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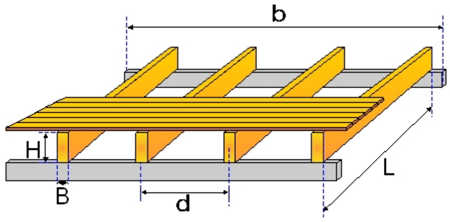
Examples of Floors

1. FLOOR-001



Floor over one span

1.1. General description, assumptions, materials, loads

1.1.1. Construction type

Timber floor, from timber C30.
Spacing between floor beams 0.600m, free beam span 3.000m
Cross section of floor beams BxH=63mmx200mm. Floor finishing thickness 25mm

1.1.2. Design codes

EN1990-1-1:2002 Basis of structural design
EN1991-1-1:2003 Actions on structures
EN1995-1-1:2009 Design of timber structures

1.1.3. Design methodology

The internal forces are computed at the ends and the middle span of the floor beam, and the elastic deflections at midspan, for all the load combinations, according to EC 1 an EC 5. All the checks of Eurocode 5 are performed in ultimate limit state, (EC5 EN1995-1-1:2009, §6). The deflections are checked in serviceability limit state, according to EC5 EN1995-1-1:2009, §7.2. The Eurocode 5 considerations are taken into account for the check of beam vibrations (EC5 EN1995-1-1:2009, §7.3.3).

1.1.4. Material properties (timber) (EC5 EN1995-1-1:2009, §3)

Timber class : C30
Service classes : Class 1, moisture content<=12% (EC5 §2.3.1.3)
Material factor γ_M=1.30 (EC5 Table 2.3)

Characteristic material properties for timber

fmk = 30.0 MPa, ft0k = 18.0 MPa, ft90k= 0.4 MPa
fc0k= 23.0 MPa, fc90k= 2.7 MPa, fvk = 4.0 MPa
E0m =12000 MPa, E005 = 8000 MPa, E90m = 400 MPa
Gm = 750 MPa, ρk = 380 Kg/m^3

1.1.5. Distributed floor loads

Floor finishing		Ge= 0.500 kN/m^2
Self weight (insulation-beams)		Gw= 0.100 kN/m^2
Ceiling under floor		Gc= 0.300 kN/m^2
Sum of permanent loads	Ge+Gw+Gf=	Gs= 0.900 kN/m^2
Live floor load		Qf= 2.000 kN/m^2

1.1.6. Line load (kN/m) on the floor beams

Permanent load Gk=0.600x 0.900= 0.540 kN/m
Live load Qk=0.600x 2.000= 1.200 kN/m

1.1.7. Cross section characteristics of floor beams

Cross section BxH=63mmx200mm, A=1.260E+004mm^2, I=9.246E+007mm4, W=4.200E+005mm^3

1.2. Maximum internal beam forces and deflections (L=3.000m)

Dead loads Gk= 0.540kN/m, maxV= 0.81 kN, maxM= 0.61 kNm, maxΔ= 0.59 mm
Live loads Qk= 1.200kN/m, maxV= 1.80 kN, maxM= 1.35 kNm, maxΔ= 1.31 mm

1.3. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

Control of deflection in middle of beam span (EC5 §7.2)

Loading [kN/m]	u[mm]	action	ψ0	ψ1	ψ2	Kdef
(G) Dead Gk = 0.540	0.590	Permanent	1.00	1.00	1.00	0.60
(Qf) Live Qk = 1.200	1.312	Medium-term	0.70	0.50	0.30	0.60

Load combination	w.inst	w.fin [mm]
1 G	0.590	0.945
2 Q1	1.312	1.548
3 G + Q1	1.903	2.493

w.fin,g=w.inst,g(1+kdef), w.fin,q=w.inst,q(1+ψ2·kdef)(EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

w.inst = 1.903 mm, w.fin = 2.493 mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections

w.inst = 1.903 mm < L/300=3000/300= 10.000 mm
w.net,fin = 2.493 mm < L/250=3000/250= 12.000 mm
w.fin = 2.493 mm < L/150=3000/150= 20.000 mm
The check is satisfied

1.4. Vibrations (EC5 EN1995-1-1:2009, §7.3.3)

Basic floor natural frequency $f=(3.14/2L^2)\sqrt{(EI/M)}$ (EC5 EN1995-1-1:2009 §7.3.3)
L=3.000 m, E=1.200E+010 Nm²/m, I=9.246E-005 m4, M=55.05 kg/m², f=24.78 Hz
f=24.78 Hz > 8 Hz. The basic natural frequency is acceptable
(EI)l/(EI)b=10, b/l=6.00/3.00=2.00, n40=4.00 (EC5 Eq.7.7)
v=4x(0.4+0.6x4.00)/(55.05x6.00x3.00+200)=0.009 (EC5 Eq.7.6)
ζ=0.01, Vlim=6.00^(24.78x0.01-1)=0.260, v=0.009<=0.260=vlim (EC5 Eq.7.4)
Requirements of EN 1995 §7.3.3 for residential floors are fulfilled

1.5. Ultimate limit state (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 0.540	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 1.200	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	1.823	1.367
2	γg.G + γq.Qf	Medium-term	0.80	4.742	3.556
	Maximum values			4.742	3.556

Shear, Fv=3.794 kN (EC5 §6.1.7)

Rectangular cross section, bef=0.67x63=42 mm, h=200 mm, A= 8 400 mm²
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fvk=4.00 N/mm², fvd=Kmod·fvk/γM=0.80x4.00/1.30=2.46N/mm² (EC5 Eq.2.14)
Fv=3.794 kN, τv0d=1.50Fv0d/Anetto=1000x1.50x3.794/8400=0.68N/mm² < 2.46N/mm²=fv0d (Eq.6.13)
The check is satisfied

Bending, Myd=2.845 kNm, Mzd=0.000 kNm (EC5 §6.1.6)

Rectangular cross section, b=63mm, h=200mm, A=1.260E+004mm², Wy=4.200E+005mm³, Wz=1.323E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fmyk=30.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm²
fmzk=30.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x2.845/4.200E+005= 6.77 N/mm^2
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.323E+005= 0.00 N/mm^2

σmyd/fmyd+Km.σmzd/fmzd=0.367+0.000= 0.37 < 1 (EC5 Eq.6.11)
Km.σmyd/fmyd+σmzd/fmzd=0.257+0.000= 0.26 < 1 (EC5 Eq.6.12)
The check is satisfied

Lateral torsional stability of beams, Myd=2.845 kNm, Mzd=0.000 kNm (EC5 §6.3.3)
Rectangular cross section, b=63mm, h=200mm, A=1.260E+004mm^2, Wy=4.200E+005mm^3, Wz=1.323E+005mm^3
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fc0k=23.00 N/mm^2, fc0d=Kmod·fc0k/γM=0.80x23.00/1.30=14.15N/mm^2
fmyk=30.00 N/mm^2, fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm^2
fmzk=30.00 N/mm^2, fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm^2

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x2.845/4.200E+005= 6.77 N/mm^2
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.323E+005= 0.00 N/mm^2

Buckling length Sk
Sky= 1.00x3.000=3.000 m= 3000 mm
Skz= 0.10x3.000=0.300 m= 300 mm

Slenderness
iy=√(Iy/A)=0.289x 200= 58 mm, λy= 3000/ 58= 51.72
iz=√(Iz/A)=0.289x 63= 18 mm, λz= 300/ 18= 16.67

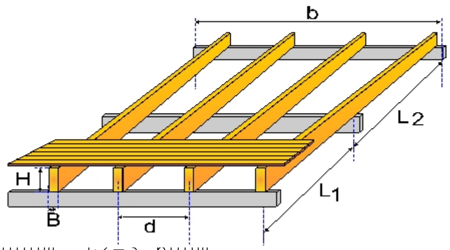
σm,crit=0.78.b^2·E005/(h·Lef)=0.78x63^{2}x 8000/(200x2700)= 45.86N/mm^2 (EC5 Eq.6.32)
σm,crit=0.78.b^2·E005/(h·Lef)=0.78x200^{2}x 8000/(63x300)=13206.35N/mm^2 (EC5 Eq.6.32)
Critical stresses
σm,crity= 45.86 N/mm^2, λrel,my= √(fmyk/σm,crity)= 0.81 (EC5 Eq.6.30)
σm,critz=13206.35 N/mm^2, λrel,mz= √(fmzk/σm,critz)= 0.05 (EC5 Eq.6.30)

λrel,my=0.81, (0.75<λrel<=1.40, Kcrit=1.56-0.75λrelm), Kcrity=0.95 (EC5 Eq.6.34)
λrel,mz=0.05, (λrel<=0.75), Kcritz=1.00 (EC5 Eq.6.34)

σmyd/(Kcrity·fmyd)+Km.σmzd/(Kcritz·fmzd)=0.385+0.000= 0.38 < 1 (EC5 Eq.6.33)
Km.σmyd/(Kcrity·fmyd)+σmzd/(Kcritz·fmzd)=0.269+0.000= 0.27 < 1 (EC5 Eq.6.33)
The check is satisfied

2. FLOOR-002

Floor over two spans



2.1. General description, assumptions, materials, loads

2.1.1. Construction type

Timber floor, from timber C30.
Spacing between floor beams 0.600m, free beam spans L1=5.000m, L2=3.600m
Cross section of floor beams BxH=68mmx200mm. Floor finishing thickness 25mm

2.1.2. Design codes

EN1990-1-1:2002 Basis of structural design
EN1991-1-1:2003 Actions on structures
EN1995-1-1:2009 Design of timber structures

2.1.3. Design methodology

The internal forces are computed at the ends and the middle span of the floor beam, and the elastic deflections at midspan, for all the load combinations, according to EC 1 an EC 5. All the checks of Eurocode 5 are performed in ultimate limit state, (EC5 EN1995-1-1:2009, §6). The deflections are checked in serviceability limit state, according to EC5 EN1995-1-1:2009, §7.2. The Eurocode 5 considerations are taken into account for the check of beam vibrations (EC5 EN1995-1-1:2009, §7.3.3).

2.1.4. Material properties (timber) (EC5 EN1995-1-1:2009, §3)

Timber class : C30
Service classes : Class 1, moisture content<=12% (EC5 §2.3.1.3)
Material factor γM=1.30 (EC5 Table 2.3)

Characteristic material properties for timber

fmk = 30.0 MPa, ft0k = 18.0 MPa, ft90k= 0.4 MPa
fc0k= 23.0 MPa, fc90k= 2.7 MPa, fvk = 4.0 MPa
E0m =12000 MPa, E005 = 8000 MPa, E90m = 400 MPa
Gm = 750 MPa, ρk = 380 Kg/m^3

2.1.5. Distributed floor loads

Floor finishing		Ge= 0.500 kN/m^2
Self weight (insulation-beams)		Gw= 0.100 kN/m^2
Ceiling under floor		Gc= 0.300 kN/m^2
Sum of permanent loads	Ge+Gw+Gf=	Gs= 0.900 kN/m^2
Live floor load		Qf= 2.000 kN/m^2

2.1.6. Line load (kN/m) on the floor beams

Permanent load Gk=0.600x 0.900= 0.540 kN/m
Live load Qk=0.600x 2.000= 1.200 kN/m

2.1.7. Cross section characteristics of floor beams

Cross section BxH=68mmx200mm, A=1.360E+004mm^2, I=9.751E+007mm4, W=4.533E+005mm^3

2.2. Maximum internal beam forces and deflections (L1=5.000m, L2=3.600m)

Dead loads Gk= 0.540kN/m, maxV= 1.62 kN, maxM= 1.35 kNm, maxΔ= 1.56 mm
Live loads Qk= 1.200kN/m, maxV= 3.60 kN, maxM= 2.99 kNm, maxΔ= 5.90 mm

2.3. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

Control of deflection in middle of beam span (EC5 §7.2)

Loading [kN/m]	u[mm]	action	ψ0	ψ1	ψ2	Kdef
(G) Dead Gk = 0.540	1.563	Permanent	1.00	1.00	1.00	0.60
(Qf) Live Qk = 1.200	5.897	Medium-term	0.70	0.50	0.30	0.60

Load combination	w.inst	w.fin [mm]
1 G	1.563	2.500
2 Q1	5.897	6.958
3 G + Q1	7.459	9.458

w.fin,g=w.inst,g(1+kdef), w.fin,q=w.inst,q(1+ψ2·kdef)(EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

w.inst = 7.459 mm, w.fin = 9.458 mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections

w.inst = 7.459 mm < L/300=5000/300= 16.667 mm
w.net,fin = 9.458 mm < L/250=5000/250= 20.000 mm
w.fin = 9.458 mm < L/150=5000/150= 33.333 mm
The check is satisfied

2.4. Vibrations (EC5 EN1995-1-1:2009, §7.3.3)

Basic floor natural frequency f=(3.14/2L²)√(EI/M) (EC5 EN1995-1-1:2009 §7.3.3)
L=5.000 m, E=1.200E+010 Nm²/m, I=9.751E-005 m4, M=55.05 kg/m², f=9.16 Hz
f=9.16 Hz > 8 Hz. The basic natural frequency is acceptable
(EI)l/(EI)b=333, b/l=6.00/5.00=1.20, n40=10.57 (EC5 Eq.7.7)
v=4x(0.4+0.6x10.57)/(55.05x6.00x5.00+200)=0.015 (EC5 Eq.7.6)
ζ=0.01, Vlim=6.00^(9.16x0.01-1)=0.196, v=0.015<=0.196=vlim (EC5 Eq.7.4)
Requirements of EN 1995 §7.3.3 for residential floors are fulfilled

2.5. Ultimate limit state (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 0.540	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 1.200	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	3.644	3.031
2	γg.G + γq.Qf	Medium-term	0.80	9.481	7.887
	Maximum values			9.481	7.887

Shear, Fv=7.584 kN (EC5 §6.1.7)
Rectangular cross section, bef=0.67x68=46 mm, h=200 mm, A= 9 200 mm²
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fvk=4.00 N/mm², fvd=Kmod·fvk/γM=0.80x4.00/1.30=2.46N/mm² (EC5 Eq.2.14)
Fv=7.584 kN, τv0d=1.50Fv0d/Anetto=1000x1.50x7.584/9200=1.24N/mm² < 2.46N/mm²=fv0d (Eq.6.13)
The check is satisfied

Bending, Myd=6.310 kNm, Mzd=0.000 kNm (EC5 §6.1.6)
Rectangular cross section, b=68mm, h=200mm, A=1.360E+004mm², Wy=4.533E+005mm³, Wz=1.541E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fmyk=30.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm²
fmzk=30.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x6.310/4.533E+005=13.92 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.541E+005= 0.00 N/mm²

σmyd/fmyd+Km.σmzd/fmzd=0.754+0.000= 0.75 < 1 (EC5 Eq.6.11)
Km.σmyd/fmyd+σmzd/fmzd=0.528+0.000= 0.53 < 1 (EC5 Eq.6.12)
The check is satisfied

Lateral torsional stability of beams, Myd=6.310 kNm, Mzd=0.000 kNm (EC5 §6.3.3)
Rectangular cross section, b=68mm, h=200mm, A=1.360E+004mm², Wy=4.533E+005mm³, Wz=1.541E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fc0k=23.00 N/mm², fc0d=Kmod·fc0k/γM=0.80x23.00/1.30=14.15N/mm²
fmyk=30.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm²
fmzk=30.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm²

```
Rectangular cross section Km=0.70 (EC5  §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x6.310/4.533E+005=13.92 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.541E+005= 0.00 N/mm²
```

Buckling length Sk

```
Sky= 1.00x5.000=5.000 m= 5000 mm
Skz= 0.10x5.000=0.500 m=  500 mm
```

Slenderness

```
iy=√(Iy/A)=0.289x 200= 58 mm, λy= 5000/ 58= 86.21
iz=√(Iz/A)=0.289x  68= 20 mm, λz=  500/ 20= 25.00
```

```
σm,crit=0.78.b²·E005/(h·Lef)=0.78x68²x 8000/(200x4500)=  32.06N/mm² (EC5 Eq.6.32)
σm,crit=0.78.b²·E005/(h·Lef)=0.78x200²x 8000/(68x500)=7341.18N/mm² (EC5 Eq.6.32)
```

Critical stresses

```
σm,crity=   32.06 N/mm², λrel,my=     √(fmyk/σm,crity)=  0.97 (EC5 Eq.6.30)
σm,critz= 7341.18 N/mm², λrel,mz=     √(fmzk/σm,critz)=  0.06 (EC5 Eq.6.30)
```

```
λrel,my=0.97, (0.75<λrel<=1.40, Kcrit=1.56-0.75λrelm), Kcrity=0.83 (EC5 Eq.6.34)
λrel,mz=0.06, (λrel<=0.75), Kcritz=1.00 (EC5 Eq.6.34)
```

```
σmyd/(Kcrity·fmyd)+Km.σmzd/(Kcritz·fmzd)=0.903+0.000= 0.90 < 1 (EC5 Eq.6.33)
Km.σmyd/(Kcrity·fmyd)+σmzd/(Kcritz·fmzd)=0.632+0.000= 0.63 < 1 (EC5 Eq.6.33)
The check is satisfied
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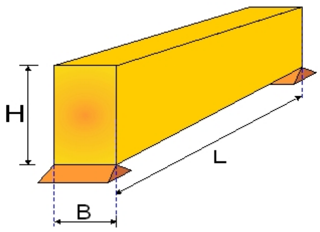
3. FLOOR-003

Simply supported beam



3.1. General description, assumptions, materials, loads

3.1.1. Construction type

Timber floor, from timber GL24h.
Beam free span 4.000 m
Beam cross section BxH=100mmx200mm

3.1.2. Design codes

EN1990-1-1:2002 Basis of structural design
EN1991-1-1:2003 Actions on structures
EN1995-1-1:2009 Design of timber structures

3.1.3. Design methodology

The internal forces are computed at the ends and the middle span of the floor beam, and the elastic deflections at midspan, for all the load combinations, according to EC 1 an EC 5. All the checks of Eurocode 5 are performed in ultimate limit state, (EC5 EN1995-1-1:2009, §6). The deflections are checked in serviceability limit state, according to EC5 EN1995-1-1:2009, §7.2. The Eurocode 5 considerations are taken into account for the check of beam vibrations (EC5 EN1995-1-1:2009, §7.3.3).

3.1.4. Material properties (timber) (EC5 EN1995-1-1:2009, §3)

Timber class : GL24h
Service classes : Class 2, moisture content<=20% (EC5 §2.3.1.3)
Material factor γM=1.25 (EC5 Table 2.3)

Characteristic material properties for timber

fmk = 24.0 MPa, ft0k = 16.5 MPa, ft90k= 0.4 MPa
fc0k= 24.0 MPa, fc90k= 2.7 MPa, fvk = 2.7 MPa
E0m =11600 MPa, E005 = 9400 MPa, E90m = 390 MPa
Gm = 720 MPa, ρk = 380 Kg/m³

3.1.5. Cross section characteristics of floor beams

Cross section BxH=100mmx200mm, A=2.000E+004mm², I=6.667E+007mm4, W=6.667E+005mm³

3.2. Maximum internal beam forces and deflections (L=4.000m)

Dead loads Gk= 0.500kN/m, maxV= 1.00 kN, maxM= 1.00 kNm, maxΔ= 2.24 mm
Live loads Qk= 2.000kN/m, maxV= 4.00 kN, maxM= 4.00 kNm, maxΔ= 8.95 mm

3.3. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

Control of deflection in middle of beam span (EC5 §7.2)

Loading [kN/m]	u[mm]	action	ψ0	ψ1	ψ2	Kdef
(G) Dead Gk = 0.500	2.239	Permanent	1.00	1.00	1.00	0.80
(Qf) Live Qk = 2.000	8.954	Medium-term	0.70	0.50	0.30	0.80

Load combination	w.inst	w.fin [mm]
1 G	2.239	4.029
2 Q1	8.954	11.103
3 G + Q1	11.193	15.132

w.fin,g=w.inst,g(1+kdef), w.fin,q=w.inst,q(1+ψ2·kdef)(EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

w.inst = 11.193 mm, w.fin = 15.132 mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections
w.inst = 11.193 mm < L/300=4000/300= 13.333 mm
w.net,fin = 15.132 mm < L/250=4000/250= 16.000 mm
w.fin = 15.132 mm < L/150=4000/150= 26.667 mm
The check is satisfied

3.4. Vibrations (EC5 EN1995-1-1:2009, §7.3.3)

Basic floor natural frequency f=(3.14/2L²)√(EI/M) (EC5 EN1995-1-1:2009 §7.3.3)
L=4.000 m, E=1.160E+010 Nm²/m, I=6.667E-005 m4, M=50.97 kg/m², f=12.09 Hz
f=12.09 Hz > 8 Hz. The basic natural frequency is acceptable

3.5. Ultimate limit state (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 0.500	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 2.000	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	2.250	2.250
2	γg.G + γq.Qf	Medium-term	0.80	9.188	9.188
	Maximum values			9.188	9.188

Shear, Fv=7.350 kN (EC5 §6.1.7)
Rectangular cross section, bef=0.67x100=67 mm, h=200 mm, A= 13 400 mm²
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.25 (Table 2.3)
fvk=2.70 N/mm², fvd=Kmod·fvk/γM=0.80x2.70/1.25=1.73N/mm² (EC5 Eq.2.14)
Fv=7.350 kN, τv0d=1.50Fv0d/Anetto=1000x1.50x7.350/13400=0.82N/mm² < 1.73N/mm²=fv0d (Eq.6.13)
The check is satisfied

Bending, Myd=7.350 kNm, Mzd=0.000 kNm (EC5 §6.1.6)
Rectangular cross section, b=100mm, h=200mm, A=2.000E+004mm², Wy=6.667E+005mm³, Wz=3.333E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.25 (Table 2.3)
fmyk=24.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x24.00/1.25=15.36N/mm²
fmzk=24.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x24.00/1.25=15.36N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x7.350/6.667E+005=11.02 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/3.333E+005= 0.00 N/mm²

σmyd/fmyd+Km.σmzd/fmzd=0.718+0.000= 0.72 < 1 (EC5 Eq.6.11)
Km.σmyd/fmyd+σmzd/fmzd=0.502+0.000= 0.50 < 1 (EC5 Eq.6.12)
The check is satisfied

Lateral torsional stability of beams, Myd=7.350 kNm, Mzd=0.000 kNm (EC5 §6.3.3)
Rectangular cross section, b=100mm, h=200mm, A=2.000E+004mm², Wy=6.667E+005mm³, Wz=3.333E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.25 (Table 2.3)
fc0k=24.00 N/mm², fc0d=Kmod·fc0k/γM=0.80x24.00/1.25=15.36N/mm²
fmyk=24.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x24.00/1.25=15.36N/mm²
fmzk=24.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x24.00/1.25=15.36N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x7.350/6.667E+005=11.02 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/3.333E+005= 0.00 N/mm²

Buckling length Sk
Sky= 1.00x4.000=4.000 m= 4000 mm
Skz= 0.10x4.000=0.400 m= 400 mm

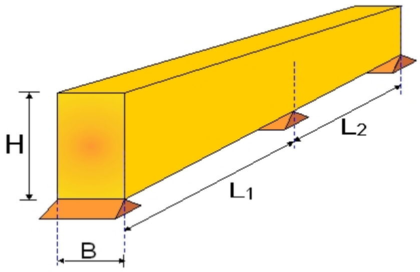
Slenderness
iy= √(Iy/A)=0.289x 200= 58 mm, λy= 4000/ 58= 68.97
iz= √(Iz/A)=0.289x 100= 29 mm, λz= 400/ 29= 13.79

σm,crit=Mycrit/Wy=π √(E005·Iz·G005·Itor)/(Lef.Wy)= 84.97N/mm² (EC5 Eq.6.31)
σm,crit=Mycrit/Wy=π √(E005·Iz·G005·Itor)/(Lef.Wy)=3058.81N/mm² (EC5 Eq.6.31)
Critical stresses
σm,crity= 84.97 N/mm², λrel,my= √(fmyk/σm,crity)= 0.53 (EC5 Eq.6.30)
σm,critz= 3058.81 N/mm², λrel,mz= √(fmzk/σm,critz)= 0.09 (EC5 Eq.6.30)

λrel,my=0.53, (λrel<=0.75), Kcrity=1.00 (EC5 Eq.6.34)
λrel,mz=0.09, (λrel<=0.75), Kcritz=1.00 (EC5 Eq.6.34)

σmyd/(Kcrity·fmyd)+Km.σmzd/(Kcritz·fmzd)=0.718+0.000= 0.72 < 1 (EC5 Eq.6.33)
Km.σmyd/(Kcrity·fmyd)+σmzd/(Kcritz·fmzd)=0.502+0.000= 0.50 < 1 (EC5 Eq.6.33)
The check is satisfied

4. FLOOR-004



Beam over two spans

4.1. General description, assumptions, materials, loads

4.1.1. Construction type

Timber floor, from timber C30.
Free beam spans L1=4.000 m, L2=3.800 m
Beam cross section BxH=68mmx200mm

4.1.2. Design codes

EN1990-1-1:2002 Basis of structural design
EN1991-1-1:2003 Actions on structures
EN1995-1-1:2009 Design of timber structures

4.1.3. Design methodology

The internal forces are computed at the ends and the middle span of the floor beam, and the elastic deflections at midspan, for all the load combinations, according to EC 1 an EC 5. All the checks of Eurocode 5 are performed in ultimate limit state, (EC5 EN1995-1-1:2009, §6). The deflections are checked in serviceability limit state, according to EC5 EN1995-1-1:2009, §7.2. The Eurocode 5 considerations are taken into account for the check of beam vibrations (EC5 EN1995-1-1:2009, §7.3.3).

4.1.4. Material properties (timber) (EC5 EN1995-1-1:2009, §3)

Timber class : C30
Service classes : Class 1, moisture content<=12% (EC5 §2.3.1.3)
Material factor γM=1.30 (EC5 Table 2.3)

Characteristic material properties for timber

fmk = 30.0 MPa, ft0k = 18.0 MPa, ft90k= 0.4 MPa
fc0k= 23.0 MPa, fc90k= 2.7 MPa, fvk = 4.0 MPa
E0m =12000 MPa, E005 = 8000 MPa, E90m = 400 MPa
Gm = 750 MPa, ρk = 380 Kg/m^3

4.1.5. Cross section characteristics of floor beams

Cross section BxH=68mmx200mm, A=1.360E+004mm^2, I=4.533E+007mm4, W=4.533E+005mm^3

4.2. Maximum internal beam forces and deflections (L1=4.000m, L2=3.800m)

Dead loads Gk= 0.500kN/m, maxV= 1.24 kN, maxM= 0.95 kNm, maxΔ= 1.27 mm
Live loads Qk= 2.000kN/m, maxV= 4.95 kN, maxM= 3.81 kNm, maxΔ= 8.66 mm

4.3. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

Control of deflection in middle of beam span (EC5 §7.2)

Loading [kN/m]	u[mm]	action	ψ0	ψ1	ψ2	Kdef
(G) Dead Gk = 0.500	1.275	Permanent	1.00	1.00	1.00	0.60
(Qf) Live Qk = 2.000	8.659	Medium-term	0.70	0.50	0.30	0.60

Load combination	w.inst	w.fin [mm]
1 G	1.275	2.039
2 Q1	8.659	10.217
3 G + Q1	9.933	12.257

w.fin,g=w.inst,g(1+kdef), w.fin,q=w.inst,q(1+ψ2·kdef)(EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

w.inst = 9.933 mm, w.fin = 12.257 mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections

w.inst = 9.933 mm < L/300=4000/300= 13.333 mm
w.net,fin = 12.257 mm < L/250=4000/250= 16.000 mm
w.fin = 12.257 mm < L/150=4000/150= 26.667 mm
The check is satisfied

4.4. Vibrations (EC5 EN1995-1-1:2009, §7.3.3)

Basic floor natural frequency $f=(3.14/2L^2)\sqrt{(EI/M)}$ (EC5 EN1995-1-1:2009 §7.3.3)
L=4.000 m, E=1.200E+010 Nm²/m, I=4.533E-005 m4, M=50.97 kg/m², f=10.14 Hz
f=10.14 Hz > 8 Hz. The basic natural frequency is acceptable

4.5. Ultimate limit state (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 0.500	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 2.000	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	2.786	2.143
2	γg.G + γq.Qf	Medium-term	0.80	11.375	8.751
	Maximum values			11.375	8.751

Shear, Fv=9.100 kN (EC5 §6.1.7)

Rectangular cross section, bef=0.67x68=46 mm, h=200 mm, A= 9 200 mm²
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fvk=4.00 N/mm², fvd=Kmod·fvk/γM=0.80x4.00/1.30=2.46N/mm² (EC5 Eq.2.14)
Fv=9.100 kN, τv0d=1.50Fv0d/Anetto=1000x1.50x9.100/9200=1.48N/mm² < 2.46N/mm²=fv0d (Eq.6.13)
The check is satisfied

Bending, Myd=7.001 kNm, Mzd=0.000 kNm (EC5 §6.1.6)

Rectangular cross section, b=68mm, h=200mm, A=1.360E+004mm², Wy=4.533E+005mm³, Wz=1.541E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fmyk=30.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm²
fmzk=30.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x7.001/4.533E+005=15.44 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.541E+005= 0.00 N/mm²

σmyd/fmyd+Km.σmzd/fmzd=0.837+0.000= 0.84 < 1 (EC5 Eq.6.11)
Km.σmyd/fmyd+σmzd/fmzd=0.586+0.000= 0.59 < 1 (EC5 Eq.6.12)
The check is satisfied

Lateral torsional stability of beams, Myd=7.001 kNm, Mzd=0.000 kNm (EC5 §6.3.3)

Rectangular cross section, b=68mm, h=200mm, A=1.360E+004mm², Wy=4.533E+005mm³, Wz=1.541E+005mm³
Modification factor Kmod=0.80 (Table 3.1), material factor γM=1.30 (Table 2.3)
fc0k=23.00 N/mm², fc0d=Kmod·fc0k/γM=0.80x23.00/1.30=14.15N/mm²
fmyk=30.00 N/mm², fmyd=Kmod·fmyk/γM=0.80x30.00/1.30=18.46N/mm²
fmzk=30.00 N/mm², fmzd=Kmod·fmzk/γM=0.80x30.00/1.30=18.46N/mm²

Rectangular cross section Km=0.70 (EC5 §6.1.6.(2))
σmyd=Myd/Wmy,netto=1E+06x7.001/4.533E+005=15.44 N/mm²
σmzd=Mzd/Wmz,netto=1E+06x0.000/1.541E+005= 0.00 N/mm²

<u>Buckling length Sk</u>
Sky= 1.00x4.000=4.000 m= 4000 mm
Skz= 0.10x4.000=0.400 m= 400 mm

<u>Slenderness</u>
iy=√(Iy/A)=0.289x 200= 58 mm, λy= 4000/ 58= 68.97
iz=√(Iz/A)=0.289x 68= 20 mm, λz= 400/ 20= 20.00

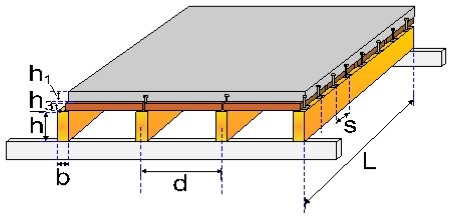
σm,crit=0.78.b²·E005/(h·Lef)=0.78x68²x 8000/(200x3600)= 40.07N/mm² (EC5 Eq.6.32)
σm,crit=0.78.b²·E005/(h·Lef)=0.78x200²x 8000/(68x400)=9176.47N/mm² (EC5 Eq.6.32)
<u>Critical stresses</u>
σm,crity=   40.07 N/mm², λrel,my=   √(fmyk/σm,crity)= 0.87 (EC5 Eq.6.30)
σm,critz= 9176.47 N/mm², λrel,mz=   √(fmzk/σm,critz)= 0.06 (EC5 Eq.6.30)

λrel,my=0.87, (0.75<λrel<=1.40, Kcrit=1.56-0.75λrelm), Kcrity=0.91 (EC5 Eq.6.34)
λrel,mz=0.06, (λrel<=0.75), Kcritz=1.00 (EC5 Eq.6.34)

σmyd/(Kcrity·fmyd)+Km.σmzd/(Kcritz·fmzd)=0.918+0.000= 0.92 < 1 (EC5 Eq.6.33)
Km.σmyd/(Kcrity·fmyd)+σmzd/(Kcritz·fmzd)=0.643+0.000= 0.64 < 1 (EC5 Eq.6.33)
The check is satisfied

5. FLOOR-005

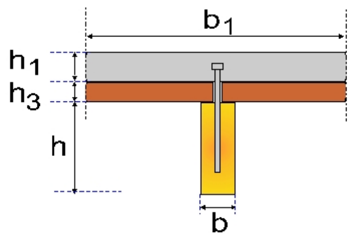
Timber-concrete composite floor



5.1. General description, assumptions, materials, loads

5.1.1. Construction type

Composite timber-concrete floor
Timber Class: C30
Concrete class: C25/30
Free span of floor beams   : L= 3.600m
Thickness of concrete slab : h1= 40mm
Cross section of floor beams: BxH=63mmx200mm
Spacing between floor beams : 0.600 m



5.1.2. Design codes

EN1990-1-1:2002 Basis of structural design
EN1991-1-1:2003 Actions on structures
EN1995-1-1:2009 Design of timber structures
EN1992-1-1:2004 Concrete structures
EN1994-1-1:2000 Composite steel and concrete structures

5.1.3. Design methodology

The internal forces are computed at the ends and the middle span of the floor beam, and the elastic deflections at midspan, for all the load combinations, according to EC 1 an EC 5. All the checks of Eurocode 5 are performed in ultimate limit state, (EC5 EN1995-1-1:2009, §6). The deflections are checked in serviceability limit state, according to EC5 EN1995-1-1:2009, §7.2. The Eurocode 5 considerations are taken into account for the check of beam vibrations (EC5 EN1995-1-1:2009, §7.3.3).

The properties of the composite concrete-timber cross section are evaluated according to: EC5 EN1995-1-1:2009, Annex B

5.1.4. Material properties

Characteristic material properties for timber (EC5 EN1995-1-1:2009, §3)
Timber class : C30
Service classes : Class 1, moisture content<=12% (EN1995-1-1, §2.3.1.3)
fmk = 30.0 MPa, ft0k = 18.0 MPa, ft90k= 0.4 MPa
fc0k= 23.0 MPa, fc90k= 2.7 MPa, fvk = 4.0 MPa
E0m =12000 MPa, E005 = 8000 MPa, E90m = 400 MPa
Gm = 750 MPa, ρk = 380 Kg/m³

Characteristic material properties for concrete (EC2 EN1992-1-1:2004, §3.1)
Concrete class: C25/30, fck=25 N/mm², fcm=2.60 N/mm², Ecm=30500 N/mm²
fcd=0.85x25/1.50=14.17 N/mm², fctmd=0.85x3/1.50=1.47 N/mm² (EC4 EN1994-1-1:2000, §4.4.1.4)
Reinforcing steel class B500C

Characteristic properties of fasteners
Diameter of fastener=10.0 mm, Tensile strength fu=500 N/mm²
Spacing of fasteners: smin=100 mm (0-L/4, 3L/4-L), smax=300 mm (L/4-3L/4)
sef=0.75x100+0.25x300=150 mm (EC5 EN1995-1-1:2009, §9.1.3(2))

5.1.5. Distributed floor loads

```
Floor finishing                 Ge= 0.500 kN/m²
Self weight of concrete slab    Gb= 0.960 kN/m²
Self weight (insulation-beams)  Gw= 0.100 kN/m²
Ceiling under floor             Gc= 0.300 kN/m²
Sum of permanent loads   Ge+Gb+Gw+Gf=  Gs= 1.860 kN/m²
Live floor load                 Qf= 2.000 kN/m²
```

5.1.6. Line load (kN/m) on the floor beams

```
Permanent load Gk=0.600x 1.860= 1.116 kN/m
Live load      Qk=0.600x 2.000= 1.200 kN/m
```

5.2. Design strength of fasteners

5.2.1. Concrete side, (EC4 EN1994-1-1:2000, §6.3.2.1)

Shear failure, Rd=0.8fu(πd²/4)/γv=25.13 kN (EC4 EN1994-1-1:2000, Eq.6.13)
Localised compression, Rd=0.23d² √(fck.Ecm/γv)=17.96 kN (EC4 EN1994-1-1:2000, Eq.6.14)
d=10.0mm, fu=500N/mm², fck=25N/mm², Ecm=30500N/mm², γv=1.25

5.2.2. Timber side, (EC5 EN1995-1-1:2009, Eq.8.10.d)

fhk=0.082(1-0.01d)ρk=28.04N/mm², (ρk=380kg/m³,d=10.0mm) (EN1995-1-1 Eq.8.32)
Myrk=0.30fuk·d^2.6=0.30x500x10.0^2.6=59716 Nmm (fuk=500N/mm²) (EN1995-1-1 Eq.8.30)
Fvrk=2.30√[Myrk·fhk·d]=9.412 kN (EC5 EN1995-1-1:2009 Eq.8.10.d)

```
Load duration classes : Permanent    , kmod=0.60   Rd=Kmod·Fvrk/γM=0.60x9.412/1.30=4.344 kN
Load duration classes : Long-term    , kmod=0.70   Rd=Kmod·Fvrk/γM=0.70x9.412/1.30=5.068 kN
Load duration classes : Medium-term  , kmod=0.80   Rd=Kmod·Fvrk/γM=0.80x9.412/1.30=5.792 kN
```

5.3. Ultimate limit state (EC5 EN1995-1-1:2009, §6)

5.3.1. Composite cross section properties (EC5 EN1995-1-1:2009 Annex B)

Effective flange width, b1=2L/8=2x3600/8=900mm and b1<=600mm. b1=600mm (EN1994-1-1, §2.2.21)
Ku=(2/3)*Kser=(2/3)(ρk)^1.5(d/23)=(2/3)x(380)^1.5x(10/23)=8333 N/mm (Tab. 4.2)
Effective spacing of fastener sef=150 mm

$A1=600x40=24000\ mm^2$ $A2=63x200=12600\ mm^2$
$I1=600x40^3/12=3.20E+006\ mm4$ $I2=63x200^3/12=4.20E+007\ mm4$
$E1=30500\ N/mm^2$ $E2=12000\ N/mm^2$
$\gamma 1=0.09$ $\gamma 2=1.00$
$\alpha 1=97.3\ mm$ $\alpha 2=42.7\ mm$
$EIef=1.51E+012\ Nmm^2$

5.3.2. Maximum internal beam forces and deflections (L=3.600m)

Dead loads Gk= 1.116kN/m, maxV= 2.01 kN, maxM= 1.81 kNm, maxΔ= 1.85 mm
Live loads Qk= 1.200kN/m, maxV= 2.16 kN, maxM= 1.94 kNm, maxΔ= 1.99 mm

5.3.3. Design actions (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 1.116	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 1.200	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	4.520	4.068
2	γg.G + γq.Qf	Medium-term	0.80	7.440	6.696
	Maximum values			7.440	6.696

5.3.4. Design stresses

Maximum Moment M=5.36 kNm, maximum Shear V=5.95 kN

Concrete side

$\sigma c1d= \gamma 1 \cdot E1 \cdot \alpha 1 \cdot M/(EI)ef=0.96\ N/mm^2$ (EC5 EN1995-1-1:2009, Eq.B.3a)
$\sigma m1d= 0.5E1 \cdot h1 \cdot Md/(EI)ef=2.17\ N/mm^2$ (EC5 EN1995-1-1:2009, Eq.B.3b)

$\sigma cd=0.96+2.17=3.13\ N/mm^2 < 14.17\ N/mm^2$ (compression)
$\sigma td=2.17-0.96=1.21\ N/mm^2 < 1.47\ N/mm^2$ (tension)

Timber side

$\sigma c2d= \gamma 2 \cdot E2 \cdot \alpha 2 \cdot M/(EI)ef=1.82\ N/mm^2$ (EC5 EN1995-1-1:2009, Eq.B.3a)
$\sigma m2d= 0.5E2 \cdot h2 \cdot Md/(EI)ef=4.27\ N/mm^2$ (EC5 EN1995-1-1:2009, Eq.B.3b)
$\tau 2max= 1.50\ Vd/(b \cdot h)= 0.71\ N/mm^2$ (EC5 EN1995-1-1:2009, Eq.B.4)

fmd = 0.80x30.00/ 1.30= 18.46 N/mm^2
ft0d= 0.80x18.00/ 1.30= 11.08 N/mm^2
fvd = 0.80x 4.00/ 1.30= 2.46 N/mm^2

$\sigma t2d/ftod+\sigma m2d/fmd = 1.82/11.08+4.27/18.46=0.40 < 1.00$
$\tau 2max =0.71\ N/mm^2 < 2.46\ N/mm^2$

5.3.5. Design of fastener

Spacing of fasteners: smin=100 mm (0-L/4, 3L/4-L), smax=300 mm (L/4-3L/4)
sef=0.75x100+0.25x300=150 mm (EC5 EN1995-1-1:2009, §9.1.3(2))
$F1d=\gamma 1 \cdot E1 \cdot A1 \cdot \alpha 1 \cdot s1 \cdot Vd/(EI)ef$ (EC5 EN1995-1-1:2009, Eq.B.4)
F1d=0.09x30500x24000x97.31x100.0x5.95/1.51E+012=2.55 kN < 5.79 kN

5.4. Serviceability limit state (EC5 EN1995-1-1:2009, §2.2.3, §7)

5.4.1. Composite cross section properties (EC5 EN1995-1-1:2009 Annex B)

Effective flange width, b1=2L/8=2x3600/8=900mm and b1<=600mm. b1=600mm (EN1994-1-1, §2.2.21)
Kser=(ρk)^1.5(d/23)=(380)^1.5x(10/23)=12500 N/mm (EC5 EN1995-1-1:2009, Tab. 4.2)
Effective spacing of fastener sef=150 mm

$A1=600x40=24000\ mm^2$	$A2=63x200=12600\ mm^2$
$I1=600x40^3/12=3.20E+006\ mm4$	$I2=63x200^3/12=4.20E+007\ mm4$
$E1=30500\ N/mm^2$	$E2=12000\ N/mm^2$
$\gamma 1=0.13$	$\gamma 2=1.00$
$\alpha 1=85.9$ mm	$\alpha 2=54.1$ mm
$EIef=1.75E+012\ Nmm^2$	

5.4.2. Maximum internal beam forces and deflections (L=3.600m)

Dead loads Gk= 1.116kN/m, maxV= 2.01 kN, maxM= 1.81 kNm, maxΔ= 1.63 mm
Live loads Qk= 1.200kN/m, maxV= 2.16 kN, maxM= 1.94 kNm, maxΔ= 1.75 mm

5.4.3. Control of deflection in middle of beam span (EC5 §7.2)

Loading [kN/m]	u[mm]	action	ψ0	ψ1	ψ2	Kdef
(G) Dead Gk = 1.116	1.627	Permanent	1.00	1.00	1.00	0.60
(Qf) Live Qk = 1.200	1.749	Medium-term	0.70	0.50	0.30	0.60

Load combination	w.inst	w.fin [mm]
1 G	1.627	2.603
2 Q1	1.749	2.064
3 G + Q1	3.376	4.668

w.fin,g=w.inst,g(1+kdef), w.fin,q=w.inst,q(1+ψ2·kdef)(EC5 §2.2.3, Eq.2.3, Eq.2.4)

Maximum deflection values

w.inst = 3.376 mm, w.fin = 4.668 mm

Check according to EC5 EN1995-1-1:2009 §7.2, Tab.7.2

Final deflections
w.inst = 3.376 mm < L/300=3600/300= 12.000 mm
w.net,fin = 4.668 mm < L/250=3600/250= 14.400 mm
w.fin = 4.668 mm < L/150=3600/150= 24.000 mm
The check is satisfied

5.5. Final state

Final modulus of elasticity for concrete (EC4 EN1994-1-1:2000, §3.1.4.2(4))
$E1,fin=Ecm/2=30500/2=15250\ N/mm^2$

Final modulus of elasticity for timber (EC5 EN1995-1-1:2009, §2.3.2.2)
$E2,fin=Eo,meam/(1+\psi 2\cdot Kdef)=12000/(1+0.50x0.60)=9231\ N/mm^2$
Kser,fin=Kser/(1+ψ2·Kdef)=12500.000/(1+0.50x0.60)=9615.385 N/mm

5.5.1. Composite cross section properties (EC5 EN1995-1-1:2009 Annex B)

Effective flange width, b1=2L/8=2x3600/8=900mm and b1<=600mm. b1=600mm (EN1994-1-1, §2.2.21)
Ku=(2/3)*Kser=(2/3)x(9615)=6410 N/mm
Effective spacing of fastener sef=150 mm

A1=600x40=24000 mm² A2=63x200=12600 mm²
I1=600x40³/12=3.20E+006 mm4 I2=63x200³/12=4.20E+007 mm4
E1=15250 N/mm² E2=9231 N/mm²
γ1=0.13 γ2=1.00
α1=98.7 mm α2=41.3 mm
EIef=1.11E+012 Nmm²

5.5.2. Maximum internal beam forces and deflections (L=3.600m)

Dead loads Gk= 1.116kN/m, maxV= 2.01 kN, maxM= 1.81 kNm, maxΔ= 2.43 mm
Live loads Qk= 1.200kN/m, maxV= 2.16 kN, maxM= 1.94 kNm, maxΔ= 2.61 mm

5.5.3. Design actions (EC5 EN1995-1-1:2009, §6)

Loading [kN/m]	action	γg	γq	ψo
(G) Dead Gk = 1.116	Permanent	1.35	0.00	1.00
(Qf) Live Qk = 1.200	Medium-term	0.00	1.50	0.70

L.C.	Load combination	duration class	kmod	V/Kmod	M/Kmod
1	γg.G	Permanent	0.60	4.520	4.068
2	γg.G + γq.Qf	Medium-term	0.80	7.440	6.696
	Maximum values			7.440	6.696

5.5.4. Design stresses

Maximum Moment M=5.36 kNm, maximum Shear V=5.95 kN

Concrete side

σc1d= γ1·E1·α1·M/(EI)ef=0.97 N/mm² (EC5 EN1995-1-1:2009, Eq.B.3a)
σm1d= 0.5E1·h1·Md/(EI)ef=1.47 N/mm² (EC5 EN1995-1-1:2009, Eq.B.3b)

σcd=0.97+1.47=2.44 N/mm² < 14.17 N/mm² (compression)
σtd=1.47-0.97=0.51 N/mm² < 1.47 N/mm² (tension)

Timber side

σc2d= γ2·E2·α2·M/(EI)ef=1.84 N/mm² (EC5 EN1995-1-1:2009, Eq.B.3a)
σm2d= 0.5E2·h2·Md/(EI)ef=4.46 N/mm² (EC5 EN1995-1-1:2009, Eq.B.3b)
τ2max= 1.50 Vd/(b·h)= 0.71 N/mm² (EC5 EN1995-1-1:2009, Eq.B.4)

fmd = 0.80x30.00/ 1.30= 18.46 N/mm²
ft0d= 0.80x18.00/ 1.30= 11.08 N/mm²
fvd = 0.80x 4.00/ 1.30= 2.46 N/mm²

σt2d/ftod+σm2d/fmd = 1.84/11.08+4.46/18.46=0.41 < 1.00
τ2max =0.71 N/mm² < 2.46 N/mm²

5.5.5. Design of fastener

Spacing of fasteners: smin=100 mm (0-L/4, 3L/4-L), smax=300 mm (L/4-3L/4)
sef=0.75x100+0.25x300=150 mm (EC5 EN1995-1-1:2009, §9.1.3(2))
F1d=γ1·E1·A1·α1·s1·Vd/(EI)ef (EC5 EN1995-1-1:2009, Eq.B.4)
F1d=0.13x15250x24000x98.71x100.0x5.95/1.11E+012=2.58 kN < 5.79 kN