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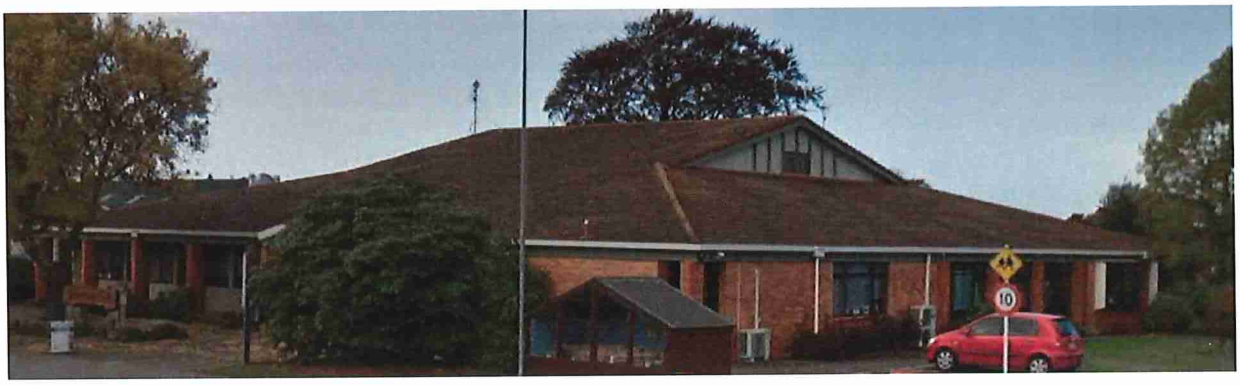
Consulting Civil & Structural Engineers



DSA Report

125 Queen Street, Waimate

Detailed Seismic Assessment

Report prepared for Waimate District Council
September 2019

Revision	Date	Description
A	September 2019	Report issued for comment
B	September 2019	Final report

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ACENZ

125 Queen Street, Waimate
Detailed Seismic Assessment

General

Purpose
This report is to test the safety of the occupants in the building. Safety is assessed against the status of the building with respect to earthquake proneness, preferably surpassing that test by a comfortable margin.

Summary of Findings
Analyses of the building for earthquake effects shows that it is not earthquake prone as defined in the Building Act 2004. A building is defined as earthquake prone if it would have its ultimate capacity exceeded in a moderate earthquake, as a result of which it might collapse, with injury or death to people ensuing or damage to other property occurring:

- A moderate earthquake is defined as one that produces an intensity of shaking at the site one-third that assumed for the design of a new building.
- An ultimate limit state is reached when the strength capacity or the deformation capacity of the building or its parts is reached.
- The concept of reaching an ultimate limit state is expanded in the Earthquake Prone Buildings legislation that became operative on 1 July 2017
- The NZSEE (New Zealand Society for Earthquake Engineering) Guidelines (see later in this report) are used for assessing this building. Those guidelines establish the attainment of the ultimate limit state at a certain fraction of the earthquake intensity assumed for the design of new buildings, with that fraction commonly expressed as X%NBS (ILY) (X% of New Building Standard and Y the respective importance level).
- A building of this type would be typically classified as an importance level 2 building. However, as the building may be used to coordinating a post disaster response, we have assessed the building as an importance level 4 structure. With the increased loading requirements for importance level 4 the buildings rating reduces to 60%NBS at IL4
- For the purpose of aiding comparisons with similar buildings, this building is unlikely to reach an ultimate limit state in an earthquake that produces shaking at the site less than 100% of what would be assumed for the design of a new importance level 2 building.
- The stone clock tower immediately to the north of the assessed building should be seismically assessed to ensure that it does not pose a risk to 125 Queen Street greater than the above reported seismic rating.

Legal Provisions: Earthquake Proneness
In brief, a building is defined as being earthquake prone if it would reach an ultimate limit state in a moderate earthquake. A moderate earthquake is defined as one that would produce shaking at the site one-third as great as would be assumed for the design of a new building at the site.

If a building is assessed as earthquake prone as assessed by the Territorial Authority, the danger presented by that condition is to be removed within a specified time specified in the act, by demolition or by improvement of the building. In discharging these duties the Territorial Authority is required to produce policies with respect to these matters.

The existing earthquake prone legislation has more prescriptive measures for assessing buildings that are potentially earthquake prone and for setting deadlines for improvement. The present threshold changes from a concept of collapse to one of reaching an ultimate limit state. However, the notion of collapse is retained by stating a rider to the attainment of an ultimate limit state (ULS), whereby a building would only be judged earthquake prone if as a consequence of any collapse injury or death might ensue. If the building is assessed as earthquake prone then it will need to be improved within a timeframe set by the legislation.

The required rating to be achieved in any upgrade that is necessary for an earthquake prone building is sufficient for the building to pass the test for earthquake proneness if that test was reapplied after the improvements were completed. This remains unchanged from the previous position, also, notwithstanding the policies of some Territorial Authorities—a position clarified in a recent judicial review and in the new legislation.

That is, the building needs to be brought up to a level of performance such that the ultimate limit state would not be reached in a moderate earthquake. The time for completion of improvement is set by the new legislation. It would be at least 35 years in this seismic zone, which is defined as of low seismic risk.

Construction and Condition of the Building

The building was originally constructed in the 1980's as a government building. It is on a flat site with no significant surrounding topography.

Immediately to the North of this building is a stone clock tower. During an earthquake event it is possible for the clock tower to collapse onto the 125 Queen Street building. However, the assessment of the stone clock tower is beyond the scope of this report.

The building is a square, single storey structure that is understood to have been constructed in the 1980's and remains generally unchanged other than some minor non-structural internal alterations to enlarge the library and adjust the layout of some of the office spaces.

The structural elements of the building typically consists of load bearing reinforced block work external walls and reinforced concrete columns that are generally clad with a brickwork veneer. These walls support a perimeter steel beam that in turn supports the roof trusses above. Internally the building has a central core of reinforced blockwork walls forming the council room, committee room and the strong room. Timber roof trusses span between these internal block walls and the external load bearing walls and columns to form a Dutch Gable roof. The buildings foundations are typically reinforced concrete ground beams, below a lightly reinforced ground bearing floor slab. While these beams are shown to be tied into the walls above, there is nothing noted on the existing drawings to show a tie between the ground floor and the foundations below.

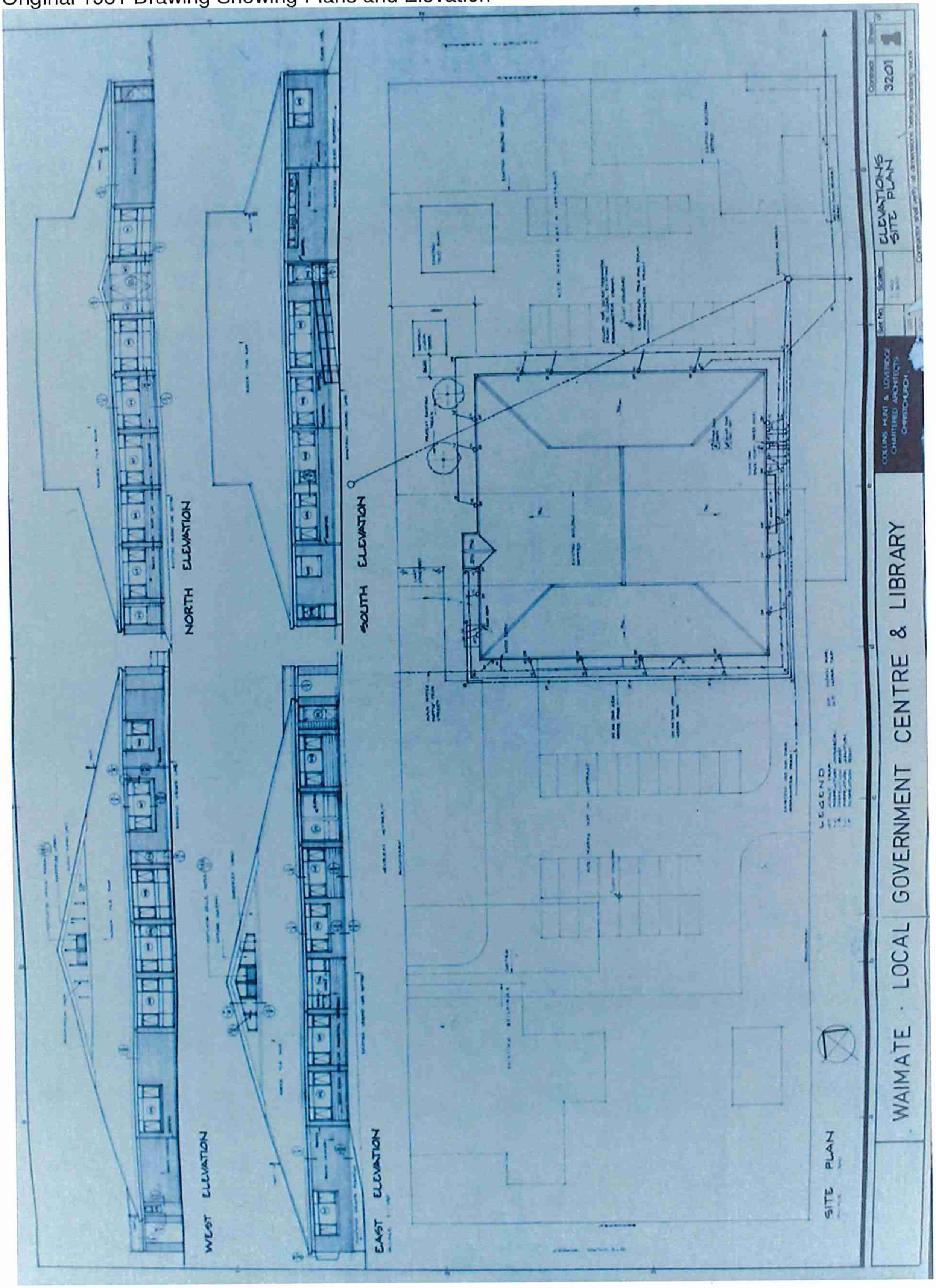
The roof is clad with clay roof tiles, having a ridge line that runs above the central core in a north east/south west direction. Small gables between the ridge and the roof below lie approximately above the north east and south west internal core blockwork walls. Outside of the central core the roof pitch is the same as above the central core, but has hips at each corner.

Image showing the tiled roof with hips in the corners and a part gable above the central core wall.

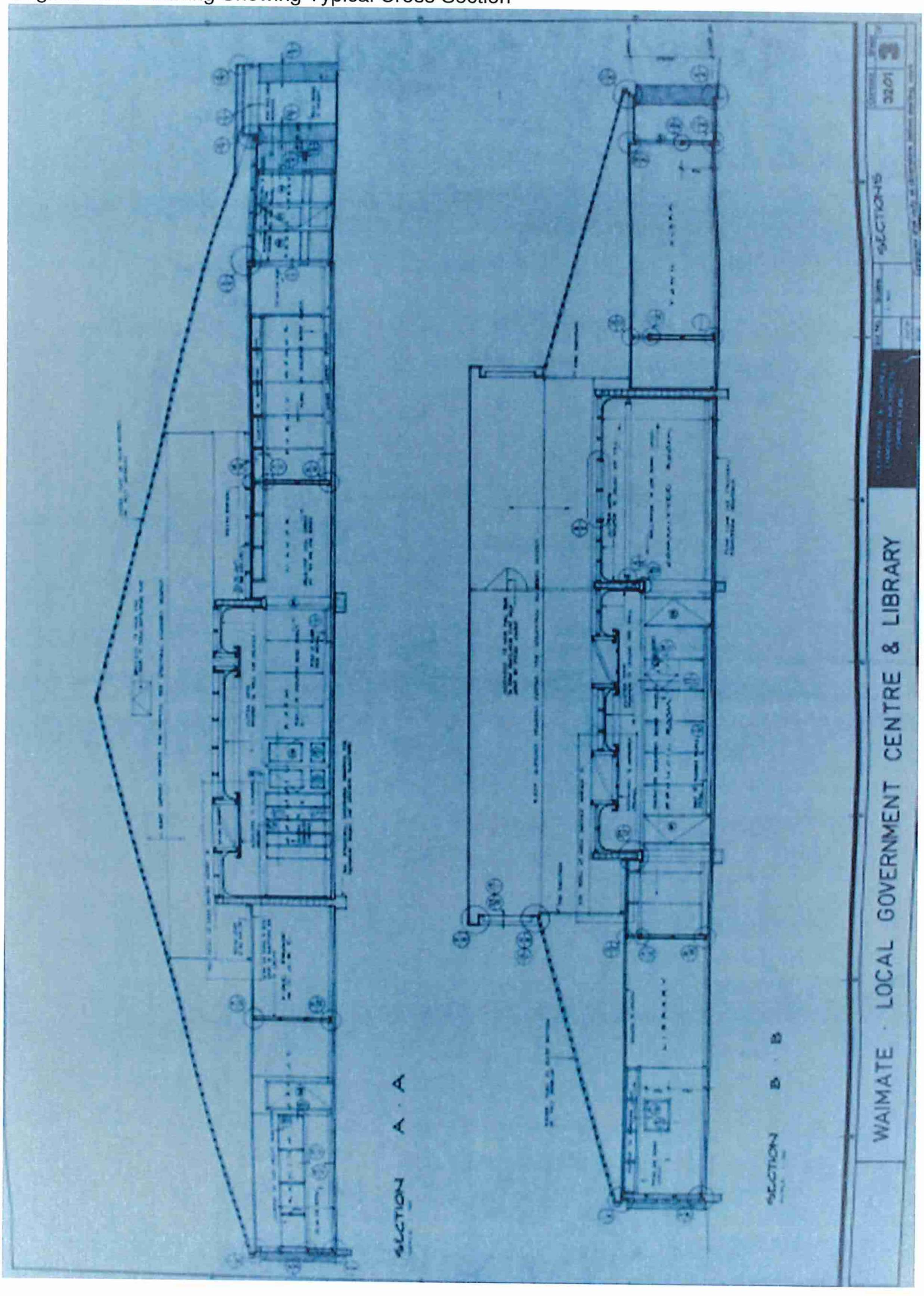
The lower hipped roof is formed by a series of simply supported timber roof trusses. Externally these trusses are supported either by the external walls or the reinforced brick clad columns that are typically present along the northern elevations. Internally these trusses are supported either by the reinforced blockwork walls of the central core or by timber girder trusses which are in turn supported by the central core walls.

As the central core is rectangular in shape these girder trusses are supported by the timber roof trusses above the central core that cantilever out beyond the line of the blockwork walls below. As the cantilevering trusses will have little capacity in plan, there is a steel lattice frame to provide lateral restraint to the girder trusses. This lattice frame is bolted to the girder truss to the north west and south east of the central core walls and then fixed down to the top of the reinforced blockwork.

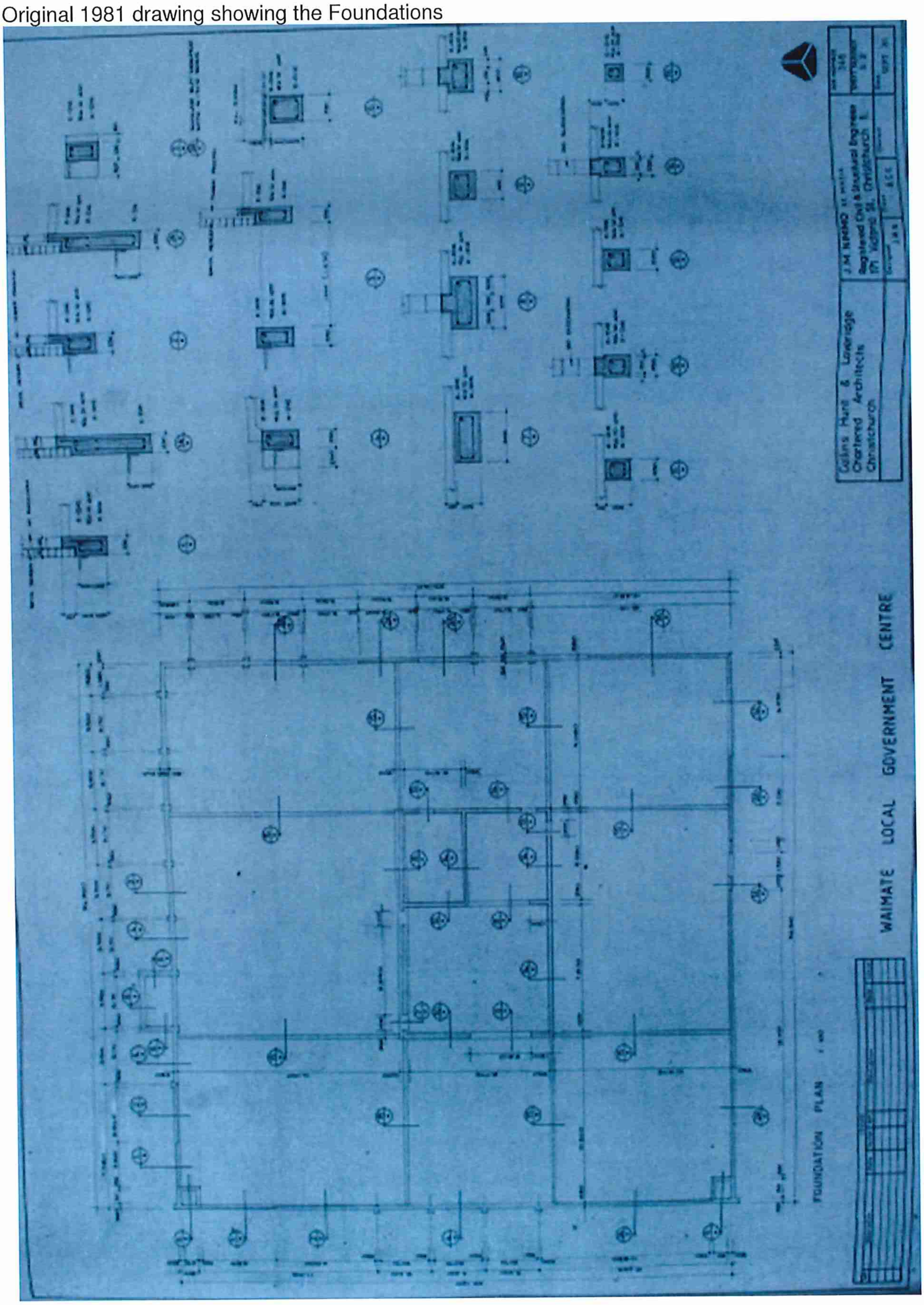
Original 1981 Drawing Showing Plans and Elevation



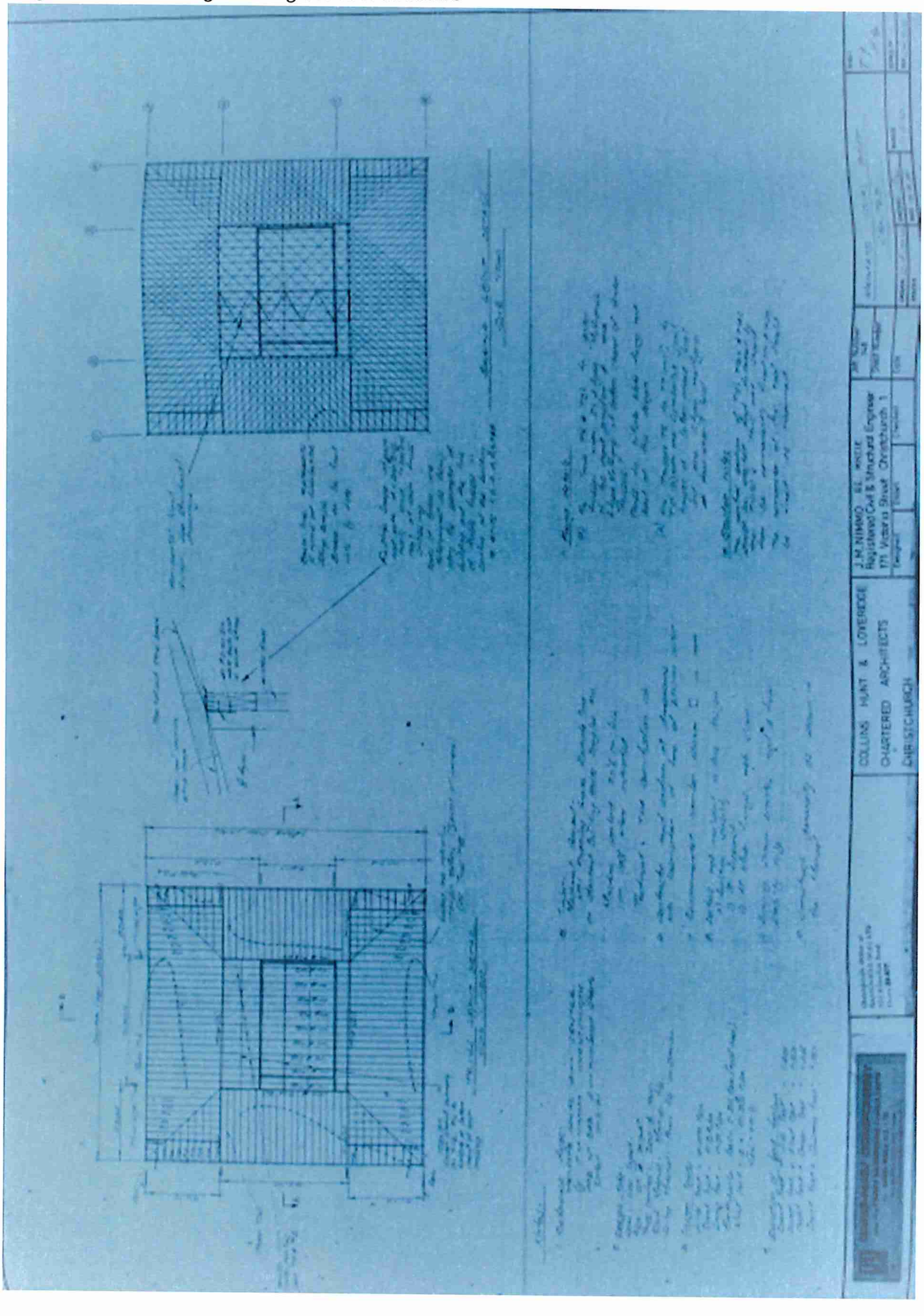
Original 1981 Drawing Showing Typical Cross Section



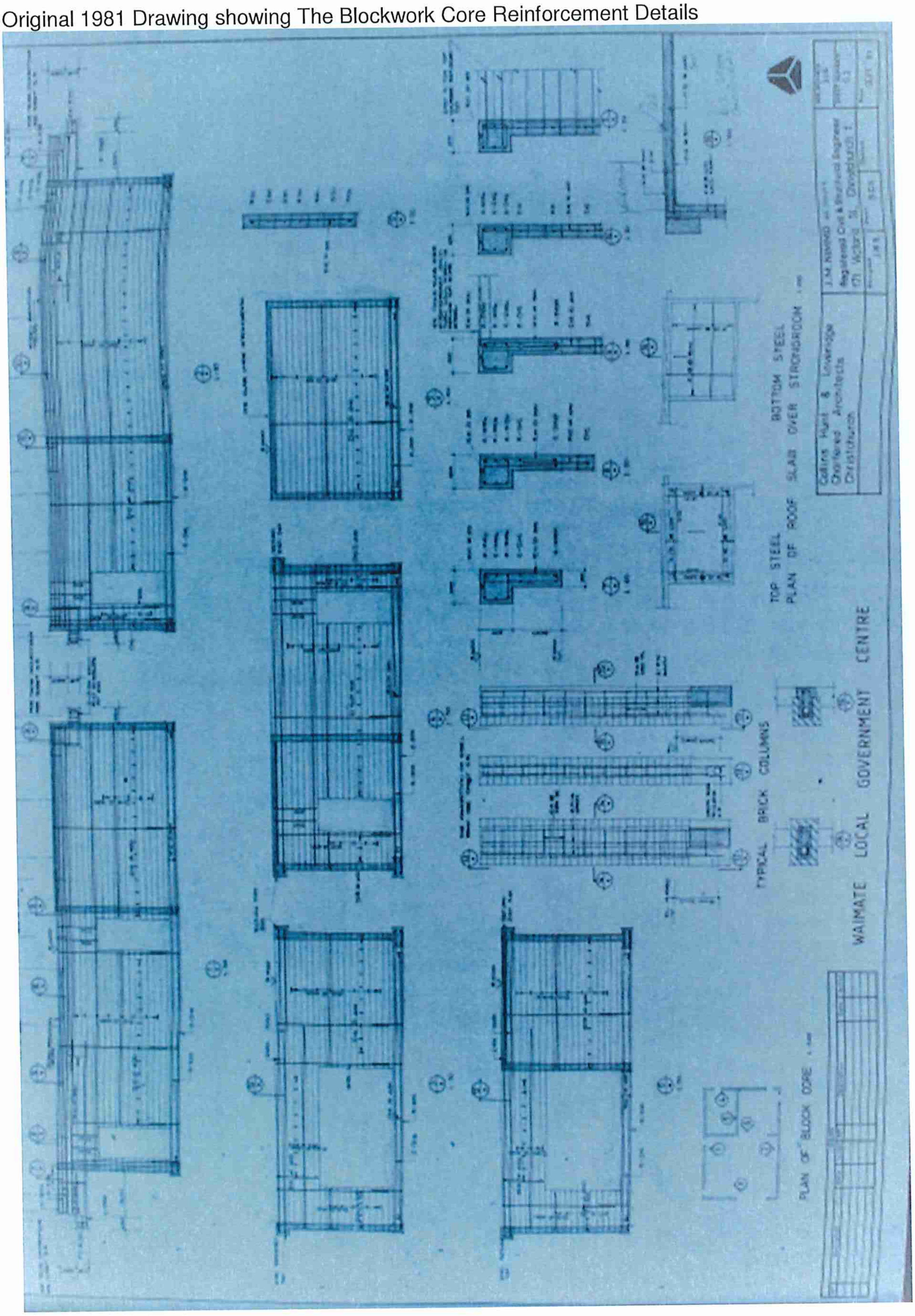
Original 1981 drawing showing the Foundations



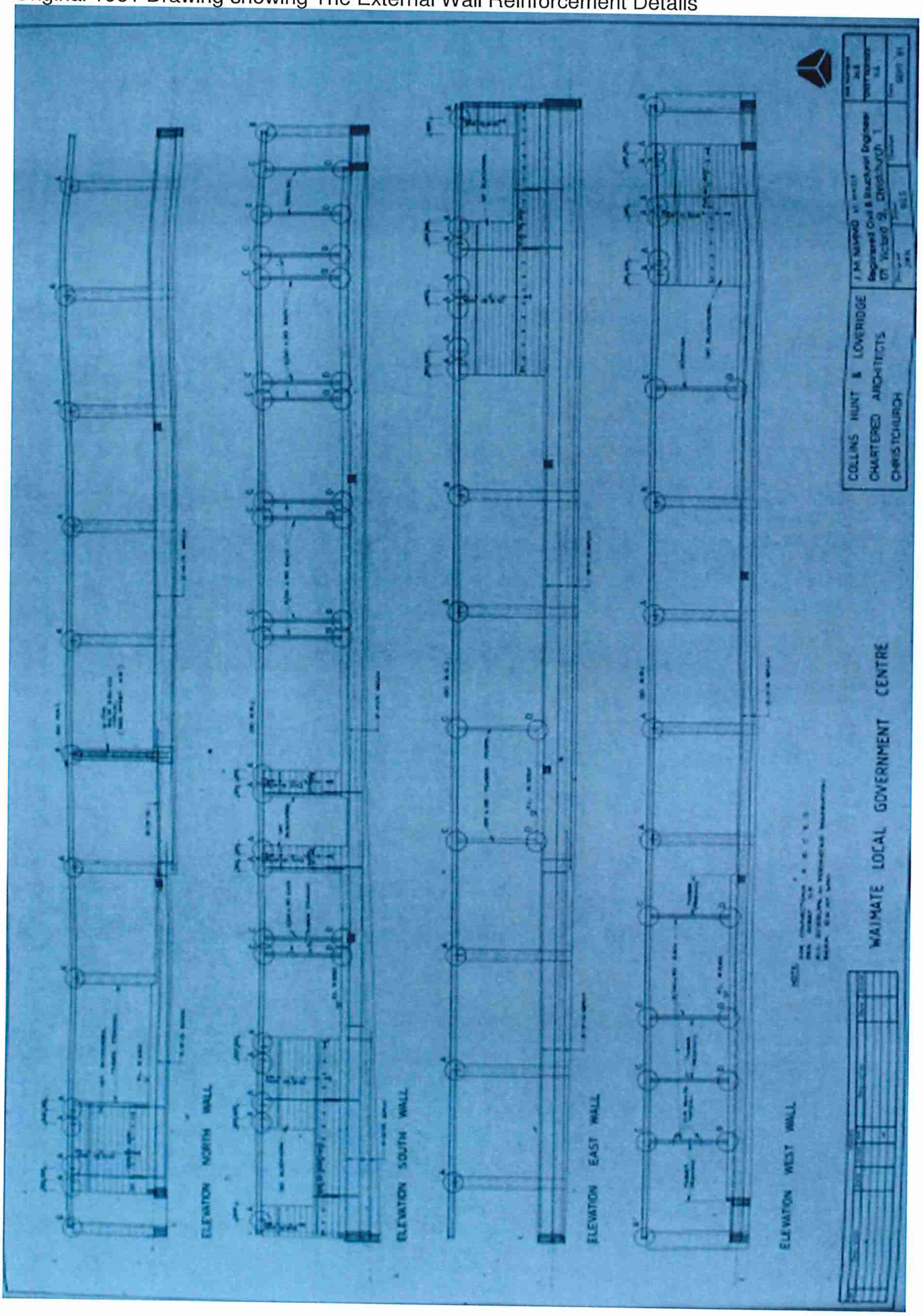
Original 1981 Drawing showing the roof structure

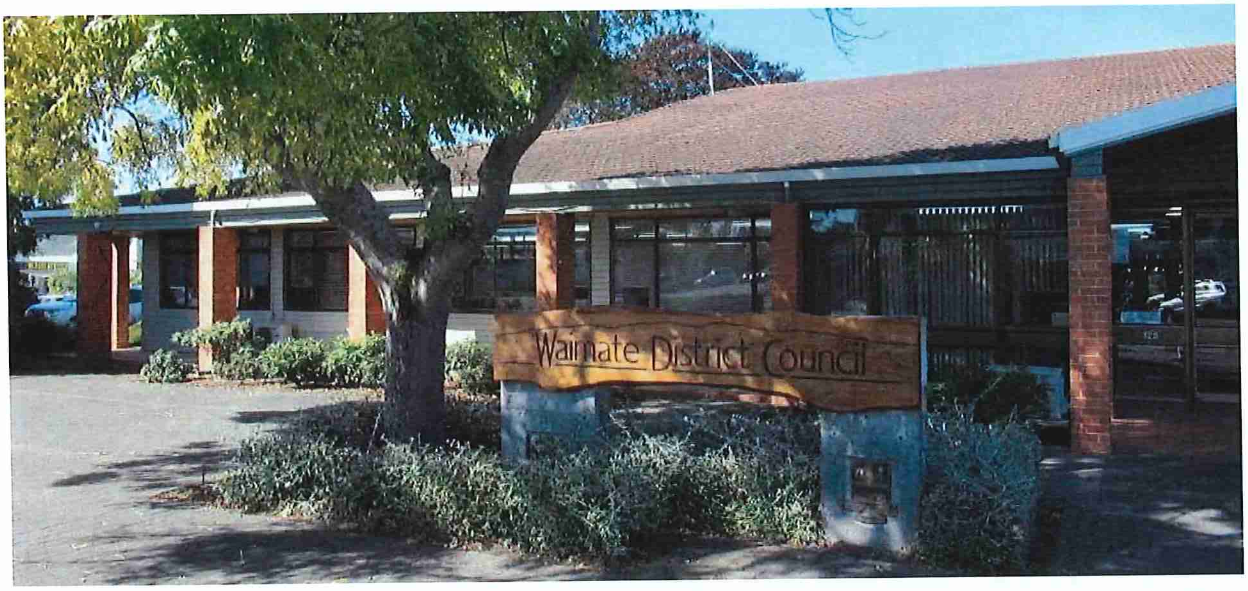


Original 1981 Drawing showing The Blockwork Core Reinforcement Details



Original 1981 Drawing showing The External Wall Reinforcement Details





***Photograph 1** – North western Façade facing onto Queen Street (part 1)*

***Photograph 2** – North western Façade facing onto Queen Street (part 2)*

Photograph 3 – *North eastern façade*

Photograph 4: *South eastern facade*

the committee who have relevant experience and knowledge of the particular artform.

The applications should be sent out with either a printed or electronic version of the Assessment Sheet for assessors to complete.

Step 3: Applying the Assessment Scale

Responsible for this step: CCS Assessors

Assessors must individually mark applications using the Assessment Scale. This ensures that the assessment process is consistent and objective. Giving each application a mark against the same scale and same set of questions allows applications to be ranked in priority before the assessment committee meets, and provides a starting point for discussion.

Assessors should complete the Assessment Sheet and return this to the CCS Administrator.

Step 4: Creating a ranked list

Responsible for this step: CCS Administrator

Once all the assessors have returned their Assessment Sheets to the CCS Administrator, the Administrator will average the marks (total marks for each application divided by the number of assessors who provided marks for that application) and produce a ranked list for the assessors to discuss at the meeting.

The ranked list should include, for each application:

> the name of the applicant
> the name of the project
> the amount requested
> the criterion that the applicant has selected.

Step 5: Prioritising applications and allocating funding

Responsible for this step: CCS Assessors

The assessment committee meets to decide which applications should have priority for funding. The committee focuses its discussion on:

> what level of support there is among committee members for those applications that scored highly on the Assessment Scale (a total mark between 16 and 20)
> which 'middle ground' applications (a mark between 11 and 15) should be given priority
> strategic funding decisions and local funding priorities that may see applications given priority even though they haven't scored as highly as others.

It's appropriate to support a project if the application is eligible and meets the funding criteria and the assessment committee believes the project should have a high priority.

Grants can be made as general contributions to a project or they can be tagged to a specific aspect of the project.

If an application has stated that the applicant is also asking for funding from other sources, the committee will need to consider how likely it is that the applicant will get that other funding and therefore whether the project will be viable.

Declined applications

If the committee decides to decline an application they will need to identify the reason for the decline. These are:

> D1: ineligible application
> D2: does not meet funding criteria
> D3: low priority for funding
> D4: incomplete application

Step 6: Notifying the applicants

Responsible for this step: CCS Administrator

Notifying successful applicants

All successful applicants must be notified in writing that their application has been granted.

Here is a sample letter for successful applicants. This template letter allows you to insert the applicant's

details, the name of the project, the amount the applicant has been awarded, and any specific conditions of the grant, eg if the funds are tagged to certain items or specific aspects of the project.

The letter restates the conditions of funding under the Creative Communities Scheme and reminds the applicant that, by making the application, they've agreed to these conditions.

You will also need to send the successful applicant a Project Completion Report form.

Projects must be completed within 12 months after funding is approved, and the Project Completion Report is due back within **two months** after the project is completed.

Notifying unsuccessful applicants

All unsuccessful applicants should be notified in writing that their application hasn't been granted. Here is a sample letter for unsuccessful applicants.

If an application is underdeveloped, the assessment committee may decide to indicate to the applicant that they can submit a reworked proposal in a future funding round.

Funding agreements

When applicants complete their application form they sign a declaration stating that if they're successful, they will:

- complete the project as described in their application, or seek written approval from the CCS Administrator for any significant changes to a project
- complete the project within a year of the funding being approved
- complete and return a Project Completion Report form within two months of the project being completed
- return any funds that they haven't spent
- keep a record of and receipts for all project expenditure
- participate, if required, in any funding audit of their organisation or project carried out by the local council
- contact the CCS administrator to notify them of any public event or presentation that is funded by the scheme
- acknowledge CCS funding at event openings, presentations or performances
- use the CCS logo in all publicity for their project, such as posters, flyers and e-newsletters, and follow the guidelines for using the logo. Download the logo and guidelines.

This declaration is the funding agreement, and the applicant is reminded of this in the letter advising that they have been successful. However, your council may prefer to establish an additional funding agreement with successful applicants, in order to be consistent with your other funding processes. If you do so, the terms of the grant need to be consistent with the requirements set out above.

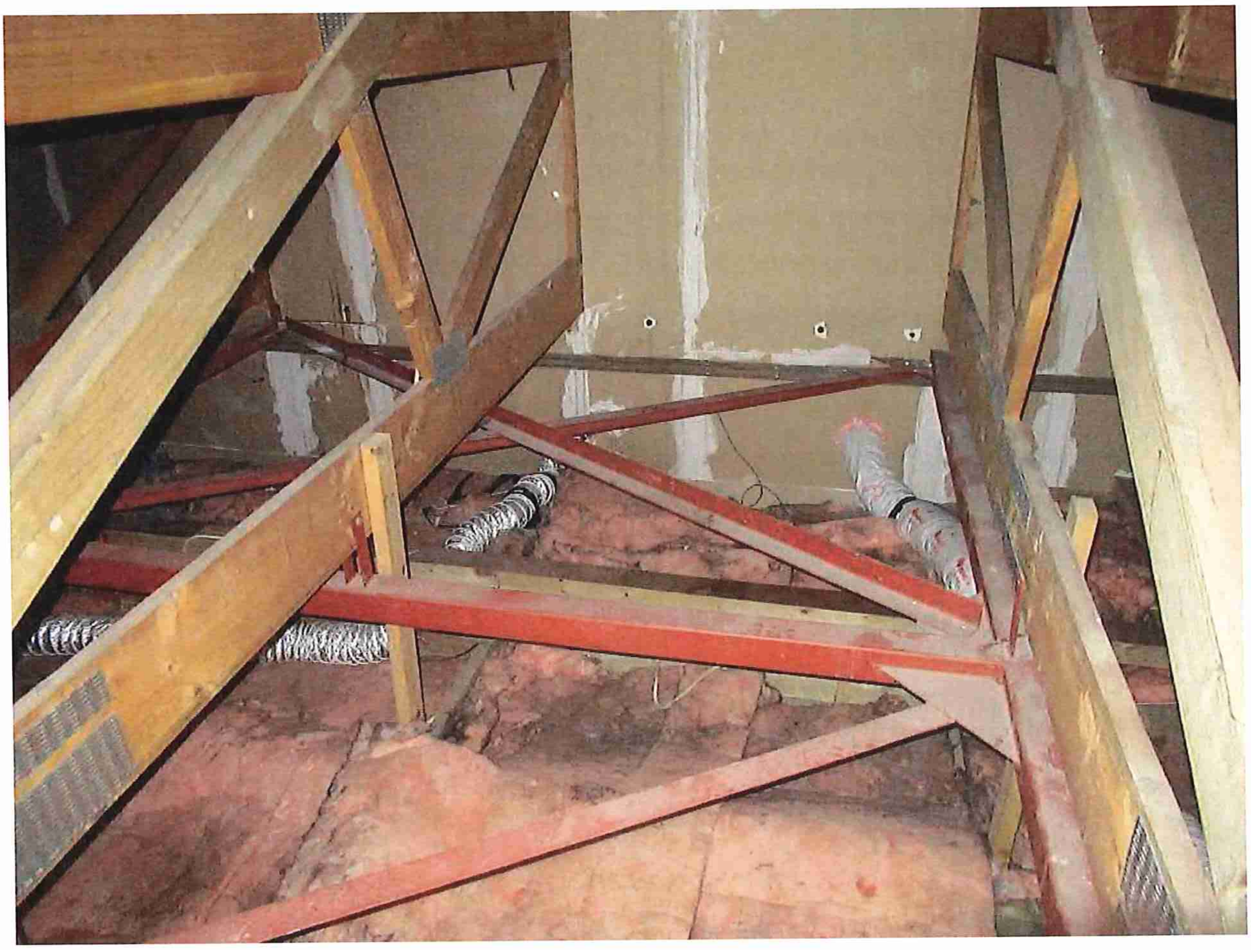
Assessment Scale

How the Assessment Scale works

On the basis of the information provided in each application for Creative Communities Scheme funding, the members of the assessment committee give a mark from 1 to 4 for each of the five assessment areas set out below. The individual marks for each assessment area will provide a total score out of 20. These are then averaged and a ranked list is created listing the applications with the highest scores at the top.

The five assessment areas:

Photograph 5: *South western facade*



Photograph 6: *Roof structure showing bracing lattice*

Methods of Assessment

The assessment methods used in the preparation of this report are generally in accordance with those outlined in the documents "The Seismic Assessment of Existing Buildings", which the New Zealand Society for Earthquake Engineering (NZSEE) prepared for the Ministry of Business Innovation and Employment.

The NZSEE documents are intended primarily for the assessment of earthquake prone buildings and the improvement of performance of a building to the extent that it would not then be earthquake prone. However, the methods are also useful in assessments for other purposes, such as improving performance to higher standards.

The analyses reported here are based on the NZSEE's Concrete Buildings C5 and Unreinforced Masonry Buildings C8, in conjunction with NZS 4230 Design of Reinforced Concrete Masonry Structures. Using the above principles the capacity of each load bearing element has been calculated to ascertain the predicted failure mode and the loading required to reach the point of failure.

These load capacities have then been compared to the loading requirements to establish to what extent the building can resist the required loading.

Design Parameters

In this report it has been assumed that the building is importance level 4 with a design life of 50 years, appropriate to a facility that may be used as part of a post disaster response. Importance level 2 has also been checked and results for this are included within this report for comparison

Several assumptions were made following the onsite investigation:-

1. The concrete grout has been taken to have a compressive strength of 20MPa
2. The reinforcement has been taken to have a yield strength of 300N/mm2
3. Mass of the concrete was taken to be 2400kg/m3
4. The sites zone factor is 0.14
5. From knowledge of the surrounding geology we expect that the buildings foundations are founded on good ground as defined by NZS 3604 and that the geotechnical conditions meet the requirements for ground class C. Ground class C is defined as shallow soils up to 55 metres thick over the underlying bedrock.

Analysis

The building consist a clay tile pitched roof, supported by brick clad concrete columns, reinforced blockwork walls. The building has a concrete floor slab and a concrete slab to the top of the strong room area. The underside of the timber trusses is lined with a plasterboard ceiling.

The elements providing lateral resistance to loading are highlighted on the floor plan below in figure 1. Resistance in the northeast-southwest direction is provided by the elements highlighted in yellow (gridlines A to E) and the resistance in the northwest-south east direction is provided by the elements highlighted in red (gridlines 1 to 5). These elements consist of the external walls and columns or are part of the internal central core of blockwork.

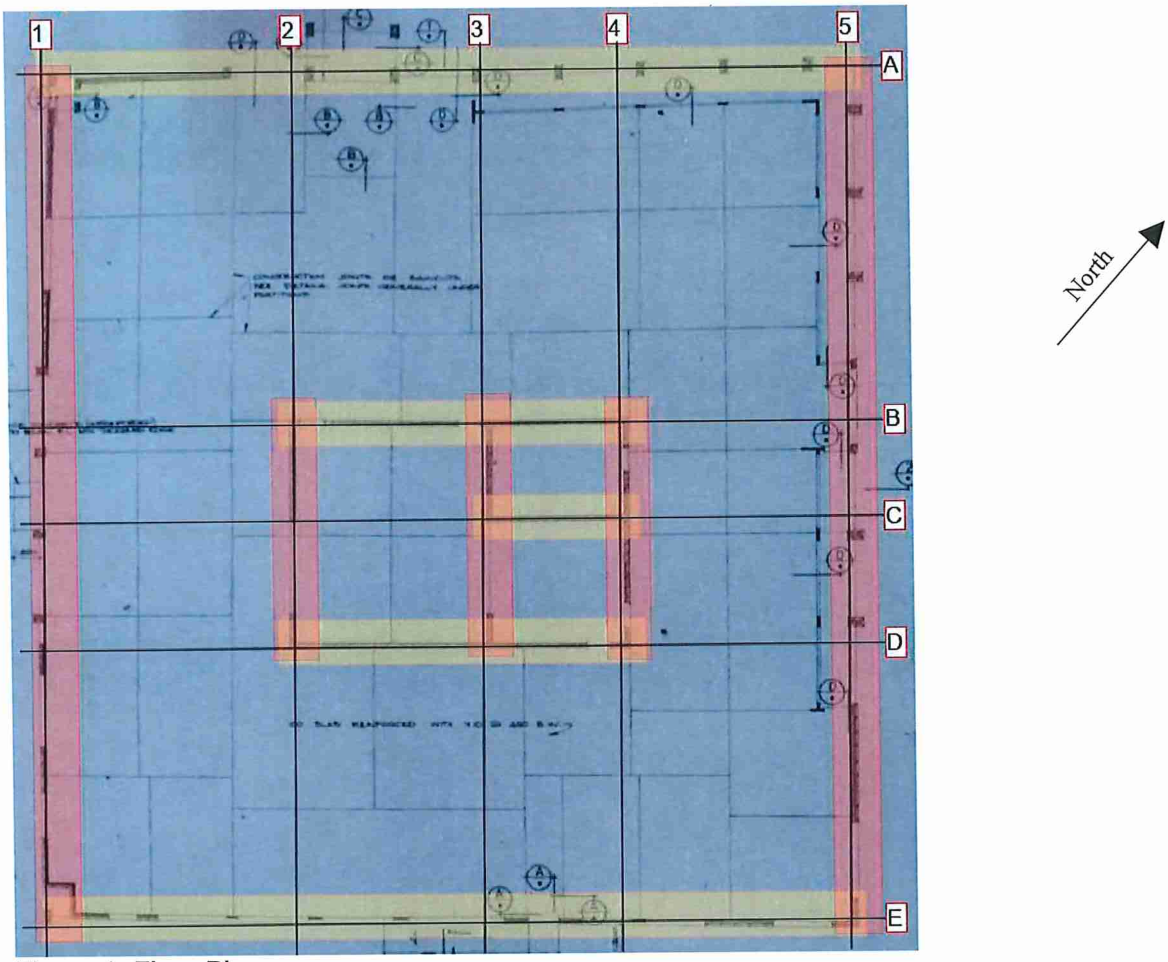


Figure 1. Floor Plan

Due to there being limited capacity in the plasterboard ceiling for redistribution of loading around the building, the simplified tributary method was used, with masses transferred to the closest element providing lateral resistance. This resulted in a maximum diaphragm width of approximately 11 metres. The plasterboard ceiling was reviewed and is capable of transferring the required horizontal loads to the highlighted elements above.

The bracing elements typically fall into two forms. Either structural frames formed by the brick clad reinforced concrete columns & the perimeter steel beams, or the reinforced concrete blockwork walls. The foundation rocking capacities along with the structural capacities of the superstructure were calculated, with foundation rocking being found to typically occur before the capacity of the superstructure is reached. Both the rocking foundations and the detailing of these structural elements is consistent with what would be required to achieve a ductility of 2.

The seismic coefficient for the building was then calculated using a ductility of 2. The masses attributed to each load bearing element were then converted into horizontal forces using the equivalent static method. Allowance for any eccentricity of the loading is provided by the bracing elements being mutually exclusive, ensuring that the building has at least the reported seismic capacity in either direction, even if loaded simultaneously.

The calculated rocking capacities were then compared to the seismic load requirements. The ratio of the demand relative to the capacity giving the elements seismic rating. The lowest of these ratings is the buildings critical structural weakness and thus the buildings overall seismic rating.

As part of our assessment we also noted that the existing roof tiles are not attached to the roof structure and so may become dislodged or fall from the roof during an earthquake event. No reduction in the reported seismic rating has been made due to this risk as the roof has a shallow pitch and so the risk to life during an event is thought to be low. The post event risks to people accessing the building due to falling tiles is also assessed to be low as the buildings main entrance canopy provides protection from falling debris.

Following this process the capacity of the wall on GL 3 was found to be the critical structural weakness, achieving a seismic rating of 60% NBS IL4.

As part of the assessment we were asked to consider the effect of replacing the heavy clay tile roof with a lightweight steel cladding. If this alteration was undertaken, the buildings rating would rise to 75% NBS IL4, with the risks associated with falling tiles removed.

Conclusion

The analysis has been conducted for the 1980's built building to establish the buildings current seismic rating relative to the loading required for an importance level 4 (IL4) building. This level was selected due to the desire to use this building as a post disaster structure. The loading code NZS1170 states that the new building standard for importance level 4 building is an earthquake with a return period of 1 in 2500 years. This is significantly higher than the 1 in 500 year return period for a normal structure.

The result of this assessment is that the overall seismic rating for the building is 60% of the new building standard (60%NBS IL4). To aid comparison with other buildings with lower importance levels, this equated to 100% of the new building standard for importance level 2 100%NBS IL2 and 80% of the new building standard for importance level 3 80%NBS IL3.

We were also asked to review the effect of replacing the existing heavy tiled roof structure with a lightweight steel cladding. Should this work be undertaken, we calculate that the rating would rise to %75NBS IL4.

If you deem that the above rating is sufficient to meet your requirements for a post disaster facility, it would be prudent to undertake site specific geotechnical investigations to confirm the validity of the above assumptions. It was not thought to be prudent to undertake these investigations until the buildings potential capacity have first been identified.

During an earthquake event structural damage and displacements are expected to occur in the load bearing elements, which may reduce the functionality and weather tightness of the building following a large seismic event. It should be noted that even if the building had achieved one hundred percent of the new building standard, it may not be in a usable condition following a large seismic event. The purpose of earthquake assessments is typically to establish the risk to life and adjacent property that the building poses during an earthquake.

As part of our assessment we note that the existing roof tiles are not attached to the roof structure and so may become dislodged or fall from the roof during an earthquake event. No reduction in the reported seismic rating has been made due to this risk as the roof has a shallow pitch and so the risk to life during an event is thought to be low. To further mitigate this risk, canopies could also be added to the buildings other exits. It should be noted that due to the unsecured roof tiles the weather tightness of the building could be seriously affected following a large earthquake event.

The assessment of the adjacent stone clock tower building is beyond the scope of this report, but it may pose a risk to 125 Queen street should it collapse. We therefore recommend that the clock tower should be assessed as an importance level 4 structure to ensure that it does not pose a risk to 125 Queen Street during a seismic event.

The above described analysis is based on expected structural capacities of the various materials used at the time of construction and detail information that was available from the original Engineers drawings.

Tim Vick
Engineer
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Consulting Engineers

Appendix A: Earthquake Proneness

NOTE: This is an extract from the present building act.

Legal Requirements — earthquake proneness

The test for earthquake prone buildings is defined in section 133AB of the Building (Earthquake-prone Buildings) Amendment Act 2016, and in associated regulations.

133AB Meaning of earthquake-prone building

(1) *A building or a part of a building is* earthquake prone *if, having regard to the condition of the building or part and to the ground on which the building is built, and because of the construction of the building or part,—*

(a) *the building or part will have its ultimate capacity exceeded in a moderate earthquake; and*

(b) *if the building or part were to collapse, the collapse would be likely to cause—*

(i) *injury or death to persons in or near the building or on any other property; or*

(ii) *damage to any other property.*

(2) *Whether a building or a part of a building is earthquake prone is determined by the territorial authority in whose district the building is situated:* see *section 133AK.*

(3) *For the purpose of subsection (1)(a),* ultimate capacity *and* moderate earthquake *have the meanings given to them by regulations.*

Compare: 1991 No 150 s 66

Section 133AB: inserted, on 1 July 2017, by section 24 of the Building (Earthquake-prone Buildings) Amendment Act 2016 (2016 No 22).

7 Moderate earthquake and ultimate capacity defined

For the purposes of section 133AB of the Act (meaning of earthquake-prone building),—

moderate earthquake *means, in relation to a building, an earthquake that would generate shaking at the site of the building that is of the same duration as, but that is one-third as strong as, the earthquake shaking (determined by normal measures of acceleration, velocity, and displacement) that would be used to design a new building at that site if it were designed on 1 July 2017*

ultimate capacity *means the probable capacity to withstand earthquake actions and maintain gravity load support assessed by reference to the building as a whole and its individual elements or parts.*

Appendix B: Earthquake Design Parameters

In the design of new buildings using NZS 1170.5, the seismic coefficient is derived as follows:

$$C_d(T) = \frac{C(T)S_p}{k_\mu} \geq (Z/20 + 0.02)R_u \geq 0.03R_u$$

Where

$$C(T) = C_h(T)ZRN(T_1, D)$$

In these expressions, *T* is the period of vibration in any mode. For the equivalent static procedure, only the first mode is considered, and *T* is then replaced with T_1.

We have assumed the building is built on shallow soils that would meet the criteria of soil class C and has a period of 0.52 seconds. The site is also remote from an active fault.

$C_h(T_1) = 2.00$ $\quad Z = 0.14$ $\quad (IL4)\ R = 1.8$ $\quad N(T_1, D) = 1.0$

$$C_d(T_1) = \frac{C(T)S_p}{K_\mu}$$

Using a ductility factor of 2,

$S_p = 0.7$

$K_\mu = 1.74$

$C_d(T_1) = 0.2$