Rehabilitation of an Existing Building: Structural Information Requirements

Scott, J. & Sumanarathna, N.

School of the Built Environment, London Metropolitan University
Contact: j.scott1@londonmet.ac.uk

ABSTRACT

Background and aim. The rehabilitation of existing buildings is an important response to the sustainability challenge by the built environment sector. Advice from the structural engineer on the ability of an existing structure to facilitate rehabilitation is often hindered by a lack of key information. Guidance is required on the collection of key structural information to inform design and investment decisions, allowing a better understanding of the opportunities for and risks to, sustainable project outcomes. This paper explores the structural information needed for rehabilitation and the role of structural engineer in collecting this.

Methods. This is a viewpoint paper, prepared at the earliest stages of a research project, drawing upon an amalgamation of industry experience and an initial exploration of the literature. A systematic, limited, literature study was undertaken to further develop the viewpoints offered. Utilising the practice and academic experience of the authors, we report upon current industry practice with regard to the rehabilitation of existing buildings, including reasons for obsolescence, interventions available, information requirements and barriers to adaptation.

Results. The paper provides suggestions for the collection and presentation of key structural information. Barriers faced by structural engineers in implementing such procedures are discussed, and options to overcome these offered. The paper concludes with recommendations for next steps to be taken within this research project.

Practical or social implications. The paper provides an outline for closer collaboration between structural engineers and facilities managers to promote more effective sustainable practices.

Type of paper. Viewpoint

Keywords. building rehabilitation, facilities management, retrofitting, structural design information, sustainability

INTRODUCTION

Researchers have recently brought forward the discussion on rehabilitation vs demolition and new construction. The rehabilitation of an existing building or structure via its re-use, refurbishment and retrofitting is becoming an increasingly important response to the ongoing climate challenge by the built environment sector (Built Environment Declares, 2023; Derwent London, 2022). From a sustainability perspective, retention and rehabilitation are often recommended, in preference to demolition and new construction, largely due to the greater environmental impact of carbon emissions from the latter. Case studies including Alba-Rodríguez et al. (2017), have proven that even a severely damaged building can be rehabilitated with repair and retrofit work, with lower cost and environmental impact compared to its demolition and new construction. However, such projects are frequently frustrated by a lack of adequate information on the existing structure (Hamida et al., 2023), on which key investment decisions can be made.

Some studies have been undertaken with a focus on the role of the architect, engineers and other designers within rehabilitation works. For example, Segonds et al. (2012) have developed a framework to carry out rehabilitation and re-design (i.e., architectural rehabilitation) projects that were re-designed to facilitate disable access. The authors suggest that the formation of closer collaborations among stakeholders such as designers, main contractor, client and end-users of projects can overcome complexities by paying better attention to end-user requirements. Nevertheless, further guidance is required on the reasons for, and current practices in, the collection and presentation of key structural information at the early design stages of a rehabilitation project. This will then allow a better understanding of the opportunities in terms of rehabilitation and the achievement of sustainable project outcomes.

This paper explores the type of structural information needed for the successful rehabilitation of an existing building or structure via re-use, refurbishment and retrofit, and the role of structural engineer at the design stage in collecting such data. The viewpoint paper is ultimately aimed at exploring how building owners and facilities managers can better collaborate with structural engineers to facilitate the collection of structural information, especially during the early stages of a rehabilitation project.

This is a viewpoint paper, where findings and research implications are an amalgamation of an initial exploration of the literature and industry experience (Vandenbogaerde et al., 2023). The paper introduces the background and aims of our contribution, and then reports on an initial literature study based on topics identified in the industry. We summarise our viewpoints based on these, including recommendations for future research activities, and draw some initial conclusions from the work undertaken to prepare the paper. This is an ongoing research project and this paper presents our preliminary findings and viewpoints.

The first author had worked as a structural engineer in the UK construction industry for more than thirty-five years and the views presented are derived from the practice and academic experience of the authors. The first author has provided design and advisory services on several significant heritage buildings and structures including; Chatham Dockyard Slipways, Norwich RC Cathedral, several Cambridge colleges (e.g. St Johns, Trinity), projects for the National Trust (e.g. Wimpole Hall, Ickworth House) and the Houses of Parliament, Westminster.

INITIAL LITERATURE STUDY

Managing the risk of obsolescence

All assets need to have relevance, without which a building or structure can swiftly become obsolete. Several authors have offered commentary on the reasons for obsolescence and the subsequent risks to existing buildings and structures when this is realised (Askar et al., 2021). A relevant building or structure needs to have value, a loss which can be due to one or more changes in the physical, technological,

functional, economic, social, legal or political demands on the asset (Rockow et al., 2019). Askar et al. (2021) have also noted that loss of value can also be caused by changes in operational conditions, emerging needs and uses not met by the asset and varying environmental and external factors.
When the risk of obsolescence is high or is realised, it is necessary for stakeholders to address this by improving the building or structure, in terms of physical, functional, or economic performance (Bullen and Love, 2011). As Askar et al. (2021) have noted, "most buildings become obsolete before their technical life comes to an end and is the dominant factor in the need for the building to be adapted or demolished" (p.11), requiring some form of adaptation or intervention to maintain relevance and, therefore, value.

When a building becomes obsolete, owners and managers of the asset are faced with a choice of actions to take; (a) to do nothing and wait for the market to change, (b) to sell the building, (c) to adapt the building, or (d) to demolish the building and redevelop the site (Baker et al., 2017). The choice is often based on the financial aspect, yet the sustainable aspects should also be considered in making such decisions.

Sustainability considerations

The sustainability case for retention of a building in lieu of demolition has been made by several authors (e.g. Baker et al.,2017) and is the subject of ongoing intense debate within current practice, as illustrated by the case of the proposed demolition and redevelopment of the flagship Marks and Spencer store in Oxford Street, London (Butler, 2023). A proposal for giving all potentially re-useable buildings and structures within the UK statutory protection from demolition, unless this is proven to be essential, has recently been mooted by structural engineer, Arnold (2022), who suggests that all such buildings should be given a grade 3 listing, beyond those current listed with grades 1, 2* and 2 (Creigh-Tyte and Gallimore, 1998). As a key response to the climate challenge, it is likely that opportunities for the re-use of existing buildings and structures will need to be fully explored by building owners and facilities managers during any project to deal with the potential obsolescence of their asset, before demolition would be permitted. This suggests that sustainable project outcomes (Bullen and Love, 2011) should be sought in all cases, which will require careful consideration of any proposed interventions, by all primary stakeholders - to maintain the relevance and value of the asset but within accepTable social, environmental and economic limits.

Sustainable project outcomes are those where the impact of the project on social, environmental and economic factors is minimised, with focus on the environmental impact. The RIBA (2019) has listed these as; *Net zero operational carbon, Net zero embodied carbon, Sustainable water cycle, Sustainable connectivity and transport, Sustainable land use and bio-diversity, Good health and wellbeing, Sustainable communities and social value and Sustainable life cycle cost*

When considering the potential re-use of an existing building or structure, the key outcomes required from any interventions to be made are likely to be net zero embodied and operational carbon. In order of preference UKGBC (2023, 2021), the following should be carefully explored; *Re-use the existing* *building or structure in lieu of demolition and redevelopment of the site, Minimise the additional embodied carbon within any physical interventions made, Minimising 'operational' carbon emissions (due to heating, lighting etc.), Minimising 'in-use' embodied carbon (due to regular maintenance, renewal of finishes etc.) and Maximise opportunities for minimising 'end of life' embodied carbon (dismantling, recycling etc.)*

In lieu of demolition

Once a decision has been made for retention of the existing building or structure in lieu of demolition, several intervention options are available to the project team (Baker et al., 2017). Options for rehabilitation include preservation, conservation, refurbishment, renovation and remodelling - each of which will enable the project team to add value to the asset and promote a return to relevance. The choice of intervention to be made will need to be assessed against the following criteria (Douglas (2006)): viability (economic feasibility), practicality (physical feasibility) and utility (functional feasibility). This will require the project team to consider the technical, legislative functional, economic, environmental, political, technological and social aspects of an evolving design proposal during the design and planning phases of the project (Hamida and Hassanain, 2022), decisions on which will require multi-stakeholder consideration (Sedhom et al., (2023). The concept of 'adaptive re-use' is well represented within the literature (e.g., Hamida and Hassanain,2022) and responds directly to the issues raised earlier, regarding decisions on interventions to be made to maintain the value of an existing building or structure.

Each of the forms of interventions, require a range of adaptations of the existing building or structure – for example, preservation requires only limited adaptation whereas remodelling often requires extensive adaptation. Many authors suggest that any interventions made should be considered as part of the whole life cycle of the building or structure, note that future adaptations are likely to be required, and that potential needs for these should be addressed. This concept has been described within the literature as 'circular building adaptability', where the intervention under consideration is seen as part of a continuum of interventions that will be required to maintain the value of the asset, within a wider circular economy. As Hamida et al. (2023) note "circular building adaptability in adaptive re-use is crucial to enable the built environment to withstand future changes, respond to cultural dynamics, eliminate waste generation, embody the regenerative capacity and create value out of the assets" (p.2)

Hamida et al. (2023) have suggested ten factors of an existing building or structure that will contribute to the successful application of circular building adaptability approach. These are: configuration flexibility, product dismountability, asset multi-usability, design regularity, functional convertability, material reverseability, building maintainability, resource recovery, volume scalability and asset refitability. These factors should be considered during the development of any design proposals for intervention works, to allow future interventions to again maintain the value of the asset, and to further promote, or maximise, sustainable outcomes for the current project. Hamida et al. (2023) also suggest that innovative design and construction is needed to reactively or proactively operationalise adaptability and circularity in buildings.

The literature offers descriptions of barriers that prevent effective adaptation of a building or structure, most commonly, the lack of records or information on the existing building (Fernandez, 2020). Others have reported that there are often errors, or inconsistencies, within documentation that may be available (e.g., Hamida and Hassanain, 2022). Without reliable and verified information on the existing building, an assessment of the quality of materials used in the construction of the asset, including their structural capabilities, cannot be undertaken. The condition of the existing structure is also cited as a barrier to effective adaptation; precisely "lack of physical flexibility due to the layout of the structural system" (Hamida and Hassanain, 2022, p.642). An inability to assess the ability of the existing structure to accommodate newly imposed, or increased loads is also a significant constraint on available options (Hamida and Hassanain, 2022).

Beyond the direct structural constraints offered by the building, difficulty in complying with legislation, the need to maintain cultural or heritage value of the asset, and financial constraints are also noted as barriers to effective adaptation (Hamida and Hassanain, 2022). These barriers are also indirectly influenced by the structural capabilities of the building.

Decisions on options for adaption require input from multiple stakeholders and specialist advisers. A key enabler of effective adaptation is the integration of knowledge and practices among primary stakeholders - in particular, during the early design phase, the promotion of client engagement with the design process, frequent budget reviews and early indication of the proposed architectural program and enabling a response by all primary stakeholders. During implementation of the works on site, they recommend competent supervision of site activities and adherence to QA/WQC procedures (Hamida and Hassanain, 2022).

Structural Information needs and requirements

Decisions on interventions to be made are often complex and multi-faceted (Oliviera et al., 2021), but most are either directly, or indirectly, influenced by the capability, or otherwise, of the existing structure to facilitate change. For example, changes of the use of the building may require changes in loadings applied to the structure, and changes in space planning within the building may require additional partitions or new building services to be installed, each with a significant influence on the existing structure. The need for adequate information on the existing building structure is key, therefore, to enable an effective contribution by the structural engineer to early discussions on the opportunities for, and risks to, sustainable project outcomes, and decisions on the viability, practicality and utility of the project.

At this stage of a project, critical, value based, investment decisions are often being made, but which are frequently informed by, or need to rely on, incomplete, or potentially inaccurate, structural information (Hamida et al., 2023). Several authors have reported on the impact of such errors within information used within early stage design and project decisions, how these become apparent in the later stages of the project, and the adverse influence they can have on project outcomes (Hamida et al., 2023).

An idealised listing of, and commentary on, information sources that should be consulted by the structural engineer during the appraisal of an existing structure has been made available (IStructE Appendix A, 2010). Table 1 presents a summary of the listing.

Table 1 Information to be consulted by the structural engineer (Source: IStructE Appendix A (2010)

Sources	Information
Primary Sources	building owners, building occupier(s), owners' and occupiers' professional advisers (solicitors, managing/estate agents/facilities managers, consulting architects, engineers, surveyors, insurers), original structural designers, other original design team members (architects, services consultants, quantity surveyors, building or party wall surveyors), adjoining owners (party wall agreements), contractors, maintenance and;
	defects data, including – with appropriate caution – anecdotal accounts, designers and contractors for refurbishment(s) or major alteration(s), Building control authority (or other warranty providers, etc.), public utilities and statutory undertakers, record offices and archives in which original drawings and other documents have been deposited and other specialist sources
Secondary Sources	topographical information, insurance plans, site and building history, geological data, constructional information (held in public or private databases)

A further paper by Fernandez (2020) illustrates a structural engineering-based approach for determining the opportunities offered by an existing structure at the early feasibility stage of a project. Fernandez notes that " it can be easy to simply focus on the risks and problems associated with keeping it, rather than the potential rewards" (p.15). Efforts should be made to explore, with the client and others, the reasons for the proposed project – questions such as 'What are the client's drivers? Why are they unhappy with their existing building?' are good starting points for discussions. Fernandez notes that "Drilling down into the detail of a client's specific issues can often inform a solution that doesn't necessarily involve demolishing and building a new" and that, following a desk study, "Carrying out a thorough early assessment can reveal exciting opportunities which can add significant value and might have been missed if reuse was not considered". This inquisitive approach to the background to the project and exploration of opportunities that the existing structure may offer is an essential means of achieving the most sustainable outcomes for the project. Whilst gathering desk-based data is of significant benefit to decision-making at the earliest stages of a project involving the rehabilitation of an existing building, validation of assumptions made is necessary, via intrusive investigations, or other on site testing (e.g., load capacity testing). Investigations are also required to determine the condition of the existing structure, especially where this is concealed behind finishes or otherwise inaccessible. Investigations also help to de-risk a rehabilitation project, which may be beneficial in resolving any procurement or contractual issues that could arise.

AUTHORS VIEWPOINTS

Opportunities for improvement: Through the lens of a structural engineer

We have identified a few key themes on the nature of rehabilitation projects and the current practice contribution to these by the structural engineer. At the earliest stages of a project, barriers to enabling effective adaptation and to achieving the most sustainable project outcomes are largely due to;

- Difficulties in obtaining adequate data on the existing building or structure
- The requirement for multi-stakeholder understanding of the nature and form of the existing building or structure, alongside risks to the values held by the asset and support with multi-dimensional decision making to mitigate against these

We suggest that there are several key areas for which further understanding is likely to be of significant benefit to enabling the retention and effective adaptation of an existing building or structure;

- The involvement of all primary stakeholders, including the structural engineer, in determining and understanding the current values held by the asset and potential risks to these.
- Allowing the form and nature of existing building or structure, and feedback on its current use, to inform opportunities for increasing the value of the asset, &/or to mitigate against risk of obsolescence.
- Beyond gaining an initial base understanding of the form and nature of the existing structure, building owners and facilities managers could consider the collection of further data to be an ongoing process and to record information in an easily accessible manner – both tasks in close collaboration with the structural engineer. This would allow frequent reviews of the potential risk of obsolescence offered by the asset, and corrective interventions made.

Research Implications and further research directions

Our initial review indicates that decisions on the potential interventions within, or adaptations of, an existing building or structure are informed by a number of key factors. These include:

- the reasons for the need for adaptation or intervention (why the value of the asset has changed)
- the extent of the intervention needed to maintain or increase the value of the asset, (and which value is driving the intervention (i.e. societal, economic, cultural, use or functional))
- the opportunities available for adaptation of, and intervention within, an existing building or structure
- risks to achieving sustainable outcomes
- the requirement for the adaptation or intervention to be based on a whole life view of the asset, or a much shorter timescale

The availability of adequate information on the existing building or structure on which to base key early investment decisions is frequently problematic and can often lead to significant adverse issues that need to be dealt with during the later stages of the project. Inaccurate or incomplete structural information is frequently cited as being a significant barrier to effective adaptation of an existing building or structure and, consequently, to the sustainable outcomes of a project.

Our review of the literature has not, so far, enabled us to explore the methods used to present or represent available structural information, to the wider project team, at the earliest stages of a project and, therefore, the potential influence of this on decisions made by multi-stakeholder teams. The perception, by the wider team, of risks due to incomplete or inaccurate structural information may be a factor causing adverse issues in the later stages of a project.

Our initial review, and the industry experience of the first author, indicates that improvements within the collection of information on the existing building or structure could be made by promoting closer collaboration between structural engineers and facilities managers. This could then allow;

- Access to all information made available to the building owner and facilities managers at purchase or handover of the asset
- Access to all data collected during routine maintenance and performance of the asset in use
- Access to information collected from, or reported by, users or occupants, on the performance of the asset
- Advanced notice of the potential for a reduction in the value of the asset and early exploration of options available to maintain this and a review of information required to enable early decisions on potential investments in adaptations or interventions.

To further progress our research, we are intending to undertake the further reviews of the literature, including case studies of refurbishment and rehabilitation projects. In particular, we will examine: project team roles, reasons for interventions or adaptations, collection of information on the existing building or structure, (re)presentations of structural information, dealing with information gaps, risk management, multi-stakeholder decision making etc. We are also intending to undertake longitudinal studies of projects involving the adaptation of buildings or structures to establish what (and how) additional structural (and other) information can be collected during and following adaptation works, in collaboration with facilities managers. We would like to determine the benefit of this additional information for future investment decision making by building owners and facilities managers to maintain the value and relevance of the asset, in the medium and longer term.

CONCLUSIONS

This viewpoint paper has aimed at exploring the type of structural information needed for the rehabilitation of buildings and the role of structural engineer at the design stage in collecting such data. Firstly, an understanding of current industry practice with regard to the rehabilitation of an existing building or structure, including the reasons for obsolescence, interventions available, information requirements and barriers to effective adaptation has been obtained. In general, the reasons for the implementation of a rehabilitation project are to maintain the value of a building or structure and thereby avoid obsolescence. From a sustainability perspective, adaptation is preferred to demolition and redevelopment, which may be given further statutory emphasis, due to the urgent need for the built environment sector to better respond to the climate emergency. Project teams will need to ensure that any interventions made to maintain the relevance and value of a built asset can be effectively undertaken with accepTable social and environmental limits. Interventions available are several, yet, beyond sustainability demands, all will need to assessed against a range of criteria including physical, functional and economic criteria. Consideration should also be given to the growing need for any intervention to be part of the circular economy, i.e. as part of the 'circular building adaptation' agenda. This suggests that an intervention not only deals with the current loss of value to the asset but also prepares the building or structure for the ineviTable next intervention, to again respond to a value challenge. Secondly, barriers to effective adaptation are several, and which tend to focus on two key areas: (1) availability of adequate information on the existing building or structure, and (2) the need for multi-stakeholder engagement with key decisions, especially early in the project cycle, have been suggested. The implications, from the structural engineers perspective, are that more effective, sustainable and efficient adaptations to existing buildings and structures - and early warning of potential reductions in value of the asset - could be achieved via the following;

- Earlier engagement, by the building owner or facility manager, with the structural engineer to enable access to all relevant information on the existing building or structure, both archival and that collected during routine maintenance, or ongoing performance monitoring etc.
- More formally enabling the form and nature of the existing building or structure, to inform opportunities for improvements in, and mitigate against risks to, the value of the asset.
- Considering the information gathering phase of a project to be part of a continuum of data collection on the asset - collecting such information prior to, throughout and beyond the immediate project lifespan.
- Undertaking frequent reviews of the risk of obsolescence of the asset and potentially mitigating against these via ongoing adaptations.

ACKNOWLEDGEMENTS

We would like to thank the reviewers for the feedback on earlier drafts of our paper, and to the staff and our colleagues at London Metropolitan University.

REFERENCES

Alba-Rodríguez, M. D., Martínez-Rocamora, A., González-Vallejo, P., Ferreira-Sánchez, A., & Marrero, M. (2017). Building rehabilitation versus demolition and new construction: Economic and environmental assessment. *Environmental Impact Assessment Review*, 66, 115-126.

Arnold, W., (2022). Architects Journal article. Retrieved from https://www.architectsjournal.co.uk/news/opinion/could-a-grade-iii-listing-for-buildings-halt-the-uks-tide-of-demolition

Askar, R., Bragança, L. and Gervásio, H. (2021). Adaptability of buildings: A critical review on the concept evolution. *Applied sciences*, 11(10), p.4483.

Baker, H., Moncaster, A. and Al-Tabbaa, A. (2017). Decision-making for the demolition or adaptation of buildings. *Proceedings of the Institution of Civil Engineers-Forensic Engineering*, 170(3), pp.144-156.

Bullen, P. and Love, P. (2011). A new future for the past: a model for adaptive reuse decision-making. *Built environment project and asset management*, 1(1), pp.32-44.

Built Environment Declares Statement (2024). Retrieved from https://builtenvironmentdeclares.com/

Butler, S., (2023), Guardian article. Retrieved from https://www.theguardian.com/business/2023/jul/20/marks-spencer-refused-permission-to-demolish-and-rebuild-oxford-street-store

Creigh-Tyte, S.W. and Gallimore, J. (1998). The built heritage in England: the history and development of government policy. *Cultural Trends*, 8(32), pp.25-36.

Derwent London Responsibility Report (2022) - Retrieved from https://reports.derwentlondon.com/responsibility-2022

Douglas, J. (2006). *Building adaptation*. Routledge.

Fernandez, S. (2020). An introduction to refurbishment. Part 1. *The Structural Engineer: journal of the Institution of Structural Engineers*, 98(11), pp.14-18.

Hamida, M.B. and Hassanain, M.A. (2022). Investigation of AEC/FM practices in adaptive reuse projects. *International Journal of Building Pathology and Adaptation*, 40(4), pp.636-660.

Hamida, M.B., Remøy, H., Gruis, V. and Jylhä, T. (2023). Circular building adaptability in adaptive reuse: multiple case studies in the Netherlands. *Journal of Engineering, Design and Technology*, (ahead-of-print).

IStructE (2010). *Appraisal of existing structure* 3rd ed., London, IStructE

Oliveira, R.A., Lopes, J.P. and Abreu, M.I. (2021). Sustainability perspective to support decision making in structural retrofitting of buildings: A case study. *Systems*, 9(4), p.78.

RIBA Sustainable outcomes guide (2019). Retrieved from https://www.architecture.com/knowledge-and-resources/resources-landing-page/sustainable-outcomes-guide

Rockow, Z.R., Ross, B. and Black, A.K. (2019). Review of methods for evaluating adaptability of buildings. *International Journal of Building Pathology and Adaptation*, 37(3), pp.273-287.

Sedhom, I., Khodeir, L.M. and Fathy, F. (2023). Investigating current practices for achieving effective participation of stakeholders in Facilities Management. *Ain Shams Engineering Journal*, 14(6), p.102099.

Segonds, F., Nelson, J., & Aoussat, A. (2012). PLM and architectural rehabilitation: a framework to improve collaboration in the early stages of design. *International Journal of Product Lifecycle Management*, 6(1), 1-19

UKGBC (2023) *Operational & Embodied Carbon Explainer Guide*. Retrieved from https://ukgbc.org/wp-content/uploads/2023/02/operational-and-embodied-carbon-1.pdf

UK Green Building Council (2021). *Net Zero Whole Life Carbon Roadmap: A Pathway for the UK Built Environment*., London, UK

Vandenbogaerde, L., Verbeke, S., Audenaert, A., Meysman, J. and van Roosmale, S. (2023). Building automation and control systems: a facility manager's secret weapon?. In *Research papers for The 22nd EuroFM Research Symposium, 9-10 November, 2023, Istanbul, Turkey* (pp. 86-93).