

Under **THE COMMISSIONS OF INQUIRY ACT 1908**
In the matter of the **CANTERBURY EARTHQUAKES ROYAL COMMISSION
OF INQUIRY INTO THE COLLAPSE OF THE CTV
BUILDING**

**SECOND STATEMENT OF EVIDENCE OF DOUGLAS ALEXANDER LATHAM
IN RELATION TO ELASTIC RESPONSE SPECTRA ANALYSIS
Dated 25th July 2012**

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SECOND STATEMENT OF EVIDENCE OF DOUGLAS ALEXANDER LATHAM IN RELATION TO ELASTIC RESPONSE SPECTRA ANALYSIS

1. My full name is Douglas Alexander Latham. I reside in Christchurch. I am a Structural Engineer.
2. In accordance with the requirements of Rule 9.43 of the High Court Rules, I confirm that I have read the Code of Conduct for expert witnesses and that my evidence complies with the Code's requirements.
3. Matters on which I express an opinion are within my field of expertise.
4. I am employed by Alan Reay Consultants Limited ("**ARCL**"), an affected party in this Royal Commission hearing.

Qualifications and experience

5. I hold a Bachelor of Engineering with Honours (2010, University of Canterbury). I am a Graduate Member of the Institution of Professional Engineers New Zealand.
6. I have been employed by ARCL since completing my studies in January 2010, over which time I have worked on a number of analysis and design projects.
7. My full resume is **annexed** to this statement.

Involvement in CTV Building analysis

8. Together with Chris Urmson, another structural engineer employed by ARCL, I have been working with Dr Alan Reay on an investigation into the collapse of the CTV Building. This work has included:
 - (a) Reviewing the draft reports by the Department of Building and Housing ("**DBH**") in December 2011 and preparing comments on the draft report, a number of which were picked up and reflected in the final report;
 - (b) Carrying out a retrospective analysis of the building's compliance with the building code at the time of design and when the drag bars were fitted in 1991 as well as reviewing the DBH collapse scenario of the building using analytical tools designed for these purposes.

9. I have already filed three statements of evidence before the Commission being a statement of evidence dated 31 May 2012 and two affidavits dated 5 and 6 June 2012.
10. In preparing this evidence I have referred to and relied upon the following principal sources of information:
 - (a) CTV Building structural drawings;
 - (b) CTV Building Structural Specification;
 - (c) Calculations;
 - (d) Reports prepared for the DBH, comprising:
 - (i) CTV Building Collapse Investigation for the DBH prepared by Dr Clark Hyland and Ashley Smith; and
 - (ii) Chapter 5 (CTV Building) of the Expert Panel Report on the Structural Performance of Christchurch CBD Buildings in the 22 February 2011 Aftershock.
 - (e) NZS 3101:1982 (Code of Practice for the Design of Concrete Structures);
 - (f) NZS4203:1984: Code of Practice for General Structural Design and Design Loadings for Buildings.
 - (g) Other information referred to in my evidence including the Seismic Analysis Report I refer to below.
11. Following an interlocutory hearing in which such information was sought by ARCL and Dr Reay from the DBH and Compusoft Engineering Limited, in early June 2012 ARCL received copies of the full input files used by the authors of the DBH report for the ERSA analyses. I have used these files to assess the inputs for the DBH ERSA analysis and to carry out further analysis.

Royal Commission ERSA panel

12. I have been a member of the ERSA panel constituted as part of the Royal Commission into the collapse of the CTV Building pursuant to the Order as to Directions in Relation to the Elastic Response Spectra Analysis Evidence dated 18 June 2012.

13. The outcome of that panel is reported in a joint report prepared by Professor Carr. Areas of agreement and disagreement are noted in that joint report.
14. I am in disagreement with a number of issues relating to the ERSA. Most of those issues have been noted in the joint report to the Commission.
15. Due to my disagreement over some of the ERSA panel issues, I have carried out a further ERSA analysis. I have prepared a Seismic Analysis Report (copy **attached**) which sets out the analysis I have undertaken and the result of the analysis.
16. I wish to explain how this report came about, and its context in relation to other work that I have done. In particular, I have undertaken three tasks arising out of the ERSA panel work. They are:
 - (a) First, I have run a static analysis of the CTV Building to determine the forces and displacements that could be used in the design of the structure in 1986. In running a static analysis I did so with the assumptions that I consider are justified on a straightforward interpretation of the relevant information available in 1986.
 - (b) Second, I performed an ERSA using the static analysis to carry out the scaling required by the Code. Of course, in doing so I adopted the same assumptions used in the static analysis.
 - (c) Third, utilising the subsequent results of my analysis, I am in the process of completing a design review of the columns with a view to ascertaining whether there was compliance with the Code as it was in 1986.

For the reasons explained below the report accompanying this part of my evidence only includes the first and second tasks noted above. The third task will be the subject of further evidence to be filed when that work is finished.

17. It is important for me to record that as a member of the ERSA panel I have always promoted the dual viewpoints that:
 - (a) First an ERSA was not required in the circumstances of the CTV Building design; and

- (b) Second, if the ERSA was going to be run it should be re-run using inputs derived from 1986. I note here that any such analysis, including a static analysis, should also only be run using inputs derived from the 1986 circumstances.
18. I understood from the Order as to Directions dated 18 June 2012 that if agreement could not be reached amongst the ERSA panel on the Compusoft ERSA's reliability, that a further ERSA would be carried out (clause 4.4).
19. From the outset on the ERSA panel, I have challenged Compusoft's ERSA reliability and, as noted above, have promoted the need for a separate ERSA to be completed using 1986 derived inputs. Notwithstanding the possibility contemplated in clause 4.4 of the Order as to Directions, no separate ERSA was run by the ERSA panel. Accordingly, I determined that I would do an appropriate analysis myself.
20. In considering running an ERSA with 1986 derived inputs I came to the view that running an ERSA was not required under the Code. It was only once I got to the point of assessing the CTV Building for running an ERSA that I reached a definitive conclusion on this issue. I concluded that, instead, it was feasible and appropriate for a static analysis to be run for the CTV Building, and that analysis was all that was required.
21. In the process of running the analysis it occurred to me that I then had all the information I needed to undertake a design review of the columns measured against the Code as it was in 1986, so I am in the process of completing that review but have not finished writing it up. In this respect, as to timing, I note:
- (a) I had intended to complete my evidence arising out of my ERSA panel work by the end of this week in time for the Code Compliance evidence that I expected to give on 31 July and 1 August 2012, including a possible ERSA "hot tub"¹. It is also relevant that it was only on 16 July that the joint ERSA report was signed and it became clear to me that the new ERSA contemplated under the 18 June Order as to Directions was not going to be run. I then set about completing the static analysis and ERSA tasks I have completed.

¹ As per the updated hearing schedule dated 27 June 2012.

- (b) On Monday 23 July I was informed that the ERSA "hot tub" would possibly proceed this week rather than next week². That has required that I complete my evidence as soon as possible including, in particular and as a priority, that part of my evidence which relates to the ERSA panel work directly.
- (c) I intend filing my further evidence on design review of the columns, relevant to the Code compliance section of the hearing, as soon as possible.

Summary of attached Seismic Analysis Report

22. In summary, my Seismic Analysis Report on my static analysis and ERSA concludes:
- (a) The CTV building is only of moderate eccentricity and therefore a static analysis can be used exclusively to determine the design forces and displacements for compliance with the 1986 Code.
 - (b) Under both the static analysis and ERSA the CTV Building complies with the drift limits in the Code³.
23. It can also be noted that the design drifts determined from both the static analysis and ERSA are such that the columns appear to comply based on the criteria used in the DBH CTV building collapse report by Messrs Hyland and Smith.

Dated this 25th day of July 2012



D A Latham

² As per the updated hearing schedule dated 21 July 2012.

³ The inter-storey drift limit specified in clause 3.8.3 of NZS 4203:1984 was 0.83%. On my analysis, the building complied with this drift limit as the maximum inter-storey drift determined was 0.47% from the equivalent static analysis and 0.53% from the ERSA.

Doug Latham

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EDUCATION

Qualifications

Bachelor of Engineering with First Class Honours in Civil Engineering University of Canterbury	2006-2009
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Professional Associations

Graduate Member of IPENZ	2010-present
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PROFESSIONAL EXPERIENCE

Structural Engineer, Alan Reay Consultants Limited	2010-present
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Selected Projects:

Analysis & Detailed Design Projects

Kilmore Street Medical Centre

Carried out structural analysis and detailed design of a three level post-tensioned steel rocking frame (steel PRESSS) medical building. Carried out non-linear static and non-linear time history analysis. Project peer reviewed by Professor Stefano Pampanin.

St. Margaret's College Gymnasium & Chapel

Carried out structural analysis and detailed design of a new gymnasium and auditorium, consisting of precast concrete walls and suspended floors and a steel framed roof. Project peer reviewed by Harris Foster.

Bascik Transport

Carried out structural analysis and detailed design of a 1000m² industrial warehouse, with mezzanine office.

Lot 4 & 5 Show Place

Carried out structural analysis and detailed design of a four level post-tensioned precast concrete rocking wall (PRESSS) office building. Carried out non-linear static analysis. Project peer reviewed by Stefano Pampanin.

Airport Business Park, Russley Road

Carried out structural analysis and detailed design for a new suspended floor retrofitted into an existing industrial structure.

Development – Corner Madras and Salisbury Streets

Carried out analysis and detailed design of a two level precast concrete retail and office building.

WDHB Carpark, Hamilton

Carried out structural analysis and detailed design of a six level precast concrete carparking structure. Project peer reviewed by Harris Foster.

Agriseeds Coating Plant

Carried out structural analysis and detailed design of a 4000m² industrial warehouse.

Analysis & Concept Design Projects

Office Building, Hereford Street

Carried out a detailed strength assessment and seismic retrofit and repair methodology for a nine level reinforced concrete shear wall office building in Hereford Street.

Office Building, Colombo Street

Carried out a detailed strength assessment and seismic retrofit and repair methodology for a six level reinforced concrete shear wall office building in Colombo Street.

Office Building, Colombo Street

Carried out structural analysis and concept design work for a new ten storey office building in Colombo Street.

Carpark Building Concept, Tuam Street

Carried out structural analysis and concept design work for a four storey reinforced concrete carparking building in Tuam Street.

Bio-Filter Tank Roof, Hastings Wastewater Treatment Plant

Carried out a buckling analysis and concept design for a fibreglass dome room for the bio-filter tanks at the Hastings Wastewater Treatment Plant.

Office Building, Lismore Street

Carried out non-linear time history analysis on a two level rocking precast concrete wall structure. Discussed modelling approaches with Professor Athol Carr.

St. John Emergency Services Building

Carried out seismic analysis using static and modal methods for the design of a six storey reinforced concrete structure.

Other Projects

Earthquake Assessments

Carried out numerous assessments of buildings following the Canterbury earthquakes.

Building Collapse, Invercargill

Carried out detailed analysis on a single level industrial / office building that collapsed during the Invercargill snowstorm of 2010, acting as an expert witness.

Building Collapse, Rangiora & Ashburton

Carried out detailed analysis on two cold-formed steel buildings that collapsed during the Canterbury snowstorm of 2004 and 2006, acting as an expert witness.

AWARDS

IPENZ Fulton-Downer Gold Medal (Joint recipient)	2011
CCANZ Concrete Prize	2009
Tonkin & Taylor Geotechnical Prize	2009
BECA Engineering in Society 3 rd Pro Scholarship	2009
Freemasons University Scholarship	2009
University of Canterbury Senior Scholarship	2008
URS Civil Engineering Scholarship	2008
BECA Engineering in Society 2 nd Pro Scholarship	2008
MWH Ltd. Geotechnical Prize	2008
Ian McMillan Prize, Civil Engineering	2007
BECA Engineering in Society 1 st Pro Scholarship	2007
MWH Ltd. / Jim McFarlane Memorial Prize	2007
University of Canterbury Emerging Leaders' Scholarship	2006



SEISMIC ANALYSIS REPORT:

BUILDING:

CTV Building
249 Madras Street
Christchurch

By:

Alan Reay Consultants Limited

Date: 25 July 2012

Revision: v1

Innovation
by design

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SEISMIC ANALYSIS REPORT

Report Prepared By:

Doug Latham, B.E. (Hons), GIPENZ



Structural Engineer

ALAN REAY CONSULTANTS LIMITED

25 July 2012

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Appendix A – CTV Building Seismic Mass Calculation

1. Introduction

1.1 *Scope*

The scope of this report covers the seismic analysis of the CTV building for the purposes of considering whether the design was consistent with the design standards and codes applicable at the time of design in 1986.

The analysis has been undertaken with a 1986 context in mind. The analysis does not intend to replicate the original design, however the basis of decisions made during the original design and the information available at the time of design have been considered and followed through where appropriate.

1.2 *Analysis Procedure*

The analysis procedure consists of running seismic analyses using ETABS to determine the lateral seismic design forces and deflections that are applicable for the design of the CTV building. Input data for the ETABS analysis has been documented in this report. The analyses have been carried out in accordance with the design loadings standard NZS4203:1984.

1.3 *References*

This report relies on and makes reference to the following documents:

- a) NZS 4203:1984 Code of practice for General Structural Design and Design Loadings for Buildings (& Commentary)
- b) NZS 3101:1982 Code of practice for the Design of Concrete Structures (& Commentary)
- c) Structural Drawings – Office Building – 249 Madras St, by ARCE dated August 1986
- d) Geotechnical report by Soils & Foundations
- e) Letter from Ian McCahon dated 5 June 2012
- f) HiBond literature applicable in 1986
- g) DBH CTV Building Collapse Report prepared by Dr. Clark Hyland and Mr. Ashley Smith
- h) ETABS Model Files (.e2k) used as part of the DBH reports and supplied to ARCL

2. **Analysis Model**

2.1 *DBH Model*

A three dimensional ETABS model of the CTV Building structure was developed and used as part of the DBH report by Dr. Hyland & Mr. Smith into the collapse of the CTV building. The input file for this model was supplied to ARCL in .e2k format in June 2012.

The model consisted of the main lateral structural elements, including the floor diaphragms, North core shear wall, South coupled shear wall and foundations. The model also included the secondary elements such as the beams and columns. Moment releases were applied to the beams to remove their contribution to the lateral resistance.

2.2 *Modifications to the DBH Model*

The DBH model file supplied to ARCL was modified by ARCL in a number of ways. The modifications included:

- Adjusting the building mass and location of centre of mass
- Adjusting the foundation stiffness
- Fully removing the contribution of the secondary elements (beams and columns) by making these null members
- Correcting the ground floor inter-storey height to 3.7m

A full list of inputs and assumptions considered in the ARCL analyses is presented in Section 3 of this report.

A screenshot of the model is shown below in Figure 1.

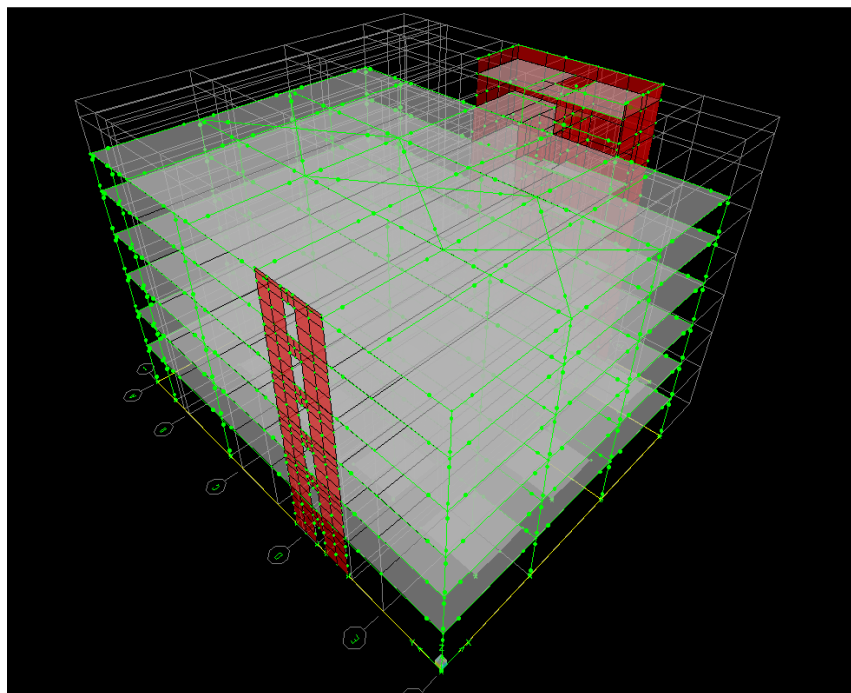


Figure 1: Screenshot of ETABS 3D model of the CTV Building

3. **Modelling Inputs**

3.1 *Building Mass*

The mass or weight of the building has been calculated based on a detailed review of the available structural and architectural drawings. The key assumptions are presented in Table 1 below:

Table 1: Mass Assumptions

Element	Weight	Unit
Concrete	2400	kg/m ³
Concrete	23.5	kN/m ³
200mm thick HiBond floor	4.0	kPa
165mm thick HiBond floor	3.2	kPa
150mm thick HiBond floor	2.9	kPa
External Cladding	0.2	kPa
Super Imposed Dead Load (SDL) floor	0.5	kPa
Super Imposed Dead Load (SDL) roof	0.15	kPa
Live load, office general	2.5	kPa
Live load, toilets	2.0	kPa
Live load, machine rooms	5.0	kPa

In accordance with Clause 4.2.1 of NZS 4203:1984 the total reduced gravity load W_t for the purpose of calculating the horizontal seismic force has been calculated as the Dead load and one third Live load as per Equation 26B.

It has been assumed that the mass is lumped at each floor level at the center of mass (COM). The mass attributed to each floor level has been taken from the mid-storey height below the floor to the mid-storey height above the floor.

A summary of the calculated mass is presented in Table 2 below:

Table 2: Summary of Building Mass

Level	Weight, W_t (kN)	COM x' (m)	COM y' (m)	Rotational Inertia, I (kN.m ²)
Level 8	473	25.24	12.30	7676
Level 7	920	18.32	13.76	126957
Level 6	5852	12.51	13.76	879875
Level 5	5941	12.61	13.76	896851
Level 4	6016	12.59	13.96	919660
Level 3	6151	12.56	14.32	959453
Level 2	6355	12.77	14.30	1002002
Total	31708			

In Table 2, x' and y' are measured from the intersection of Grid A and Grid 1, with positive x in the east direction and positive y in the north direction.

A detailed breakdown of the mass calculation is provided in Appendix A. The mass calculation in Appendix A has used a difference reference coordinate system.

3.2 Building Element Stiffness

The elements of the structure have been modelled with geometry and properties as per the ARCE structural drawings. The elastic modulus of concrete has been calculated in accordance with Clause 3.3.4.1 of NZS 3101:1982. Effective stiffnesses have been assigned to the shear walls in accordance with recommendations made in the paper “The Analysis and Design of and the Evaluation of Design Actions for Reinforced Concrete Ductile Shear Wall Structures” by T. Paulay and R Williams, published in 1980. A rigid diaphragm was applied to the floors.

A summary of the stiffness assumptions are presented in Table 3 below:

Table 3: Summary of Building Element Stiffness

Element	Specified Concrete Strength (MPa)	Elastic Modulus (MPa)	Effective Stiffness (Ie/Ig)
North Core Shear Walls	25 MPa	23500 MPa	0.6
South Shear Wall – Compression Pier	25 MPa	23500 MPa	0.8
South Shear Wall – Tension Pier	25 MPa	23500 MPa	0.5
South Shear Wall – Coupling Beams	25 MPa	23500 MPa	0.4
Floor Slab	25 MPa	23500 MPa	Rigid
Foundation Beams	20 MPa	21019 MPa	0.5

3.3 Foundation Stiffness

The foundations have been modelled with elastic springs to represent the foundation flexibility. The recommendations from Ian McCahon as per his 1985 report and outlined in his letter of 5 June 2012 have been adopted.

A summary of the foundation stiffnesses are presented in Table 4 below:

Table 4: Summary of Foundation Stiffnesses

Foundation Line	Width (m)	Area Stiffness (kN/m ² /m)	Line Stiffness (kN/m/m)
Grid 1	3.0	5200	15600
Grid 1	2.5	5800	14500
Column Pad	4.0	4600	
Column Pad	4.5	4600	
Column Pad (soft)	4.5	2600	
Grid A	1.7	7660	13022
Grid F	2.5	5800	14500
Grid F (soft)	2.5	3500	8750
Grid 4	2.5	5800	14500
Grid 4 (soft)	2.5	3500	8750
Core	5.9	4600	
Core	8.2	4600	
Core (soft)	8.2	2600	
Core (soft)	5.9	2600	

4. **Structural Characteristics**

4.1 *Natural Period of Vibration*

The fundamental natural period of the building has been calculated using Rayleigh's Method in accordance with Equation 29 of NZS 4203:1984. The modal period determined from the 3D ETABS model has also been considered. The natural periods are presented in Table 5 below:

Table 5: Natural Period of Vibration

Direction	Rayleigh's Method Period, T (sec)	Modal Method Period, T (sec)
North-South	2.07 sec	2.07 sec (1 st mode)
East-West	1.19 sec	1.27 sec (2 nd mode)

The first mode is purely translational so the first mode natural period is in very close agreement to the period obtained from Rayleigh's Method. The second mode has a degree of torsional behaviour in addition to translational, so there is a small difference between the second mode natural period and the period obtained using Rayleigh's Method.

4.2 *Centre of Rigidity*

The centre of rigidity (COR), also known as the centre of stiffness or centre of rotation, was determined from the ARCL 3D ETABS model.

A summary of the COR coordinates along with the COM coordinates and difference to the COM, is presented in Tables 6 and 7 below:

Table 6: Centre of Rigidity Coordinates, x

Level	COR x' (m)	COM x' (m)	COR-COM (m)
Level 8	20.58	25.24	-4.66
Level 7	19.79	18.32	1.47
Level 6	19.45	12.51	6.94
Level 5	19.00	12.61	6.39
Level 4	18.49	12.59	5.90
Level 3	17.91	12.56	5.35
Level 2	17.24	12.77	4.47

Table 7: Centre of Rigidity Coordinates, y

Level	COR y' (m)	COM y' (m)	COR-COM (m)
Level 8	13.61	12.30	1.31
Level 7	13.51	13.76	-0.25
Level 6	13.41	13.76	-0.35
Level 5	13.27	13.76	-0.49
Level 4	13.14	13.96	-0.82
Level 3	13.01	14.32	-1.31
Level 2	12.93	14.30	-1.37

4.3 Degree of Eccentricity

A definition for the degree of eccentricity was suggested in the commentary to NZS 4203:1984. In Clause C3.4.7.1 the code stated “Structures of moderate eccentricity are those for which the torsional component of shear load in the element most unfavourably affected does not exceed three quarters of the lateral translational component of shear load.” It can be taken that the structure was considered to have a high degree of eccentricity if the torsional component did exceed three quarters of the translational component of shear load.

The translational and torsional components of shear load can be determined from principles of statics using the centre of mass and centre of rigidity coordinates.

The translational component of shear load can be considered by applying the horizontal forces through the centre of rigidity (COR), thus generating zero rotation. The shear components in each wall are dependent on the relative distances from the point of applied force or COR. A distribution of horizontal force has been assumed in proportion to the storey mass and height, in accordance with the equivalent static method of NZS 4203:1984. An arbitrary base shear of 10000kN has been applied.

For the East-West direction of loading, the translational components of the shear load along Grids 1 and 5 are presented in Table 8 below:

Table 8: Translational Component of Shear Load

Level	Fi (kN)	e1 (m)	e2 (m)	V1 (kN)	V5 (kN)
Level 8	277.2	20.58	6.32	65	212
Level 7	479.4	19.79	7.11	127	353
Level 6	3637.9	19.45	7.45	1007	2631
Level 5	2157.2	19.00	7.90	634	1524
Level 4	1657.0	18.49	8.41	518	1139
Level 3	1155.0	17.91	8.99	386	769
Level 2	636.2	17.24	9.67	229	408
Sum	10000			2965	7035
Three quarters				2224	5276

The torsional component of shear load can be considered by applying a moment at the centre of rigidity (COR) equal to the product of the horizontal force applied at that level and the eccentricity between the centre of mass and centre of rigidity at that level. For the East-West direction of loading, the torsional components of the shear load along Grids 1 and 5 are presented in Table 9 below:

Table 9: Torsional Component of Shear Load

Level	Fi (kN)	COM-COR (m)	M* (kNm)	V1 (kN)	V5 (kN)
Level 8	277.2	-4.66	-1291	-48	48
Level 7	479.4	1.47	706	26	-26
Level 6	3637.9	6.94	25262	939	-939
Level 5	2157.2	6.39	13780	512	-512
Level 4	1657.0	5.90	9773	363	-363
Level 3	1155.0	5.35	6179	230	-230
Level 2	636.2	4.47	2841	106	-106
Sum	10000			2128	-2128

The most unfavourably affected element is the coupled shear wall along Grid 1. The torsional component of shear load is less than three quarters of the translation component of shear load, therefore it can be concluded that the structure was only of moderate eccentricity as per the NZS 4203:1984 definition for the East-West direction of loading.

For the North-South direction of loading, the eccentricity between the COM and the COR is much smaller than the East-West direction. In fact the structure is near symmetric in the North-South direction. It is clear that the structure was only of moderate eccentricity as per the NZS 4203:1984 definition for the North-South direction of loading.

5. Equivalent Static Analysis

5.1 *Total Horizontal Force*

In accordance with NZS 4203:1984, the total design horizontal force has been calculated, and is presented in Table 10 below:

Table 10: Total Horizontal Force

Factor	Symbol	North-South Direction	East-West Direction
Natural Period	T	2.07 sec	1.19 sec
Seismic Coefficient	C	0.075	0.076
Risk Factor	R	1.0	1.0
Structural Type Factor	S	1.0	1.0
Material Factor	M	0.8	0.8
Design Coefficient	Cd=CRSM	0.0600	0.0607
Seismic Weight	Wt	31708 kN	31708 kN
Design Base Shear	V=Cd.Wt	1902 kN	1924 kN

5.2 *Distribution of Horizontal Seismic Forces*

The horizontal force has been distributed up the height of the structure in accordance with NZS 4203:1984, and is presented in Table 11 below:

Table 11: Distribution of Horizontal Seismic Forces

Level	Weight, Wt (kN)	Height, h (m)	Wt x h (kN.m)	North-South Force (kN)	East-West Force (kN)
Level 8	473	21.66	10245	52.7	53.3
Level 7	920	19.26	17719	91.2	92.2
Level 6	5852	16.66	97494	692.1	700.0
Level 5	5941	13.42	79728	410.4	415.1
Level 4	6016	10.18	61243	315.3	318.8
Level 3	6151	6.94	42688	219.7	222.2
Level 2	6354	3.70	23514	121.0	122.4
Total	31709		332631	1902	1924

Note that 0.1V has been applied at Level 6, being the top storey, in accordance with Clause 3.4.6.1 of NZS 4203:1984. The remaining 0.9V has been distributed in proportion to the floor mass and height.

5.3 *Horizontal Torsional Moments*

Horizontal torsional moments have been considered in accordance with NZS 4203:1984 by applying the horizontal seismic shear force in turn at two points each distant 0.1b from the centre of mass. The locations for the application of horizontal seismic shear force are presented in Tables 12 and 13 below:

Table 12: Coordinates for Application of Horizontal Force, X Direction

Level	COM x' (m)	+0.1b COM x' (m)	-0.1b COM x' (m)
Level 8	25.24	25.68	24.80
Level 7	18.32	21.01	15.63
Level 6	12.51	15.20	9.82
Level 5	12.61	15.30	9.92
Level 4	12.59	15.28	9.90
Level 3	12.56	15.25	9.87
Level 2	12.77	15.46	10.08

Table 13: Coordinates for Application of Horizontal Force, Y Direction

Level	COM y' (m)	+0.1b COM y' (m)	-0.1b COM y' (m)
Level 8	12.30	13.43	11.16
Level 7	13.76	16.79	10.74
Level 6	13.76	16.78	10.73
Level 5	13.76	16.78	10.73
Level 4	13.96	16.99	10.94
Level 3	14.32	17.34	11.29
Level 2	14.30	17.33	11.28

5.4 Shear Wall Design Forces

From the ETABS analysis model, the design shear forces can be determined in each of the shear walls.

The core wall complex is the main lateral load resisting element for North-South actions, therefore resists nearly all of the design shear load. For East-West actions, the critical load case for the core wall design shear is with a 0.1b eccentricity applied North of the centre of mass.

For the South coupled shear wall, the wall is predominately acting in the East-West direction. The critical load case is with a 0.1b eccentricity applied South of the centre of mass.

A summary of the design shear forces in each of the shear walls is presented in Table 14 below:

Table 14: Shear Wall Design Forces (kN), Equivalent Static Analysis

	EQ Direction		
	North-South	East-West	East-West
Shear Wall:	Core	Core	South Wall
Load Case:	EQSX	EQSYP	EQSYN
Level 8	52.7	53.3	-
Level 7	145.0	116.2	42.8
Level 6	832.4	517.6	469.6
Level 5	1243.9	751.1	728.3
Level 4	1552.9	927.8	929.4
Level 3	1790.6	1060.9	1063.7
Level 2	1817.4	758.0	1438.9

The bending moment up the height of the wall can be obtained by taking the product of the difference in shears at each level and the height from that level to the point of interest.

5.5 Building Deflections

The building deflections have been determined from the ETABS analysis model, and scaled in accordance with NZS 4203:1984. Deflections have been calculated neglecting foundation rotations in accordance with Clause 3.8.1.2 of NZS 4203:1984. The deflections have then been scaled by the K/SM factor where K=2 for equivalent static analysis.

For North-South actions, the critical case for deflections was along Grid A, with a 0.1b eccentricity West of the centre of mass. The deflections along Grid F have also been considered, applying a 0.1b eccentricity East of the centre of mass. A summary of the deflections is presented in Tables 15 and 16 below:

Table 15: North-South Deflections along Grid A

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	133.2	101.9	78.3	12.2	0.47
6	114.6	88.1	66.1	15.3	0.47
5	91.3	71.0	50.8	15.0	0.46
4	68.2	53.9	35.8	14.0	0.43
3	45.4	36.7	21.8	12.4	0.38
2	23.3	19.6	9.4	9.4	0.25

Table 16: North-South Deflections along Grid F

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	129.5	100.9	71.3	11.7	0.45
6	111.2	87.3	59.6	14.6	0.45
5	88.3	70.3	45.0	14.1	0.44
4	65.7	53.4	30.9	12.9	0.40
3	43.5	36.4	17.9	10.8	0.33
2	22.2	19.4	7.1	7.1	0.19

For East-West actions, the critical case for deflections was along Grid 1, with a 0.1b eccentricity South of the centre of mass. The deflections along Grid 2 have also been considered, with the same eccentricity. A summary of the deflections is presented in Tables 17 and 18 below:

Table 17: East-West Deflections along Grid 1

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	65.0	37.1	69.9	11.9	0.46
6	55.3	32.1	58.1	15.0	0.46
5	43.0	25.8	43.0	14.6	0.45
4	31.0	19.6	28.4	13.0	0.40
3	19.5	13.4	15.4	10.1	0.31
2	9.3	7.1	5.3	5.3	0.14

Table 18: East-West Deflections along Grid 2

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	53.9	32.0	54.7	9.1	0.35
6	45.9	27.7	45.5	11.6	0.36
5	35.9	22.3	33.9	11.3	0.35
4	26.0	16.9	22.6	10.1	0.31
3	16.5	11.5	12.5	8.0	0.25
2	8.0	6.1	4.5	4.5	0.12

6. Spectral Modal Analysis

6.1 *Requirement for Spectral Modal Analysis*

A spectral modal analysis was not required for this building. Clause 3.3.9 of NZS 4203:1984 states “Buildings shall be analysed by the equivalent static force method... In addition a spectral modal analysis shall be approved for any building and may be required by the Engineer for any building, where, in his opinion, special circumstances exist, for example where a building is of particular importance to the community, or where a special study is required...” The CTV building was not subject to any of these special circumstances.

Further, Clause 3.4.7 of NZS 4203:1984 outlines methods for dealing with horizontal torsional moments and accidental eccentricities. There are three sub-clauses for dealing with different types of structures:

- a) Reasonably regular symmetric or moderately eccentric structures
- b) Reasonably regular structures with a high degree of eccentricity
- c) Irregular structures

The CTV building was reasonably regular and only of moderate eccentricity, as shown in Section 4 of this report.

The requirements of part a) of this clause required horizontal torsional effects to be taken into account either by the static method, two-dimensional modal analysis method, or the three-dimensional modal analysis method. Any of these methods are considered valid, and there is no requirement to consider one analysis method over the other. For completeness, a spectral modal analysis will be considered in addition to the equivalent static analysis, although it is not specifically required.

6.2 *Design Spectrum and Scaling*

The design spectrum has been determined from the spectrum presented in Figure 3 of NZS 4203:1984. This spectrum has been scaled by a factor K such that the both the computed base shear from the spectral modal analysis is not less than 90% of the equivalent static base shear, and that the shear at any level from the spectral modal analysis is not less than 80% of the equivalent static force, in accordance with the procedures outlined in NZS 4203:1984. A summary of the scaling factors K is presented in Table 19 below:

Table 19: Spectral Modal Analysis Scaling Factor, K

Direction	COM	+0.1b COM	-0.1b COM
North-South	0.854	0.869	0.877
East-West	1.003	0.977	1.030

6.3 *Horizontal Torsional Moments*

Horizontal torsional moments have been considered in accordance with NZS 4203:1984 by considering the effective location of the centre of mass to be in turn at two points each distant 0.1b from the actual centre of mass. The locations for the effective centre of mass are as per Tables 12 and 13,

presented in Section 5 of this report. The rotational inertia was applied at the actual centre of mass for all cases.

6.4 Combination of Modes

In accordance with NZS 4203:1984, the modes have been combined using the square root of the sum of the squares method. The first 20 modes have been considered, in excess of the minimum number specified in NZS 4203:1984.

6.5 Shear Wall Design Forces

From the ETABS analysis model, the design shear forces can be determined in each of the shear walls.

The core wall complex is the main lateral load resisting element for North-South actions, therefore resists nearly all of the design shear load. For East-West actions, the critical load case for the core wall shears is with a 0.1b eccentricity applied North of the centre of mass.

For the south coupled shear wall, the wall is predominately acting in the East-West direction. The critical load case is with a 0.1b eccentricity applied South of the centre of mass.

A summary of the design shear forces in each of the shear walls is presented in Tables 20 below:

Table 20: Shear Wall Design Forces (kN), Spectral Modal Analysis

	EQ Direction		
	North-South	East-West	East-West
Shear Wall:	Core	Core	South Wall
Load Case:	SMX	SMYP	SMYN
Level 8	79.6	61.4	
Level 7	193.2	125.9	71.5
Level 6	708.1	395.1	514.4
Level 5	1060.2	591.7	804.8
Level 4	1322.2	738.2	1016.7
Level 3	1559.3	857.5	1193.6
Level 2	1643.1	656.9	1455.5

6.6 Building Deflections

The building deflections have been determined from the ETABS analysis model, and scaled in accordance with NZS 4203:1984. Deflections have been calculated neglecting foundation rotations in accordance with Clause 3.8.1.2 of NZS 4203:1984. The deflections have then been scaled by the K/SM factor where K=2.2 for equivalent static analysis.

For North-South actions, the critical case for deflections was along Grid A, with a 0.1b eccentricity West of the centre of mass. The deflections along Grid F have also been considered, applying a 0.1b eccentricity East of the centre of mass. A summary of the deflections is presented in Tables 21 and 22 below:

Table 21: North-South Deflections along Grid A

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	115.9	86.9	79.8	12.4	0.48
6	99.7	75.2	67.4	15.5	0.48
5	79.5	60.6	51.9	15.2	0.47
4	59.3	45.9	36.8	14.3	0.44
3	39.5	31.3	22.5	12.7	0.39
2	20.3	16.7	9.8	9.8	0.26

Table 22: North-South Deflections along Grid F

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	112.8	87.0	71.1	11.6	0.45
6	96.9	75.2	59.5	14.5	0.45
5	77.0	60.6	45.0	14.1	0.43
4	57.2	46.0	31.0	12.9	0.40
3	37.9	31.3	18.1	10.8	0.33
2	19.4	16.7	7.3	7.3	0.20

For East-West actions, the critical case for deflections was along Grid 1, with a 0.1b eccentricity South of the centre of mass. A summary of the deflections is presented in Table 23 below:

Table 23: East-West Deflections along Grid 1

Level	ETABS Elastic Deflection (mm)	ETABS Foundation Rotation (mm)	K/SM Scaled Deflection (mm)	Inter-storey Drift (mm)	Inter-storey Drift (%)
7	67.2	38.1	80.0	13.6	0.52
6	57.2	33.0	66.5	17.1	0.53
5	44.5	26.6	49.3	16.7	0.51
4	32.0	20.2	32.6	15.0	0.46
3	20.2	13.7	17.6	11.6	0.36
2	9.5	7.3	6.0	6.0	0.16

7. Conclusions

7.1 *Degree of Eccentricity*

As shown in this report, the CTV building can be considered to have only a moderate degree of eccentricity. On this basis, the structure can be analysed using the static method and / or the spectral modal method. It is acceptable to use either method exclusively.

7.2 *Compliance with Inter-storey Drift Limits*

The inter-storey drift limit specified in Clause 3.8.3 of NZS 4203:1984 was 0.83%. It can be concluded that the building complied with this drift limit, as the maximum inter-storey drift determined was 0.47% from the equivalent static analysis and 0.53% from the spectral modal analysis.

7.3 *Further Work*

The design forces and deflections determined in this report can be used as the basis for assessing whether the structural elements were designed in accordance with the relevant codes and standards. Further work is required to carry out this assessment.

7.4 *Column Compliance*

The DBH CTV Building Collapse Report by Dr. Hyland and Mr. Smith has determined the elastic deformation limits for the columns, as shown in Tables 13 and 14 of their report. This appears to be the basis for determining whether the column design was in accordance with the relevant codes and standards.

It is noted that the drift levels determined from both the equivalent static analysis and the spectral modal analysis do not exceed the elastic deformation limits determined in the DBH report.

APPENDIX A – CTV BUILDING SEISMIC MASS CALCULATION

Calculation of Seismic Mass - 249 Madras St**Legend**

Origin	Intersection of Grid A and Grid 1
Positive X Direction	Increasing letter grids (A-F)
Positive Y Direction	Increasing number grids (1-5)
Level 1	Ground floor (as per drawings)
Level 2	First suspended floor (as per drawings)
...	Etc.
Level 7	Roof (as per drawings)
Level 8	Plant deck (as per drawings)

Generic Weights

Concrete	23.5 kN/m ³	(2400 kg/m ³)
200 Hibond Floor	4.0 kPa	Refer HiBond Literature
165 HiBond Floor	3.2 kPa	Refer HiBond Literature
150 HiBond Floor	2.9 kPa	Refer HiBond Literature
External Cladding	0.2 kPa	Lightweight / Single Glazing
SDL	0.5 kPa	Typical floor
	0.15 kPa	Roof
Live	2.5 kPa	Office general
	2.0 kPa	Toilets
	5.0 kPa	Machine rooms
Seismic Live	L/3	For L=5.0kPa or less

Mass Summary	Wt	x'	y'	I	(in kg)
Level 8	473	17.95	25.24	7676	782.7
Level 7	920	16.49	18.32	126957	12946.0
Level 6	5852	16.49	12.51	879875	89722.3
Level 5	5941	16.49	12.61	896851	91453.3
Level 4	6016	16.29	12.59	919660	93779.3
Level 3	6151	15.93	12.56	959453	97837.0
Level 2	6354	15.95	12.77	1002002	102175.8
Total	31709				

Level 2	x	y	z	Unit Weigt	Weight	x'	y'	Wx	Wy	I	r2	mr2	
Beams													
Grid 1 (Grids A-A/B)	2.55		0.4	0.55	23.5	13.2	1.275	0.07	17	1	7	377	4964
Grid 1 (Grids A/B-D)	15.2		0.96	0.55	23.5	188.6	10.15	-0.21	1914	-40	3646	202	38115
Grid 1 (Grids D/E-F)	7.71		0.96	0.55	23.5	95.7	26.605	-0.21	2545	-20	481	282	26989
Grid 2 (A-B)	4.75		0.4	0.423	23.5	18.9	2.375	7.5	45	142	36	212	4003
Grid 2 (B-E)	21		0.4	0.55	23.5	108.6	15.25	7.5	1656	814	3991	28	3069
Grid 2 (E-F)	4.23		0.4	0.418	23.5	16.6	27.865	7.5	463	125	25	170	2823
Grid 3 (A-B)	4.75		0.4	0.423	23.5	18.9	2.375	15	45	283	36	189	3572
Grid 3 (B-E)	21		0.4	0.55	23.5	108.6	15.25	15	1656	1629	3991	5	592
Grid 3 (E-F)	4.23		0.4	0.418	23.5	16.6	27.865	15	463	249	25	147	2444
Grid 4 (Grids A-B)	3.85		0.4	0.55	23.5	19.9	1.925	22.43	38	446	25	290	5770
Grid 4 (Grids B-C)	7.75		0.96	0.55	23.5	96.2	7.725	22.71	743	2184	489	166	15999
Grid 4 (Grids C-C/D)	3.75		0.4	0.55	23.5	19.4	13.775	22.5	267	436	23	99	1927
Grid 4 (Grids C/D-D/E)	7.2		0.4	0.55	23.5	37.2	19.55	22.5	728	838	161	108	4007
Grid 4 (Grids D/E-F)	7.31		0.96	0.55	23.5	90.7	26.805	22.71	2431	2060	411	217	19656
Grid A	0.14		21.16	0.43	23.5	29.9	0.07	11.25	2	337	1117	254	7614
Grid F	0.96		22.92	0.55	23.5	284.4	30.46	11.25	8663	3199	12472	213	60567
Columns													
C1			0.126	2.92	23.5	8.6	30.25	0	261	0	1	368	3171
C2			0.126	2.92	23.5	8.6	10.25	0	88	0	1	196	1686
C3			0.126	2.92	23.5	8.6	2.75	0	24	0	1	337	2908
C4	0.3		0.4	2.92	23.5	8.2	0.15	0.07	1	1	1	411	3383
C5			0.126	2.92	23.5	8.6	30.25	7.5	261	65	1	232	2004
C6			0.126	2.92	23.5	8.6	25.75	7.5	222	65	1	124	1068
C7			0.126	2.92	23.5	8.6	18.75	7.5	162	65	1	36	307
C8			0.126	2.92	23.5	8.6	11.75	7.5	101	65	1	45	391
C9			0.126	2.92	23.5	8.6	4.75	7.5	41	65	1	153	1320
C10	0.3		0.4	3.12	23.5	8.8	0.15	7.5	1	66	1	277	2440
C11			0.126	2.92	23.5	8.6	30.25	15	261	129	1	210	1807
C12			0.126	2.92	23.5	8.6	25.75	15	222	129	1	101	872
C13			0.126	2.92	23.5	8.6	18.75	15	162	129	1	13	111
C14			0.126	2.92	23.5	8.6	11.75	15	101	129	1	23	195
C15			0.126	2.92	23.5	8.6	4.75	15	41	129	1	130	1124
C16	0.3		0.4	3.12	23.5	8.8	0.15	15	1	132	1	254	2239
C17			0.126	2.92	23.5	8.6	30.25	22.5	261	194	1	299	2581
C18			0.126	2.92	23.5	8.6	23.15	22.5	200	194	1	147	1264
C19			0.126	2.92	23.5	8.6	4.05	22.5	35	194	1	236	2037
C20	0.3		0.4	2.92	23.5	8.2	0.15	22.43	1	185	1	343	2823
C21			0.126	1.3	23.5	3.8	31.36	22.5	120	86	1	332	1276
C22			0.126	1.3	23.5	3.8	31.36	25	120	96	1	387	1486
C23			0.126	1.3	23.5	3.8	30.25	25	116	96	1	354	1360
Spandrels													
S1	7.33			0.25	23.5	43.1	7.925	23	341	990	193	169	7277
S2	6.68			0.25	23.5	39.2	26.7	23	1048	903	146	220	8645
S3			7.08	0.25	23.5	41.6	30.75	18.75	1279	780	174	255	10603
S4			7.08	0.25	23.5	41.6	30.75	11.25	1279	468	174	221	9212
S5			7.08	0.25	23.5	41.6	30.75	3.75	1279	156	174	301	12501
S6	7.28			0.25	23.5	42.8	26.4	-0.5	1129	-21	189	285	12207
S7	7.28			0.25	23.5	42.8	14.1	-0.5	603	-21	189	180	7678
S8	7.08			0.25	23.5	41.6	6.5	-0.5	270	-21	174	265	11037
Walls													
Grid 1 Block Wall	2.2		0.14	1.3	23.5	9.4	1.425	-0.06	13	-1	4	375	3533
Grid 1 Wall (Piers)	4.1		0.4	3.47	23.5	133.7	20.25	0	2708	0	189	182	24288
Grid 1 Wall (Spandrels)	0.9		0.4	1.65	23.5	14.0	20.25	0	283	0	1	182	2535
Grid 4 Block Wall	3.5		0.14	1.3	23.5	15.0	2.075	22.56	31	338	15	288	4315
Grid 4 Block Wall	11.325		0.14	1.3	23.5	48.4	17.2625	22.5	836	1090	518	96	4669
Grid 4 Block Wall	6.65		0.14	1.3	23.5	28.4	26.5	22.5	754	640	105	206	5860
Grid 5 Wall	11.65		0.3	3.47	23.5	285.0	17.425	26.9	4966	7666	3226	202	57520
Grid A Block Wall	0.14		21.01	3.04	23.5	210.1	0.07	11.25	15	2364	7730	254	53449
Grid C Wall	0.3		4.5	3.47	23.5	110.1	11.75	24.5	1294	2697	187	155	17083
Grid C/D Wall	0.3		4.45	3.47	23.5	108.9	15.8	24.525	1720	2670	180	138	15043
Grid D Wall	0.3		3.125	3.47	23.5	76.4	18.4	25.1875	1407	1926	63	160	12247
Grid D/E Wall	0.3		2.3	3.47	23.5	56.3	23.1	25.6	1300	1440	25	216	12141
Grid D/E Wall (Thickening)	0.1		0.6	1.2	23.5	1.7	23.3	24.75	39	42	0	198	334
Cladding (Grid 1)	25.25			2.12	0.2	10.7	15	0.325	161	3	569	156	1668
Cladding (Grid 4)	18.9			2.12	0.2	8.0	15	22.175	120	178	239	89	716
Cladding (Grid F)			22.5	2.12	0.2	9.5	29.925	11.25	285	107	402	198	1886
Floors													
200 HiBond (Grids 1-2)	29.84		7.03		4.0	839.1	15.06	3.785	12637	3176	65719	82	68410
200 HiBond (Grids 2-3)	29.84		7.1		4.0	847.5	15.06	11.25	12763	9534	66443	3	2625
200 HiBond (Grids 3-4)	29.84		7.03		4.0	839.1	15.06	18.715	12637	15704	65719	36	30308
200 HiBond (Grids C-C/D)	3.75		3.5		4.0	52.5	13.775	24.35	723	1278	115	139	7287
200 Slab (Grids C-C/D)	2.35		0.65	0.2	23.5	7.2	13.075	26.425	94	190	4	195	1398
Stair landing (top)	1.11		0.175	0.2	23.5	0.9	16.505	22.7875	15	21	0	101	92
Stair landing (top)	1.19		1	0.2	23.5	5.6	17.655	23.2	99	130	1	112	625
Stair landing (mid)	2.3		1.2	0.15	23.5	9.7	17.1	26.15	166	254	5	180	1755
200 HiBond (Grids D)	0.3		1		4.0	1.2	18.4	23.2	22	28	0	115	138
200 HiBond (Grids D-D/E)	4.7		1.875		4.0	35.3	20.9	23.6375	737	833	75	143	5028
SDL (Grids 1-4)	29.775		21.85		0.5	325.3	15.0375	11.25	4892	3660	36974	3	1021
SDL (Core Grids C-C/D)	3.75		4.5		0.5	8.4	13.775	24.5	116	207	24	142	1201
SDL (Core Grids D-D/E)	5.0		2.325		0.5	5.8	20.75	23.4125	121	136	15	136	792
Live (Grids 1-4)	29.775		21.85		0.833	542.2	15.0375	11.25	8153	6099	61624	3	1701
Live (Core Grids C-C/D)	3.75		4.5		0.667	11.3	13.775	24.5	155	276	32	142	1601
Live (Core Grids D-D/E)	5.0		2.325		0.833	9.7	20.75	23.4125	201	227	25	136	1321
Stair (internal)						1.6	17.1	24.5	27	39	0	139	222
Stair (external)						2.4	20.25	-1	49	-2	0	208	500
Roof													
Canopy roof	8.035		2.5		0.15	3.0	27.3425	23.75	82	72	213	250	755
Totals					6354.5			101327.8	81151.0	338817.4		663185	
							W	6354					
							x'	15.95					
							y'	12.77					
							I	1002002					

Level 3	x	y	z	Unit Weigt	Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams												
Grid 1 (Grids A-A/B)	2.55	0.4	0.55	23.5	13.2	1.275	0.07	17	1	7	371	4891
Grid 1 (Grids A/B-D)	15.2	0.96	0.55	23.5	188.6	10.15	-0.21	1914	-40	3646	197	37083
Grid 1 (Grids D/E-F)	7.71	0.96	0.55	23.5	95.7	26.605	-0.21	2545	-20	481	277	26500
Grid 2 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	7.5	45	142	36	210	3957
Grid 2 (B-E)	21	0.4	0.55	23.5	108.6	15.25	7.5	1656	814	3991	26	2834
Grid 2 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	7.5	463	125	25	168	2792
Grid 3 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	15	45	283	36	190	3585
Grid 3 (B-E)	21	0.4	0.55	23.5	108.6	15.25	15	1656	1629	3991	6	696
Grid 3 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	15	463	249	25	148	2464
Grid 4 (Grids A-B)	3.85	0.4	0.55	23.5	19.9	1.925	22.43	38	446	25	294	5845
Grid 4 (Grids B-C)	7.75	0.96	0.55	23.5	96.2	7.725	22.71	743	2184	489	170	16382
Grid 4 (Grids C-C/D)	3.75	0.4	0.55	23.5	19.4	13.775	22.5	267	436	23	103	2005
Grid 4 (Grids C/D-D/E)	7.2	0.4	0.55	23.5	37.2	19.55	22.5	728	838	161	112	4162
Grid 4 (Grids D/E-F)	7.31	0.96	0.55	23.5	90.7	26.805	22.71	2431	2060	411	221	20056
Grid A	0.14	21.16	0.43	23.5	29.9	0.07	11.25	2	337	1117	253	7586
Grid F	0.96	22.92	0.55	23.5	284.4	30.46	11.25	8663	3199	12472	213	60490
Columns												
C1		0.126	2.69	23.5	7.9	30.25	0	240	0	1	363	2882
C2		0.126	2.69	23.5	7.9	10.25	0	81	0	1	190	1511
C3		0.126	2.69	23.5	7.9	2.75	0	22	0	1	332	2635
C4	0.3	0.4	2.69	23.5	7.6	0.15	0.07	1	1	1	405	3074
C5		0.126	2.69	23.5	7.9	30.25	7.5	240	60	1	231	1831
C6		0.126	2.69	23.5	7.9	25.75	7.5	205	60	1	122	969
C7		0.126	2.69	23.5	7.9	18.75	7.5	149	60	1	34	267
C8		0.126	2.69	23.5	7.9	11.75	7.5	93	60	1	43	343
C9		0.126	2.69	23.5	7.9	4.75	7.5	38	60	1	151	1197
C10	0.3	0.4	2.89	23.5	8.1	0.15	7.5	1	61	1	275	2240
C11		0.126	2.69	23.5	7.9	30.25	15	240	119	1	211	1675
C12		0.126	2.69	23.5	7.9	25.75	15	205	119	1	102	812
C13		0.126	2.69	23.5	7.9	18.75	15	149	119	1	14	110
C14		0.126	2.69	23.5	7.9	11.75	15	93	119	1	23	186
C15		0.126	2.69	23.5	7.9	4.75	15	38	119	1	131	1041
C16	0.3	0.4	2.89	23.5	8.1	0.15	15	1	122	1	255	2079
C17		0.126	2.69	23.5	7.9	30.25	22.5	240	179	1	304	2412
C18		0.126	2.69	23.5	7.9	23.15	22.5	184	179	1	151	1198
C19		0.126	2.69	23.5	7.9	4.05	22.5	32	179	1	240	1906
C20	0.3	0.4	2.69	23.5	7.6	0.15	22.43	1	170	1	347	2629
Spandrels												
S1	7.33		0.25	23.5	43.1	7.925	23	341	990	193	173	7454
S2	6.68		0.25	23.5	39.2	26.7	23	1048	903	146	225	8823
S3		7.08	0.25	23.5	41.6	30.75	18.75	1279	780	174	258	10722
S4		7.08	0.25	23.5	41.6	30.75	11.25	1279	468	174	221	9201
S5		7.08	0.25	23.5	41.6	30.75	3.75	1279	156	174	297	12360
S6	7.28		0.25	23.5	42.8	26.4	-0.5	1129	-21	189	280	11983
S7	7.28		0.25	23.5	42.8	14.1	-0.5	603	-21	189	174	7443
S8	7.08		0.25	23.5	41.6	6.5	-0.5	270	-21	174	260	10801
Walls												
Grid 1 Wall (Piers)	4.1	0.4	3.24	23.5	124.9	20.25	0	2529	0	177	176	22034
Grid 1 Wall (Spandrels)	0.9	0.4	1.19	23.5	10.1	20.25	0	204	0	1	176	1776
Grid 5 Wall	11.65	0.3	3.24	23.5	266.1	17.425	26.9	4637	7158	3012	208	55288
Grid A Block Wall	0.14	21.01	2.81	23.5	194.2	0.07	11.25	14	2185	7145	253	49224
Grid C Wall	0.3	4.5	3.24	23.5	102.8	11.75	24.5	1208	2518	174	160	16446
Grid C/D Wall	0.3	4.45	3.24	23.5	101.6	15.8	24.525	1606	2493	169	143	14546
Grid D Wall	0.3	3.125	3.24	23.5	71.4	18.4	25.1875	1313	1798	59	165	11810
Grid D/E Wall	0.3	2.3	3.24	23.5	52.5	23.1	25.6	1214	1345	24	221	11626
Cladding (Grid 1)	25.25		1.89	0.2	9.5	15	0.325	143	3	507	151	1438
Cladding (Grid 4)	18.9		1.89	0.2	7.1	15	22.175	107	158	213	93	666
Cladding (Grid F)		22.5	1.89	0.2	8.5	29.925	11.25	255	96	359	197	1679
Floors												
200 HiBond (Grids 1-2)	29.84	7.03		4.0	839.1	15.06	3.785	12637	3176	65719	78	65301
200 HiBond (Grids 2-3)	29.84	7.1		4.0	847.5	15.06	11.25	12763	9534	66443	2	2110
200 HiBond (Grids 3-4)	29.84	7.03		4.0	839.1	15.06	18.715	12637	15704	65719	39	32398
200 HiBond (Grids C-C/D)	3.75	3.5		4.0	52.5	13.775	24.35	723	1278	115	144	7539
200 Slab (Grids C-C/D)	2.35	0.65	0.2	23.5	7.2	13.075	26.425	94	190	4	200	1438
Stair landing (top)	1.11	0.45	0.2	23.5	2.3	16.505	22.925	39	54	0	108	253
Stair landing (top)	1.19	1	0.2	23.5	5.6	17.655	23.2	99	130	1	116	649
Stair landing (mid)	2.3	1.2	0.15	23.5	9.7	17.1	26.15	166	254	5	186	1809
200 HiBond (Grids D)	0.3	1		4.0	1.2	18.4	23.2	22	28	0	119	143
200 HiBond (Grids D-D/E)	4.7	1.875		4.0	35.3	20.9	23.6375	737	833	75	147	5192
SDL (Grids 1-4)	29.775	21.85		0.5	325.3	15.0375	11.25	4892	3660	36974	3	823
SDL (Core Grids C-C/D)	3.75	4.5		0.5	8.4	13.775	24.5	116	207	24	147	1242
SDL (Core Grids D-D/E)	5.0	2.325		0.5	5.8	20.75	23.4125	121	136	15	141	819
Live (Grids 1-4)	29.775	21.85		0.833	542.2	15.0375	11.25	8153	6099	61624	3	1372
Live (Core Grids C-C/D)	3.75	4.5		0.667	11.3	13.775	24.5	155	276	32	147	1655
Live (Core Grids D-D/E)	5.0	2.325		0.833	9.7	20.75	23.4125	201	227	25	141	1365
Stair (internal)					1.6	17.1	24.5	27	39	0	144	230
Stair (external)					2.4	20.25	-1	49	-2	0	203	486
Totals					6151.0			98016.6	77276.7	336986		622467
						W		6151				
						x'		15.93				
						y'		12.56				
						I		959453				

Level 4	x	y	z	Unit Weigt	Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams												
Grid 1 (Grids A-A/B)	2.55	0.4	0.55	23.5	13.2	1.275	0.07	17	1	7	382	5040
Grid 1 (Grids A/B-D)	15.2	0.96	0.55	23.5	188.6	10.15	-0.21	1914	-40	3646	202	38023
Grid 1 (Grids D/E-F)	7.71	0.96	0.55	23.5	95.7	26.605	-0.21	2545	-20	481	270	25859
Grid 2 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	7.5	45	142	36	220	4147
Grid 2 (B-E)	21	0.4	0.55	23.5	108.6	15.25	7.5	1656	814	3991	27	2933
Grid 2 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	7.5	463	125	25	160	2658
Grid 3 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	15	45	283	36	199	3766
Grid 3 (B-E)	21	0.4	0.55	23.5	108.6	15.25	15	1656	1629	3991	7	747
Grid 3 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	15	463	249	25	140	2323
Grid 4 (Grids A-B)	3.85	0.4	0.55	23.5	19.9	1.925	22.43	38	446	25	303	6034
Grid 4 (Grids B-C)	7.75	0.96	0.55	23.5	96.2	7.725	22.71	743	2184	489	176	16898
Grid 4 (Grids C-C/D)	3.75	0.4	0.55	23.5	19.4	13.775	22.5	267	436	23	104	2026
Grid 4 (Grids C/D-D/E)	7.2	0.4	0.55	23.5	37.2	19.55	22.5	728	838	161	109	4049
Grid 4 (Grids D/E-F)	7.31	0.96	0.55	23.5	90.7	26.805	22.71	2431	2060	411	213	19313
Grid F	0.96	22.92	0.55	23.5	284.4	30.46	11.25	8663	3199	12472	203	57616
Columns												
C1		0.126	2.69	23.5	7.9	30.25	0	240	0	1	353	2808
C2		0.126	2.69	23.5	7.9	10.25	0	81	0	1	195	1549
C3		0.126	2.69	23.5	7.9	2.75	0	22	0	1	342	2716
C4	0.3	0.4	2.69	23.5	7.6	0.15	0.07	1	1	1	417	3166
C5		0.126	2.69	23.5	7.9	30.25	7.5	240	60	1	221	1754
C6		0.126	2.69	23.5	7.9	25.75	7.5	205	60	1	115	917
C7		0.126	2.69	23.5	7.9	18.75	7.5	149	60	1	32	254
C8		0.126	2.69	23.5	7.9	11.75	7.5	93	60	1	47	370
C9		0.126	2.69	23.5	7.9	4.75	7.5	38	60	1	159	1264
C10	0.3	0.4	2.89	23.5	8.1	0.15	7.5	1	61	1	286	2334
C11		0.126	2.69	23.5	7.9	30.25	15	240	119	1	201	1594
C12		0.126	2.69	23.5	7.9	25.75	15	205	119	1	95	757
C13		0.126	2.69	23.5	7.9	18.75	15	149	119	1	12	94
C14		0.126	2.69	23.5	7.9	11.75	15	93	119	1	26	210
C15		0.126	2.69	23.5	7.9	4.75	15	38	119	1	139	1104
C16	0.3	0.4	2.89	23.5	8.1	0.15	15	1	122	1	266	2170
C17		0.126	2.69	23.5	7.9	30.25	22.5	240	179	1	293	2328
C18		0.126	2.69	23.5	7.9	23.15	22.5	184	179	1	145	1154
C19		0.126	2.69	23.5	7.9	4.05	22.5	32	179	1	248	1970
C20	0.3	0.4	2.69	23.5	7.6	0.15	22.43	1	170	1	357	2710
Spandrels												
S1	7.33		0.25	23.5	43.1	7.925	23	341	990	193	178	7678
S2	6.68		0.25	23.5	39.2	26.7	23	1048	903	146	217	8504
S3		7.08	0.25	23.5	41.6	30.75	18.75	1279	780	174	247	10274
S4		7.08	0.25	23.5	41.6	30.75	11.25	1279	468	174	211	8772
S5		7.08	0.25	23.5	41.6	30.75	3.75	1279	156	174	287	11950
S6	7.28		0.25	23.5	42.8	26.4	-0.5	1129	-21	189	274	11703
S7	7.28		0.25	23.5	42.8	14.1	-0.5	603	-21	189	176	7537
S8	7.08		0.25	23.5	41.6	6.5	-0.5	270	-21	174	267	11117
Walls												
Grid 1 Wall (Piers)	4.1	0.4	3.24	23.5	124.9	20.25	0	2529	0	177	174	21759
Grid 1 Wall (Spandrels)	0.9	0.4	1.19	23.5	10.1	20.25	0	204	0	1	174	1754
Grid 5 Wall	11.65	0.3	3.24	23.5	266.1	17.425	26.9	4637	7158	3012	206	54816
Grid A Block Wall	0.14	21.01	1.19	23.5	82.3	0.07	11.25	6	925	3026	265	21789
Grid C Wall	0.3	4.5	3.24	23.5	102.8	11.75	24.5	1208	2518	174	162	16693
Grid C/D Wall	0.3	4.45	3.24	23.5	101.6	15.8	24.525	1606	2493	169	143	14497
Grid D Wall	0.3	3.125	3.24	23.5	71.4	18.4	25.1875	1313	1798	59	163	11641
Grid D/E Wall	0.3	2.3	3.24	23.5	52.5	23.1	25.6	1214	1345	24	216	11325
Cladding (Grid 1)	25.25		1.89	0.2	9.5	15	0.325	143	3	507	152	1452
Cladding (Grid 4)	18.9		1.89	0.2	7.1	15	22.175	107	158	213	93	668
Cladding (Grid A)		22.5	1.62	0.2	7.3	0	11.25	0	82	308	267	1948
Cladding (Grid F)		22.5	1.89	0.2	8.5	29.925	11.25	255	96	359	188	1597
Floors												
200 HiBond (Grids 1-2)	29.84	7.03		4.0	839.1	15.06	3.785	12637	3176	65719	79	66361
200 HiBond (Grids 2-3)	29.84	7.1		4.0	847.5	15.06	11.25	12763	9534	66443	3	2809
200 HiBond (Grids 3-4)	29.84	7.03		4.0	839.1	15.06	18.715	12637	15704	65719	39	32722
200 HiBond (Grids C-C/D)	3.75	3.5		4.0	52.5	13.775	24.35	723	1278	115	145	7589
200 Slab (Grids C-C/D)	2.35	0.65	0.2	23.5	7.2	13.075	26.425	94	190	4	202	1448
Stair landing (top)	1.11	0.45	0.2	23.5	2.3	16.505	22.925	39	54	0	107	251
Stair landing (top)	1.19	1	0.2	23.5	5.6	17.655	23.2	99	130	1	114	640
Stair landing (mid)	2.3	1.2	0.15	23.5	9.7	17.1	26.15	166	254	5	184	1795
200 HiBond (Grids D)	0.3	1		4.0	1.2	18.4	23.2	22	28	0	117	140
200 HiBond (Grids D-D/E)	4.7	1.875		4.0	35.3	20.9	23.6375	737	833	75	143	5049
SDL (Grids 1-4)	29.775	21.85		0.5	325.3	15.0375	11.25	4892	3660	36974	3	1097
SDL (Core Grids C-C/D)	3.75	4.5		0.5	8.4	13.775	24.5	116	207	24	148	1250
SDL (Core Grids D-D/E)	5.0	2.325		0.5	5.8	20.75	23.4125	121	136	15	137	796
Live (Grids 1-4)	29.775	21.85		0.833	542.2	15.0375	11.25	8153	6099	61624	3	1828
Live (Core Grids C-C/D)	3.75	4.5		0.667	11.3	13.775	24.5	155	276	32	148	1666
Live (Core Grids D-D/E)	5.0	2.325		0.833	9.7	20.75	23.4125	201	227	25	137	1327
Stair (internal)					1.6	17.1	24.5	27	39	0	142	228
Stair (external)					2.4	20.25	-1	49	-2	0	200	481
Totals					6016.4			98006.6	75762.2	332057		587604
						W		6016				
						x'		16.29				
						y'		12.59				
						I		919660				

Level 5	x	y	z	Unit Weigt	Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams												
Grid 1 (Grids A-A/B)	2.55	0.4	0.55	23.5	13.2	1.275	0.07	17	1	7	389	5127
Grid 1 (Grids A/B-D)	15.2	0.96	0.55	23.5	188.6	10.15	-0.21	1914	-40	3646	205	38586
Grid 1 (Grids D/E-F)	7.71	0.96	0.55	23.5	95.7	26.605	-0.21	2545	-20	481	267	25501
Grid 2 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	7.5	45	142	36	225	4258
Grid 2 (B-E)	21	0.4	0.55	23.5	108.6	15.25	7.5	1656	814	3991	28	3003
Grid 2 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	7.5	463	125	25	155	2583
Grid 3 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	15	45	283	36	205	3873
Grid 3 (B-E)	21	0.4	0.55	23.5	108.6	15.25	15	1656	1629	3991	7	789
Grid 3 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	15	463	249	25	135	2244
Grid 4 (Grids A-B)	3.85	0.4	0.55	23.5	19.9	1.925	22.43	38	446	25	309	6145
Grid 4 (Grids B-C)	7.75	0.96	0.55	23.5	96.2	7.725	22.71	743	2184	489	179	17206
Grid 4 (Grids C-C/D)	3.75	0.4	0.55	23.5	19.4	13.775	22.5	267	436	23	105	2040
Grid 4 (Grids C/D-D/E)	7.2	0.4	0.55	23.5	37.2	19.55	22.5	728	838	161	107	3989
Grid 4 (Grids D/E-F)	7.31	0.96	0.55	23.5	90.7	26.805	22.71	2431	2060	411	208	18896
Grid F	0.96	22.92	0.55	23.5	284.4	30.46	11.25	8663	3199	12472	197	55992
Columns												
C1		0.126	2.69	23.5	7.9	30.25	0	240	0	1	348	2766
C2		0.126	2.69	23.5	7.9	10.25	0	81	0	1	198	1573
C3		0.126	2.69	23.5	7.9	2.75	0	22	0	1	348	2764
C4	0.3	0.4	2.69	23.5	7.6	0.15	0.07	1	1	1	424	3219
C5		0.126	2.69	23.5	7.9	30.25	7.5	240	60	1	215	1710
C6		0.126	2.69	23.5	7.9	25.75	7.5	205	60	1	112	888
C7		0.126	2.69	23.5	7.9	18.75	7.5	149	60	1	31	248
C8		0.126	2.69	23.5	7.9	11.75	7.5	93	60	1	49	386
C9		0.126	2.69	23.5	7.9	4.75	7.5	38	60	1	164	1303
C10	0.3	0.4	2.89	23.5	8.1	0.15	7.5	1	61	1	293	2390
C11		0.126	2.69	23.5	7.9	30.25	15	240	119	1	195	1548
C12		0.126	2.69	23.5	7.9	25.75	15	205	119	1	91	726
C13		0.126	2.69	23.5	7.9	18.75	15	149	119	1	11	86
C14		0.126	2.69	23.5	7.9	11.75	15	93	119	1	28	224
C15		0.126	2.69	23.5	7.9	4.75	15	38	119	1	144	1141
C16	0.3	0.4	2.89	23.5	8.1	0.15	15	1	122	1	273	2224
C17		0.126	2.69	23.5	7.9	30.25	22.5	240	179	1	287	2280
C18		0.126	2.69	23.5	7.9	23.15	22.5	184	179	1	142	1129
C19		0.126	2.69	23.5	7.9	4.05	22.5	32	179	1	253	2007
C20	0.3	0.4	2.69	23.5	7.6	0.15	22.43	1	170	1	364	2758
Spandrels												
S1	7.33		0.25	23.5	43.1	7.925	23	341	990	193	181	7812
S2	6.68		0.25	23.5	39.2	26.7	23	1048	903	146	212	8324
S3		7.08	0.25	23.5	41.6	30.75	18.75	1279	780	174	241	10021
S4		7.08	0.25	23.5	41.6	30.75	11.25	1279	468	174	205	8530
S5		7.08	0.25	23.5	41.6	30.75	3.75	1279	156	174	282	11718
S6	7.28		0.25	23.5	42.8	26.4	-0.5	1129	-21	189	270	11547
S7	7.28		0.25	23.5	42.8	14.1	-0.5	603	-21	189	178	7596
S8	7.08		0.25	23.5	41.6	6.5	-0.5	270	-21	174	272	11303
Walls												
Grid 1 Wall (Piers)	4.1	0.4	3.24	23.5	124.9	20.25	0	2529	0	177	173	21615
Grid 1 Wall (Spandrels)	0.9	0.4	1.19	23.5	10.1	20.25	0	204	0	1	173	1743
Grid 5 Wall	11.65	0.3	3.24	23.5	266.1	17.425	26.9	4637	7158	3012	205	54575
Grid C Wall	0.3	4.5	3.24	23.5	102.8	11.75	24.5	1208	2518	174	164	16846
Grid C/D Wall	0.3	4.45	3.24	23.5	101.6	15.8	24.525	1606	2493	169	142	14481
Grid D Wall	0.3	3.125	3.24	23.5	71.4	18.4	25.1875	1313	1798	59	162	11552
Grid D/E Wall	0.3	2.3	3.24	23.5	52.5	23.1	25.6	1214	1345	24	212	11158
Cladding (Grid 1)	25.25		1.89	0.2	9.5	15	0.325	143	3	507	153	1462
Cladding (Grid 4)	18.9		1.89	0.2	7.1	15	22.175	107	158	213	94	670
Cladding (Grid A)		22.5	3.24	0.2	14.6	0	11.25	0	164	615	274	3994
Cladding (Grid F)		22.5	1.89	0.2	8.5	29.925	11.25	255	96	359	182	1550
Floors												
200 HiBond (Grids 1-2)	29.84	7.03		4.0	839.1	15.06	3.785	12637	3176	65719	80	67069
200 HiBond (Grids 2-3)	29.84	7.1		4.0	847.5	15.06	11.25	12763	9534	66443	4	3310
200 HiBond (Grids 3-4)	29.84	7.03		4.0	839.1	15.06	18.715	12637	15704	65719	39	33006
200 HiBond (Grids C-C/D)	3.75	3.5		4.0	52.5	13.775	24.35	723	1278	115	145	7625
200 Slab (Grids C-C/D)	2.35	0.65	0.2	23.5	7.2	13.075	26.425	94	190	4	203	1454
Stair landing (top)	1.11	0.45	0.2	23.5	2.3	16.505	22.925	39	54	0	106	250
Stair landing (top)	1.19	1	0.2	23.5	5.6	17.655	23.2	99	130	1	114	635
Stair landing (mid)	2.3	1.2	0.15	23.5	9.7	17.1	26.15	166	254	5	184	1787
200 HiBond (Grids D)	0.3	1		4.0	1.2	18.4	23.2	22	28	0	116	139
200 HiBond (Grids D-D/E)	4.7	1.875		4.0	35.3	20.9	23.6375	737	833	75	141	4971
SDL (Grids 1-4)	29.775	21.85		0.5	325.3	15.0375	11.25	4892	3660	36974	4	1292
SDL (Core Grids C-C/D)	3.75	4.5		0.5	8.4	13.775	24.5	116	207	24	149	1255
SDL (Core Grids D-D/E)	5.0	2.325		0.5	5.8	20.75	23.4125	121	136	15	135	784
Live (Grids 1-4)	29.775	21.85		0.833	542.2	15.0375	11.25	8153	6099	61624	4	2153
Live (Core Grids C-C/D)	3.75	4.5		0.667	11.3	13.775	24.5	155	276	32	149	1674
Live (Core Grids D-D/E)	5.0	2.325		0.833	9.7	20.75	23.4125	201	227	25	135	1306
Stair (internal)					1.6	17.1	24.5	27	39	0	142	227
Stair (external)					2.4	20.25	-1	49	-2	0	199	478
Totals					5941.4			98000.9	74918.8	329338		567512
						W		5941				
						x'		16.49				
						y'		12.61				
						I		896851				

Level 6	x	y	z	Unit Weigt	Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams												
Grid 1 (Grids A-A/B)	2.55	0.4	0.55	23.5	13.2	1.275	0.07	17	1	7	386	5092
Grid 1 (Grids A/B-D)	15.2	0.96	0.55	23.5	188.6	10.15	-0.21	1914	-40	3646	202	38091
Grid 1 (Grids D/E-F)	7.71	0.96	0.55	23.5	95.7	26.605	-0.21	2545	-20	481	264	25262
Grid 2 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	7.5	45	142	36	224	4237
Grid 2 (B-E)	21	0.4	0.55	23.5	108.6	15.25	7.5	1656	814	3991	27	2891
Grid 2 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	7.5	463	125	25	154	2567
Grid 3 (A-B)	4.75	0.4	0.423	23.5	18.9	2.375	15	45	283	36	205	3880
Grid 3 (B-E)	21	0.4	0.55	23.5	108.6	15.25	15	1656	1629	3991	8	841
Grid 3 (E-F)	4.23	0.4	0.418	23.5	16.6	27.865	15	463	249	25	136	2253
Grid 4 (Grids A-B)	3.85	0.4	0.55	23.5	19.9	1.925	22.43	38	446	25	311	6182
Grid 4 (Grids B-C)	7.75	0.96	0.55	23.5	96.2	7.725	22.71	743	2184	489	181	17396
Grid 4 (Grids C-C/D)	3.75	0.4	0.55	23.5	19.4	13.775	22.5	267	436	23	107	2078
Grid 4 (Grids C/D-D/E)	7.2	0.4	0.55	23.5	37.2	19.55	22.5	728	838	161	109	4064
Grid 4 (Grids D/E-F)	7.31	0.96	0.55	23.5	90.7	26.805	22.71	2431	2060	411	210	19089
Grid F	0.96	22.92	0.55	23.5	284.4	30.46	11.25	8663	3199	12472	197	55948
Columns												
C1		0.126	2.37	23.5	7.0	30.25	0	212	0	1	346	2420
C2		0.126	2.37	23.5	7.0	10.25	0	72	0	1	195	1368
C3		0.126	2.37	23.5	7.0	2.75	0	19	0	1	345	2416
C4	0.3	0.4	2.37	23.5	6.7	0.15	0.07	1	0	1	422	2819
C5		0.126	2.37	23.5	7.0	30.25	7.5	212	52	1	214	1501
C6		0.126	2.37	23.5	7.0	25.75	7.5	180	52	1	111	776
C7		0.126	2.37	23.5	7.0	18.75	7.5	131	52	1	30	211
C8		0.126	2.37	23.5	7.0	11.75	7.5	82	52	1	48	333
C9		0.126	2.37	23.5	7.0	4.75	7.5	33	52	1	163	1140
C10	0.3	0.4	2.57	23.5	7.2	0.15	7.5	1	54	1	292	2117
C11		0.126	2.37	23.5	7.0	30.25	15	212	105	1	196	1368
C12		0.126	2.37	23.5	7.0	25.75	15	180	105	1	92	644
C13		0.126	2.37	23.5	7.0	18.75	15	131	105	1	11	79
C14		0.126	2.37	23.5	7.0	11.75	15	82	105	1	29	201
C15		0.126	2.37	23.5	7.0	4.75	15	33	105	1	144	1008
C16	0.3	0.4	2.57	23.5	7.2	0.15	15	1	109	1	273	1980
C17		0.126	2.37	23.5	7.0	30.25	22.5	212	157	1	289	2024
C18		0.126	2.37	23.5	7.0	23.15	22.5	162	157	1	144	1009
C19		0.126	2.37	23.5	7.0	4.05	22.5	28	157	1	255	1782
C20	0.3	0.4	2.37	23.5	6.7	0.15	22.43	1	150	1	365	2442
Spandrels												
S1	7.33		0.25	23.5	43.1	7.925	23	341	990	193	183	7900
S2	6.68		0.25	23.5	39.2	26.7	23	1048	903	146	214	8410
S3		7.08	0.25	23.5	41.6	30.75	18.75	1279	780	174	242	10078
S4		7.08	0.25	23.5	41.6	30.75	11.25	1279	468	174	205	8523
S5		7.08	0.25	23.5	41.6	30.75	3.75	1279	156	174	280	11648
S6	7.28		0.25	23.5	42.8	26.4	-0.5	1129	-21	189	267	11437
S7	7.28		0.25	23.5	42.8	14.1	-0.5	603	-21	189	175	7482
S8	7.08		0.25	23.5	41.6	6.5	-0.5	270	-21	174	269	11190
Walls												
Grid 1 Wall (Piers)	4.1	0.4	2.92	23.5	112.5	20.25	0	2279	0	159	171	19198
Grid 1 Wall (Spandrels)	0.9	0.4	1.19	23.5	10.1	20.25	0	204	0	1	171	1717
Grid 5 Wall	11.65	0.3	2.92	23.5	239.8	17.425	26.9	4179	6451	2714	208	49881
Grid C Wall	0.3	4.5	2.92	23.5	92.6	11.75	24.5	1088	2270	157	166	15403
Grid C/D Wall	0.3	4.45	2.92	23.5	91.6	15.8	24.525	1447	2247	152	145	13271
Grid D Wall	0.3	3.125	2.92	23.5	64.3	18.4	25.1875	1184	1620	53	164	10576
Grid D/E Wall	0.3	2.3	2.92	23.5	47.3	23.1	25.6	1094	1212	21	215	10183
Cladding (Grid 1)	25.25		1.89	0.2	9.5	15	0.325	143	3	507	151	1438
Cladding (Grid 4)	18.9		1.89	0.2	7.1	15	22.175	107	158	213	96	683
Cladding (Grid A)		22.5	3.24	0.2	14.6	0	11.25	0	164	615	274	3988
Cladding (Grid F)		22.5	1.89	0.2	8.5	29.925	11.25	255	96	359	182	1548
Floors												
200 HiBond (Grids 1-2)	29.84	7.03		4.0	839.1	15.06	3.785	12637	3176	65719	78	65573
200 HiBond (Grids 2-3)	29.84	7.1		4.0	847.5	15.06	11.25	12763	9534	66443	4	3077
200 HiBond (Grids 3-4)	29.84	7.03		4.0	839.1	15.06	18.715	12637	15704	65719	41	34040
200 HiBond (Grids C-C/D)	3.75	3.5		4.0	52.5	13.775	24.35	723	1278	115	148	7749
200 Slab (Grids C-C/D)	2.35	0.65	0.2	23.5	7.2	13.075	26.425	94	190	4	205	1474
Stair landing (top)	1.11	0.45	0.2	23.5	2.3	16.505	22.925	39	54	0	109	255
Stair landing (top)	1.19	1	0.2	23.5	5.6	17.655	23.2	99	130	1	116	647
Stair landing (mid)	2.3	1.2	0.15	23.5	9.7	17.1	26.15	166	254	5	186	1814
200 HiBond (Grids D)	0.3	1		4.0	1.2	18.4	23.2	22	28	0	118	142
200 HiBond (Grids D-D/E)	4.7	1.875		4.0	35.3	20.9	23.6375	737	833	75	143	5051
SDL (Grids 1-4)	29.775	21.85		0.5	325.3	15.0375	11.25	4892	3660	36974	4	1202
SDL (Core Grids C-C/D)	3.75	4.5		0.5	8.4	13.775	24.5	116	207	24	151	1275
SDL (Core Grids D-D/E)	5.0	2.325		0.5	5.8	20.75	23.4125	121	136	15	137	797
Live (Grids 1-4)	29.775	21.85		0.833	542.2	15.0375	11.25	8153	6099	61624	4	2003
Live (Core Grids C-C/D)	3.75	4.5		0.667	11.3	13.775	24.5	155	276	32	151	1701
Live (Core Grids D-D/E)	5.0	2.325		0.833	9.7	20.75	23.4125	201	227	25	137	1328
Stair (internal)					1.6	17.1	24.5	27	39	0	144	231
Stair (external)					2.4	20.25	-1	49	-2	0	197	472
Totals					5851.7			96497.5	73195.8	328979		550897
						W		5852				
						x'		16.49				
						y'		12.51				
						I		879875				

Level 7 / Roof	x	y	z	Unit Weight		Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams													
Grid 1 Rafter	31.0			0.22	6.8	15.625	0	107	0		546	336	2293
Grid 2 Rafter	31.0			0.22	6.8	15.625	7.5	107	51		546	118	803
Grid 3 Rafter	31.0			0.22	6.8	15.625	15	107	102		546	12	80
Grid 4 Rafter	31.0			0.22	6.8	15.625	22.5	107	153		546	18	124
Columns													
C1		0.126	1.5	23.5	4.4	30.25	0	134	0		1	525	2325
C2		0.126	1.5	23.5	4.4	10.25	0	45	0		1	374	1658
C3		0.126	1.5	23.5	4.4	2.75	0	12	0		1	524	2322
C4	0.3	0.4	1.5	23.5	4.2	0.15	0.07	1	0		1	600	2537
C5		0.126	1.5	23.5	4.4	30.25	7.5	134	33		1	306	1357
C6		0.126	1.5	23.5	4.4	25.75	7.5	114	33		1	203	898
C7		0.126	1.5	23.5	4.4	18.75	7.5	83	33		1	122	541
C8		0.126	1.5	23.5	4.4	11.75	7.5	52	33		1	139	618
C9		0.126	1.5	23.5	4.4	4.75	7.5	21	33		1	255	1128
C10	0.3	0.4	1.5	23.5	4.2	0.15	7.5	1	32		1	384	1624
C11		0.126	1.5	23.5	4.4	30.25	15	134	66		1	200	888
C12		0.126	1.5	23.5	4.4	25.75	15	114	66		1	97	429
C13		0.126	1.5	23.5	4.4	18.75	15	83	66		1	16	71
C14		0.126	1.5	23.5	4.4	11.75	15	52	66		1	33	148
C15		0.126	1.5	23.5	4.4	4.75	15	21	66		1	149	659
C16	0.3	0.4	1.5	23.5	4.2	0.15	15	1	63		1	278	1175
C17		0.126	1.5	23.5	4.4	30.25	22.5	134	100		1	207	917
C18		0.126	1.635	23.5	4.8	23.15	22.5	112	109		1	62	299
C19		0.126	1.5	23.5	4.4	4.05	22.5	18	100		1	172	763
C20	0.3	0.4	1.5	23.5	4.2	0.15	22.43	1	95		1	284	1200
Core	0.3	0.3	1.2	23.5	2.5	15.8	22.8	40	58		0	21	52
Walls													
Grid 1 Wall (Piers)	4.1	0.4	1.5	23.5	57.8	20.25	0	1171	0		82	350	20214
Grid 1 Wall (Spandrels)	0.9	0.4	0.75	23.5	6.3	20.25	0	128	0		1	350	2219
Grid 5 Wall (Below floor)	11.65	0.3	1.3	23.5	106.8	17.425	26.9	1861	2872	1208		75	7961
Grid 5 Wall (Above)	11.65	0.15	1.2	23.5	49.3	17.425	26.975	859	1329	557		76	3738
Grid 5 Wall (Thickening)	5	0.15	1.2	23.5	21.2	20.75	26.825	439	567	44		91	1916
Grid C Wall (Below)	0.3	4.5	1.3	23.5	41.2	11.75	24.5	485	1010	70		61	2502
Grid C Wall (Above)	0.15	4.25	1.2	23.5	18.0	11.675	24.775	210	445	27		65	1166
Grid C/D Wall (Below)	0.3	4.45	1.15	23.5	36.1	15.8	24.525	570	885	60		39	1408
Grid D Wall (Below)	0.3	3.125	1.3	23.5	28.6	18.4	25.1875	527	721	24		51	1457
Grid D Wall (Above)	0.3	4.1	1.2	23.5	34.7	18.4	24.7	638	857	49		44	1541
Grid D/E Wall (Below)	0.3	2.3	1.3	23.5	21.1	23.1	25.6	487	540	9		97	2041
Grid D/E Wall (Above)	0.3	4.1	1.2	23.5	34.7	23.1	24.7	801	857	49		85	2931
Cladding (Grid 1)	25.25		1.5	0.2	7.6	15	0.325	114	2	402		326	2469
Cladding (Grid 4)	18.9		1.5	0.2	5.7	15	22.175	85	126	169		17	97
Cladding (Grid A)		22.5	1.5	0.2	6.8	0	11.25	0	76	285		322	2172
Cladding (Grid F)		22.5	1.5	0.2	6.8	29.925	11.25	202	76	285		231	1556
Floors													
150 HiBond (Grids C-D)	6.35	4.1		2.9	75.5	15.075	24.7	1138	1865	359		43	3227
Stair opening	0.7	1.65		-2.9	-3.3	17.9	25.185	-60	-84	-1		49	-165
Live (Grids C-D)	6.35	4.1		1.7	43.4	15.075	24.7	654	1072	207		43	1855
Less opening	0.7	1.65		-1.7	-1.9	17.9	25.185	-34	-48	-1		49	-95
Stair (internal)					1.6	17.1	24.5	27	39	0		39	62
Stair (external)					1.2	20.25	-1	24	-1	0		387	465
Roof													
Brownbuilt Purlins	31.12	24.24		0.07	52.8	15.56	11.25	822	594	6847		51	2682
Cladding, Roof buildup	31.12	24.24		0.07	52.8	15.56	11.25	822	594	6847		51	2682
SDL	29.775	21.85		0.15	97.6	15.0375	11.25	1467	1098	11092		52	5078
Totals					920.1			15168.7	16853.3	30871			96086
						W		920					
						x'		16.49					
						y'		18.32					
						I		126957					

Level 8 / Plant	x	y	z	Unit Weight	Weight	x'	y'	Wx	Wy	I	r2	mr2
Beams												
Beam 26	0.3	3.95	0.35	23.5	9.7	15.8	24.925	154	243	13	5	46
Beam 27	4.4	0.2	0.75	23.5	15.5	20.75	24.475	322	380	25	8	130
Columns												
Core	0.3	0.3	1.2	23.5	2.5	15.8	22.8	40	58	0	11	27
Walls												
Grid 5 Wall	11.65	0.15	2.2	23.5	90.3	17.425	26.975	1574	2437	1022	3	298
Grid 5 Wall (Thickening)	5	0.15	1.65	23.5	29.1	20.75	26.825	603	780	61	10	301
Grid C Wall	0.15	4.25	2.2	23.5	33.0	11.675	24.775	385	817	50	40	1306
Grid D Wall	0.3	4.1	1.2	23.5	34.7	18.4	24.7	638	857	49	0	17
Grid D/E Wall (Below)	0.3	4.1	1.2	23.5	34.7	23.1	24.7	801	857	49	27	929
Grid D/E Wall (Above)	0.15	4.1	1	23.5	14.5	23.175	24.7	335	357	20	28	398
Floors												
165 HiBond (Grids C-C/D)	3.75	4.25		3.2	51.0	13.625	24.775	695	1264	137	19	966
165 Slab (Grid C/D-D)	0.8	4.25	0.165	23.5	13.2	16.35	24.775	216	327	21	3	37
150 Slab (Grid C/D-D)	1.5	1.71	0.15	23.5	9.0	17.5	23.505	158	213	4	3	29
150 Slab (Grids D-D/E)	4.4	4.1	0.15	23.5	63.6	20.75	24.7	1320	1571	192	8	516
SDL (Grids C-C/D)	3.75	4.25		0.15	2.4	13.625	24.775	33	59	6	19	45
SDL (Grid C/D-D)	0.8	4.25		0.15	0.5	16.35	24.775	8	13	1	3	1
SDL (Grid C/D-D)	1.5	1.71		0.15	0.4	17.5	23.505	7	9	0	3	1
SDL (Grids D-D/E)	4.4	4.1		0.15	2.7	20.75	24.7	56	67	8	8	22
Live (Grids C-C/D)	3.75	4.25		1.7	26.6	13.625	24.775	362	658	71	19	503
Live (Grid C/D-D)	0.8	4.25		1.7	5.7	16.35	24.775	93	140	9	3	16
Live (Grid C/D-D)	1.5	1.71		1.7	4.3	17.5	23.505	75	100	2	3	14
Live (Grids D-D/E)	4.4	4.1		1.7	30.1	20.75	24.7	624	743	91	8	244
Totals					473.4			8498.1	11947.3	1829		5847
						W		473				
						x'		17.95				
						y'		25.24				
						I		7676				