beams span 30m between column supports. The structure cross-section is shown in Figure 1. The bridge carries a traffic live load of 3kPa over its full area.

(a) Calculate the dead and live loads in kN/m for a single 30m spanning beam. Combine dead and live loads to calculate (i) the serviceability limit state load in kN/m for each beam, assuming load factors of 1.0 and 0.7 for the dead and live loads respectively and (ii) the ultimate limit state load in kN/m for each beam, assuming load factors of 1.2 and 1.5 for the dead and live loads respectively. (90%)

(b) Explain the difference between ultimate and serviceability limit state design. (10%)

Density of steel = 78.5 kN/m^3. Density of concrete = 24 kN/m^3.
Density of asphalt = 20 kN/m^3 Assume 1 kg ≈ 10 N.

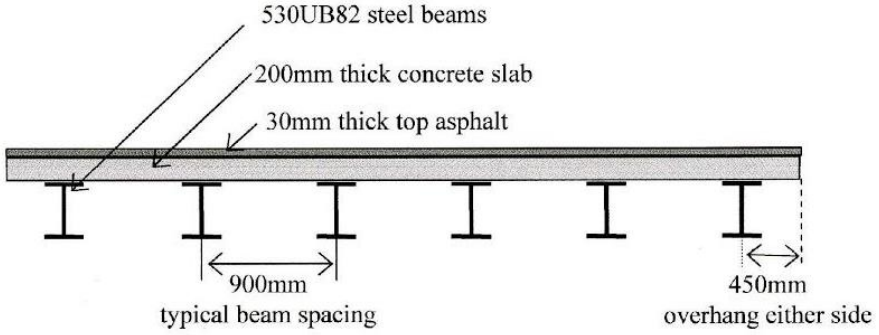


Figure 1: Bridge Cross-section

a) DL = conc + aspalt + beam
= 24×0.2×0.9 + 20×0.03×0.9 + 0.82 KN/M
= 4.32 KN/M + 0.54 KN/M + 0.82 KN/M
= 5.68 KN/M

LL = 3KPa×0.9m = 2.7KN/M

SLS = DL + 0.7LL = 7.57 KN/M

ULS = 1.2DL + 1.5LL = 10.87 KN/M

b) ULS design - is design against Failure, (ie buckling + yield) where you carry out a strength check.
ULS Load = 1.2DL + 1.5LL

SLS design is design against excessive deflection where you check the structure does not deflect too much (eg. span/250) SLS Load = DL+0.7LL

a) A timber plank, 150 mm thick, 3 m wide and 6 m long, is supported by two equally loaded steel beams, each 9m long. The structure is shown in Figure 1(a). The timber plank supports a uniformly distributed live load of 3kN/m² as shown in the Figure. The steel beams each directly carry a live load of 4kN/m at one of their ends.
Density of timber = 15 kN/m³; self-weight of the steel beam = 100 kg/m.
Calculate the Ultimate limit state design loads in kN/m, on each beam by applying the appropriate load factors and show this on a beam diagram. (6marks)

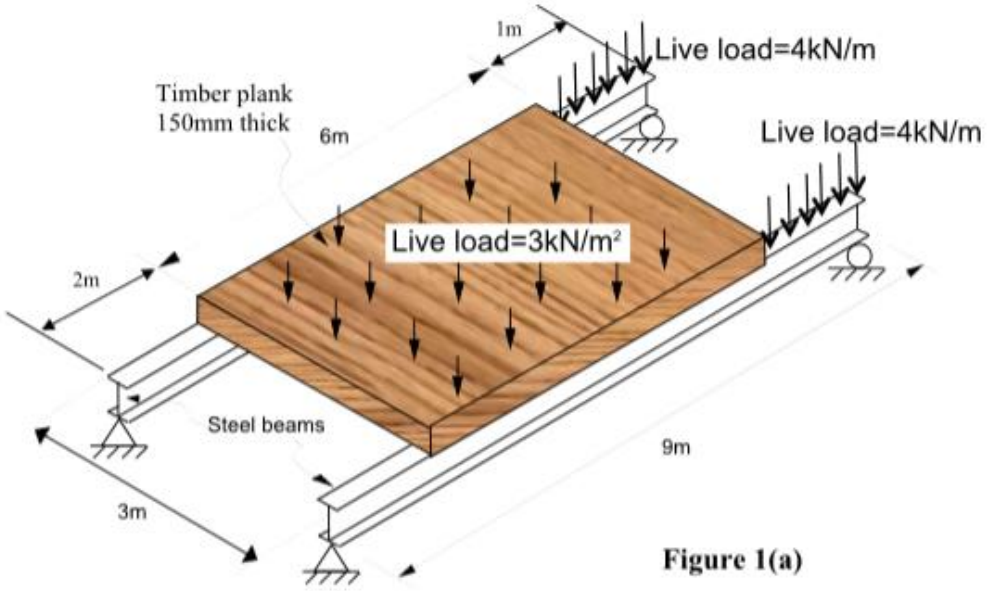
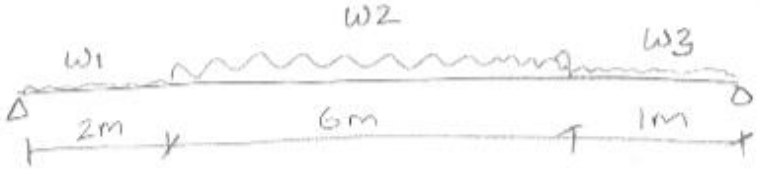


Figure 1(a)

a) DL [Timber plank (kN/m) = 1.5 × 1.5 × 0.15 = 3.375kN/m
steel beam (kN/m) = 1kN/m

LL [3 × 1.5 = 4.5kN/m
4 kN/m



$w_1 = 1.2(1) + 0 = 1.2\,kN/m$

$w_2 = 1.2(1 + 3.375) + 1.5(4.5) = 12\,kN/m$

$w_3 = 1.2(1) + 1.5(4) = 7.2\,kN/m$