A review of the engineering constraints and project management challenges involved in utilising Scot’s Church as a heritage asset through responsible adaptive reuse and conservation strategies

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2020
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Abstract:
In the field of structural building, there has been a rising popularity in adaptive reuse of older structures, which stems from a variety of stimuli. Apart from preserving built heritage, providing old buildings with new functions promotes sustainability while preventing and containing urban sprawl. Target 11.4 of the United Nation’s Sustainable Development Goals Agenda 2030 explicitly outlines that “more efforts to protect and safeguard the world’s cultural and natural heritage” are required (United Nations 2015). In order to valorise and regenerate obsolescent structures, intervention is often required. The dissertation provides a comprehensive overview of conservation engineering and demonstrates the importance of an engineer’s role on such projects, in order to understand, interpret, and manage the complexities involved. The project uses Scot’s Church as a primary case study to demonstrate the potential of such redundant historic buildings and sets out to encourage imaginative thinking towards utilising such existing structures. The phenomenon of ‘adaptive reuse’ has been examined throughout the study using Scot’s Church as an exemplar of responsible utilisation of Ireland’s cultural heritage. Through an appraisal of printed publications, fieldwork and desktop surveys of Scot’s Church, and comparison with the adaptive reuse of another historic church within Dublin City Centre, the study assesses the engineering constraints and compromises encountered on such projects and outlines recommendations for overcoming common barriers, and mitigating the typical risks involved.
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“Projects we have completed demonstrate what we know - future projects decide what we will learn.” - Dr Mohsin Tiwana

Many heritage structures across the country have outlived their original purpose, however, they still stand as a testimony to the historic design and workmanship of their period, providing us with knowledge of previous engineering achievements and an understanding of how projects were designed and constructed in the past. Repurposing such buildings often requires unconventional approaches from those who ‘think outside the box’.

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1. Introduction

1.1 Aims and Objectives

The aim of the dissertation is to assess the design and construction constraints involved in the adaptive reuse of Scot’s Church. Examining the challenges involved gives insight on how such barriers can be overcome through responsible and sustainable approaches to conservation. The study has been directly focused on the following objectives;

- To analyse and elucidate the process of adaptive reuse in the context of the built environment; provide reasons for adapting older buildings; and describe the many challenges involved.
- To outline the typical intervention options available to accommodate the adaptive reuse process; in particular, those undertaken on protected structures.
- To examine the ideology behind interventions to protected structures.
- To assess the nature of historic buildings, traditional construction methods and materials, and review typical structural issues encountered and repair methods.
- To analyse the suitability of Scot’s Church for adaptive reuse, through assessment of its structural configuration, and examination of the existing fabrics.
- To summarise the key design intervention proposals on the project and outline the barriers to implementing such proposals and the compromises required.
- To investigate the operational challenges and the coordination of works by the main contractor and review the planning and safety considerations during the construction phase of the project.
- To undertake qualitative analysis of the adaptive reuse process by: gathering questionnaire information from building conservation professionals; providing comparative feedback from another redundant church adaptation project; and investigating the design and construction approaches taken and how they relate.
- To discuss the findings of the overall research project and provide recommendations for the adaptation of further obsolete protected structures.
- To promote sustainability of cultural built heritage and encourage integration of historic building stock into current and future planning and development models.
1.2 Relevance of Study

Important built heritage survives throughout Ireland, with an abundance of derelict sites strewn across the country. Apart from the historic significance of such heritage, conserving these structures is a fundamental contributor to achieving a more sustainable environment. However, many of Ireland’s heritage assets are at risk of neglect, deterioration, and inappropriate repairs. Where historic structures lie unoccupied for long periods, they become susceptible to vandalism and detrimental decay, and eventually cross beyond the point of potential repair. Adaptation of old buildings for new uses is not a new practice (Camocini & Rebaglio 2012), and the current discourse on preservation and sustainability has triggered a surge in adaptive reuse of disused structures across the country in recent years.

As part of the UN’s sustainable development goals agenda, Ireland has committed to curbing carbon emissions and meeting specific milestone target dates. This year’s periodic review report (Climate Change Advisory Council 2017) has highlighted that Ireland requires major new policies and measures in order to meet its 2020 targets for reducing carbon emissions and stated the country may be at risk of missing 2050 targets set out to lower emissions by at least 80%. This may result in substantial fines for the country, money which would be better invested into meeting such targets at the outset. Adaptive reuse projects can offer significant opportunities for energy saving by lowering material, transport and energy consumption and pollution (Gregory 1997). Sustainable development is one of the most universally endorsed aspirations of the present day, which further supports the adaptive reuse of Ireland’s built heritage.

This dissertation sets out to demonstrate the potential of Dublin’s historic building stock, by reviewing the responsible interventions undertaken on Scot’s Church, highlighting the project as an exemplar of adaptive reuse. The research intends to raise awareness of the current state of such buildings and their vulnerability, and aims to promote innovative and sensitive design methods which would increase longevity and naturally enhance Ireland’s heritage assets.

“For too long, empty pledges and fine words have died in our mouths – now is the time to turn promises into action for this generation.” Michael D. Higgins, President of Ireland, speaking at a gathering of political leaders in Istanbul, May 23, 2016.
1.3 Structure of the Research Project

The aims and objectives outlined are followed by a literature review in chapters 2-4. Chapter 2 provides a brief synopsis of the adaptability of existing buildings, reasons why changes may be required or sought after, negative effects of neglected buildings, and considerations for the adaptation process.

Chapter 3 outlines the common constraints involved with adapting traditional buildings, reviews the protected status given to certain structures which local authorities consider to be of special interest, provides an overview of the fundamental principles of conservation, and closes with an insight into the adaptive reuse of church buildings as a preamble for the case studies to follow later in the project.

Chapter 4 examines the various types of interventions commonly undertaken on adaptive reuse projects, analyses the ideology behind such changes, provides a review of the structural condition and form of historic buildings, and outlines the typical materials used in their construction. Common structural issues are also examined, with typical repair methods summarised. The chapter draws an end to the literature review with a discussion on the management of change on such projects.

Chapter 5 offers an introduction to the background and location of Scot’s Church, and reviews the history and context of the site, including the adaptive reuse project scope which was granted planning permission in 2008.

Chapter 6 provides detailed surveys of Scot’s Church and its ancillary buildings, with an insight into the configuration, form, fabric, and condition of the existing structures. The combination of desktop and on-site field surveys carried out by the author in this chapter builds a bridge of relevancy between the theoretical concepts outlined in the literature review and practical research based on site.

Chapter 7 gives a breakdown of the principal interventions on the Scot’s Church project, outlines the design constraints involved and compromises required for each, and demonstrates how the new design benefits of adaptive reuse have outweighed the complete preservation of the entire structure, while still paying tribute to its history.
Chapter 8 identifies the various operational constraints faced by the contractor on such a complex adaptive reuse project within an urban setting, and reveals how these typical challenges can be overcome in order to execute such a project successfully.

Chapter 9 offers comparative research on another adaptive reuse project in Dublin City Centre which also utilises a redundant church to create new office space, and demonstrates how two projects with similar deliverables may require exceptionally contrasting design ideas. The chapter provides an overview of the innovative design on St Luke’s Church and further emphasises the importance of specialist engineering input on such exemplar projects. Questionnaires were undertaken with experienced conservation professionals who were involved in the design of these projects, which provide qualitative insight to the diversity of challenges, constraints and compromises on each. The information compiled from the case study, questionnaires, and comparative analysis paved the way for an interesting discussion to summarise and close out the chapter.

Chapter 10 presents practical recommendations which could be put in practice for adaptive reuse projects in the future. The advice is based on the overall findings of the dissertation and clearly outlines how these proposals may contribute to overcoming the challenges involved on such projects. The recommendations trace directly to a conclusion in Chapter 11.
2. Adaptation of Buildings

2.1 Introduction
The word adaptation is derived from late Middle English and French *adapter*, which is a combination of the prefix ‘*ad-*’ (to) and ‘*apter*’ (fit). In the context of buildings, adaptation involves the process of adjustment and alteration to a building to meet new requirements. Any work undertaken which is over and above maintenance can be considered as adaptation (*Douglas 2015*). Figure 2.1 below shows that such works can range from modest preservation to complete demolition and reconstruction.

![Graph outlining the levels of intervention on adaptive reuse projects](image)

*Fig 2.1: Graph outlining the levels of intervention on adaptive reuse projects (Douglas 2015).*

2.2 Building Flexibility
Once a building becomes redundant, adaptation can provide a long-term use for the structure. The built environment is undergoing an increasing rate of transformations due to rapidly advancing technology, updated regulations, performance requirements, lifestyle changes, economic growth and urbanisation (*Wong 2017*). When determining the suitability of a building for a change of use, several factors must be considered, such as the previous function of the building, exposure conditions, the intended future use of the structure, client expectations and if the new use will comply with statutory obligations. The level of a building’s flexibility to adapt to a new use depends on several factors and must be reviewed on a case by case basis (*Kincaid 2002*).
2.3 Reasons for Building Adaptation

The reasons for adapting existing buildings are manifold, and include: deterioration prevention, performance enhancements, change of use, planning constraints and conservation motives. Adaptation not only increases the longevity of the built environment, but also indirectly lowers energy consumption and waste generation by avoiding unnecessary development, and in some cases, it may reduce the effect of urban sprawl by relieving pressure from development outside central urban areas of low density, car-dependent communities (Gregory 1997).

2.4 Building Obsolescence

All buildings eventually reach a point of redundancy either functionally or financially, or both. The life expectancy will vary from one building to another as a result of many different factors, including: the type and arrangement of construction materials, exposure conditions, and operational arrangements. Commercial buildings, for instance, often require more frequent adaptation than other properties due to constant shifting of market forces which can often change the way in which a company operates, and the performance requirements of its building. The prime factors which may affect the life span of a building are as follows:

i) Economic life is the duration for which a building can provide profitable service, until a point where alternative economical options are available. This will depend on its cost-effectiveness, rate of return, depreciation and point at which the building becomes vulnerable to replacement.

ii) Functional life relates to the duration for which a building can satisfy the demands of its users and provide the technological needs of modern-day society.

iii) Physical life relates to the structural performance of a building. It is the duration in which a building withstands the effects of deterioration, up until the point of structural failure.

iv) Social life refers to the duration for which a structure satisfies human needs and cultural requirements.

v) Legal life refers to the duration for which a building is compliant and is dictated by its ability to perform under modern day regulations. (Langston et al. 2007)
Some buildings are more susceptible to redundancy than others, particularly historic buildings, which often provide less flexibility in terms of the ease with which they can be adapted to a new use. The over-supply of many historic buildings, such as places of worship, have resulted in many vacant structures that have outgrown their original intended use. Many such buildings hold high value in terms of their heritage, however they are expensive to maintain and inflexible for adaptation. Without occupancy, deterioration of such structures is inevitable (Douglas 2015).

2.5 Building Decay

Deterioration of buildings is often regarded as a complex phenomenon, the nature and extent of which depends on the fabric type, building arrangement, surrounding environment, exposure levels and interference. The accurate prediction of the life expectancy of any existing building is a complex interdisciplinary process with many variables and uncertainties (Langston & Shen 2010).

A building can be viewed as an energy system, to which the Second law of Thermodynamics can be applied. “Energy flows from a higher and ordered state to a lower and more random state” (Harris 2001), thus increasing its “entropy”. All structures will eventually collapse, unless entropy is counteracted by additional energy, perhaps in the form of maintenance or adaptation of the building.

Fig 2.2: Typical adaptation and/or maintenance required on a building to decrease the rate of entropy – sketch by author.
Different building materials, and sub types of each material, will be subject to different rates of deterioration. A brick, for instance, consists of the same amount of material as an equivalent portion of its undisturbed clay; however, it carries additional value in the form of a brick. Energy is required during each of the steps leading up to brick formation; extraction, shaping, cutting, drying, firing and finally building. While serving a function in a wall structure, a brick is subject to greater environmental demands than its original form within the soil. As deterioration occurs over time, the energy originally provided to the material becomes lost and the fabric drops into an entropic state. In the case of a brick, the rate of such deterioration will depend on several factors, including the clay type and origin of soil extraction, the standard of workmanship in formation and construction, the built environment, and any interference over time. “The nature of deterioration is, therefore, not a matter of whether a material will deteriorate; all materials deteriorate. The questions for which our studies are relevant are how and at what rate deterioration will occur” (Harris 2001).

2.6 Causes of Building Deterioration

The three primary causes of building deterioration are; dampness, movement, and bio-decay (Addleson and Rice 1994), each of which can be further categorised into more specific sources, such as condensation (dampness), subsidence (movement), and dry-rot (bio-decay). As noted by Addleson (1994), the causes are few, but the sources are many, thus it may often prove difficult to determine the root of a problem. The primary factors which influence the rate of building deterioration are; environmental agencies, functional activities, and level of ongoing maintenance.

2.7 Mothballing

When the life of a building expires, there are many options available to the property owner to assess its future use. Mothballing is a process by which the building becomes closed and protected until it can be put into productive use again. It is often employed where the future use of a redundant building is under review. Mothballing is often undertaken where time is required for planning the future of a building or when funds are not currently available to put a deteriorating structure into a useable condition.

Mothballing should only be considered as a temporary option for a disused building and form part of a long-term plan for its future use. A vacant building will not survive indefinitely without regular upkeep; therefore, a maintenance regime should be agreed
upon prior to mothballing in order to prevent deterioration from water ingress, biological growth and any undesirable interference. Routine tasks may be carried out by a guardian or an assigned caretaker (Douglas 2015).

Fig 2.3: A traditional 19th Century dwelling (LHS) in Portobello, Dublin 8, which had “not been occupied for many years”. Insufficient mothballing measures resulted in the dwelling reaching a state of “disrepair”, and left it “unsuitable for renovation” (Dublin City Council Planner’s Report 2017). It was subsequently demolished in 2018 (RHS) – photos by Author.

2.8 Building Composition
The nature and extent of adaption required will largely depend on the composition of the original building, and whether it is traditional or modern in form. Traditional buildings are typically constructed with load-bearing masonry, with the exception of timber-framed construction. These structures tend to be thick, porous and permeable, and as a result consist of a high thermal mass. In contrast, modern structures often incorporate non-porous, impermeable materials as part of a thin, light-weight design that is heavily insulated and air-conditioned, as opposed to the breathable and thick-walled nature of traditional buildings (Beckman & Bowles 1995).

2.9 Breathability Issues
All buildings, old and new, must breathe to avoid condensation build-up and dampness, however traditional buildings comprising absorbent and porous materials undergo a more complex and less controlled process. Modern construction typically relies on barrier and cavity systems that prevent moisture ingress, breathing in a more controlled and artificial environment and often relying on ventilation and air-conditioning units (Harris 2001).
Fig 2.4: Typical sections through traditional and modern masonry walls – sketch by author.

2.10 Considerations for Adaption

When planning to adapt a building, there are fundamental issues which require careful consideration in order to provide a sustainable future for the structure. With any adaptation, the rehabilitated building should be durable to provide longevity to the structure, be adaptable and flexible to accommodate changes that cannot at present be envisaged, be energy efficient to ensure economical operation, be weather tight to protect from advanced deterioration, and also be comfortable to provide a healthy environment for the human activities it is designed for.

Large scale building adaptations will require a designer to carefully review all factors listed above with the client as part of a project design brief. The intentions of the client must be clearly outlined, including the purpose of the project, its future use, constraints, and any special requirements (Kincaid 2002).
3. Adaptive Reuse of Historic Buildings

3.1 Adaptation constraints

Creating a future use for old buildings is of great importance but is often challenging for designers. As a viable alternative to demolition and replacement, sustainability of historic structures may often require careful blending of sustainable design and conservation principles. Typical problems which may be encountered are as follows:

i) Geometry of historic buildings

Coordination of services and other technological requirements proves difficult enough in the design of modern buildings, however may often be acute within older structures. The typical layout of traditional buildings differs greatly from those of the present day. Such buildings more often contain internal load bearing walls for example which creates design challenges on adaptive reuse projects (Grammenos & Russell 1997).

ii) Availability of materials

The use of compatible materials is very important for sympathetic restoration work to any historic buildings, not only for the appearance of materials, but also for its physical performance. Availability of such materials often proves problematic (Forsyth 2012).

iii) Availability of skilled labour

Traditional skills have become scarce, due to the different nature and demands of modern construction. Traditional crafts are not always well understood in terms of material requirements and performance. Sourcing and programming such trades on a project can often prove to be challenging. (Forsyth 2012).

iv) Regulations

When a historic building undergoes any form of adaptation, there may be difficulties in complying with modern regulations and standards such as; fire safety, disabled access, loading requirements, thermal performances, and sound proofing (Douglas 2015).

v) Building condition

The structure may be in poor condition and require extensive restoration and repair work to bring it back to an operational condition.
vi) Conservation Considerations

The building may be registered on the Record of Protected Structures and thus may be restricted to certain types of adaptation. Historically significant buildings may often have important architectural and historical character which prevent the changes required for certain adaptations thus limiting the types of reuse that are possible.

In the inspirational book “How Buildings Learn”, Steward Brand provides an insight to the life of some awkward structures, and to their afterlives, through retrofit, conversion, and other forms of development. Brand discusses the mutable nature of buildings, with examples of where creative design, ingenuity and determination from designers has lead to the revival of many redundant historic buildings (Brand 2012). This type of imaginative design is critical for the successful adaptation of protected structures.

3.2 Traditional Building Constraints

The extent of adaptation to old buildings may be restricted for several reasons. Primarily, traditional buildings were typically designed for one particular use, with little allowance made for a possible alternative function in the future. In contrast, modern buildings are usually designed with added flexibility, enabling them to respond to changing socio-economic and environmental conditions.

Adaptation of historic buildings can be challenging, and often requires a level of compromise. Internal modification may not be possible without extensive support measures and localised demolition to existing components.

Depending on the client’s requirements and applicable regulations for the intended use, several factors may require careful consideration during the planning and design stages of the adaptation as listed below;

i) External Constraints

Extensions and modifications to an existing building may be restricted depending on its position, layout, and environment. Mid-terraced buildings may be constrained on all sides, particularly in built-up urban areas where front façades often abut a public footpath. In some cases, such buildings may create additional space by means of vertical extension, however this may be objected by the planning authorities in areas where roofline restrictions are in place.
ii) Internal Constraints

The morphology, structural configuration, and internal layout of an existing building may limit new proposals. Where floor-to-ceiling height is excessive, fenestration may restrict the insertion of a mezzanine level. In contrast, where there is a low ceiling, there may be insufficient room to install services. Some old buildings which have an open-plan may be unsuitable for adaptations where sub-divided spaces are required. Many traditional buildings which rely on natural light and ventilation may not be compatible with certain adaptations. Modifying the internal layout of a historic building often requires very careful planning and creative design ideas (Kincaid 2002).

3.3 Protected Status of a Structure

A protected structure is a structure that a planning authority considers to be of special importance from an “architectural, historical, archaeological, artistic, cultural, scientific, social or technical interest” (Part IV of the Planning and Development Act 2000). Listing a building on the Record of Protected Structures provides the building with statutory protection against unauthorised demolition or alterations.

If a building is listed on the record of protected structures, the owner has an obligation to ensure the structure does not become endangered by deliberate or accidental damage, decay, or neglect. The building should be kept in a habitable condition, with regular maintenance to ensure its longevity. If a planning authority consider the building to be endangered, a notice may be served to the owner for work to be done within an 8-week period. If such notice is ignored, the planning authority may take enforcement action.

3.4 Adaptive Reuse of Protected Structures

Adaptive reuse of a protected structure often involves both restoration and adaptation for a use different than its original purpose, which may involve a combination of the following:

i) Repairs to the existing structure and fabric

ii) Strengthening and stabilisation of the existing structure

iii) Reconstruction of missing elements

iv) Additions or localised removals

v) Rearrangement of the original layout
3.5 Regulation Compliance

Designers often face greater challenges posed by adapting heritage buildings compared to a new build. Stringent building regulations often limit the extent of adaptation; however, legislation may be more flexible with protected structures and allow some tolerance for a practical solution to be developed without compromising the significance of the structure. Some proposals may not be viable, in which case alternative solutions should be reviewed. Council policies and statutory requirements may relate to fire safety and egress, disabled access, insulation and energy performance, occupational health and safety, asbestos removal, and car parking (Douglas 2015).

i) Energy Conservation

As noted by RIAI Conservation Guidelines (RIAI 2010), protected structures are exempt from compliance with Part L of the Building Regulations, unless parts of the structure are to be “substantially replaced”. Old buildings cannot be expected to meet the same performance standards as modern structures; however, they can be appreciated for their unique character, and should be regarded as ‘embodying energy within themselves’ (Forsyth 2007).

Fig 3.1: Examples of the ‘embodied energy’ within an existing building – sketch by author.
ii) Fire Safety

The current edition of *Technical Guidance Document B (Government of Ireland 2006)* outlines fire safety regulations which must be complied with during any adaptation work. Fire engineering on adaptive reuse projects may often prove complicated for designers who must develop appropriate and reversible solutions which impact as little as possible on the original elements and fabric of the structure. Innovative fire safety details should be reviewed, with a balance to be struck between active provisions, such as fire detection, suppression and sprinkler systems which may be aesthetically intrusive, and passive provisions, such as compartmentation and escape systems which can often prove to be more effective. Existing elements which are expected to resist the passage of fire for a specified duration should be assessed carefully in terms of their existing condition, as fire response is a performance-based design, and historic fabric performance cannot be simulated or studied theoretically (*Theodossopoulos 2012*).

iii) Access and Use

Any alteration or adaptation to a protected structure must comply with *Technical Guidance Document M (Government of Ireland 2010)*, which states; “In the case of material alterations of existing buildings, the adoption without modification of the guidance in this document may not, in all circumstances, be appropriate”. Most historic buildings were not originally designed for people with disabilities, and many will present challenges in providing easy and independent access. Historic structures should be accessible, and useable by all those who could be expected to use them, including people with disabilities or injuries, the elderly, carers with young children and expectant mothers. Accessibility aims to cater for the needs of all people to ensure historic buildings can be enjoyed by everyone, thus design compromises may be required to permit interventions which provide for disabled people (*Foster 1997*).

![Disabled Access Lift](image)

*Fig 3.2: Disabled access at side entrance to Scot’s Church—photo by author.*
3.6 Conservation Principles

“Conservation is very largely the art of controlling (or managing) change” (Earl 2015). Conservation may often be confused with ‘preservation’. In contrast to conservation, preservation attempts to maintain buildings in their present condition, which may often threaten their survival. While some historic structures may be maintained in a “preserved” state, the majority of such buildings need to have a working purpose and be practical for the needs of their occupants, thus, adaptation is often fundamental to the core principle of conservation.

“Buildings are not museums and should not be fossilised” (Bridgwood & Lennie 2013). With sufficient imagination and enterprise, protected structures can be adapted to a new use while maximising retention of the original features with sensitive restoration techniques and appropriate repairs carried out where necessary. Any reconstruction works or added design should harmonise both new and old features, while creating an obvious distinction between them (Bond & Worthing 2016).

The main principles of conservation are as follows;

i) Retention of historic significance

It is important to maintain the historical authenticity and integrity of all cultural heritage. Any adaptation to a historic structure should be compatible with the needs of the building and protect its historic significance (Historic England 2008).

ii) Record making

Records play an important role in the planning and implementation of conservation projects. It is therefore important to undertake extensive surveys and detailed recordings before and during adaptation works (Historic England 2016).

iii) Minimum intervention

Any intervention to a historic building should be the minimum necessary to keep as much, and change as little, as possible. Practically all interventions result in some loss of value, however should be justified in a broader context by attaining worthy goals, whilst preserving as much of the original as possible (Historic England 2008).
iv) Repair rather than replace

All character-defining elements of a historic building should be repaired where damaged and susceptible to further harm. If such elements have undergone extensive deterioration, they may require sensitive replacement with compatible materials. Therefore, it is important to examine the existing condition of the material to determine whether a repair is practical, or a replacement is necessary (Historic England 1995).

v) Honesty of repairs and alterations

Any repairs or alterations to a historic building should be honest, but not visually intrusive. They should be discernible at close range without adversely affecting its integrity. Obscured alterations are considered bad practice in building conservation, as they may confuse the building’s historical record. (Bond & Worthing 2016).

vi) Use of appropriate materials and methods

Compatible materials and appropriate repair methods are imperative to ensure longevity of a historic building. ‘Like-for-like’ repairs should be carried out where possible. Modern construction materials such as cement may often result in advanced deterioration of old buildings (Forsyth 2012), which will be explained in more detail in section 5.5.

v) Reversibility

All interventions to historic buildings must be carefully analysed, and allowances should be made where possible for the structure to be returned to its former state if required. In the event of an unforeseen damaging effect of an intervention, or where any future technical advances introduce a preferable material, the intervention should be reversible (Forsyth 2007).

vi) Sustainability

Historic buildings should be recycled and reused to ensure their long-term sustainability. Conservation of existing buildings is part of the overall sustainable development process, which can reduce energy consumption, pollution, and waste (Oxley 2003). Appropriate adaptation of historic structures is a vital part of conserving the built heritage.
3.7 Adaptive reuse of Churches

As noted previously, the repurposing of protected structures can be a controversial and complex process for designers, particularly historic churches which were originally constructed with unique configurations to that of other buildings and intended to operate specifically as places of worship. The combination of cultural, social, demographic, and economic changes has left many of these buildings, which were once the centrepiece of neighbourhood gathering, in neglect and disrepair (Huber 2018).

Ireland has inherited a large number of unique church buildings, several of which were constructed during the reign of Queen Victoria (Curl 2007). Many of these structures have since outgrown their intended use and been added to the growing list of Ireland’s adaptable cultural heritage stock which are in dire need of new functions and salvation.

In the context of sustainability, the financial and energy costs of demolishing these old church structures are usually more environmentally harmful than incorporating adaptation strategies for new functions (Oxley 2003). However, many such buildings were constructed before the establishment of energy efficient code, thus will often require creative solutions to satisfy modern requirements. Adaptive reuse may create many challenges for designers and contractors; however, these barriers can be overcome through innovative design and construction methods. The case studies to follow later in this project explore the adaptation of two formerly redundant church buildings, which are paragons of the adaptive reuse process.

Fig 3.3: Examples of the creative reuse of different Irish churches; St. Mary’s Church in Kilkenny converted into the Medieval Mile Museum – photo by Mccullough Mulvin Architects (LHS), St. James Church in Dublin 8 converted to a visitor centre and distillery – photo by TOT Architects (Centre), and the redevelopment of former church of St. Marys in Dublin 1 to a restaurant and bar – photo by DMOD Architects (RHS).
4. Structural Design and Interventions in Building Conservation

4.1 Types of interventions:
Old buildings often require alterations and extensions to accommodate a new use of the structure. When adapting a protected structure, such changes should “not detract from the interesting parts of the building, its traditional setting, the balance of its composition and its relation with its surroundings” (Venice Charter 1964, Article 13). Rather, the new design should harmonize with, and be sensitive towards the old existing building.

i) Lateral Extensions
Availability of space is one of the main reasons for extending any building. Horizontal expansion is a common form of such adaptation, whereby the capacity of a property is enlarged to the front, end, sides, rear or corners. The interface between old and new requires careful detailing, particularly with lateral extensions (Fort et al. 2006).

There are many structural issues to be addressed during the design process of such extensions. Without adequate design consideration, differential movement may occur, resulting in subsidence and cracking (Kuipers & De Jonge 2017). The existing soil conditions must be investigated by means of trial pits. A geotechnical engineer may be required to analyse soil samples and provide a more accurate reflection of the type and condition of subsoil, and subsequent load-bearing properties (Ratay 2005).

The next stage of planning and design is to review flexible expansion joint details to allow for differential movement. A new extension will require settlement time upon completion, whereas the original building has already undergone this process before. Specification of appropriate building materials is of great importance and a separation material may often be required where dissimilar materials occur (Deplazes 2005).

![Fig 4.1: Lateral extensions to historic structures in Dublin. Glazed roof (LHS), copper cladding (Centre), and modern brickwork (RHS) - photos by OC Architects & Design](image-url)
ii) Vertical Extensions

There are many ways to extend a building without expanding the footprint. Additional floor space can be created by vertically extending a building down by means of a basement, or up within or above a roof space. Such adaptations are often suitable alternatives to lateral extensions in restrictive urban areas (Jenks & Dempsy 2005).

The majority of vertical adaptations are in the form of upward extensions, however, evaluating the facility of such proposals often proves challenging for designers, and requires careful consideration of the existing building type, condition, and availability of design documentation. Where building records are not available, which is often the case with historic structures, extensive site surveys and investigations may be required (Forsyth 2007).

Upward vertical extensions pose special design problems, not least of which is overcoming height restrictions, but also achieving structural requirements for the proposed extension, which may often include provisions for stairwells and lift cores. Where a building does not have the structural capacity to satisfy the demands of a new extension, additional supports or independent foundations may be required. This is particularly relevant for vertical extensions to protected structures, for which such interventions may cause damage to existing fabric, or where the adaptation should be easily reversible (Kuipers & De Jonge 2017).

Many structures which undergo later extensions would have been built with traditional methods and materials and must be assessed thoroughly. Such old buildings are unlikely to have been constructed under the same rigorous modern-day standards of building regulations, and quality auditing of materials and workmanship (Oxley 2003).

Fig 4.2: Vertical extension to Dublin Dental University Hospital, a protected structure located in Dublin City Centre – photos by McCullough Mulvin Architects
iii) Structural Alterations

Adaptation of an old building will generally require some alterations to its existing structural layout, composition, or morphology. The capacity of a building to accommodate new space and function requirements may also need to be considered (Wong 2017).

Two common structural alterations in existing buildings include; the creation of an opening in a load-bearing wall to accommodate a new door or window opening, and removal of a redundant chimney breast to maximise on overall floor space. If any such alterations are undertaken without consultation with a structural engineer, this may result in catastrophic consequences (Fischetti 2009).

Most structural alterations to an existing building will require both permanent supports, such as beams or pattress plates, and temporary supports, such as adjustable steel props and needle pins. Where structural alterations are required, the engineer must agree a methodology with the contractor, and provide creative solutions to these ongoing challenges which can be expected to arise on a typical adaptation project. In the case of protected structures, alterations must be sympathetic in nature (Institution of Civil Engineers, Great Britain 1989).

![Fig 4.3: Structural alterations on a protected Georgian structure in Dublin 2, where an opening is formed in a load bearing wall – photo by author during a site visit Feb 2019.](image)
iv) Structural Repairs

The structural integrity of a building and the materials it is made of should be clearly understood when undertaking any adaptation works to an existing structure. Different materials are susceptible to varying forms of deterioration, such as rot or corrosion, and each will require specific methods of repair. A project engineer should evaluate not only the existing condition of the structure, but also the impact that a proposed new intervention may have on it (Croci 1998).

Structural repairs to protected structures should be carried out sympathetically using good conservation principles and practices. All necessary repairs should be achieved with the use of compatible materials and carried out by a suitable tradesperson experienced in working with traditional materials. When conserving any building during an adaptation process, it is imperative to ensure the existing building is left structurally sound to allow for its long-term survival and sustainable use (Croci 1998).

v) Strengthening Historic Structures

During any adaptation work to a historic structure, it is good practice to conserve as much of the original fabric as possible. New structural elements are often required to strengthen the existing building and accommodate its new function. A new use may be accompanied by larger crowds for example, such as an assembly hall, or heavy machinery in the case of a plant room. Whatever the circumstance, BS 6399 sets out dead and minimum recommended imposed loads for use in designing buildings (British Standards 1996). Any adaptive reuse project should comply with such standards; however, many old buildings necessitate substantial upgrading to their structure in order to adhere to such modern requirements (Theodossopoulos 2012).

All repair materials and methods should be assessed by an engineer with experience on traditional building projects. Creative solutions should be sought, with efforts to repair or reinforce existing structural systems, rather than replacing them with new. In situations of advanced decay, where the existing elements are beyond repair, or unable to perform sufficiently, replacement material may be required. Any such structural interventions should be honest and identifiable as new. Typical examples of such repairs are sistering of structural timbers for roof or floor elements, or the use of pattress plates and tie rods for unstable masonry structures (Forsyth 2013).
vi) Alterations to Floors

Timber is one of the most common materials used in traditional floor construction (Yeomans 2003). Depending on the type of adaptation, wood floors may need to be strengthened, repaired, replaced, added or removed to accommodate the new use of a structure. Many floors have been subjected to excessive wear, water and fire damage.

Existing floors may require localised strengthening where damage or deterioration has occurred, or where higher imposed loads are expected due to a change in use of a building. There are many ways in which additional support may be provided, such as the insertion of steel beams or angles, or alternatively sistering of the floor joists may be a more sympathetic approach. Where fungal attack is present, sections may need to be cut and spliced with new treated timber, which can be cleated and bolted back to unimpaired sections (Ross 2009).

Where existing timber cannot be repaired or salvaged, entire elements may require replacement with like-for-like materials. Additionally, floors may often be replaced and redesigned to accommodate for a new building use. Concrete floors and screeds are commonly installed where underfloor heating systems are desired. Such systems are often considered in an attempt to reduce energy consumption, particularly in open space historic churches, which are seldom insulated and often include large areas of single glazing. Floor insulation may be very beneficial to old buildings, as it is often not viable to introduce insulation to other elements of a traditional structure (Beggs 2012).

Adaption may also require the introduction of a new floor level, particularly where there is an excessive floor to ceiling height. In contrast, a floor may need to be completely removed from certain buildings to enlarge the capacity of a room (Stratton 2000). Façade retention is an example of an adaptive reuse process which requires the original façade of a building to be retained while new internal floors are constructed.

Fig 4.4: Sistering of floor joists – photos by author during site visit in Dublin 2.
vii) Alterations to Walls

It is important to identify any load-bearing walls as part of an adaptation scheme, as some walls may need to be removed, altered or reinforced to accommodate a new use. Load-bearing walls are typically parallel to the roof ridge, supporting the floor and roof joists, and either directly above or below other load-bearing walls, however, some may not be as easily identifiable and require careful assessment from an engineer prior to any alterations (Beckmann & Bowles 2016).

Inserting openings in walls is common on adaptation projects where alternative access doors and circulation routes are required, or where windows are needed to provide additional natural light. Sometimes an entire wall may need to be removed on a conversion project where an open-plan layout is required (Rabun & Kelso 2009).

Depending on the extent of wall removal, and the composition and condition of the wall, temporary supports may be required during the formation work, and permanent supports thereafter. Any such interference with the existing structure will inevitably result in the changing of load paths and potentially over-stress critical elements, leading to potential distortion, excessive cracking or complete failure (Rabun 2007). Therefore, it is imperative that any such alterations are assessed carefully by a structural engineer prior to undertaking any work.

![Fig 4.5: Open formation in masonry wall on Dublin 1 project—photo by author.](image)

Where a wall is in poor condition, damaged or deteriorated, strengthening works may be necessary. Steel tie rods and pattress plates are often inserted where an unstable wall requires lateral support. Alternatively, buttressing at regular intervals is another common method of wall strengthening. Depending on the type of wall fabric, consolidation products may be an option for vulnerable areas of a structure to slow down the effects of deterioration (Theodossopoulos 2012).
viii) Alterations to Roofs

The roof is an important feature of any historic building. Functionally, it acts as a first line of defence against the elements. Visually, it gives the building its distinctive profile and character. The removal or alteration of any element of a roof could affect how it performs and may result in movement or overstressing of other members (Costa et al. 2014).

Converting a loft is a common alteration taken during adaptation projects. However, ceiling ties in many historic buildings may require additional support as they were often never intended to be load-bearing, rather they act as lateral restraints to prevent roof spread. Depending on the type, size and condition of the ties, additional bolted members may be required, or in some cases localised replacement of existing sections may be necessary.

The formation of roof openings is a common adaptation to old buildings. Dormers and rooflights are typical examples of such alterations, the details of which should be carefully assessed to ensure the integrity of the roof is not adversely affected (Douglas 2015).

Fig 4.6: Formation of roof openings to Scot’s Church Hall – photos by author.
ix) Underpinning

There are several reasons why foundation underpinning may be required as part of an adaptation scheme. The existing foundation may need to be increased in size or even repaired where damage has occurred. Cracks along the structure are a typical indication that a poor foundation may be present, and often suggest that underpinning may be necessary (Rabun 2007). Where additional storeys are to be constructed above an existing building, underpinning may be required to strengthen the existing foundation to adequately support the modified load.

The most common form of underpinning is the mass pour method, where localised pits are excavated at regular intervals and filled with concrete. Further pits are then excavated in sequence between those already poured and the process is repeated until the entire foundation has been underpinned (Beckmann & Bowles 2016).

There are several other techniques of underpinning which may be adopted, such as pouring beams between piles or pads. In recent years, modern techniques, such as resin injections, have been introduced, however the method should be outlined by a competent structural engineer following assessment of the building and proposed alteration, and inspection of ground conditions and necessary trial pits (Beckmann & Bowles 2016).

Fig 4.7: Mass pour underpinning to an existing structure in Dublin 2, which had been done prior to the bulk excavation – photo by author during a site visit Feb 2019.
x) Partial Demolition

Adaptation projects often necessitate some localised demolition of a structure to facilitate a new use. This may include the demolition of an existing floor, side, or corner of a building. However, in some cases only the façade may be retained and supported while the remainder of the structure is removed. The extent of demolition required will depend on the extent and nature of adaptation, and the operational requirements of the new use (Mynors 2006).

Demolition of any part of a building will typically result in the reduction of available floor space, however, partial demolition on adaptation projects is usually undertaken to accommodate extensions or additional floors (Douglas 2015). Similar to previously mentioned alterations, partial demolition of any element of a building should be approached with care, particularly areas which are likely to have structural implications.

Fig 4.8: 19th Century Roof structure over former lecture hall, 20th Century Roof Structure over former yard, and partial section of original perimeter masonry wall at rear of Scot’s Church, Dublin 1 (LHS - highlighted in blue) was demolished (Centre) to accommodate for the new office block development (RHS) – photos by Author.

4.2 Ideology of Interventions

A protected structure should not be regarded as an inflexible finished article, nevertheless it should neither be considered as a new ‘blank canvas’. Rather, the structure ought to be accommodating towards new interventions which respect and retain the character and significance of the building with a contemporary layer that provides value into the future (Inglese & Ippolito 2018).
Conservation of existing buildings provides authentic evidence of the technical knowledge and abilities of their original designer and the culture of its period. Creative adaptation can be integrated with careful preservation of the original fabric through strengthening, repairs and interventions to ensure the sustainability of these structures for the enjoyment and experience of future generations. In this context, preservation aims to protect the interest of the building, as opposed to keeping it entirely unchanged (Inglese & Ippolito 2018).

Providing modern functionality to historic buildings has become increasingly complex with tensions existing between retention of the original building and conformance with regulatory requirements, such as health and safety, access provision, fire safety and energy efficiency, among others. Thus, the philosophy and the scope of regulatory framework often creates challenges in striking a balance between sustainable green building technologies and good conservation principles. There has been a surge in technical innovation to respond to such demands and an extensive list of options available, however any intervention to a traditional building should be project specific and adopted on a case by case basis (Bloszies 2014).

4.3 Structural Condition and form of Historic Buildings

Prior to undertaking any intervention, the structural scheme and existing condition of a building should be, where possible, determined by means of a desktop survey, or other forms of non-intrusive assessment. Technical characteristics of the fabric should be analysed, and structural elements identified to understand its limitations and capabilities (Rabun 2007).

Unfortunately, there is rarely any form of plans, drawings, or original documentation available to provide design information for a traditional building. Creators of historic buildings had less understanding of their structural behaviour, and knowledge of structures would often be based on the mistakes of others in the past (Croci 1998). Structural elements were typically constructed at regular dimensions with symmetrical arrangements, and generally oversized with large redundancy, which advantageously provides additional scope for modern adaptation. The 20th Century introduced more scientific practice to structural design with primary focuses on stress limits, risk and safety factors, identifying limit states, particularly where cracked and friable material or masonry exists, and elastic analysis for elements such as timber or steel (Rabun 2007).
Elastic analysis cannot be used to simulate masonry strength responses or conclude on structural safety of such. Rather an on-site stability assessment should be undertaken determining the locations of cracks, voids, and dislodged sections, with particular attention on the thrust lines within arches. Masonry typically has a very high compressive strength and a very low tensile strength (Hendry 1990).

Structural engineers play an important role in the suitability assessment of adaptive reuse projects and defining a suitable scope of works for such. Fire performance is often a primary concern as many traditional materials are highly combustible. While historic buildings often consist of robust load bearing masonry walls with high compressive strengths, their structural integrity may be destabilised in the event of a fire due to failure of a supporting timber floor or roof structure (Rabun 2007).

4.4 Historic Building Materials

Traditional buildings differ greatly from those of the present day, relying mainly on thermal mass, breathability, flexibility, and a sacrificial skin. The use of traditional materials and design has been largely overtaken by modernisation. The pressure of urbanisation, and the desire for modern living conditions, with modern materials and technologies, have resulted in a gradual decline in the use of such materials and design. Historic craftwork has become replaced by factory-built components, which are typically assembled on site by an operative guided by a specific drawing or product manual. In contrast, traditional construction enabled tradesmen to create more expressive handwork with timber, stone, glass, and other fabrics (Fischetti 2009).

(i) Lime

Lime based plasters and mortars have played an important role throughout history in building construction, with the durability of surviving structures standing testimony to its performance. Portland cement has now virtually replaced lime, and the ancient tradesman knowledge is under threat of obsolescence, often to the detriment of historic masonry and conservation of old buildings. The use of lime is essential to the successful maintenance and repair of traditional buildings, and there is a belated realisation of the unsuitability of hard cement mortars on old buildings. The declining use of lime in the twentieth century has led to a shortage of knowledge and skill required to conserve them appropriately (Forsyth 2013). Fig 4.9 (LHS) shows an image of a 19th Century
structure which had been inappropriately rendered along the gable wall with sand and cement, resulting in cracks and blown sections. Brick quoins along the corner suggest that the wall was originally intended to be rendered and was likely to have been done so with a sacrificial coat of lime. As noted in section 3.10, traditional buildings by their nature would typically require absorbent and porous materials, and so replacing the original lime render with sand and cement has led to damage (i) and subsequent water ingress and biological growth (iii). The use of mastic (ii) is further evidence of inappropriate repairs along joints. The adjacent photo (RHS) shows an arch which has been repointed with lime as an example of appropriate repairs to traditional brickwork.

![Inappropriate use of cement (LHS) and correct use of lime (RHS) – by author.](image)

**Fig 4.9: Inappropriate use of cement (LHS) and correct use of lime (RHS) – by author.**

In contrast to modern buildings, historic structures were typically built with soft and porous materials, together with lime bedding and plastering. Solid walls were constructed without cavities, and often rose from less stable, shallower foundations that are susceptible to settlement and movement due to seasonal fluctuations in temperature and ground conditions. Lime bedding should be softer than the masonry that it bonds with, allowing for such movement to be unaccompanied by substantial cracking. Small cracks within lime mortars can heal by re-carbonation (Kreh 2014).

The permeability of lime-based materials is another important characteristic, which allows a building to absorb water, during wet periods, and evaporate the moisture during warmer and drier weather. Impermeable cement is often inappropriately used to plaster and point historic masonry, restricting its flexibility, and forcing water through the stone or brick rather than through the joints. This increases the risk of trapped
moisture, salt attack and frost damage. Lime is required to act as a sacrificial layer on old buildings to help conserve the historic building fabric (Forsyth 2007).

(ii) Masonry

Masonry is a heterogenous material typically constructed using a combination of stones with lime or clay mortar (Fort et al. 2006). Transportation of historic masonry was an arduous undertaking, and therefore stone was often quarried locally. Kilns and quarries were scattered throughout the country, providing materials to local developments, each of which would typically reflect the surrounding geology (Aalen et al. 2011).

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**Fig 4.10**: Site visit to C McEvoy & Sons Quarry, Ballynockan, Wicklow. The business dates back 5 generations to 1865. Records show that the first phase of large-scale quarrying began in Ballynockan in the 1820s. The granite was used extensively in church construction during this period (Ó Maitiú & O'Reilly 1997) - photos by Author.

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**Fig 4.11**: Annotation of an original lime kiln at Blarney Castle - photo by Author.
Whilst the main building stones may sometimes be extracted nearby, feature stones were often imported from afar. Limestones were commonly sourced from parts of England or even France to be carved as ornate dressings or decorative feature pieces (McAfee 2016).

![Fig 4.12: Limestone dressings along the facades of Scot’s Church on Abbey Street, which were imported for construction during the 19th Century (Built Heritage Assessment Report, Dublin City Council Planning Application Ref 1546/08).](image)

Brick became more commonly used in historic construction from the sixteenth century onwards. As with stone sourcing, materials for brick making were often locally extracted where suitable clays were available, however bricks were commonly imported later in the eighteenth and nineteenth centuries (Bridgwood & Lennie 2013).

The mechanical behaviour of masonry depends on various factors, such as the mechanical and shear strength of each individual component, including the type of mortar and masonry unit itself, block dimensions, material density, among others. Assessment of load bearing capacity is best undertaken by in situ testing, as the number of variables and complexity of each individual structure is likely to provide an imprecise evaluation (Beckmann & Bowels 2016). However, in situ testing may require several samples, thus can be a destructive method which is not often practical.

Reliable structural analysis is critical, as inaccurate assessment may result in excessive intervening in the original structure, causing avoidable loss of material or cultural value. Alternatively, it may inadequately remedy any hazardous defects within the structure which may create risks to people or heritage (Forsyth 2007).
(iii) Other traditional building materials

There is an extensive list of other building materials that have been typically used in traditional construction which require specialist care and maintenance. The Irish Department of Culture, Heritage and the Gaeltacht provides a “series of illustrated booklets designed to guide owners and others responsible for historic structures on how best to repair and maintain their properties”. Information on traditional thatch, paving, bricks, iron, roofs, windows, among other elements are provided in the ‘Advice for Owners’ series, with specific guidance on how to maintain old buildings, identify common defects, and choose appropriate repair methods and materials (Department of Culture, Heritage and the Gaeltacht 2007-2015).

Fig 4.13: Clockwise from top left; Demonstrations of roof thatching, timber truss preparation, stone carving, and hot lime mixing at SPAB Ireland (Society for the Protection of Ancient Buildings of Ireland) Working Party, polychromatic tile and timber floor reinstatement on Scot’s Church project on Abbey Street, Tuck Pointing to front façade of a protected structure on Gardiner Street Dublin 1, and a demonstration of historic stained glass restoration during a visit to a specialist heritage glazing contractor’s workshop in Co. Meath – photos by author.

4.5 Structural Issues

Materials, methods, and structural systems have evolved greatly over time, however as noted previously, original data is rarely available on existing historic structures, therefore careful analysis is usually required. The first step in analysing an old building is to determine the condition of existing materials and extent of deterioration to
Structural elements, which can be followed by further desktop studies (Rabun 2007). Structural problems may arise from many sources, often stemming from original design issues, lack of maintenance, previous interventions, or changes in the use of a structure. Structural issues may affect vertical or lateral stability, cause failure of ties or joints, among many other potential problems (Beckmann & Bowels 2016). Traditional buildings were typically constructed in a cellular format, providing in-plane strength both horizontally and vertically, and stability by intersecting walls which naturally restrain each other (Rabun 2007). However, each building differs from the next depending on the period, use, and type of construction.

![Fig 4.14: A dilapidated structure in Dublin 8 which was brought to the attention of the Dangerous Buildings Section in Dublin City Council. A temporary steel restraint system was subsequently installed comprising steel PFCs and tension rods - photos by author.](image)

When carrying out adaptation work to a historic structure, an evaluation of the in situ structural components may be necessary to certify that the building is suitable for such use and will comply with all relevant standards. Allowable stresses often rest upon assumptions due to the complexities involved with structural analysis and pathology of historic fabric, however conservative approaches can be adopted to help determine load capacities through modern diagnostic methods of examination of fabric decay from extrinsic factors. Building deterioration is an inevitable, progressive, and complicated process which affects individual fabrics and sub-types of each material different by the next. Each material will experience varying rates of decay based on different factors, thus, the type and extent of structural issues may be difficult to determine (Ratay 2005).

4.6 Strengthening and repairing methods

Each historic building has its own configuration of unique construction materials across its structure in varying conditions, depending on typology, orientation, and exposure to
various environmental factors. There is an extensive range of options to be explored for repairing historic fabric, with special materials and techniques available for specific restoration works (Forsyth 2007).

*Masonry repairs*

Masonry structures should be carefully assessed prior to undergoing any repair or strengthening works due to the large variability and complexity of stone and brick materials. Developing structural models and interventions require suitable knowledge of both the existing and any new materials, and how they will interact with each other under environmental and loading conditions (Beckmann & Bowels 2016).

Masonry structures can change shape, become fractured, and develop cracks for various reasons including; ground settlement and subsidence, shell buckling, thrusting forces within arches, or cohesion failure within the material itself (Costa et al. 2014). Therefore, strengthening and repair methods must be determined on a case-by-case basis, by a competent designer with knowledge and experience in working with traditional materials. Techniques for such works are extremely wide ranging, which include; structural repointing with lime mortars to replace dislodged or decayed bedding, grout injections to walls or foundations to provide stability, application of consolidation mortars with stainless steel pins and resin to repair damaged masonry units, insertion of reinforcement bars within mortar joints, or installation of steel tie-rods and beams as restraining systems (Forsyth 2012).

Fig 4.15: Reinforcement bars at wall junction of property in Dublin 2 – photo by author.

*Timber repairs*

Timber is one of the oldest materials used in construction, and still used to this day due to its capacity to resist both in tension and compression (Detkin 2016). However,
without sufficient care and maintenance, timber is often the most vulnerable element within historic buildings and susceptible to advanced decay if neglected. Factors affecting wood properties include; biological decay leading to infestation, decay caused by fungi resulting in timber rotting, or mechanical decay in the form of cracks, splits, deformations, or disconnections (Ridout 2000).

Fig 4.16: Advanced timber decay in a derelict dwelling in Dublin 8 – photo by author.

Like stone, an abundance of repair options for historic timber have been introduced over recent years due to the diversity of types of failure and decay. Again, the designer must have a solid understanding of traditional materials and choose a suitable repair method which will render the structure safe. Several methods can be adopted for like-for-like repairs such as; scarf joints, sistering, and dowel connections. Using new suitable timber will reduce the risk of incompatibility problems between old and new fabrics. Where additional support is required, flitch plates can be incorporated. Stainless steel is usually a preferred option, as it will typically provide improved strength and offer better protection against corrosion (McCaig & Ridout 2012).

Fig 4.17: Steel truss to support a subsiding traditional roof in Drogheda – photo by author.
4.7 Management of Change

In today’s fast-paced society, adaptive reuse projects are often undertaken with tighter programmes and less flexibility during the construction stage. Unexpected issues will inevitably arise on historic building projects, and therefore input is required from experienced professionals with inquisitive attitudes during the early stages of planning to remove as many unknown factors as possible. Vigilant management and control should be further adopted by all parties as part of a continuous planning strategy throughout all stages of the project (Davey 1991).

In order to achieve economic, social and environmental sustainability of the built environment, change must be managed rather than be avoided. Conservation of historic buildings within the fast and intensively changing built environment can only be controlled through ongoing active management of heritage assets (Teutonico et al. 2004). This requires flexibility from experienced professionals during the planning, design and management process to avoid threats likely to occur if such decisions are beyond their control (Theodossopoulos 2012).

Traditional forms of contract are often preferable on conservation projects where the design team can play a more central role, or where the scope of works may involve considerable unknowns and risks. These forms of contract permit specialist contractors to be nominated during the project, depending on traditional work which may require the expertise of certain artisans or the sourcing of suitable materials from specialist supply chains (Murdoch & Hughes 2008).
5. Scot’s Church Background and Location

5.1 Site Location

Abbey Street Lower is situated in central Dublin, running parallel to the River Liffey on the north side of the city between O’Connell Street and Beresford Place. The area has developed progressively over the centuries and presently is zoned for mixed use of commercial, tourism and office.

The history of Abbey Street Lower dates back several centuries, with significant alterations of its character shown over time on historic maps. Through comparison of 18th and 19th Century maps shown below in Fig 5.1, there is evidence of substantial development north of the river during this period, and realignment of the roads by the Wide Street Commission, which was established by an Act of Parliament in 1757. The 19th Century brought further change to the street with the construction of many public buildings, including the Royal Hibernian Academy, a Trustee Savings Bank, and several places of worship such as Scot’s Presbyterian Church.

![Fig 5.1: Rocque's map of Dublin 1756 (LHS) and OSi map 1876 (RHS).](image)

The main features of Abbey Street are the collection of lower order land uses, the rundown physical urban characteristics, and the poor adaptation of historic buildings. With varied property uses evolving over time, the street has branched away from its fine urban grain, with substantial new development and neglect of the existing buildings. Much of the original characteristics of the street have been diminished and completely replaced with larger buildings, however, within the current diverse urban grain, an abundance of unique heritage has survived, with many protected structures – whose survival relies on appropriate care and maintenance, still existing. While the functional and financial life of a historic building may expire, its physical life should not. Through adaptive reuse of an obsolete protected structure, its overall lifespan may be extended indefinitely to preserve its historic significance.
5.2 Site Context
Formerly known as the Abbey Church, Scot’s Presbyterian Church (1869) is a disused protected structure located on the southern side of Abbey Street Lower, with an adjacent early 20th Century building, currently occupied by the VHI, along its eastern boundary. The church and its ancillary buildings have been left unoccupied for many years and do not fulfil the purpose for which they were originally designed. Adapting and altering of such historic buildings to perform new roles has become more acceptable in recent years, as a building with a beneficial use has a better chance of surviving. A new owner and purpose often incentivises regular upkeep of a building and injects new life into the area. Scot’s Church was purchased by the neighbouring VHI in 2004 following almost a decade of vacancy.

To create additional office space, planning permission was sought by the VHI in 2008 for a multi-storey building with a new modern façade design, which would wrap around, and above sections of the historic buildings and act as a shelter to provide added protection to the historic fabric. The innovative design was set out to delineate a clear divide between the old and the new, and create a sense of curiosity, subtle anachronism and style to naturally enhance the historic church.

![Fig 5.2: Scot’s Presbyterian Church, Abbey Street Lower (Google Maps 2014).](image-url)
5.3 Project Scope

Scot’s Presbyterian Church is currently undergoing restoration and adaptation work as part of a greater project to expand the adjacent VHI headquarters.

“The key concept and challenges of the dynamic design were to respect and preserve all of the significant cultural, religious, historical and architectural heritage of the church and its ancillary buildings whilst meeting the client’s requirements for a new innovative, state-of-the-art, sustainable office extension that would fully integrate with the existing office headquarters, re-branding the building and creating a new iconic building with a sense of identity and place.” – MDO (appointed architect).

The brief for Scot’s Church was to integrate the historic building with a modern office block, providing several hundred work stations, dedicated meeting areas, and collaborative spaces. While acting as the new entrance for the offices, the adapted main church has also become an important civic and public space within the City Centre, and provided the redundant church, adjoining hall, and former lecture theatre, with a new identity and purpose.

Fig 5.3: A 3D model of the new proposed development (MDO Architects Ltd).
6. The Existing Structure

The following surveys were carried out in order to assess the existing condition of Scot’s Church along with its ancillary buildings.

6.1 Site Configuration

The grouping of the church, hall and former lecture hall occupied most of the footprint of the site, with a moderate area of open space limited to the front of the church along Abbey Street Lower, and narrow passageways either side of it. As shown in the drawing below, the church hall abutted an adjoining property along the western boundary, while the lecture hall occupied over half of the southern boundary facing onto a lane at the rear known as Old Abbey Street.

*Fig 6.1: Configuration of Scot’s Church and its ancillary buildings – illustration by author using image extracted from Google Maps.*

The existing church and accompanying buildings were all single storey structures, with the exception of the church balcony. There was no physical connection between the existing VHI building and the adjacent church.
6.2 Façades

Scot’s Presbyterian Church is a three-bay, double-height, gable-fronted structure built in 1869. It is the only remaining building in Dublin built to a design of William Fogerty (Dictionary of Irish Architects 1720-1940). As shown on the front elevation in Figure 6.2, the church displays many typical gothic revival features, such as pointed arches, steep sloping roofs, lancet windows, hood mouldings, label stops and decorative gothic style patterns and tracery. The rear of the church exhibits a large gothic rose window with decorative stained glass, which had been safeguarded for many years with a protective steel mesh. Ashlar granite was used as the main building stone across all elevations of the church and attendant buildings, with ornate limestone dressings displayed throughout.

Fig 6.2: North Elevation of Scot’s Church – photo by author.
6.3 Fabric Analysis

6.3.1. Church Hall

**General**

The church hall, situated along the western boundary, was mainly rectangular in form and consisted of niched areas inset along the south-west splayed section, which utilised space along the irregular boundary line. The pale Portland stone dressings across the façades differed to the buff-coloured Caen stone dressings along the main church and former lecture hall building, which suggested it was part of a separate scheme. Historic documentation suggested the Hall was built circa 1890, and evidence of mass concrete foundations beneath the cut building stone would support such a date. Records also show that the church was constructed after the adjoining Georgian building, which has a basement. Following preliminary survey inspections, the foundations of the church hall were discovered at an unexpectedly high level considering the existing ground was largely composed of past dredging sludge from the River Liffey. However, following further examination of the structure, no obvious signs of advanced settlement or building defects were identified.

![Section through church hall east masonry wall](image)

*Fig 6.3: Section through church hall east masonry wall – sketch by author.*

**Walls**

The primary structural scheme of the church hall consists of ashlar granite used as the main building stone, brickwork piers with plastered finishes supporting timber roof
trusses 5m apart, and brick arches typically supporting heads of doors and windows. The door at the south-east corner showed signs of structural issues in the past, where a mass concrete fill was used to form a new door head. Following further inspection by means of localised removal of lime plaster, large cracks were exposed from the door head which were creeping up to the timber purlin inset overhead. This suggested that an ope was broken out at some point as an additional access point, which had resulted in structural defects and crack formation.

Fig 6.4: Photos of cracks above Church Hall door and concrete infill at head.

Roof

Elaborately carved timber trusses with spans of 8m, arch across the hall from east to west at 5m intervals, supporting four timber purlins running north to south (two either side), which support cross braced rafters at 300mm centres – see figure 6.5. Dark stained v-sheeting sarking boards are nailed to the rafters with a slated roof above fixed down to timber battens. The roof timber was noted to be in structurally good condition, however slates had slipped in some areas and localised water ingress was observed. Replacement pitched roof coverings were noted, along with repairs to the tapered valley between the neighbouring property.
Fig 6.5: Section through Church Hall roof - sketch by author.

North Window

The front elevation of the hall, as shown in Figure 6.6, is largely taken up by a tripartite window with Portland stone surrounds that had suffered from the effects of atmospheric staining, dissolution, scaling and varying levels of deterioration.

Fig 6.6: North and East façades of Church Hall – photo by author.

Heritage features

Many alterations were carried out to the building over time, however several important features of the original structure still survive and should be retained, most notably the rock-faced granite walls, portland stone tripartite window dressings and timber roof trusses. The historic value of the church hall is enshrined in its function as an attendant building of the original church, thus preservation of its prominent features is vital.
6.3.2 Lecture Hall

Walls

Along the south boundary, the external granite walls of the former lecture hall faced onto Old Abbey Street with sloping rock-armoured granite abutments battered up towards the limestone windowsills, as shown below in Figure 6.7. The rear gable wall of the church was shared between the two structures with a lime plaster finish internally. Following inspections of the wall by localised removal of plaster, it was noted the wall was built with random rubble, which concurred with evidence that it was built in conjunction with the main church. The rock-armoured plinth along the lane, together with the lecture hall walls, performed as buttresses which provided support for the high-rising rear wall of the church and for the lecture hall roof itself.

Fig 6.7: South wall and roof of Lecture Hall building prior to construction – photo by author.

Roof

The roof, that has now been removed for reasons which will be outlined in section 7.3.4., consisted largely of timber rafters, collar ties and ceiling joists. While the roof timber appeared to be original, sarking felt, replacement copper gutters and slate reinstatement were noted. Deterioration of the valleys resulted in water ingress and there were obvious signs of fungal growth and advanced timber decay.
**South Windows**

The fenestration along the rear boundary wall displays Portland stone surrounds that have suffered from varying levels of atmospheric staining. The original timber sash windows were still intact and had been covered for many years with protective steel cages.

**Heritage Features**

As part of the original build, this ancillary building played an important role in the historic value of the overall site. With slight alterations carried out over time, the layout of the original building had survived relatively well, and the structure contained many of the original features, including: the shared wall of the main church, which it abuts as shown below in Figure 6.8; the external rock-armoured wall with decorative fenestration, many internal doors and lime plastered walls. There were exceptionally well-preserved limestone dressings surrounding the north-facing door and windows within a sheltered bay between the church and hall. While the building lacked the overall grandeur of the church and hall, its condition was generally good due to continuous occupancy throughout its existence.

*Fig 6.8: Position of lecture hall relative to surrounding structures - photo by author.*
6.3.3 Church

The layout of the building was that of a typical church design. The narthex was separated from the central nave by a lime plastered brick wall, with original doors either end that led onto each side aisle. A gallery was supported with structural timbers at the rear of the church directly above the narthex, and a pulpit to the front centred beneath a gothic rose window with original decorative stained glass.

Walls

The rock-faced granite building stone appeared to be in relatively good condition. Some cementitious pointing was noticed at high level – which did not coincide with good conservation principles, as high cement mortars may have trapped moisture within the substrate, which was intended to be breathable. The limestone dressings across the façades had been subject to advanced levels of decay, as shown below in Figure 6.9, and suffered from scaling, dissolution, gypsum crust formation and biological growth. Any deterioration of stone surrounding opes of windows and doors were of concern and had the potential to encourage further water ingress.

![Figure 6.9: Evidence of stone decay prior to any cleaning – photos by author.](image)

Roof

Following an inspection within the ceiling space, it was noted the vaulted design was for aesthetics rather than structure. Within the roof space, timber trusses were noted to span 15m across the nave at 5m spacings supporting purlins, which further supported the rafters. The roof timbers were well ventilated and in good condition due to a steady flow of air from the eaves up into the roof space. The original slates, which were fixed to timber battens, were in very poor condition, particularly along the west side of the
roof. Many slates had slipped, and delamination had occurred throughout as a result of exposure to prevailing winds. Sections of slates were removed for investigation at lower levels of the roof that were inaccessible from within the vaulted ceilings. Most timber rafters were noted to be in good condition with the exception of some localised wet rot at eaves level.

![Image of roof vault, ceiling, and inspection area](image)

*Fig 6.10: Roof vault (LHS), ceiling (centre), inspection area (RHS) - photos by author.*

**Windows**

The front façade of the gable-fronted church at high level largely comprised a quadripartite geometric tracery window – as shown in figure 6.2. The pointed-arched window was formed in limestone with 20th Century replacement glazing. There were lancet window openings at low-level either side of the entrance, which were also replicated along the side aisles formed in limestone surrounds. Clerestory windows ran along the east and west elevations, and a large rose window feature was displayed at high level centred on the south face of the church.

**Rose Window**

As one of the key features of gothic style architecture, the rose window consumed a 5m diameter space on the south elevation. The window was one of the most important architectural features within the structure, not only for its unique tracery stonework design, but also for its extraordinary stained glass, which is all that remained of the church’s original glazing. The stonework was noted to be in very poor condition, which needed careful review by a structural engineer with competence in assessing historic masonry. Rose windows are inherently fragile and would have proved challenging to architects and engineers of the past when designing such structures to support as much glass as possible with as little stone as possible. Therefore, careful surveys were undertaken of the existing condition of the fabric.
Fig 6.11: Rose window prior to cleaning/interventions - internal (LHS) and external (RHS) – photos by author.

Floors

The suspended floors of the church consisted of finished timber floorboards that were attached to floor joists. The joists were suspended above the subfloor of the foundation by wall plates resting on small sleeper walls. The side aisles consisted of filled dry soil between the timber edging and the sleeper walls which supported the adjacent floor. A slight bed of mortar was noted under the tiles which sat directly over the dry soil fill.

Fig 6.12: Original church timber floor build-up – sketch by author.
7. Project Interventions

7.1 Principal Interventions

Successful integration of modern design within the urban built environment poses many challenges for designers, however there are many projects across the developed world that have successfully demonstrated that modern and historical architecture can coexist.

As noted in Chapter 5, the creative challenge on the Scot’s Church project was to sensitively suspend seven floors over and around the existing church and its ancillary buildings, with a contemporary ventilated triangular exo-skeleton lattice design façade, which sympathises in nature with the gothic window tracery on the existing church. In order to achieve such a complex design, four principal interventions were proposed;

i) Superimposition

Modifying the roofing of an existing building and imposing its aspect upward contrary to its original form.

ii) Enshrouding

Surrounding and covering of an existing structure and internalising its existing building fabric.

iii) Object Insertion

Inserting new contemporary elements within the existing context of a structure to accommodate its new form and use.

iv) Abutment

Introducing a new structure, which makes physical contact with the original fabric of the old building.

Planning permission was granted for the development in August 2008 and the proposed interventions were deemed acceptable, which ensured the historic grouping’s future use. The principle of ‘minimum intervention’ remained at the forefront of all design decisions, and any loss of original fabric was carefully considered against the benefits of ensuring a future occupancy, and thus the increased longevity, of the protected structures.
7.2 Key Structural Interventions

As part of the new design for the innovative office block extension, structural principles and details were carefully incorporated for the construction of the works as follows;

7.2.1 Piling

As noted previously, the existing upper layers of soft soil and dredging fill from the River Liffey bed were considered to be unstable, with low bearing capacity. Therefore, deep pile foundations were specified to transfer the loads from the new superstructure onto stronger, more compact, less compressible, and stiffer soil.

*Pile Type*

The selection of pile type was dependant on several factors, including soil type, proximity to existing structures, access requirements and environmental considerations. Mini-piling was chosen as the most effective and sensitive method, as opposed to larger Continuous Flight Auger (CFA) piles. The narrow corridors and doorways throughout the site, restrictive head heights, proximity to protected structure fabric and occupied neighbouring buildings, necessitated a low vibration approach using small and compact equipment. Thus, mini piling was deemed to a suitable option as illustrated below in Figure 7.1.

*Fig 7.1: Site Plan showing piling locations (top) and sketch of a mini-piling rig in church hall with timber floor section removed (bottom) – sketch by author.*
Methodology

A specialist piling contractor was appointed to install 210 segmental mini piles throughout the site. Each auger was rotated into the ground, with penetrating soil flighted to the surface by the auger. Once a suitably sized hole was drilled at the required location, a 3m long bottom driven steel casing of 220mm diameter was inserted into the hole and struck down repeatedly with the assistance of a drop hammer rig, until a sufficient depth and hard ground had been reached. Further 3m extensions were welded where additional depth was required. The mini piles throughout the project were typically driven 6-8m deep until contact was made with deep layers of rock with higher bearing capacity. Once the tubular section was found to be dropping under 20mm per 10 no. 500kg drop-hammer strikes, the ground was accepted as having good bearing capacity. The piles were subsequently cut to the specified level for pile caps.

Following the installation of the steel casing sections, wet concrete would be poured into the hollow sections with a 12mm threaded steel bar inserted into the middle, and left with a 600mm extension beyond the pile, which was to be tied and cast in with the reinforcement cage for the next stage of foundations, such as pile cap pads or beams.

Pile Tests

As part of a professional duty of care, the project engineer requested the contractor to provide static and dynamic pile testing to ensure risk management and quality workmanship. The piles were originally designed with the capability of supporting 300kN each. Dynamic testing was carried out using Pile Dynamics Inc PAL-Analyser (PDA) equipment. Static tests were carried out by applying loads on the pile with a test jack as demonstrated below in Figure 7.2.

Fig 7.2: Static pile testing undertaken within lift pit area – photo by author.
**Constraints and compromises**

One of the main challenges in the adaptive reuse of the project was constructing independent foundations to support the proposed multi-storey structure over such a confined development, while retaining the original buildings and avoiding additional loading on them. Apart from the inadequacy of the original structure to support the new loads, separation of new reversible load paths from the original structure was assured to follow good principles and practice of conservation.

Excavation space was limited across the development with internal floor area occupying approximately 70% of the overall footprint. The original ground floor finishes were carefully removed to accommodate all works required to construct such deep foundations, some of which, including original internal timber floor boards, polychromatic tiles, and external granite steps, were to be integrated back within the new finishing scheme.

Noise, dust, and vibration were monitored throughout the piling works and effects of such were greatly mitigated. There was ongoing commitment and communication with stakeholders, and the works were carried out during agreed hours. Vibration was considered to be the primary risk, with the potential to cause damage to the protected structures and any nearby buildings, thus bespoke vibration monitoring equipment as shown in Figure 7.3 was used to ensure minimal disturbance. BS5228 recommends that an imposed ground vibration limit of 5mm/s Peak Particle Velocity (PPV) should be specified for such buildings, which is the standard accepted threshold for protected structures.

![Vibration monitoring equipment](image)

*Fig 7.3: Vibration monitoring equipment – photo by author.*
7.2.2 Reinforced Concrete Core

As part of the new multi-storey office block development, there was a requirement to provide a main stair-core so that upper floors would be accessible, in addition to a secondary escape stairway and lift shaft. Provision for such requirements on protected structures is a common challenge among structural engineers, largely due to sensitive fabric and restricted space.

Core Design

The foundations for the high-rise concrete core comprised 106 no. mini-piles, typically spaced at 700mm apart as shown in Figure 7.4, and supporting a large pile cap on top. Rising reinforced concrete walls and structural steel perimeter columns were constructed up full height of the new structure, with beams spanning on each level supporting reinforced concrete slabs, stairs, and landings throughout the building.

The reinforced concrete lift pit required deep excavations adjacent to the south wall of the church hall, and thus underpinning of the structure was recommended as shown in Figure 7.5. Polyethylene sheets were left between the existing south facing wall of the church hall and the new structure to allow for movement and separation.

Fig 7.4: Piling core foundations - photo by author.

Fig 7.5: Underpinning of Hall – sketch by author.
Core Function

The core provides lateral support and stiffness to the new diagrid façade superstructure. The network of reinforced concrete walls, slabs, and stairs interconnect with each other to form a rigid shear core at the corner of the structure as shown in Figure 7.6, with the capability of supporting the new irregular shaped complex building.

Fig 7.6: Concrete core relative to steel frame - illustration and photos by author.

Constraints and Compromises

Within the confines of the property, the south-west corner was chosen as the most suitable location, which would be least obstructive for the new core. A 20th Century roofed structure had occupied this former yard for several years, however it has now been sacrificed and demolished to provide independent access from the escape stair-core onto Old Abbey Street in the event of an emergency. Some localised original fabric at the south-west corner of the church hall was removed to accommodate this new reinforced concrete core, however this critical intervention was weighed as a statutory requirement for the new build, so a minimal impact approach was adopted in this less significant corner of the property, which is the only part of the development without an original structure.

Challenges were encountered during the construction stage of the project. The deep excavation for the lift pit against the south wall of the church hall necessitated localised underpinning with concrete. As the walls were constructed upwards from the deep foundation, polyethylene sheets were placed against the existing granite wall to create separation between old and new fabric. Temporary propping was undertaken from inside the church hall to support the existing wall while the concrete was curing as shown in Figure 7.7.
Fig 7.7: Back propping to support the south wall of church hall while pouring the lift shaft – photos by author.

7.2.3 Façade

The new lightweight structure encases the church hall below the third floor. The design ambition was to ensure the hall would be visible from Abbey Street Lower without any obstructions. The filigree diagrid sections rise up to 3 stories with triangular lattice grids supporting clear glazed units and allowing for an atrium in front of the church hall as shown in Figure 7.8. A further three stories of clear glazing and slender diagrid ascend above the atrium reaching the lowest point on the main roof above level 5.

Fig 7.8: Extent of the atrium relative to new façade and church - photo by author.
On the south face of the building, glass and aluminium panels rise to level 7, with a similar façade arrangement of glass and aluminium panels gradually sloping down along the east elevation. The west elevation contains three glass panels, and the remaining area is covered with aluminium cladding and composite panels against the neighbouring Georgian building.

**Structural Advantages**

The diagrid concept was an effective choice of design both architecturally and structurally. Apart from the aesthetic merit, diagonal members have many structural advantages in providing strength and stiffness to a superstructure.

The superimposed façade is supported by a lightweight triangulated frame which allows the structural elements to be calculated as having pinned connections and minimised dimensions. The diagrid members create a stiff plane to provide structural stability to the frame and minimise the need for additional shear walls. These members are stabilised in the plane parallel to the line of glazing, thus their structural buckling length is reduced.

![Fig 7.9: Sketch indicating typical load paths along the diagrid at node points – sketch by author.](image)
Design Intention

As part of the design intention, all columns and load bearing elements were to be located along the façade grid, except for four feature columns, which supported the west elevation above the church hall roof as shown below in Figure 7.10. Slender façade sections were modelled throughout the diagrid frame, with steel sections typically sized at 150*150*10SHS, and the longest element being 13.5m at the inclined south-west corner.

Fig 7.10: Tree columns supporting the west façade above the church hall roof – photo by author (LHS), and snip from 3D model by CORA Consulting Engineers (RHS).

The glazed surfaces defined by each triangle are flat, resulting in an intricate, but gentle faceted design, which provides flexibility of the system within such irregular spaces and complex conditions. In addition, the trellis grid provides a contemporary form of the gothic tracery windows along the adjacent main church. With such slender sections and transparent glazing, the new design harmonizes old and new structures, allowing both to co-exist.

Constraints and Compromises

The new façade will inevitably have a visual impact on the protected structure, city and neighbouring scales, however by following careful design efforts and considerations, the sensitive proposal was deemed acceptable by the planning authorities.

As noted, extensive coordination between the engineer and architect during the design and planning process was critical to ensure a sensitive design was achieved. The engineer meticulously modelled a lightweight slender structure to satisfy the intentions.
and expectations of the architect in creating a dynamic building that would not detract from, but rather complement the original structures.

Constructability was also considered, which proved challenging for the contractor. Figure 7.11 below shows the extent of the confined external footprint highlighted in yellow. Storage space, scaffolding, crane erection and operational space required extensive coordination. Only contractors experienced in the field of construction in the context of delicate fabric were selected to tender for the works.

![Fig 7.11: Confined external footprint of the site – illustration by author.](image)

7.2.4 Structural Steel and Concrete Floor Plates

The structure comprises 500 tonnes of steel rolled box-column and I-beam profiles, all fireproofed with fire-cladding or intumescent paint, depending on their location. Columns were typically encased with fire rated boards, while floor beams were generally coated with intumescent paint. All steel was designed to be situated behind the line of the new façade cladding.
Floor Beams and Plates

The floor beams were supported by the diagrid ring beams and positioned at typically 2.4m centres, as shown in Figure 7.12, with reinforced concrete coffer slabs cast between each. Exposed concrete soffits were specified by the architect and a special design mix was outlined to provide both strength and an aesthetic finish.

Fig 7.12: Floor beams typically centred at 2.4m – photo by author.

Temporary decks were erected from the ground with scaffolding to rest the suspended floor beams above the original structures during construction. As part of this strategy, removal of original roof fabric was required over both the former lecture hall and the church hall. Judgement was employed in the identification of material categories, ranging from that which deserves most protection, to where change could be accommodated. It was decided that the church hall roof was to be temporarily removed and later reinstated, but the roof of the lecture hall was to be permanently sacrificed to allow a consistent floor level on the first floor – only the existing wall top was left exposed at eaves level with a new suspended coffered concrete slab poured independently above, supported by the new steel structure.

The decks were raised for each floor in sequence until the roof steel was fixed in position. The scaffold was then dismantled back down to facilitate concrete works. U-head jacks were fitted on top of each tube with timber beams levelled to support a deck.
Coffered marine plywood shutters were prepared, in which a reinforced concrete slab was cast to achieve a high-quality finish on the soffits as shown in Figure 7.13. The floors were poured in sequence, allowing for sufficient curing time between each pour.

![Concrete soffit above church hall roof – photo by author.](image1)

**Fig 7.13: Concrete soffit above church hall roof – photo by author.**

**Hanging Balconies**

Galleries were hung on first and second floor levels from the underside of the third-floor beams. Localised sections of sarking boards, rafters and purlins were removed from the hall roof between each truss to allow for steel frames to be suspended through the ceiling, which were hung with Macolloy bars, and concrete slabs later cast between the beam sections.

![Hanging balconies on first floor – photo by author.](image2)

**Fig 7.14: Hanging balconies on first floor – photo by author.**
**Constraints and Compromises**

Removal of the church hall roof required permission from local authorities, which included the removal of slates, battens, felt, and v-sheeted sarking boards, with only structural timbers remaining. The scaffolding was designed with a tube and fitting system to allow flexibility in erecting uprights that would carefully pass through the existing rafters, purlins and roof trusses, while ensuring all scaffold components were outside a 50mm contact zone of each timber to tolerate any movement during the erection of steel. The roof was later reinstated, however as noted, original pockets along the east elevation were permanently removed as part of a design compromise for penetration of hanging balconies.

![Steel upright tubes erected between roof timbers to support deck over Church Hall](image)

**Fig 7.15**: *Loading deck for level 3 steel beams above church hall – photos by author.*

In the case of the former lecture hall, permanent removal of the roof was required to accommodate the south glazed link to the existing VHI building, which was part of a necessary change to justify the overall development. As there were obvious modifications to the original roof over the course of its lifetime, and evidence of advanced wet rot throughout, the hall was considered the least significant of all three 19th Century buildings, thus the intervention was deemed acceptable. As shown in Figure 7.16, floor sections were removed to accommodate mini-piling, which in-turn supported the steel frame and floor plates above. The new structure was ensured to be independent from the original fabric and cantilevered over the south masonry wall to align the new façade with the stonework below.

![Lecture hall piling details and roof removal sketch by author](image)
7.2.5 Feature Tree Columns

Four slender tree columns were incorporated into the design just prior to construction stage following aesthetic concerns raised by the planning authorities with regard to an original proposal of spanning a larger sectioned steel truss above the church hall roof. The columns were required to support the structure along the west side of the hall. Protruding through the roof, each column consisted of 4no. welded sections branching above the existing slated roof, connecting with, and supporting floor beams on level 3.

Feature Design

In order to support the lofty tree columns, large 2m$^3$ reinforced concrete pile caps (Figure 7.17a) were poured below the church hall floor, followed by a box-plinth on top with cast-in holding bolts (Figure 7.17b). Each 273*25CHS was designed at a length of 8.250m, which included a solid steel pyramid shaped cap consisting of 7 no. 50mm thick plates (Figure 7.17c), one on top of another, gradually increasing in size from 309*288mm to 551*465mm sections, with full butt welds along each entire joint. On top of each pyramid cap, 4 no. 219*20CHS branched up to the underside of the 3rd floor beams (Figure 7.17d). Each branch contained a 300mm long, 15mm thick internal cruciform section at each end to provide stiffness to the section.

![Fig 7.17: Sequence of works for tree column supports – images by author.](image)

Constraints and Compromises

The original design intention was to create a column-free area within the hall by cantilevering over the existing walls and church hall roof with a continuous transfer truss, which would provide support to the floors from level 3 and above without causing any interference to the structure below. However, following extensive deliberation over this prominent element, the idea was abandoned and subsequently replaced with the revised tree column design concept.
The decision involved compromise from a conservation perspective, as further sections of the church hall roof were to be sacrificed to accommodate the new intervention. Pockets along the west side of the roof would allow the tree columns to rise from independent pile caps rather than bearing on the existing structure in any way.

7.2.6 Circulation Routes

Altering the original function of a historic building will often require alterations to its circulation routes, configuration, and the relationship between spaces. As part of the new use of Scot’s Church, several alterations were required such as those listed below;

*New link door from Church to lobby*

As part of the adaptation works, the church will serve as an entry point for all staff with lateral circulation routes from the church to the existing VHI headquarters, and to the new multi-storey office block above. To facilitate such circulation routes, a new glazed link was formed by the creative modification of a window, which was transformed into a new doorway at the south-west corner of the church, providing direct access to the lift lobby. In order to remove the existing mullion, the arches and reveals were temporarily propped to remove the sill (Figures 7.19a and 7.19b). Bricks were built either side up to existing propped reveals (Figure 7.19c). Localised stone sections were cut out at high level either side of the window below the spring point to allow for a steel support plate, with the sill piece resting on top and reused as a door head. This declared an obvious intervention while acknowledging its previous location (Figure 7.19d). The change incorporates original material within the new glazed link creating a transit point from a place of old, to a place of new. *Fig 7.18: Lobby Access Route*

*Fig 7.19: Sequence of works for church window alteration – photos by author.*
Glazed links to Existing Office Block

Breakthrough links from the new development to the existing VHI Office Headquarters, were required at four locations as shown in Figure 7.20. The two-storey suspended link along the south of the development required access routes between the buildings from ground, first and second floor levels. A separate link was also needed at the north-east corner of the church as part of a disabled access requirement.

At the south-east corner where the new structure abuts the existing offices, opes were formed through the external stone walls of the VHI house property at each level. Whilst considered a historic building, VHI house is not a protected structure. The sections were demolished in accordance with a temporary works design, which included needle supports and propping. As expected, the walls were of traditional construction form, built substantially thick at 900mm, with large stone units bedded in lime mortar and a rubble infilled centre. Steel beams were supported on concrete bearing pads either side and packed with lime above prior to the removal of needles and props.

On the opposite end of the site at the proposed north-east link, a previously infilled ope at the existing church required localised demolition to create a through passage. Great care was taken so as not to damage the limestone dressings surrounding the previously infilled ope. Another breakthrough was required from this link into VHI house, which was later encased within a glazed box which was supported by a slender steel frame.

Fig 7.20: Architectural model by MDO Architects Ltd (LHS), showing new link areas from new building to existing – photo by author (RHS).
New Entrance Opening to Church

As part of the adaptive reuse of the church, the building will now provide for office use, however its ecclesiastical configuration precludes the provision of other functions. The two existing side aisle door openings were deemed insufficient to accommodate the main entrance access route of such a large development, and so an opening through the simply constructed lobby wall was considered necessary. The localised demolition of this wall section involved standard temporary works design procedures. The wall was propped with steel needle supports until a permanent steel beam head was fitted over concrete bearing pads on either side. The opening was later housed with a glazed screen with automated doors as part of a grand entrance to the new modern reception area. The side aisle doors remain in a closed position, with one permanently locked, and the other allowing access to a security desk.

Fig 7.21: Before and after images of new entrance breakthrough area in the main church – photos by author.
7.2.7 Masonry Repairs

Stonework along façade

Extensive atmospheric staining was evident throughout the façades of the existing structures, as is common in built-up urban environments. In particular, the soft and porous limestone dressings had acted as a passive repository for emissions such as sulphur dioxide, black smoke, lead, and nitrogen oxides. The high level of soiling was likely to be a primary result of vehicle emissions within such a densely populated city such as Dublin. The elevations appeared to have been left uncleaned and unmaintained for long periods of time resulting in accumulative layers of black gypsum crusts.

The north elevation was noted to be in the worst condition due to its sheltered orientation. Biological growth was thriving across the damp stonework with evidence of dissolution and scaling throughout. Cement pointing was obvious in isolated areas creating further problems of water entrapment and advanced deterioration.

Cleaning

Cleaning of masonry was undertaken across all façades, not only for aesthetic reasons, but to expose the masonry for examination to determine the locations and extent of repair work which was required. An accurate condition assessment of the blackened façade was practically impossible to undertake without extensive cleaning, and so a specialist heritage contractor was nominated early in the construction stage, to execute the works.

Fig 7.22: Before and after cleaning of limestone on the church – photos by author.
**Pointing**

NHL 3.5 mortar was used for pointing sections along each elevation where open, defective, or recessed mortar joints were evident. The mortar selected was found to be compatible with the original in terms of colour, texture, and performance. Sound, original lime mortar was left in place as part of good conservation practice and following the principle of minimal intervention. Many areas along the façade displayed evidence of earlier re-pointing with cement-based mortars as shown below in Figure 7.23, which had detrimental effects on the original masonry by altering the way in which the walls handled water and vapour, affecting its breathability, and trapping water. Dissolution, scaling, and biological growth along the stonework were indicators of dampness. This was particularly evident in the soft and porous limestone dressings, and suggested that the hard, impervious cement pointing was forcing the trapped moisture through the stone, rather than through the joints, and encouraging the transportation of salts, leaving the stone susceptible to further deterioration by freeze thaw and salt attack.

*Fig 7.23: Existing cement pointing along south wall of church – photo by author.*
**Repair Work**

Several sections of Caen stone along the façades experienced damage due to weathering. Many of such stones required replacement fabric in the form of either a stone graft piece or some patching with a suitable repair mortar.

- **Graft Repairs**

Fortunately, original Caen stone which was salvaged during the localised demolition work was available for the formation of new graft repairs. A specialist stone mason was employed to undertake such works. Poor quality stone was cut back to sound fabric, and a pre-formed graft piece was fixed with stainless steel fixing pins bonded with resin. Many original limestone feature sections along the façades were found to have cast iron fixing pins which showed signs of corrosion. The stone appeared to have split and deteriorated in many of these areas, resulting in the unrecognisable condition of the original details. These sections were cut out individually and replaced with new stainless-steel pins and resin.

*Fig 7.24: Sequence of work for masonry graft repairs on the church - photos by author.*
- Repair Mortars

In the case of smaller damaged sections, repair mortars were applied and shaped into the required areas. A specially formulated mortar was specified, which was based on Natural Hydraulic Lime (NHL) and aggregates, and chosen for its high vapour permeability, low modulus of elasticity and exceptional bonding capabilities. Such repair mortars proved ideal for repairing the fine decorative features which were easily formed with an edge trowel and were also used to blend any new graft insertions with surrounding stones.

![Image of repair mortar application along clerestory windows](image1)

*Fig 7.25: Repair mortar application along clerestory windows – photo by author.*

Water Repellents

Localised hydrophobic treatment was applied to the limestone dressings along the front façade of Scot’s Church. The north elevation had experienced the most extensive level of deterioration due to its orientation and exposure with much of the original fabric eroded by weathering. The use of a conservation sensitive water repellent was deemed appropriate in order to protect this vulnerable area from further loss of original material in the future.

![Image of water repellent application on lecture hall window-sill](image2)

*Fig 7.26: Water repellent application on lecture hall window-sill – photos by author.*
7.2.8 Rose Window

Structural Interventions

One of the most remarkable features of the gothic style church was the rose window along the south elevation, which was structurally in jeopardy and in need of urgent repair in order to ensure its long-term survival. The design team undertook a condition survey during the construction stage once access was provided, to assess the level of damage and outline a specific scope of work, which included replacement of stone, reinforcement pinning and application of repair mortars. However, to effectively repair the stonework, removal of all stained glass was required. Great care was taken during the work due to the inherently fragile nature of rose windows, which were often historically constructed to support as much glass as possible with as little stone as possible. The friable condition of the masonry was a concern, thus temporary frames were fitted within fragile areas, and the window was further reviewed by a structural engineer upon removal of all glass units. The scope of works was specified and subsequently undertaken by a competent and experienced heritage stone mason.

Fig 7.27: Stained glass removal by specialist glazing contractor – photos by author.

Constraints and Compromises

Due to the nature of conservation work, unknown conditions of the building are often uncovered during the constructions stage, in which repair materials are limited and methods for repairs must be sensitive and compatible with the protected structure. Countering the unexpected conditions of the rose window was a challenging process which required careful input from the structural engineer, conservation architect, and specialist heritage contractor in which compromise was required. Unstable and friable sections of the original stone required removal, which were replaced with salvaged graft pieces fixed into position with stainless steel pins and resin. Repair mortars were used across several areas, along with pointing of joints with suitable lime mortar.
7.2.9 Drainage works

Drainage works for the new project required careful planning and design as follows:

*Foul Drainage*

All wastewater from the new development is to be disposed through an existing 300mm diameter combined sewer which runs from east to west along Old Abbey Street.

*Surface Water Drainage*

Collection of water along the church roof was improved following the removal of existing replacement gutters, and installation of larger half-round cast iron gutters and downpipes. The church hall is now sheltered by the new structure, with rainwater collection along the new roof several stories above, diverted down into underground attenuation tanks which collect all surface water on the new development.

*Attenuation Tanks*

The attenuation tanks were a requirement by Dublin City Council Drainage Department, and designed for a 100-year storm event with an outflow restricted to 2.5l/s through a hydro-brake manhole. Each tank has an overflow pipe which can bypass the hydro-brake in the event of such an extreme storm. Positions for installing the system were limited.

*Rainwater Harvesting Tank*

A separate rainwater harvesting tank was incorporated into the design to pump filtered rainwater to a high-level tank in a plantroom on Level 7. This tank is used to supply ‘grey water’ to toilets throughout the building below. Following careful review and consultation with the conservation architect, the design team considered the front of the existing church as the most suitable location for excavations to install such systems.

*Surface Water Outlet*

It was agreed with local authorities at planning stage that a 225mm diameter pipe would transport water from the outlet manhole at the south-east corner of the development, eastward along Old Abbey Street to saddle into an existing surface water drain at a depth of 5m on Beresford Place.
Constraints and Compromises

(i) Utilizing the existing drainage system was not an option, as one of the conditions of the granted planning permission was the requirement to incorporate Sustainable Drainage Systems (SuDS) into the new expanded development. Within the confines of the site, the front of the main church was the only suitable area to accommodate the manholes and tanks required for this system. With a required depth of 2.4m, concerns were raised over the potential need for underpinning of the church.

The depth of the original church footings was unknown at design stage, and underpinning was noted on the tender drawings in the event of the church being undermined during excavation works. Fortunately, upon excavating a trial pit down the required depth of 2.4m, as shown in Figure 7.28, the base of the original footings was never reached, thus underpinning was not required. The base for the adjacent front railings however was found to be shallow, and so localised temporary support propping was required. This is a good example of a decision that needed to wait for investigation work and required the designers to be prepared to improvise if necessary.

Fig 7.28: Inspection pit at the church entrance – photo by author.
(ii) The substantial size of the tank systems dictated the deep invert levels for the outfall manhole. As noted, a 225mm diameter pipe was intended to convey all runoff towards Beresford Place to saddle into an existing drain 5m deep on one of Dublin City Centre’s busiest roads, however upon further examination of the existing underground utility infrastructure during construction stage, the area was considered too congested, as illustrated in Figure 7.29 below. With a live historic combined sewer nearby, practicality and safety concerns prevailed, and permission was subsequently granted by the local authorities to make a temporary connection to the adjacent sewer. A 1m dead-leg was provisionally left available from the outfall manhole as a future connection point in the event of surface water network expansion there in the future.

![Fig 7.29: Congestion of underground services along Old Abbey Street – image by author.](image)

(iii) As part of foul drainage coordination, localised core drilling was necessary through the existing foundations to accommodate for the drainage runs required. Coring proposals were reviewed carefully with the design engineer and the locations decided upon were not foreseen to be excessively damaging to the historic structure.
8. Operational Constraints and Challenges for the Contractor

The successful completion of the diverse project was largely hinged upon the ability of the contractor to be strategic, innovative, and decisive during the construction stage, all of which are discussed throughout this chapter.

8.1 Nature of the site

The complex nature of the urban construction site provided a host of unique challenges which required innovative methods of site management. Congested access, confined space, proximity to historic structures, and the constructability of the proposed high-rise building design were among many challenges faced by the contractor.

The external space constituted approximately 30% of the overall footprint, with the remaining 70% occupied by the internal spaces of the historic church and its ancillary buildings. The mid-terraced property was restricted by the LUAS on the northern boundary, thus Old Abbey Street, highlighted in green in Figure 8.1, was the only available area for the main entrance to the site for operatives and deliveries.

As noted in chapter 7, the closest storm water connection point was situated along Beresford Place approximately 80m away from the proposed outfall manhole, with an abundance of varying services within the congested ground.

Fig 8.1: Ariel view highlighting the access restrictions of the mid-terraced site – illustration by author using image extracted from Google Maps.
8.2 Pedestrian Access and Traffic Management
The contractor prepared a traffic management plan to identify hazards posed on the high volume of traffic in the area, including motorists, cyclists, and pedestrians.

With the lack of available parking or loading areas, and a recurrent deluge of delivery vehicles to be coordinated between the site and neighbouring businesses, a full-time traffic management coordinator was employed.

8.3 Management and Coordination of Deliveries
The effective management and coordination of deliveries and collections within the constraints of Old Abbey Street required diligent planning. Ongoing meetings were held with subcontractors to organise deliveries on a just-in-time basis, so that materials would arrive as they were needed. Figure 8.2 shows large attenuation tanks delivered along Old Abbey Street which were swiftly lifted off the public road and placed directly into the prepared excavation. Careful forecasting and ongoing communication with the supply chain was paramount, as any disruption could have a detrimental effect on programme. Fabricators held material off-site and released it as part of a sequential process of delivery and expeditious installation.

Alternative arrangements were often made to accommodate distinctive arrivals, such as concrete lorries or larger deliveries. Such arrivals were scheduled for early mornings or weekends so as not to interfere with daily deliveries and to avoid traffic congestion.

Fig 8.2: Attenuation tanks delivered to site (LHS) and lifted straight into the excavation (RHS) – photos by author.
8.4 Public Safety

Working within the densely populated urban area of Dublin City created additional hazards to the health, safety, and welfare of people who did not work directly in the industry, thus meticulous attention was focused on public safety. Suitable perimeters and barriers were provided and maintained throughout the project to safely separate the public from all working activities. Risk management systems were implemented for all tasks to identify the likelihood and severity of all hazards and to indicate which were likely to affect members of the public.

Two of the greatest concerns were the dangers involved with lifting materials and working overhead. Hazards were kept within fenced locations at all times, with clear signs in place visible to pedestrians. Daily planning of activities ensured that exclusion zones were set up prior to operatives undertaking any overhead works.

Another primary concern was the congestion along Old Abbey Street and lack of turning space, which often resulted in delivery vehicles reversing through the lane. The drivers’ restricted views and consequent range of blind spots presented significant hazards to the public. Prior to arrival on site, drivers of large vehicles were advised to provide an audible reversing alarm and flashing beacons and give adequate notice to site management to ensure the traffic management coordinator was available to segregate the public and provide directional assistance for the vehicle operator.

8.5 Work at Height

Many works on the project were conducted over public ways or areas, and over adjoining buildings. Falling equipment and materials posed the greatest threat. As part of any overhead works in such areas, a thoroughly detailed method statement was set out and reviewed with operatives to identify all hazardous issues and mitigate the risks. Figure 8.3 shows an exclusion zone set up in front of the north elevation, which was a primary concern due to pedestrians and the LUAS rail system directly below.

Safety net fans and exclusion zones were set up below many work zones. Further risk mitigations were adopted over public areas by undertaking such works during off-peak hours, such as early mornings and weekends. All tools and building materials were tethered with safety lanyards in order to virtually eliminate the risk of fallen objects. Mesh guardrails were installed along the roof perimeter due its steep pitch.
8.6 Overcrowding

Another major health and safety concern was the risks of overcrowding within the workplace. The confined site had the propensity for increased accidents due to the large volumes of plant, machinery and personnel required. Therefore, all tasks were carefully coordinated by the contractor throughout the project using software tools such as Microsoft Project.

The issues of overcrowding had potential to be exacerbated with certain tasks requiring the use of chemicals and hazardous substances. Specialist PPE was mandatory for various activities where operatives were required to work with such chemicals within cordoned-off areas, such as during application of alkaline cleaning products along the external masonry of the church. During such extensive works, access routes were changed, and exclusion zones were set up, leaving many areas of the site inaccessible. Such activities were carefully incorporated into the programme and coordinated with other trades operating within the spatially-congested surrounding areas.
8.7 Storage Space

One of the main challenges faced when constructing on a complex and spatially restricted site is the inherent lack of storage area. Within the confined site, space was considered a finite resource which required continuous management. The adverse environment required intelligent use of this space, and so regular site audits were carried out by the main contractor throughout the project to adapt to the ongoing works, and shift or recreate storage space where possible. Layout plans were marked up weekly through careful coordination with subcontractors to ensure efficiency and utilisation of all available space to accommodate the various tasks and ancillary items, while having minimal impact to access routes. Good housekeeping was essential on the project.

Other arrangements included the use of an off-site storage yard which was located nearby for limited storage of unique deliveries.

8.8 Crane Set up

Setting up a tower crane proved to be much more than a trivial issue. Options were limited within the constricted external areas of the overall footprint. The south-west corner was considered as the most suitable location for the erection of large tower crane which required a height of 38m to the hook and a jib length of 44m. As this was planned to be the only fixed crane on site, its capability and size was carefully assessed.

Positioning the crane outside the footprint had many advantages. Apart from avoiding an obstacle to works within the site boundaries, it would allow for a more flexible date of removal without affecting the construction process.

Following extensive CAT scan surveys and review of local services drawings at the proposed location, the contractor engaged with a chartered engineer to provide a temporary works design for a crane base. To avoid substantially large excavations and interference with the multitude of underground services, the engineer proposed a 500mm thick pile cap to be supported on a number of bored mini-piles at each corner. Following construction of the base, concrete cube samples were tested until a strength of 25N was reached, permitting the base to be loaded.

With no site space to lay out the crane components, a road closure was sought from Dublin City Council to close Old Abbey Street during off-peak hours on a Saturday. The operation was undertaken with the use of a mobile crane and sequential deliveries.
Mobile cranes were hired during various multi-stage phases of the project where the programmed works required additional crane assistance. Space was created within the site compound of the adjoining property allowing for steel to be erected along the south link, while reinforced concrete works progressed along the west upper floors.

8.9 Proximity to Neighbouring Buildings and Protected Structures
Construction work within such a built-up urban environment has the potential to cause harm to neighbouring buildings. Apart from the protected structure groupings within the site itself, the adjacent historic structures on either side of the development were also of great concern; in particular, the protected Georgian structure along the west elevation, which physically abuts the church hall. Figure 8.5 demonstrates the confined working space for installing façade panels alongside the existing Georgian structure.

Prior to the commencement of works, a protection plan was put in place by the contractor. Historic fabric from the existing structure was protected throughout the project where required using suitable plywood and screening materials. Several historic items were temporary removed and put into safeguarded storage at a nearby compound.
As noted in Chapter 7, vibration monitoring systems were adopted early in the project during piling works to record the ambient vibrations. The readings were carefully monitored to ensure vibrations were kept with the acceptable limits, so as not to affect the structural integrity of the nearby buildings.

8.10 Stakeholder Management

Within the highly developed city of Dublin, the site is embedded in a diverse community of neighbouring residents, adjoining businesses, and members of the general public. Thus, mitigation of acrimony and disruption amongst the various external stakeholders was critical. To avoid any relationship dilemmas, the contractor made continuous efforts to proactively engage with the local community through regular phone calls, meetings, and monthly newsletters. Understanding the triggers and expectations of each stakeholder proved effective in alleviating their concerns, and avoiding conflict, public controversy, and any potential threats to the ongoing project.

Contingency measures were put in place to minimise disruption on the project in terms of noise, dust, and vibration. Through active collaboration and good neighbourly relations, any substantial noise or vibration, such as that caused by hammer-piling, was minimised and managed carefully. This often involved adjusting the working hours of such activities. Dust was controlled with water suppression systems and extractor fans.

8.11 Specialist Contractors

Several specialist contractors were employed throughout the adaptive reuse project to undertake works which required unique skill and competence in the use of specialised building trades, crafts, and technologies.

The protected structures on the site carried different requirements to those of the new building. Sourcing specialist heritage contractors with tradition skills, expertise, and understanding of the principles and practices of conservation was of vital importance. An array of traditional tradesmen were employed throughout the project; including stone masons, carpenters, roofers, and historic window and stained glass specialists. Each contractor involved in the restoration process required an in-depth understanding of the need for conservation-based practices and materials. Separate specialist contractors for stained glass, sash window, masonry, and iron restoration were sourced from the ‘Traditional Building Skills Register’ on the Irish Georgian Society’s website.
Other specialised contractors were required for the new building, included façade installers, steel erectors, and reinforced concrete formwork specialists. The competence and skillset of these contractors was of great importance, not alone for workmanship and quality, but for their level of experience of working on such large complex projects where coordination of each other’s tasks was critical.

8.12 Scaffolding Designs
Specialised scaffolding played a vital role on the project, where challenges were overcome by clever designs allowing for multi-use sequential systems for access, loading and formwork. The contractor engaged with the services of a chartered engineer to design several bespoke, risk assessed, methodical scaffolding systems, which were incorporated across many aspects of the project without compromising safety or interfering with the structural integrity of the protected structures. The use of traditional tube and fitting provided flexibility for the delicate work involved in suspending several floors of the new uniquely shaped building over the existing historic groupings within such a confined footprint.

Amicable stakeholder relationships proved helpful, with the willingness of neighbours to compromise and accommodate temporary scaffolding within the grounds of the adjacent properties.

8.13 Unknowns
As with every heritage project, uncertainties formed a natural part of the conservation process. Buildings are complex systems, and notwithstanding the importance of initial investigation work, the contractor encounters many unforeseen challenges during the construction stage. A true understanding of the site foundations, masonry, timber, and roof structures became more evident as the project progressed. Many hidden defects were uncovered, resulting in additional timely repairs which were unaccounted for within the programme.

The effective management and success of the project relied on planning, budgeting, and scheduling in advance. However, such pre-planning was hampered by these uncertainties. Risks may have been avoided at planning stage through early investigation, however they were mitigated at the construction stage through ongoing
design team engagement, early contractor investigation, and forward planning. Typical examples are summarised below:

(i) *Condition of masonry after cleaning* – A lot of work was required on all façades once stone was clean and defects exposed. Removal of inappropriate cementitious pointing, and extensive masonry repairs, required scaffolding to remain in place for longer than expected.

(ii) *Rose Window* – Once access was provided, protective cages were removed and stone was cleaned, only then could the masonry be assessed properly. Removing all the stained glass to allow for masonry repairs was a delicate task which had an impact on cost and programme.

(iii) *Wall cracks* – Several cracks along masonry wall were uncovered throughout the course of the project. Some cracks were superficial along the surface of the lime plastered walls which required minimal interference. However, larger cracks within the masonry were uncovered following localised removal of hallow plaster sections. Such cracks required careful monitoring with tell-tales, but fortunately they were not deemed as a major concern. Localised packing and lime pointing were advised by the project engineer and this had minimal impact on cost or programme.

(iv) *Roof timber condition* – Following removal of roof slates, some timber was noted to have localised wet rot, particularly at eaves level and along coping stones. Minor splits were noticed on some rafters and one of the purlins showed signs of defects and some cracks – fortunately these timber sections could be replaced with other original members which had been left over from previously removed sections at hanging balcony pockets.

(v) *Excavation works and piling* – It was to the relief of the contractor that the Church foundations were very deep, allowing excavation work to commence along the north elevation without the need for underpinning. In contrast, the contractor was required to underpin the south of the church hall wall, to allow for excavating the lift pit area. The foundations were found to be shallower than expected, as this structure was built decades after the original church and consisted of shallow concrete strip foundations. The ground conditions varied throughout the site with some areas made up of substantial depths of fill material. Piles ranged from depths of 5-8m.
9. Comparative Study

In order to further demonstrate the potential of redundant cultural heritage, summarise the typical challenges involved in adaptive reuse projects, and outline risk mitigation methods for such, another adapted historic church in Dublin City Centre has been analysed and compared to the Scot’s Church project. As stated in earlier chapters, adaptive reuse projects pose many unique challenges which must be overcome through compromise and creative thinking. ‘Engineering’ can be defined as ‘the action of working artfully to bring something about’ (Oxford 2010). By analysing the engineering approaches on this comparative project, the chapter reveals how two contrasting designs can be so strikingly different - yet so closely related. Both projects set out to utilise the city’s religious heritage assets and promote sustainable urban development, by creating new office space during a period of high demand in central Dublin. However, each project needed a different approach and required specialist vision from a qualified engineer. The following comparative study demonstrates how a similar project deliverable may require an exceptionally contrasting design strategy.

9.1 Context

St Luke’s is a historic parish church situated in Dublin 8, within the mixed-use core of a dense historic urban block. The protected structure and recorded monument lies within the zone of archaeological constraint for the city. Built between 1715 and 1716, it is a fine remnant of the early 18th Century Irish church architecture in Dublin. The building ceased to be used as a place of worship in 1975. A fire in 1986, which gutted the church, left it in a ruinous and dilapidated condition, as shown in Figure 9.1 below.

Fig 9.1: Dilapidated condition of St Luke’s Church prior to construction – photo provided by CORA Consulting Engineers.
There has been a great deal of redevelopment within the Coombe area in recent years, with roads substantially widened and the scale of buildings remarkably increased from subtle cottage dwellings to multi-floor apartment blocks and retail units along street level. Many derelict sites and vacant structures remain within the area and require a new purpose.

9.2 Proposal
Following extensive conservation planning and consultative processes with stakeholders and interest groups, an adaptive reuse proposal was submitted during a period of social and physical change, and extensive development within the Liberties/Coombe area. Permission for the project was granted in 2009, with one of the primary objectives to identify an appropriate contemporary use for the church, while creating a new public parklet on the north of the site facing St Luke’s Avenue, and restoring the south church yard as a historic graveyard and contemplative space.

The proposal to transform the ruinous church into state-of-the-art new offices was approved on the basis that it would provide the protected derelict building with a sustainable future, while retaining much of its historic and architectural significance.

9.3 Challenge
While the early conceptual phase of design identified preliminary solutions to challenges faced by the adaptive reuse scheme, it also recognised that a clear and coherent strategy would require collective and considered agreements throughout the project for any unforeseen challenges encountered. Such challenges were faced throughout the development, which required practical and responsible solutions through collaborative problem solving between the architect, engineer, contractor, and heritage consultant to deliver a successful project.

(i) Protected Structure Status

The future use and adaptation of the building was restricted by several factors which threatened its vitality and viability, most notably its protected structure status, which provides statutory protection against any unauthorised alterations or additions. The significance and sensitivity of the church limited the level and nature of intervention and adaptation permitted to accommodate the new use.
(ii) Location and restricted access

The nature of the site, and its location within the urban city centre environment, created further problems from a constructability perspective, mainly due to access and logistics. With a gated residential estate south of the development and adjoining properties east and west, access was limited to the northern boundary along St. Luke’s Avenue as shown in Figure 9.2.

Fig 9.2: Ariel photograph of St Luke’s Church – image extracted from Google Maps.

(iii) Existing Condition and Overgrowth

Following the fire in 1986 and decades of obsolescence thereafter, the structure remained roofless with many areas throughout the building left obscured by a high level of overgrowth across its masonry ledges and wall tops, as shown in Figure 9.3, resulting in biological decay and other concealed issues. Weathering and atmospheric pollution was also noted across the exposed structure. While the neglected church was evidently in a poor condition, true assessment of the extent was hindered by its overgrown and dilapidated state. The level of investigation was also restricted by the lack of safe access to such vulnerable areas.
(iv) Archaeological issues

As one of the more unique features of the building, the 30 no. crypts which extend beneath the entire church as shown in Figure 9.4, were to be kept in their original state. The labyrinth of red brick vaults which form these crypts at ground level, as shown in Figure 9.5, were noted to be in good condition; however, they were not capable of taking additional loads.

The graveyard comprised extensive areas of shallow burials with remains exposed at depths of as little as 60mm, which were unlikely to be moved due to the high sensitivity involved with excavation of cemeteries, and the storage of human remains. The extent of groundworks was therefore greatly restricted due to the archaeological constraints of the site.
9.4 Solution

The cumulative effect of the above factors posed a significant challenge in providing an adapted use for the church which could work within such restrictions and satisfy all statutory requirements. Creative engineering proposals were required as part of the plan to renovate and refurbish the building, converting it into a new modern office area. Interventions undertaken were as follows;

(i) New Floor over existing Brick Vaults:

The brick vaults were carefully exposed in order to identify the location of all vertical subfloor support walls. A special proprietary fabric membrane was dressed over the vaults to create a separation layer, allowing the new intervention to be totally reversible in future without damage to the existing bricks.

Fig 9.5: Exposed brick vaults – photo provided by CORA.

Concrete strip footings were then poured between vaulted sections as load transfer points over impost foundations. A subfloor was further poured across the entire floor area, providing a solid surface from which to erect scaffolding for overhead roof works.

Fig 9.6: Proprietary fabric membrane dressed over vaults prior to pouring subfloor – photo provided by CORA.
(ii) New Steel Roof Structure:

The original walls were conserved using lime pointing and localised repair techniques. Wall tops were prepared as required, and limecrete bedding applied for spreader beam installation.

![Fig 9.7: Spreader beam on existing wall to support roof structure - photo provided by CORA.](image)

7 no. steel trusses were installed spanning from north to south walls supported on the spreader beams. Floor beams were hung within the body of the building from the new steel roof using a proprietary high strength 32mm steel rod system to support the 2 no. suspended floors. A steel beam and timber joist system was proposed as a lightweight construction arrangement which could be easily carried out from within the walls of the church area, with the additional benefit of allowing for services to be fitted within the floor structure.

![Fig 9.8: Steel floor beam hanging from truss roof structure - photo provided by CORA.](image)
(iii) Integrating New Services

The brick vaults were utilised for the new services required. Rather than repairing damaged sections of brickwork, these were reused as opes for passage of such services between ground level and underground crypts.

![Image of a crypt passage with opes for services]

*Fig 9.9: Circulation space within the barrel-vaulted crypt passage (top), and existing ope which was later used for the passage of services (bottom) – photos provided by CORA.*

Due to the archaeological restrictions, excavating new drainage lines was not an option and so the original routes (installed in 1869) were replicated. As part of good sustainable urban development planning, a rainwater harvesting tank was installed within the crypt.
9.5 Questionnaires

9.5.1. Intro

Considering the objectives of the research project, it was decided to further the comparative study by issuing questionnaires to some of the parties involved in the adaptation of both Scot’s Church and St Luke’s Church, in order to better understand the design rationale behind such projects and the typical challenges encountered. The qualitative approach involves empirical work undertaken by gathering feedback from those closely involved with such challenges, allowing for greater capacity within the study to gain more depth and meaning based on each individual’s experiences.

9.5.2 Structure of the questionnaire

Following a review of the challenges involved on the Scot’s Church project in previous chapters, a detailed questionnaire was prepared for the conservation consultant on the St Luke’s project to develop an improved understanding of the level of compromise required on a correlative adaptive reuse project.

Fortunately, the same engineering consultancy firm was employed for both unique projects. This provided the opportunity for a second impartial questionnaire to compare both projects from an engineering perspective and assess the challenges involved.

9.5.3 Design development of St Luke’s Church

The first questionnaire was issued to Peter Cox, Director of Carrig Conservation International. Apart from acting as the Conservation Consultant on the project, Mr Cox and Derek Tynan, Director of DTA Architects, were the successful purchasing tenderers for the property in 2006. With a detailed understanding of the existing building, Carrig outlined the constraints and challenges involved and held a workshop meeting with DTA Architects to initiate a design concept. The underground brick vaulted crypts were an obvious challenge from the outset and so an engineering input was required at this early stage to review the proposal of hanging the floors from the existing masonry walls. The following questionnaire issued to Mr Cox provides a qualitative insight to the design development of the project and typical challenges encountered;
St. Luke’s Church is an exemplar of historically conscious adaptive reuse which demonstrates how a redundant protected structure can be sensitively adapted through sustainable and responsible approaches to conservation;

1) Were there any alternative approaches at the conceptual stage?

“Yes, we did look at a number of options but when we understood the complications of the crypts, we really only had one option left.”

2) What was the rationale behind the final decision to hang the structure?

“To get 3 floor levels of loading there was no other option, but we felt this was innovation at its best and a statement for the robustness of the original early 18th century church structure.”

3) By their nature, conservation projects will typically involve a certain degree of unknowns – How accurate were the original condition surveys, and how did they compare to the findings during the construction stage?

“Perfectly - as a practice we believe in undertaking very detailed surveys so that there are no surprises on site. The fact there was so little left also contributed to the definition of interventions.”

4) What repair works were required to accommodate the new interventions?

“Very little! The walls were totally stable considering they had been left exposed for over 30 years. The tops of the walls had some growth and overburden, but this was easily removed. The top stones were re-seated in a lime mortar and the new roof was carefully designed to spread the load and be completely reversible if ever required.”

5) Adaptive Reuse projects often involve a level of compromise for the sustainability of the structure - Were there any elements of the building beyond repair?

“The roof of the chancel was beyond repair, but we had enough evidence of the original to re-create it as it would have been, using all-natural products. The decorative plasterwork was also badly damaged but good enough to restore and repair. The
mosaic floor was badly damaged, and so was carefully recorded, taken up and put into storage to go back down at some stage in the future.”

6) What impact do the new elements have on the original character of the structure?

“This is a hard one as the church was a ruin, and the new main roof obviously is a statement and could be interpreted as having an impact. We feel that the minimum impact any element has on this church is far outweighed by the positive re-use and re-purposing of this building.”

Any intervention to protected structures and recorded monuments should be of a sensitive nature.

7) Describe how this development followed the fundamental principles of conservation?

“We always follow the principles of the Venice and Burra Charters and this case is no exception – the internal lime render had perished over 30 years of exposure to the elements, and so we removed most of it (keeping a couple of reference points with original stencilling) and the rest was re-plastered with a lime / hemp plaster to improve the thermal performance. All other interventions are reversible. Lime was used as opposed to cement. The remaining decorative elements of the altar were restored using traditional skills and we are happy that this is an exemplar project.”

9.5.4 Engineering challenges faced on both St Luke’s Church and Scot’s Church

The second questionnaire was directed towards CORA Consulting Engineers, whom were appointed as the structural design engineers on both projects. The following questionnaire gathers feedback from two engineers involved in the design challenges on these projects and demonstrates how such creative concepts can become a reality;

All parties involved on an adaptive reuse project will be challenged by the existing site constraints and preservation requirements. Reflecting on the project, what were the primary challenges you encountered and how were they overcome?
St Luke’s Church

“(i) Existing Layout

The nature of working with any existing building is that the design must adapt to suit the existing layout. That is particularly evident in the overall scheme of St Luke’s. The church itself has several brick vaulted crypts below ground within the footprint of the building. It was deemed appropriate that these vaults would not have sufficient capacity for modern day office block loading. As such, the structural solution was to hang the first and second floor plates from new steel roof trusses, carrying and spreading the load over the existing masonry walls.

(ii) Existing Masonry Walls

The condition of the existing walls was closely assessed and monitored before and during works. As the walls would now be carrying the building, their integrity was vital. Organic growth was evident throughout the masonry and issues arose around the detailing of walls that were far from square and true. All issues were overcome through collaboration with all parties and ongoing site meetings. Ideas were shared and proposals put forward until a decision was made. Fitting the load bearing spreader beam on a limecrete topping to the existing wall was a typical example of an innovative proposal which was agreed upon.

(iii) Loading over delicate Vaults

A further example of the design team working together can be seen at ground floor level where a new concrete floor had to be installed without overloading the vaults. An initial solution called for steel beams to span over the vaults. However, once on site a solution was presented to utilise aerated concrete to spread the load to the supporting walls. The aerated concrete had sufficient strength to transfer loads while maintaining conservation practices in being completely reversible.”

– Alan Garvey, CORA Consulting Engineers.
○ Scot’s Church

“(i) Existing Layout

Working with the constraints of existing buildings. The small footprint to work within and had to develop a design that worked around the church hall. Tree columns, hanging façade on west façade all needed particular attention.

(ii) 3D modelling.

Due to the complex shape of the building accurate 3D modelling was essential to ensure design intent was followed. This required constant communication with architect and steel fabricator.

(iii) Connection Design.

Unorthodox connection design was much more onerous than on most projects. Slender steel sections were part of the overall design intentions; thus all connections were generally required to be kept with a 150mm square zone.

(iv) Buildability

The erection sequence of frame and slabs required a close working relationship with the contractor to achieve a building sequence which didn’t compromise the structural design. This was particular challenging as the church hall inhibited standard erection sequence. i.e. we had to ensure the load on three storey scaffolding was limited. De-propping of slabs critical.”

– Dermot Brennan, CORA Consulting Engineers.
9.5.5 Comparison of diverse challenges on both projects:

The comparative study on St Luke’s Church highlights the diversity of challenges involved on adaptive reuse projects. The study also concludes that there is no ‘one size fits all’ solution. Although both historic projects were obsolete church buildings in central Dublin, the constraints and compromises involved on both projects are entirely different and therefore each will require unique solutions. Some of the key differences worth noting are as follows;

(i) *Existing Conditions*

Scot’s Church was found to be in good physical condition compared with St Luke’s Church. With most of the original building fabric intact, there was more to preserve which set limitations on the new proposal. St Luke’s Church was found neglected in a ruinous condition following a fire in 1986, and without a roof much of its original fabric was subject to advanced deterioration over several decades.

(ii) *Structural Requirements*

The new addition to Scot’s Church required a building that was structurally independent of the original structure, with loads transferred to pile cap foundations. On the contrary, the new addition to St Luke’s Church was reliant on the existing masonry wall due to the archaeological sensitivity of the graveyard and conservation of the vaulted crypts.

(iii) *Spatial Considerations*

Both historic structures experienced changes to their original space configuration. While ‘space’ is often considered by many conservationists as an object of conservation itself, changing the purpose of a building often relies on alterations to its spatial composition to attend to new socio-functional and pragmatically requirements. While most of Scot’s Church has retained its internal spatial character, there have been significant changes to the building’s external setting and surrounding streetscape, creating an old building within a new building. In contrast; St Luke’s Church was not as visually dominant from public spaces, with a contemporary roof indicating that some alterations had taken place, but most of which were concealed behind the existing masonry walls, creating a new building within an old building.
9.5.6 Common Objectives

While both projects have inherited different constraints, they follow similar objectives;

(i) *Protection of Local Heritage from Loss and Depletion*

 Implicit in conservation’s objectives is the obligation to arrest decay or mitigate the risk of further deterioration. With both previously redundant churches now occupied, new custodians have been assigned the responsibility of maintaining the protected structures.

(ii) *Adherence to good conservation principles*

While the interventions on both projects differed significantly due to the unique nature of each structure, the same principles of conservation were followed. The interventions were honest and sensitive to the protected structures, with minimum impact on the original fabrics. Should this be disputed in the future, the interventions are reversible.

(iii) *Sustainability of the Built Environment*

The new developments have created central office spaces within Dublin City, which are currently in high demand. Rapid growth within a city can have a significant impact on the environment, however reuse of such built heritage contributes to the concept of sustainability. Rather than sourcing new development space, the ‘embodied energy’ of the structures, consumed by the process of their original construction, has been retained, providing essential office space through innovative adaptation of these heritage assets.

9.6 Discussion

9.6.1 Introduction

With great difficulty comes great innovation. The role of an engineer on heritage projects has become extremely complex due to a wider range of parameters involved, compared with a typical new build. The use of smart engineering methods has provided sustainable new uses for both Scot’s Church and St. Luke’s Church. The buildings now strike visual contrasts between old and new, accentuating their historic fabric with sensitive contemporary additions. The projects are emblematic of the potential of such structures to wed preservation with sustainable development as two common practices.
9.6.2 Project Engineer

As noted in the *Architectural Heritage Protection: Guidelines for Planning Authorities*; “good conservation practice allows a structure to evolve and adapt to meet changing needs”. To achieve this goal, the industry requires creative and competent engineers to overcome the challenges associated with heritage projects without destroying their very essence. This primarily requires a knowledge and understanding of traditional building construction, allowing for accurate investigations and condition assessments to be undertaken during the conceptual stage of the project and to determine the design feasibility. By their nature, old buildings are constructed with traditional materials, and often with configurations uncommon in modern architecture. Thus, an experienced engineer should have a thorough understanding of the capabilities and limitations of such structures, design solutions that employ a detailed analysis of existing conditions, react promptly to unanticipated issues during the construction stage, and adapt positively to the architect’s iterative design approaches.

9.6.3 Project Manager

For a complex project to be successful, it will also require an innovative contractor to adopt smart construction methods and react efficiently to unforeseen challenges. A project manager is often employed by the contractor with the overall responsibility for the successful planning, execution, monitoring, control, and closure of a project. Just like a project engineer, the project manager is also a problem solver. Both are concerned with constructability, and each encounter challenges which require creative, practical, and efficient solutions. Thus, the clear relationship between planning and problem solving suggests that the attributes of an engineer may be useful in the role of a project manager. The contractors involved in both Scot’s Church and St. Luke’s Church employed project managers with an engineering background which is believed to have been beneficial to the overall execution of the project.

9.6.4 Summary

Engineering knowledge and experience is indispensable on adaptive reuse projects. The input of an engineer with specialist knowledge may often be required so that least-invasive options can be explored for any alterations or interventions carried out.
10. Recommendations

This research project has presented a broad overview of the diverse challenges faced on the adaptation of historic buildings. Following a review of structural design, smart interventions, project challenges, and innovative solutions on adaptive reuse projects, the following recommendations are proposed for cultural heritage adaptation projects going forward;

10.1 Early Engineering Engagement

Project teams involved on adaptive reuse projects are faced with a broad range of challenges when introducing a new development within the confines of existing historic settings. In such a multidisciplinary environment, early engagement with engineers is crucial to develop a constructible safe design concept with a strong input to the form, material, and texture of the proposed structure. An experienced engineer will often best foresee the risks and opportunities involved during the construction stage and advise on the practical buildability of the overall proposal which contractors can later tender for, thus reducing the likelihood of budget overruns, programme issues or a delivered product which does not perform as expected. Often, the early design process is architect-led with engineering experts entering the design process after the fundamental design decisions have been made – this is not good enough.

Engineers must play a proactive role at the conceptual stage of an adaptive reuse project, rather than reacting to it later in the design development process, resulting in potential design changes throughout the project and costly resolution of structural issues. The design of tree columns on the Scot’s Church project was an example of a design change which required swift innovative engineering proposals. The original steel truss design which was considered to be visually intrusive by the local authorities, was a significant structural component. The replacement of such an important element necessitated substantial design changes at a critical point on the project.

Prior to planning for any adaptation, condition surveys and structural analysis may be required as part of a feasibility study. If the concept is accepted into the advanced stages of design, the engineer must ensure that the contractor is provided with sufficient information and detailed design drawings in order to construct the project safely.
10.2 Extensive Condition Surveys
Adaptive reuse of old buildings often involves complex and non-standard work when compared with the construction of a new building. A qualified engineer should carefully assess all building components to diagnose an appropriate course of action. An existing condition survey of the structure will shape the overall scope of work required to adapt the building for its new use. There are always factors which limit the extent of a condition survey, such as time, accessibility, and cost. However, these should not be unjustly compromised. Rather, greatest practical efforts should be taken to understand the existing structure to mitigate risks, understand limitations and gain a better understanding of potential options for building and engineering techniques.

While Scot’s Church was noted to be in good condition, this is not always the case with existing structures on adaptive reuse projects. The comparison study of Luke’s Church clearly demonstrates the importance of condition surveys. Due to the existing crypts below ground, adaptive reuse of this structure required an engineer to think ‘outside the box’ and design a structure with alternative load paths. The decision to hang the new floors from the existing masonry walls was another great example of innovative engineering and required careful assessment of the existing fabric by an experienced conservation engineer. The structural scheme of the project depended entirely on condition surveys, which is a fundamental difference from a new-build project.

Early investigation work is beneficial to all parties involved. The client and design team will benefit by gaining a better understanding of the constraints of the project, enabling contractors to later tender from a clearly defined specification and bill of quantities. The RIAI yellow form of contract ‘where quantities do form part of the contract’, is often used for conservation projects, in which provisional sums can be set aside for items which cannot be defined at tender stage.

10.3 Conservation Accreditation Register for Engineers (CARE)
The success of both Scot’s Church, and St.Luke’s Church projects relied on the experience and knowledge from the project team assigned. All professionals involved in building conservation should have an in-depth understanding of traditional construction, including; architects, engineers, and contractors. Without training and conservation accreditation schemes, historic structures would become under threat of inappropriate repairs and interventions, resulting in irreparable damage to cultural heritage.
The Conservation Accreditation Register for Engineers (CARE) identifies engineers skilled in the conservation of historic structures and sites. Whether working as a design engineer for the design team or site engineer for the contractor, engineers play a vital role on adaptive reuse schemes by adopting innovative construction methods throughout the project. Through a rigorous approval procedure, the Institute of Engineers Ireland (IEI) Chartered Engineers (Civil and Structural disciplines) can become accredited by demonstrating an understanding and appreciation for conservation philosophy and methods applied to heritage projects. Engineering is following the architectural profession in this regard. Registration is only valid for five years. After this time, the accredited engineer must apply for revalidation by providing a curriculum vitae and a record of continuous professional development in the field of conservation. Therefore; appointing a conservation accredited engineer on heritage projects provides reassurance that the engineer is maintaining the knowledge and skills required to work on them.

10.4 Commitment to Continuous Professional Development (CPD)
All parties involved in conservation work should commit to ongoing CPD in the field. Courses and seminars are frequently organised by a variety of professional bodies, including; the Construction Industry Federation (CIF) of Ireland, Engineers Ireland (IEI), the Royal Institute of the Architects of Ireland (RIAI), among others. Organisations should encourage staff to partake in such courses by providing funding and allowing time off work for training.

The main contractor on Scot’s Church provided funding to the author to undertake a post-graduate diploma in ‘Applied Building Repair and Conservation’ in Trinity College during the course of the project. Funding has also been provided to support the author’s membership with the Institute of Engineers Ireland, the Chartered Institute of Building (CIOB) Ireland, the International Council on Monuments and Sites (ICOMOS) of Ireland, and the Society for the Protection of Ancient Buildings (SPAB) of Ireland. The author attends regular CPD events organised by each of these groups which has proven to be very beneficial in the understanding and management of heritage work on recent conservation projects. This dissertation has also been funded by the main contractor and has been a valuable addition to the author’s ongoing CPD.
10.5 Register of Heritage Contractors

Contractors with the skills to work sensitively and effectively on protected structures also form part of the chain of responsibility. Historic buildings require a considered approach, and main contractors should have a broad range of experience across different categories, and in coordinating and controlling various specialist contractors to execute separate aspects of heritage projects. To be registered on the list of Heritage Contractors, applicants must demonstrate their level of competency by submitting a resume of previous projects and experience in the field of built heritage and conservation.

The Scot’s Church project provided the main contractor with a wealth of additional experience in the field of conservation. Some of the investigation work carried out, such as; exposing the masonry along the façade through careful cleaning methods, and gaining access to uncover the rose window at high level of the south elevation, lead to many unforeseen challenges during the construction stage. Extensive repairs to the stonework and rose window required specialist contractors to be sourced, which had a natural impact on both cost and programme. On the other hand, other investigation work, such as; lifting slates from the church to expose roof timbers, and excavating a trial pit to review depth of the existing church foundation, provided reassuring results which required no further intervention. It was evidently important for the main contractor to understand the risks associated with such heritage projects, along with the nature of traditional work involved and managing programmes for such work.

A registered list provides public and private clients with an accessible selection of competent heritage contractors qualified to undertake conservation work. On large projects, registered main contractors should ensure only registered specialist sub-contractors should be appointed to undertake any works relating to historic fabric. During the procurement stage, a main contractor will instinctively favour the lowest bid from sub-contractors based on standards set out in the specification, thus the end product will be created by sub-contractors whom have won their contracts largely based on price, resulting in a compromise on quality. The expertise of all contractors involved is of fundamental importance to the overall success of conservation projects, and it is therefore essential that accreditation systems are in place to ensure all contractors involved in heritage work are sufficiently qualified and experienced.
10.6 Design Compromise

Striking a balance between the growth of a city and preserving its built heritage is challenging. With the rapid urban agglomeration of Dublin, and a large amount of vacant disused historic building stock, there is great incentive and potential for such buildings to be provided with a new function before further neglect will result in advanced deterioration, irreparable damage, and loss of such valuable heritage assets. However, promoting the concept of adaptive reuse requires a degree of compromise for the greater good of such protected structures which are under threat. There must be flexibility for change within the historic environment allowing for old buildings to sensitively evolve and adapt to modern requirements.

The Architectural Heritage Protection Guidelines set out by the Irish Government contains detailed guidance on the general principles of conservation, development control standards, and conservation of specific architectural elements. Part 2 of the guidelines provide detailed standards for architectural heritage. Section 7.3.1 of the guidelines note; “It is generally recognised that the best method of conserving a historic building is to keep it in active use” (Department of Culture, Heritage and the Gaeltacht 2011). In light of this, the compromises required for the successful adaptation of Scot’s Church can be considered appropriate when compared to the threat of further redundancy and subsequent deterioration. Straight-forward design modifications greatly improved the constructability and future operation of the development. The formation of new openings through existing walls to improve access and efficiency of the building is a prime example of such design compromise.

The principles of conservation should be followed as far as is reasonably practical to ensure best practice in conservation. However, there is often a bigger picture and some level of alteration to the original is often required to ensure longevity of the overall structure. Building adaption has played an important role throughout history and has led to a rich building heritage in Ireland. Building conservation relies on responsible and sustainable decisions. Some significant elements of a structure may require careful preservation, and some may need to be compromised for the greater good. It is often difficult to find the right balance, but forward-thinking philosophy must be adopted in order to provide compromise and occupancy to new buildings. This will outweigh inevitable deterioration of such structures if they remain without function.
11. Conclusions

This document has explored in detail the engineering constraints and project management challenges on adaptive reuse projects, using Scot’s Church as a primary case study. A comprehensive assessment on the adaptive reuse process, typical interventions and challenges involved on such projects, along with an introduction to traditional construction methods and materials, was provided as part of the literature review, which formed a foundation for the overall research project. The dissertation has carefully examined the constraints and compromises involved on the Scot’s Church development and set out recommendations for future adaptive reuse projects going forward. The project demonstrates the valuable contribution that innovative and experienced engineers can have on the adaptation of heritage structures.

The adaptive reuse of protected structures plays a pivotal role in regenerating the built heritage and preserving the prestige of such historic buildings which may otherwise fall into disrepair and further decay. Conserving such architectural heritage requires a multi-disciplinary approach, and it is important for members from all parties to understand the special legislations, conservation ethics and guidelines involved in such projects. Innovative engineering is key to overcoming many barriers and challenges which typically arise on such projects to provide these old buildings with new functions. In recent decades, irresponsible repairs and alterations to traditional buildings have resulted in irreparable damage. Unlike the design of modern structures, there is no clear set of guidelines for the repair and conservation of historic buildings which often leads to ambiguities and arbitrary decisions. The large variety of existing building stock in Ireland poses many challenges for specification, as there are no standard solutions. Therefore, conservation engineers with an in-depth understanding of traditional construction are required to assist in developing design ideas which incorporate fundamental principles of conservation and long-term sustainability of the nation’s cultural endowment.

With the rapid development of urban agglomerations, practices which combine heritage protection and sustainable development are gaining momentum within cities such as Dublin. Many adaptive reuse projects have created difficult challenges such as; speed of construction, design complexity, short deadlines, spatial constraints, safety management, and increasing pressure from clients. However, through innovative
thinking and careful management, the potential of these old buildings to be integrated within modern society can be unlocked.

The creative adaptation of Scot’s Church highlights the flexibility and potential of historic buildings to become reinvented. Overcoming the challenges involved in such a complex project sets it aside as an exemplar of historically conscious adaptive reuse by demonstrating the innovative engineering methods undertaken. Through the adoption of responsible approaches to conservation, this new iconic building serves as a catalyst for such creative and sustainable development, encouraging such imaginative thinking towards further integration of Ireland’s built heritage for the benefit and inheritance of future custodians.
References


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