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Check the adequacy of the continuous composite profiled deck slab with spans of 3.5 m. The cross section of the profiled sheeting is shown in Fig. A1. The slab is propped at the centre during construction stage. [γ_{ap} = 1.15, M20 concrete is used]

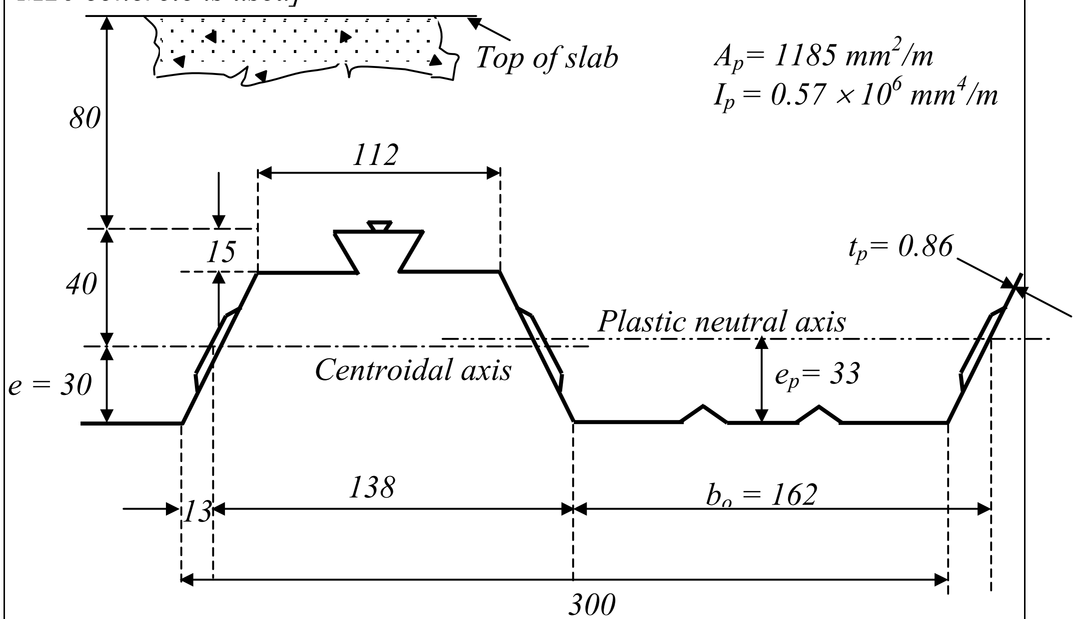

Fig. A1 Cross-section of composite slab

1.0 *Decking Sheet Data:* *(Data is taken from manufacturer's tables)*

Yield strength of steel, f_{yp} = 280 N/mm^2

Design thickness, allowing for zinc, t_p = 0.86 mm

Effective area of cross-section, A_p = 1185 mm^2/m

Moment of inertia, I_p = 0.57 * 10^6 mm^4/m.

Plastic moment of resistance M_{pa} = 4.92 kN-m/m

Distance of centroid above base e = 30 mm

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Distance of plastic neutral axis above base, $e_p = 33\ mm$

Resistance to vertical shear, $V_{pa} = 49.2\ kN/m.$

For resistance to longitudinal shear, $m = 184\ N/mm^2$

$k = 0.0530\ N/mm^2$

Modulus of elasticity of steel, $E_a = 2.0 * 10^5\ N/mm^2$

2.0 Load Data:

	Loads(kN/m^2)	Factored loads(kN/m^2)
Imposed load	4.5	4.50 * 1.50 = 6.75
Dead load of slab	2.41	2.41 * 1.35 = 3.25
Construction load	1.5	1.50 * 1.50 = 2.25

3.0 Profiled steel sheeting as shuttering:

3.1 Effective length of the span:

The profiled deck sheet is propped at the centre as shown in Fig. A2. Assume the top flanges of the supporting steel beams are at least 0.15 m wide and the width of the prop is neglected.

The effective length of each of the two spans is given by

$$\lambda_e = \frac{3500 - 150 + 70}{2} = 1710\,mm$$

The depth of the sheeting is 70 mm.

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3.2 Factored moments and vertical shears: (See table – 7 and table – 8 of chapter titled Composite Beams – II)

Assume end supports are unrestrained.

Moments:

$$Sagging\ moment = \left(\frac{w_{u,DL}}{12} + \frac{w_{u,LL}}{10}\right)\lambda_e^{\,2} = \left(\frac{3.25}{12} + \frac{2.25}{10}\right)(1.71)^2$$

$$= 1.45\ kNm/m$$

$$Hogging\ moment = \left(\frac{w_{u,DL}}{10} + \frac{w_{u,LL}}{9}\right)\lambda_e^{\,2} = \left(\frac{3.25}{10} + \frac{2.25}{9}\right)(1.71)^2$$

$$= 1.68\ kNm/m$$

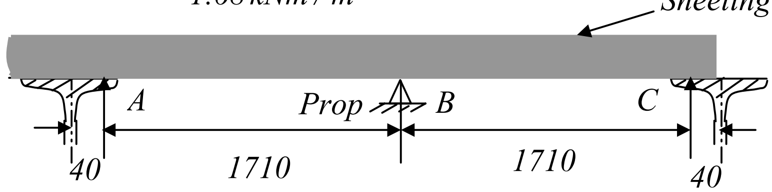

Fig.A2 Profiled sheeting during construction

Vertical shear:

$$Shear\ force\ at\ A = (0.5\,w_{u,DL} + 0.5\,w_{u,LL})\lambda_e = (0.5\times 3.25 + 0.5\times 2.25)(1.71)$$

$$= 4.7\ kN/m$$

$$Shear\ force\ at\ B = (0.6\,w_{u,DL} + 0.6\,w_{u,LL})\lambda_e = (0.6\times 3.25 + 0.6\times 2.25)(1.71)$$

$$= 5.64\ kN/m$$

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3.3 Check for moment:

Design moment = $M_{pa} / \gamma_{ap} = 4.92/1.15 = 4.27$ *kN-m/m > 1.68 kN-m/m*

Hence, the profiled deck is safe in flexure at construction stage.

3.4 Check for shear:

Vertical shear rarely governs design of profiled sheeting.

Design shear = $V_{pa} / \gamma_{ap} = 49.2/1.15 = 42.8$ *kN/m > 5.64 kN/m*

Design shear is more than actual vertical shear, hence OK..

3.5 Check for deflection:

Design load at construction stage = $2.41 + 1.5 = 3.91$ *kN/m*^{2}
(Assumed that the prop does not deflect).

The maximum deflection in span AB, if BC is unloaded, is

$$\delta_{max} = \frac{w\lambda_e^4}{185 E_a I_p} = \frac{3.91 * 1.71^4}{185 * 0.20 * 0.57} = 1.6\,mm$$

This is span/1068, which is very low.

4.0 Composite slab:

4.1 Effective span: *[Propping is removed]*

Distance between centres of supports = 3.5 m

Clear distance between the supports + effective depth of the slab
= (3.5 – 0.15) + 0.12 = 3.47 m

Hence, effective length = 3.47 m

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4.2 Flexure and vertical shear:

The design ultimate loading = $(w_{u,\,DL} + w_{u,\,LL}) = 3.25 + 6.75 = 10.0\ kN/m^2$

Mid-span bending moment is

$M_{sd} = 10.0 * (3.47)^2/8 = 15.1\ kN\text{-}m/m$

For vertical shear consider effective span as 3.5 m.

Then, vertical shear at supports is

$V_{sd} = (3.5 * 1.0 * 10.0)/2 = 17.5\ kN/m$

4.3 Check for moment:

For the bending resistance, from equation (1) of previous chapter

$$N_{cf} = \frac{A_p f_{yp}}{\gamma_{ap}} = 1185 * \frac{0.28}{1.15} = 289\,kN/m$$

Design compressive strength of the concrete =$0.36 * 20 = 7.2\ N/mm^2$

So, from equation (2) of a previous chapter, the depth of the stress block is

$$x = \frac{N_{cf}}{b(f_{ck})_{cu}} = \frac{289}{1 \times 7.2} = 40.1\ mm$$

This is less than h_c*, so from equation (4) of previous chapter*

$M_{p.Rd} = 289\,(0.12 - 0.017) = 29.8\ kN\ m/m > 15.1\ kN\ m/m$

Hence, the bending resistance is sufficient.

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4.4 Check for vertical shear: [See Fig. A1]

The shear resistance is given by equation (20) of previous chapter.

$b_o = 162$ mm, $b = 300$ mm, $d_p = 120$ mm.

The area A_p is

$A_p = 0.86\ (162 - 26 + 66) = 174\ mm^2$,

$$\rho = \frac{174}{162 * 120} = 0.009$$

and

$k_v = 1.6 - 0.12 = 1.48\ m$

The basic shear strength is $\tau_{Rd} = 0.30\ N/mm^2$, so from equation (20) of previous chapter

$$V_{v.Rd} = \frac{162}{300} * 120 * 0.3 * 1.48 (1.2 + 0.36) = 45\, kN / m$$

$V_{v.Rd} > V_{sd,}$ *hence composite slab is OK in shear.*

4.5 Check for longitudinal shear:

Longitudinal shear is checked by 'm-k' method.

$b = 1.0\ m$ $m = 184\ N/mm^2$

$d_p = 120\ mm$ $k = 0.0530\ N/mm^2$

$A_p = 1185\ mm^2/m$ $\gamma_{vs} = 1.25$

$\lambda_s = \lambda/4 = 3470/4 = 867\ mm$

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The m-k method gives the vertical shear resistance as

$$V_{i.Rd} = bd_p \frac{\left[\frac{mA_p}{b\lambda_s} + k\right]}{\gamma_{vs}} = (1000)(120)\frac{\left[\frac{184 \times 1185}{1000 \times 867} + 0.053\right]}{1.25} \times 10^{-3} = 29.2\,kN /$$

The design vertical shear is 28.3 kN/m, so composite slab is safe against longitudinal shear. Note partial safety factor for shear studs is taken as 1.25.

4.6 Check for serviceability:

4.6.1 Cracking of concrete above supporting beams

The steel beams should be provided by reinforcement of area 0.4% of the area of concrete, since the floor is propped during construction. Hence, provide reinforcement of

A_s = (0.4/100) * 1000 * 80 = 320 mm^2/m.

4.6.2 Deflection

In calculation of deflection, effects due to the use of propped construction and the presence of the reinforcement of area, A_s, provided for cracking are neglected. Both effects reduce deflections.

Span/depth = 3470/120 = 28.9 < 32 (For end span)

Hence, there is no need for deflection check.