CAREER EPISODE 3

INTRODUCTION:

CE3.1

Project Name	Design of Steel Beams with UB 250 Beams and SHS Columns and a design of Beams for a Residential Building
University	Australian College of Management and Innovation
Code	RIICWD501E
Duration	25/Jan/2021
Position	Student
Location	Combo, Perth

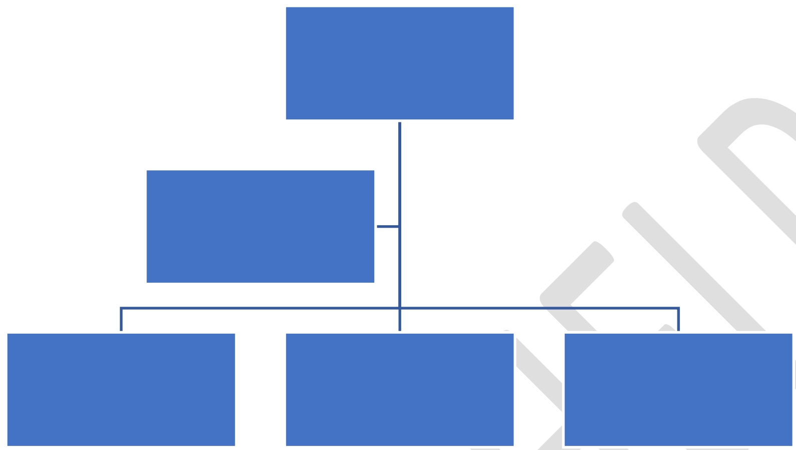
BACKGROUND:

CE3.2 The project involves the design of a steel-framed structure for a recreational room and 10 chalets located on a rectangular site near Como, Perth. The site has a flat grade across most of the area with a five percent slope in a triangular region towards the road. The design must comply with Council regulations, which specify no special building restrictions. The site is owned by a private client and leased to Professional Associates.

CE3.3 The project involves designing a steel beam for a residential building near Fremantle, Perth, adhering to AS 4100 (Steel Structures) and AS 1170 (Structural Design Actions). The site features a rectangular plan with a slight slope towards the road. The design will ensure structural integrity while accommodating the site's flat terrain and minor slope. The beam will support the residential

structure in compliance with all relevant Australian Standards and Council regulations. The scope includes structural analysis, material selection, and design verification to ensure the beam meets safety and performance requirements.

CE3.4 Project Hierarchy:



CE3.5 Roles and Responsibilities:

- I designed a steel-framed recreational room using SHS and RHS columns, UB beams, and a truss roof.
- I conducted engineering calculations to select appropriate steel sections and determined critical locations for structural elements.
- I designed slabs, footings, and a retaining wall to ensure structural integrity and alignment.
- I designed and detailed a truss system for the roof with specific pitch and bracing arrangements.
- I conducted stress analysis, bending moment, and shear force calculations for various structural components.
- I designed simply supported beams for specific loads, including developing shear force and bending moment diagrams.
- I calculated load combinations, and section properties, and ensured compliance with safety and structural requirements.
- I designed and analyzed flooring systems with joists and bearers for effective load distribution.
- I applied material strength principles and safety factors to finalize beam and structure designs.

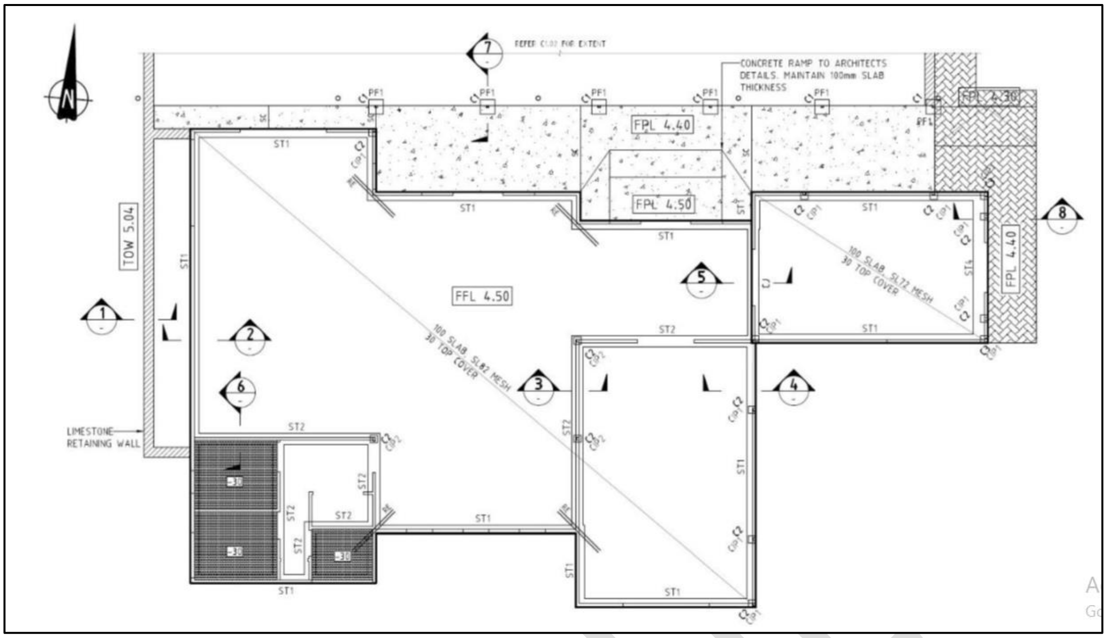
PERSONAL ENGINEERING ACTIVITIES:

CE3.6 I was responsible for designing a steel-framed recreational room using SHS and RHS columns, UB200 or UB250 beams, and a truss roof, ensuring compliance with Australian Standards and City Council regulations. Therefore, I conducted engineering calculations to select suitable steel sections and marked critical locations for roof bracing, columns, and beams. I developed a cross-section and a detailed view using AutoCAD which is given below.

Figure 1 Survey Drawing

CE3.7 I developed the drawing to design a recreational room by carefully planning all structural and civil elements. I designed the slabs to have a thickness of 100 mm, reinforced with SL72 mesh, with a 30 mm top concrete cover for structural integrity and compliance with construction standards. I incorporated elevation levels such as FPL 4.40 and FFL 4.50 to define the finished floor levels and ensure proper alignment across the structure.

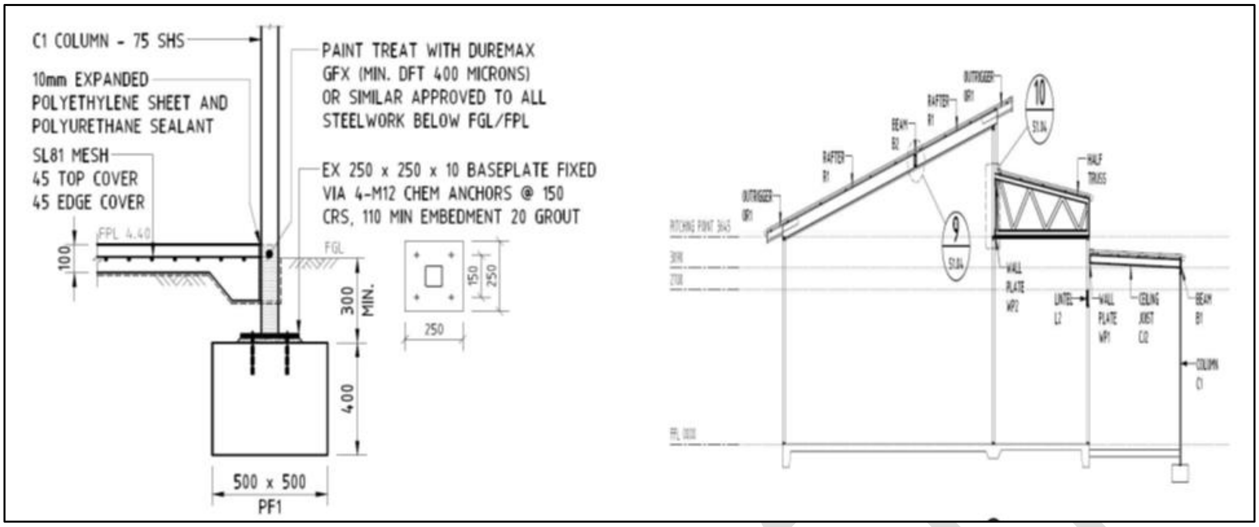
CE3.8 As shown in the figure, I positioned footings labeled ST1 and ST2 to support the walls and distribute loads efficiently. I ensured the dimensions of the footings and slabs were consistent with the design requirements. For the external ramp, I maintained a 100 mm slab thickness and ensured it connected seamlessly with the main structure, providing accessibility and a smooth transition to the interior spaces. I incorporated a limestone retaining wall along the boundary to provide lateral support and enhance the stability of the structure. I positioned this retaining wall at a height of 5.04 meters (TOW) to counter soil pressure effectively. I added concrete pads labeled PF1 to anchor and support structural elements. I ensured the precise alignment of these pads with the overall design layout to achieve stability.



FOOTING SCHEDULE		
MARK	SIZE (L x B x D)	REINFORCEMENT
ST1	300 x 400 DEEP	3-L8TM MESH, 60 COVER
ST2	400 x 250 DEEP	4-L8TM MESH, 60 COVER
ST3	1000 x 1000 x 300 DEEP	SL82 MESH, 60 COVER
ST4	500 x 400 DEEP	5-L8TM MESH, 60 COVER
PF1	500 x 500 x 400 DEEP	
RW1	600 x 300 DEEP	REFER SECTION 2

CE3.9 I used a 75 SHS (Square Hollow Section) steel column for the structural framework, painted with Duremax GFX or a similar coating with a minimum dry film thickness of 400 microns to protect all steelwork below the Finished Ground Level (FGL) or Finished Floor Level (FFL). I added a 10mm expanded polyethylene sheet and polyurethane sealant for sealing and durability. I incorporated SL81 mesh reinforcement into the slab, providing 45mm of top cover and 45mm of edge cover for corrosion resistance and structural integrity. I designed the base plate as an EX 250 × 250 × 10mm plate fixed with four M12 chemical anchors at 150mm centers, ensuring a 110mm embedment depth with 20mm of grout for proper load transfer to the foundation. The footing (PF1) measured 500mm × 500mm and extended to a depth of 400mm below ground.

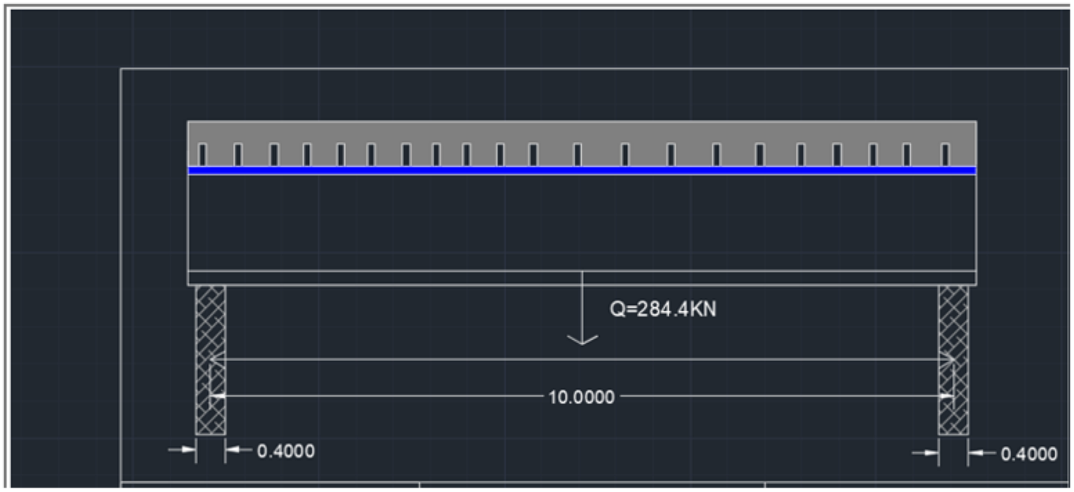
CE3.10 I detailed the truss system to support the roof structure, including rafters R1 and R2 connected to beam B2. The roof pitch was set at a 36.5-degree angle to optimize drainage and structural efficiency. I included outriggers for extending the roof and maintaining overhang stability. Beam B1 supported the ceiling joist C2 and wall plate WP1 ensuring proper load distribution to the structural framework.



CE3.11 I considered a simply supported 530UB92.4 steel beam of Grade 300 with fy=300 MPa spanning 10m. I made sure that as indicated in the given figure the concrete slab continually restrained the beam laterally and against twist along its top flange. I used the given section modulus Zex=2370×103 mm3 and the distance from the neutral axis c=10 mm. I determined the highest live load (Q) that could be applied to the bottom flange of the beam at its center span as a downward point load. I ignored the self-weight of the concrete slab in the calculations. I referred to the design capacity table for the 530UB92.4 beam for relevant values. I assumed Kss=1.0 considering that the beam was uncoped.

CE3.12 I performed the calculations by determining the bending moment at the center span of the simply supported beam due to the applied live load. I ensured that the applied bending moment did not exceed the design moment capacity of the beam, derived from Md=fy·Zex. I compared the maximum bending moment under the applied load with the beam's capacity and ensured it adhered to safety requirements. Through these steps, I determined the maximum live load (QQQ) that the beam could safely support without exceeding its design limits.

CE3.13 I developed the CAD design of a simply supported beam spanning 10 meters, designed to carry a maximum live load of Q=284.4 kN, applied as a point load at the center of the span. I ensured that the beam was adequately restrained laterally and against twisting by a concrete slab along its top flange. I incorporated a total beam span of 10.0 m, with overhangs of 0.400m on both ends, to ensure proper placement and effective load transfer to the supports. I modeled the supports as fixed supports to provide stability and resistance to the applied loads. I calculated the bending moments and shear forces in the beam to verify that the design adhered to structural engineering principles.



CE3.14 I calculated stress using the formula: Stress (σ) = (Bending Moment (M) × Distance from Neutral Axis (c)) / Section Modulus (Z). I considered stress (σ) in Pascals (Pa) or N/mm² (MPa). I took the bending moment (M) in Newton-meters (Nm). I used the distance from the neutral axis (c) measured in meters (m) and the section modulus (Z) in mm³. I determined the allowable stress (σ) for a steel beam based on AS 4100 standards, using the material's yield strength (fy). I calculated allowable stress as 0.9 times the yield strength. For a material with a yield strength of 300 MPa, I used the formula Allowable Stress (σ) = 0.9 × fy.

CE3.15 I calculated areas where necessary. I also calculated the mass of the steel beam by using the formula:

Mass of Steel = Volume × Density of Steel

I assumed a typical steel density of 7.85 g/cm³ (7,850 kg/m³). I calculated the volume of the steel beam using the formula:

Volume of Steel = Area × Length

I multiplied the gross area of the cross-section by the beam's length (10 m). I also determined the shear force capacity as part of my analysis.

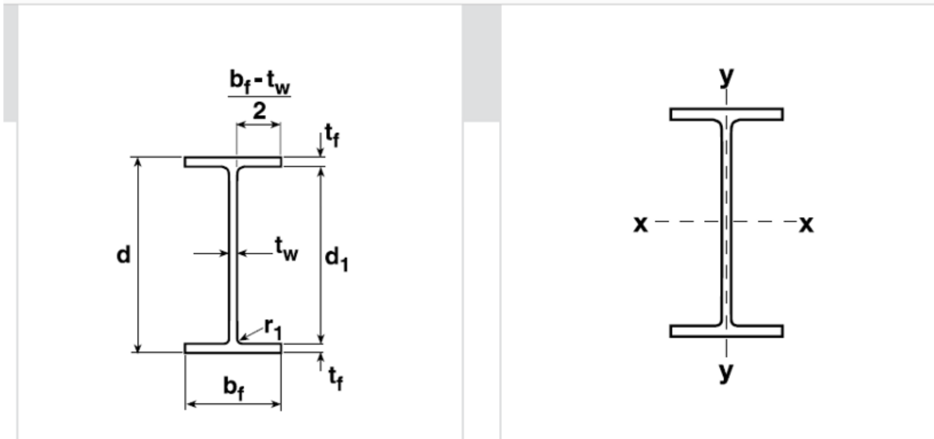


Figure 2 I Beam Cross section diagram.

CE3.16 Now, to design a design of the residential building, I calculated the maximum bending moment and maximum shear force using the load combination, 1.35 Dead Load. I calculated the dead load (w) as the total of the flooring board's weight and the UB joist's self-weight:

Dead Load = weight of flooring board + self-weight of beam

(0.02mm x 0.4m x 850 kg/m) + 14 kg/m] x 9.81

= 204.1 N/m

Live Load = 1.8 kPa

= 1800 N/m^2 x 1m

= 1800 N/m

Value of Maximum Bending; Mmax	Mmax = (w L^2)/8 ((486)(4)^2)/8 972 N-m
Value of Maximum Shear; Vmax	Vmax = (w L)/2 = ((486)(4))/2 = 972 N

CE3.17 I calculated the maximum bending moment and maximum shear force using the load combination:

1.2 Dead Load+1.5 Live Load.

where:

L = length of Joist = 3.5 m

c-c of Joist = 400mm

I calculated the value of dead load and live load as shown below:

Dead Load = weight of flooring board + self-weight of beam

= (0.02mm x 0.4m x 850 kg/m) + 14 kg/m] x 9.81

= 204.1 N/m

Live Load = 1.8 kPa

1800 N/m^2 x 1m

= 1800 N/m

I combined the loads using the given load combination:

Design Load = 1.2 Dead Load + 1.5 Live Load

= 1.2 (204.1 N/m) + 1.5 (1800 N/m)

= 2944.9 N/m

CE3.18 I designed a simply supported beam subjected to a uniformly distributed load (U.D.L.) over its entire span. I started by defining the load W per unit length, ensuring the beam could withstand the applied loads effectively. I calculated the reactions at both supports which were equal to WL/2 on each side, considering the symmetry of the loading and support conditions. I developed the shear force diagram (S.F.D.) for the beam where the shear force started at WL/2 at the left support, decreased linearly to zero at the midpoint, and then became negative, reaching −WL/2 at the right support. This linear variation in shear force indicated the effect of the U.D.L. across the span.

CE3.19 I calculated the bending moment at every section of the beam and plotted the bending moment diagram (B.M.D.). The bending moment was zero at the supports and reached its maximum value at the mid-span, which I calculated as WL2/8. The B.M.D. showed a parabolic variation due to the uniformly distributed load. For the beam section, I selected a UB-150-18 universal beam. This section had a depth of 150 mm, and its weight was 18 kg/m, as per standard specifications. I modeled the cross-section of the beam in detail to ensure it met the structural requirements. I considered the beam's geometry, flange width, web thickness, and other dimensional properties to ensure the section could resist the bending and shear stresses effectively.

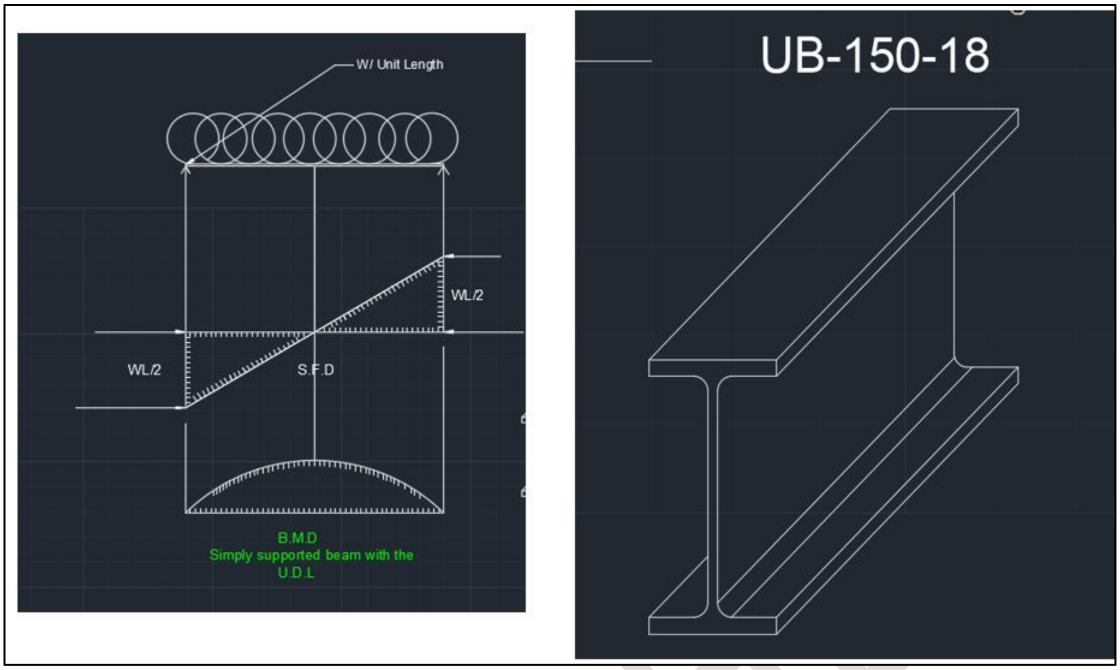


Figure 3 Simply Supported Beam with U.D.L

CE3.20 I designed a flooring system, as shown in the plan and side views. I considered the structural elements, including the bearers and joists, which were arranged to support the flooring load effectively. The span of the flooring system was 4.000 meters, as indicated in both the plan and side views. I positioned the joists parallel to each other, ensuring uniform spacing for efficient load distribution. Each joist carried a tributary area, which was the load-sharing region, and I calculated the loads acting on each joist based on this area. I placed the bearers perpendicular to the joists to provide additional support and stability.

CE3.21 I included arrows in the side view to represent the uniformly distributed load (U.D.L.) acting on the system, ensuring that the design could withstand the anticipated loads without deflection or failure. I detailed the connections between the joists and the bearers to ensure proper load transfer and structural integrity.

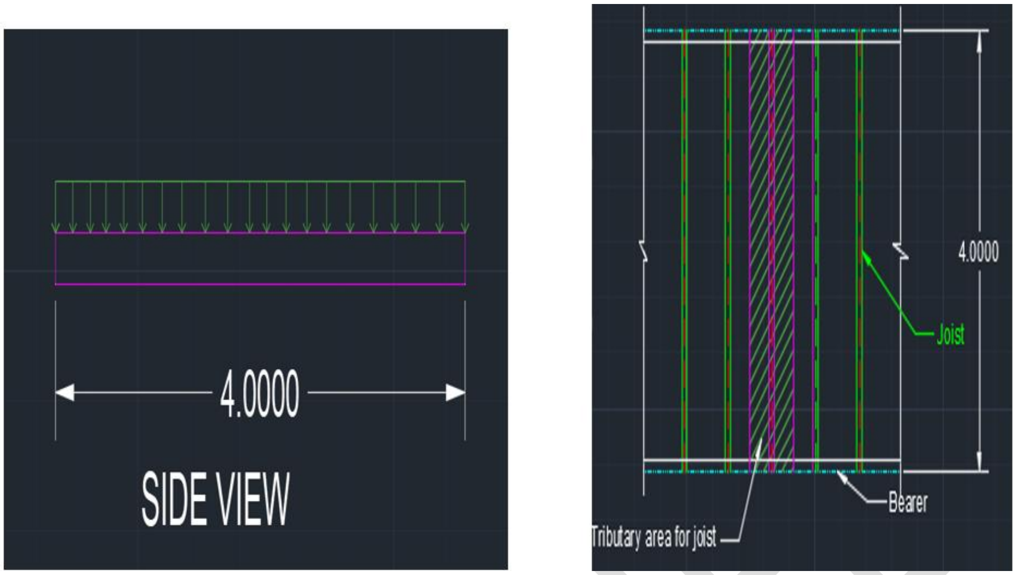


Figure 4 Plan View of Flooring System

CE3.22 I evaluated design options by assessing the structural integrity and safety of various beam sizes and materials. For Part A, I selected standard beam sizes to meet strength and deflection criteria as per AS 4100, considering the moderate bending moments and shear forces. For Part B, where higher bending moments and shear forces were observed, I chose beams with larger sections or higher section moduli to safely accommodate these loads.

CE3.23 I applied material strength principles to ensure that the selected beam sections provided adequate resistance to bending and shear. I calculated the required section modulus and shear area, ensuring they exceeded the maximum moments and shear forces. I also incorporated safety factors to address uncertainties in load assumptions and material properties. To finalize my design, I verified all selections against relevant code requirements and conducted sensitivity analyses to ensure robustness under varying conditions. For the civil steel structure, I evaluated two design options Conventional Steel Frame Design and Composite Steel-Concrete Design. Based on these considerations, I recommended the Composite Steel-Concrete Design for the project because it controls the strengths of both steel and concrete, providing enhanced load-bearing capacity with thinner sections.

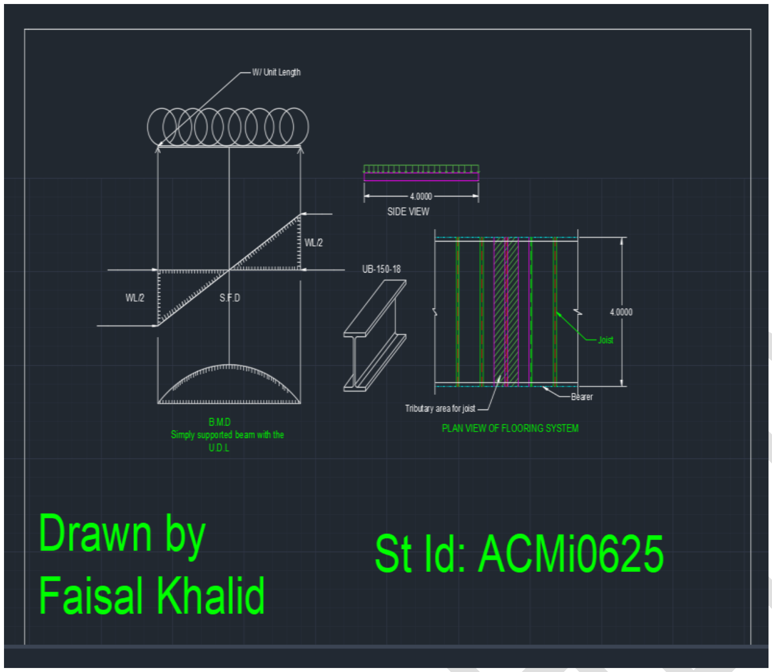


Figure 5 Finalize Design Processes of Civil Steel Structure

CE3.24 I made sure to document all the details of the project which includes drawings, calculations, and compliance statements with relevant Australian Standards (AS 4100 and AS 1170). I shared the design documentation and approval request with the team members ensured the information was correct and followed up if necessary. I also created internal reports detailing the current status of design, construction progress, and cost performance.

CE3.25 I regularly met with the project supervisor to gather their feedback on the current steel beam design. I implemented the suggested changes to the design based on the feedback. This may include modifying dimensions, materials, or other design elements to better meet the project's objectives. During the meetings, I used graphs and charts to illustrate data and trends related to the specific occasion.

CE3.26 I analyzed risks including adverse weather conditions, structural failure of steel components, and site safety and accident risks. I implemented control strategies to mitigate these risks, including weather monitoring, design reviews, and site safety plans. I adhered to building codes and standards, such as AS/NZS 4100, to ensure safety and regulatory compliance. I conducted regular quality control checks to ensure that the design and construction met specified standards. I documented these checks and any corrective actions taken to address deviations or deficiencies.

SUMMARY:

CE3.27 I have completed the evaluation of the steel beam design for the residential project near Fremantle. During this project, I focused on ensuring compliance with AS 4100 and AS 1170, as well as assessing the overall structural integrity. By designing several civil structures, I enhanced my engineering knowledge which allowed me to develop a detailed understanding of structural analysis.