Loft Renovation - Additional Storey

A short overview and how ClearCalcs was applied to increase living space

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About ClearCalcs

ClearCalcs helps engineers design without compromise by bringing together powerful FEA analysis with easy to use design tools for wood, steel, cold-formed steel and concrete.

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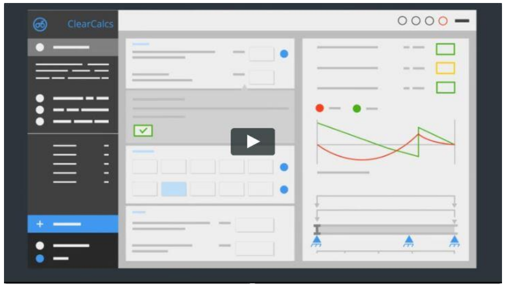
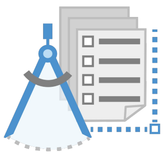
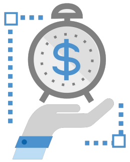


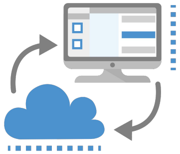
Intro
Video
Hyperlink



More Accurate
Design more accurately with unrestricted and accessible FEA analysis



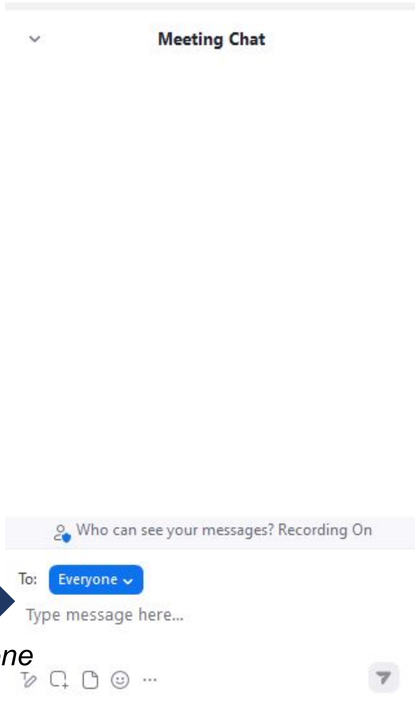
Eliminates Wasted Time
Eliminate time wasted using clunky methods or waiting for software licenses to free up



Available Everywhere
Empower engineers to work effectively from office, home, or site

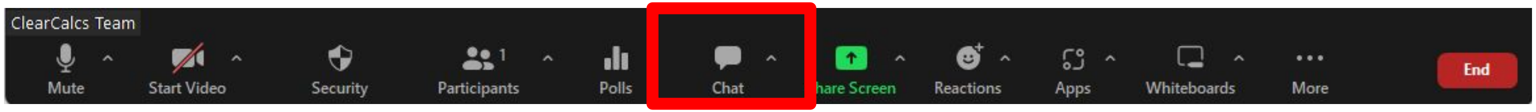
How to Ask Questions

- **Type your questions in the Chat tab on your Zoom control panel and click Send**
  - Please send your questions to "everyone"
  - We will address all questions in the second half of the webinar during the 15-minute Q&A session
  - We might invite you to unmute yourself to ask your question live!



Ask your questions here

Send to everyone



Meet the Presenters

- **Kyle Conway, Project Manager (Structural) for Aus Engineered**
  - Bachelor of Civil Engineering (Honours)
  - Bachelor of Commerce (Finance Major)
  - 5 years experience in major infrastructure projects including civil structures (bridges, culverts, gantrys) as well as residential and commercial buildings for a range of client sizes.
  - Aus Engineered is a structural engineering and project management consultancy for ClearCalcs

Agenda – Today’s Goals

- **Introducing a typical ‘space addition’ renovation**
    - Gathering information to inform design
- **Design Procedure**
    - Steel Beam, Timber Beam, Steel Columns, Connections
- **Project Deliverables**
    - Outputs for construction and permits

The Project

The builder engaged Aus Engineered to provide structural engineering services for a loft conversion project.

The loft apartment was on the second story of mixed use building with a 5.5 metre high ceiling.

The owner wanted to add a mezzanine space above the kitchen accessible via a ladder to be used as an office/storage space.

Step 1: The Concept

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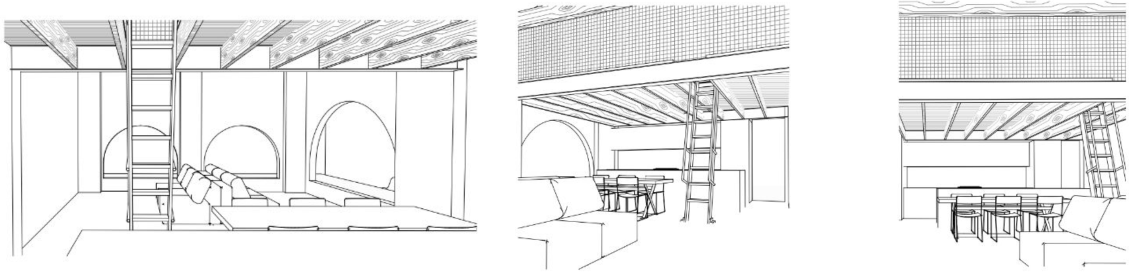
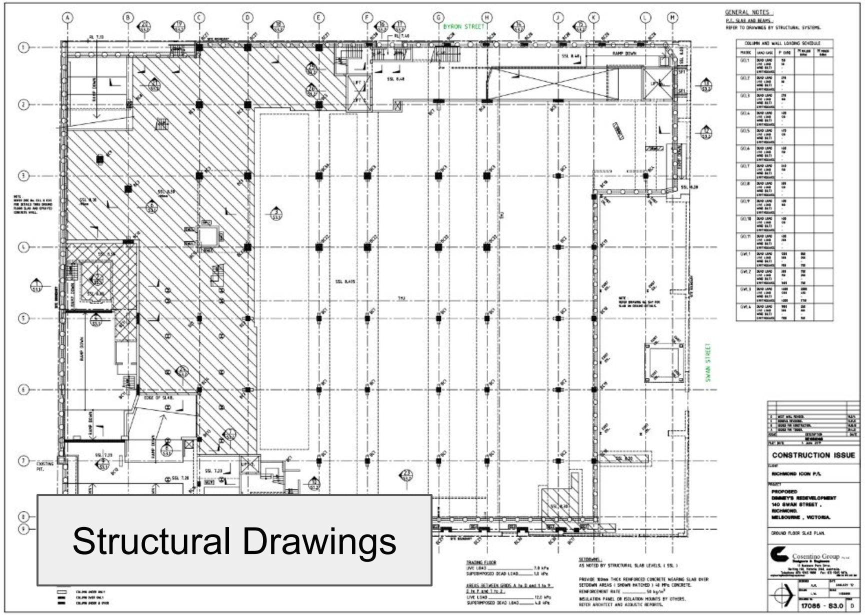


Step 2: Assess As-Built Drawings

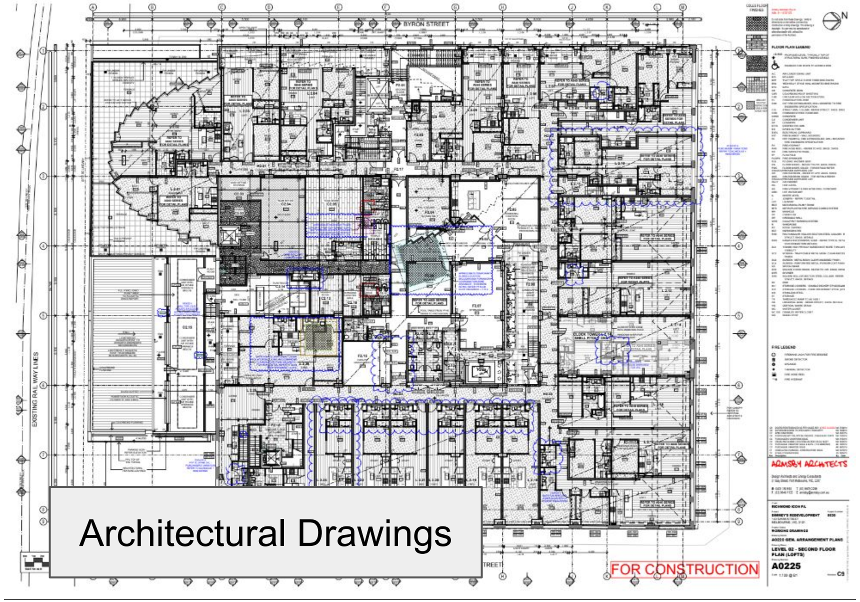
This loft apartment was part of a building managed by a body corporate.

The body corporate was engaged early to understand their requirements for Private Building Works, as this varies between body corporates.

Fortunately we were able to secure the existing structural and architectural drawings from the body corporate to assist in the design.



Structural Drawings



Architectural Drawings

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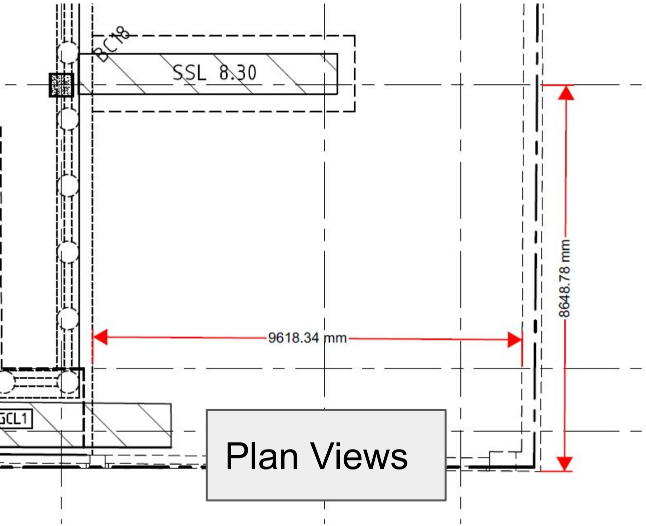
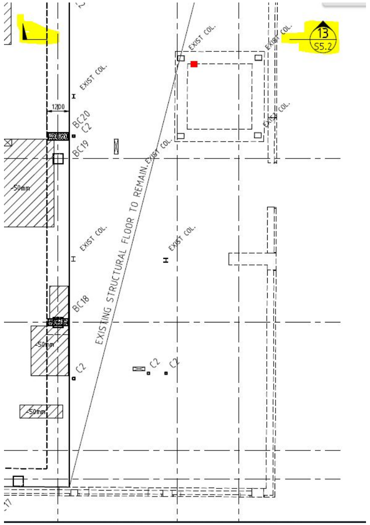
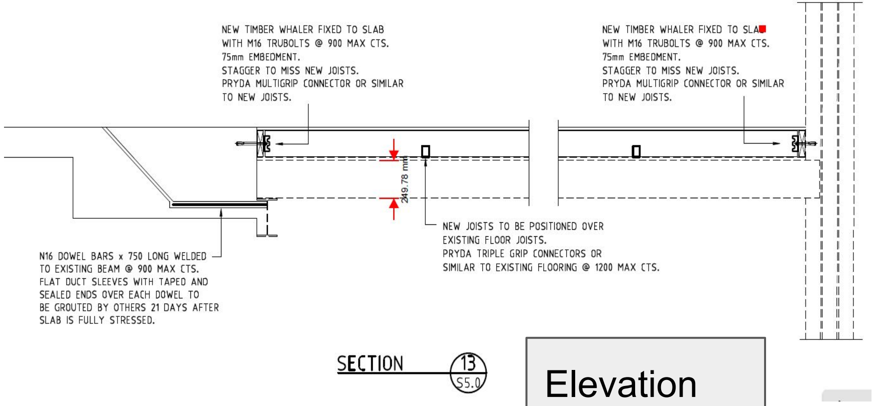




Plan Views



Elevation

Step 3: Consider Council/Shire Planning Laws

Depending on the use case of the space being added, planning permit requirements can be triggered.

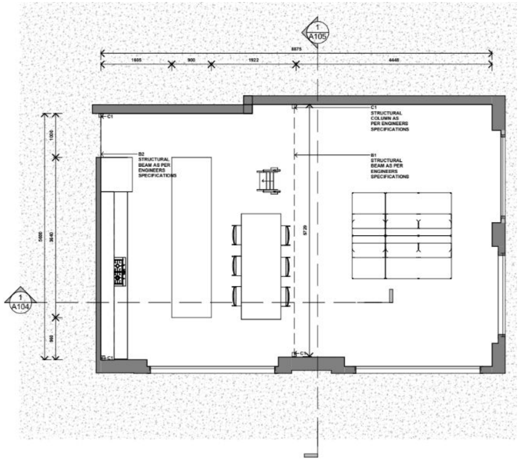
Be sure to consult the local council about the project and engage a town planner to assist with any required planning applications.

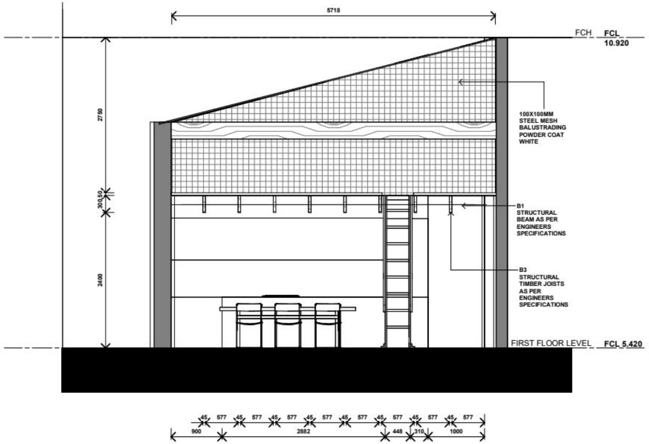
Often adding storage space (non-habitable rooms) will be exempt from a planning permit but the loads required for storage calculation as per AS1170 are often much greater than general use spaces.

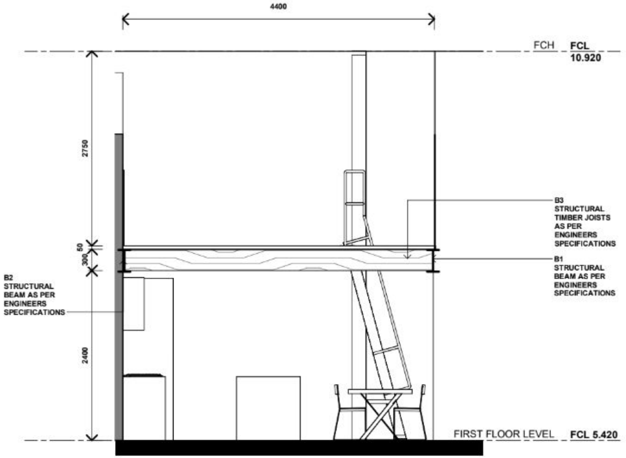
Step 4: Architectural Drawings

Once there was confidence that there was sufficient structural capacity and that planning laws would permit the construction, a qualified architect was engaged to draw up some plans.

The drafter detailed the beams and columns that required specification by the engineer.







Step 5: Determine Loading Requirements

Loads as per AS 1170.1 Table 3.1

- UDL 2kPa
- Point load of 1.8kPa over 350mm for punching or crushing

TABLE 3.1

REFERENCE VALUES OF IMPOSED FLOOR ACTIONS

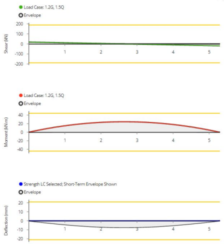
Type of activity/occupancy for part of the building or structure	Specific uses	Uniformly distributed actions kPa	Concentrate actions kN
A Domestic and residential activities (also see Category C)			
A1 Self-contained dwellings	General areas, private kitchens and laundries in self-contained dwellings	1.5	1.8[1]
	Balconies, and roofs used for floor type activities, in self-contained dwellings— (a) less than 1 m above ground level (b) other	 1.5 2.0	 1.5 kN/m ru along edge 1.8[1]
	Stairs[2] and landings in self-contained dwellings	2.0	2.7
	Non-habitable roof spaces in self-contained dwellings	0.5	1.4[8]

Step 6: Design Primary Steel Beams (B1/B2)

Using the tributary width of the new mezzanine area and the specified loads, ClearClacs' Steel Beam Calculator was used to find the most structurally efficient member in an instant.

Distributed Loads

Label	Start Location x_s (mm)	End Location x_e (mm)	Start Load Width LW_s (mm)	End Load Width LW_e (mm)	$w =$ Load Magnitudes w
UDL	0	5300	2220	2220	Q: 2 kPa Edit...

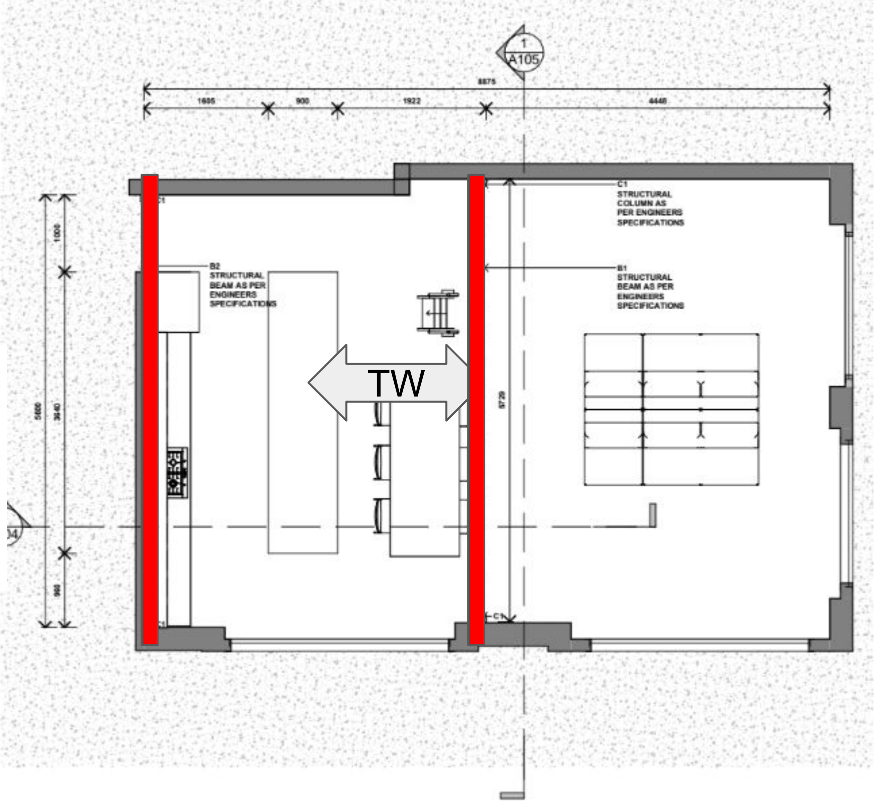


If we were completing hand calculations or using excel files we would have had to iterate the design many times to find a structurally efficient member.

Moment	Shear	ST Deflect	LT Deflect	Governing
55%	10%	35%	21%	55%

The selected member from ClearCalcs was a 200 UB 25.4 - Gr.300PLUS

Steel Beam Design Procedure



Step 7: Design Secondary Timber Beams (B3)

In the design of this member, we could put a constraint on the beam depth that it had to be less than 200mm deep to fit in the flange of the primary beam B1. We also were able to specify a grading and manufacturer that was locally available to select our member.

Centre-to-Centre Spacing (= load width) $s =$ 400 mm

Distributed Loads $w =$

Label	Start Location x_s (mm)	End Location x_e (mm)	Start Load Width LW_s (mm)	End Load Width LW_e (mm)	Load Magnitudes w
Floor Load	0	4430	400	400	G: 0.4 kPa, Q: 2 kPa Edit...

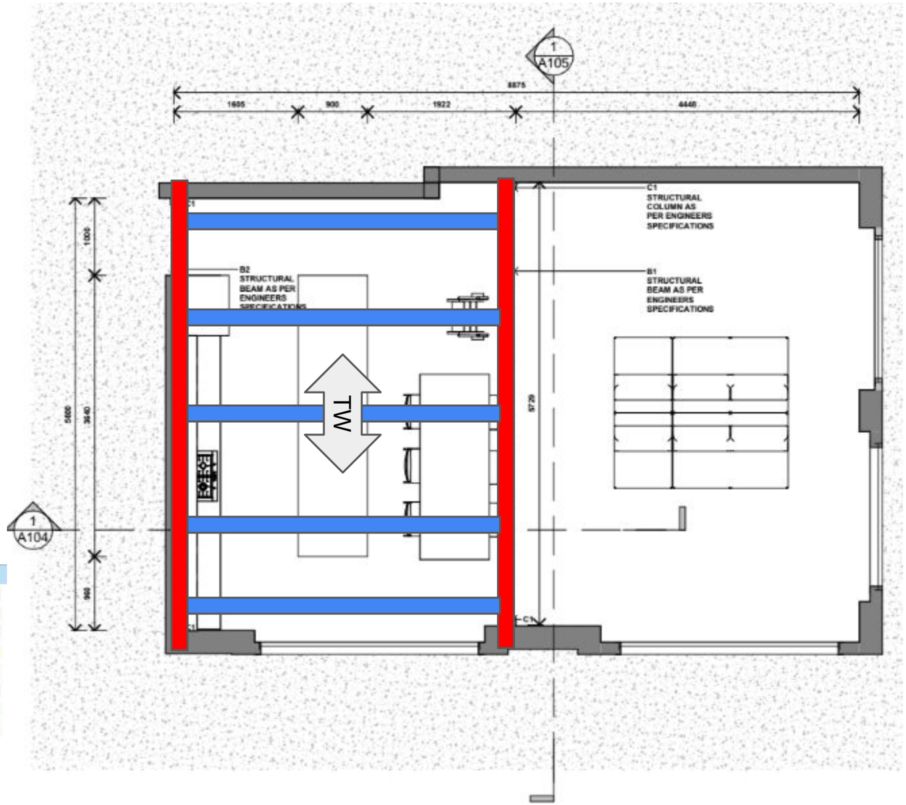
Instantaneous feedback was provided when the spacings were adjusted.

The selected member from ClearCalcs was a 195 x 65 GL15, Beam 15 (Hyne) at 400mm spacings

Stress Grade: GL15 | Manufacturer: Hyne Timber, Pty Ltd | Max Depth (mm): 200 | Max Breadth (mm)

	grade	mfr	ρ (kg/m³)	I_x (mm⁴)	species	M_d	V_d	δ_l	δ_s	Governing limit
✔ 195 x 65 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	40 200 000	Beam 15 (Hyne)	33%	12%	64%	51%	64%
130 x 65 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	11 900 000	Beam 15 (Hyne)	72%	18%	206%	167%	206%
165 x 65 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	24 300 000	Beam 15 (Hyne)	45%	14%	103%	83%	103%
130 x 85 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	15 600 000	Beam 15 (Hyne)	56%	14%	162%	130%	162%
165 x 85 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	31 800 000	Beam 15 (Hyne)	35%	11%	82%	65%	82%
195 x 85 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	52 500 000	Beam 15 (Hyne)	26%	10%	51%	40%	51%
130 x 130 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	23 800 000	Beam 15 (Hyne)	38%	9%	113%	88%	113%
165 x 130 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	48 700 000	Beam 15 (Hyne)	24%	8%	58%	45%	58%
195 x 130 GL15, Beam 15 (Hyne)	GL15	Hyne Timber, Pty	650	80 300 000	Beam 15 (Hyne)	17%	7%	37%	28%	37%

Timber Floor Joist Design Procedure



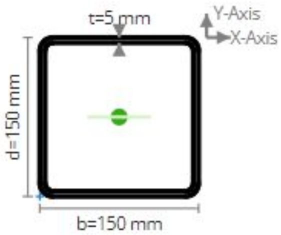
Step 8: Design of Steel Columns (C1)

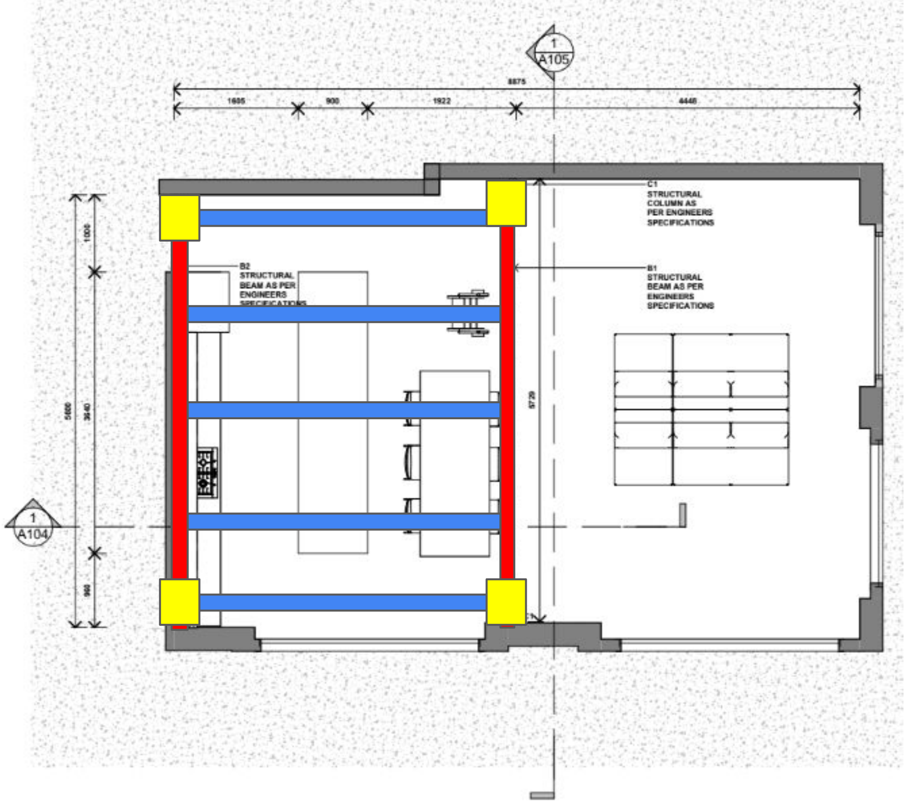
The loads from the Primary Beam (B1/B2) could be linked to Steel Column (C1) to save time in the design process.

Axial, Lateral & Moment Loads $P, N, M =$

Label	Location z (mm)	Axial Eccentricity x (mm)	Load Magnitudes P, N, M	
Axial Load	2700	75	G: 0 kN, 3.03 kN, 0 kN m, Q: 0 Edit...	Link

The ClearCalcs member selector tool was used to find a member that had sufficient width for the flanges of the Steel Beams (B1/B2) to be connected to the flange of the RHS.





The selected member from ClearCalcs was a 150 x 150 x 5.0 SHS Gr 300

[Steel Column Design Procedure]

Step 9: Design of Connections

B1/B2 (Steel Beam) – B3 (Timber Beam) Connection

Dead loads = self weight of 1/2 of timber member = ½ * 7.69 kg/m * 4.5m = 17.31kg = 0.17kN

Live loads = UDL 2kPa * Tributary Area = 0.002MPa * ½ * 4500mm * 400mm = 3600N = 3.6kN

Additional Live load = point load of 1.8kN over 350mm for punching or crushing

Factored load = 1.2G + 1.5Q = (1.2*0.17kN) + (1.5*(3.6kN + 1.8kN)) = 8.304kN

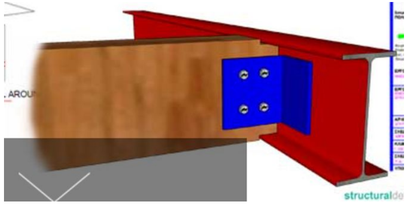
Selected Connection:

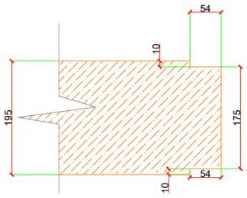
Timber Secondary Beam to Steel Beam Angle Connection

4 No. 4.6/S (Snug Tightened) M12 Bolts - Designed using ClearCalcs Steel Bolt Calculator to AS4100

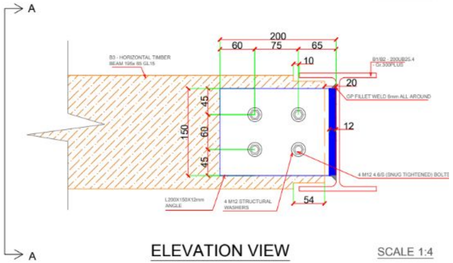
12mm thick angle cleat with GP Fillet Weld 6mm to Web of B1/B2 - Designed using ClearCalcs Weld Connection Calculator to AS4100

[Connection Design Procedure]

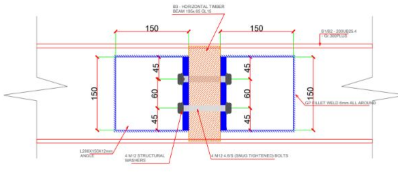




TIMBER BEAM CUTOUT DETAIL SCALE 1:4



ELEVATION VIEW SCALE 1:4



SECTION A-A SCALE 1:4

Step 9: Design of Connections

B1/B2 (Steel Beam) -C1 (Steel Column) Connection

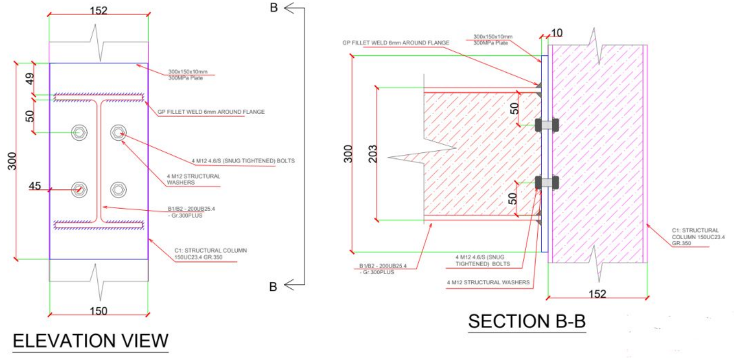
Shear on Bolt Group = 1.2G + 1.5Q = (1.2*3.03kN) + (1.5*(12.6kN + 1.8kN)) = 25.236kN

Design Out of Plane Moment on Bolt Group = 3kNm

Selected Connection:

150 x 150 x 10 300MPa plate GP Fillet Weld 6mm to Flanges of B1/B2- Designed using ClearCalcs Weld Connection Calculator to AS4100

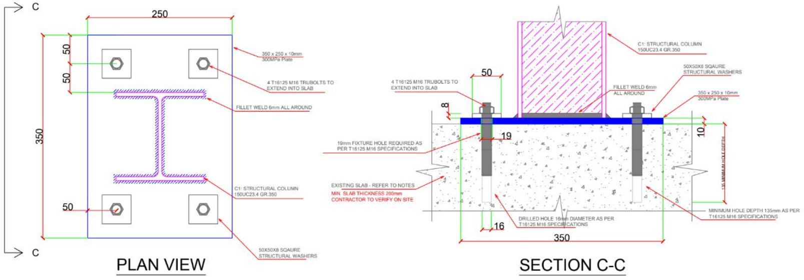
4 No. 4.6/S (Snug Tightened) M12 Bolts through the plate into the flange of C1 - Designed using ClearCalcs Steel Bolt Calculator to AS4100



C1 - Existing Slab Connection

200 x 200 x 10 300MPa Plate with 6mm fillet weld around perimeter of C1 - Designed using ClearCalcs Weld Connection Calculator to AS4100

4 No. N16 Trubolts through plate post fixed into slab - Designed using manufacturer's technical guide



Step 10: Drafting

GENERAL

G1. UNLESS NOTED OTHERWISE:

ALL DIMENSIONS ARE IN MILLIMETRES

ALL REDUCED LEVELS ARE IN METRES

ALL LEVELS ARE TO AUSTRALIAN HEIGHT DATUM (AHD)

ALL CHAINAGES REFER TO THE ROAD DESIGN LINE AND ARE NOTED IN METRES

G2. ALL DIMENSIONS RELEVANT TO SETTING OUT AND OFF-SITE WORK SHALL BE CONFIRMED AND VERIFIED BY THE CONTRACTOR BEFORE CONSTRUCTION AND FABRICATION IS COMMENCED. THE CONTRACTOR SHALL REPORT ANY DISCREPANCIES TO THE SUPERINTENDENT. THE DRAWINGS SHALL NOT BE SCALED.

G3. DUE ATTENTION AND CARE SHALL BE TAKEN BY THE CONTRACTOR REGARDING THE CARRYING OUT OF CONSTRUCTION ACTIVITIES IN AREAS CONTAINING EXISTING SERVICES.

G4. DURING CONSTRUCTION THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING THE STRUCTURE IN A STABLE CONDITION AND ENSURING NO PART IS OVER STRESSED UNDER CONSTRUCTION ACTIVITIES. THE CONTRACTOR SHALL REQUEST A SEPARATE DESIGN FOR ANY TEMPORARY BRACING, FALSEWORK & FORMWORK AND ALL RELEVANT TEMPORARY WORKS AS REQUIRED.

G5. THE CONTRACTOR SHALL PROVIDE FOR THE METHOD OF CONSTRUCTION AND THE MAINTENANCE OF SAFETY DURING CONSTRUCTION. IF ANY STRUCTURAL ELEMENT PRESENTS DIFFICULTY IN CONSTRUCTABILITY OR SAFETY, THE MATTER SHALL BE REFERRED TO THE ENGINEER FOR RESOLUTION BEFORE PROCEEDING WITH THE WORK.

G6. IF THE CONTRACTOR INTENDS TO VARY THE SCOPE OR METHOD OF WORKS OR MATERIALS USED THE CONTRACTOR SHALL SUBMIT FULL DETAILS OF THE PROPOSAL TO THE ENGINEER FOR DESIGN REVIEW.

G7. ALL PROPRIETARY PRODUCTS SHALL BE INSTALLED STRICTLY IN ACCORDANCE WITH MANUFACTURER'S REQUIREMENTS AND RECOMMENDATIONS.

G8. EXISTING SLAB IS ASSUMED TO BE ADEQUATE FOR EXISTING LOADS SPECIFIED BY CONSENTINO GROUP (LIVE LOAD 4.0 KPA, SUPERIMPOSED DEAD LOAD 1.0 KPA).

G9. CONTRACTOR TO VERIFY EXISTING SLAB IS MINIMUM 200MM THICK

G10. CONSTRUCTION WORKS SHOULD CEASE IF ANY EXISTING DEGRADED, CORRODED, CRACKED OR DAMAGED STRUCTURAL COMPONENTS ARE UNCOVERED.

G11. ALL DEFECTS TO BE REPORTED TO SURVEYOR AND ENGINEER

G12. ABBREVIATIONS

T - TOP

EJ - EXPANSION JOINT

B - BOTTOM

CJ - CONSTRUCTION JOINT

EW - EACH WAY

FW - FILLET WELD

EF - EACH FACE

CFW - CONTINUOUS FILLET WELD

NF - NEAR FACE

CPBW - COMPLETE PENETRATION BUTT WELD

FF - FAR FACE

CPS - CONSTRUCTION PHASE SERVICES

LV - LENGTH VARIES

UNO - UNLESS NOTED OTHERWISE

ABR - ALTERNATE BAR REVERSED

DEMOLITION

D1. DEMOLITION WORK (IF ANY) SHALL BE AS PER AS2601. TAKE PRECAUTIONS NECESSARY FOR PROTECTION OF PERSONS AND PROPERTY.

D2. OBTAIN NECESSARY PERMITS AND APPROVALS FROM RELEVANT AUTHORITIES BEFORE COMMENCING WORK ON SITE. DO NOT COMMENCE DEMOLITION WORK BEFORE DEMOLITION PERMIT/SCAFFOLD PERMIT OBTAINED.

D3. THE CONTRACTOR SHALL DEMONSTRATE THAT ALL DEMOLITION WORKS SHALL NOT CRACK OR OTHERWISE DAMAGE REMAINING STRUCTURAL COMPONENTS. METHOD STATEMENTS FOR DEMOLITION SHALL BE SUBMITTED AND APPROVED BY THE BODY CORPORATE PRIOR TO STARTING DEMOLITION.

D4. CARE SHALL BE TAKEN TO RETAIN THE INTEGRITY OF EXISTING ELEMENTS BEING RETAINED/INCORPORATED INTO THE PROJECT WORKS. DAMAGED COMPONENTS SHALL BE REPORTED TO THE ENGINEER BEFORE REINFORCEMENT/FORMWORK INSTALLED AND SHALL BE RECTIFIED TO THE SATISFACTION OF THE ENGINEER.

DESIGN SPECIFICATION

DS1. DESIGN BASIS:

DEAD AND LIVE LOADS CALCULATED BASED ON AS1170.1

WIND LOADS DICTATED AS NOT GOVERNING BASED ON AS1170.2

EARTHQUAKE LOADS DICTATED AS NOT GOVERNING BASED ON AS1170.4

DESIGN OF STEEL MEMBERS IN ACCORDANCE WITH AS4100

DESIGN OF TIMBER MEMBERS IN ACCORDANCE WITH AS1720

DS2. DESIGN LIFE:

- 50yrs (NEW STRUCTURAL ELEMENTS)
- 10yrs (ARCHITECTURAL ELEMENTS)

DS3. DESIGN LOADS:

PERMANENT ACTIONS: AS1170.1 SECTION 2 MEMBER SELF WEIGHTS

IMPOSED ACTIONS: AS1170.1 SECTION 3 SELF CONTAINED DWELLINGS: GENERAL AREAS (UNIFORMLY DISTRIBUTED ACTIONS: 1.5 KPA, CONCENTRATED ACTIONS 1.8 KPA)

DS11. MATERIAL UNIT WEIGHTS

REINFORCED CONCRETE: 26.5kN/m3

PRESTRESSED CONCRETE: 26.5kN/m3

STRUCTURAL STEEL: 77kN/m3

TIMBER: 10jN/m3

STRUCTURAL STEEL

S1. ALL BOLTS, NUTS AND ACCESSORIES SHALL BE HOT DIP GALVANISED TO AS/NZ 5680-2006 UNO.

S2. ALL WELDS SHALL BE CATEGORY SP WELD CARRIED OUT BY AN EXPERIENCED OPERATOR IN ACCORDANCE WITH AS 1554.

S3. CFW DENOTES CONTINUOUS FILLET WELD TO AS 1554.1-2014 AND SHALL BE 6CFW BOTH SIDES U.N.O. CPBW DENOTES PREQUALIFIED COMPLETE PENETRATION BUTT WELD TO AS 1554.1-2014.

TIMBER:

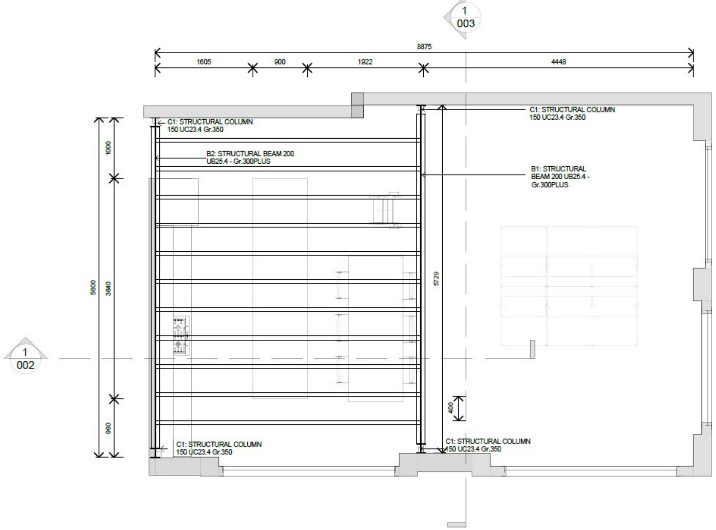
T1. ALL CONSTRUCTION TO BE IN ACCORDANCE WITH THE BUILDING CODE OF AUSTRALIA

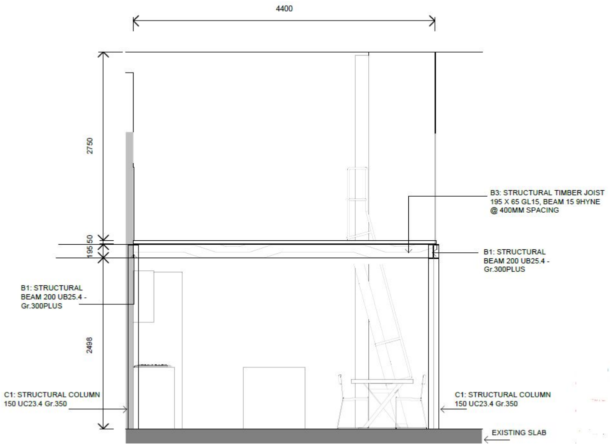
T2. ALL DIMENSIONS TAKE PRECEDENCE OVER SCALES

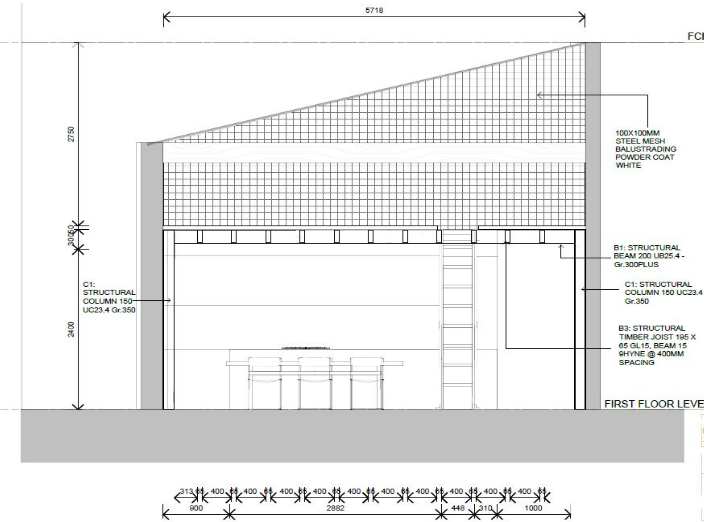
T3. BUILDER AND TRADES ARE TO CONFIRM ALL MEASUREMENTS, DETAILS AND SPECIFICATIONS PRIOR TO SETOUT AND ORDERING OF MATERIALS

T4. ANY ERRORS ARE TO BE ADDRESSED TO THE DESIGNER AS NO RESPONSIBILITY WILL BE TAKEN AFTER CONSTRUCTION HAS COMMENCED

T5. ALL TRADES ARE TO CONFORM WITH THE CURRENT AUSTRALIAN STANDARDS RELATING TO HIS OR HER OWN WORK

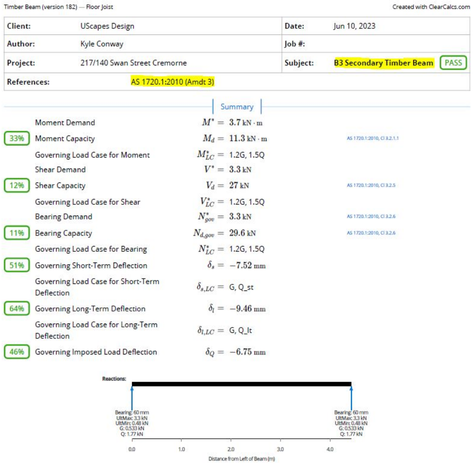






Step 11: Project Deliverables

1. Structural Drawings
2. Form 126
3. Structural Calculations (exported neatly formatted from ClearCalcs)

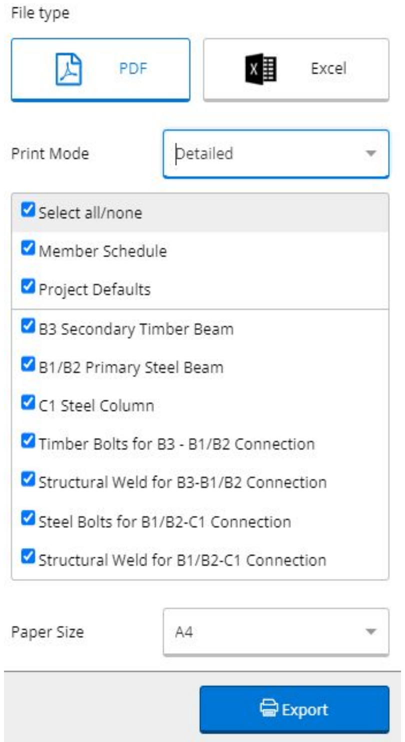


Timber Beam (version 182) — Floor Joist | Created with ClearCalcs.com

Client:	UScapes Design	**Date:**	Jun 10, 2023
Author:	Kyle Conway	**Job #:**	
Project:	217/140 Swan Street Cremorne	**Subject:**	B3 Secondary Timber Beam PASS
References:	AS 1720.1:2010 (Amdt 3)		

Summary

	Moment Demand	$M^* = 3.7\ \mathrm{kN \cdot m}$	
33%	Moment Capacity	$M_d = 11.3\ \mathrm{kN \cdot m}$	AS 1720.1:2010, Cl 3.2.1.1
	Governing Load Case for Moment	$M^*_{LC} =$ 1.2G, 1.5Q	
	Shear Demand	$V^* = 3.3\ \mathrm{kN}$	
12%	Shear Capacity	$V_d = 27\ \mathrm{kN}$	AS 1720.1:2010, Cl 3.2.5
	Governing Load Case for Shear	$V^*_{LC} =$ 1.2G, 1.5Q	
	Bearing Demand	$N^*_{gov} = 3.3\ \mathrm{kN}$	AS 1720.1:2010, Cl 3.2.6
11%	Bearing Capacity	$N_{d,gov} = 29.6\ \mathrm{kN}$	AS 1720.1:2010, Cl 3.2.6
	Governing Load Case for Bearing	$N^*_{LC} =$ 1.2G, 1.5Q	
51%	Governing Short-Term Deflection	$\delta_s = -7.52\ \mathrm{mm}$	
	Governing Load Case for Short-Term Deflection	$\delta_{s,LC} =$ G, Q_st	
64%	Governing Long-Term Deflection	$\delta_l = -9.46\ \mathrm{mm}$	
	Governing Load Case for Long-Term Deflection	$\delta_{l,LC} =$ G, Q_lt	
46%	Governing Imposed Load Deflection	$\delta_Q = -6.75\ \mathrm{mm}$	



	Calculation	Member	Quantity	Comments
64%	**B3 Secondary Timber Beam**	195 × 65 GL15, Beam 15 (Hyne)	4430 mm	
55%	**B1/B2 Primary Steel Beam**	200 UB 25.4 - Gr.300PLUS	5300 mm	
15%	**C1 Steel Column**	150 × 150 x 5.0 SHS - Gr.C350L0	2700 mm	
77%	**Timber Bolts for B3 - B1/B2 Connection**	M12 Wood Bolts	4 bolts	
3%	**Structural Weld for B3-B1/B2 Connection**	Other fillet weld - 4.242640687119285 mmmm throat	400 mm	
43%	**Steel Bolts for B1/B2-C1 Connection**	M12, 4.6/S Steel Bolts	4 bolts	
13%	**Structural Weld for B1/B2-C1 Connection**	Other fillet weld - 4.242640687119285 mmmm throat	300 mm	

Questions?