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2 July 2014

Doug Tate
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126-148 Oxford Street
Levin 5510
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Dear Doug

Horowhenua District Council Building SH1, Levin - Seismic Assessment

As requested we have completed the Detailed Seismic Assessment (DSA) of the new Council Building and attach the full DSA report for your review.

We have in accordance with your request reviewed the seismic assessment and performance of the building for the Ultimate limit state (ULS) in accordance with the NZSEE 2006 Assessment Guidelines to the levels required for an Importance Level 4 (IL4) building with post disaster function. At your request the requirements for post earthquake Serviceability Limit State SLS2 was not reviewed.

We have also provided ratings for the building when assessed as a standard IL2 Commercial office building usage for comparison of the Life safety rating.

Summary of Results and Conclusions

The New Council Building was designed in 2006 and is a low rise structure with a mezzanine concrete floor for office purposes and a car-park basement and consists of precast concrete elements and features lightweight steel roofs.

This type of building has been shown to perform reasonably well in the recent Christchurch Earthquakes with the main issues observed around damage or failure of individual components of the buildings rather than the building as a whole.

The HDC building was found to have some detailing that does not have a suitable level of robustness and therefore our analysis and rating has been based on these critical elements that govern the building strength in accordance with the NZSEE guidelines procedure.

It is our assessment that the HDC building has a likely strength in the order of 50% NBS when assessed as an Importance Level 4 building with post disaster function, or if assessed as a normal commercial building (without post disaster function) in the order of 87% NBS.



The results of our seismic assessment are presented in the table below.

Table 1: Analysis Results

Importance Level	%NBS	Comments
IL2	87%	This importance level is focussed solely on life safety requirements
IL4	50%	This importance level is focussed on ensuring life safety and continued use of the building. It is a greater requirement than the original design brief.

This results of this assessment mean the building is Not Earthquake Prone in accordance the Building Act 2004.

When considered at IL2, the Council Building is also classified as a Low Earthquake Risk according to the NZSEE 2006 Risk Grading Scheme since the minimum seismic rating achieved is between the 33% and 67%NBS threshold as this 1/500 year return period is the usual threshold the life safety rating is compared against.

It is however at 50% NBS (LI4) classified as Moderate Earthquake Risk according to the NZSEE 2006 Risk Grading Scheme when considered as an IL4 building with post disaster function and a higher return period of 1/2500 years.

If you require any further explanation of anything outlined in our report please do not hesitate to contact the undersigned.

Yours Faithfully

Opus International Consultants Ltd



Carl Ashby

BE Civil, MIPENZ (Civil, Structural), CPEng, IntPE

Manager Structural Engineering, Wellington





Horowhenua District Council

**New Council
Building
126-148 Oxford St,
Levin**

Detailed Seismic Assessment Report





Horowhenua District Council

New Council Building

126-148 Oxford St, Levin

Detailed Seismic Assessment Report

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Horowhenua District Council

New Council Building

**126-148 Oxford St,
Levin**

Detailed Seismic Assessment Report



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1 Executive Summary

A Detailed Seismic Assessment has been carried out for the Horowhenua District Council on their New Council Building in Levin. The purpose of the assessment is to establish whether the seismic performance of the building satisfies the Building Act 2004 minimum standards for existing buildings and to identify improvements required to meet those standards if necessary.

The seismic performance was assessed in terms of new building design standard (%NBS), where %NBS is the estimated lateral resistance of the existing building relative to the current Building Code requirements for a new building at the site with the same functional requirements.

The current Horowhenua District Council policy requires Earthquake Prone buildings to be strengthened to a minimum of 34%NBS.

The results of the assessment is summarised in the following Table.

Table 1: Analysis Results

Importance Level	%NBS	Comments
IL2	86%	This importance level is focussed solely on life safety requirements
IL4	50%	This importance level is focussed on ensuring life safety and continued use of the building. It is a greater requirement than the original design brief.

This assessment rating of greater than 33% NBS means the building is Not Earthquake Prone in accordance the Building Act 2004.

The Building was designed recently in 2006 and is a low rise structure with a mezzanine floor and partially buried basement carpark. The building structure in general consists of precast concrete elements with structural steel frames and lightweight steel roofs.

This type of building has been shown to perform reasonably well in the recent Christchurch Earthquakes with the main problems observed around damage or failure of individual components of the buildings rather than the building as a whole.

Our assessment has identified some areas of detailing that does not have a suitable level of robustness or ductility and consequently the buildings overall performance rating above is based on these critical elements.

2 Introduction

2.1 Purpose

Opus International Consultants Ltd has been engaged by Horowhenua District Council to undertake a Detailed Seismic Assessment of the New Council Building located at 126–148 Oxford St in Levin. The purpose of the assessment is to establish whether its seismic performance satisfies the Building Act minimum standards for existing buildings.

The New Council Building was designed by Kevin O'Connor & Associates Ltd in 2006 and is a purpose built double height office building structure with a large mezzanine concrete floor and basement car park. The construction consists of precast concrete elements and structural steel and features elements of Architectural Precast concrete and lightweight steel roofs.

The building is marked in Figure 1 below.



Figure 1: Site Aerial View (Source: Google Earth)

2.2 Scope of Work

The scope of work for this Seismic Assessment includes the following.

- Sourcing of drawings and undertaking a site visit to review the building.
- Review of Structural Detailing for potential Critical Structural Weaknesses (CSW's)
- Undertaking a quantitative structural assessment in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" 2006.

- The purpose of the assessment was to determine the percentage of New Building Standards (%NBS) at Ultimate Limit State (ULS) considering Importance Level 4, and identify any CSW's.
- Consideration of the performance of the building with respect to “Operational Continuity” i.e. Serviceability Limit State considerations that apply to IL4 buildings was not included in this assessment.
- The seismic bracing of the building contents has not reviewed or assessed in this report.

2.3 Performance Standards

The building performance is assessed in terms of new building design standard (%NBS), where %NBS is the estimated earthquake resistance of the existing buildings relative to the current Building Code requirements for a new building at the site with the same functional requirements.

Current design standards require buildings to be designed for two levels of performance or “Limit States”.

1. Serviceability Limit State (SLS): The degree of damage to the structure is minor, readily repairable and will not prevent immediate occupancy of the building.
2. Ultimate Limit State (ULS): Damage may be extensive but will permit safe exiting of the building. Occupancy may be restricted until repairs are made, or the building might be demolished if it is not feasible to repair.

The design standards depend upon the building’s importance level (IL) as shown in Table 2. These importance levels are defined in NZS 1170.0¹.

Table 2: Importance Levels and Seismic Design Loads

Importance Level	Annual Probability of Exceedance of Load	
	SLS	ULS
IL2: normal occupancy, e.g. commercial offices	1/25	1/500
IL3: public utilities not having special post-disaster function	1/25	1/1000
IL4: facilities with special post-disaster function.	1/25 and 1/500 (SLS2)	1/2500

The Horowhenua District Council has requested that the building be reviewed as an IL4 Building for assessing its seismic performance at Ultimate Limit State (ULS). This has then been compared to the performance of the building required as a standard IL2 office building without post disaster operational continuity.

¹ NZS 1170.0, 2002, Structural Design Actions: General principles.

2.4 Proposed Changes to the Building Act 2004

In August 2013 the Government announced proposed changes to the Building Act 2004 that may affect strengthening timeframes and levels for Earthquake Prone buildings.

2.5 Horowhenua District Council Earthquake-Prone Building Policy²

The Horowhenua District Council adopted their Earthquake-Prone Building Policy in May 2006. The current policy acknowledges that the Building Act 2004 does not insist on a particular strengthening level for the Earthquake-Prone buildings but encourages their owners to strengthen them to the greatest possible extent.

In lieu of a definitive strengthening level, the Horowhenua District Council requires that all buildings defined as Earthquake-Prone must be strengthened to no less than 34%NBS. Buildings that score between 34% and 67%NBS will be classified as Potentially Earthquake Risk and no further action will be required.

2.6 Assessment Methodology

The New Zealand standard methodology for assessing the earthquake performance of existing buildings is specified in guidelines that were prepared by the New Zealand Society for Earthquake Engineering³.

The general process is to (1) assess the seismic loads or **demand** in accordance with the new building seismic loadings standard NZS1170.5:2004⁴, and (2) assess the **capacity** of the structure to withstand seismic loads using processes and criteria in the NZSEE guidelines. The building's rating in terms of %NBS is then defined.

$$\%NBS = \frac{\text{capacity}}{\text{demand}} \times 100$$

2.7 Sources of Building Data

Building construction data available in following drawings obtained from HDC was used to assess the seismic performance of the structure.

- » Architectural Construction Drawings by Designgroup Elliott Architects dated 2006, Sheets P02-P07, A02-A25, A30-A43, A50-A51 and A60-A61.
- » Structural Drawings by Kevin O'Connor & Associates Ltd dated 2006, Sheets S1-S7, S10-S28, S200-S204, S210-S220 and S225-S236.

These drawings were used to confirm the structural system of the building, investigate potential critical structural weaknesses of its framing system and identify details which required particular attention.

² <http://www.horowhenua.govt.nz/Council/Council-Documents/Policies/Insanitary, Dangerous and Earthquake-Prone Building Policy 2006.pdf>

³ Assessment and Improvement of the Structural Performance of Buildings in Earthquakes, guidelines prepared by the New Zealand Society for Earthquake Engineering, 2006.

⁴ NZS 1170.5, 2004, Structural design actions: Earthquake actions – New Zealand

Observations during the non-intrusive site investigations were restricted to structural aspects only of the building.

Waterproofing elements, electrical and mechanical equipment, fire protection and safety systems, services connections as well as secondary elements such as windows and fittings were not inspected and have not been reviewed as part of this report.

2.8 Geotechnical

We have not undertaken any site specific assessment of the geotechnical parameters or any subsurface investigations for the building to determine Liquefaction Risk.

The Site Subsoil Class for this report has been assumed as Class D (Deep or Soft Soil sites) based on the GNS Geological maps and review of a preliminary assessment carried out for another nearby site in Levin by Opus.

3 Building Description

The New Council Building of Horowhenua District Council in Levin is a purpose built double height office building structure with a large mezzanine concrete floor and basement car park .

The construction that consists of precast concrete elements and structural steel and features elements of Architectural Precast concrete and lightweight steel roofs

The building has a rectangular footprint of 73.6m x 30.0m on plan and a maximum height of 8.1m relative to the Ground Floor level.

The foundation system of the structure comprises single concrete pads in conjunction with strip footings and foundation beams.

The site is characterised by flat terrain.

Figure 2 shows a view of the New Council Building of Horowhenua District Council in Levin.



Figure 2: New HDC Council Building in Levin viewed from Oxford Street

3.1 Structural System

The roof structure is made up of steel purlins and beams that support roof cladding and ceiling.

The Mezzanine Floor level is a proprietary concrete ribbed slab floor supported by reinforced concrete frames and in some areas are directly transferred to the precast concrete panels through steel beams.

Lateral loads induced by earthquake actions are distributed through the building at roof level by steel roof bracing elements and at the mezzanine through the concrete floor diaphragms.

These connect to the portal frames and precast concrete panels that primarily resist seismic loads in both principal directions.

Both gravity and lateral loads are transferred to the ground through the building's foundation system that consists of single concrete pads in conjunction with strip footings and foundation beams.

Views of the building are presented in Figures 3 and 4.

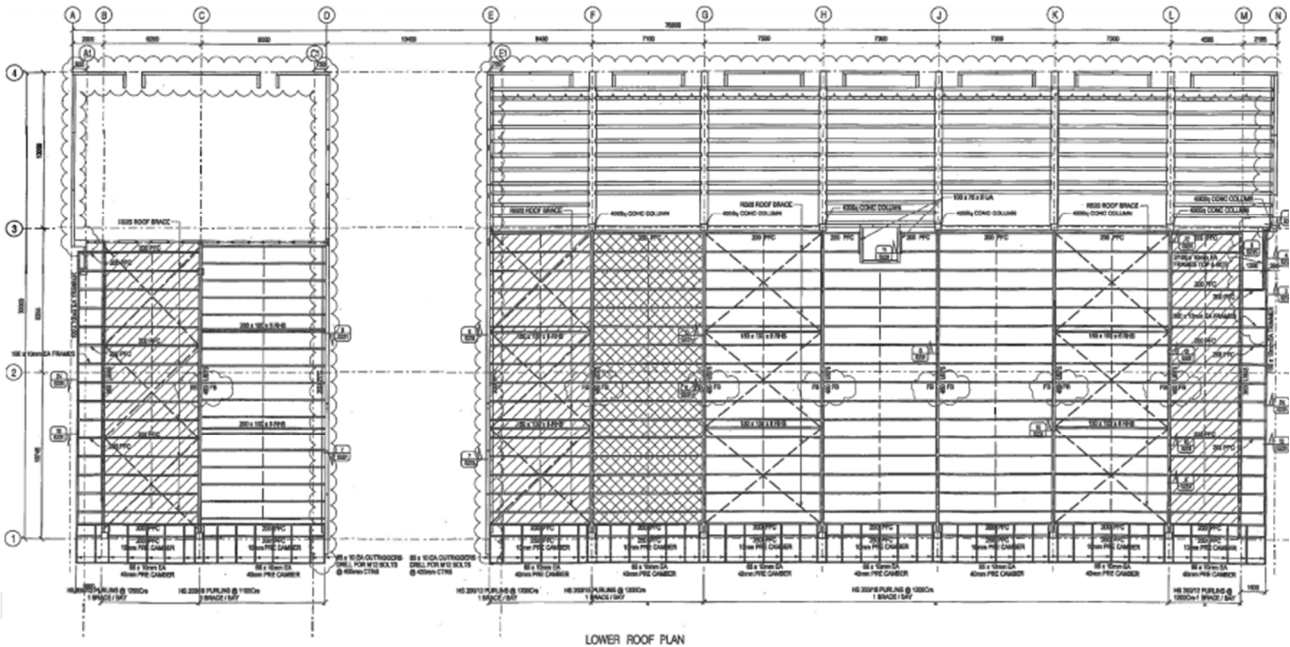


Figure 3: New Council Building of HDC in Levin – Lower Roof Plan

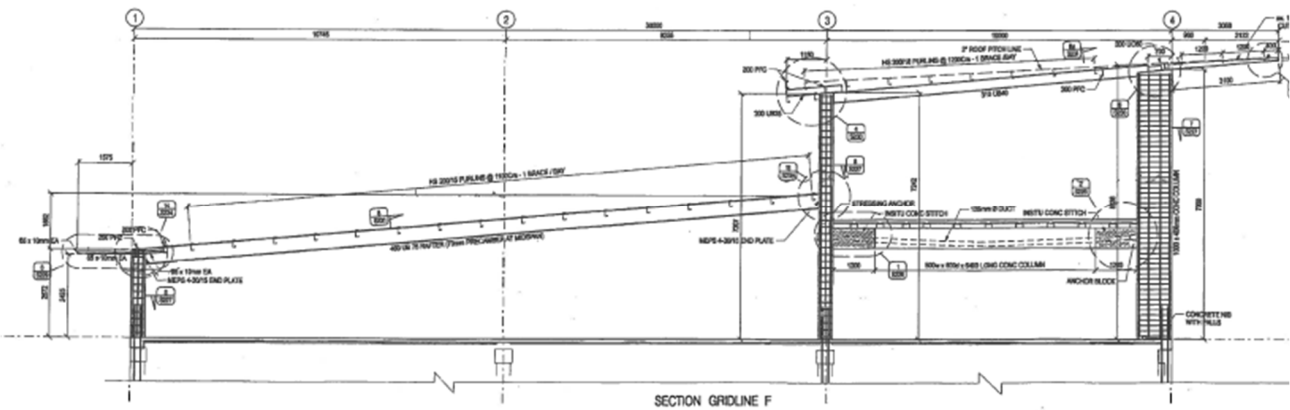


Figure 4: New Council Building of HDC in Levin – Typical Frame Elevation

3.2 Building Condition

A non-intrusive inspection of the building was completed and it showed that it is visually in good condition and generally accordance with the layout shown on the drawings sourced.

4 Seismic Loading

The criteria in Table 3 taken from the earthquake loadings standard NZS 1170.5:2004⁵ were used to determine the site loading spectrum. NZS 1170.5 loads are derived from a 2002 version of the New Zealand Seismic Hazard Model. This model has been updated subsequently, but there have been no significant changes that would affect the design loadings.

Table 1: Parameters for Seismic Loads

Parameter	Value	Comments
Site Subsoil Class	D	Deep / Soft subsoil based on GNS mapping.
Z	0.40	Seismic hazard factor for Levin
R _i (ULS)	1.8	Importance Level 4
N(T,D)	1.0	D>20km from nearest major fault
Displacement Ductility μ	1.25	Concrete Portal Frames & Precast Concrete Walls

A nominal density of 24.0kN/m³ has been adopted for both cast in-situ and precast reinforced concrete elements of the structure.

Values of 0.45kPa and 3.2kPa respectively have been considered for the self-weight load of the lightweight steel roofs and the concrete slab at the Mezzanine Floor level.

The self-weight load at Ground Floor level varies with the Double-Tee panel sections and the thickness of the topping indicated.

A provision of 0.6kPa has been allowed at both Mezzanine and Ground Floor levels to account for floor finishes, suspended ceilings and building services.

An imposed load has been applied at the Mezzanine Floor Level of the building in accordance with the specified use. Its relative proportion has been included in the building's seismic mass. A uniformly distributed imposed load of 5.0kPa has also been considered at the Ground Floor level. However, the weight of both Ground Floor and Basement of the structure is not included in its seismic mass.

Table 4: Imposed Seismic Mass

Floor Level	Imposed Load Q _i	Combination Factor ψ_E
Mezzanine Floor level	3.0kPa	0.3

No additional imposed live loads have been considered for the roof of the structure as the $\psi_E = 0$ for a roof structure without pedestrian access.

⁵ NZS 1170.5, 2004, Structural design actions: Earthquake actions – New Zealand

5 Material Properties

Strengths presented in Table 5 were adopted in accordance with NZSEE 2006 Guidelines for “Assessment and Improvement of the Structural Performance of Buildings in Earthquakes”, NZS 3101: Parts 1 & 2: 2006 “Concrete Structures Standard” and NZS 3404: Parts 1 & 2: 1997 “Steel Structures Standard”.

These values have been used in the analysis process.

Table 5: Strength values for existing materials

Material	Nominal Strength	Strength Reduction Factor ϕ
Precast Concrete	$f'_c = 45\text{MPa}$	1.0
Cast-in-situ Concrete	$f'_c = 30\text{MPa}$	1.0
Steel Reinforcement	$f_y = 500\text{MPa}$	1.0
Structural Steel	$f_y = 320\text{MPa}$	1.0

6 Analysis

The New Council Building of Horowhenua District Council in Levin is a single height structure with a mezzanine concrete floor and car-park basement that consists of precast concrete elements and features lightweight steel roofs.

Due to the geometry and layout of the building, the bracing demand to the critical elements was based on equivalent static linear analysis.

Calculations were used to assess the strength of the distinct components of the structure such as portal frames, precast concrete panels and roof bracings.

The total bracing capacity in each principal direction of the building was then compared to the demand generated by earthquake loadings.

7 Results and Discussion

In general, it appears that the building has a number of complicated load paths with non-ductile connections that may result in unexpected or higher than intended levels of damage.

The analysis results of the critical components areas are summarised in Table 6 below.

Table 6: Analysis Results (IL4)

Area	Parameter		%NBS (IL4)	%NBS (IL2)
HDC New Council Building	Mezzanine Concrete Portal Frames & Precast Concrete Panel Walls		50%	87%
	Precast Concrete Panels (Out-Of-Plane Bending)	Wall panels ($\mu=1.25$)	55%	96%
		Spandrels Grid D ($\mu_p=1.25$)	50%	87%
	Roof Bracing	Tension Only Elements ($\mu=1.25$)	85%	>100%

A lot of the building details do not have a suitable level of ductility and therefore our analysis for the structure as a whole has been based on these critical elements and assessed on the basis of $\mu=1.25$, nominally ductile actions. This nominal ductility leads to higher forces in the building and contributes to the lower than expected rating of many of the elements.

It should be noted there are significant structural elements within the building that have more ductile detailing and are capable of higher performance than the ratings above however in accordance with the NZSEE assessment procedures the limiting performance ratings critical to the building are provided.

These elements of concern are discussed in the following sections.

7.1 High Level Roof SW End

At the SW end of the building, the high roof part is a flexible steel framed structure welded to the chords of the horizontal trusses at the top level of the precast panel returns.

The welded connections allow for rotation at the base of the posts which will increase the corresponding frame displacements.

The ULS drifts achieve a minimum 50%NBS in the NE-SW direction and are likely to cause damage to the cladding, roofing and internal fittings.

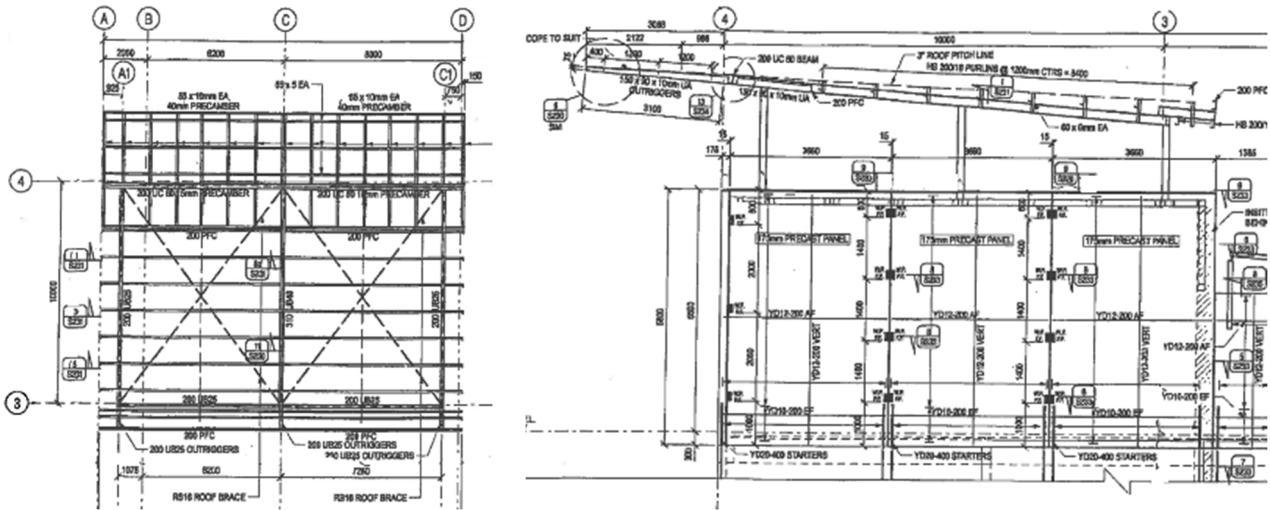


Figure 5: High level roof at the SW end of the HDC's New Council Building – Roof Plan and Elevation

7.2 Precast Walls Grid D & E

The wall system on Elevations D and E achieve a minimum rating of between 40% to 60% NBS in the NE–SW direction indicating an area of potential damage in a moderate earthquake event.

Specific concerns include:

- The precast concrete panel walls are transversely restrained by whalers that are generally aligned with the lower roof angle. The whalers are tied to the panels through chemical anchors but they are not properly restrained to the lateral load system at their ends.
- The reinforcement provided for the in-situ stitch joints on both wall elevations is not consistent with the demands generated from the multiple load paths formed.
- The walls support the lower canopy roof part of the structure which itself appears to lack a diaphragm.
- The reduction of the panel thickness, at the locations of the beam-to-panel connection, along with the reduction in reinforcement indicate a highly stressed region that is potentially subject to local damage.

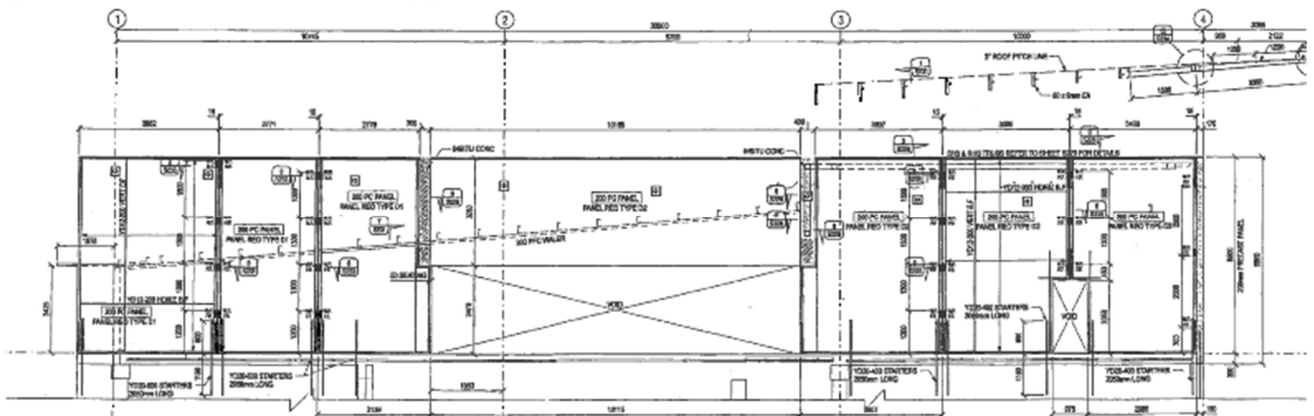


Figure 6: Elevation D of HDC's New Council Building – Precast Concrete Panel Walls

To summarise our main concerns are that these large and very heavy concrete spandrel panels suspended at height above the foyer do not have very robust connections and could become dislodged or lose support in a major earthquake.

These elements have the lowest structural element rating of 40% to 60% and govern the overall rating of the building. An average value of 50% has been used for reporting in the table 6 above.

7.3 Columns at Grid 4

There are a number of issues with the detailing of the concrete columns along Grid 4 on the outside edge of the Mezzanine that will affect the performance of this frame.

These are:

- The starter bars provided at the base of columns on Gridline 4 are not able to develop the required moment connection.
- The columns themselves are not directly connected to the diaphragm at the Mezzanine Floor level due to the voids at the slab edge .
- The connection between the columns and the post-tensioned concrete beams to the columns terminates early within the column and the bars are bent down and not into the centre affecting the ability to transfer loads through the joint as a suitable concrete (strut and tie) mechanism cannot form.
- This does not appear consistent with the design intent for this element.

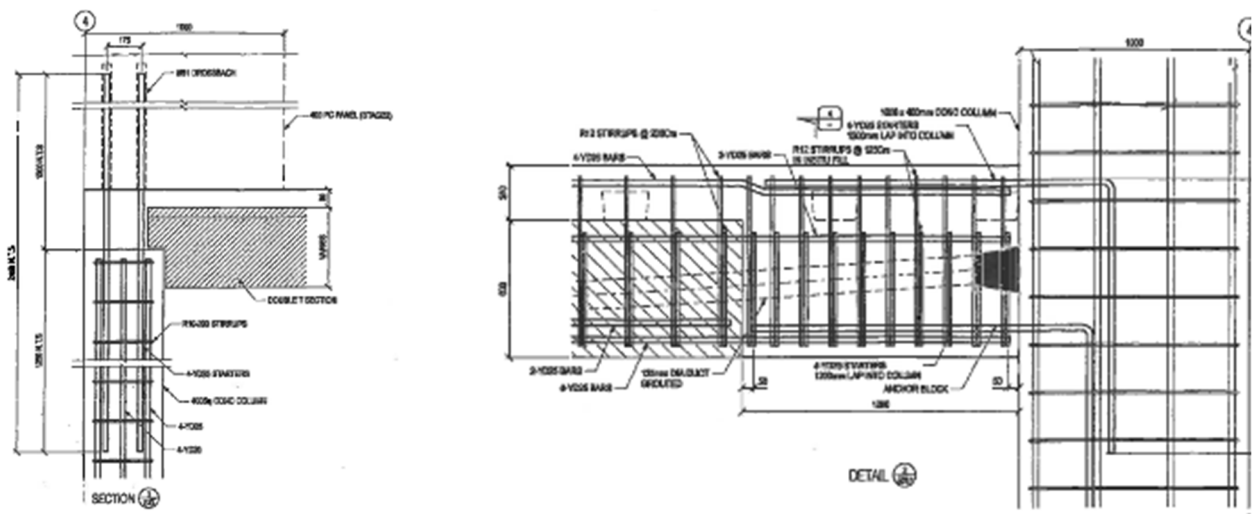


Figure 7: Gridline 4 – Starter bars at the columns' base and Beam-to-Column reinforcement detail

7.4 Mezzanine Floor Slabs

During an earthquake event, lateral loads induced at the Mezzanine level will be distributed through the floor slab diaphragm amongst the precast concrete panel walls and the concrete frame on Gridline 3.

The slab is reinforced with a non-ductile 335 mesh and there are a number of openings at the slab edge adjacent to the connections to the main vertical structure which cause stress concentrations.

Non-ductile mesh has been proven to perform poorly in highly stresses diaphragms in the Christchurch Earthquakes and is no longer used in this type of construction.

Our assessment is that the slab will despite this will still be able to work as a diaphragm via a strut and tie mechanism however significant cracking and damage will occur and rupture of the mesh in the concrete slab is expected this damage will be amplified by openings at the slab edge.

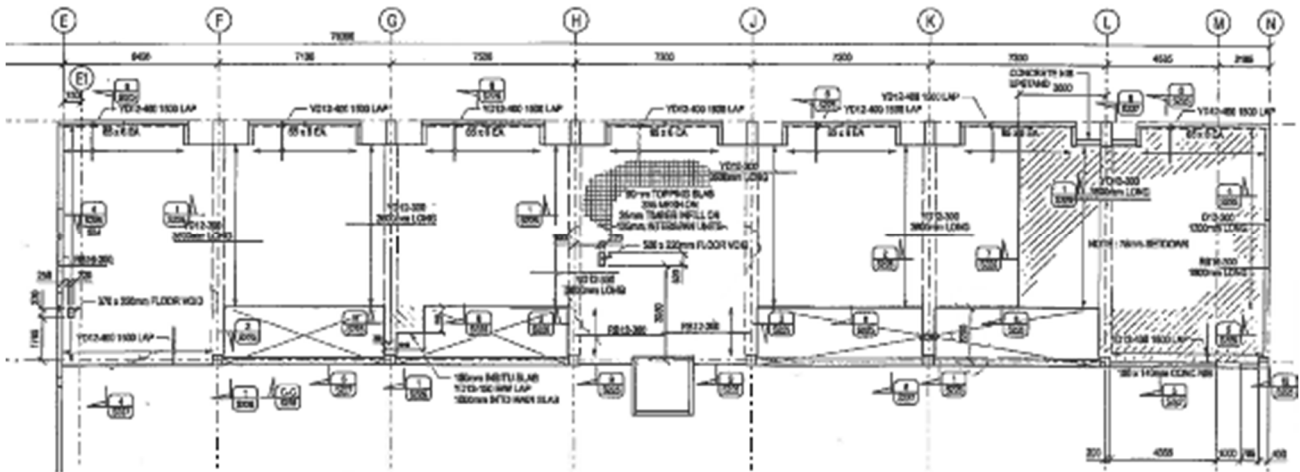


Figure 8: Mezzanine Floor level at the HDC's New Council Building

7.5 Frame Elements – Grid 3 Lateral Deflection Compatibility

The frame formed on Gridline 3 is poorly detailed and will have a low capacity to resist any type of lateral displacement or loads induced in the NE–SW direction of the structure.

The longitudinal reinforcing bars do not penetrate through the column and therefore no beam–column joint is formed and the joint has a very low displacement and force capability.

It is likely that a brittle failure mode such as vertical shear failure through the column or premature fracture of the longitudinal bars at the connection is likely to occur if the frames are displace horizontally and the beams will eventually lose their support.

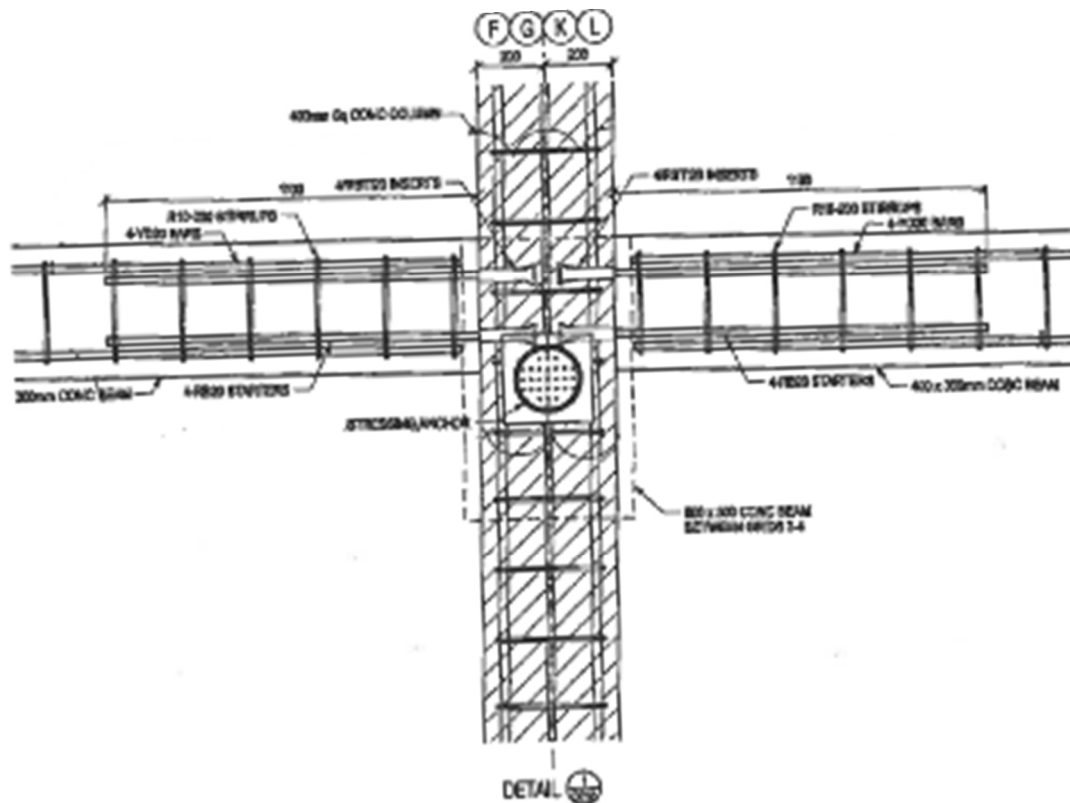


Figure 9: Beam-to-Column reinforcement detail.

7.6 Frame Elements – Roof

The connection detail of the lower roof rafters to the columns on Gridline 1 may also lead to a load distribution that differs from that intended in the original design of the elements.

The top group of bolts is placed at 75mm from the columns edge and therefore it is of question whether the full moment capacity of the connection can be achieved.

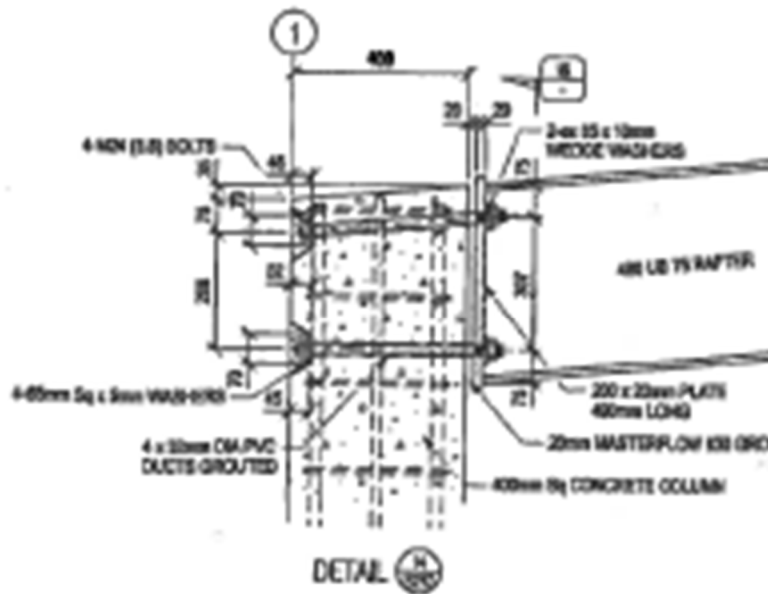


Figure 10: Beam-to-Column 460UB75 connection detail

8 Conclusions

The New Council Building was designed in 2006 and is a low rise structure with a mezzanine concrete floor for office purposes and a car-park basement. The building structure consists of precast concrete elements and features lightweight steel roofs.

This type of building has been shown to perform reasonably well in the recent Christchurch Earthquakes with the main issues observed around damage or failure of individual components of the buildings rather than the building as a whole.

The HDC building has some detailing that does not have a suitable level of robustness and therefore our analysis has been based on these critical elements and it should be noted there are significant structural elements within the building that have more ductile detailing and are capable of higher performance than the ratings above however in accordance with the NZSEE assessment procedures the limiting performance ratings critical to the building are provided.

It is our assessment that the HDC building has a likely strength in the order of 50% NBS when assessed as an Importance Level 4 building with post disaster function, or if assessed as a normal commercial building (without post disaster function) in the order of 87% NBS.

The results of our seismic assessment are presented below.

Table 7: Analysis Results

Importance Level	%NBS	Comments
IL2	87%	This importance level is focussed solely on life safety requirements
IL4	50%	This importance level is focussed on ensuring life safety and continued use of the building. It is a greater requirement than the original design brief.

This assessment means the building is Not Earthquake Prone in accordance the Building Act 2004.

When considered at IL2, the HDC's New Council Building in Levin is classified as Low Earthquake Risk according to the NZSEE 2006 Risk Grading Scheme since the minimum seismic rating achieved is between the 33% and 67%NBS threshold.

It is however classified as Moderate Earthquake Risk according to the NZSEE 2006 Risk Grading Scheme when considered as an IL4 building with post disaster function.



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