Dunning Thornton consultants

Ref: 7527 L02

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Nelson City Council
PO Box 645
NELSON 7040

Attention: Drew Hayes

Dear Drew

Trafalgar Centre Seismic Evaluation Peer Review

Executive Summary

In accordance with the terms of our engagement Dunning Thornton Consultants Ltd (DTC) have undertaken a peer review of the seismic evaluation of the Trafalgar Centre as prepared by Holmes Consulting Group Ltd (HCG). The peer review is limited to primary structures only and does not include secondary elements such as glazing, cladding, ceilings etc.

To complete the peer review independent calculations were undertaken by DTC without reference to the HCG evaluation. A comparison with the overall building ratings has then been made as follows with the appropriate Importance Level stated:

Building	% New Building Standard		
	DTC	HCG	Importance Level
Northern Building	35% - 40%	<15%	3
Main Hall	20% - 35%	20-25%	3
Southern Extension	15% - 20%	25-30%	3
Civil Defence Building	35-40%	<15%	4

In general, we believe there is reasonable correlation between the peer review values and the original HCG values given the independent approach taken in the review. In the main body of this report we discuss reasons for the variances. In general, it should be noted that HCG's seismic evaluation is much more detailed than DTC's and the DTC values should be considered suitable for calibration purposes only.

The Tonkin & Taylor geotechnical report suggests the site is prone to liquefaction and lateral spreading although the %New Building Standard trigger level is not

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expressly stated. This is likely to be in the 30-35%NBS range for Importance Level 3 buildings based on the values of peak ground acceleration stated by Tonkin and Taylor Ltd. It is therefore unlikely to affect the reported seismic evaluation values stated above for the Main Hall and Southern Extension but may affect the results of the Northern Building and Civil Defence Building.

Scope

The Trafalgar Centre has been considered in the original HCG seismic evaluation as consisting of four separate structures, the Northern Building, the Main Hall, the Southern Extension and the Civil Defence Building. In structural terms there is likely to be some interconnection between the buildings but we understand these buildings were originally designed having independent structural systems with no designed structural linkages between them. For simplicity sake we have also considered the buildings to be seismically independent. In practice some damage must be expected during moderate seismic events to any linking claddings, linings, services or structure that connect the separate buildings.

Our peer review has included the following stages of work:

- Completion of independent abbreviated calculations of the seismic demand and capacity of the four separate buildings. This has included determining appropriate seismic coefficients, applicable ductilities etc. We have assumed the importance level values stated in the HCG Evaluation Report are appropriate.
- A brief review of the HCG seismic evaluation calculations to endeavour to understand major differences in the achieved percentage NBS values.
- A review of the HCG Seismic Evaluation Report and the Tonkin & Taylor Geotechnical report for the site.
- Completion of a summary report.

In order to complete our peer review we have used the following documentation:

- HCG Seismic Evaluation Report dated May 2013.
- Tonkin & Taylor Geotechnical report dated June 2013.
- Original structural drawings for the Northern Building as prepared by Sanders & Lane, 1970.
- Original structural drawings for the Main Hall as prepared by Sanders & Lane, 1970.
- Original structural drawings for the Southern Extension as prepared by W.R Andrew Ltd, 2007.
- JJS Ltd shop drawings for the Southern Extension dated 2008.
- Original Architectural drawings for the Proposed Office for the Civil Defence Office, Nelson City Council 1980.

Northern Building

The northern building is a single storey structure consisting of reinforced concrete block masonry walls supporting a light weight roof structure. The foundations are detailed as reinforced concrete bulb piles (Frankie type) with an unknown pile length.

A summary of DTC calculated capacities is given below.

Element of Structure	Calculated %NBS
Transverse Direction (East/West)	
Blockwork wall, face load	35%
Longitudinal Direction (North/South)	
Blockwork wall, face load	85%
Roof Diaphragm	40%

HCG have reported a seismic strength of less than 15% for this Importance Level 3 building. This is likely to be a result of different approaches taken in methodology of how seismic face loads to the blockwork walls are resisted. We believe the majority of blockwork walls are supported by intersecting perpendicular walls when subject to seismic face loads and effectively act as panels supported on three sides. This gives much higher capacities than if the walls are considered to only span floor to roof diaphragm and also dramatically reduces loads on the roof diaphragm. The major exception to this is the northern wall elevation when subject to longitudinal direction face loads. This wall only has support at the floor and roof diaphragm. Although the building is close to some of the worst areas of liquefaction potential for the site this would not appear to be triggered at a 35%NBS level.

Main Hall

The Main Hall structure typically consists of glue laminated timber arches spanning circa 45m onto concrete superstructures on the east and west sides. The eastern concrete superstructure is a braced structural frame which we consider to be significantly stiffer than the western concrete frame structure. We have therefore made the simplistic assumption that all of the seismic loads in the transverse (east/west) direction are taken by the stiffer eastern braced structure.

A summary of our independent calculations is given below:

Element of structure	Calculated %NBS
Transverse Direction	
Arch	90%
Eastern concrete buttress	35%
North elevation	10%
Longitudinal Direction	
Eastern structure	
Gallery beams	90%
Gallery columns	100%
Gallery foundation	65%
Western structure	
Cantilever upper columns	20%
Blockwork wall	100%
Connection of wall to floor beam	90%
Roof bracing	30%

It is recommended our reported strength of the north elevation is not considered to be the limiting capacity as failure of this frame is unlikely to lead to structural collapse because the roof bracing will redistribute loads.

For primary structure we have selected a ductility factor of μ=1.25 as appropriate compared to the μ=1.0 value used in the HCG evaluation.

Given the reasonable level of detailing for the concrete structure we believe that this is appropriate. This reduces the seismic demand on the building by approximately 20%.

In the transverse direction we believe the critical elements are the eastern concrete buttress raking struts. These limit the capacity of the building in this direction to 35%NBS. It should be noted that this buttressed structure will be very susceptible to ground settlements should the ground liquefy or laterally spread. Rotation of the foundation structures could conceivably lead to overloading of the arch structure and potential collapse. Any strengthening options for the building should rigorously address this issue with adequate margin for error in the geotechnical predictions and closely consider pile capacities especially when liquefaction occurs.

If foundation structures are to be relied upon when lateral spreading occurs an assessment of the flexural capacity of the piles during the expected ground displacements must be undertaken.

In the longitudinal direction the cantilever upper level columns on the western side of the building appear to govern the seismic capacity closely followed by the roof bracing capacity.

In terms of the overall rating of the Main Hall building we have a very similar result to the HCG values although we have used a less conservative achievable displacement ductility value.

Southern Extension

The southern extension is an unusual structure which may behave in an unpredictable manner in a significant seismic event. It effectively consists of two towers at the western and eastern ends of the building linked by a diagonally braced roof diaphragm. Although this diaphragm is considered to be flexible there is the potential for the two towers to seismically vibrate out of phase with unpredictable consequences for the roof diaphragm. This could only be better understood with significant structural modelling. For the purposes of this review we have completed hand calculations of the eastern tower only due to time constraints and that this appears to be the most critical section of the building. It is considered likely that the findings from these calculations are applicable to the western structure.

A summary of the DTC calculated capacities is given below. Note the transverse direction is in the north/south direction and the longitudinal is in the east/west direction.

Element of structure	Calculated %NBS
Transverse Direction	
Grid F diagonal brace	40%
Brace strut	20%
SHS column	60%
Column fixing	15%
225 insitu panel	85% at μ=2
300 insitu wall	55% at μ=2
300 insitu wall foundation	65%
Longitudinal direction	
Diagonal bracing	50%
200UB column	60%
Column fixing	20%
Roof bracing	30%
Roof struts	90%

Typically we have used a ductility of μ=1.25 for primary structure except for checks on the insitu concrete walls where we have used a ductility of μ=2. We have used μ=1 loads for checking foundations and roof diaphragm.

The seismic resisting structure to the eastern and western towers typically consists of diagonal tension only braced frames "founded" on concrete panels at level 1. HCG have identified the "Reidbrace" connectors as being poor performers in the recent Christchurch earthquakes. We acknowledge there are instances of Reidbrace components failing in a non ductile manner but still believe for seismic assessment purposes a ductility of μ=1.25 is appropriate.

Our calculations indicate the capacity of the braced bay column fixings is the critical element. Failure of one fixing could likely lead to collapse or partial collapse of the building. It is our view that these fixings may limit the capacity of the building to circa 15%NBS. Other braced frame elements such as the horizontal struts have similar capacities and buckling of these elements would have major consequences. Given the reasonable difference in overall reported capacities of the building it is recommended HCG undertake a further detailed review of these elements. Overall however the results of DTC and HCG agree that this building should be considered potentially earthquake prone.

Civil Defence Building

The Civil Defence Building is a light weight addition to the Northern Building constructed on the eastern elevation. The building is effectively a lean to with a light weight roof and timber framed walls to all sides except the northern elevation. This wall consists of reinforced concrete masonry. Only one Architectural drawing has been reviewed. This drawing indicates the building has gib lined timber framed walls but only Pinex ceiling lining. It therefore does not appear to have an adequate roof diaphragm.

For lateral loads in the longitudinal direction (north/south) the plasterboard lined walls on the eastern elevation resist loadings while the existing timber framed wall to the Northern building also provide lateral bracing. The width of the building is

4.0m which is less than the maximum allowable top plate span of 6m in accordance with NZS3604. Therefore in the longitudinal direction a roof diaphragm is not required.

In the transverse direction lateral loads are resisted directly by the studs to the eastern elevation of the Northern Building. Therefore the capacity of the Civil Defence Building is governed by the transverse capacity of the Northern Building in this direction.

A summary of the DTC calculated capacities is given below:

Direction	Calculated %NBS
Transverse	35%
Longitudinal	90-95%

General

We understand you require comment of the likely response of the four buildings in a moderate earthquake. Moderate earthquakes are defined in the NZ Building Act as 33% of New Building Standard. New Building Standard is the current structural loadings code NZS1170.5 for seismic loadings. It should be noted that the level of seismic load defined in the standard is a probabilistic level of earthquake based on the site location, geology etc. It is not the maximum level of earthquake the site can expect. It is therefore important that structures have a good level of robustness to resist seismic activity and that where practical site conditions that may lead to uncertainties and early failure are mitigated. In particular the prediction of liquefaction trigger levels is known to be difficult and practically, likely to occur over a wide %NBS range.

We would expect the Northern Building to be a relatively robust structure with the exception of the wall to the northern elevation which is reliant on the roof diaphragm. Failure of this wall would not lead to collapse of the entire building. From our peer review results in a moderate earthquake the wall to the northern elevation would have collapsed or be at the point of collapse. The rest of the structure is likely to be badly damaged including the roof diaphragm. It is likely secondary elements such as ceilings, glazing etc would have been damaged to such an extent that they would have failed.

The Main Hall has a number of susceptible elements in or around the moderate level seismic event. This includes the eastern concrete buttress, the western frame cantilever upper columns and the roof bracing. Failure of any one of these elements could lead to at least part of the roof structure (arch and cladding) collapse and therefore represents a serious life safety hazard. The structure will be particular prone to ground movements due to liquefaction and lateral spreading which coincidentally appears to be triggered at about the moderate level seismic event.

The Southern extension is a hybrid form of structure with load paths susceptible to failure of single elements. Our review indicates the braced frame column fixings will fail before a moderate level earthquake. Failure of these elements eliminates the braced frames as lateral load resisting elements. Alternate means of resisting lateral loads appear to be absent. We therefore believe that the structural form of

the lateral load resisting system is not particularly robust. It is our view that collapse of at least part of building is probable during a moderate seismic event.

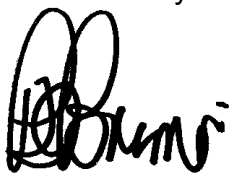
The Civil Defence Building is a single storey lean to. In our view its strength is governed by the neighbouring Northern Building. Given the lightweight nature of this building we would expect life safety risks in this building to be low in a moderate seismic event. It is likely there is more hazard from any collapse of the Northern Building rather than the Civil Defence Building itself.

Summary

A peer review of the HCG seismic assessment of the Trafalgar Centre in Nelson has been completed. Our review found reasonable correlation with the HCG assessment. It is recommended that the robustness of the structures is considered of prime importance rather than solely the percentage NBS rating. We believe the Main Hall and Southern extension are not particularly robust structures in seismic events.

We trust this provides you with the information you require. Should you have any queries on this matter please do not hesitate to contact the undersigned.

Yours faithfully



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