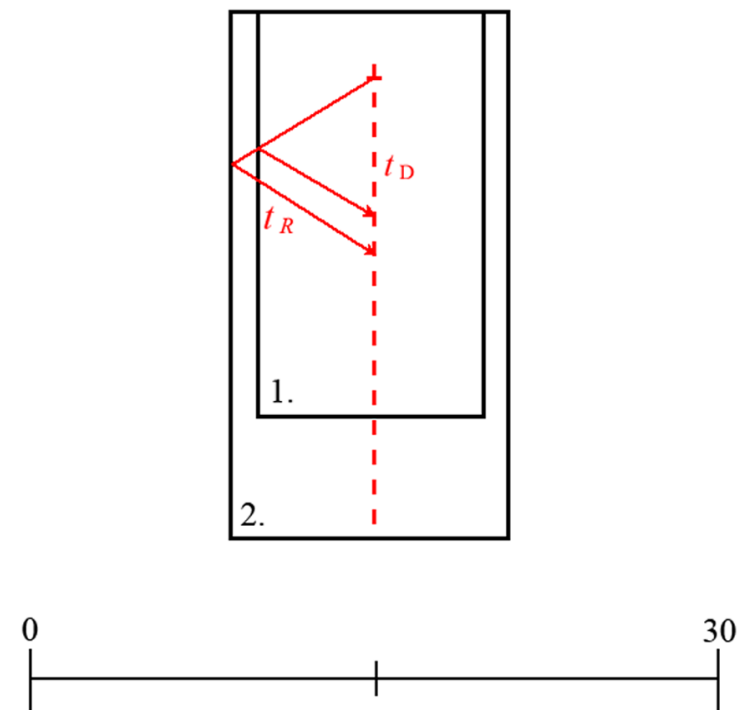


[Fig 6.33] Diagram comparing the proposed NZSM Recital Hall with the Concertgebouw.

- 1. NZSM Recital Hall
- 2. The Concertgebouw

By author, 2011

¹⁷ The aspect ratio of length over width for both the Concertgebouw and the proposed NZSM Recital Hall is 3:2.



[Fig 6.34] Diagram comparing the proposed NZSM Multipurpose Hall with the Altes Gewandhaus.

- 1. NZSM Multipurpose Hall
- 2. The Altes Gewandhaus

By author, 2011

Interior Summary

The interior logic produces an acoustic solution to three small-scaled concert spaces with alternate acoustic requirements. It also provides a generic acoustic solution for typical classroom usage. Each of these rooms has demonstrated an ability to adjust their interior acoustics with both simple and complex devices. In doing so the design solution has fulfilled the requirements for speech, jazz, and amplified music, while developing an acoustic range between Classical and Romantic styles in the main Recital Hall. A coherent architectural language is established in the main concert spaces with an appropriate timber panel system. The arrangement of clean and broken surface is adjusted throughout the spaces to suit the required reverberation time. Finally, a solution to the exterior traffic noise is resolved by structurally isolating the main performance venues from envelope. In addition sound isolation between classrooms is resolved with a proposed room-in-room construction method.

The following chapter summarises the main topics of this thesis and re-outlines its primary focus. The chapter will also concluded with a statement of significant findings, and establish a point of departure for future research.

Chapter 7 | *Conclusion*

Chapter 7 | *Conclusion*

This chapter summarises the key topics discussed in this thesis. To reiterate, the primary focus of this study is on adapting an analysis of large-scale concert halls to the design of small-scale concert space. Focusing specifically on the shoebox model, this study assimilates large-scale acoustic principles to the design of three small-scale concert venues. Through site analysis, this study develops an inquiry into the social role of the concert hall and proposes solutions in which to promote public interaction with the concert programme. Finally, this section concludes by identifying the significant findings established in this study, and develops a point of departure for future research.

This thesis has analysed both the contextual and acoustic functions of the concert hall, from its historic beginning in the late seventeenth century to its iconic status in the present day. This study has confirmed that the design principles, both interior and exterior, of large-scale concert halls may be down scaled to the design of small-scale concert spaces. Furthermore, it argues that the shoebox archetype is the most suitable acoustic model for the NZSM because of its potential for acoustic variability and multi-functionality.

In analyzing the acoustic functions of the shoebox concert hall, the findings from this study establish that the acoustic principles of large-scale concert halls may be adapted to the design of small-scale concert spaces by using a method of proportionate variation. As demonstrated in the adaption of the Neues Gewandhaus and the Musikvereinssaal for the Boston Symphony Hall, an excellent hall may be adapted to give identical acoustics. Furthermore, the volumetric difference between the four large-scale precedents discussed in this study (Leipzig, Vienna, Amsterdam and Boston) suggest that the proportionate variability of the shoebox model is so great that it becomes more a matter of establishing certain limits. Provided the width of the hall does not exceed 23m, to ensure an initial-time-delay gap of less 20ms; and an average volume of 10-12m³ per person is maintained for an adequate reverberation time, the shoebox model is capable of almost any dimensional variation.

However, the dimensions of the performance space become more contrived when ensuring the acoustic ambience and musical genre is stylistically akin. This point is demonstrated with the comparisons made between the Classical and Romantic periods, and the findings applied in the design of the Recital Hall. It establishes reverberation time as the most significant acoustic variable in determining the required ambience of a performance space. However, it also concludes that reverberation time may be adjusted by altering room

volume, acoustic material treatments or fluctuating audience capacities. This is illustrated in the design solution which adapts the shoebox paradigm to the design of the Multipurpose Hall and the Lecture Theatre.

These findings offer significant scope for future research in small-scale acoustic design. The next step would be to test these findings with digitally simulated models to fine-tune dimensions and calculate early reflections. In addition, further research could be undertaken to determine the most effective materials for both the reflection and absorption of sound. There is also further scope for future research in the field of adjustable acoustics. Although this study has discussed an acoustic range between Romantic and Classical styles, specific research could be undertaken to develop solutions for more contemporary musical genres. The next step in this field would be to build on those acoustic mechanisms which possess both absorbent and reflective properties, and develop a design strategy that seeks to increase their functionality.

In analyzing the civic functions of large-scale concert halls, the significant findings from this study argue that although these culture icons operate on a comparatively larger scale, the principles applied to both the exterior envelope and urban territory may be adapted for the purposes of the NZSM. As illustrated through an observation of historical examples, traditionally acoustic requirements for sound isolation have removed the concert hall from any strong physical links to the urban environment. In appropriating the social theories applied in the Muziekcentrum Vredenburg, the findings from this study argue that increased accessibility and the integration of public space can help to promote increased interaction with the concert programme. Additional findings argue that locating the NZSM programme at the intersection of existing concert infrastructure and densely populated urban territories further promotes public interaction with the NZSM. Thus, the integration of the NZSM with the central city site transcends from semi-private programme to cultural institution. This finding is particularly relevant to the NZSM programme, as is defined in the design brief, a lack of public interaction is one of the major reasons why the school has been unable to achieve substantial growth.

The solutions discussed in this study are significant to both acoustic and societal aspirations within architecture. The design solution accommodates the programmatic requirements of the NZSM brief, achieving the required capacities with acoustically appropriate fitness for purpose. Meanwhile, through urban analysis, the design proposal delivers a sensitive response to the existing context. The response considers scale, for both the programme and also in respect to other cultural institutions nearby. The relationship between performance space, public interface and urban territory effectively locates the New Zealand School of Music programme within the context of the city.

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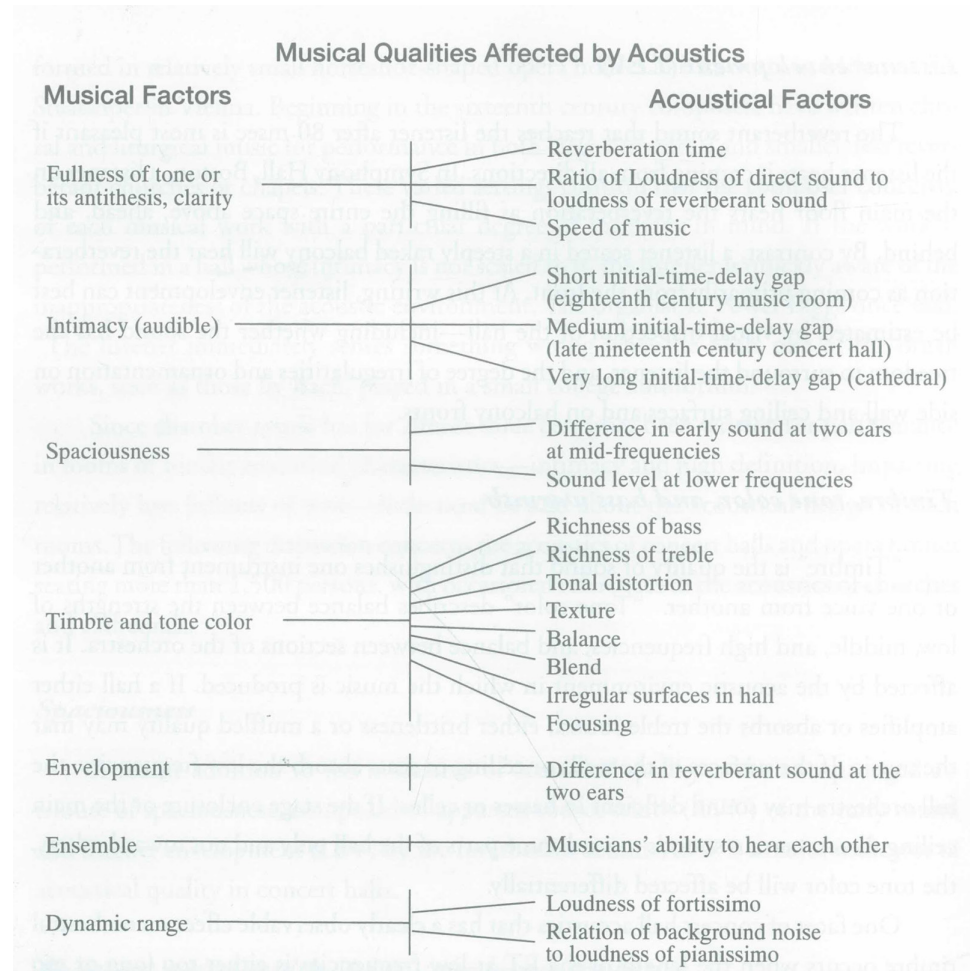
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Appendix 1

Chart of interrelations between the musical and acoustical factors of concert halls.

From: Concert and opera halls: How they sound (p. 38),
L.L. Beranek, 1996, New York, Acoustical Society of
America.



Appendix 2

Human Ethics Approval



Phone 0-4-463 5676

Fax 0-4-463 5209

Email Allison.kirkman@vuw.ac.nz

MEMORANDUM

TO	John Mauvan
COPY TO	Tobias Danielmeier
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee
DATE	5 July 2010
PAGES	1
SUBJECT	Ethics Approval: No 17759 Flexibility of Industrial Buildings/ (Design Project) Incorporating the New Zealand School of Music (NZSM) into the Old John Chambers Building

Thank you for your applications for ethical approval, which have now been considered by the Standing Committee of the Human Ethics Committee.

Your applications have been approved from the above date and this approval continues until 02 December 2010. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Allison Kirkman

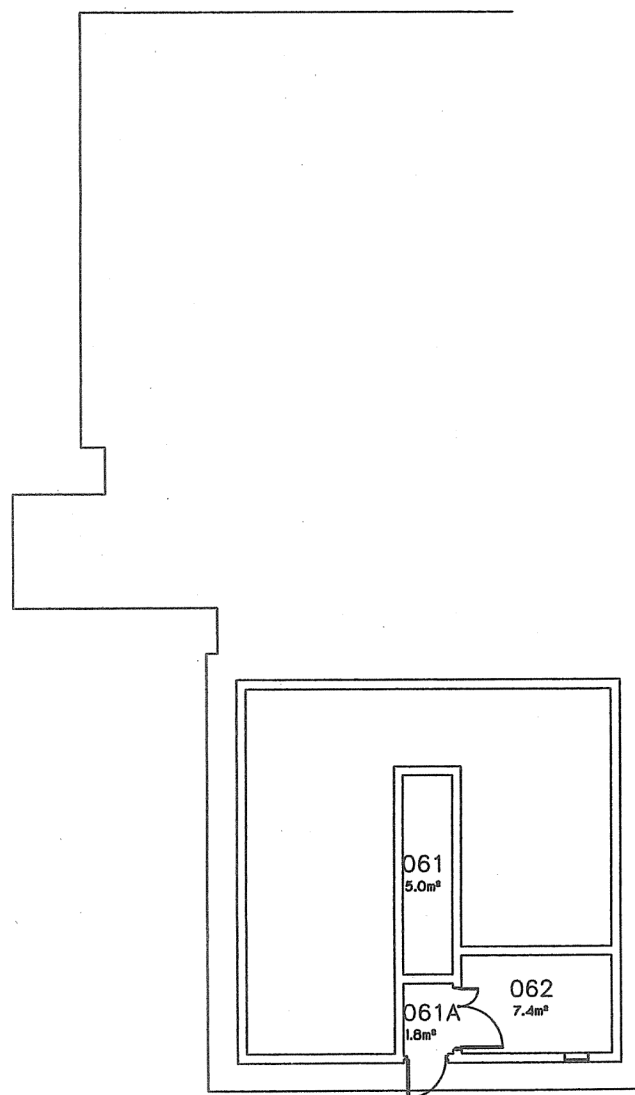
Convener

Appendix 3

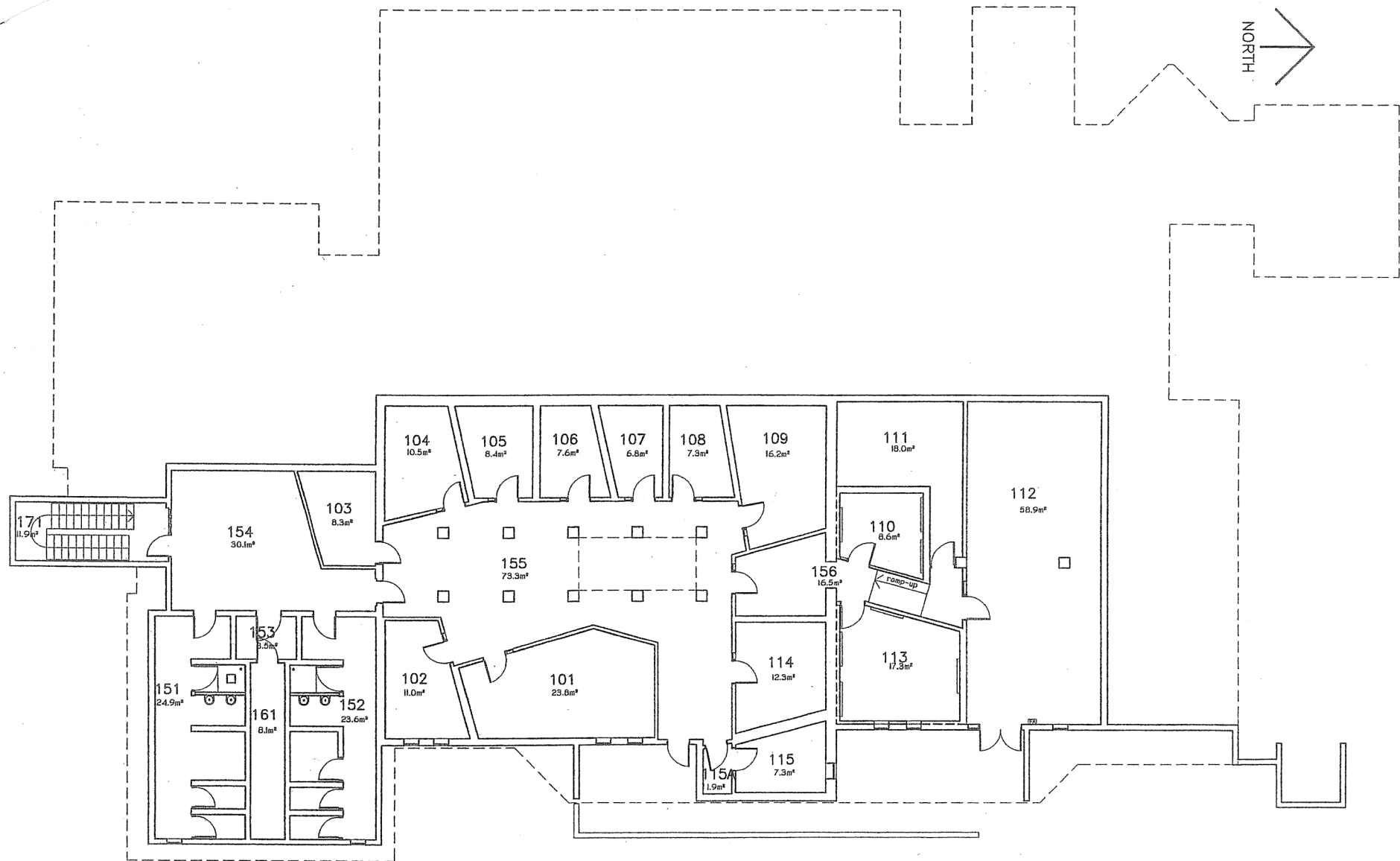
Existing NZSM Plans

Victoria University Wellington Campus.

From: The New Zealand School of Music, 2010.

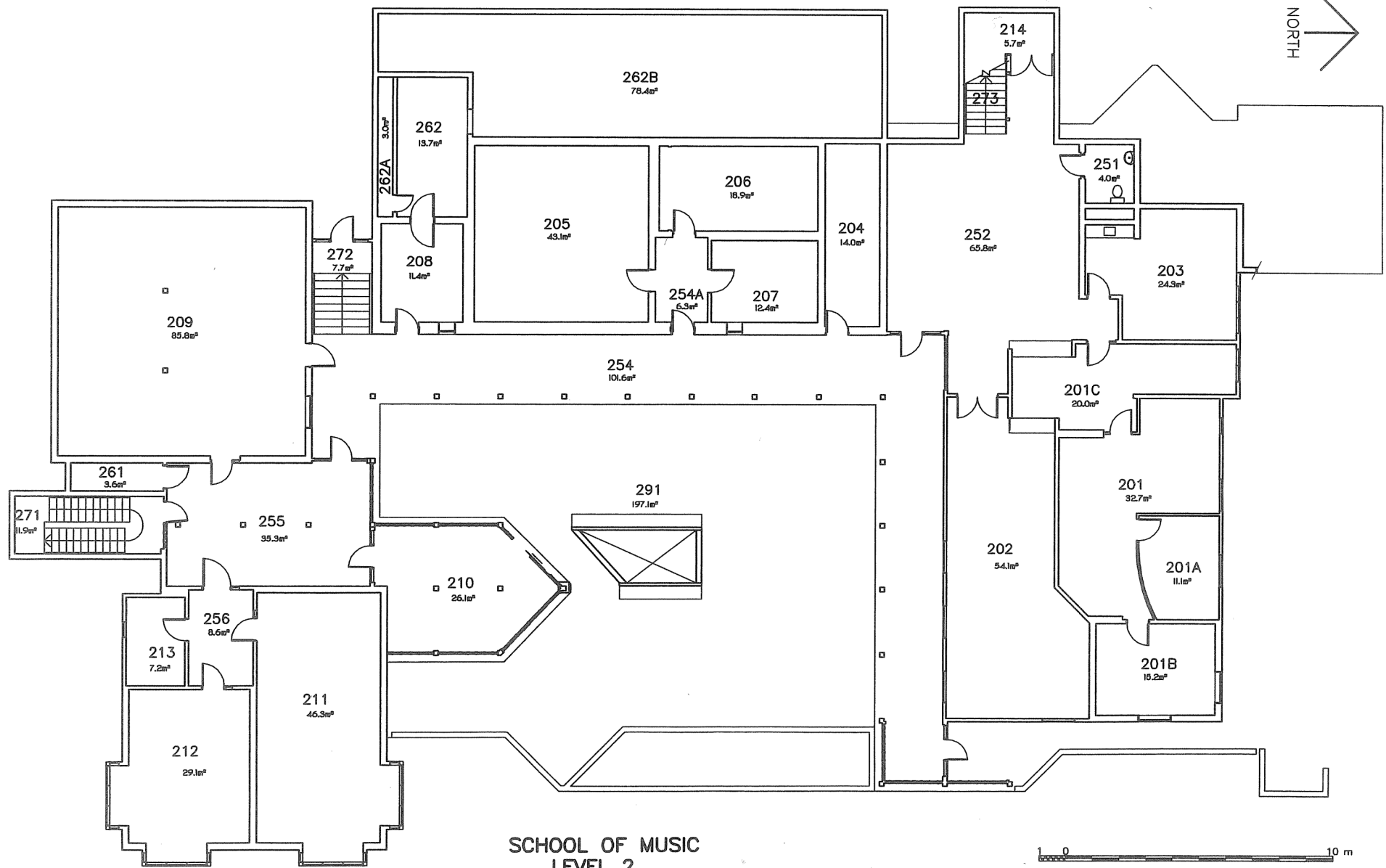


SCHOOL OF MUSIC
LEVEL 0



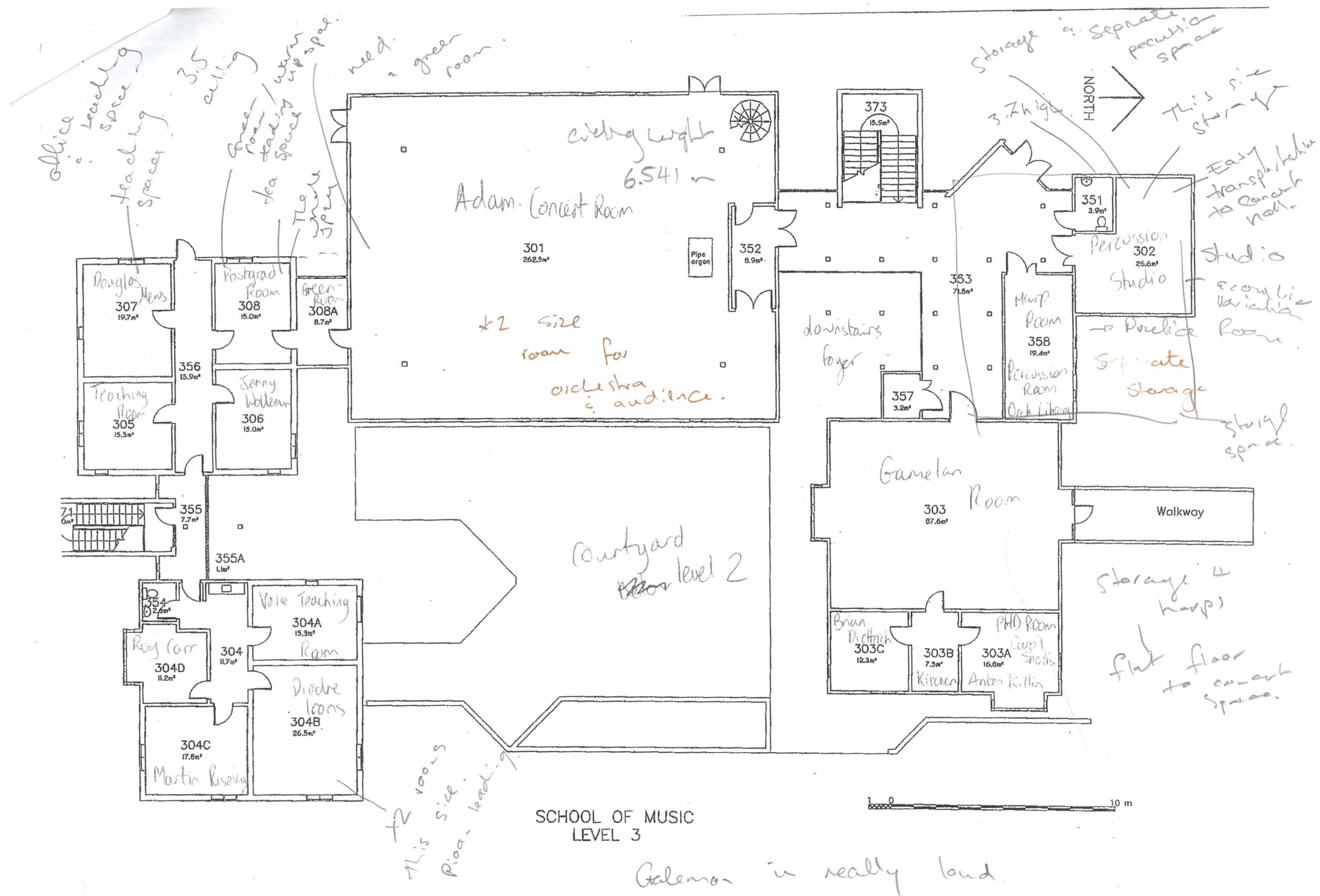
SCHOOL OF MUSIC
LEVEL 1

1 0 10 m

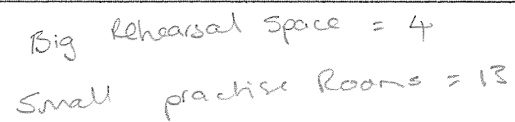


SCHOOL OF MUSIC
LEVEL 2





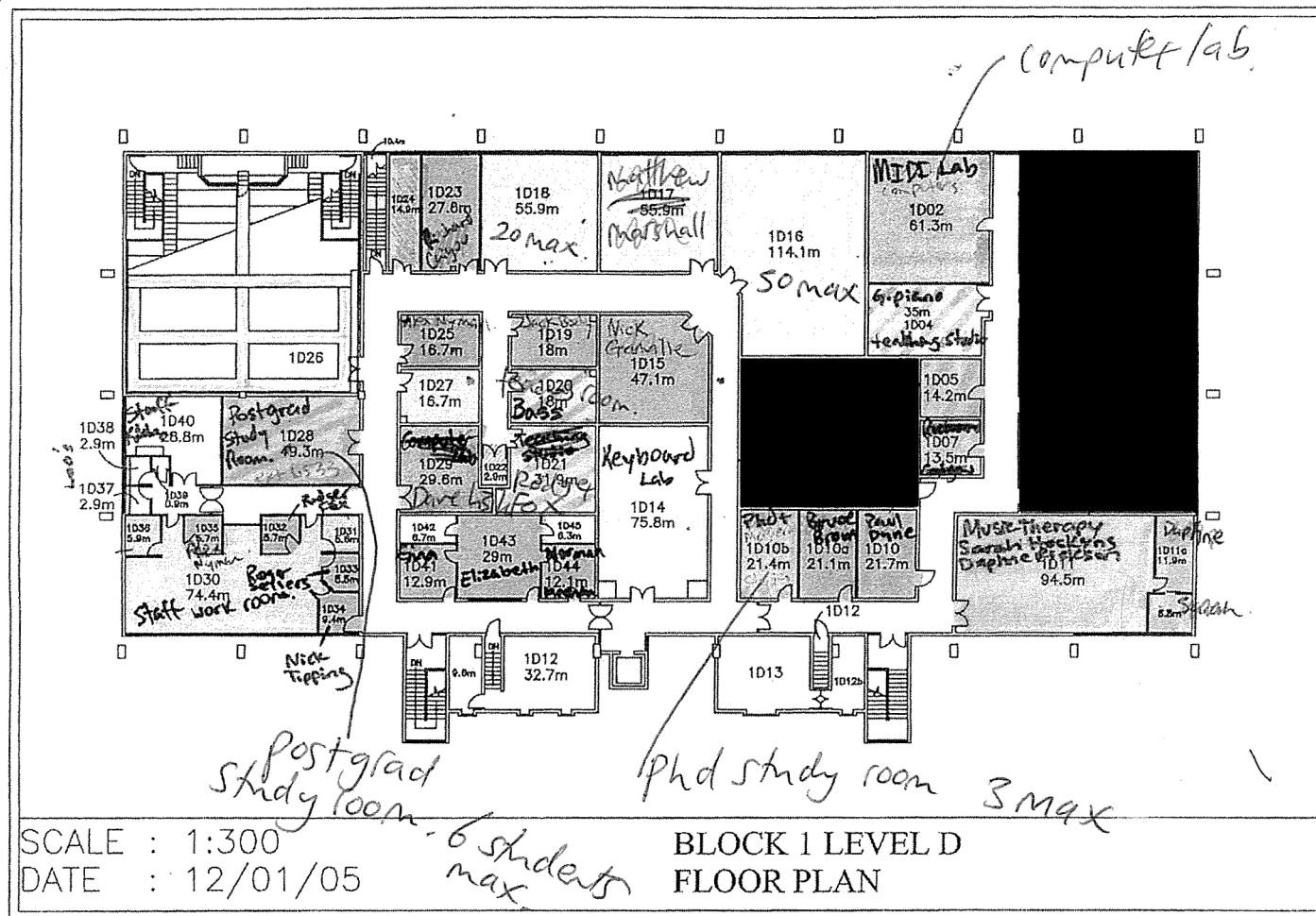
From: The New Zealand School of Music, 2010.



95 jazz students
20 music therapy students

23 full time staff.

Theatrette lecture theatre
200 max



13 -

Senior Room 3 groups
Key board lab > 1

Appendix 4

Proposed Watermark development, Wellington, by Studio Pacific Architects, 2006.

Adapted from: Land Equity, 2008, Retrieved from www.landequity.co.nz/the-Watermark. (accessed 12/07/2010).



