Beam design example 1 - Solid timber

Consider a simply supported floor beam spanning 3.0m with uniformly distributed loads
Beam supporting floor joists @ 450crs

Dead load	G =	0.84	kN/m				
Live load	Q =	3.15	kN/m				
Load combinations from AS1170.0							
Strength limit state:							
	1.35G	1.1	kN/m				
	1.2G+1.5Q	5.7	kN/m				
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

Try double component 240x45 MSG8 machine stress graded timber

d =	240	b =	45

Check bending strength (NZS3603 3.2.4)
Design strength:

ϕM_n =	$\phi k_1 k_4 k_5 k_8 f_b Z$	for sawn timber			
ϕ =	0.8				
k_1 =	0.6	for a permanent load or	0.8	for medium term load	
k_4 =	1.14	parallel support factor, 2 components			
k_5 =	1.0				
L_{ay} =	450	mm distance between restraints			
S =	1.35 (L_{ay} / b ((d/b)^2 - 1)^0.5)^0.5 =	9.77	(or use Fig 3.1)		
k_8 =	1.0	from Table 2.8			
f_b =	14.0	MPa	for MSG8, from NZS3603 Amendment 4, Table 2.3		
$Z = bd^2/6$ =	864000	mm^3			
$\phi M_{n\,long}$ =	6.62	kNm for long term loading (permanent)			
$\phi M_{n\,med}$ =	8.83	kNm for medium term loading			

Compare with design load

$M^*_{1.35G}$ =	1.3	kNm	<	$\phi M_{n\,long}$ =	6.62	OK
$M^*_{1.2G+1.5Q}$ =	6.4	kNm	<	$\phi M_{n\,med}$ =	8.83	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 =	3.8	MPa	for MSG8 radiata, from NZS3603 Amendment 4, Table 2.3
$A_s = ⅔bd$ =	14400	mm^2	
$\phi V_{n\,long}$ =	29.9	kN for long term loading (permanent)	
$\phi V_{n\,med}$ =	39.9	kN for medium term loading	

Compare with design load

$V^*_{1.35G}$ =	1.7	kN	<	$\phi V_{n\,long}$ =	29.9	OK
$V^*_{1.2G+1.5Q}$ =	8.6	kN	<	$\phi V_{n\,med}$ =	39.9	OK

Check bearing strength (NZS3603 3.2.9)
assume bearing on 75mm wide top plate
Design strength:

ϕN_{nbp} =	$\phi k_1 k_3 f_p A_p$

k_1	from above						
k_3 =	1.15						
f_p =	8.9	MPa	for MSG8, from NZS3603 Amendment 4, Table 2.3				
A_p =	6750	mm^2	bearing area				
$\phi N_{nbp\ long}$ =	33.2	kN					
$\phi N_{nbp\ med}$ =	44.2	kN					
$N^*_{1.35G}$ =	1.7	kN	<	$\phi N_{nbp\ long}$ =	33.2		OK
$N^*_{1.2G+1.5Q}$ =	8.6	kN	<	$\phi N_{nbp\ med}$ =	44.2		OK

Check serviceability design limit state

E =	8.0	GPa	for MSG8, from NZS3603 Amendment 4, Table 2.3
E_{lb} =	5.4	GPa	lower bound modulus of elasticity, NZS3603 A4 Table2.3
Δ_G =	1.1	mm	instanteous dead load deflection, using E = 8.0
Δ_Q =	4.0	mm	instanteous live load deflection, using E = 8.0
k_2 =	2.0		creep factor for solid timber
$\Delta_{G+\psi sQ}$ =	3.9	mm	
$\Delta_{k2(G+\psi lQ)}$ =	5.3	mm	

these is the most likely deflections, however it is possible that these timber members may have a lower stiffness than the average, from NZS3603 A4 2.4.2.3 b) for 2 components, use:

	$E=(E+E_{lb})/2$	6.7	GPa				
so	$\Delta_{G+\psi sQ}$ =	4.6	mm	Span/400=	7.5	mm	OK
	$\Delta_{k2(G+\psi lQ)}$ =	6.4	mm	Span/250=	12	mm	OK

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

Example prepared by David Reid, Structural Engineer.