Circa 1930s

Circa 1950s

Circa 2010s

STRUCTURAL REPORT

MASTERTON DISTRICT COUNCIL MUNICIPAL BUILDING & TOWN HALL

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Structural Report on the Masterton Town Hall and Masterton Municipal Building

Prepared for

Masterton District Council

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Executive Summary

- The Town Hall and Municipal Building had a detailed seismic assessment completed in 2004 by Spencer Holmes. This report rated the buildings at 40%NBS based on a soil type of 'C'.
- The calculations completed for this report confirm the results of the Spencer Holmes review. Recently provided Geotechnical information for the Wairarapa region indicates that the soil type is 'D'. This means the Spencer Holmes result of 40%NBS becomes a result of 30%NBS for the now confirmed Wairarapa soil types.
- There are three structures on the site, with the focus of this report the 1915 Hall and Municipal building (ie the civil defence structure is not included in this report).
- A structural review has been completed to determine what is required to improve the seismic compliance of the Hall and Municipal Building.
- The works required to improve the Hall are substantial, and appear to be of a scope similar to constructing a new Hall structure.
- The works required to improve the seismic performance of the Municipal building to a minimum of 80%NBS are as shown in the attached plans S1-S24 tilted 'Seismic Improvement Scheme, Masterton Municipal Building'. The street façade will be retained and re-supported. The scheme will require demolition of portions of brick walls, and the complete stripping of internal finishes to allow for construction.
- The final structural and architectural requirements of the project will be dictated by the future desired use of the site.

Contents

1. Overview of the Site

The site is home to three structures in total, as shown in the aerial photo below. This report focuses on the original Municipal and Town Hall buildings, outlined in red and hatched below.

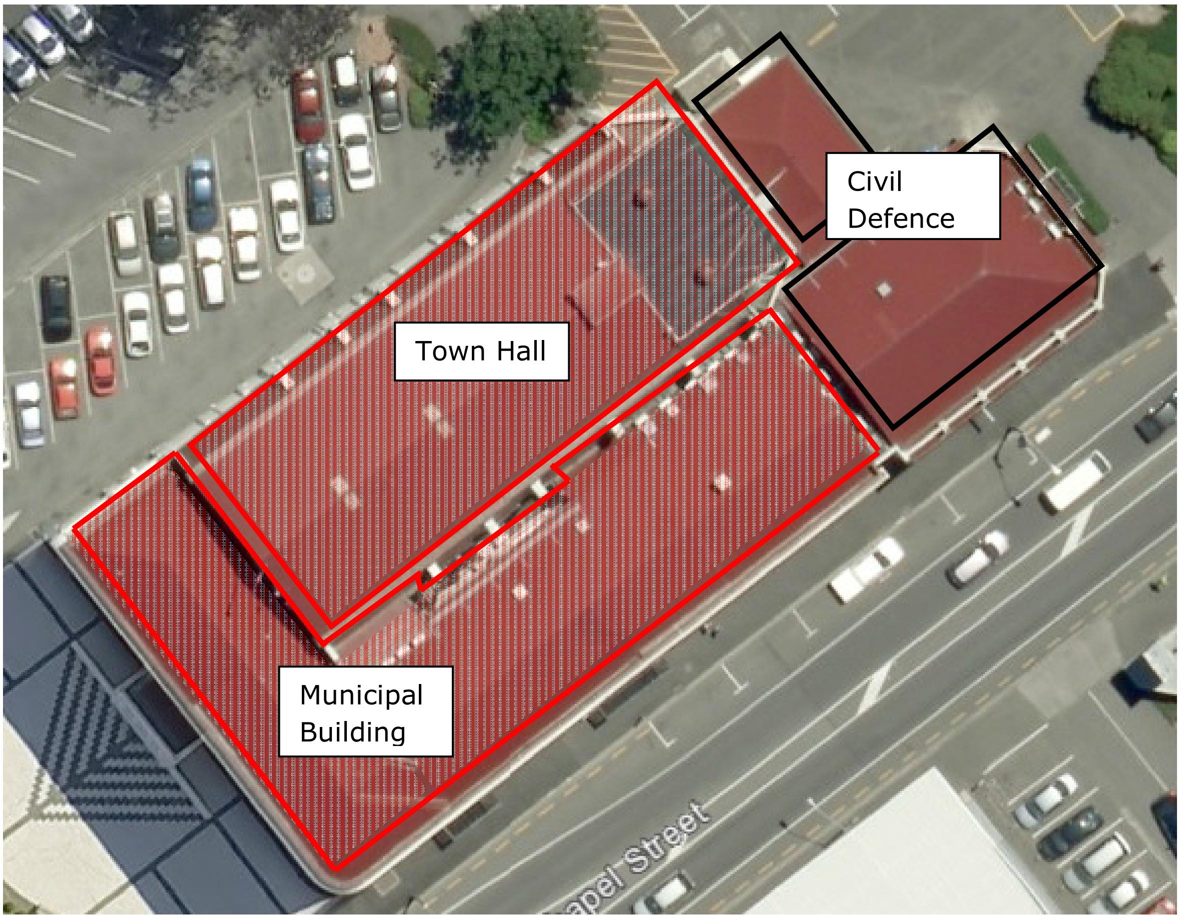

Figure 1 – Aerial photograph

The Civil Defence buildings were constructed in 1984 as an extension to the Municipal buildings.

2. History of the Structure

The Town Hall and Municipal building were constructed in 1915. The structure was originally of unreinforced masonry (URM) construction, typical of the era. There have been several additions to the original structure, namely the civil defence building and a rear extension to the main hall. This report focuses on the Hall and Municipal building, indicated in the aerial photograph above.

Though there is some connectivity between the Town Hall and Municipal building, they are in essence two structures. As such, each structure is discussed individually.

2.1 Original Construction

2.1.1 Masterton Town Hall

The Masterton Town Hall was originally an unreinforced masonry (URM) structure. The hall was formed with timber trusses spanning between the external URM side walls. The side walls were 20′ (6.1m) high and were typical for the era, with 9″ (230mm) brick structural walls and a 4½″ (115mm) brick veneer separated by a 2″ (50mm) cavity. The external side wall had 14″ brick piers at each truss location.

At the front of the Town Hall building there is a two storey section, housing the entrance on the ground floor, and a cloak room and lounge above.

Figure 2 – Masterton Town Hall Circa 1920s

Figure 3 – Original Section through hall and municipal building

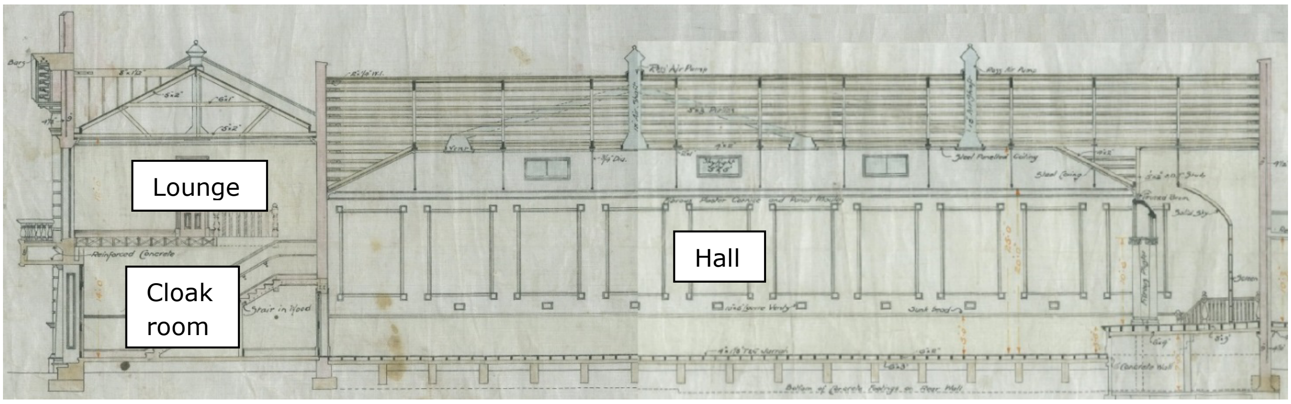

Figure 4 – Original Section through Town Hall

2.1.2 Masterton Municipal Building

The Municipal Building was also constructed of unreinforced masonry (URM) walls. It is a two storey building, with a ground floor stud height of 14’ (4.3m) and a first floor stud height of 12’ (3.6m).

The ground floor has an entry section with concrete slab on grade, however the majority of the floor structure is timber. The first floor is formed by timber joists spanning between steel beams which are in turn supported on the brick walls.

The original floor plan for the building showed multiple internal brick walls on both the ground floor and first floor.

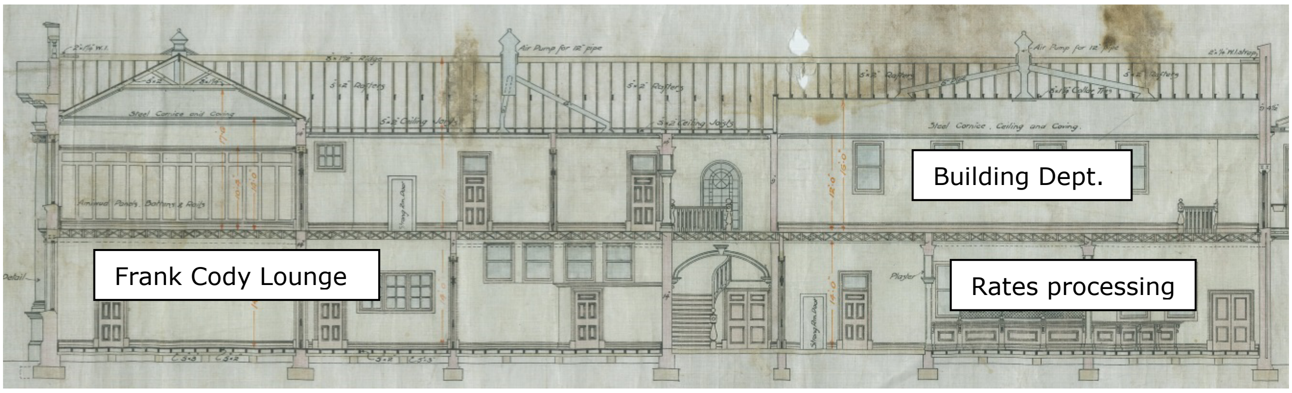

Figure 5 – Original Section through Municipal building

The Municipal building was originally separate from the Hall structure, with an open void between the buildings.

Figure 6 – Photo of roof – note space between the Hall & Municipal Building

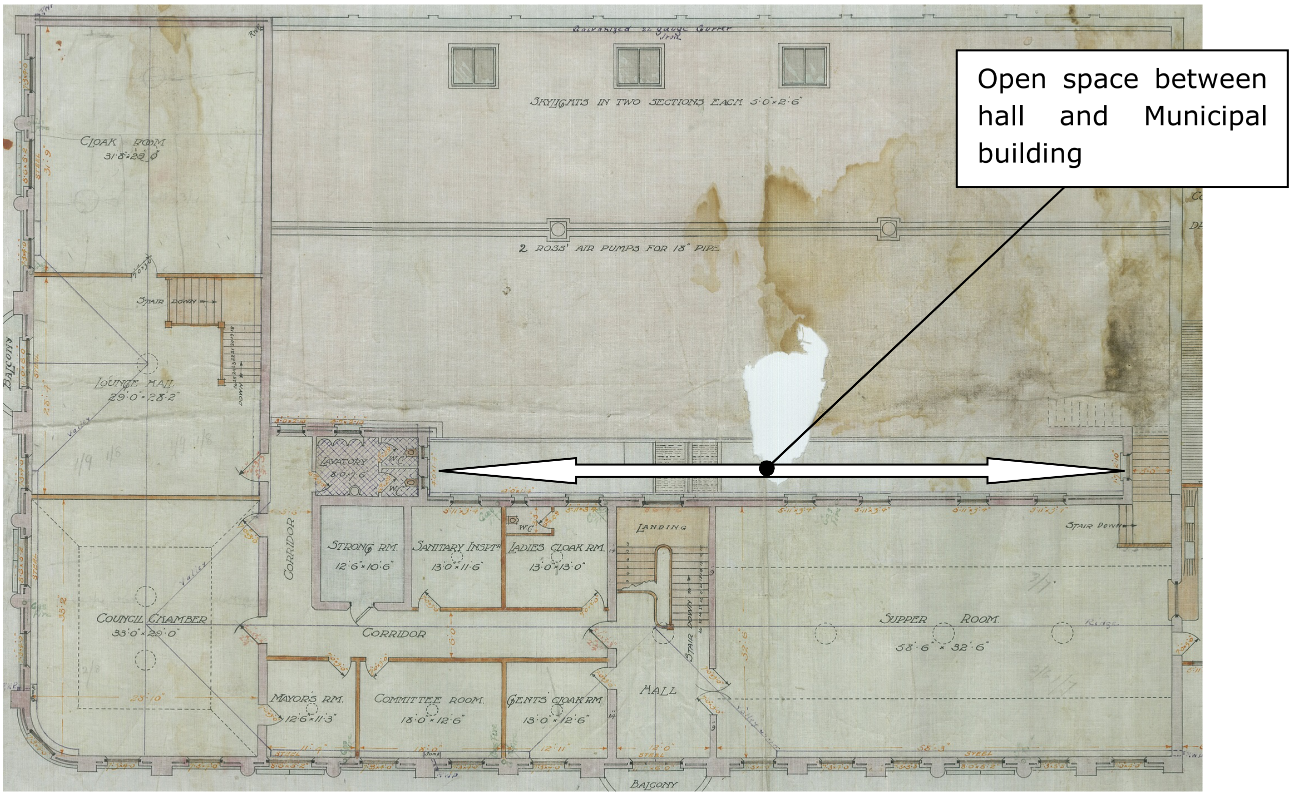

Figure 6 – Original 1915 First Floor Plan – note space between hall and offices

2.2 1942 Wairarapa Earthquakes

In 1942, the Wairarapa was subject to two earthquakes. The earthquakes are estimated to have provided moderate shaking levels compared to current design standards, however they caused a reasonable amount of local damage.

The Municipal building suffered some damage at the time, with a photograph available of the Chapel St frontage. This photograph shows damage to the parapets on Chapel St, with brick sections falling to the street.

Figure 7 – Post 1942 earthquake showing minor damage.

The Masterton Borough Surveyors report on the 1942 earthquake damage noted the following in regards to this building:

"This is a very large building with exceptionally massive brick frontages to Chapel and Perry Streets. There are brick partition walls in the office portion, but the continuity of the structure is badly broken by several large chambers. Although it suffered little damage in this earthquake, it can only be classed as a bad public risk. The extremely heavy street parapets, together with ornamental cornices etc should be taken down immediately, and the earliest opportunity seized of equipping the building with a carefully designed system of reinforced concrete framing."

2.3 1954 Strengthening / Refurbishment / Extensions

In response to the above, the building was subjected to substantial works in the 1950s.

2.3.1 Masterton Town Hall

The Town Hall had a major alteration as part of these works. The entire roof was lifted by approximately 5.2m. This was achieved by placing reinforced concrete components through the original brick structure. New concrete frames were constructed across the width of the hall at regular centres. Around the external perimeter of the hall a new concrete parapet was constructed, supported by the original URM walls.

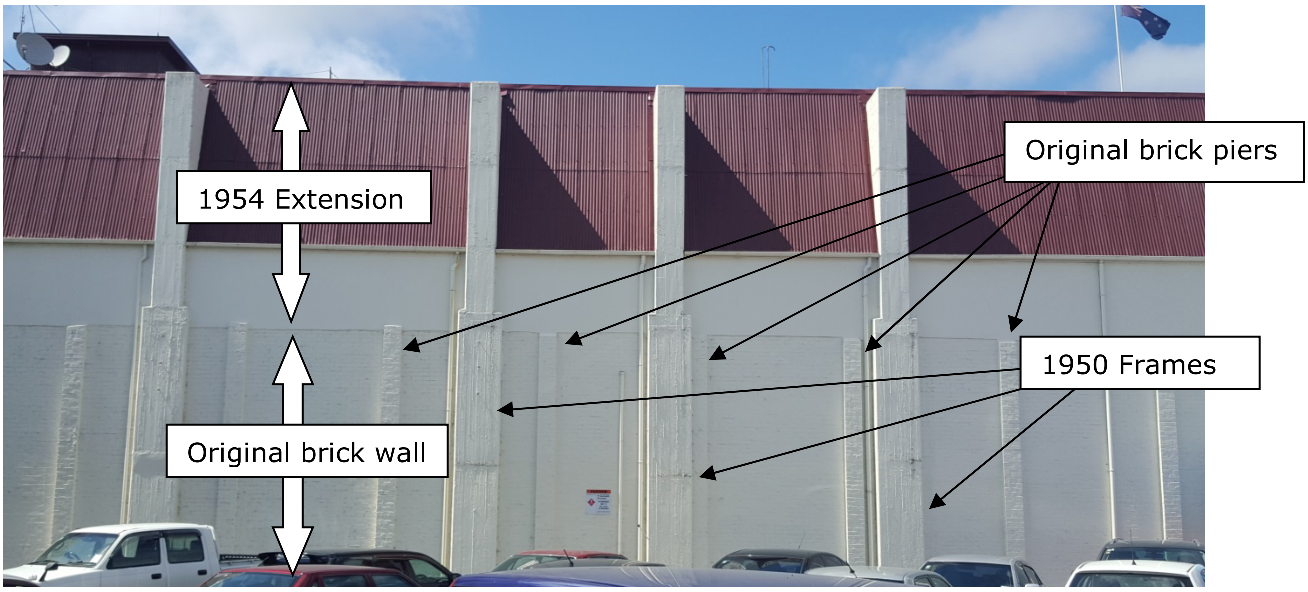

Figure 8 – Side wall of Hall – new frames marked, original brick side wall visible

The frames are reasonably well detailed for their era, however they are lightly reinforced.

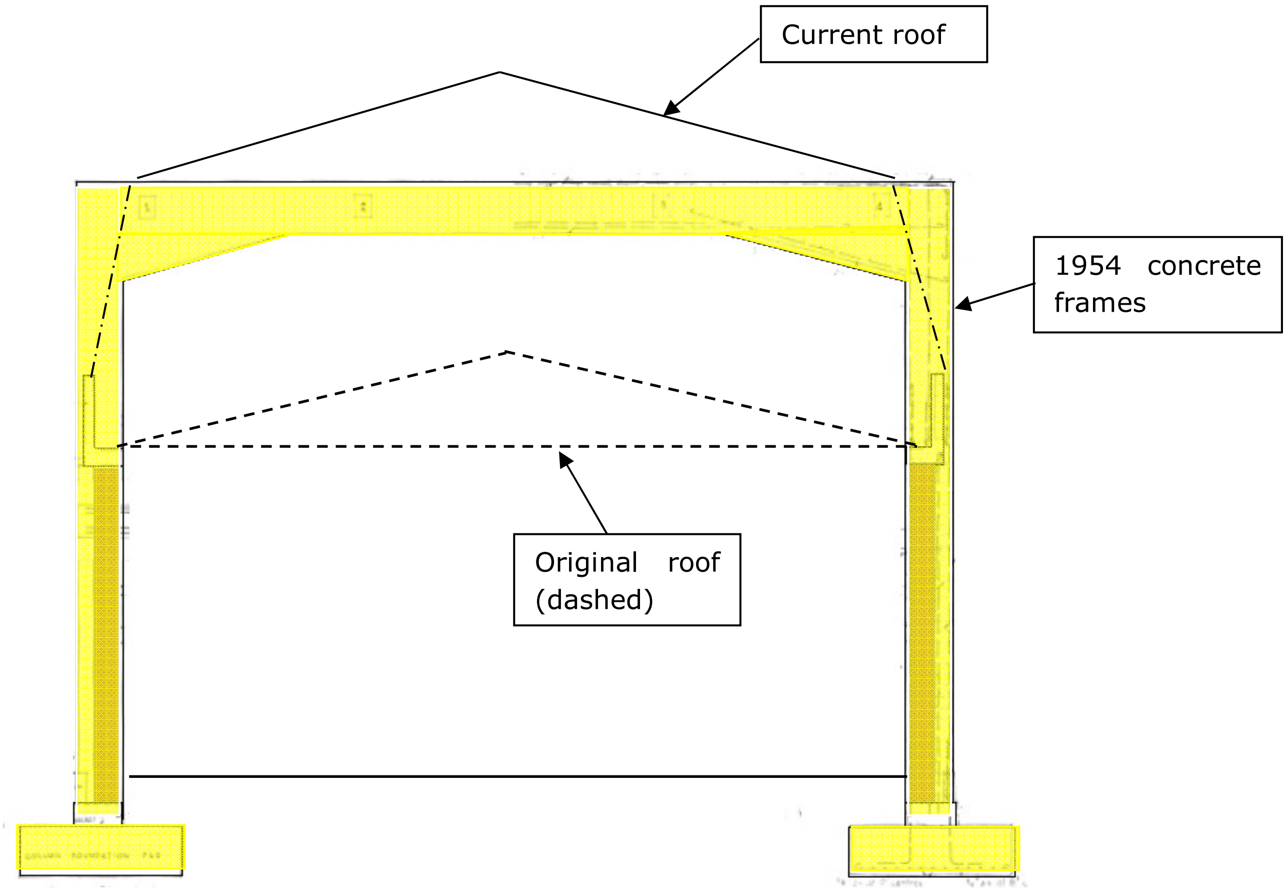

Figure 9 – Hall Transverse Frames

The rear of the Town Hall was extended to form the current stage area. This extension was formed with reinforced concrete walls. The quality of the construction is typical of the era, with areas on "boney" concrete visible and exposed sections of reinforcing steel.

Figure 10 – Rear of Hall showing reinforced concrete extension

Figure 11 – View of hall extension "boney" concrete – poorly vibrated concrete resulting in exposed aggregate.

New elevated seating was erected which is supported on a fabricated steel beam spanning across the hall. A new projector room was also constructed. This projector room is formed with reinforced concrete walls, floor and roof. It is supported at the rear via the original brick wall, and the front by two slender reinforced concrete columns

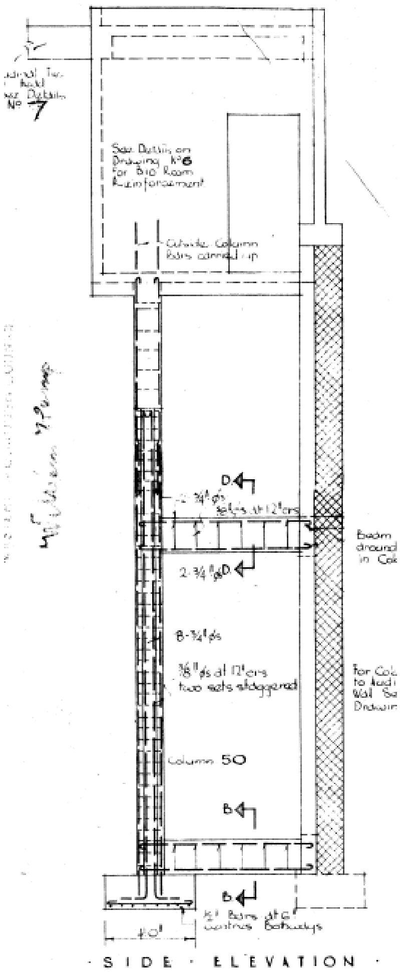

Figure 12a – Elevation of the projector room, showing the heavy concrete 'box' supported on the URM wall at the rear and on concrete columns at the front.

Figure 12b – Projector room

Figure 12c – Poor construction details evident in this beam to column joint

2.3.2 Masterton Municipal Building

To address the seismic risk presented by the Chapel and Perry Street URM frontages, a new reinforced concrete façade was constructed.

The original building façade consisted of a 9" thick URM wall with a brick veneer on a 2" cavity. During these works, the brick veneer was removed, and a 'skin' of reinforced concrete was wrapped around the building façade. The façade concrete is doubly reinforced and reasonably well detailed for its era.

On the inside of the building structural steel elements were placed hard against the brick wall. Steel rods were used to sandwich the original brick between the new reinforced concrete and the new steel members.

Though the façade (shown in yellow in figure 13) had a complete and substantial reinforced concrete 'skin' wrapped around it, the rear wall line (shown in red in figure 13) of the Municipal office building was left largely as original, (ie 9" thick brick with veneer). The rear wall lines had reinforced concrete bands installed in and around the brick work. The bands do not form a complete frame system, and are offset where required to accommodate the original structure. There is some poor quality construction in these concrete components.

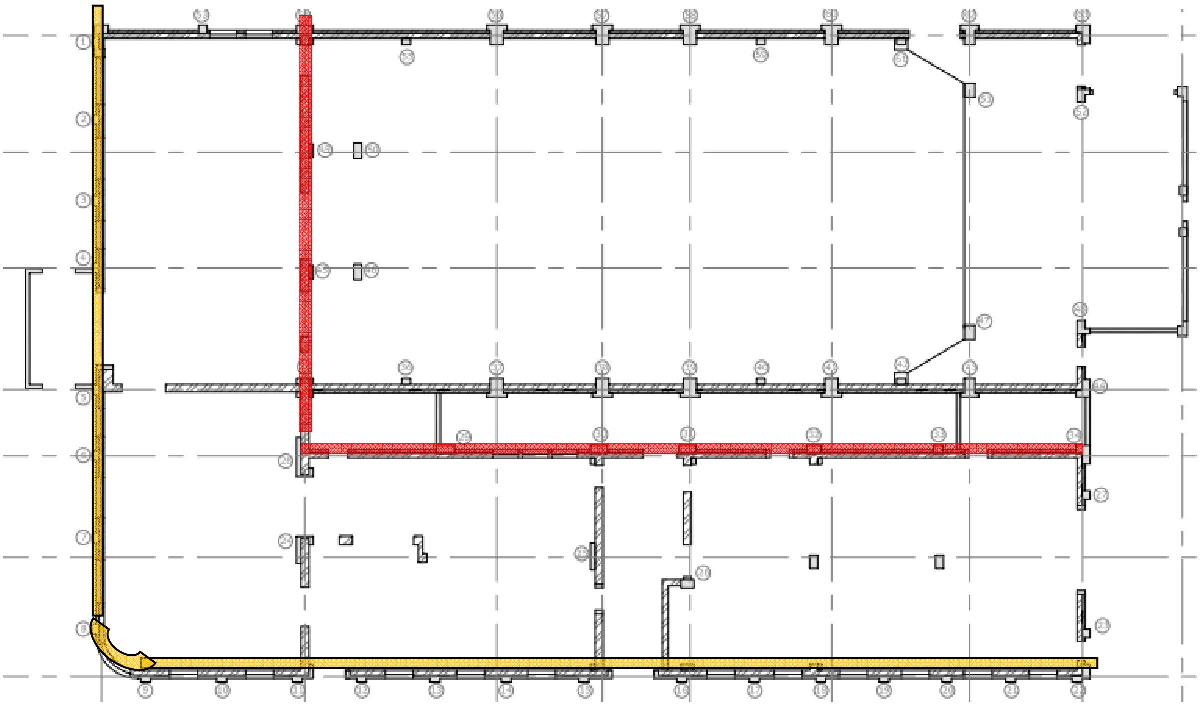

Figure 13 – Ground floor plan. Façade concrete highlighted yellow. Rear wall line shown in red.

This means that the lateral load resisting system along these external wall lines is still original 9” brick wall.

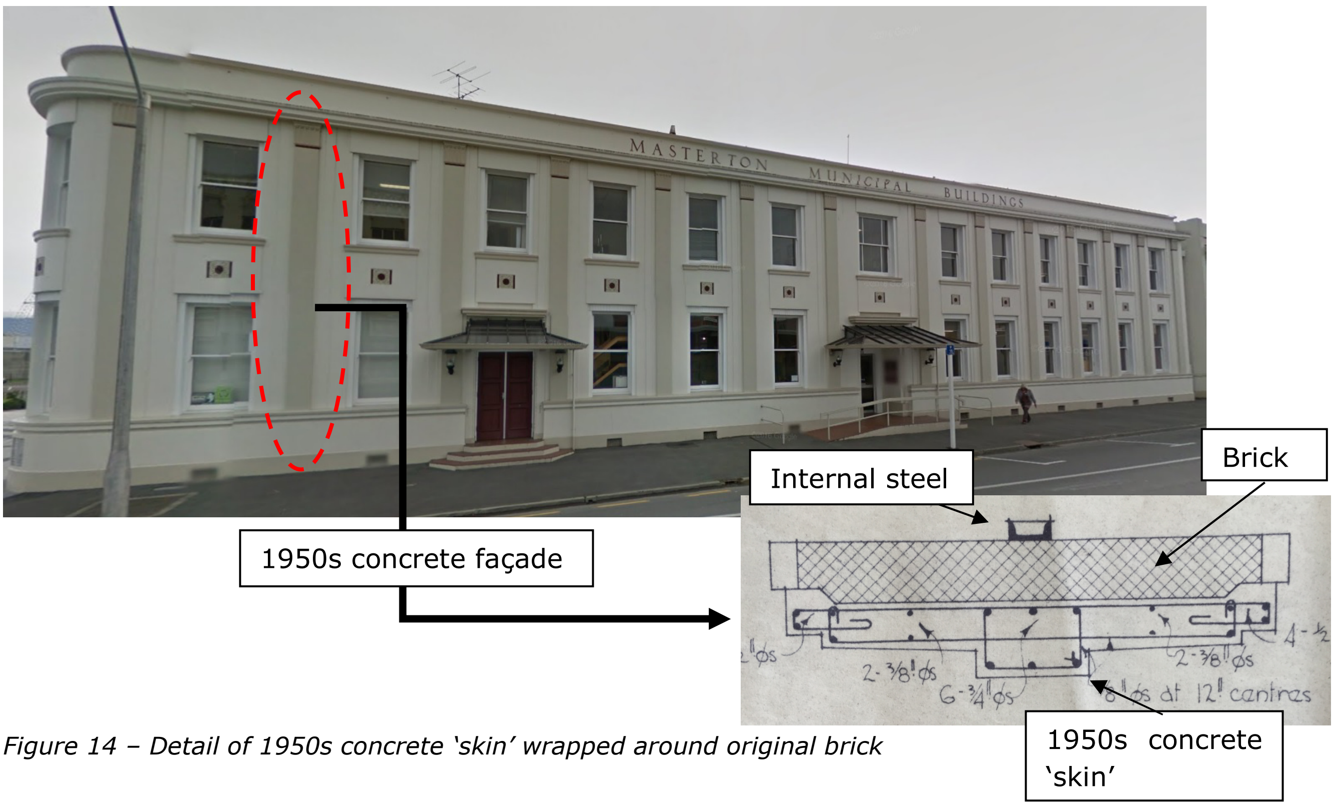

Figure 14 – Detail of 1950s concrete ‘skin’ wrapped around original brick

Figure 15 – External view of wall line at rear of Municipal building (shown in red in figure 13)

Also during the 1950s strengthening work, on the first floor of the Municipal building the roofing was extended over the void between this building and the Hall. Floor joists were placed across the void to form additional office floor space. The first floor brick wall was entirely removed from this section of the building.

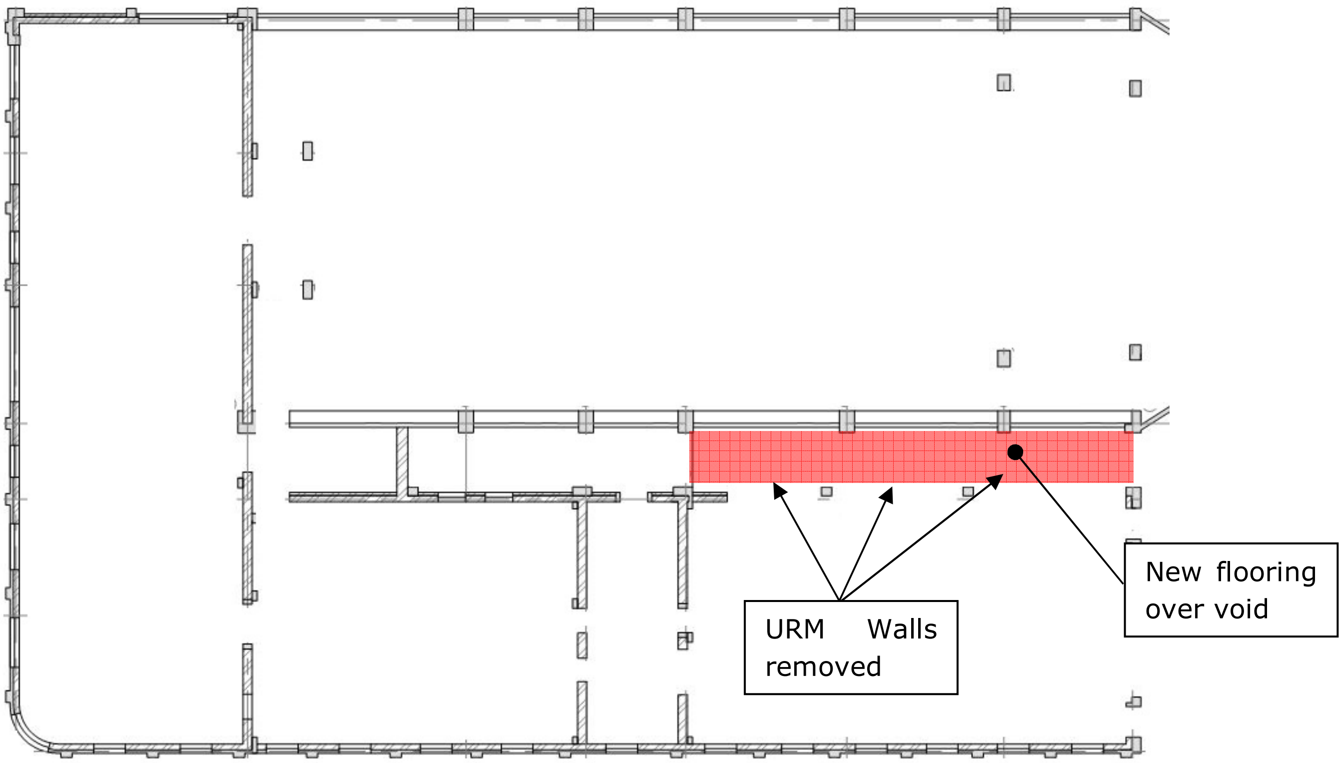

Figure 16 – First Floor Plan after 1950s work – note walls removed

The Hall and the Municipal building are two different structures, ie one has very high concrete frames in the transverse direction (see figure9), while the other is two storied with in-plane URM walls. This means the buildings are likely to move out-of-sync relative to each other during an earthquake. The new flooring spans the void between the two buildings, and is supported on a stringer attached to the Hall. This means there is a potential loss of gravity support to this section of flooring during a seismic event.

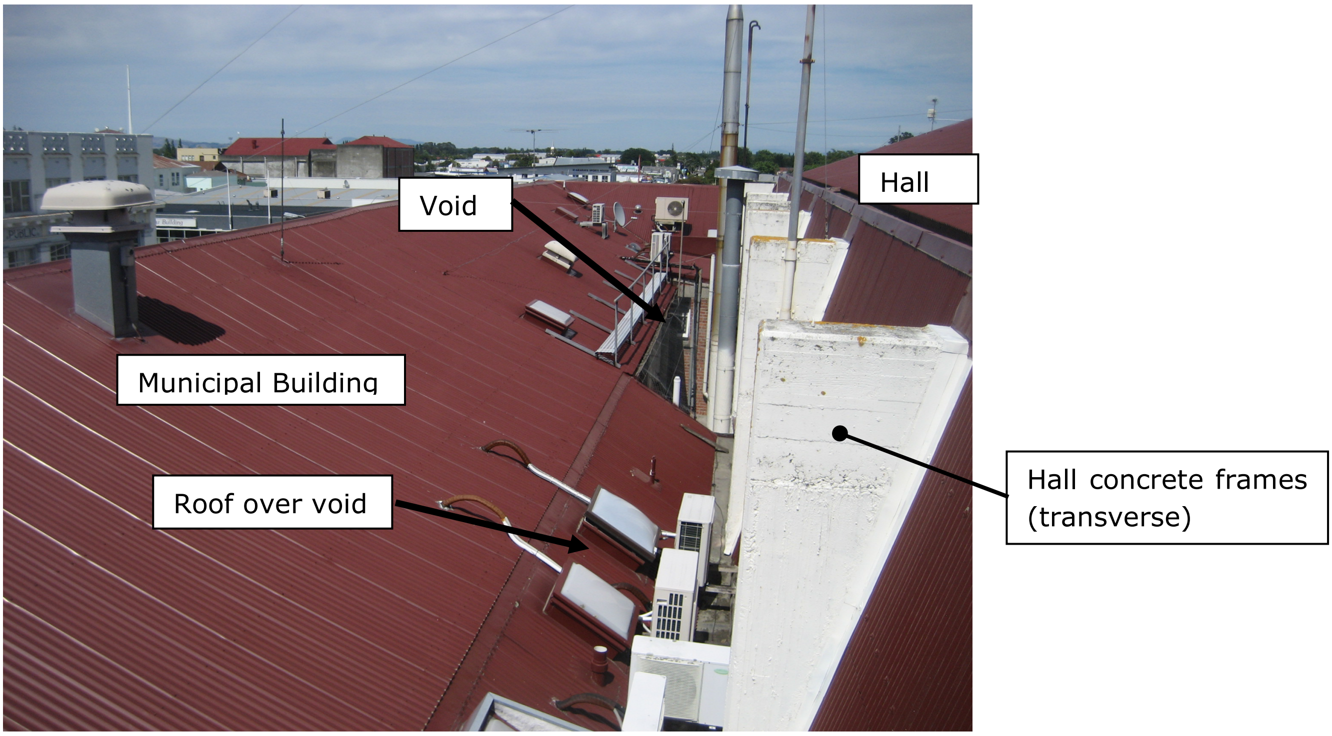

Figure 17 – Roof Plan – note new roof bridging the gap between the Hall and Municipal Building

2.4 Alterations between 1954 to Present Day

2.4.1 Masterton Town Hall

The Town Hall building appears to be as per the 1950 structural plans. An alteration to the staging area was recently completed, with minor structural works.

The ground floor foyer area of the front two storey hall area has been subject to alterations. These involved removing internal URM walls on the ground floor.

2.4.2 Masterton Municipal Building

The Municipal Building has also had ongoing alterations, particularly to the ground floor. Internal sections of URM wall have been removed as required to accommodate refurbishments.

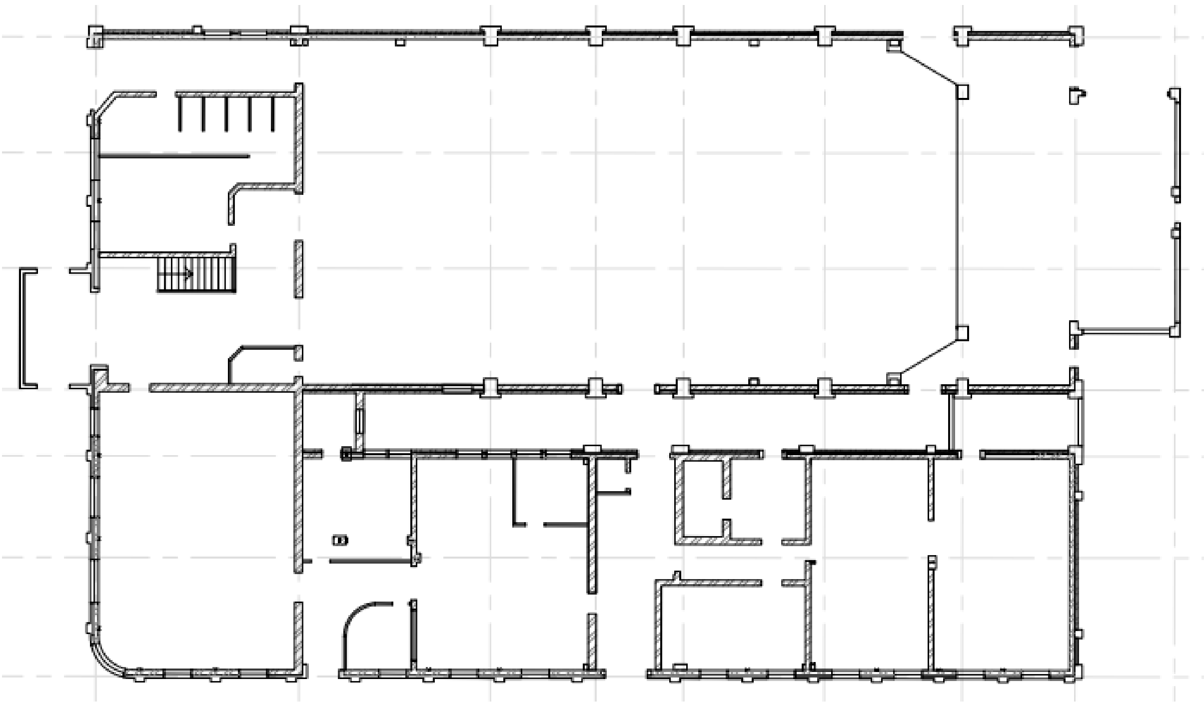

Figure 17a - Circa 1920s floor plan

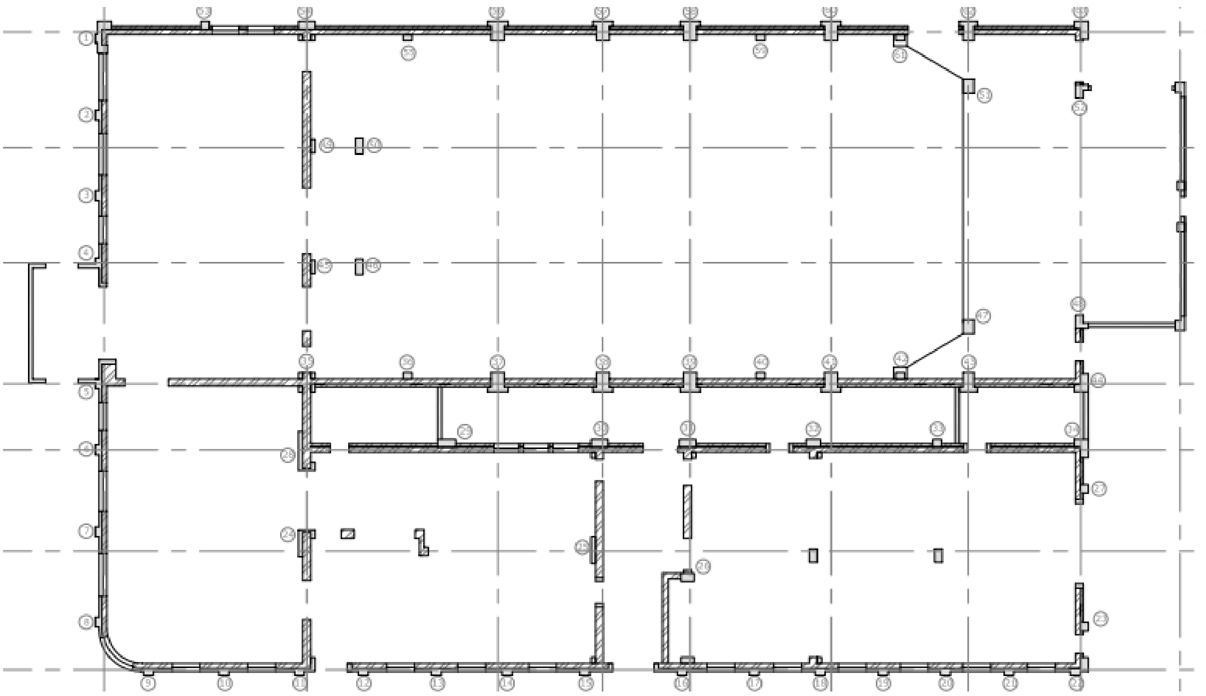

Figure 17b - Current floor plan – note internal walls removed

3. Previous Structural Reviews Completed

In 2007, Spencer Holmes completed a report on the Town Hall and Municipal buildings. The assessment completed at this time appears to have been an overview of specific structural components in the building. The report notes that the site was assessed as a sub-soil class ‘C’ soil.

In 2008, GNS Science provided a draft sub-soil map for the greater Wellington region. This map designates the Masterton urban area as sub-soil class 'D'.

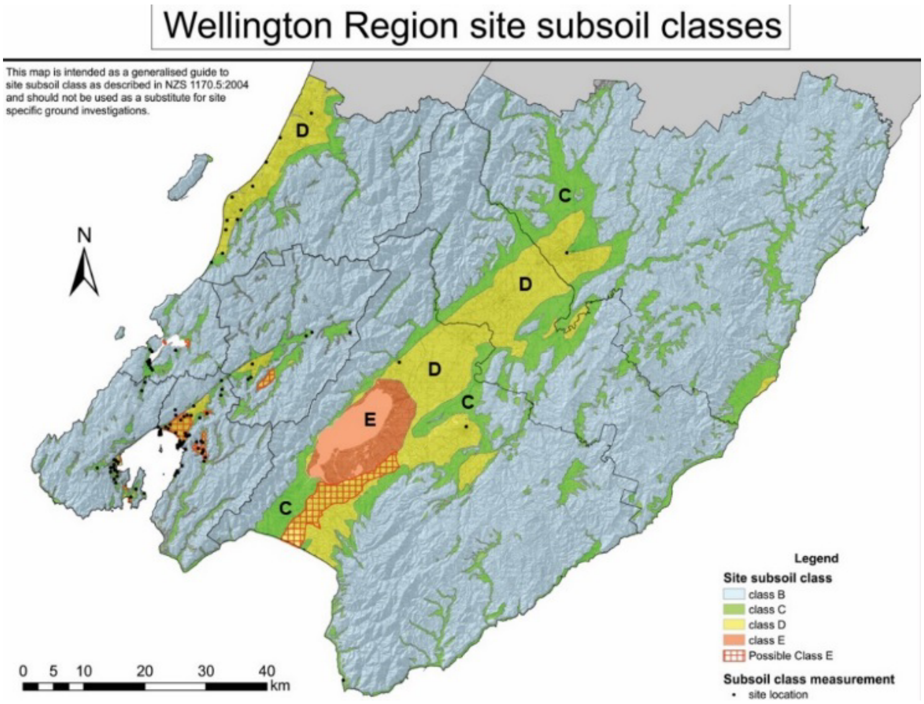

Figure 18 – DRAFT GNS sub-soil map for the Wairarapa

For seismic design, the site sub-soil class directly influences the magnitude of forces a building must be designed for. A structure being designed on a site with a sub-soil class of 'D' must be designed for approximately 30% greater loads than the same structure on a site with a sub-soil class of 'C'.

The Spencer Holmes report notes that with a soil type of 'C', the building achieves 40% New Building Standard (NBS). Modifying this figure to allow for the load increase due to a soil type 'D' would provide a compliance level of approximately 30%NBS.

4. Structural Load Resisting System

The Loadings Code AS/NZS1170 tells an Engineer what loads a building must be designed for based on the Importance Level of a building. Importance level is determined by the use of the building. For example, a hospital is considered Importance Level 4, while a farm shed is Importance Level 1. The Hall has been assessed as Importance Level 3 as it contains an area where over 300 people can congregate. The Municipal Building has been assessed as Importance Level 2.

A structure must be designed to resist lateral (sideways) loads in both orthogonal directions, ie 'across' the building, and 'along' the building. The capacity of each direction needs to be independently assessed.

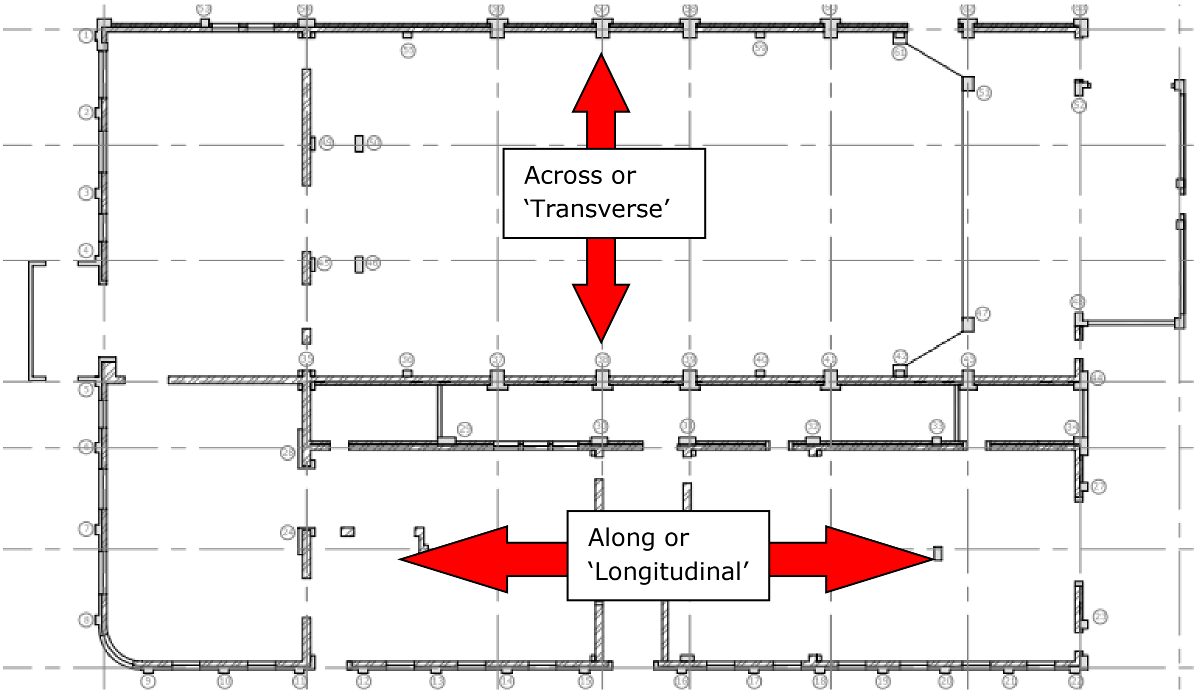

Figure 19 – Floor Plan showing 'along' and 'across'.

This report will also reference walls acting 'in-plane' and 'out-of-plane'. The following figure illustrates these concepts.

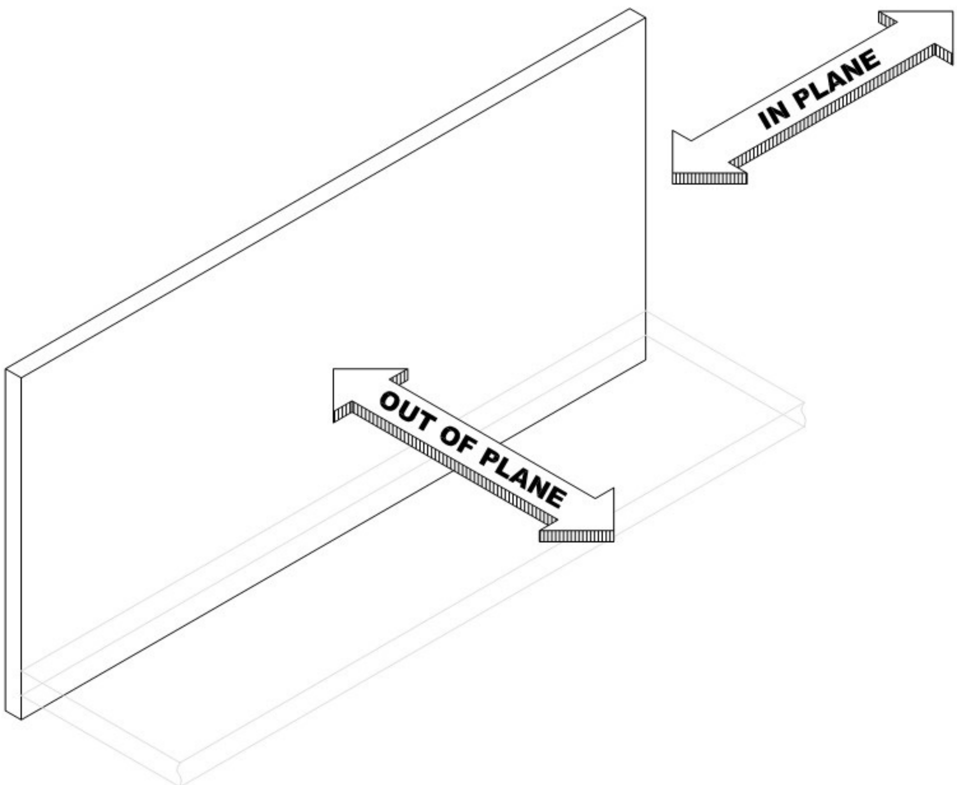

Figure 20 – Schematic Illustrating In-Plane vs Out-Of-Plane.

4.1.1 Town Hall

The Town Hall resists lateral loads in the transverse direction via the 1950s reinforced concrete frames. The frames are tall, with light levels of reinforcing.

In the longitudinal direction the seismic loads are resisted via the original brick walls acting in-plane. Above the brick walls the reinforced concrete frames will resist loads by bending about their weak axis.

4.1.2 Municipal / Office Building

The municipal / office building lateral loads are resisted by the URM wall sections acting in-plane. The first floor and roof level diaphragms support out-of-plane elements and transfer loads to the in-plane walls.

5. Assessment of Existing Structure

We have assessed the building in accordance with the NZSEE "Guidelines for Assessment and improvement of the Structural Performance of Buildings in Earthquakes". The seismic demand has been calculated using the New Zealand design standard AS/NZS 1170.

The assessment has been completed based on a two-dimensional analysis using the structural analysis program Microstran.

Material properties used were as follows;

- Concrete strength – 25MPa
- Reinforcing Steel grade – 300MPa

5.1 Town Hall

5.1.1 Transverse Direction

The capacity of the Town Hall frames in the transverse direction has been reviewed. The ductility of the concrete frames was assessed using Response2000, adopting a maximum concrete strain of 0.04. This provided an available section ductility of 2. The mechanism for these frames is yielding in the columns.

The frames were also limited by the capacity of the connection to the footings. Though this was not identified to provide a loss of gravity support, it may produce an undesirable failure mechanism.

Additional load is placed on the rear frame by the elevated seating at the rear of the Hall. This frame however also lacks the capacity to accommodate the additional loads placed on it.

In the transverse direction, the Hall frames are able to achieve 25-30%NBS. Note that this correlates well to the Spencer Holmes assessment of 40% for Soil Type C.

5.1.2 Longitudinal Direction

In the Longitudinal direction the loads at roof level are taken by the frame columns bending about their weak axis above the parapet line. The loads are then taken by the brick walls acting in-plane.

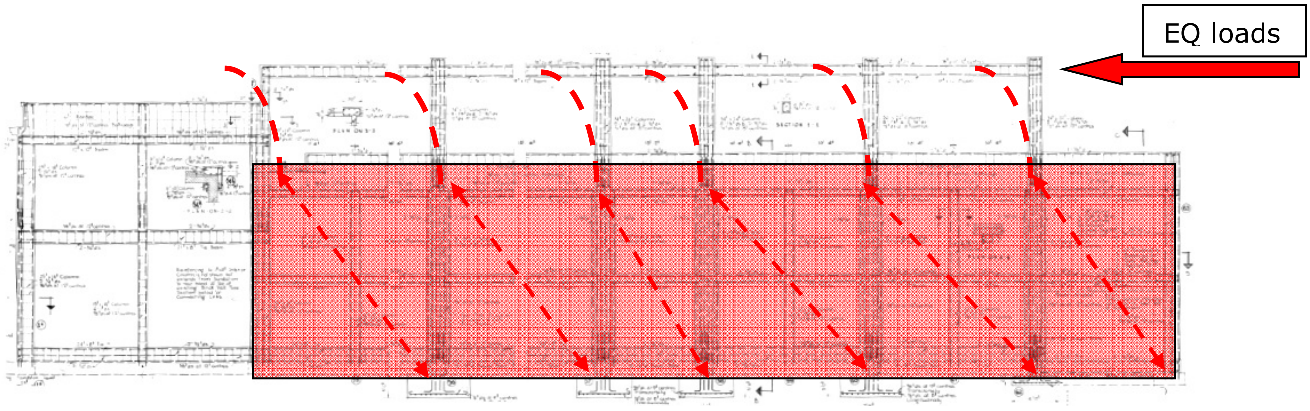

Figure 21 – Schematic of Longitudinal Load path through Town Hall Side Walls

A similar ductility has been allowed for the frame columns in this direction as that used for the transverse assessment. Based on this, these columns are able to accommodate 100% of seismic demand.

In-plane there are long lengths of unperforated URM walls. These walls are also able to accommodate 100% of seismic demand. This also correlates well to the Spencer Holmes assessment of 115% for Soil Type C.

5.2 Municipal Building

5.2.1 Transverse Direction

The façade is supported out-of-plane by the diagonal timber sarking at roof level, and the timber flooring at first floor level. The sarking and flooring act as a diaphragm and transfer loads to the walls acting in-plane. The removal of internal URM walls has compromised the capacity of the building in this direction.

It is worth noting that this may help explain why the building suffered minor damage in the 1943 earthquake series. The internal URM walls would have reduced the span required of the sarking and flooring to act as a diaphragm. The additional wall lengths in plane would have provided additional resistance to seismic loads.

Removing these wall elements has had the effect of increasing the seismic demand on the diaphragms, and reducing the structural elements available to resist seismic loads.

5.2.2 Longitudinal Direction

In the longitudinal direction, the internal URM walls are supported out-of-plane by the timber sarking at roof level and the timber flooring at first floor level. As per the above, the sarking and flooring act as a diapraghm and transfer loads to the façade and rear wall which are acting in-plane.

5.3 Summary of Assessment Results

The following table summarises the assessment results. Note that Appendix A (attached) has several sketches provided which illustrate these results.

Element	**%NBS**
TOWN HALL (Importance Level 3)	
Transverse	
Transverse Frames across Hall (Grids D, E & F)	25%NBS
Transverse Frame supporting elevated seating (Grid C)	20%NBS
Support to the Projector Room	10-20%NBS
Rear wall in-plane	75%NBS
Longitudinal	
Columns bending about their weak axis	100%NBS
URM walls acting in-plane	100%NBS
Rear wall out-of-plane	25%NBS
MUNICIPAL BUILDING (Importance Level 2)	
Transverse	
Diaphragm at roof level	30-35%NBS
Diaphragm at First floor level	30-35%NBS
Façade acting out-of-plane, spanning between roof and first floor, and first floor and ground.	100%NBS
Connection of façade to diaphragms	20-30%NBS
Ground floor URM wall sections in-plane	Grid H – 60%NBS Grids D & E – 60-65%NBS
First floor URM wall sections in-plane	Grid E - 35%NBS Grid D – 60%NBS
Longitudinal	
Diaphragm at roof level	90%NBS (if continuous)
Diaphragm at First floor level	100%NBS (if continuous)
Façade acting in-plane	100%NBS
Ground Floor URM sections out-of-plane	100%NBS
First floor URM sections out-of-plane	30%NBS

Table 1 – Summary of Assessment Results

5.4 Areas with a Potential Loss of Gravity Support

There are local areas within the structure which may be susceptible to a loss of gravity support during a seismic event.

These areas are highlighted in the attached Appendix A sketch titled 'Potential gravity support issues under seismic displacements'.

The main area is the flooring which has been erected over the void between the Hall and the Municipal building. This flooring is supported on a stringer bolted to the hall, and has been previously discussed.

The next is between grids B and C, where floor joists span from the façade to an internal beam adjacent to an in-situ slab section. The joists have only nominal seating on the central beam, and there is no tie across to the in-situ concrete slab adjacent. The in-situ slab sections are tied to the Hall.

The above items are vulnerable to movements expected during an earthquake.

6. Scheme to Improve

The scheme plan developed aims to utilise as much beneficial strength as possible from the existing structural fabric. The schemes are outlined in the attached plans S1-S24 tilted 'Seismic Improvement Scheme, Masterton Municipal Building'.

The following main concepts have been used to shape the scheme;

- The finished structural system should maintain an open floor plan. Over the last 60 years wall sections have been removed from the ground floor and first floor to accommodate internal fit-out. It was considered that a strengthening scheme which proposes to enclose spaces would not be future proof.
- Retain as much of the first floor and wall structural fabric as possible.
- Incorporate the existing façade with minimal changes to the external appearance of the critical line along Dixon St and fronting the Town Square.
- A minimum of 80% New Building Standard was considered.

In general, the aim is to separate the original buildings into three seismically separated structures. The configuration of the structures means that damage will occur where structured with differential stiffness are joined together.

To control this expected damage, it is proposed to separate the buildings. The proposed options for each section are discussed below.

6.1 Town Hall

The Town Hall presents challenges in regards to seismic improvements. The high open spaces must be maintained for the Hall to function. This means that the type of improvements are limited to the existing frame geometry.

The critical issue for the Town Hall is the transverse direction. We have reviewed options to optimise the existing structure, including;

- An assessment of the existing frames' ductility to ensure the correct failure mechanism and likely performance is accounted for.
- Removing the existing brick wall components to reduce the weight and therefore the seismic demand on the frames.
- Remove the existing concrete parapets to reduce weight as per above point.

However due to the configuration of the existing frames the above measures are unable to provide a significant improvement to the seismic performance of the Hall.

The requirements for the Hall would be to basically replicate the existing 'frames'. This would involve;

- Removing all internal wall and ceiling linings
- Cutting into the existing brick section
- Excavating locally for new foundations
- Constructing the new transverse frames. Full scaffolding would be required at each location to allow for construction.

The intrusiveness and scope of these works means the existing hall would be stripped back to a structural skeleton, cut into, and then re-built.

The extent of the works would be similar to that required to construct a new hall structure.

6.2 Municipal Building

The Municipal building scheme relies heavily on making the best use of the existing structural features of the building. These include;

- The 1950s reinforced concrete street façade, being reasonably well detailed and in good condition.
- The 1950s façade has cast-in structural elements which have been adopted into the scheme to secure the façade out-of-plane
- The location of the existing first floor steel beams has been used to determine the moment frame locations.

The scheme for the Municipal Building consists of the following, and will achieve a minimum of 8%NBS for an Importance Level 2 structure;

General

- Local demolition of internal URM walls to reduce the seismic weight of the structure, and remove the need to secure the walls out-of-plane.
- Local demolition of the existing suspended first floor slabs at the entry and original safe areas to reduce seismic weight, and reduce complexity associated with securing the suspended slabs were they to remain.
- Removal of the flooring spanning the void between the Hall and the Municipal buildings to ensure the Municipal building is seismically separated from the Hall.

- Demolition of the URM wall sections along the rear wall line (Grids B and 5) to reduce seismic mass and remove the requirement to strengthen the walls out-of-plane. Removing this weight means the new transverse portal frames are of a more economical size, and the existing first floor and roof plane diaphragms are acceptable.

Transverse

- New two-storied transverse steel moment frames, with a new ground beam footing. These frames have been positioned to also provide gravity support to the existing first floor structure by supporting the original steel beams.
- Connect the new steel moment frames to the concrete façade at eaves level to secure the façade out-of-plane
- Connect the new steel moment frames to the first floor diaphragm to secure the façade out-of-plane

Longitudinal

- New eccentrically braced frames along the rear wall line, both on the ground floor and first floor
- New external wall line footing
- New light timber framing to replace the URM walls and provide the water-tight envelope to the building adjacent to the Hall structure.

CONSTRUCTION NOTES

- The scheme allows for retaining the existing concrete 'banding' along the rear of the Municipal building adjacent to the void between the Hall. This will provide gravity support to the roof while works are being completed. Temporary propping to the first floor will be necessary.
- The transverse moment frames could be installed in stages. This could act as temporary propping to the façade, as well as being incorporated into the permanent structural system.

7. Limitation of Report

This report has been prepared solely for Masterton District Council. Any reliance on this report by third party members is at their own risk.

The assessment is limited to section B1 Structure of the New Zealand Building Code (NZBC) for seismic loading, and no assessment for compliance with other sections of the NZBC have been undertaken.

This report does not quantify any risk associated with geotechnical conditions.

8. Summary

Having reviewed the Municipal Buildings on the site, and their multiple alterations over the last 100 years, we note the following;

- The works required to improve the Hall are substantial, and of a scope similar to constructing a new Hall structure.
- The works required to the Municipal building to 80%NBS are as shown in the attached plans S1-S24 tilted 'Seismic Improvement Scheme, Masterton Municipal Building'. The scheme presented will require a total refurbishment of the building interior.
- The future use of the Municipal building will dictate the final shape of both the structural and architectural requirements.

Further guidance is required prior to completing a full structural picture. This would include looking at the site as a whole and what the Council and community would like from the buildings in the future.

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