

**UNIVERSITY OF SOUTH AUSTRALIA
SCHOOL OF NATURAL AND BUILT ENVIRONMENTS**

FIRST SEMESTER EXAMINATIONS, JUNE 2004

BUILDING FOR PEOPLE N

GENERAL INSTRUCTIONS TO CANDIDATES:

Lecturer: J. Mills

Reading Time: 10 mins

Exam Duration: 3 hours

1. Attempt ALL questions.
 2. Marks for questions are shown in brackets.
 3. You may use the following books/information:
 - SAA HB2.2 – Australian Standards for civil engineering students Part 2: Structural Engineering 2003 edition (or 2002 edition with the green paper amendment)
 - Onesteel 300 plus “Hot Rolled and Structural Steel Products”, Third edition (photocopy)
 - A total of 2 double sided A4 pages with any notes, formulae, information etc you desire to include
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PART A: Timber Design

QUESTION 1

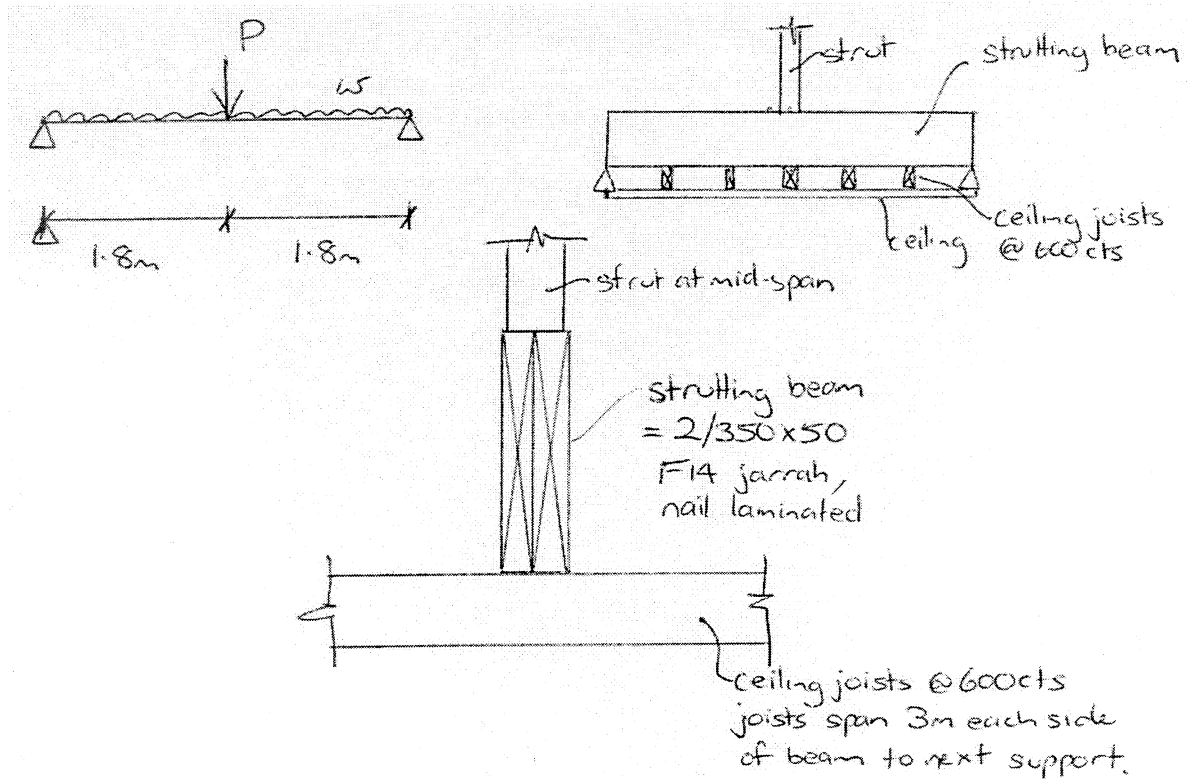
A strutting beam in a house roof system is shown below. It supports a vertical strut carrying roof loads at mid-span. It also supports ceiling joists attached to the bottom edge of the beam at 600 mm centres. The ceiling joists support the ceiling (0.15 kPa permanent load, unfactored) and span 3m each side of the strutting beam before they are supported at another beam/wall. The vertical strut does not provide any lateral restraint to the beam.

Design loads (unfactored) are:

$w = \text{self-weight of beam} + \text{ceiling self-weight (permanent loads)} \text{ (kN/m)}$

$P = \text{roof loads} = 6 \text{ kN permanent load} + 5 \text{ kN imposed load from construction/maintenance}$

The proposed beam is constructed from 2/350 x 50 F14 unseasoned jarrah timber members, nail laminated together to form a single member. The beam is located in a roof in Sydney.



- (a) Check whether the proposed beam is adequate for the serviceability limit state. To avoid cracking of the ceiling, the maximum deflection under permanent load must be limited to a total value of 12 mm. The maximum deflection at mid-span from a single point load is given by:

$$\Delta = \left(\frac{PL^3}{48EI} \right) \quad , \text{ and for a udl load } \quad \Delta = \left(\frac{5wL^4}{384EI} \right)$$

(12 marks)

- (b) Check whether the proposed beam is adequate for the bending moment caused by the appropriate strength limit state combination of permanent and imposed loads.

(18 marks)

Total = 30 marks

QUESTION 2

The principal roof truss shown below is located in an art gallery in Darwin. It is located inside the building, not exposed to weather. The truss supports a load at the bottom central panel point due to hanging of displays, and loads at the top panel points from roof dead and live loads.

The **unfactored** design loads are:

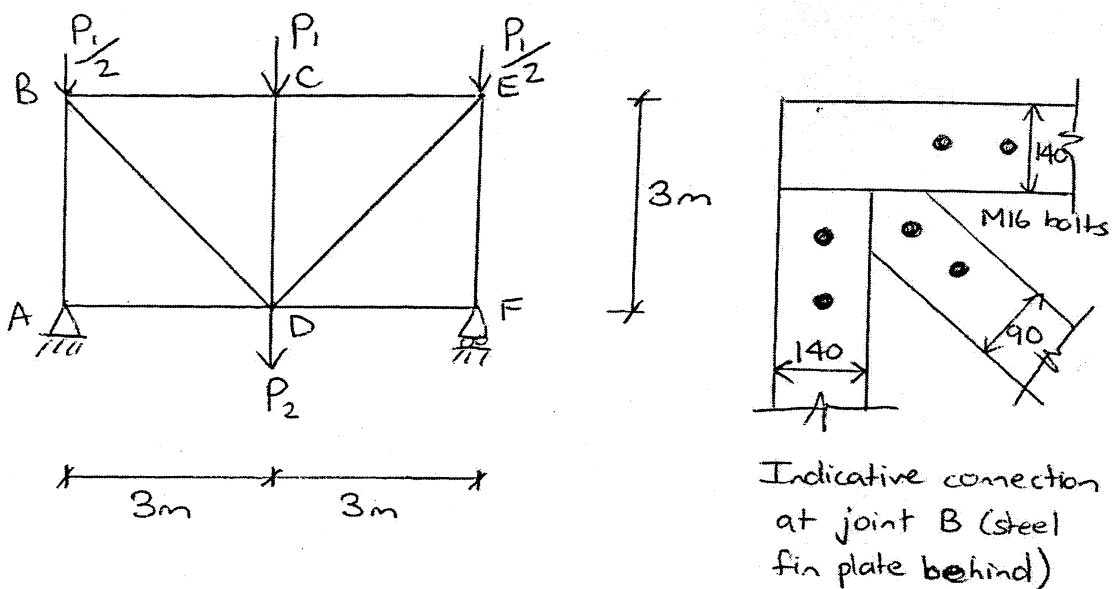
$P_1 = 4$ kN permanent load from roof self-weight

$P_1 = 4$ kN construction/maintenance load

$P_2 = 2$ kN display hanging load (assume 5 months duration)

Ignore truss self-weight

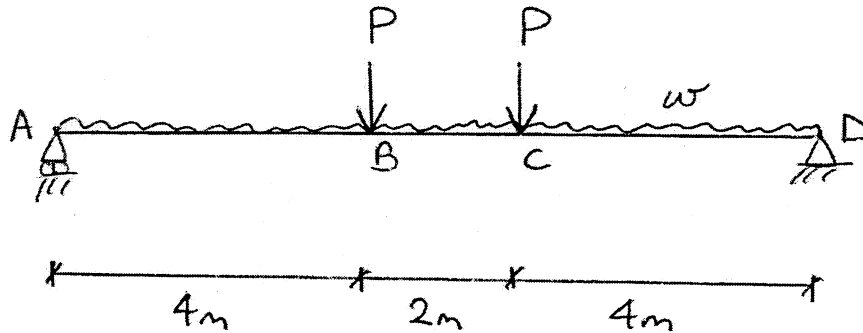
Assume that the likelihood of roof maintenance occurring at the same time that displays are hanging is very low.



Assume all connections are M16 bolts in a line in the direction of the force, i.e. a single bolt in any row across the member, with at least 2 bolts at each end of each member. There are no other restraints between member ends.

- Determine critical design loads in members AB and BD (8 marks)
- Check the adequacy of member AB under the critical design load if it is constructed from 140 x 90 F7 radiata pine. (8 marks)
- Check the adequacy of member BD under the critical design load if it is constructed from 90 x 90 F7 radiata pine. Please note that there is a misprint in formula 3.4(2) in the code – f'_s should be f'_t in the formula. (4 marks)

Total = 20 marks

PART B: Steel Design**QUESTION 3**

Determine an appropriate Grade 300 Universal Beam for the simply supported beam shown above. The beam is laterally restrained at A, B, C and D. The applied, **unfactored** loads are as follows:

w = self-weight kN/m (G)

P = reactions from intersecting beams = 30 kN permanent (dead) load (G) and 20 kN imposed (live) load (Q)

- (a) Select a beam size that satisfies the serviceability limit state. Total maximum deflection due to dead load and short term live load to be limited to 20 mm. (Ignore self-weight). Assume this is a floor beam in an office building.

Note: Maximum deflection at mid-span due to **both** point loads, P acting together

$$\Delta = \left(\frac{PL^3}{25EI} \right)$$

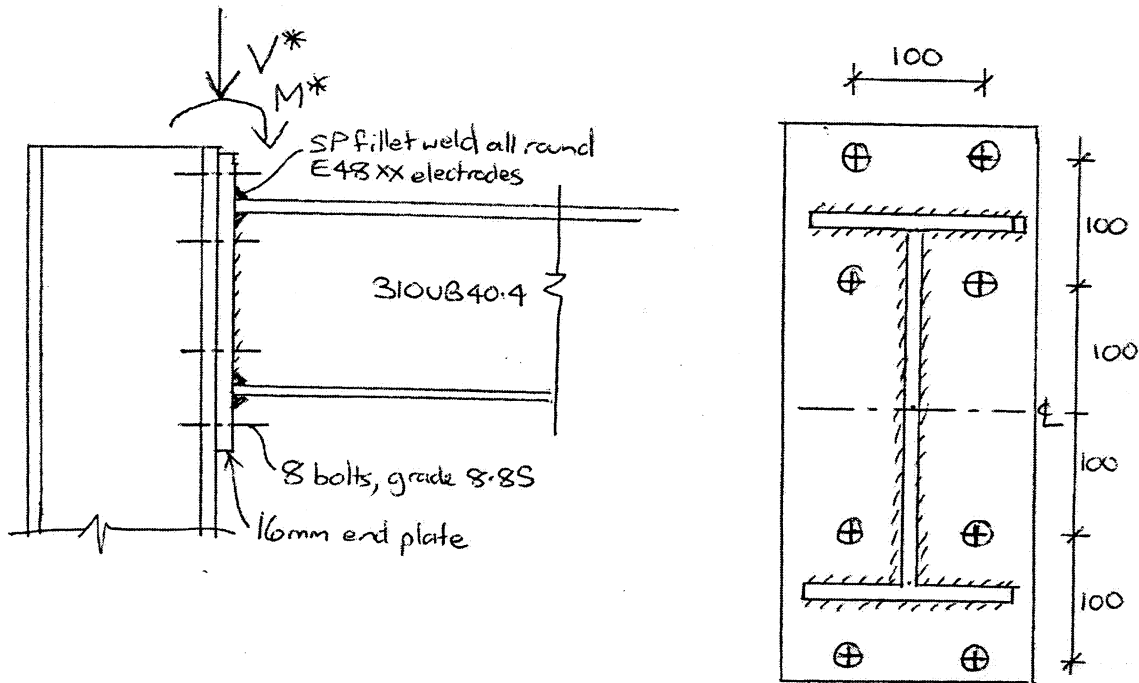
(4 marks)

- (b) Draw the shear force and bending moment diagrams for the strength limit state loads (6 marks)
- (c) Check section moment capacity (2 marks)
- (d) Check member moment capacity in **each** segment AB and BC. As part of this check, determine first whether the member is fully laterally restrained in these segments and calculate an accurate value of β_m and α_m for each segment. (12 marks)
- (e) Check that the beam is satisfactory in shear. (4 marks)
- (f) Show that the beam is satisfactory in combined bending and shear at B. (2 marks)

Total = 30 marks

QUESTION 4

A knee joint connection in a portal frame constructed from 310 UB 40 beam and columns is shown below.



The joint must be designed for a vertical shear force, $V^* = 200$ kN and a clockwise bending moment of $M^* = 150$ kNm.

- (a) Determine a satisfactory bolt diameter for the 8 bolts that carry the combined shear and axial loads that arise in the connection. Assume that the connection will rotate about the bottom row of bolts when determining the axial tension on the bolts. Use the AISC design capacity table in Appendix A for bolt capacities. (7 marks)
- (b) Determine the size of the SP fillet weld required to connect the beam to the end-plate if E48XX electrodes are used. Assume that the welds on each side of the web share the shear load, and the welds around the top flange will carry the tension shear caused by the bending moment. (13 marks)

Total = 20 marks

Appendix A

9.1.3(b) Design Capacities of Commonly Used Bolts – Strength Limit State

HIGH STRENGTH STRUCTURAL BOLTS
8.8/S, 8.8/TB, 8.8/TF BOLTING CATEGORIES

GRADE 8.8

TABLE 9.1.3(b): Design Capacities
($f_{t1} = 830 \text{ MPa}$)

Bolt Size	Axial Tension ϕN_{t1} kN	Single Shear		Plate Tearout in kN												Bearing in kN			
		Threads included in Shear Plane ϕV_{tn} kN	Threads excluded from Shear Plane ϕV_{tx} kN	ϕV_b for t_p & a_e of:												ϕV_b for t_p			
				$t_p = 6$				$t_p = 8$				$t_p = 10$				$t_p = 12$			
M16	104	59.3	82.7													190	122	162	203
M20	163	92.6	129	83	95	107	111	127	143	139	158	178	166	124	152	203	253		
M24	234	133	186														182	243	304
M30	373	214	291														228	304	380
M36	541	313	419														274	355	456
		$\phi = 0.8$		$\phi = 0.9$												$\phi = 0.9$			
		8.8N/S		8.8X/S												$f_{up} = 440 \text{ MPa}$			

Note: The above table lists the design capacity of a ply in bearing for Grade 300 ($f_{up} = 440 \text{ MPa}$) steel only. For listings and guidance on design capacities for ply failure in other grades of steel refer to Section 9.1.4.

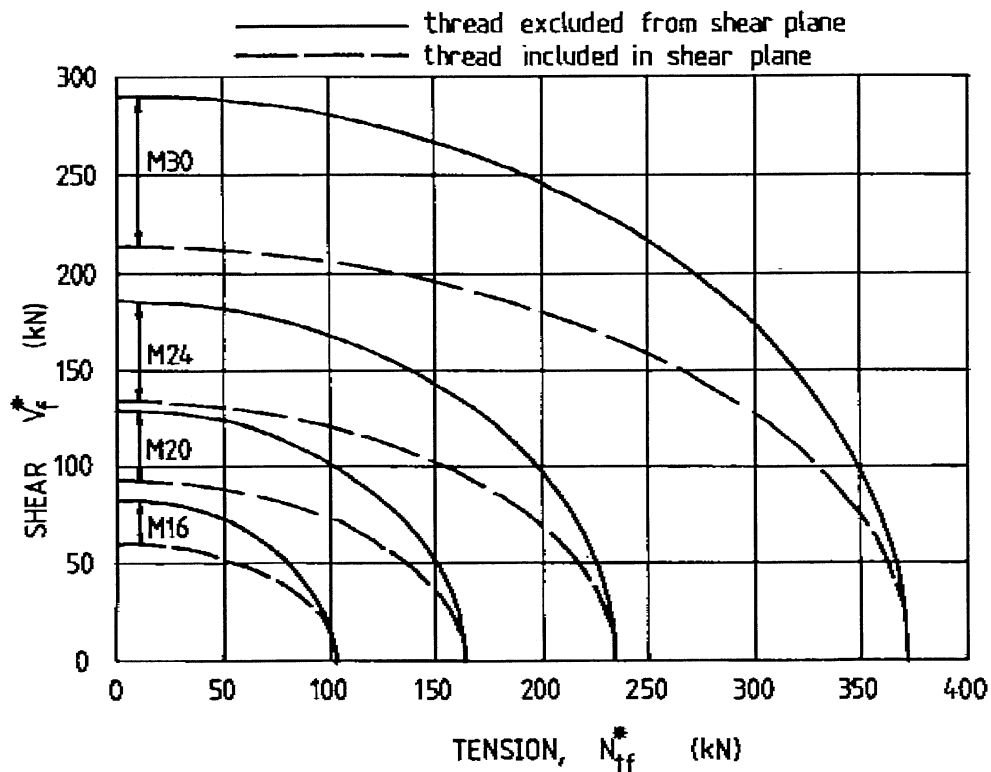


Figure 9.1.3(b): Shear – Tension Interaction Diagram