Evaluating designs on existing buildings using Heritage Evaluation Framework

D. Partington, D. Dizhur & J. Ingham
Department of Civil Engineering, The University of Auckland, Auckland

T. Egbelakin
School of Advanced Technology and Engineering, Massey University, Albany Campus, Auckland

2017 NZSEE Conference

ABSTRACT: New Zealand owes a significant portion of its unique culture to its built heritage. While design provisions introduced into New Zealand attempt to encourage the preservation of heritage buildings, due to the high cost of remediation coupled with a short deadline for completion, many earthquake prone buildings (EPBs) are ultimately being demolished. The Heritage Evaluation Framework (HEF) is a new multi-disciplinary decision-making tool that aims to guide proposed seismic retrofit designs by gathering inputs from all parties involved in a project and using them to evaluate a particular design against client's expectations. This research aims to analyse the performance of the HEF in relation to its potential to evaluate the appropriateness of proposed strengthening designs on EPBs. Testing of the framework was conducted via interviews, site walkthroughs and regular meetings with the teams and clients of two live heritage retrofit projects. Results were then presented back to the project members where appropriate adjustments to the design could then be achieved for the following design. Results show that the HEF is reasonably capable of analysing conceptual designs and able to give useful feedback whilst encouraging early collaboration to each project's design team.

1 INTRODUCTION

When a Heritage Building is classified as Earthquake Prone (EPB), seismic retrofit work cannot be avoided. Additionally, the original architectural features of the building must be protected to ensure the safeguarding of Heritage value. This is a challenging undertaking that requires an iterative design process and a multidisciplinary team approach. Current literature includes a range of assessment principles to help guide the design process, however these frameworks fail to include a collaborative approach to their design assessments.

Egbelakin et al (2015) developed the multi-disciplinary assessment tool, known as the HEF. The tool was developed as a means to encourage a collaborative approach from professionals during the early design phases of retrofit projects. The framework uses qualitative inputs into an excel spreadsheet that creates a 'Spider Graph' to visually represent a designs effectiveness. It is expected that by developing and implementing a multi-disciplinary assessment tool, design solutions can be made to generate an optimal seismic design that meets the client's expectations. The development of the HEF is essential due to its relevance with the large number of heritage buildings within NZ as well as the standard of seismic strengthening they adhere to. The testing and development of the HEF ultimately highlights the requirements and qualities that a tool of this nature would need in order to be adequately utilized within the industry.

The development of the HEF has given a greater insight to the multidisciplinary nature of the framework, and promoted the thinking that successful design solutions are most effectively produced collaboratively at an early stage (Pattison 2015). It is found that the HEF has its own niche separate to other assessment

frameworks as it takes qualitative input from all professions as opposed to pre-existing tools that could only measure designs specifically against its structure or architectural values for example.

The framework is compatible with any form of existing heritage building, and can be used at either the conceptual design, construction or evaluation phase. Therefore, the tool provides a cost and time effective solution for increasing the efficiency of live seismic retrofit projects. As retrofit projects become more affordable to clients this will translate to a general discouragement of demolition to NZ heritage buildings.

The aim of this research was to establish a comprehensive test scenario to analyse the performance of the HEF. This aim was validated through the following objectives:

- Testing the frameworks ability to evaluate a live heritage retrofit project based on a proposed design against client's priorities
- Determining the frameworks capability of encouraging early collaboration amongst the many professions involved in a project

From the above objectives, the usefulness and feasibility of the HEF was determined which gave indications of where this framework fits in holistically with the engineering and construction industry.

2 LITERATURE REVIEW

The aim of this literature review is to assess current assessment frameworks that can be compared within this research, to gain a thorough understanding of their limitations and the need for a newly developed framework. It will be seen that there is a limited amount of research around suitable assessment frameworks that meet this current study's research objectives.

Cattanach et al. (2008) developed a tool that focused on equipping engineers with a framework for appraisal. The author tested the performance of the framework on a project where they applied the qualitative based framework to assess intervention methods. It measures the appropriateness of structural interventions by a series of principles that have been listed in table form. The principles are coupled with small written assessments that are to be checked off and ultimately used for critiquing the proposed strengthening method. The framework "is intended to be an assessment for just the structural intervention, and not for the heritage impact of the whole building" (Cattanach et al., 2008, p.12). There is also not enough architectural consideration to the building. Furthermore, the table itself fails to incorporate any type of grading scheme. This means that there are no definitive methods of improving a design, only a rough guideline to ensure the structural capacity of the building.

Similarly, McClean (2010) created an assessment framework that takes into consideration the effectiveness of retrofit solutions in heritage EPBs. This consists of four basic criteria and several sub criteria. The main criteria are listed as:

1. Sustainable management of historic heritage principles (e.g. respect for physical material & the degree that intervention is kept minimal)
2. Alterations of historic building principles (e.g. not altering or removing important heritage fabric)
3. Best practice engineering principles (e.g. considering existing strength inherent in existing structure)
4. Other matters for consideration (e.g. cost, building disruption, space planning)

Whilst the four main points do cover a wide range of issues when considering strengthening an EPB, it fails to clearly designate the contributions of several disciplines from the assessment. Rather, it concentrates on a basic overview of what is required by law. Furthermore, the framework does not

implement any type of grading system that can be used to clearly visualize where improvements can be made to a particular solution.

Conclusively, there is a need within the industry to development a tool that benefits the clients and key stakeholders in the following ways:

- Qualitative assessment of proposed designs
- Multidisciplinary approach that encourages early collaboration
- Graphical display of design performance against client priorities
- Clear communication across disciplines as well as stakeholders involved the project
- Tracking tool throughout each design stage

The Heritage Evaluation Framework (HEF) is an EPB design assessment tool developed by Pattison (2015). It includes six main categories that require input from members of the design team. These are then collected and summarized visually into the Spider Graph where feedback can be given into exactly which portions of the design are lacking attention as well as those exceeding client expectation. Pattison (2015) mentioned that in order to maximise potential the 'framework will need to be implemented from very early in the project, ideally before any concept designs have been developed'. Once the design team and early design phases are completed, they are then presented with the diagram similar to that shown in Figure 1 with a completed client brief constraint line. This gives the team a clear understanding of client priorities in regards to the project which will act as a guideline for the design process. It is at this stage that several concept designs can be made, each with its own assessment showing how the particular design matches up with client expectations.

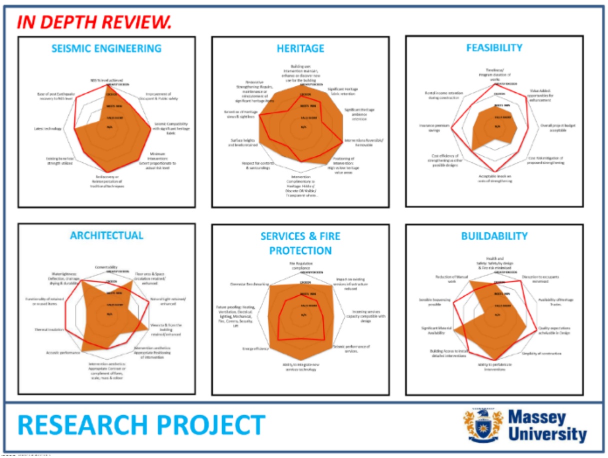

Figure 1: Spider Graph covering all sub categories of assessment (Pattison, M 2015)

3 METHODOLOGY

The multi-method approach that included face-to-face interviews, analysis of project documents relevant to the study and recording of observations during team meetings, were used to test the developed HEF tool. The tool requires multiple methods approach to data collection based on the research conceptual design of radial threads of the spider web that requires the convergence of different layers of recommendations from the multi-disciplined stakeholders.

The initial step was to acquire two real-life projects for testing the HEF tool. Two buildings were selected as the case study and are discussed in subsequent sections. Once, the approval to use a project was sought, all necessary documents relating to the project such as existing and proposed building plans, structural, mechanical and fire engineering plans, consents and the heritage impact analysis were obtained from the respective project team members to help familiarise the researchers with the project, as well as understand the proposed seismic design. Initial introductions to project team members during a site meeting then commenced as well as a presentation by the researchers providing an introduction

and overview all aspects of the research, the HEF multi-disciplinary tool, how it will be used and what is expected from team members in order properly take advantage of the tool.

Face-to-face interviews were conducted with all key project team members. An interview protocol and the HEP excel spreadsheet was used as a guide to conduct the interview. During the interviews, the team members where presented with HEP spreadsheets where they were asked to input any design preferences and expectations. Written memos were used to track seismic conceptual design progress. Data from the interviews were added to HEP spreadsheet, a graphical presentation was then developed from the excel file that displayed an overall evaluative diagram showing the areas of the proposed designs that needed improving as well as areas that are below or have exceeded client expectation. The project team members were then asked to view the diagrams, in order gain a better understanding regarding the extent to which proposed seismic retrofit design have met the client requirements or not. This gave the design team an opportunity to make several adjustments to their proposed requirements and design inputs into spreadsheets in order to generate a best-fit design. Details of the buildings used as case studies and research findings from testing the HEF tool are discussed next.

4 CASE STUDY BUILDING 1

The University of Auckland's Alfred Nathan House was the first of two live heritage retrofit projects that implemented the HEF into their design phase. New additions for the building included a fourth floor, extension to rear end of the building for office space and overall seismic strengthening. Interviews began with the client (UoA Property Services) who made it clear that the building was to reach an NBS Level of approximately 34%. "We are not aspiring to lift this building to 100%, particularly as there is no correlation between NBS Level and Richter scale" as mentioned by an Auckland Council representative. Likewise, ensuring the seismic compatibility with the significant heritage fabric of the building was found to be a key priority. Cost was found to be less of a concern from the client despite initial reports revealing asbestos within the building which would ultimately delay the programme and increase overall cost. In addition to this, the services and buildability was deemed less important than preserving the architectural and heritage values of the building which the ultimate requirement demanded by the Heritage Architect and Client.

Figure 2: Case Study 1 – Facade of Alfred Nathan House

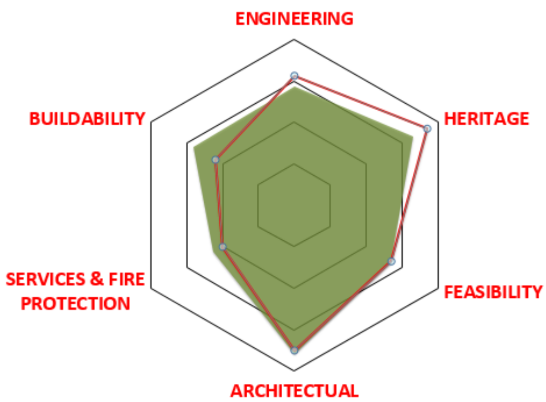

Figure 3: Overall Client Expectations Verse Design outcomes for the Alfred Nathan House

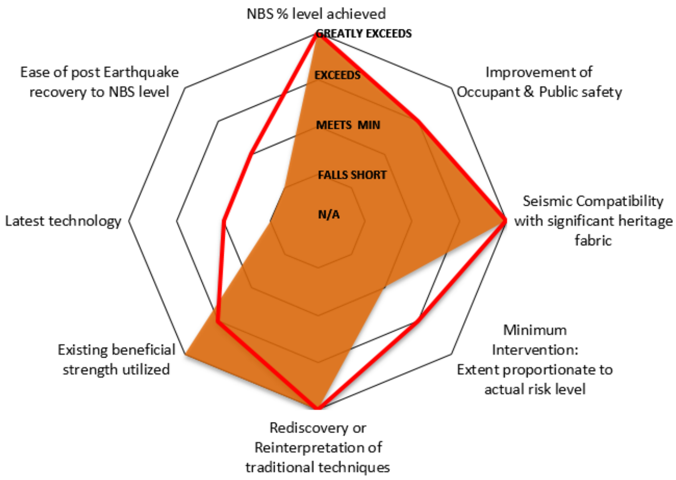

Figure 4: Client expectation and design score relating to Seismic Engineering

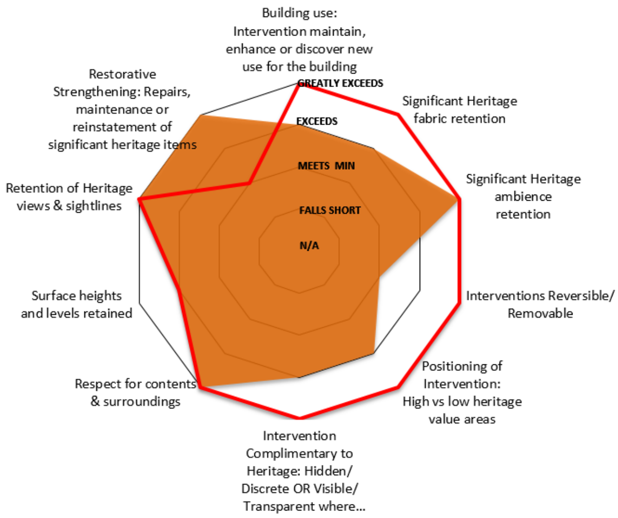

Figure 5: Client expectation and design score relating to Architectural Heritage

4.1 **Seismic Engineering**

The final design saw a NBS level of 45% reached as one engineer stated "we saw this was the best practical outcome for the project". Some of the major structural additions included the installation of steel beams recessed within the floorboards as placing them through the ceiling would architecturally "damage the design". This also meant the design could utilize the existing strength of the building. Furthermore, the design saw a post tensioned front façade and steel ties positioned behind the brick walls as to not cause a visual obstruction to the building.

4.2 **Architecture and Heritage**

Externally, it was imperative to both the design and heritage architects that the unique aesthetics of the façade must be preserved and therefore structural design suffered largely in this area. The final design showed an inability to reverse/remove structural interventions although this was found to be acceptable by the architects as they had been sufficiently hidden behind brick walls or floorboards which ultimately had a much lower disruption to the heritage architecture of the building.

Finally, the steel ties mentioned previously have been 'recessed and plastered over in order to keep the buildings original appearance' as required by the heritage architects.

4.3 **Remaining Design Aspects**

The areas that both the client and design team showed significantly lower levels of importance regarding the feasibility, services, and fire protection to the final design. As the building had existing fire services that were sufficient for the new designs and cost was 'heavily outweighed by the interest in architecture and seismic strengthening' this meant the design would not have to take too much consideration into these aspects. Despite buildability being of minor interest to the client, it had taken high precedence over the final design due to the team foreseeing major issues and delays with the large amount of asbestos removal that the building would require, which ultimately would halt the construction process on several occasions.

5 CASE STUDY BUILDING 2

The building on 3 Victoria Road is one of several Auckland Council heritage strengthening projects currently being worked on. This building includes a detailed schedule of heritage items as well as more recent alterations made in the past (specifically internal). Primary drivers of the design from the client's perspective was to ensure minimum intervention and maintain visual appearance. Likewise, it 'was essential to reuse the existing strength of the walls to prevent the reduction of floor space area' as stated by an EQStruc engineer. Finally, a 34% NBS Level was requested by the client as an absolute minimum.

Figure 6: Case Study 2 – Facade of 3 Victoria Road

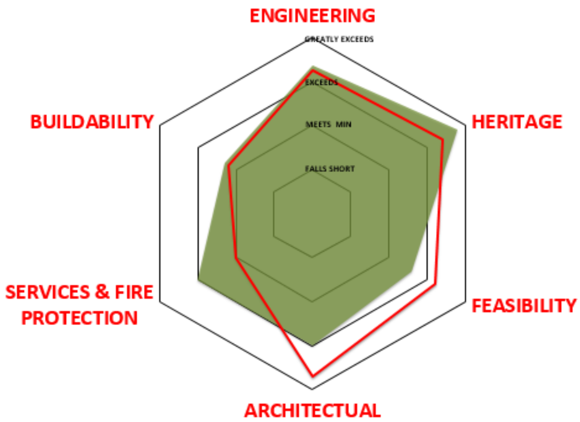

Figure 7: Overall Client Expectations Verse Design outcomes for 3 Victoria Road

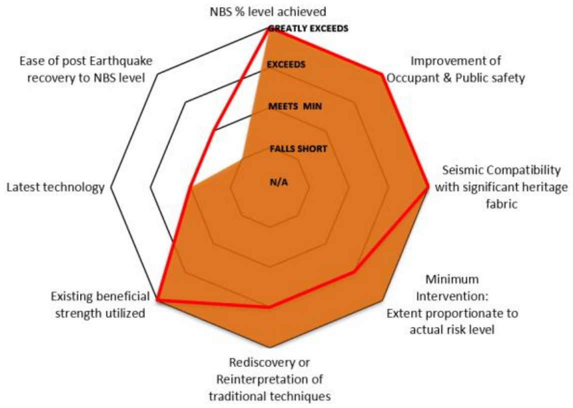

Figure 8: Client expectation and design score relating to Seismic Engineering

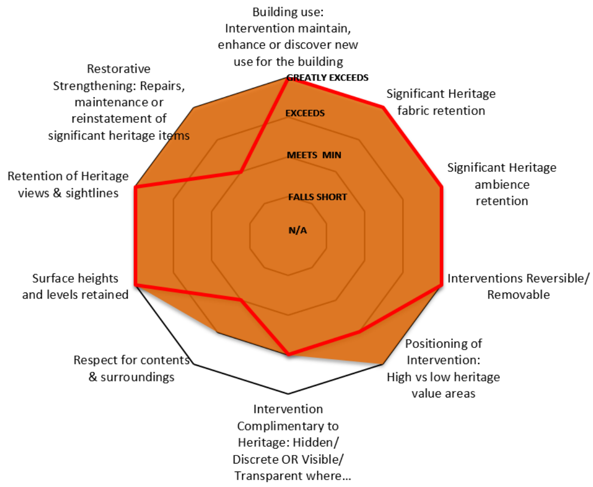

Figure 9: Spider Graph highlighting Architectural Heritage related expectations and outcomes

5.1 Seismic Engineering

The final design shows a variety of engineering techniques carried out both internally and externally. The unreinforced masonry walls were anchored for precautionary measures, as they were not fixed to the diaphragms and therefore 'rely on out of plane forces during earthquakes' which equates to quite a poor structural performance as mentioned by the structural engineers. Additionally, a steel bridge frame was introduced to the design into the roof structure to transfer loads to the internal walls to

minimize the load of internal items that require restraint. Post tensioning and steelwork is used throughout the design, use of latest technology was unnecessary as there were concerns of it affecting 'cost and impact on heritage'.

5.2 **Architecture and Heritage**

Heritage values were clearly met in the final design chosen although various aspects relating to the architecture had suffered because of it. Areas where the architecture failed to meet client expectation primarily were in the designs ability to enhance thermal, acoustic and natural light performance, even though it was successfully maintained. Unlike the Alfred Nathan House, reversibility of interventions was essential to this design to ensure a minimal potential loss of heritage. In addition to this, if any existing items are removed, the design states they 'must be reinstated as a replica or original of the building' as required by the heritage architects.

5.3 **Feasibility**

Due to the current number of EPBs that Auckland Council are looking at strengthening over the coming years, cost is becoming an 'increasingly important issue to each project' according to the client. Current concerns with funding have temporarily prevented most of the projects from reaching their construction phases until further notice. This caused problems with the design team as the budget, and programme would ultimately be affected.

5.4 **Remaining Design Aspects**

The client's expectation of services, fire protection and buildability was overall quite low. This is somewhat reflected in the final design outcomes, apart from the services and fire protection. This area in particular could have been adjusted to potentially allow for further improvement into areas that require it i.e. Architecture and Feasibility.

6 **DISCUSSION**

6.1 **Performance Evaluation**

The results of the Heritage Evaluation Framework for both projects highlight the major design considerations from both the client and remaining stakeholders. The summary graphs (Figure 3 and 7) clearly show overwhelming attention into the designs seismic engineering and architectural heritage capabilities. As one respondent mentions, 'this is to be expected although the HEF fails to reflect it'. Currently the HEF allocates an equal amount of options available to the user amongst all categories (Fire Protection, Engineering, Architecture etc.) which was found to be unnecessary when considering projects that would be almost redundant in one category but highly specialized in another. Likewise, the actual process of developing purposed designs is an iterative one with many unique parameters that cultivate into one final design. The HEF attempts to list and quantify these parameters although in reality, each project is unique and 'there is no set formula' that can achieve a best fit design. Therefore, the HEF is more appropriate for use on smaller, more standardized projects rather than large complex ones.

Furthermore, as the test sites were so diverse, there should be a reflection of this within the HEF inputs. This could be achieved via initial team meetings with the client to discuss some of the major factors that will affect the project as well as underlining precisely what the client expects out of the design rather than having to choose from a list. For example, the leading issues affecting the Alfred Nathan House included removal of asbestos, strengthening whilst preserving heritage on the façade and ceiling, improving floor space area by removal of walls and maintaining improvement of overall NBS level to at least 34%. These specific issues fail to be properly categorized within the HEF as it is not a design specific tool, 'it uses a broad brush over all projects'. One addition to the HEF that was

recommended by several project team members was the inclusion of the buildings conservation plan to give a clear understanding of the 'buildings type, scale, and level of heritage' to all stakeholders prior to design commencement.

Ultimately, the HEF was capable of giving a basic evaluation to the project team members in regards to the conceptual designs proposed. Although the feedback graphs lacked accuracy of what was actually required within the design. To improve this for future use, adjustments should be made to available options by generating data sheets unique to each project.

6.2 Encouragement of Design Discussion

The importance of early collaboration in heritage strengthening was highlighted in the interviews due to non-standard solutions required in Heritage Strengthening. Sharing of vital information before any designs were produced was noted as a key way in which the framework aided early collaboration.

During the initial phases of interviews and inductions, the HEF received criticism as many of the industry professionals questioned its capabilities. This was to be expected, as the tool had yet to undergo any real testing on live heritage projects. Despite this, the HEF achieved a great deal of discussion around the conceptual designs, early within the project. The tool was able to encourage stakeholders to constantly mention what aspects of the design held precedence over others which gave the design a clear indication of where it needed to be and what it was currently lacking.

Peter Reed from Salmond Reed Architects states that 'the best tool for a project, is experience and collaboration'. Whilst the HEF lacked experience, it certainly had the ability to encourage collaboration and discussion amongst parties. Design is a repetitive process with constant back and forth communication between stakeholders, the HEF 'helped to facilitate early collaboration by providing a common language for the design team' according to one respondent. Another finding was that the users found a need to keep the framework simple and well worded to enhance its usability.

Finally, it was acknowledged that cost is a critical assessment criterion and its inclusion improved the frameworks ability to facilitate early collaboration because it better positioned the client to provide an overarching brief which the design team should strive to meet.

Overall through the analysis of interviews conducted, it was found that with both projects tested the HEF promoted the thinking that successful design solutions are most effectively produced collaboratively at an early stage.

7 CONCLUSIONS

This research addressed a gap in current studies by evaluating a collaborative assessment tool called the Heritage Evaluation Framework for examining the effectiveness of a strengthening designs on both the Alfred Nathan House and 3 Victoria Road project. The developed framework functioned reasonably well in measuring design performance against client priorities. The 6 assessment categories lacked the ability to reflect the unique characteristics of either project, although the multidisciplinary nature of the tool promoted early communication and collaboration amongst team members. Conclusively, with further alteration and refining of the HEF, many industry professionals believe it has a place within New Zealand Heritage retrofit projects.

7.1 Further Research

A number of future research opportunities exist to improve the current framework. These include industry testing of live sites during their construction phase, incorporating weightings to various principles and categories, producing templates of different project types, and exploring ways in which

mismatches between client priorities and design performance are handled and presented back to the team.

7.2 **Limitations**

Due to the unique nature of the tool, it is important to identify its limitations. Firstly is the tools need for cooperation amongst all stakeholders. This requires immense time and effort to ensure that the entire team is willing and able to effectively utilize the HEF. Secondly, the use of assessment weightings and handling mismatches is a key limitation of the framework that would likely need addressing prior to further industry testing. This coincides with the ability to retrieve honest and accurate feedback from all participants of the HEF, as skewed data ultimately gives inaccurate descriptions of the design.

REFERENCES

Allaf, N. & Charleson, A. (2014). *The relationship between seismic retrofitting and architectural qualities. Wellington, NZ.*

Cattanach, A., Alley, G. & Thornton, A. (2008). *Appropriateness of Seismic Strengthening Interventions in Heritage Buildings: A Framework for Appraisal. NZ.*

Egbelakin, T. (2013). *Assessing Regulatory Framework Efficacy for Seismic Retrofit Implementation in New Zealand, NZ.*

Egbelakin, T. & Wilkinson, S. (2008). *Factors affecting motivation for improved seismic retrofit implementation, Australia, Earthquake Engineering Conference.*

Fisher, D. (2003). *Tourism, culture and development: whose culture? Whose development? NZ.*

Gately, J. (2010). *The heritage identification of modern public housing: the New Zealand example.* NZ: The Journal of Architecture, Vol. 15, 2010, pp. 683-696.

Ingham, J.M & Griffith, M.C. (2011). *The performance on unreinforced masonry buildings in the 2010/2011 Canterbury earthquake swarm. Australia, Earthquake Engineering Conference.*

Isaacs, Phillip Nigel. (2015). *Making the New Zealand House 1792-1982, NZ.*

Pattison, M. (2015). *An assessment Tool for Strengthening Heritage Buildings, NZ.*

Russel, A.P. (2010). *Characterisation and seismic assessment of unreinforced masonry buildings, NZ.*

McClean, R. (2010). *Earthquake Strengthening. Improving the Structural Performance of Heritage Buildings Sustainable Management of Historic Heritage Guidance Series. Wellington, NZ.*