

Beam design example 2 - Glued laminated timber

Design a Glulam floor beam, simply supported, spanning 6.0m with uniformly distributed loads
Beam supporting floor joists @ 450crs

Dead load $G = 1$ kN/m
Live load $Q = 2.9$ kN/m

Load combinations from AS1170.0

Strength limit state:

$1.35G = 1.4$ kN/m
 $1.2G+1.5Q = 5.6$ kN/m

Serviceability limit state:

$G + \psi_s Q = 3.03$ kN/m short term deflection where $\psi_s = 0.7$
 $G + \psi_l Q = 2.16$ kN/m long term deflection $\psi_l = 0.4$

Using GL grades from AS/NZS 1328.2

Try 360x90 GL10 Glulam beam, using 45mm laminations

$d = 360$ $b = 90$

Check bending strength (NZS3603 3.2.4)

Design strength:

$\phi M_n = \phi k_1 k_4 k_5 k_6 k_8 k_{24} f_b Z$ for Glulam
 $\phi = 0.8$
 $k_1 = 0.6$ for a permanent load or 0.8 for medium term load
 $k_4 = 1.0$ taken as 1.0 for GL grades
 $k_5 = 1.0$ taken as 1.0 for GL grades
 $L_{ay} = 450$ mm distance between restraints
 $S = 1.35 (L_{ay} / b ((d/b)^2 - 1)^{0.5})^{0.5} = 5.94$ (or use Fig 3.1)
 $k_8 = 1.0$ from NZS3603 Table 2.8
 $f_b = 22.0$ MPa for GL10 from AS/NZS 1328.2 Table 1.2
 $Z = bd^2/6 = 1944000$ mm³
 $\phi M_{n\text{ long}} = 20.5$ kNm for long term loading (permanent)
 $\phi M_{n\text{ med}} = 27.4$ kNm for medium term loading

Compare with design load

$M^*_{1.35G} = 6.1$ kNm < $\phi M_{n\text{ long}} = 20.5$ OK
 $M^*_{1.2G+1.5Q} = 25.0$ kNm < $\phi M_{n\text{ med}} = 27.4$ OK

Check shear strength (NZS3603 3.2.3)

Design strength:

$\phi V_n = \phi k_1 k_4 k_5 f_s A_s$
 ϕ, k_1, k_4, k_5 factors from above
 $f_s = 3.7$ MPa for GL10 from AS/NZS 1328.2 Table 1.2
 $A_s = \frac{2}{3}bd = 43200$ mm²
 $\phi V_{n\text{ long}} = 76.7$ kN for long term loading (permanent)
 $\phi V_{n\text{ med}} = 102.3$ kN for medium term loading

Compare with design load

$V^*_{1.35G} = 4.1$ kN < $\phi V_{n\text{ long}} = 76.7$ OK
 $V^*_{1.2G+1.5Q} = 16.7$ kN < $\phi V_{n\text{ med}} = 102.3$ OK

Check bearing strength (NZS3603 3.2.9)

assume bearing on 100mm wide top plate

Design strength:

$\phi N_{nbp} = \phi k_1 k_3 f_p A_p$

k_1	from above					
$k_3 =$	1.06					
$f_p =$	8.9	MPa		using MSG8 value, from NZS3603 Amendment 4, Table 2.3		
$A_p =$	13500	mm ²		bearing area		
$\phi N_{nbp \text{ long}} =$	61.1	kN				
$\phi N_{nbp \text{ med}} =$	81.5	kN				
$N^*_{1.35G} =$	4.1	kN	<	$\phi N_{nbp \text{ long}} =$	61.1	OK
$N^*_{1.2G+1.5Q} =$	16.7	kN	<	$\phi N_{nbp \text{ med}} =$	81.5	OK

Check serviceability design limit state

$E =$	10.0	GPa		for GL10 from AS/NZS 1328.2 Table 1.2		
The lower bound modulus of elasticity, NZS3603 A4 doesn't need to be considered for Glulam						
$\Delta_G =$	4.8	mm		instaneous dead load deflection		
$\Delta_Q =$	14.0	mm		instaneous live load deflection		
$k_2 =$	1.5			creep factor for Glulam NZS3603 8.7.4		
$\Delta_{G+\psi_s Q} =$	14.6	mm		Span/400=	15 mm	OK
$\Delta_{k2(G+\psi_l Q)} =$	15.6	mm		Span/250=	24 mm	OK

refer to AS/NZS 1170.0 Table C1 for suggested serviceability limits

need to make a judgement call on the expected actual long term live load, the standard says 40% of live load ($\psi_l = 0.4$), but probably 25% of the live load would be more accurate for a domestic situation ($\psi_l = 0.25$)

using $\psi_l =$	0.25		
$\Delta_{k2(G+\psi_l Q)} =$	12.5	mm	
Camber =	12.0	mm	

use 360 x 90 GL10 Glulam, camber 12mm