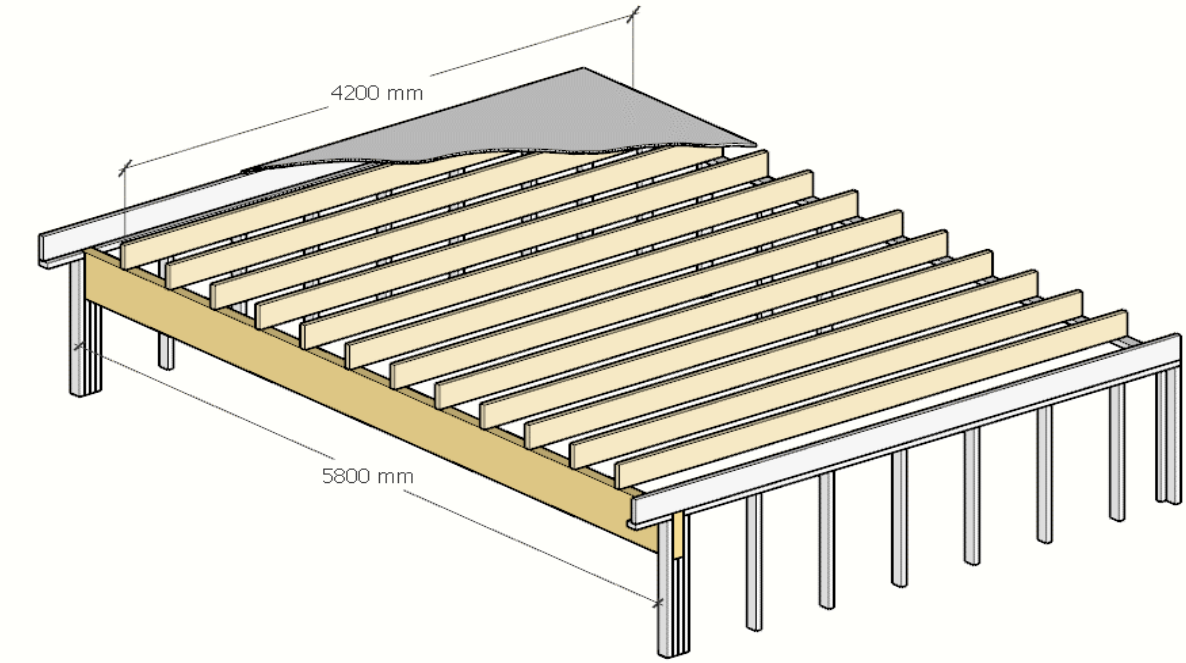
Beam design example 2 - Gluelaminated timber beam Design to NZS-AS 1720.1 2022



Design a Glulam floor beam, simply supported, spanning 5.8m with uniformly distributed loads
Beam supporting floor joists @ 450crs spanning 4.2m, Say dead load including self weight is 0.4kPa
From AS/NZS1170, live load 1.5kPa UDL or 1.8kN point load

	L	5.8	m				
	trib width s	2.1	m				
Dead load	G =	0.84	kN/m				
Live load	Q =	3.15	kN/m	or	1.8	kN	

Load combinations from AS1170.0

Strength limit state:

	1.35G	1.1	kN/m				
	1.2G+1.5Q	5.7	kN/m				
	1.2G+1.5Qc	1.0	kN/m	plus	2.7	kN	

Serviceability limit state:

$G+\psi_s Q$ =	3.05	kN/m	short term deflection	where	ψ_s=	0.7
$G+\psi_l Q$ =	2.10	kN/m	long term deflection		ψ_l =	0.4

Timber properties:

GL8 and GL10 are the common glulam grades available in New Zealand
Properties from Table ZZ7.1

Try 360x90 GL10 Glulam beam, using 45mm laminations

d =	360	b =	90

Check bending strength (AS/NZS 1720 Section 2.1)

Design capacity:

M_d $\phi\ k_1\ k_4\ k_6\ k_9\ k_{12}\ f'_b\ Z$

ϕ	0.8	from section ZZ2.3
k_1	0.57	for permanent action - tables 2.3 and G1
	0.8	for medium term action - floor live load UDL - tables 2.3 and G1
	0.94	for short term action - floor live load concentrated- tables 2.3 and G1

k_4	1.00	moisture condition "seasoned" timber 2.4.2.3	
k_6	1.00	temperature factor 2.4.3	
k_9	1.00	Section 7.4.3	
L_{ay}	450	mm distance between restraints (joist spacing)	
ρ_b	0.85	Table 7.2(A) for r = 0.25	
S_1	5.6	3.2.3.2a	
$\rho_b.S_1$	4.8		
k_{12}	1.0	3.2.4	
f'_b	22.0	MPa	for GL10, from table ZZ7.1
$Z = bd^2/6$	1944000	mm^3	section modulus
$M_{d\ long}$	19.50	kNm for long term action (permanent)	
$M_{d\ med}$	27.37	kNm for medium term action	
$M_{d\ short}$	32.16	kNm for short term action	

Compare with design load

$M^*_{1.35G}$ =	4.8	kNm	<	$M_{d\ long}$ =	19.50	OK
$M^*_{1.2G+1.5Qu}$ =	24.1	kNm	<	$M_{d\ med}$ =	27.37	OK
$M^*_{1.2G+1.5Qc}$ =	8.2	kNm	<	$M_{d\ short}$ =	32.16	OK

Check shear strength (AS/NZS1720 3.2.5)

Design strength:

V_d	$\phi\ k_1\ k_4\ k_6\ f'_s\ A_s$		
ϕ, k_1, k_4, k_6	factors from above		
f'_s	3.7	MPa	for GL10, from table ZZ7.1
$A_s = ⅔bd$	21600	mm^2	
$V_{d\ long}$	36.4	kN for long term loading (permanent)	
$V_{d\ med}$	51.1	kN for medium term loading	

Compare with design load

$V^*_{1.35G}$ =	3.3	kN	<	$V_{d\ long}$ =	36.4	OK
$V^*_{1.2G+1.5Q}$ =	16.6	kN	<	$V_{d\ med}$ =	51.1	OK

Check bearing strength (AS/NZS1720 3.2.6)

assume bearing on 90mm wide top plate

Design strength:

$N_{d,p}$	$\phi\ k_1\ k_4\ k_6\ k_7\ f_p\ A_p$		
$k_1\ k_4\ k_6$	from above		
k_7	1.00	length and position of bearing 2.4.4	
f'_p	6.9	MPa	Using SG8/10 value as this is the material used for GL
A_p	8100	mm^2	bearing area
$N_{d,p\ long}$	25.5	kN	
$N_{d,p\ med}$	35.8	kN	

$N^*_{p\ 1.35G}$	3.3	kN	<	$N_{d,p\ long}$	25.5	OK
$N^*_{p\ 1.2G+1.5Q}$	16.6	kN	<	$N_{d,p\ med}$	35.8	OK

Check serviceability design limit state

E'	10.0	GPa	for GL10, from table ZZ7.1			
no need to apply the lower bound modulus of elasticity as glulam has lower variation in stiffness						
I	349920000	mm^4	moment of inertia			
Δ_G	3.5	mm	instanteous dead load deflection			
Δ_{Qu}	13.3	mm	instanteous live load deflection			
Δ_{Qc}	2.1	mm	instanteous live load deflection due to point load			
j_2 =	1.5		creep factor for glulam in bending from ZZ7.4.2			
$\Delta_{G+\psi sQ}$ =	12.8	mm	Span/400=	14.5	mm	OK
$\Delta_{k2(G+\psi lQ)}$ =	13.3	mm	Span/250=	23.2	mm	OK

refer to AS/NZS 1170.0 Table C1 for suggested serviceability limits, but apply engineering judgement

Example prepared by David Reid to NZS3603:1993 for NZ Timber Design Society website

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