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	ψ_s=	0.7
	$G+\psi_l Q$ =	2.16	kN/m	long term deflection		ψ_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:

ϕM_n =	$\phi k_1 k_4 k_5 k_6 k_8 k_{24} f_b Z$	for Glulam			
ϕ =	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	mm^3			
$\phi M_{n\,long}$ =	20.5	kNm for long term loading (permanent)			
$\phi M_{n\,med}$ =	27.4	kNm for medium term loading			

Compare with design load

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

Check shear strength (NZS3603 3.2.3)
Design strength:

ϕV_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		
$A_s = ⅔bd$ =	43200	mm^2			
$\phi V_{n\,long}$ =	76.7	kN for long term loading (permanent)			
$\phi V_{n\,med}$ =	102.3	kN for medium term loading			

Compare with design load

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

Check bearing strength (NZS3603 3.2.9)
assume bearing on 100mm wide top plate
Design strength:

ϕN_{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			
$\phi N_{nbp\ long}$ =	61.1	kN					
$\phi N_{nbp\ med}$ =	81.5	kN					
$N^*_{1.35G}$ =	4.1	kN	<	$\phi N_{nbp\ long}$ =	61.1		OK
$N^*_{1.2G+1.5Q}$ =	16.7	kN	<	$\phi N_{nbp\ med}$ =	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						
Δ_G =	4.8	mm	instanteous dead load deflection			
Δ_Q =	14.0	mm	instanteous live load deflection			
k_2 =	1.5		creep factor for Glulam NZS3603 8.7.4			
$\Delta_{G+\psi sQ}$ =	14.6	mm	Span/400=	15	mm	OK
$\Delta_{k2(G+\psi lQ)}$ =	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 (ψ_l = 0.4), but probably 25% of the live load would be more accurate for a domestic situation (ψ_l = 0.25)

using ψl =	0.25	
$\Delta_{k2(G+\psi lQ)}$ =	12.5	mm
Camber =	12.0	mm

use 360 x 90 GL10 Glulam, camber 12mm

Example prepared by David Reid, Structural Engineer.