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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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 [1]. 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. The project demonstrates the valuable contribution that innovative engineers can have on the adaptation of heritage structures and promotes further integration of Ireland's built heritage for the benefit and inheritance of future custodians.

KEY WORDS: Adaptive Reuse, Conservation, Sustainability; Innovative Engineering.

1 INTRODUCTION

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 [2], 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. Recent periodic review reports [3] have 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 [4]. 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.

2 LITERATURE REVIEW

In order to fully understand the principles of building adaptation, reasons for adaptive reuse of historic buildings, and the structural design and interventions typically undertaken on building conservation projects, a review of existing literature was undertaken, and supported throughout the chapters by various site visits and comparisons with other paragon projects.

2.1 Adaptation of buildings

In the context of buildings, adaptation involves the process of adjustment and alteration to a building to meet new requirements. Any work which is over and above maintenance can be considered as adaptation. It is inevitable that buildings

will age and outgrow their original function. Therefore, the adaptive reuse process can provide the built environment with a sustainable future.

2.2 Adaptive reuse of historic buildings

Creating a future use for historic buildings is of great importance, however it can often be very 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. There are no 'one size fits all' solutions, and there are many challenges which vary from one structure to the next, such as; the existing conditions of the structure, geometry and layout of historic buildings, availability of traditional materials and skilled labour, regulation compliance, and conservation considerations.

2.3 Conservation principles

"Conservation is very largely the art of controlling (or managing) change" [5]. 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 principles of conservation. "Buildings are not museums and should not be fossiled" [6]. 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 [7].

2.4 Structural design and interventions in building conservation

Historic buildings often require alterations and extensions to accommodate a new use of the structure, and there are various types of interventions which can be incorporated on such building conservation projects. When adapting a protected structure for a new purpose, 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" [8]. Rather, any new proposed intervention should harmonise with, and be sensitive towards the existing building.

Structural engineers play an important role in the suitability assessment of adaptive reuse projects and defining a suitable scope of works for such. If substantial alterations are undertaken without consultation with a competent engineer with experience of traditional construction, this may result in catastrophic consequences [9]. An engineer is often required to evaluate not only the existing condition of the structure, but also the impact that a proposed new intervention may have on it [10].

3 CASE STUDY ON SCOT'S CHURCH

The objective of the case study was to assess the design and construction constraints involved in the adaptive reuse of Scot's Church. Examining the constraints and challenges involved provided insight on how such barriers could be overcome through responsible and sustainable approaches to conservation, highlighting the new design as an exemplar of adaptive reuse.

3.1 Project scope

The brief for Scot's Church was to integrate the historic building with a modern office block, providing several hundred workstations, 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.

3.2 The existing structure

Various surveys were carried out in order to assess the existing condition of Scot's Church along with its ancillary buildings, including; the site configuration, the extent of decay along the facades, and the general condition of the existing fabric and elements of the structure – all of which are extensively detailed within the research project.

3.3 Project interventions

Successful integration of the contemporary design within the urban built environment posed many challenges for the Scot's Church project. Through extensive coordination, creative design proposals, and compromise, planning permission was granted for the development in August 2008, and the following principal interventions were deemed acceptable;

- Superimposition: *Modifying the roofing of an existing building and imposing its aspect upward contrary to its original form (Figure 1)*

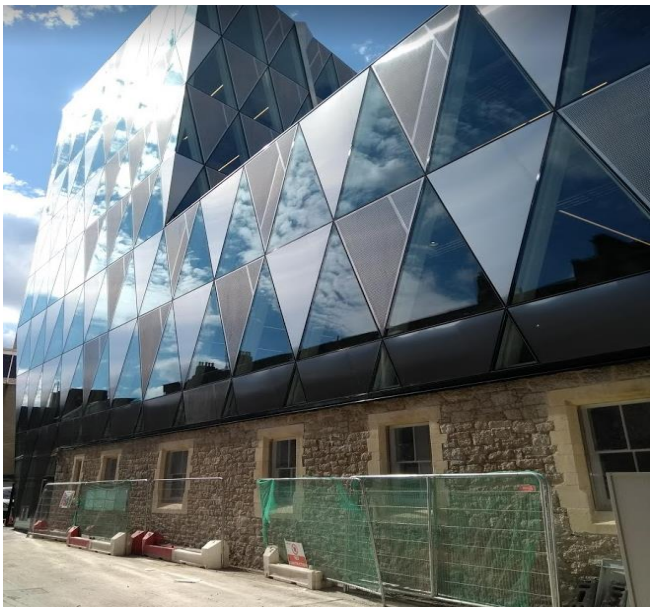

Figure 1: View of the new façade over the existing Lecture Hall structure along Old Abbey Street – photo by author.

- Enshrouding: *Surrounding and covering of an existing structure and internalising its existing building fabric (Figure 2)*

Figure 2: View of existing Church Hall structure enclosed within the new multi-story structure – photo by author.

- Object insertion: *Inserting new contemporary elements within the existing context of a structure to accommodate its new form and use (Figure 3)*

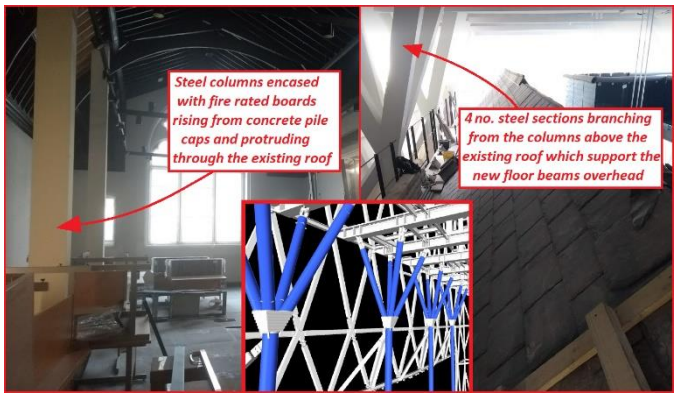

Figure 3: Views of encased steel columns within the existing Church Hall (LHS) which branch off above the slated roof to support new floor beams overhead (RHS) – photos by author.

- Abutment: *Introducing a new structure, which makes physical contact with fabric of the old building (Figure 4)*

Figure 4: Interface between new façade and existing church at glazed link joining new and old structures – photo by author.

The interventions formed part of a complex design which ensured the historic grouping's future use. The principal 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 for the site, and thus the increased longevity, of the protected structures.

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 compliment the original structure. The design process created many challenges for the engineer due to the sensitive fabric and restricted space on the site. This highlights the importance of appointing competent engineers on such projects, with great knowledge of traditional construction. Constructability was considered a major challenge, and therefore experience on adaptive reuse projects within a restricted urban setting was also critical.

3.4 Project Management Challenges

The successful completion of the diverse project was largely hinged upon the ability of the contractor to be strategic, innovative, adopt smart construction methods, and react efficiently to unforeseen challenges during the construction stage.

The complex nature of the urban construction site provided a host of unique challenges which required innovative methods of site management. The mid-terraced protected property was restricted by the LUAS on the northern boundary, flanked by neighbouring historic structures on the eastern and western boundaries, and the only available access for construction along the narrow one-way system on Old Abbey Street (figure 5). Congested access, confined space, proximity to historic structures (Figure 6), public safety and the constructability of the high-rise building were among the many challenges faced by the contractor.

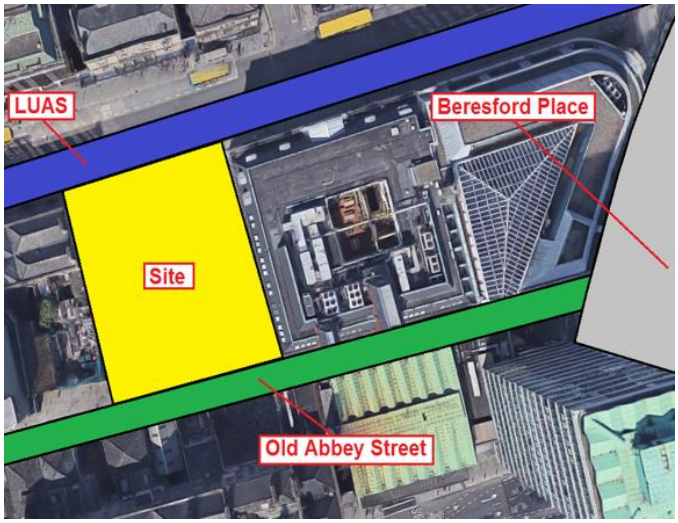

Figure 5: Aerial view highlighting the access restrictions of the mid-terraced site – illustration by author using image extracted from Google Maps.

Figure 6: Erection of tower crane on Scot's Church project (LHS), and operative fitting new façade panels within a confined space at the interface of neighbouring Georgian building (RHS) – photos by author.

4 COMPARATIVE STUDY ON ST LUKE'S CHURCH

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 had been analysed and compared to the Scot's Church project.

4.1 Introduction

St Luke's Church, situated in the Liberties area of Dublin 8, remained derelict for many decades, and was left in a ruinous state following a fire in 1986. An adaptive reuse proposal was submitted during a period of social and physical change, and extensive development within the Coombe area. The adaptation of this inner-city project posed many unique, but different, engineering challenges which required creative thinking and compromise.

'*Engineering*' can be defined as '*the action of working artfully to bring something about*' [11]. By analysing the engineering approaches on this comparative project, the study reveals how two contrasting designs can de so strikingly different – yet so closely related. Both projects set out to utilise the cities' 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 comparative study demonstrates how a similar project deliverable may require an exceptionally contrasting design strategy.

4.2 Project challenges

The proposal to transform St Luke's Church from a ruinous derelict building, into state-of-the-art new offices, posed many challenges at both the planning and construction stages, which required practical and responsible solutions through collaborative problem solving between all parties.

Similar to Scot's Church, this project was a protected structure, situated in a restricted urban setting. However, there were unique challenges which differed significantly such as the existing condition and archaeological issues.

The structure was in very poor condition and had remained roofless for many years with many areas throughout the building left obscured by a high level of overgrowth and subsequent biological decay. Many original features of the building had been lost following years of neglect.

Archaeological issues were one of the greatest challenges at the conceptual stage of design. As one of the more unique features of the building, 30 no. crypts which extended beneath the entire church were to be kept in their original state. The labyrinth of brick vaults which form these crypts at ground level (Figure 7) were noted to be in good condition; however, they were not capable of taking additional loads. The graveyard at the south yard of the church comprised extensive areas of shallow burials with remains exposed at depths of as little as 60mm, which were unlikely to be removed 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 on the site.

Figure 7: Exposed brick vaults on St Luke's Church project – photo provided by CORA Consulting Engineers.

4.3 Solution

The challenges involved in the adaptive reuse of St Luke's Church required creative engineering ideas to propose a design which could work within the restrictions and satisfy all statutory requirements. The following interventions were undertaken as follows;

- New floor over existing brick vaults: *The brick vaults were carefully exposed, dressed over with a proprietary fabric separation membrane (ensuring the intervention was reversible), concrete strip footings poured between vaulted sections as load transfer points, and a subfloor poured across the floor areas (Figure 8).*

Figure 8: Proprietary fabric membrane dressed over vaults prior to pouring subfloor – photo provided by CORA Consulting Engineers.

- New steel roof structure: *The original walls were conserved using lime pointing and localized repair techniques, and the wall tops received a limecrete bedding to ensure a suitable surface for the installation of spreader beams. 7 no. 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 2 no. suspended floors (figure 9).*

Figure 9: Steel floor beams hanging from the steel truss roof structure – photo provided by CORA Consulting Engineers.

- Integrating new services: *The brick vaults (Figure 10) were utilized 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. 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.*

Figure 10: Circulation space within the barrel-vaulted crypt passage (top), and existing ope used for routing of services (bottom) – photos provided by CORA Consulting Engineers.

4.4 Qualitative Research

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 form a deeper understanding of the design rationale behind such projects and the typical challenges encountered. The qualitative approach involved empirical work undertaken by gathering extensive 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 experience.

Following a review of the challenges involved on the Scot's Church project earlier in the project, 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.

4.5 Comparison of challenges

The comparative study on St Luke's Church highlighted the diversity of challenges involved on adaptive reuse projects and concluded 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 were entirely different and therefore each required unique solutions. The key differences between the two projects were as follows;

- existing conditions
- structural requirements
- spatial considerations

Scot's Church was found to be in good physical condition with most of its original fabric intact, compared with the ruinous state of St Luke's Church. It also required the new building to be 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 walls due to the archaeological sensitivity of the site. Both historic structures experienced changes to their original space configuration. 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 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'.

4.6 Common Objectives

While both projects had inherited different constraints, they had the following similar objectives;

- protection of local heritage from loss of depletion
- adherence to good conservation principles
- sustainability of the built environment

4.7 Discussion

With great difficulty comes great innovation. The role of an engineer on conservation projects has become extremely complex due to a wider range of parameters involved, compared with a new typical build. The use of innovative engineering methods has provided sustainable new uses for both Scot's Church and St Luke's Church by converting the redundant protected structures into central new urban office spaces. Both buildings strike visual contrasts between old and new, accentuating their features with sensitive contemporary additions. The projects are emblematic of the potential of such buildings to wed preservation with sustainable development as two common practices. This study has demonstrated how innovative engineers can unlock the potential of such heritage assets through clever design methods and strategies.

5 RECOMMENDATIONS

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;

5.1 Early Engineering engagement

Often, the early design process is architect-led with engineering experts entering the design process after the fundamental design decisions have been made.

5.2 Extensive Condition Surveys

The client and design team will benefit from early investigation work 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.

5.3 Conservation Accreditation Register for Engineers (CARE)

Through a rigorous approval procedure, the Institute of Engineers Ireland (IEI) Chartered Engineers can become accredited with CARE and recognised as skilled in the conservation of historic structures and sites. Engineering is following the architectural profession in this regard. Appointing an accredited engineer on heritage projects provides assurance of competency in the field of conservation.

5.4 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 organized by a variety of professional bodies, including; the Construction Industry Federation (CIF) or Ireland, Engineers Ireland (IEI), the Royal Institute of Architects of Ireland (RIAI), among others.

5.5 Register of Heritage Contractors

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.

5.6 Design Compromise

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 note; "It is generally recognized that the best method of conserving a building is to keep it in active use" [12]. 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 the longevity of the overall structure. Building conservation relies on responsible and sustainable decisions, thus forward-thinking philosophy must be adopted in order to provide compromise and occupancy to buildings, which will outweigh inevitable deterioration of such structures if they remain without function.

6 CONCLUSIONS

Unlike the design of modern structures, there is no clear set of guidelines for the 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 experienced in traditional construction are required to assist in developing design ideas which incorporate the fundamental principles of conservation and sustainability of the nation's cultural endowment.

The creative adaptation of Scot's Church highlights the flexibility and potential of historic buildings to become reinvented. Through the adoption of responsible approaches to conservation, the exemplar project serves as a catalyst for such creative and sustainable development, encouraging such imaginative thinking towards further integration of Ireland's built heritage for the inheritance of future custodians.

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