Detailed Seismic Assessment

Marton Civic Centre

Corner of Broadway and High Street, Marton

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Executive Summary

Background

WSP Opus has been engaged by the Rangitikei District Council to conduct a Detailed Seismic Assessment (DSA) on four buildings located at 304-318 Broadway Street, Marton. The buildings form part of the Marton Civic Centre project. Under this project, WSP Opus has been commissioned by the district council to provide concept design proposals for the new Marton Civic Centre in order to give new life to these historic structures and preserve their character and contribution to the streetscape of Marton.

Objective

The purpose of this assessment is to determine the overall condition, seismic performance and seismic ratings in terms of a %NBS of the buildings in accordance with the latest MBIE earthquake engineering guidelines, July 2017.

This report also presents the ratings of several structural components (façade, canopy, chimneys) and aligns the findings to the component's heritage value as identified by the heritage architect. This provides a connection between the heritage value and the degree of strengthening works involved for each component and assists in making informed decisions regarding retention, replacement or strengthening of different elements based on their importance to the heritage fabric. The information is also used to prepare the scope and pricing of works involved and to incorporate the structural strengthening into the architectural concept design for the new Civic Centre.

Site Description

The site consists of four unreinforced brick masonry buildings forming the corner of Broadway and High Street in Marton as shown in Figure A below. The structures are two storey buildings that were constructed between 1900 and 1920. The buildings are heritage listed as Category 2 and are considered important to the streetscape of the Marton Township.

Figure A. Marton Civic Centre - Layout and photo of buildings looking northward

DSA Results

Based on the outcome of our DSA, the buildings have a seismic rating of 15 %NBS (IL2). The buildings are considered high risk structures and pose a relative risk to life safety that is 25 times higher as compared to a new building in accordance with the Guidelines.

The governing factors for the NBS rating are;

- **Out-of-plane capacity URM elements.** The unsupported URM cantilever elements such as the wall piers, chimneys, and parapets are at risk of collapse under low seismic loads, which would result in falling debris on footpaths and access ways, creating a life safety risk.
- **In-plane capacity of URM façade piers.** The geometry and condition assessment of the masonry piers leads to these elements being vulnerable to rocking and toe-crushing failure. This would result in a loss of lateral load resisting capacity of the system and potential collapse.

Recommendations

A building with an earthquake rating less than 34 %NBS fulfils one of the requirements for the Territorial Authority to consider it to be an Earthquake-Prone Building (EPB) in terms of the Building Act 2004.

Given the low rating, we recommend carrying out seismic strengthening to the buildings. In this regard, WSP Opus architects are currently in discussion with the building owners (Rangitikei District Council) regarding future use of the building and are conducting concept design studies for the development of a new Civic Centre for Marton. The design of strengthening works from WSP Opus will take in to account the proposed future use of the building and the outcome of this DSA. The primary components of the structural strengthening are summarised below.

Elements	*Strengthening*
• Front façade elements	Construction of a concrete skin wall tied to existing masonry.
• Parapets, chimneys and fireplaces	Replace the ornaments with light-weight replicas or tie the components to the floor and walls through steel framing.
• Floor and roof diaphragm	Install steel diaphragm trusses within the existing floor space to connect the walls together. Re-nail the floorboards to rafters/joists. Provide ply bracing to the roof trusses.
• Side and rear walls	Provide steel portal frames to take the seismic loads and tie to the masonry walls. Provide timber strong-backs and ply lining on the inner face to improve the out of plane strength of the masonry.
• Ground-level subfloor	Raise the existing timber sub-floor or provide a concrete foundation and reinstate the existing timber floor.

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1 Scope and Objectives

WSP Opus has been engaged by the Rangitikei District Council to conduct a Detailed Seismic Assessment (DSA) on four buildings. These buildings are situated at the corner of Broadway Street and High Street and form part of the Marton Civic Centre project. Under this project, WSP Opus has been commissioned by the district council to provide concept design proposals for the new Marton Civic Centre in order to give new life to these historic structures and preserve their character and contribution to the streetscape.

Detailed seismic assessment of these buildings forms part of the overall project in order to assess the seismic risk and NBS ratings of these historic unreinforced masonry (URM) buildings and identify the critical structural weaknesses and issues. The results presented in this DSA report will be used to;

- Provide seismic performance of the structures in their current state,
- Recommendations on the seismic risk, rating and regulatory requirements and
- Design the concept strengthening scheme for the buildings during the concept design phase

This report also presents the ratings of several structural components (façade, canopy, chimneys etc.) in comparison to their heritage value as identified by the heritage architect. This creates a connection between the heritage value and the degree of strengthening works involved. This assists in making informed decisions about whether to retain and strengthen or demolish and replace the elements which are intrusive to the heritage value or pose significant structural concerns. The information is also useful in preparing the scope and pricing of works involved and to incorporate the structural strengthening design into the architectural concept design for the new Civic Centre.

We have conducted the DSA in accordance with 'The Seismic Assessment of Existing Buildings: Technical Guidelines for Engineering Assessments, July 2017, Version 1', which are referred to here as 'The Guidelines'. The Guidelines have been produced by New Zealand engineering technical societies in conjunction with the Ministry of Business, Innovation and Employment (MBIE) and the Earthquake Commission and came into force on 1 July 2017.

1.1 Sources of Building Data

1.1.1 Structural

- Cobbler A Original Drawing, Permit Plan, no date
- Abraham and Williams Original Drawing, New Building – Marton, Drawing No. 1, no date
- Existing ISA report on Abraham and Williams building and Cobbler buildings from Charles Consultants, 2015.

1.1.2 Site Investigations

- Site Survey, WSP Opus, February 2019
- Drone survey/3D mapping of the exterior of the precinct, WSP Opus, March 2019
- Geotechnical Desktop Study, WSP Opus, March 2019

2 Building Description

2.1 General Layout

The Marton Civic Centre comprises of four unreinforced brick masonry buildings forming the corner of Broadway and High Street in Marton. The buildings are two storey structures constructed between 1900 and 1920. The buildings are listed as heritage Category 2 and are named as follows;

- Cobbler B (List number: 1243)
- Cobbler A (List number: 1243)
- Davenport Brothers (List number: 1244)
- Abraham and Williams (List number: 1240)

Figure 1. Marton Civic Centre - Layout and photo of buildings looking northward

2.2 Structural System

The lateral load (seismic and wind) resistance and the gravity load resistance in unreinforced brick masonry buildings is provided by the masonry walls, which generally form the perimeter of the structure. Additional support for large spanning timber floors is provided by gravity columns, which are either timber or cast iron.

The URM walls around the perimeter of the buildings vary in thickness from 4 courses (450 mm) to 2 courses (230 mm) thick with no cavity. Concrete bond beams are present at floor and roof levels of the walls, which provide an improved connection between the spandrel and pier elements of the walls. Concrete lintel beams span across window openings

The roof diaphragms of the buildings comprise of light-weight timber trusses spanning between URM walls with timber sarking. The floor diaphragms consist of timber joists with timber floorboards.

The foundations of the buildings consist of brick strip footings located under the walls of the structures. Brick footings are also in place to provide gravity support the timber floor joists.

2.2.1 Cobbler B

The Cobbler B building was built in 1913 on the corner of Broadway and High street. The two storey structure consists of 3 course URM walls with large openings at ground level of the street-facing façade.

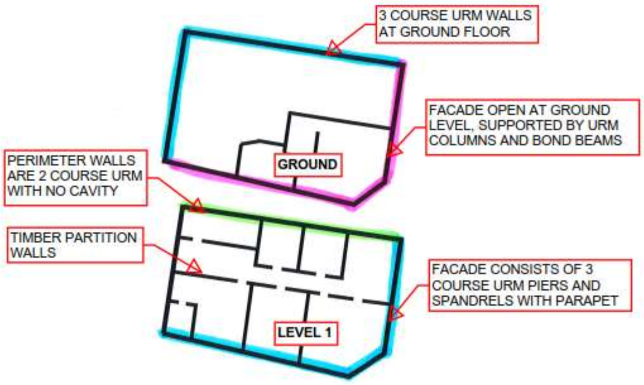



Figure 2. Cobbler B façade and plan views

2.2.2 Cobbler A

The Cobbler A building was built in 1914 as an addition to the Cobbler B building. The buildings are connected through at only the upper level. Construction consists of columns at ground level of the façade and URM walls without bond beams around the perimeter. The rear section of the building contains a cantilevered steel beam supporting the brickwork.


Figure 3. Cobbler A façade and plan views

2.2.3 Davenport Brothers

The Davenport Brothers building is the oldest structure of the four in the precinct. It was constructed in approximately 1905 with a floor area of 200 m2 and consists of URM perimeter wall with cast iron gravity columns providing support to the upper level.

Figure 4. Davenport façade and plan views

2.2.4 Abraham and Williams

The Abraham and Williams Building was constructed in approximately 1915 with a floor area of 295 m2. The original building contained URM perimeter walls with internal URM and timber-framed walls. The lower level has been altered to be open plan and now contains columns providing the gravity support.

Figure 5. Abraham and Williams' façade and plan views

3 Condition Assessment

A site inspection was carried in February 2019 by WSP Opus to determine the structural condition and layout of the building. The following is a summary of the key findings of the inspection[1].

3.1 Material Deterioration and Cracking

The façade of Abraham and Williams has large diagonal cracks at the top corners of the window spandrels. These cracks travel up into the parapet section of the façade. The cracking pattern significantly limits the shear capacity of the walls and may lead to the URM walls becoming more susceptible to out-of-plane failure.

Sections of the URM walls at the rear of the buildings contain washed out areas of mortar in the joints. There are signs of cracking in the concrete bond beams, bricks and mortar joints in all of the buildings. This can negatively affect the in-plane performance of the walls. Several areas of rear walls have water damage due to broken drain pipes. There is corrosion observed in the bond beams reinforced with steel rail sections causing large splitting cracks.

Figure 6. Cracks in Abraham and Williams façade and washed out mortar joints

3.2 Parapets and Ornaments

Heavy URM parts have been observed behaving poorly in past earthquakes. Parts such as parapets, ornaments and chimneys are vulnerable to collapse under small movements and pose a hazard to neighbouring properties and footpaths. The buildings in the Marton Civic Centre contain these URM parts as is seen below on the Cobbler and Davenport buildings

Figure 7. Protruding URM chimneys that extend pass the roofline and heavy ornaments/parapets at the top of Davenport's façade

[1] Site Inspection Summary Report – Marton Civic Centre and Heritage Precinct, February 2019

3.3 Layout of Buildings

The connection between the two Cobbler buildings is provided at the upper level by means of a link structure with open corridor access underneath, as shown below, creating an area of potential weakness due to the absence of structural walls, which is vulnerable to damage from the independent movement of the two buildings to which it rigidly connects.

The front façade of all buildings have large openings on the ground floor supporting the heavy weight of the upper storey façade, which is transferred to the ground floor URM walls and columns using spandrels and bond beams. This creates stiffness irregularity in the building due to a discontinuous lateral load resisting system.

The rear section of Cobbler A contains a 400 mm deep cantilevered steel beam that provides support to a two course URM wall. The concrete bond beam that supports the brick is displaying signs of deterioration with cracks spread the length of the member.

Figure 8. Link between Cobblers and cantilevered Cobbler A wall

The Abraham and Williams building appears to share a common sidewall with Davenport and only has a single brick wall to support the diaphragms, instead of a dedicated lateral load resisting URM wall. This is based on the historic drawings and observations from the 3D Drone survey.

3.4 Alterations

The ground floor of Abraham and Williams originally contained internal walls, which provided gravity support to the upper-level timber floor. The structure has undergone significant modifications to the layout of the URM walls at the ground floor, which now contains boxed out columns and is open plan. Remaining sections of the walls/beams above the ground floor were observed within the ceiling cavity, which span between these new columns. Large sections of internal timber partition walls have been stripped off their linings or removed completely.

Figure 9. Removed walls in Abraham and Williams and significant modification in Cobbler A

4 Assessment Methodology

4.1 General philosophy

To assess the seismic performance of the URM buildings in Marton Civic Centre, we have adapted the general philosophy in accordance with chapter 8 of the Guidelines. The masonry elements are assessed for the In-plane, Out-of-plane and local failure mechanisms. The floor diaphragms are assessed for compatibility deformation and any attachments or parts are assessed in accordance with the relevant material chapters of the guidelines. The seismic demands on the walls and façade elements were determined using the 3D numerical model created in SAP2000 as well as supplementary hand calculations.

4.2 In-Plane

The URM walls were treated as one-way walls spanning between floor levels. The in-plane strength capacity of the wall elements was taking as the minimum of the following mechanism shown in the figure below.

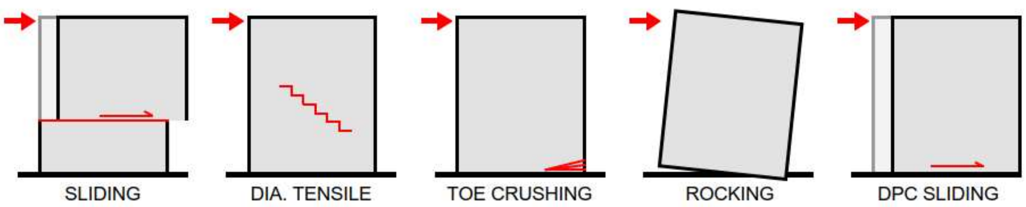


Figure 10. In-plane failure mechanisms of masonry piers

The governing mode was then compared to the calculated demand of the element, determined from the analysis of the SAP2000 model.

4.3 Out-of-Plane

Wall elements under face loading have been assessed in line with section C8.8.5 of the Guidelines using the displacement-based inelastic method. The maximum out of plane displacement was limited to 0.6 times the instability displacement for simply supported walls and 0.3 times for cantilevering walls.

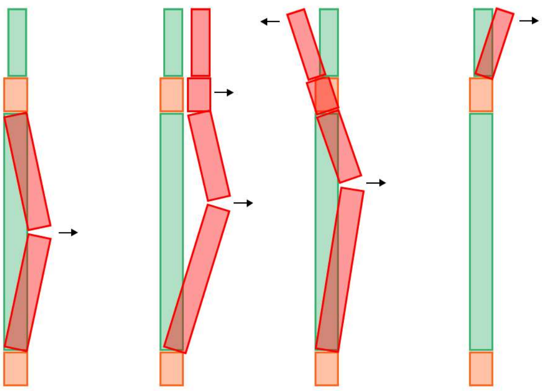


Figure 11. Out-of-plane failure mechanisms

4.4 Diaphragms

The timber roof and floor diaphragms of the buildings were assessed with section C8.8.3 and C9.6.3.3 of the Guidelines. By calculating a stiffness of the diaphragm from the detailing and condition, a probable strength and deformation capacity was calculated. The maximum diaphragm in-plane displacement capacity was limited as half the thickness of the face-loaded walls.

The timber floor diaphragm in general rests on top of the masonry walls on the offset created by transition of wall thickness from three to two layers between ground floor and first floor. The details and integrity of the existing connection is not known, however, global sliding of the timber diaphragm is not expected as the floors are bounded within the perimeter of URM walls and bond beams and a flexible diaphragm behaviour is expected. The impact of diaphragm connectivity on the face loaded walls has been considered through a sensitivity analysis of available connectivity on the out of plane response of face loaded walls and also through the local failure mechanism analysis.

4.5 Parts

Secondary elements of the buildings such as chimneys, heavy ornaments, and canopies were assessed using parts loading.

4.6 Local Failures

A local failure analysis was completed to determine any areas of the buildings vulnerable to failure due to the condition, layout, or position of elements. The analysis was completed with reference to both the displacement compatibility and the accelerations required to cause instability of the element[2]. Sections such as the façade of Abraham and Williams, which contained cracks at the upper corners of the windows were highlighted as potential local failures and treated as block elements shown in the figure below.

Figure 12. Local failure mechanism analysis for Abraham and Williams' front façade

[2] F. Gálvez (2018). *Using the macro-element method to seismically assess complex URM buildings*

5 Detailed Seismic Assessment

5.1 Assessment Criteria

5.1.1 Design Life

The structures assessed in the Marton Heritage Precinct were constructed between the year 1900 and 1920. Therefore, the structures being approximately 100 years old are beyond their intended life spans.

5.1.2 Importance Level

The assessment has been carried out considering the buildings as Importance level 2 structures as the buildings are proposed to be used as office space and are not likely to contain crowds of people in excess of 300. If the buildings were to be categorised as a ‘major structure’ as per NZS1170.0, they would require to be considered as Importance Level 3 structures. This would result in approximately a 30% increase in seismic demands.

5.1.3 Soil Classification

A geotechnical desktop study of the area has been completed by WSP Opus in March 2019. Based on the findings the likely site subsoil class is ‘Class D’, deep or soft sites as per NZS1170.5:2004.

5.1.4 Seismic Loads

The following parameters have been considered to define the acceleration spectra from NZS1170.5:2004.

Table 1. Parameters for Seismic Loads – ULS

Parameter	Value	Comments
Site Subsoil Class	D	WSP Opus Memo, 13/03/2019
Period	<0.5 seconds	Based on analysis and as per C8.10.2.2
Z	0.30	Seismic hazard factor for Marton
R_u (ULS)	1.0	Importance Level 2 – 1/500 yr RP
N(T,D)	1.0	No known near faults
K_R	1.0	As per table C8.15

5.1.5 Material Properties

A series of scratch tests were conducted on the bricks and mortar throughout the buildings where accessible during the site inspection to help determine the probable material strengths. The Guidelines provide a relationship between material hardness and the probable strength, referred to as Scratch Test. Scratching the surface of the bricks and mortar with different materials/objects (finger, aluminium, copper) can determine the relative hardness of the materials.

For the URM walls, the brick hardness was determined to be ‘medium’ and the mortar was also determined to be ‘medium’. These values are used to evaluate material strengths based on the NZSEE Guidelines July 2017 C8.7.

5.2 DSA Results with Correlation to the Heritage Value

The %NBS score for building's structural elements are assessed in terms of a capacity over demand ratio with the associated governing failure mechanism. The assessment also took into consideration the heritage significance of each element and indicates the work required to strengthen the buildings to 100% IL2.

The heritage significance of each of the elements is presented in Figure 13 below as per the heritage architect's recommendations. The %NBS score for building structural elements is provided in Table 3 below.

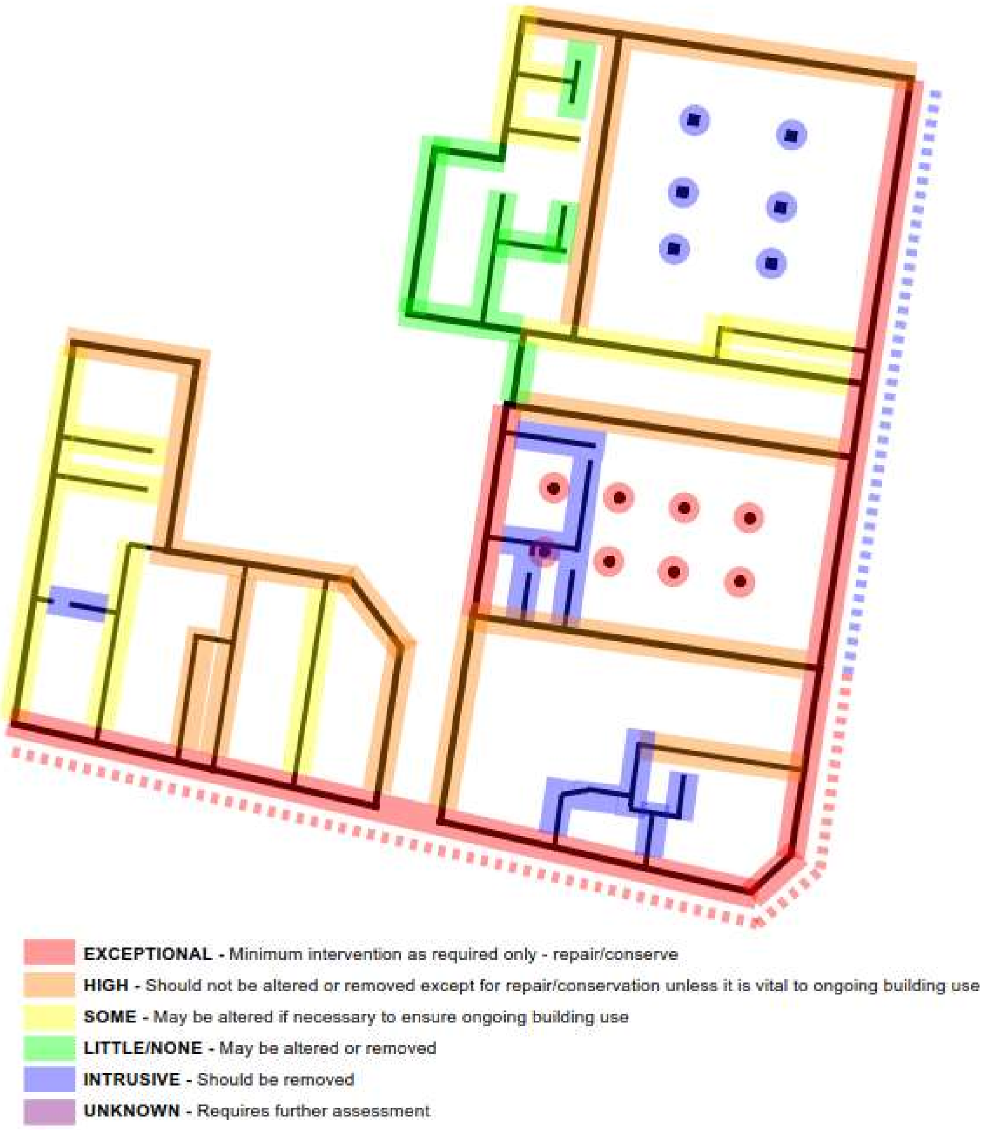


Figure 13. Heritage significance

Table 2. Structural elements %NBS rating, heritage value and required strengthening

Element	Cobblers A and B	Davenport Brothers	Abraham and Williams
Primary Structure			
Façade	Exceptional 25% - Column shear Intrusive Strengthening • *Concrete skin wall on the internal face of existing wall* • *Create a seismic gap between the two Cobbler buildings*	Exceptional 30% – Out of plane failure Intrusive Strengthening • *Steel frame internally at ground level to support front openings* • *Concrete skin wall on the internal face of existing wall*	Exceptional 20% - In plane shear Intrusive Strengthening • *Steel frame internally at ground level to support front openings* • *Concrete skin wall on the internal face of existing wall*
Side Walls	High 55% - Out of plane failure Intrusive Strengthening • *Remove wall lining and install timber strong-backs and ply lining OR Concrete skin wall on internal face*	High 40% - Out of plane failure Intrusive Strengthening • *Remove wall lining and install timber strong-backs and ply lining internally AND Concrete skin wall on external face*	High 25% - Out of plane failure Intrusive Strengthening • *Concrete skin wall on the internal face of existing wall. Leave shared walls from neighbouring building in-place*
Rear Walls	High 55% - In plane shear Intrusive Strengthening • *Concrete skin wall on the internal face of existing wall* • *Repointing on external face and ties to new skin wall*	Exceptional 15% - In plane failure Intrusive Strengthening • *Concrete skin wall on the internal face of existing wall* • *Repointing on external face and ties to new skin wall*	High 20% - In plane shear Intrusive Strengthening • *Concrete skin wall on the internal face of existing wall* • *Repointing on external face and replace damaged bricks*
Interior Gravity Columns	Not Applicable	Exceptional 100% Non-Intrusive • *Repair timber sections where required due to condition*	Intrusive Unknown Intrusive Strengthening • *Remove columns and replace with new gravity steel framing*
Level 1 Timber Floor	High 70% Non-intrusive Strengthening • *Improve connection of joists to the URM walls, re-nail floor boards and remove rotten timber*	High 70% Non-intrusive Strengthening • *Improve connection of joists to the URM walls, re-nail floor boards and remove rotten timber*	High 70% Non-intrusive Strengthening • *Improve connection of joists to the URM walls, re-nail floor boards and remove rotten timber*
Roof Trusses	High 70% Non-intrusive Strengthening • *Improve connection of truss members to the URM walls, reline roof and provide plywood bracing*	Exceptional 70% Non-intrusive Strengthening • *Improve connection of truss members to the URM walls, reline roof and provide plywood bracing*	High 100% Non-intrusive Strengthening • *Improve connection of truss members to the URM walls, reline roof and provide plywood bracing*
Parts and Ornaments			
Parapets	Exceptional 15% - Out of plane failure Intrusive Strengthening • *Brace URM for OOP by concrete skin wall anchored to URM OR tie it to side walls with steel framing*	Exceptional 15% - Out of plane failure Intrusive Strengthening • *Brace the URM parapet with concrete skin wall OR tie it to side walls with steel framing*	Exceptional 25% - Out of plane failure Intrusive Strengthening • *Brace URM for OOP by concrete skin wall anchored to URM OR tie it to side walls with steel framing*
Chimneys above the roof	High 15% - Stability Intrusive Strengthening • *Remove and replace with light weight replica OR* • *Repoint bricks, concrete fill within and tie existing bricks*	Not Applicable	High 15% - Stability Intrusive Strengthening • *Remove and replace with light weight replica OR* • *Repoint bricks, concrete fill within and tie existing bricks*
Canopy	Exceptional 35% - Fixing pull-out Intrusive Strengthening • *Replace corroded tie rods, improve connections to URM walls*	Intrusive 70% - Fixing pull-out Intrusive Strengthening • *Remove and redesign canopy as per architectural requirements*	Intrusive 55% - Fixing pull-out Intrusive Strengthening • *Remove and redesign canopy as per architectural requirements*

In addition to the structural elements, Table 4 below presents strengthening works required for the non-structural elements to address the associated life safety risk due to their poor performance and relates it to the heritage significance.

Table 3. Non-structural elements heritage value and required strengthening

Element	Cobblers A and B	Davenport Brothers	Abraham and Williams
Alterations and Additions			
Rear Addition behind Abraham and Williams	Not Applicable	Not Applicable	Some - • *Remove intrusive buildings from rear section*
Mezzanine Floor	Not Applicable	Intrusive - • *Remove the intrusive elements and restore the original layout as per architecture design*	Intrusive - • *Remove the intrusive elements and restore the original layout as per architecture design*
Non-Structural Components			
Fire Places	High - Intrusive Strengthening • *Install bracing and gravity support along with URM walls*	Not Applicable	High - Intrusive Strengthening • *Install bracing and gravity support along with URM walls*
Stairs	Exceptional - Non-Intrusive • *Retain the stairs and improve the framing as required*	Little/None - Non-Intrusive • *Remove as required by the architect*	Some - Non-Intrusive • *Remove as required by architect*
Partition Walls and Linings	Intrusive - Intrusive • *Remove as required by the architect* • *URM linings required to be removed to provide access for strengthening, reinstate afterwards*	Exceptional - Intrusive • *Remove as required by the architect* • *URM linings required to be removed to provide access for strengthening, reinstate afterwards*	Intrusive - Intrusive • *Remove as required by the architect* • *URM linings required to be removed to provide access for strengthening, reinstate afterwards*
Ceiling Linings	High - Non-Intrusive • *Leave in place except where required for access to perform strengthening works in the ceiling space*	Exceptional - Non-Intrusive • *Leave in place except where required for access to perform strengthening works in the ceiling space*	High - Non-Intrusive • *Leave in place except where required for access to perform strengthening works in the ceiling space*
Ground Level Timber Subfloor	High - Intrusive Strengthening • *Removal of flooring required to access foundations for strengthening. Raising of floor height may be required to comply with building code.*	High - Intrusive Strengthening • *Removal of flooring required to access foundations for strengthening. Raising of floor height may be required to comply with building code.*	High - Intrusive Strengthening • *Removal of flooring required to access foundations for strengthening. Raising of floor height may be required to comply with building code.*

5.3 Critical Structural Weakness and %NBS Rating

The governing factors for the NBS rating of buildings are the;

- **Out-of-plane capacity URM elements.** The unsupported URM cantilever elements such as the wall piers, chimneys, and parapets are at risk of collapse under low seismic loads, which may result in falling debris on footpaths and access ways creating a life safety risk.
- **In-plane capacity of URM façade piers.** The geometry and condition assessment of the masonry piers leads to these elements being vulnerable to rocking and toe-crushing failure. This would result in a loss of lateral load resisting capacity of the system and potential collapse.

Therefore, the final rating of all buildings in the Marton Civic Centre is **15 %NBS (IL2)**.

Table 4. %NBS rating for each building and critical elements

Building	%NBS (IL2)	Critical elements
Cobblers A and B	15%	Parapets, ornaments, chimneys
Davenport Brothers	15%	Rear wall piers, parapet, façade ornaments
Abraham & Williams	15%	Façade piers and columns, parapet, chimneys

5.4 Consequence of Failure

The Detailed Seismic Analysis has identified some structural elements as scoring less than 33 %NBS (IL2). The consequences of each element failing are outlined in the table below.

Table 5. Risk and consequence of failure

Risk Element	Consequence of Failure
Front façade	The masonry on the front façade is likely to crack and drop small sections of masonry onto the canopy/footpath. Out of plane failure would result in large sections of masonry falling
Parapet	The 1-1.5 m parapets would disconnect from the façade and topple over, dropping from a height of 10 m onto the footpath below and egress routes
Chimneys	Chimneys are likely to rock and collapse, dropping masonry onto the footpath, egress routes and through the roof/ceiling space
Canopy	Failure of fixings would result in the canopy losing support, which would lead it dropping onto the footpath below and the blocking egress routes out of the buildings
False ceilings	Unrestrained false ceilings are likely to break connection and drop down onto the floor below
Glazing	Windows are likely to break during earthquake loading, leading to glass dropping onto the footpath and road

5.5 Risk Elements not Specifically Assessed

The following items were not specifically assessed in the detailed seismic assessment due to information not being available. These are identified below as the risk items which may affect the serviceability or life safety performance of the building during a seismic event and would, therefore, need to be considered in the concept strengthening design.

5.5.1 Timber Floor and Roof Connection to the URM walls

The type and condition of the floor and roof diaphragm connections to the URM walls are not fully known. The connection is relied upon to transfer the diaphragm forces into the in-plane walls under earthquake loading. The connection also provides support to the URM walls acting out-of-plane. The assessment for out-of-plane loading has considered both cases of the diaphragms being effective and non-effective at providing supporting to the masonry wall. The connection detail does not impact the overall %NBS rating of the building, but is indicated as a risk item which would require evaluation and possibly need strengthening as part of the overall strengthening design.

5.5.2 Foundations

The condition of the foundations of the Abraham and Williams building is unknown. Their construction is indicated on the original drawing to be URM strip footings on a concrete base. Differential settlement could have occurred, causing a redistribution of forces and creating localised stress concentrations.

5.5.3 Masonry Condition

The condition of the URM brick and mortar has been determined from limited site inspections and testing. The condition of the brick and mortar directly influences the material properties used in the assessment, which are a sensitive element in assessing the capacities of the URM piers and walls.

5.5.4 Bond Beam Condition & Strength

Bond beams in URM buildings help provide restraint and connection to the brickwork walls of the structures. The effectiveness of bond beams is dependent on their detailing and condition. It was observed that some of the bond beams were detailed with either a central railway iron or low amounts of reinforcing bar. Cracking was visible on the concrete, which indicates potential corrosion of the steel.

5.6 Buildings Regulations

The Building (Earthquake-prone Buildings) Amendment Act 2016 is the current amendment to the Building Act 2004 that sets the performance objectives for buildings and provides a system for managing earthquake-prone buildings that include the MBIE guidelines. The intent of the act is to protect people and property and therefore performance limits are set in terms %NBS as an ultimate limit state (ULS).

6 Conclusions and Recommendations

Based on the outcome of our DSA, the buildings have a seismic rating of 15 %NBS (IL2). The buildings are considered high risk structures and pose a relative risk to life safety that is 25 times higher as compared to a new building in accordance with the Guidelines.

A building with an earthquake rating less than 34 %NBS fulfils one of the requirements for the Territorial Authority to consider it to be an Earthquake-Prone Building (EPB) in terms of the Building Act 2004.

Given the low rating, we recommend carrying out seismic strengthening to the buildings. WSP Opus architects are currently in discussion with the building owners (Rangitikei District Council) regarding future use of the building and are conducting concept design studies for the buildings. The suitable strengthening works from WSP Opus would take in to account the newly proposed architectural layout and the outcome of this DSA when designing the concept strengthening for these buildings.

Our work is in progress for the concept strengthening design to bring the building to 100 %NBS as part of a separate stage of the project. The primary components of the structural strengthening are presented in Figure 14.

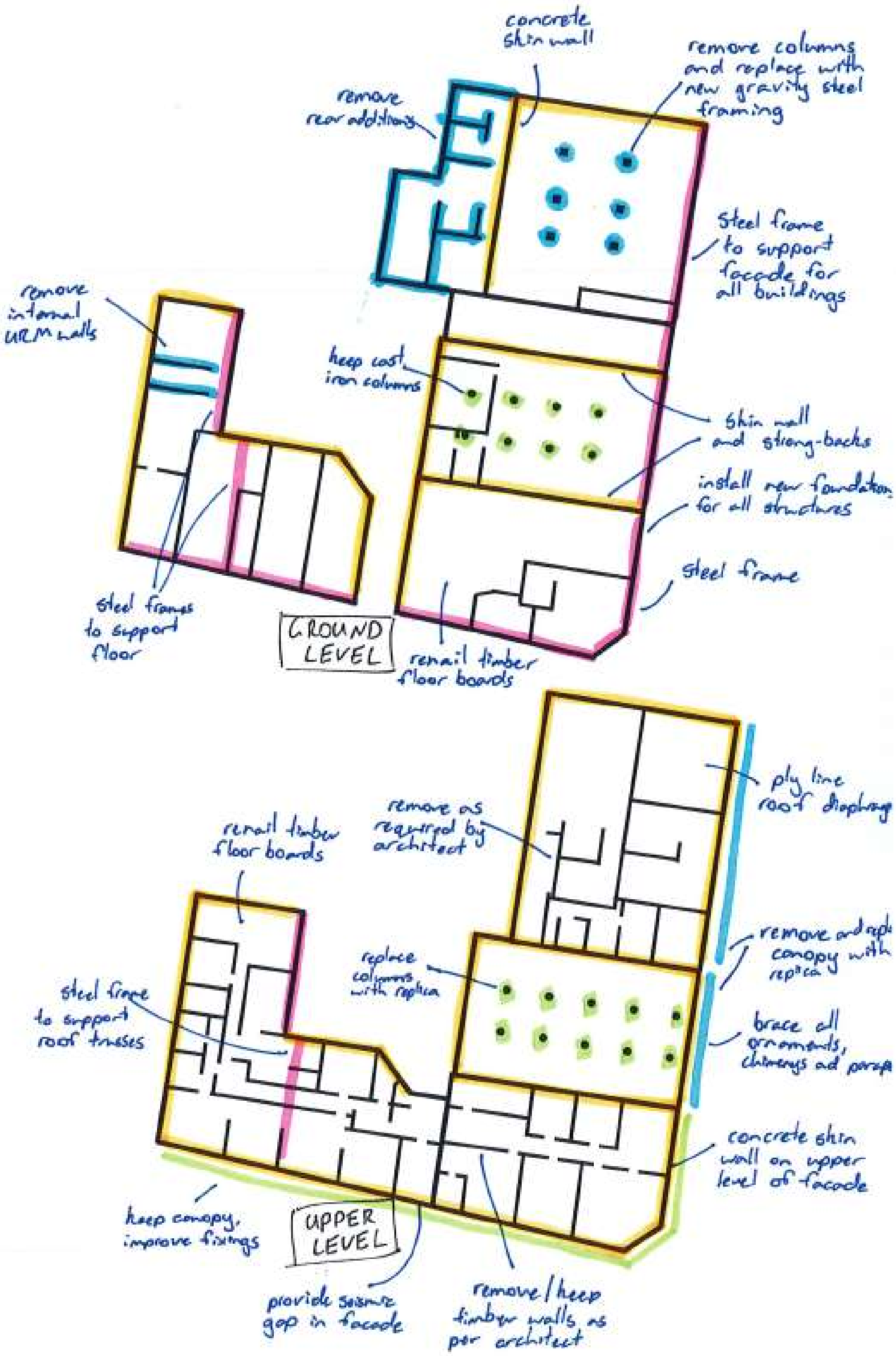


Figure 14. Concept strengthening

7 Limitations

The assessment and consequent opinions of the authors in this report are based on the limited data collected during the visual site inspection and the 3D drone survey in the absence of original design information at the time of the DSA.

8 Disclaimer

This report and conclusions within are prepared for the Rangitikei District Council in accordance with our clients brief and should not be relied on by other parties for any other purpose or use without written confirmation from WSP Opus of the purpose and suitability.

Appendix A
Geotechnical Desktop Study

Marton Township
WSP Opus, March 2019

Memorandum

To	Brenda O'Shaughnessy
Copy	
From	Mark Frampton
Office	Whanganui
Date	13 March 2019
File	5-WT489.01
Subject	Marton Community Centre - Geotechnical Appraisal Desk Study

1 Introduction

Rangitikei District Council have engaged WSP Opus to progress the Marton Community Civic Centre project to concept design phase. WSP Opus original report provided an assessment of the Marton Heritage Precinct and high-level options for the redevelopment of the Cobbler Buildings (A&B), Davenport Building and Abraham & Williams Building to create a new Community Civic Centre. Several options were presented in the original report, which are to be refined and explored further in the concept design phase.

As part of the current phase of work, an understanding of the geotechnical and geological conditions at the site is required to inform the concept design process.

The objective of this geotechnical appraisal is to review the ground conditions and to understand the geotechnical parameters that will be used in the assessment of the existing buildings, and to understand the foundation requirements of any new structures.

This appraisal is based on a desk study of available information. No specific ground investigations have been undertaken as part of this geotechnical appraisal.

2 Site Location and Description

The site is located on the corner of High Street and Broadway, Marton. The buildings included in the redevelopment plans include the Cobbler Buildings (A&B), Davenport Building and Abraham & Williams Building.

The location of the site is shown in Figures 1 & 2.

Figure 1 : Site location (Sourced from the LINZ Data Service and licensed for reuse under the CC BY 4.0 license)

Figure 2 : Heritage buildings (Sourced from the LINZ Data Service and licensed for reuse under the CC BY 4.0 license)

3 Regional Geology

The regional geology is described on Geology of the Taranaki area, GNS 1:250,000 geological map 11 (Townsend, Vonk and Kamp 2008). It indicates the site to be underlain by river gravel and fan deposits.

The geological map also indicates an inferred active fault passes close to the site.

The GNS active fault database (http://data.gns.cri.nz/af/) shows the active Leedstown Fault (#435) passing about 3km to the ESE of the site. The fault is described as a reverse fault with the recurrence interval of >5000 to <10,000 years. No further data is available on the fault.

The Marton anticline, running generally N-S is shown passing about 2.5km to the west of the site.

4 Local Geology

Information on existing groundwater bores from Horizons Regional Council was obtained for bores within a 1km radius of the site. Some of these bores have basic lithology information. From the data available the ground conditions are consistent within the general area, with gravels to about 30 metres below ground level (BGL), underlain by silts, sands and clay. Soft rock (papa) is indicated to be more than 50 metres BGL. The depth to groundwater is noted on four of the bores, and ranges between 52 m and 65 m BGL.

Figure 3 : Bores within a 1km radius of site (from Horizon Regional Council data)

Sewer and water renewal waters have been completed both on Broadway and High Streets in the past 20 years. During the trenching works the ground conditions were found to comprise tightly packed sandy/silty small to medium gravels (P O'Connor, personal communication, 13 March 2019). The trenches were self-supporting, but due to the depth of excavation required trenching shields.

Similar ground conditions are exposed in the steep sides of the Tutaenui Stream as it passes through Marton. This stream is incised into the alluvial gravels by about 3.0 m, and exposures of a weathered gravel can be readily observed.

Photograph 1 : Tutaenui Stream at Russell Street, Marton

5 Ground Conditions

No specific ground investigations have been undertaken as part of this study. Due to a lack of recent development in the Marton CBD area there are little previous investigation records available to help inform this study.

From data that is available and from anecdotal evidence, the ground conditions are likely to comprise alluvial gravels to a depth of about 30 metres below ground level.

The depth to ground water is uncertain, and it is possible that there are perched groundwater levels in the gravels.

6 Site Subsoil Class

GNS Science reported to the Manawatu-Whanganui Lifelines Advisory Group with a report updating its 2005 Risks and Responsibilities report. This report (Dellow, et al. 2016) presented the updated hazards information provided to the Horizons Regional Council for use by the Lifelines Group. Part of this information was the inferred earthquake ground shaking site sub-soil class. The GNS Science maps produced for the above report are only suitable for regional-scale use. Site-specific information including the soil profile with depth is not included in this analysis.

Based on the GNS Science report, and our present knowledge of the local geology, this site is classified as Class D – Deep or soft soil sites as per the NZS1170.5:2004 classification.

7 Ground Shaking

The horizontal PGA for the Marton site has been estimated (Dellow, et al. 2016) using the National Seismic Hazard Model and is presented in Table 1.

Table 1 : Peak Ground Acceleration incorporating inferred site class (from Dellow et al, 2016)

1 in 500 years	1 in 1,000 years	1 in 2,500 years
0.30 – 0.35	0.35 – 0.40	0.45 – 0.50

The *estimated* Modified Mercalli shaking intensity return periods for Marton is given in below. The estimate has been made by interpolation from other nearby centres.

Table 2 : Modified Mercalli shaking intensity return periods in years for Marton

Town	MM7	MM8	MM9	MM10
Marton	c.38	c.160	c.1,750	c.26,000

8 Liquefaction

No specific liquefaction study has been undertaken for Marton as far as we are aware.

Based on the expected ground conditions the liquefaction susceptibility of the site is likely to be low to moderate.

Further data on the density of the gravels and the level of groundwater would be required to assess the risk further.

9 Further Investigations

Should greater certainty as to the specific ground conditions at the site be required for future stages of the project we would recommend two or more boreholes are completed to about 20m depth. The boreholes should include testing as the holes are completed, and at least one should have a standpipe piezometer installed to confirm groundwater levels.

10 References

Dellow, G D, E R Abbott, B J Scott, W F Reis, and B Lukovic. *Update of hazard Information for 2015 Lifelines Risk & Responsibilities Report.* GNS Science Consultancy Report 2016/40, Lower Hutt: GNS, 2016, 33p.

Townsend, D., A. Vonk, and P.J.J. Kamp. *Geology of the Taranaki area: scale 1:250,000*. Lower Hutt: Institute of Geological & Nuclear Sciences Ltd, 2008, 77 p. + 1 folded map .

Appendix B
Seismic Performance of URM Buildings in New Zealand

Seismic Performance of URM Buildings in New Zealand

The following failure modes and structural weaknesses are highlighted as potential issues for the Marton Heritage Precinct. They are some of the common modes of failure and issues in the URM buildings in New Zealand that are observed and reported in the literature after earthquakes.

Information sourced from;

- NZSEE, The Seismic Assessment of Existing Buildings, Technical Guidelines, 2017
- E L Blaikie and D D Spurr, Earthquake Vulnerability of Existing Unreinforced Masonry Buildings, EQC, Works Consultancy Services Limited
- Dmytro Dizhur and Jason Ingham, Seismic Improvement of Loadbearing Unreinforced Masonry Cavity Walls, BRANZ, University of Auckland

Out-of-Plane Wall Failure

Out-of-plane (OOP) loading on URM walls is one of the commonly occurring failure modes. Cracking and more substantial damage due to OOP loading has been observed frequently, even in moderate magnitude earthquakes. Failure results in cracking, bowing of walls, and collapse of the brick.

Figure 1. OOP Failure of URM Wall (BRANZ)

In-Plane Wall Failure

The main in-plane failure models in moderate-strong shaking intensities are reported to be:

- Cracks at the corner of openings
- Vertical and “X” cracking in spandrels and piers
- Horizontal cracking at top and bottom of piers

Diagonal cracking of walls and piers has historically been a serious cause of failure and collapse. In-plane rocking and sliding on horizontal flexural cracks can help absorb earthquake deformations.

Figure 2. In-Plane Failures of URM Wall (NZSEE Guidelines)

Age of Construction and Deterioration over time

It has been observed that ‘newer’ buildings have performed better than ‘older’ buildings, referred to as pre-1930, The implication of this is that deterioration over time, in particular, the mortar and veneer ties, has a large impact in the overall damage that a building might experience.

Diaphragm Flexibility and Strength

The diaphragm flexibility is more often the concern for URM walls instead of the floor diaphragm itself due to reduced lateral restraint at the top of the walls. It has been observed that damage of walls can occur due to excessive deflections of the diaphragm.

Figure 3. OOP Failure due to Diaphragm Displacement (NZSEE Guidelines)

Corner Damage

It has been frequently observed that corners of buildings are susceptible to damage and collapse due to concentrated forces. Vertical cracks at wall junctions can result in a separation of the exterior walls and increases their vulnerability to OOP loading.

Figure 4. Examples of Building Corner Failures (BRANZ)

Falling Hazards

Heavy items such as brick parapets and chimneys are recognised as a serious life safety risk due to their location and support conditions. Heavy ornaments placed at the roof level rely on cantilever actions to resist earthquake locating.

Figure 5. Failure of Secondary Elements (NZSEE Guidelines)

Appendix C
DSA Summary Tables

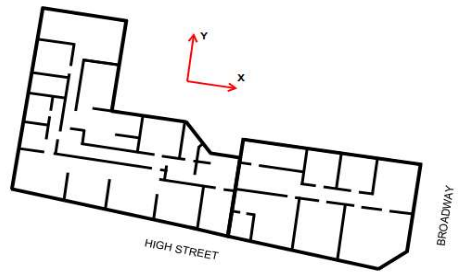
DETAILED SEISMIC ASSESSMENT - SUMMARY OF RESULTS

Cobbler 1 and 2

Marton

14/06/2019

ELEMENT	COMPONENT	CAPACITY/DEMAND RATIO	COMMENTS
URM IN-PLANE	Façade ground level columns	55%	High street side coloumns at base of façade
		25%	Broadway side coulumns at base of façade
	Façade upper level piers	75%	Upper level façade piers - x direction
		30%	Upper level façade piers - y direction
	Rear wall	55%	wall at rear of cobbler addition, covered in vegetation
	Side wall	100%	side wall of cobbler addition with no openings
URM OUT-OF-PLANE	Façade Pier	60%	
	Façade Pier Full Height	45%	
	Façade Pier Cantilever	20%	
	Rear Wall Pier	25%	
	Internal Wall	40%	
COOBLER 1 DIAPHRAGMS	Roof - Parallel	90%	
	Roof - Perp	100%	
	Floor - Parallel	70%	
	Floor - Perp	100%	
COOBLER 2 DIAPHRAGMS	Roof - Parallel	70%	
	Roof - Perp	100%	
	Floor - Parallel	55%	
	Floor - Perp	100%	
PARTS	Parapet - General	20%	
	Parapet - on bed joint	15%	
	Façade Ornament	15%	
	Chimney	15%	
	Canopy Rods	65%	
	Canopy Connections	35%	



BUILDING RATING

CRITICAL STRUCTURAL WEAKNESS

BUILDING

COMMENTS

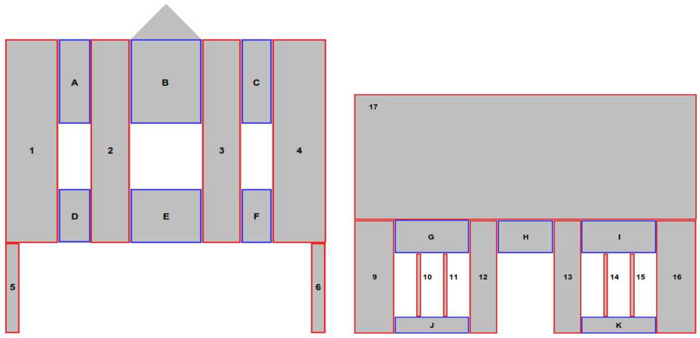
DETAILED SEISMIC ASSESSMENT - SUMMARY OF RESULTS

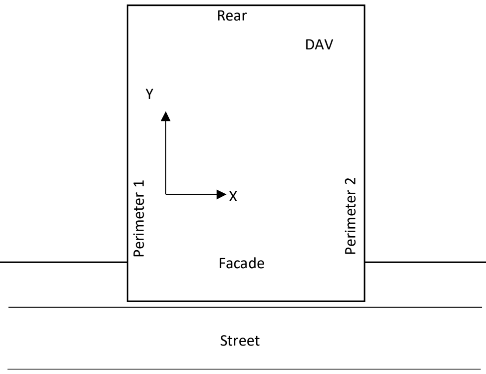
Davenport Brothers

Marton

24/05/2019

	COMPONENT	CAPACITY/DEMAND RATIO	COMMENTS
URM IN-PLANE	Pier 1	100%	
	Pier 2	80%	
	Pier 3	80%	
	Pier 4	100%	
	Pier 7	50%	
	Pier 8	50%	
	Pier 9	20%	
	Pier 12	15%	
	Pier 13	15%	
	Pier 16	20%	
	Pier 17	30%	
	Spandrel A	-	
	Spandrel B	-	
	Spandrel C	-	
	Spandrel D	-	
	Spandrel E	-	
	Spandrel F	-	
	Spandrel G	-	
	Spandrel H	-	
	Spandrel I	-	
	Spandrel J	-	
	Spandrel K	-	
URM OUT-OF-PLANE	Façade Pier	45%	
	Façade Pier Full Height	30%	
	Side Wall	40%	
	Rear Wall	40%	
	Rear Pier	40%	
DIAPHRAGMS	Roof - X Direction	90%	
	Roof - Y Direction	100%	
	Floor - X Direction	70%	
	Floor - Y Direction	100%	
GRAVITY COLUMNS	Timber Columns	100%	
	Cast Iron Columns	100%	
PARTS	Parapet - Solid Section	30%	
	Parapet - Post Section	15%	
	Façade Ornament	25%	
	Canopy	70%	





BUILDING RATING 15-20% NBS (IL2)

CRITICAL STRUCTURAL WEAKNESS Parts and in-plane

COMMENTS

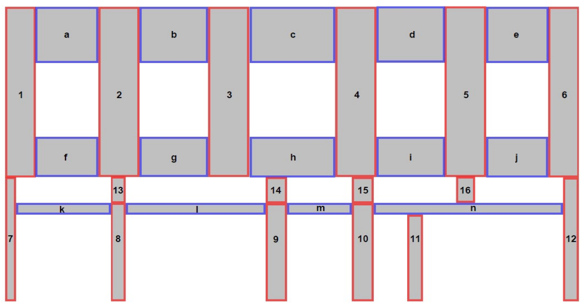
DETAILED SEISMIC ASSESSMENT - SUMMARY OF RESULTS

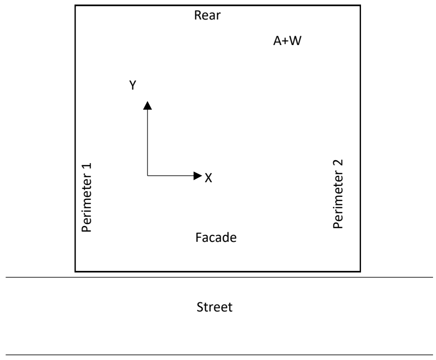
Abraham and Williams

Marton

10/05/2019

	COMPONENT	CAPACITY/DEMAND RATIO	COMMENTS
URM FACADE IN-PLANE	Pier 1	45%	
	Pier 2	30%	
	Pier 3	25%	
	Pier 4	80%	
	Pier 5	15%	
	Pier 6	20%	
	Pier 7	20%	
	Pier 8	30%	
	Pier 9	20%	
	Pier 10	20%	
	Pier 11	15%	
	Pier 12	15%	
	Pier 13	95%	
	Pier 14	100%	
	Pier 15	80%	
	Pier 16	15%	
	Spandrel a	100%	
	Spandrel b	100%	
	Spandrel c	100%	
	Spandrel d	100%	
	Spandrel e	100%	
	Spandrel f	100%	
	Spandrel g	100%	
	Spandrel h	55%	
	Spandrel i	100%	
	Spandrel j	100%	
URM FACADE OUT-OF-PLANE	Pier 1	40%	
	Pier 2	40%	
	Pier 3	40%	
	Pier 4	40%	
	Pier 5	40%	
	Pier 6	40%	
	Full Height Pier	25%	
IN-PLANE PERIMETER WALLS	Perimeter 1	100%	
	Perimeter 2	100%	
	Rear	20%	
OUT-OF-PLANE PERIMETER WALLS	Perimeter 1	25%	
	Perimeter 2	25%	
	Rear	35%	
DIAPHRAGMS	Roof - X Direction	55%	
	Roof - Y Direction	50%	
	Floor - X Direction	100%	
	Floor - Y Direction	100%	
LOCAL FAILURES	Façade Top bay	20%	
	Façade Corner	20%	
	Rear Wall Corner	20%	
PARTS	Parapet	25%	
	Canopy	55%	
	Chimney	15%	





BUILDING RATING 15-20% NBS (IL2)

CRITICAL STRUCTURAL WEAKNESS Building parts and in-plance piers

COMMENTS

Appendix D
Earthquake Prone Building Assessment Table

1. **Building Information**	
Building Name/ Description	Abraham and Williams Davenport Brothers Cobblers
Street Address	304-310 Broadway, Marton 312 Broadway, Marton 314-318 Broadway, Marton
Territorial Authority	Rangitikei District Council
No. of Storeys	Two
Area of Typical Floor (approx.)	300 m^2 200 m^2 500 m^2
Year of Design (approx.)	1915 1905 1913-1914
NZ Standards designed to	NA
Structural System including Foundations	**Roof –**Roof diaphragm consists on timber trusses with horizontal timber sarking and light-weight steel roofing iron. **Lateral Load Resisting System –** Unreinforced 3 wythe thick brick masonry perimeter walls (no cavity), concrete bond beams at floor and roof level. Ground level of the façade consists of brick columns **Foundations –** URM Brick strip footings under wall locations with a concrete bedding, brick pads for floor joist supports.
Does the building comprise a shared structural form or shares structural elements with any other adjacent titles?	The building are within a row of unreinforced brick masonry buildings. Both side walls of the structure are either immediately adjacent or shared with the neighbouring structures
Key features of ground profile and identified geohazards	The soil is classified as class 'D'
Previous strengthening and/ or significant alteration	Internal layouts of buildings have been altered over time Mezzanine floor levels and false ceilings have been added
Heritage Issues/ Status	Historic Place Category 2, List numbers 1240, 1243, 1244
Other Relevant Information	NA

2. Assessment Information	
Consulting Practice	WSP Opus
CPEng Responsible, including: • Name • CPEng number • A statement of suitable skills and experience in the seismic assessment of existing buildings[1]	Brendon Cornell Principle Structural Engineer CPEng 1154597 (Australia) Brendon is a Principle Structural Engineer with 20 years of consulting engineering experience and is a technically skilled design manager across a wide range of engineering projects. He has undertaken numerous seismic assessments, which forms part of his practice area.
Documentation reviewed, including: • date/ version of drawings/ calculations[2] • previous seismic assessments	- Original Drawing of Abraham and Williams, Marton, Drawing No. 1 - Original Drawing of Cobblers stage 2
Geotechnical Report(s)	NA
Date(s) Building Inspected and extent of inspection	February 2019 – Full building investigation of external and internal walls, including photos, brick and mortar scratch tests, and measurements. March 2019 – Drone survey/mapping of the building exterior.
Description of any structural testing undertaken and results summary	Onsite scratch testing of bricks and mortar in distributed locations as per section C8 of the guidelines to determine the relative hardness of the materials. It was found that the brick and mortar were in 'medium' condition.
Previous Assessment Reports	NA
Other Relevant Information	Cracking was observed at the corners of the window openings at the upper level of the Abraham and Williams façade.

[1] This should include reference to the engineer's Practice Field being in Structural Engineering, and commentary on experience in seismic assessment and recent relevant training

[2] Or justification of assumptions if no drawings were able to be obtained

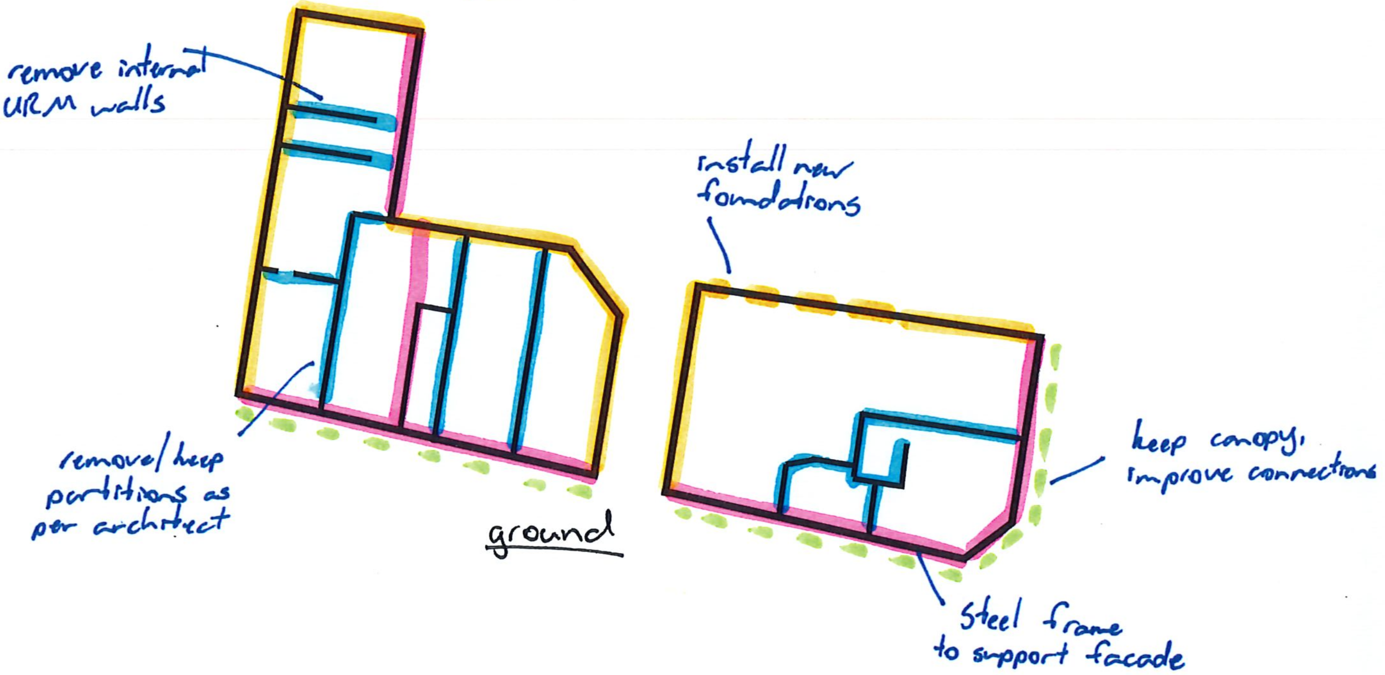
3. Summary of Engineering Assessment Methodology and Key Parameters Used	
Occupancy Type(s) and Importance Level	Importance Level 2
Site Subsoil Class	Subsoil Class D – NZS1170.5
For a DSA:	
Summary of how Part C was applied, including: • the analysis methodology(s) used from C2 • other sections of Part C applied	The seismic assessment of the unreinforced brick masonry walls was carried out using a force based approach, using tributary areas to calculate the demands on the URM walls. The façade was modelled in SAP2000 and ETABS to determine axial loads, demands, and building performance. Displacement critical failure modes, such as out-of-plane capacities of URM walls, were assessed using the methods outlined in section C8 of the Guidelines. Parts such as chimneys and roof members were assessed using parts loading in accordance to NZS1170.5
Other Relevant Information	No

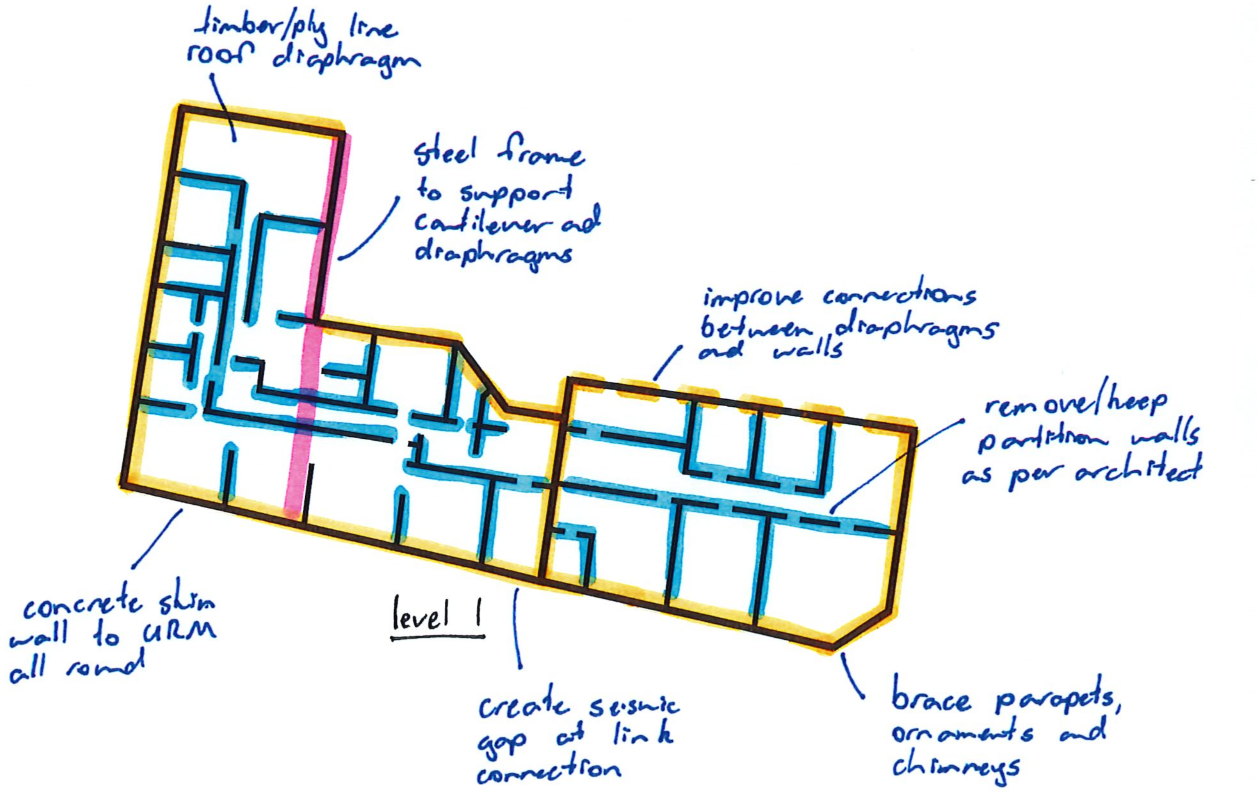
4. Assessment Outcomes		
Assessment Status (Draft or Final)	**DRAFT**	
Assessed *%NBS* Rating	15% NBS (IL2)	
Seismic Grade and Relative Risk (from Table A3.1)	E, Very high risk	
<u>For a DSA:</u>		
Comment on the nature of Secondary Structural and Non-structural elements/ parts identified and assessed	**Parapet** – The buildings contain cantilever URM parapets supported at roof level. **Canopy** – The canopies are supported by the façade with weathered and deteriorated connections. **Chimneys** – URM chimneys extend above the URM walls and roof.	
Describe the Governing Critical Structural Weakness	The governing critical structural weaknesses of the buildings are: **- Out-of-plane capacity URM elements.** The unsupported URM cantilever elements such as the piers, chimneys, and parapets are at risk of collapse under low seismic loads, which would result in falling masonry on footpaths and access ways. **- In-plane capacity of façade piers.** The geometry and condition assessment of the masonry piers leads to these elements being vulnerable to rocking and toe-crushing failure. This would result in a loss of lateral load resisting system and potential collapse.	
If the results of this DSA are being used for earthquake prone decision purposes, <u>and</u> elements rating <34*%NBS* have been identified (including Parts)[3]:	**Engineering Statement of Structural Weaknesses and Location** In-plane and out-of-plane capacity of the façade unreinforced masonry piers and parapets	***Mode of Failure and Physical Consequence* Statement(s)** Loss of lateral load resisting system from pier failure, falling masonry units on footpaths and access ways.
Recommendations (*optional for EPB purposes*)		

[3] If a building comprises a shared structural form or shares structural elements with other adjacent titles, information about the extent to which the low scoring elements affect, or do not affect the structure.

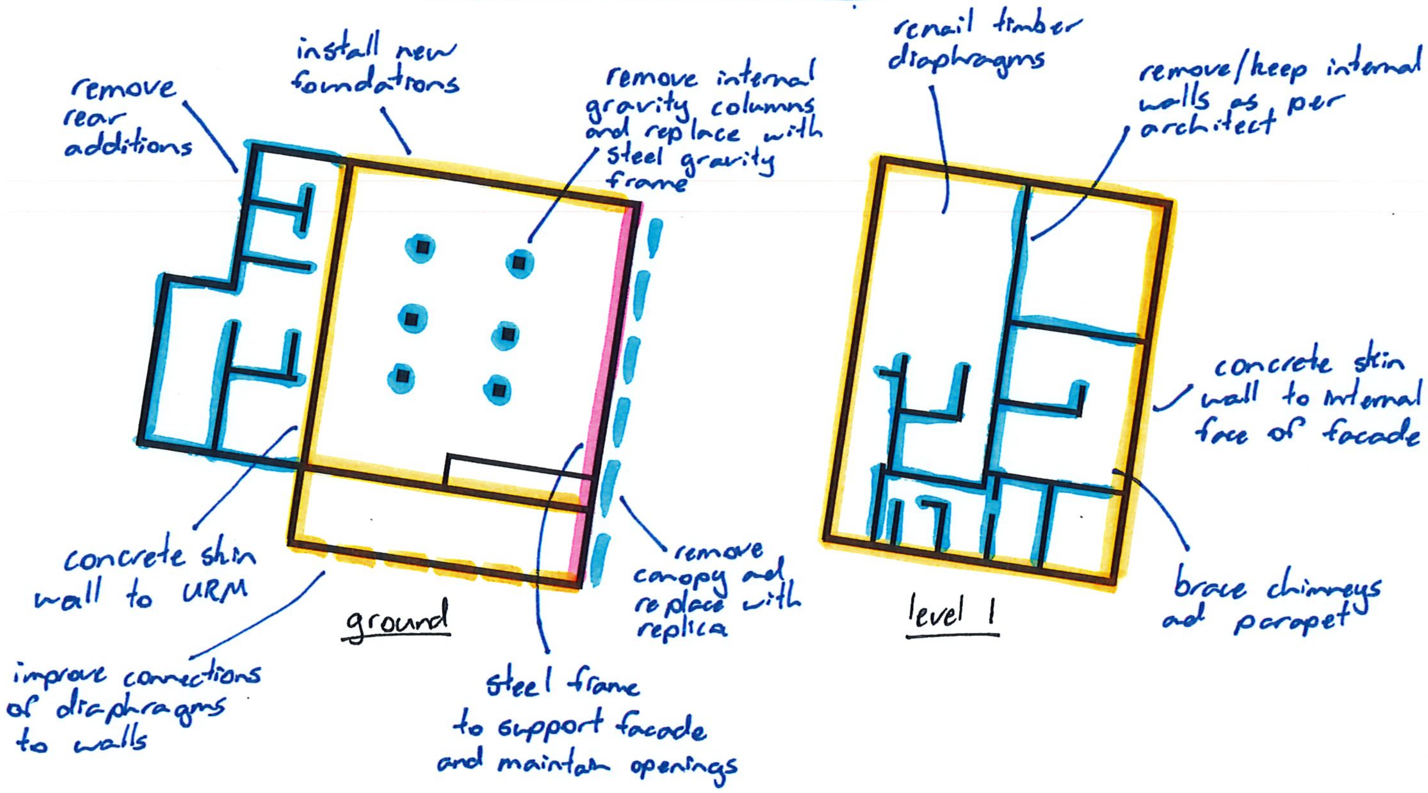
Appendix E
Concept Strengthening Sketches

COBBLERS

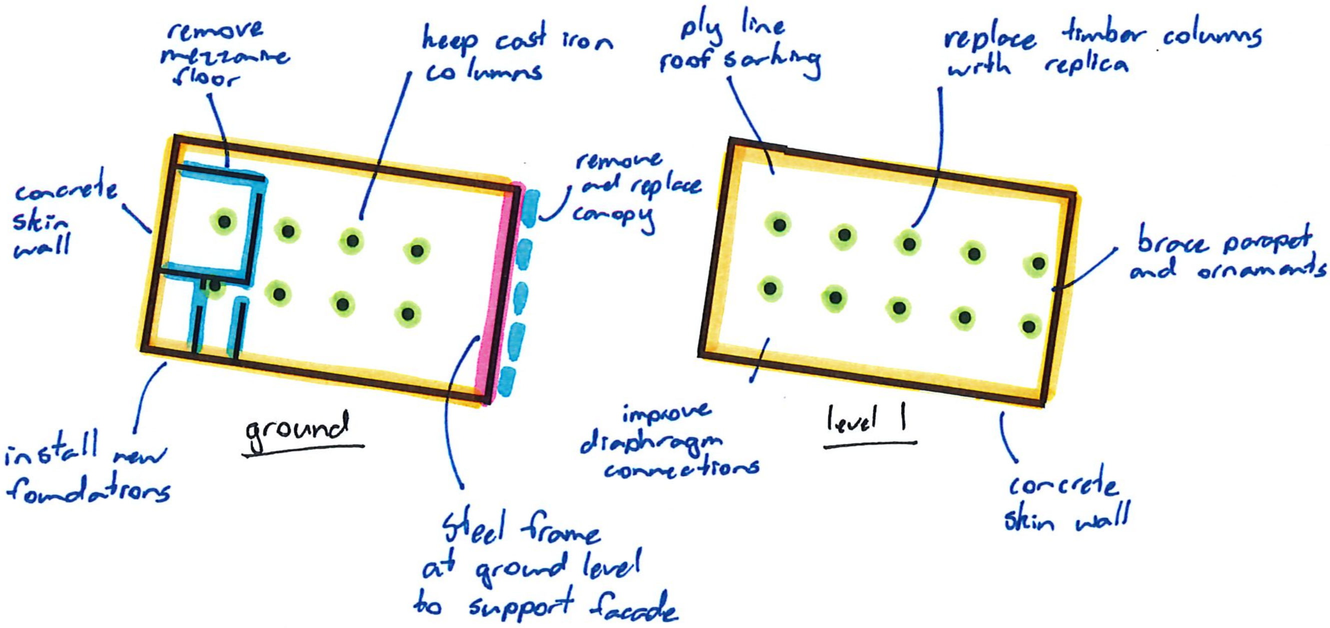

remove internal URM walls
install new foundations
remove/keep partitions as per architect
ground
keep canopy, improve connections
steel frame to support facade


timber/ply line roof diaphragm
steel frame to support cantilever and diaphragms
improve connections between diaphragms and walls
remove/keep partition walls as per architect
concrete skin wall to URM all round
level 1
create seismic gap at link connection
brace parapets, ornaments and chimneys

ABRAHAM AND WILLIAMS



DAVENPORT BROTHERS



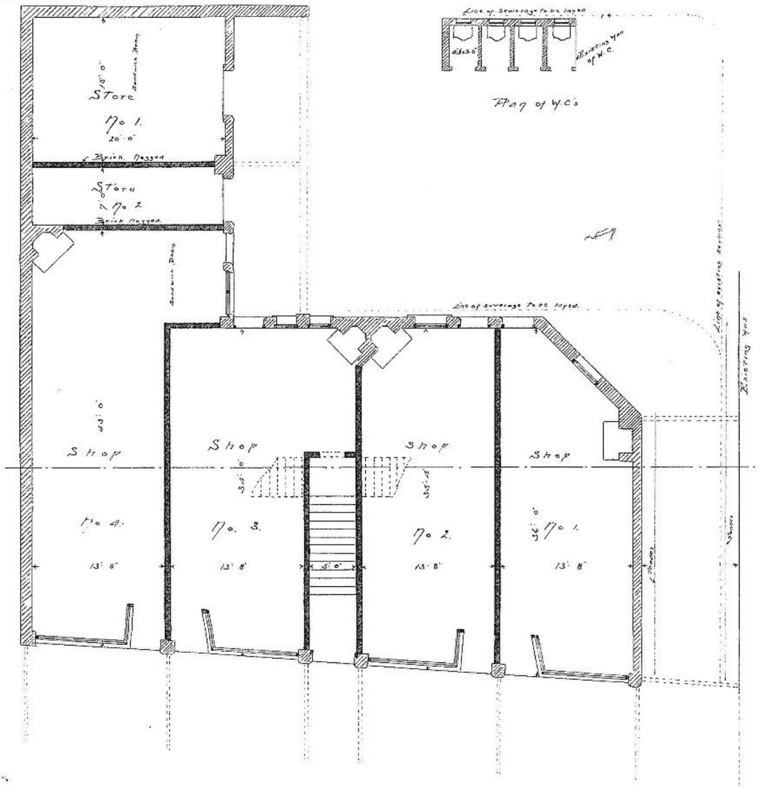
Appendix F
Original Drawings

Abraham and Williams
Cobbler Addition

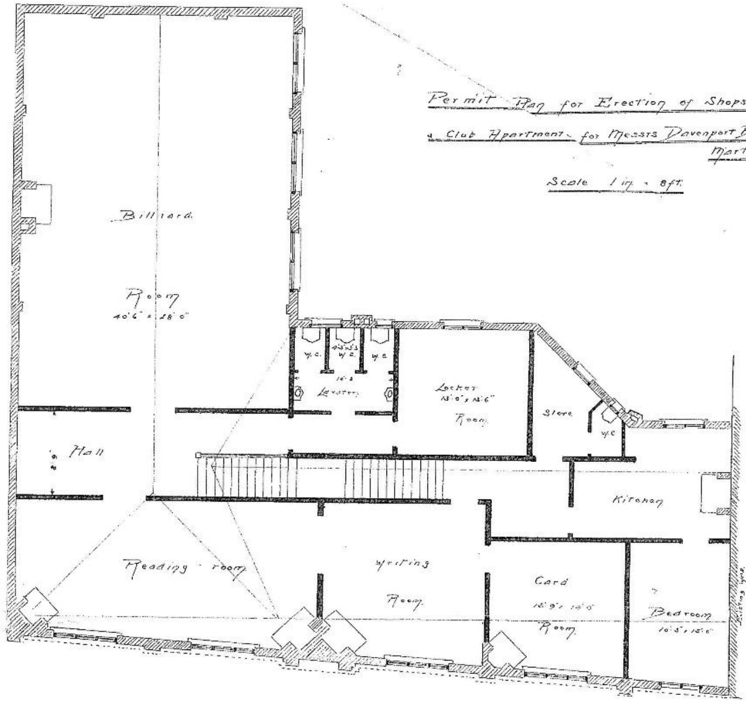

NEW · BUILDING — MARTON
MESSRS ABRAHAM & WILLIAMS LTD
FRONT ELEVATION
SECTION CC
SECTION AA
SECTION BB
SCALE 8 FEET TO AN INCH
EXISTING STORE
OFFICE
GENERAL OFFICE
STRONG ROOM
SHOP
ROOM
PUBLIC
STORE
LAND OFFICE
GROUND PLAN
FIRST FLOOR PLAN

Permit Plan for Erection of Shops
& Club Apartment for Messrs Davenport Bros
Morton

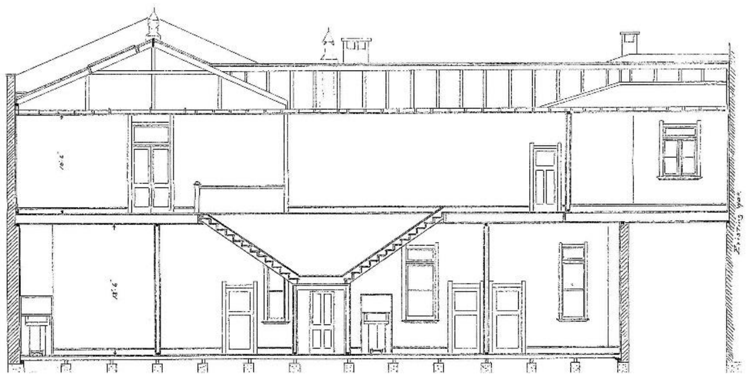
Scale 1 in = 8 ft.



Ground Floor Plan



First Floor Plan



LAND TRANSFER OFFICE.

RECEIVED: 22/11/23 PROVL No. 6521

TITLE REF.: C.T. Vol 11 fol 217

REFERRED TO DRAUGHTSMAN: 22/11/23

L.T. DRAUGHTSMAN.

EXAMINED: A.D.D. 10.12.23

TRAV. REDns.: VOL. LXXXII, FOL. 1-2

FIELD-BOOK: No. 75, PAGE 244

COMPn. Bk.: No. ______, REPORT No. ______

REF. PLANS: A/3126

FILE:

FOR SURVEYS UNDER THE LAND TRANSFER ACT ONLY.

BOROUGH OF MARTON

6521

This space to be reserved for Deposit No.

DEPOSITED this 18th day of December, 1923.

[signature] District Land Registrar.

WELLINGTON DISTRICT LAND REGISTRAR NEW ZEALAND

K903

Place Deposit Stamp here.

MCA

Total Area A. R. P. 0 : 0 : 10.41

The Marton Borough Council hereby approves of this plan of subdivision as required by section 335(1) of Municipal Corporations Act 1920. Such approval is without reservation. In Testimony whereof The Common Seal of The Marton Borough Council is hereby affixed this Ninth day of November 1923

Fred Purnell Mayor

A.W. Bill Councillor

A.H. Kingge Town Clerk ~~Councillor~~

Approved,

Saml. J. Davenport

German M Davenport

Applicant [or Registered Owner].

Approved as to Survey.

M. Waters for Chief Surveyor, 17/12/1923

Plan of subdn of part of Lot 1A of Sec. 17 (A/3126) Rangitikei Agricl Res.
Block III, Rangitoto S.D. (Township of Marton)

Comprised in C.T. 11/217

Surveyed by P.R. Earle, Licensed Surveyor, October, 1923

(Field-work by ______, Authorized Assistant.)

SCALE: 30lks to an inch.

DECLARATION.

I, Percival Richard Earle, of Hunterville, Licensed Surveyor, do solemnly and sincerely declare that this plan has been made from surveys executed by me ~~[or under my own personal supervision, inspection, and field check]~~, and that both plan and survey are correct, and have been made in accordance with the regulations of the Surveyors' Board, dated the 5th day of August, 1907.

And I make this solemn declaration conscientiously believing the same to be true, and by virtue of the provisions of the Justices of the Peace Act, 1908.

Declared at Hunterville, this 25 day of October, 1923

before me,— W. Haydon Maclean Justice of the Peace [or Solicitor, or Notary Public]

P.R. Earle Licensed Surveyor.

THREE SHILLINGS

6521