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Research Article

Structural Analysis for a Composite Parallel Beam Structures Using QSE 7 Staad Pro Software in Accordance to BS 5950- 1 Advanced UK Beams

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Abstract: This technical paper presents a structural analyzing and manual calculations for a composite Parallel Beam with Steel class (S275) and Concrete class (C30/37) with a Decking (Ribdeck AL) a single unpropped support condition, 1mm gauge, 0.103 kN/m^2 Self weight, assumed slab depth 150mm from RLSD website with a concrete volume is 0.125 m^3/m^2. The calculations includes bending design, shear stress, shear connection, deflection (Elastic), checking of non-composite state, bending design and shear stress of spine beam. Furthermore, the forces, shear and bending moment diagrams for rib beam are also presented (using QSE 7 Staad Pro). As per BS 5950- 1 Advanced UK Beams**.**

Keywords: Composite parallel beam, structural analysis, BS 5950-1 Advanced UK beams, QSE 7 Staad Pro.

1.INTRODUCTION

The dimensions of the parallel beam are L1 = 5.1 m, L2 = 8.1 m

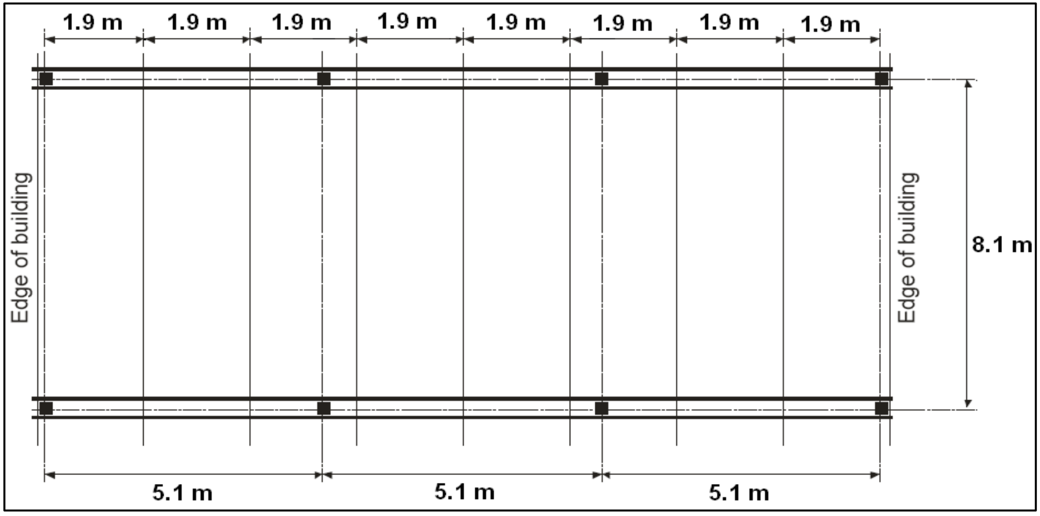

Figure 1: Top view of the analyzed parallel beam.

1.1 Material used

- Steel (S275) $f_{yk} = f_{yd} = 275$ N/mm^2
- Concrete (C30/37) $f_{ck} = 30$ N/mm^2
- Decking (Ribdeck AL) support condition: Single – unpropped
Gauge = 1.0 mm
Self weight = 0.103 kN/m^2
Assumed slab depth 150mm from RLSD website the concrete volume is 0.125 m^3/m^2

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1.2 Loading

- Self weight of concrete $24\ \text{kN/m}^3 \times 0.125\ \text{m}^3/\text{m}^2 = 3.000\ \text{kN/m}^2$
- Self weight of decking $= 0.103\ \text{kN/m}^2$
- Dead load $= 1.200\ \text{kN/m}^2$

Total Dead load $= 4.303\ \text{kN/m}^2$

Live Load $= 3.000\ \text{kN/m}^2$

Total Load $(1.35 \times 4.303\ \text{kN/m}^2) + (1.5 \times 3.000\ \text{kN/m}^2) = 10.31\ \text{kN/m}^2$

2.METHODOLOGY

2.1 Rib beam

- Loading on rib beam $= 10.31\ \text{kN/m}^2 \times 1.9\ \text{m}$
  $= 19.59\ \text{kN/m}$
- Loading on spine beam $= 19.59\ \text{kN/m} \times 8.1\text{m} \times 0.5$
  $= 79.34\ \text{kN}$
- M_{Max} $= w \times l^2 / 8$ (1)
  $= 19.59 \times 8.1^2 / 8$
  $= 161\ \text{kNm}$

- M_X $= 3 \times w \times l^2 / 32$ (2)
  $= 3 \times 19.59\ \text{kN/m} \times (8.1\text{m})^2 / 32$
  $= 120.5\ \text{kNm}$

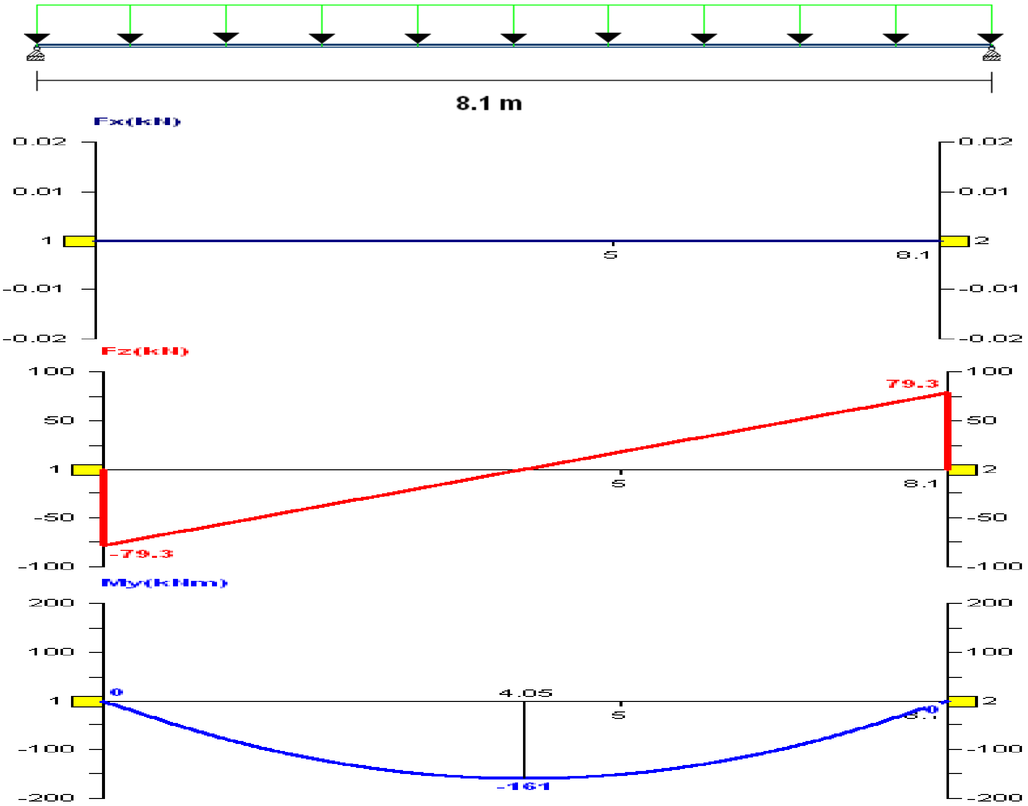

Figure 2: Forces, shear and bending moment diagrams for rib beam (using QSE 7 Staad Pro).

2.2 Bending Design

- b_{eff} $= 0.25 \times L$ (3)
  $= 0.25 \times 8.1\ \text{m} = 2.03\ \text{m}$

Assuming steel beam carries 50% so,

- M_{Ed} $= 80.5\ \text{kNm}$

Note: we are using S275, therefore, the value of f_{yd} will be 275 kN/mm^2

- S_x $= M_{Ed} / f_{yd}$ (4)
  $= (80.5\ \text{kNm} \times 10^6) / (275\ \text{kN/mm}^2 \times 10^3) = 293\ \text{cm}^3$

- From BS 5950- 1 (Advanced UK Beams), use section 254 x 146 x 37

$S_x = 483\ cm^3$, $A = 47.2\ cm^2$

- $T_d = A \times f_{yd}$ (5)

$= (47.2\ cm^2 \times 10^2 \times 275\ N/mm^2) / (10^3)$

$= 1298\ kN$

- $T_d = C_d$

$= 0.85 \times \alpha_c \times (f_{ck} / \delta_c) \times b_{eff} \times z$ (6)

Thus,

- $Z = (T_d \times \delta_c) / (0.85 \times \alpha_c \times f_{ck} \times b_{eff})$ (7)

$= [\ (1298\ kN \times 1.5) / (0.85 \times 0.85 \times 30\ N/mm^2 \times 2030mm)\ ] \times 10^3$

$= 44\ mm$

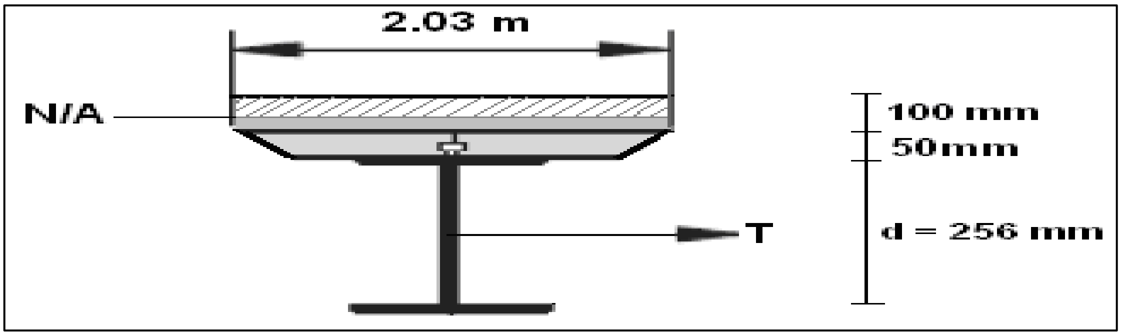

Figure 3: Section view of the beam.

d = 256 mm
Thickness = 150 mm
Overall depth = 406 mm
½ Z = 22 mm
= 384 mm
b_{eff} = 203 mm
x = 181 mm

- $M_{pl,Rd} = T_d \times$ lever arm

$= C_d \times x$ (8)

$= (1298\ kN \times 0.181\ m)$

= 235 kNm > 161 kNm OK

- $M_{pl,a,Rd} = f_{yd} \times S_x$ (9)

$= (275\ N/mm^2 \times 483\ cm^3) / 10^3$

= 132.8 kNm > 80.5 kNm OK

2.3 Shear stress

Section 254 x 146 x 37 $A = 47.2\ cm^2$ $t = 6.3\ mm$

$B = 146.4\ mm$ $r = 7.6\ mm$

$T = 10.9\ mm$

- $A_{shear} = A - 2 \times T \times (B - t - 2r)$ (10)

$= 4720\ mm^2 - 2 \times 10.9\ mm \times (146.4\ mm - 6.3\ mm - 2 \times 7.6\ mm)$

$= 1997\ mm^2 = 20\ cm^2$

- $V_{pl,a,Rd} = A_{shear} \times (f_{yd} / \sqrt{3})$ (11)

$= 20\ cm^2 \times (27.5\ kN/cm^2 / \sqrt{3})$

= 317.5 kN > 79.34 kN OK

3.RESULTS

3.1 Shear connection

The below equations has been used and the lower value of them was considered for the number of shear connection.

1. P_{Rd} Steel = $(0.8 \times f_u \times \pi \times d^2) / (4 \times \delta_v)$ (12)
2. P_{Rd} Concrete = $[0.29 \times \alpha \times d^2 \times \sqrt{(f_{ck} \times E_{cm})}] / \delta_v$ (13)

Assumed $f_u = 450$ N/mm^2 $\alpha = 1$
Stud diameter d = 20 mm $f_{ck} = 30$ N/mm^2
$\delta_v = 1.25$ $E_{cm} = 33000$ N/mm^2
Assumed $h_{SC} / d > 4$

- P_{Rd} Steel $= [(0.8 \times f_u \times \pi \times d^2) / (4 \times \delta_v)] / 10^3$
$= (0.8 \times 450 \text{ N/mm}^2 \times \pi \times 20^2) / (4 \times 1.25)$
$= 90.48$ kN

- P_{Rd} Concrete $= (0.29 \times \alpha \times d^2 \times \sqrt{f_{ck}} \times E_{cm}) / \delta_v$
$= [0.29 \times 1 \times 20^2 \times \sqrt{(30 \text{ N/mm}^2 \times 33000 \text{ N/mm}^2)}] / 1.25$
$= 73.7$ kN

Note: P_{Rd} Concrete 73.7 kN < P_{Rd} Steel 90.48 kN, therefore, choose P_{Rd} Steel since it is lower than Concrete.

- $N = F / F_{Stud}$ where $F = M_X / la$ (14)
$F = 120.5 \text{ kNm} / 0.181 \text{ m} = 665.7$ kN
and $F_{Stud} = P_{Rd}$ Concrete = 73.7 kN (15)
Thus, $N = F / F_{Stud}$
$N = 665.7 \text{ kN} / 73.7 \text{ kN} = 9.03 \approx 10$

Number of shear connectors over first/last 2.03m, N ≈ 10 shear connectors over 2.03 m @ 200mm spacing ≥ 5d

- $N = F / F_{Stud}$ where $F = (M_{Max} - M_X) / la$ (16)
$F = (161 \text{ kNm} – 120.5 \text{ kNm}) / 0.181 \text{ m} = 223.8$ kN
and $F_{Stud} = P_{Rd}$ Concrete = 73.7 kN
Thus, $N = F / F_{Stud}$
$N = 223.8 \text{ kN} / 73.7 \text{ kN} = 3.04 \approx 4$

Number of shear connectors over middle 2.02m, N ≈ 4 shear connectors over 2.02 m @ 510mm spacing ≥ 5d

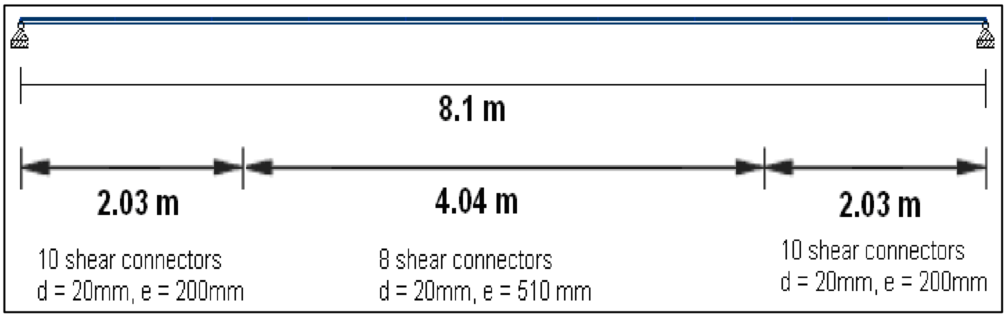

Figure 4: Distribution of shear connectors with dimensions through the beam.

3.2 Deflection (Elastic)

- Loading on rib beam $= (4.303 \text{ kN/m}^2 + 3.0 \text{ kN/m}^2) \times 1.9$ m
$= 13.9$ kN/m

- m $= E_S / E_{cm}$ (17)
$= 205000 \text{ N/mm}^2 / 33000 \text{ N/mm}^2 = 6.21$

- Section 254 x 146 x 37 ~ Area of section = 47.2 cm^2
- Width $= b_{eff} \times E_{cm} / E_S$ (18)
$= (2.03 \text{ m} \times 33000 \text{ N/mm}^2) / 205000 \text{ N/mm}^2$
$= 0.327$ m
- $A_C = b \times h$ (19)
$= 327 \text{ mm} \times 150 \text{ mm} = 49050 \text{ mm}^2$

- $L_a = 0.5 \times h_C + H$ (20)
$= 0.5 \times 150mm + 256\ mm = 331\ mm$

- $M_C = A_C \times L_a$ (21)
$= 49050\ mm^2 \times 331\ mm = 16235550\ mm^3$

- $A_S = 4720\ mm^2$

- $L_a = 0.5 \times H$
$= 0.5 \times 256\ mm = 128\ mm$

- $M_S = A_S \times l_a$ (22)
$= 4720\ mm^2 \times 128\ mm = 604160\ mm^3$

- Neutral Axis $= (M_C + M_S) / (A_C + A_S)$ (23)
$= (16235550\ mm^3 + 604160\ mm^3) / (49050\ mm^2 + 4720\ mm^2)$
$= 313.2\ mm$

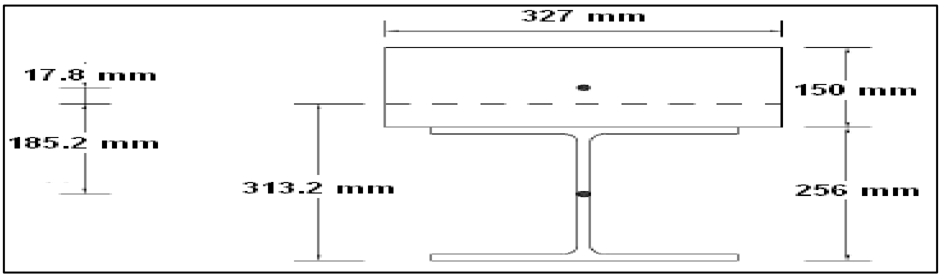

Figure 5: Geometry of the beam section.

Table 1: Moment of Inertia of the analyzed parallel beam.

Description	**A (mm^2)**	**r (mm)**	**Ar^2 (mm^4)**	**Iyy (mm^4)**
Concrete	49050	17.8	15021563	91968750
Beam	4720	185.2	161891469	55370000
∑			176913032	147338750

The inertia of the section is the sum of Ar^2 and Iyy.

Thus, $\mathbf{I = \sum Ar^2 + \sum Iyy}$ (24)
$= 176913032 + 147338750 = 324251782\ mm^4$

- $\delta_{Max} = L / 300$ (25)
$= 8.1\ m / 300 = 27\ mm$

$$\delta = \frac{5wL^4}{384EI} = \frac{5 \times 19.59 N/mm \times (8100mm)^4}{384 \times 205000 N/mm^2 \times 324251782\,mm^4} \quad (26)$$

$= 16.5\ mm$ ≤ span / 300 = 27 mm **OK**

3.3 Checking of non-composite state

Loading:

- Self weight of concrete $24\ kN/m^3 \times 0.125\ m^3/m^2 = 3.000\ kN/m^2$
- Self weight of decking $= 0.103\ kN/m^2$

Total Dead load $= 3.103\ kN/m^2$

Live Load $= 1.500\ kN/m^2$

Total Load $(1.35 \times 3.103\ kN/m^2) + (1.5 \times 1.500\ kN/m^2) = 6.439\ kN/m^2$

- Loading on rib beam $= 6.439\ kN/m^2 \times 2.03\ m = 13.07\ kN/m$
- $M_{Ed} = 13.07\ kN/m \times (8.1\ m)^2 / 8$
$= 107.20\ kNm$
- $M_{el,a,Rd} = f_{yd} \times S_x$
$= (275\ N/mm^2 \times 433\ cm^3) / 10^3$
$= 119.08\ kNm$ $> 107.20\ kNm$ OK

3.4 Spine beam

- p $= w \times l / 2$

$= 19.59$ kN/m × 8.1 m / 2 = 79.34 kN

The reaction R1, R2, R3 and R4 has been obtained from QSE 7 Staad Pro and the values were as follows:

R1 = 147.56 kN
R2 = 209.47 kN
R3 = 209.47 kN
R4 = 147.56 kN

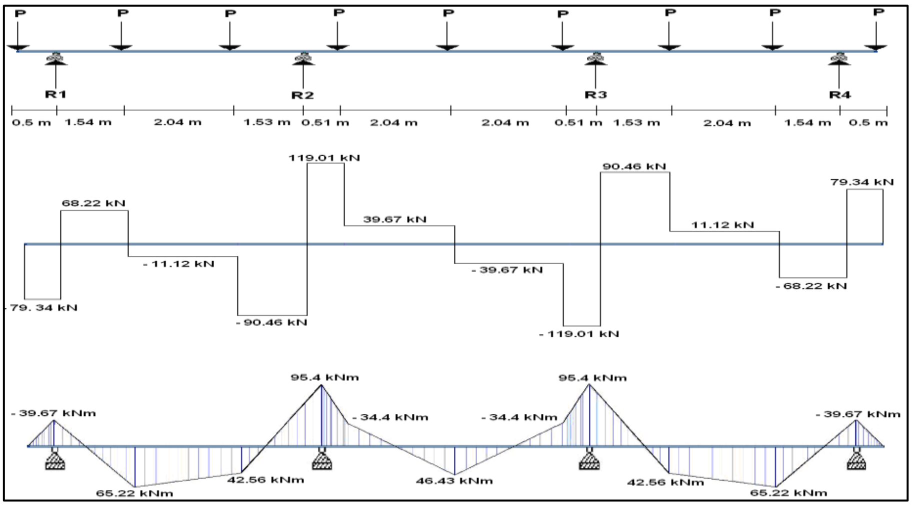

Figure 6: The below illustrates the forces, shear and bending moment diagrams for spine beam (using QSE 7 Staad Pro).

4.CONCLUSION

4.1 Bending design

Max $M_{Ed} = 95.4$ kNm

- $S_x = M_{Ed} / f_{yd}$

$= (95.4 \text{ kNm} / 275 \text{ N/mm}^2) \times 10^3 = 347 \text{ cm}^3$

- From BS 5950- 1 (Advance UK Beams), use section 305 x 102 x 33

$S_x = 481 \text{ cm}^3$, $A = 41.8 \text{ cm}^2$

- $M_{pl,a,Rd} = f_{yd} \times S_x$

$= (275 \text{ N/mm}^2 \times 481 \text{ cm}^3) / 10^3$

= 132.3 kNm **> 95.4 kNm** **OK**

4.2 Shear Stress

- Section 305 x 102 x 28 $A = 41.8 \text{ cm}^2$ $t = 6.6$ mm

$B = 102.4$ mm $r = 7.6$ mm

$T = 10.8$ mm

- $A_{shear} = A - 2 \times T \times (B - t - 2r)$

$= 4180 \text{ mm}^2 - 2 \times 10.8 \text{ mm} \times (102.4 \text{ mm} - 6.6 \text{ mm} - 2 \times 7.6 \text{ mm})$

$= 2439 \text{ mm}^2 = 24.4 \text{ cm}^2$

- $V_{pl,a,Rd} = A_{shear} \times (f_{yd} / \sqrt{3})$

$= 24.4 \text{ cm}^2 \times (27.5 \text{ kN/cm}^2 / \sqrt{3})$

= 387.4 kN **> 119.01 kNm** **OK**

REFERENCES

1. RICHARD LEES STEEL DECKING LTD. (2010). Technical manual (TMI),Ashbourne, Derbyshire. Available Online [http://www.rlsd.com/pdf/RLSD_TM1.pdf] access date: 15th November 2010 at 17-35.
2. The ‘blue book’. (2010). to BS 5950 – 1. Available Online [http://csbluebook.steel-sci.org/support/entry.htm] access date: 18th November 2010 at 19:10.
3. SMITH, F. (2010). Innovative Structures Notes, Department of Civil Engineering, University of Dundee.