TSC Beam/Girder Design

Project **Y-1** 2025-05-08 16:05:39

Member 039_25TG1 Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-VW 2175.0×1680.0×12.0×16.0(250.

- height H = 2175.0 mm
- width B = 1680.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 250.0 mm

(2) composite beam section:

- length L = 12.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 2500.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Fixed

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	8	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 90584 N/m
- live load W_c = 2500.0 N/m^2

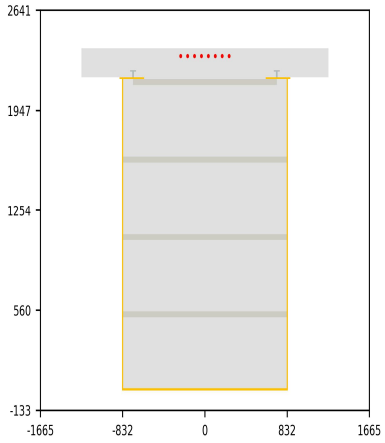
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 5000 N/m^2
- additional dead load W_{ud} = 1000 N/m^2
- required moment $M_{u,pos}$ = 9049 kN·m
- required moment $M_{u,neg}$ = 21313 kN·m
- required shear V_u = 5558 kN

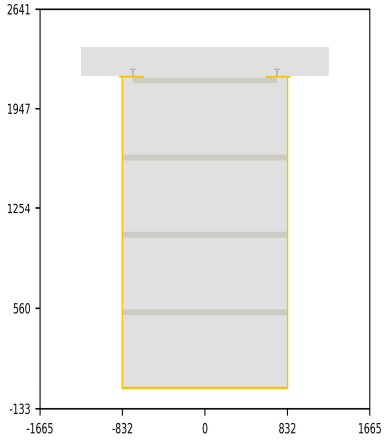
(5) Material properties:

- Concrete: E_c = 28825 MPa, f_{ck} = 35.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 84408 mm^2
- centroid from bottom flange C_{yb} = 821 mm
- moment of inertia I_{xs} = 5217848 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 63490 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 38560 cm^3
- plastic section modulus Z_x = 58663 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 2.58, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 16.34 ⇒ Compact
- web: $\lambda = h_c/t_w$ = 223.53, $\lambda_{p,singly\ sym.}$ = 40.41, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Slender

<negative bending>

- web: $\lambda = h_c/t_w$ = 134.3, $\lambda_{p,singly\ sym.}$ = 138.63, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 103.5, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.14 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L^2 \times 9/128$ = 1344 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 9829 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 10921 kN·m
  - compression flange buckling $M_{nc,fb}$ = -
  - tension flange yielding $M_{nc,fyt}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.19 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L^2/8$ = 2390 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 12319 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 22539 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 13718 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.71 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L$ x5/8 = 996 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x $0.6F_y(2Ht_w)C_v$ = 1396.14 kN
  where, shear coefficient C_v = 0.14

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(5) Deflection:

<vertical displ.> δ_c = 1.05 mm < limit value = L/360.0 = 33.33 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 600.0 mm

- web: $\lambda = h_{input}/t_w$ = 50.0, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 50.0, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 103.5, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Slender

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle}\text{x}0.5B_{angle})$ = 985.32 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row}Q_n L_{pos}/S_{stud} + Q_{nh}L_{pos}/S_{angle}$ = 8974.08 kN
  where, entire positive moment region $L_{pos,ent}$ = 6928 mm ⇒ moment 0 ~ max. region L_{pos} = 3464 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row}Q_n L_{neg}/S_{stud} + Q_{nh}L_{neg}/S_{angle}$ = 7138.16 kN
  where, entire negative moment region $L_{neg,ent}$ = 5071 mm ⇒ moment 0 ~ max. region L_{pos} = 2535 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.6 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 14875.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 29964.84 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 2.46 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab}f_{yr,slab}$ = 2906.2 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.3 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 9049 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 29976.19 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.96 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 21313 kN·m
- (Slender) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{cr,pos}$ = 22303.22 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.56 ⇒ **O.K.**

- required shear strength V_u = 5558.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 10006.74 kN

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(6) Deflection

<Short-term> Vertical displacement 0.01 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 33963959 cm^4
- effecitive stiffness EI_{eff} = 0.6EI_{pos} + 0.4EI_{neg} = 57664591 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 1.06 mm

<Long-term> Vertical displacement 0 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0002
- overall deflection (construction + composite stage) : 1.82 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 14:50:50

Member 050_25TB1 Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 975×600×9×12(110)

- height H = 975.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 9.0 mm
- thk. t_w = 9.0 mm
- thk. t_{bf} = 12.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 12.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 2500.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Pin

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	4	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 15209 N/m
- live load W_c = 2500.0 N/m^2

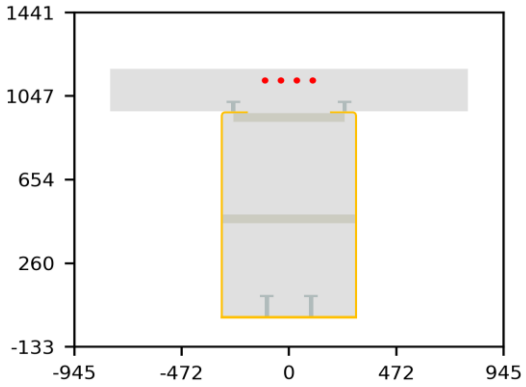
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 5000 N/m^2
- additional dead load W_{ud} = 1000 N/m^2
- required moment $M_{u,pos}$ = 3246 kN·m
- required moment $M_{u,neg}$ = 3994 kN·m
- required shear V_u = 1401 kN

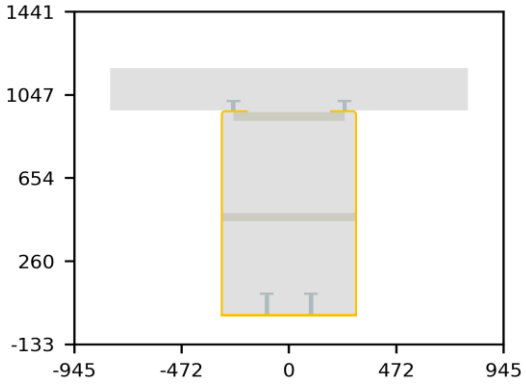
(5) Material properties:

- Concrete: E_c = 28825 MPa, f_{ck} = 35.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 26352 mm^2
- centroid from bottom flange C_{yb} = 393 mm
- moment of inertia I_{xs} = 319941 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 8136 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 5499 cm^3
- plastic section modulus Z_x = 8148 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 12.72, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 17.21 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 127.29, $\lambda_{p,singly\ sym.}$ = 44.42, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 84.71, $\lambda_{p,singly\ sym.}$ = 137.45, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.5, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.28 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 428 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1526 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 1952 kN·m
  - compression flange buckling $M_{nc,fb} = [R_{pc} M_y - (R_{pc} M_{yc} - F_L S_{x,tf}(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{bf})]$ = 1696 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.43 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 762 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1757 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 2888 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 2460 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.24 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 317 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x $0.6F_y(2Ht_w)C_v$ = 1337.29 kN

  where, shear coefficient C_v = 0.4

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(5) Deflection:

<vertical displ.> δ_c = 4.51 mm < limit value = L/360.0 = 33.33 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 477.0 mm

- web: $\lambda = h_{input}/t_w$ = 53.0, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 53.0, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.5, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle}\text{x}0.5B_{angle})$ = 346.29 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row}Q_n L_{pos}/S_{stud} + Q_{nh}L_{pos}/S_{angle}$ = 6683.08 kN
  where, entire positive moment region $L_{pos,ent}$ = 9000 mm ⇒ moment 0 ~ max. region L_{pos} = 4500 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row}Q_n L_{neg}/S_{stud} + Q_{nh}L_{neg}/S_{angle}$ = 3590.67 kN
  where, entire negative moment region $L_{neg,ent}$ = 3000 mm ⇒ moment 0 ~ max. region L_{pos} = 3000 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.71 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 14875.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 9354.96 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 2.47 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 1453.1 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.57 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 3246 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 5731.07 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.96 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 3994 kN·m
- (compact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 4166.4 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.42 ⇒ **O.K.**

- required shear strength V_u = 1401.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 3364.34 kN

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(6) Deflection

<Short-term> Vertical displacement 0.44 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 2476727 cm^4
- effecitive stiffness EI_{eff} = 0.8EI_{pos} + 0.2EI_{neg} = 3861497 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 4.94 mm

<Long-term> Vertical displacement 6 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0003
- overall deflection (construction + composite stage) : 10.93 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 14:50:56

Member 051_25TB1A Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 975×600×12×16(110)

- height H = 975.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 15.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3750.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Fixed

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	8	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 15682 N/m
- live load W_c = 2500.0 N/m^2

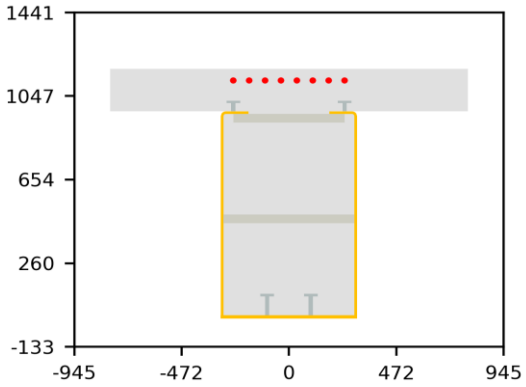
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 5000 N/m^2
- additional dead load W_{ud} = 1000 N/m^2
- required moment $M_{u,pos}$ = 2924 kN·m
- required moment $M_{u,neg}$ = 5745 kN·m
- required shear V_u = 1923 kN

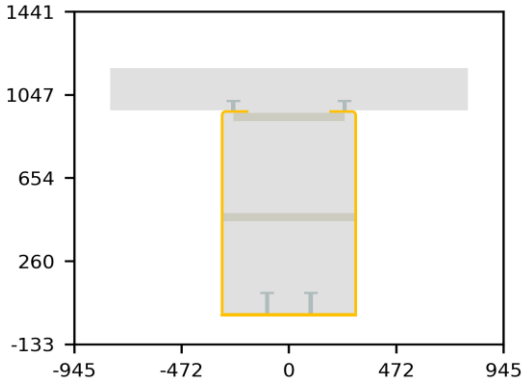
(5) Material properties:

- Concrete: E_c = 28825 MPa, f_{ck} = 35.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 34968 mm^2
- centroid from bottom flange C_{yb} = 393 mm
- moment of inertia I_{xs} = 420928 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 10696 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 7238 cm^3
- plastic section modulus Z_x = 10764 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 18.53 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 94.92, $\lambda_{p,singly\ sym.}$ = 44.05, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 62.92, $\lambda_{p,singly\ sym.}$ = 135.96, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 36.0, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Noncompact

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.53 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 1213 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 2280 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 2569 kN·m
  - compression flange buckling $M_{nc,fb} = [R_{pc} M_y - (R_{pc} M_{yc} - F_L S_{x,tf}(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{bf})]$ = 2534 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.93 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 2156 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 2312 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 3797 kN·m
  - compression flange buckling $M_{nc,fb} = M_p - (M_p - F_y S)(3.57 b/t\sqrt{(F_y/E)} - 4.0)$ = 3790 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.22 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 718 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6$F_y(2Ht_w)C_v$ = 3216.91 kN

  where, shear coefficient C_v = 0.72

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(5) Deflection:

<vertical displ.> δ_c = 13.62 mm < limit value = L/360.0 = 41.67 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 473.5 mm

- web: $\lambda = h_{input}/t_w$ = 39.46, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 39.46, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 36.0, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85 f_{ck}(L_{a,angle} \text{x} 0.5 B_{angle})$ = 342.72 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row} Q_n L_{pos}/S_{stud} + Q_{nh} L_{pos}/S_{angle}$ = 6484.4 kN
  where, entire positive moment region $L_{pos,ent}$ = 8661 mm ⇒ moment 0 ~ max. region L_{pos} = 4330 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row} Q_n L_{neg}/S_{stud} + Q_{nh} L_{neg}/S_{angle}$ = 4778.24 kN
  where, entire negative moment region $L_{neg,ent}$ = 6339 mm ⇒ moment 0 ~ max. region L_{pos} = 3169 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.52 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85 f_{ck} B_{eff} D_s$ = 22312.5 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 12413.64 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 1.64 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 2906.2 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.42 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 2924 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 7000.35 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.94 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 5745 kN·m
- (compact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 6137.28 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.43 ⇒ **O.K.**

- required shear strength V_u = 1923.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6 F_y A_w$ = 4485.78 kN

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(6) Deflection

<Short-term> Vertical displacement 1.03 mm ≤ $L/360.0$ = 41.67 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 3057853 cm^4
- effecitive stiffness EI_{eff} = $0.6EI_{pos}$ + $0.4EI_{neg}$ = 4587346 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 14.65 mm

<Long-term> Vertical displacement 7 mm ≤ $L/360.0$ = 41.67 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0003
- overall deflection (construction + composite stage) : 21.17 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 14:51:09

Member 054_25TB3 Code: KDS 41 Series 2022

1. Design Conditions

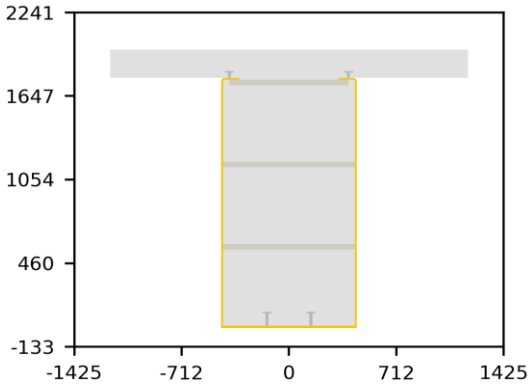
(1) steel section: TSC-NI/NO 1775×900×12×16(110)

- height H = 1775.0 mm
- width B = 900.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 12.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3000.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Pin

<Beam section-End (mm)>

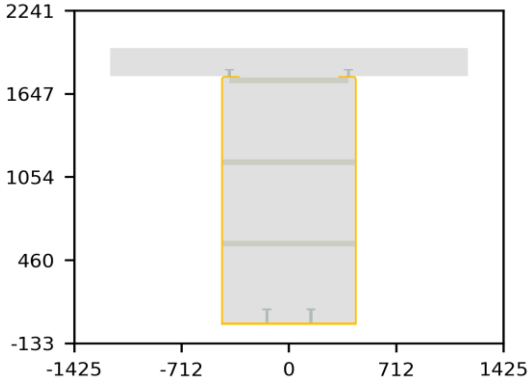


(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	0	40	End

<Beam section-Center (mm)>



(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 40777 N/m
- live load W_c = 2500.0 N/m^2

<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 15000 N/m^2
- additional dead load W_{ud} = 6750 N/m^2
- required moment $M_{u,pos}$ = 4375 kN·m
- required moment $M_{u,neg}$ = 6297 kN·m
- required shear V_u = 2574 kN

(5) Material properties:

- Concrete: E_c = 28825 MPa, f_{ck} = 35.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 58968 mm^2
- centroid from bottom flange C_{yb} = 713 mm
- moment of inertia I_{xs} = 2207130 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 30929 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 20794 cm^3
- plastic section modulus Z_x = 31886 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, λ_p = 0.38√(E_s/F_y) = 9.24, λ_r = 0.95√($k_c E_s/F_L$) = 16.34 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 174.9, $\lambda_{p,singly\ sym.}$ = 41.89, λ_r = 5.70√(E_s/F_y) = 138.63 ⇒ Slender

<negative bending>

- web: $\lambda = h_c/t_w$ = 116.27, $\lambda_{p,singly\ sym.}$ = 123.93, λ_r = 5.70√(E_s/F_y) = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 54.75, λ_p = 1.12√(E_s/F_y) = 27.24, λ_r = 1.40√(E_s/F_y) = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.14 ⇒ **O.K.**

- required moment $M_{c,pos}$ = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L^2 x 9/128 = 861 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 5959 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 6744 kN·m
  - compression flange buckling $M_{nc,fb} = R_{pg}[F_y - (0.3F_y)(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]S_{x,tf}$ = 6622 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.23 ⇒ **O.K.**

- required moment $M_{c,neg}$ = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L^2/8 = 1531 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 6643 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 10979 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 9050 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.37 ⇒ **O.K.**

- required shear strength V_c = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L x5/8 = 638 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6F_y(2Ht_w)C_v = 1720.86 kN
  where, shear coefficient C_v = 0.21

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(5) Deflection:

<vertical displ.> δ_c = 1.42 mm < limit value = L/360.0 = 33.33 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 1747.0 mm

- web: $\lambda = h_{input}/t_w$ = 145.58, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 145.58, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Slender
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 54.75, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle} \text{x} 0.5B_{angle})$ = 521.22 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row} Q_n L_{pos}/S_{stud} + Q_{nh} L_{pos}/S_{angle}$ = 8082.52 kN
  where, entire positive moment region $L_{pos,ent}$ = 9000 mm ⇒ moment 0 ~ max. region L_{pos} = 4500 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row} Q_n L_{neg}/S_{stud} + Q_{nh} L_{neg}/S_{angle}$ = 4115.46 kN
  where, entire negative moment region $L_{neg,ent}$ = 3000 mm ⇒ moment 0 ~ max. region L_{pos} = 3000 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.45 ⇒ **Possible**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 17850.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 20933.64 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 1.0 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 0.0 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.26 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 4375 kN·m
- (yield) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{y,pos}$ = 16675.17 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.98 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 6297 kN·m
- (Slender) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{cr,pos}$ = 6426.92 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.32 ⇒ **O.K.**

- required shear strength V_u = 2574.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 8166.42 kN

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(6) Deflection

<Short-term> Vertical displacement 0.52 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 14398105 cm^4
- effecitive stiffness EI_{eff} = 0.8EI_{pos} + 0.2EI_{neg} = 17620611 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 1.94 mm

<Long-term> Vertical displacement 4 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0003
- overall deflection (construction + composite stage) : 6.08 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 16:09:09

Member 079_29TG1 Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-VW 2175.0×1680.0×12.0×16.0(250.

- height H = 2175.0 mm
- width B = 1680.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 250.0 mm

(2) composite beam section:

- length L = 12.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 2500.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Fixed

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	4	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 90584 N/m
- live load W_c = 2500.0 N/m^2

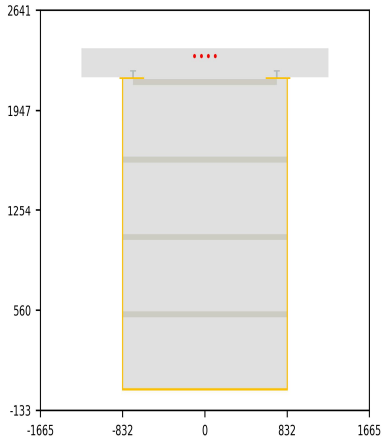
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 5000 N/m^2
- additional dead load W_{ud} = 1000 N/m^2
- required moment $M_{u,pos}$ = 6731 kN·m
- required moment $M_{u,neg}$ = 18738 kN·m
- required shear V_u = 4919 kN

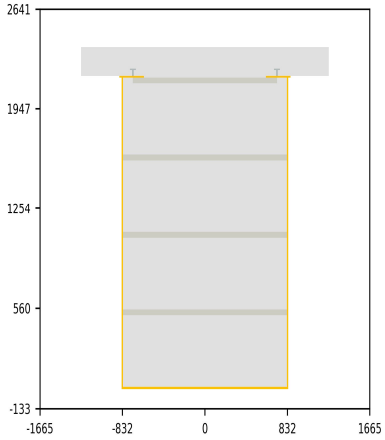
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 84408 mm^2
- centroid from bottom flange C_{yb} = 821 mm
- moment of inertia I_{xs} = 5217848 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 63490 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 38560 cm^3
- plastic section modulus Z_x = 58663 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 2.58, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 16.34 ⇒ Compact
- web: $\lambda = h_c/t_w$ = 223.53, $\lambda_{p,singly\ sym.}$ = 40.41, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Slender

<negative bending>

- web: $\lambda = h_c/t_w$ = 134.3, $\lambda_{p,singly\ sym.}$ = 138.63, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 103.5, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.14 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L^2 \times 9/128$ = 1344 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 9829 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 10921 kN·m
  - compression flange buckling $M_{nc,fb}$ = -
  - tension flange yielding $M_{nc,fyt}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.19 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L^2/8$ = 2390 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 12319 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 22539 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 13718 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.71 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab}) \times L$ x5/8 = 996 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x $0.6F_y(2Ht_w)C_v$ = 1396.14 kN
  where, shear coefficient C_v = 0.14

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(5) Deflection:

<vertical displ.> δ_c = 1.05 mm < limit value = L/360.0 = 33.33 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 600.0 mm

- web: $\lambda = h_{input}/t_w$ = 50.0, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 50.0, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 103.5, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Slender

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85 f_{ck}(L_{a,angle} \text{x} 0.5 B_{angle})$ = 844.56 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row} Q_n L_{pos}/S_{stud} + Q_{nh} L_{pos}/S_{angle}$ = 8129.52 kN
  where, entire positive moment region $L_{pos,ent}$ = 6928 mm ⇒ moment 0 ~ max. region L_{pos} = 3464 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row} Q_n L_{neg}/S_{stud} + Q_{nh} L_{neg}/S_{angle}$ = 6434.36 kN
  where, entire negative moment region $L_{neg,ent}$ = 5071 mm ⇒ moment 0 ~ max. region L_{pos} = 2535 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.64 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85 f_{ck} B_{eff} D_s$ = 12750.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 29964.84 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 4.43 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 1453.1 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.23 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 6731 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 29020.01 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.96 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 18738 kN·m
- (Slender) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{cr,pos}$ = 19617.69 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.49 ⇒ **O.K.**

- required shear strength V_u = 4919.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6 F_y A_w$ = 10006.74 kN

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(6) Deflection

<Short-term> Vertical displacement 0.01 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 32729023 cm^4
- effecitive stiffness EI_{eff} = 0.6EI_{pos} + 0.4EI_{neg} = 65496285 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 1.06 mm

<Long-term> Vertical displacement 0 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0002
- overall deflection (construction + composite stage) : 1.71 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 14:55:24

Member 091_29TB1A Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 975×600×12×16(110)

- height H = 975.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 15.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3750.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Fixed

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	7	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 15682 N/m
- live load W_c = 2500.0 N/m^2

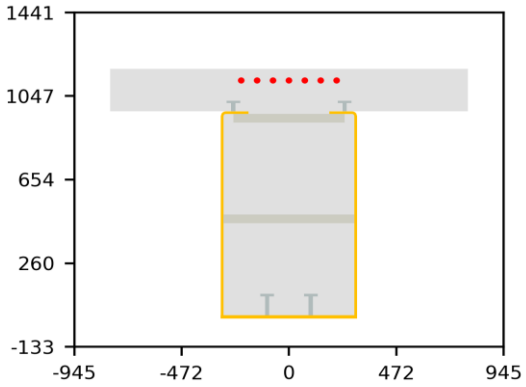
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 5000 N/m^2
- additional dead load W_{ud} = 1000 N/m^2
- required moment $M_{u,pos}$ = 2927 kN·m
- required moment $M_{u,neg}$ = 5790 kN·m
- required shear V_u = 1933 kN

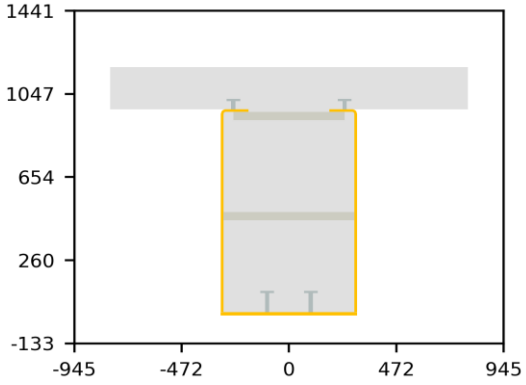
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 34968 mm^2
- centroid from bottom flange C_{yb} = 393 mm
- moment of inertia I_{xs} = 420928 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 10696 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 7238 cm^3
- plastic section modulus Z_x = 10764 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 18.53 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 94.92, $\lambda_{p,singly\ sym.}$ = 44.05, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 62.92, $\lambda_{p,singly\ sym.}$ = 135.96, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 36.0, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Noncompact

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.53 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 1213 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 2280 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 2569 kN·m
  - compression flange buckling $M_{nc,fb} = [R_{pc} M_y - (R_{pc} M_{yc} - F_L S_{x,tf}(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{bf})]$ = 2534 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.93 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 2156 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 2312 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 3797 kN·m
  - compression flange buckling $M_{nc,fb} = M_p - (M_p - F_y S)(3.57 b/t\sqrt{(F_y/E)} - 4.0)$ = 3790 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.22 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 718 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6$F_y(2Ht_w)C_v$ = 3216.91 kN

  where, shear coefficient C_v = 0.72

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(5) Deflection:

<vertical displ.> δ_c = 13.62 mm < limit value = $L/360.0$ = 41.67 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 473.5 mm

- web: $\lambda = h_{input}/t_w$ = 39.46, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 39.46, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 36.0, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle} \text{x} 0.5B_{angle})$ = 293.76 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row} Q_n L_{pos}/S_{stud} + Q_{nh} L_{pos}/S_{angle}$ = 6092.72 kN
  where, entire positive moment region $L_{pos,ent}$ = 8661 mm ⇒ moment 0 ~ max. region L_{pos} = 4330 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row} Q_n L_{neg}/S_{stud} + Q_{nh} L_{neg}/S_{angle}$ = 4484.48 kN
  where, entire negative moment region $L_{neg,ent}$ = 6339 mm ⇒ moment 0 ~ max. region L_{pos} = 3169 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.49 ⇒ **Possible**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 19125.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 12413.64 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 1.76 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 2542.65 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.43 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 2927 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 6777.31 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 1.0 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 5790 kN·m
- (compact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 5797.22 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.43 ⇒ **O.K.**

- required shear strength V_u = 1933.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 4485.78 kN

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(6) Deflection

<Short-term> Vertical displacement 1.06 mm ≤ $L/360.0$ = 41.67 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 2960618 cm^4
- effecitive stiffness EI_{eff} = $0.6EI_{pos}$ + $0.4EI_{neg}$ = 4465614 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 14.68 mm

<Long-term> Vertical displacement 7 mm ≤ $L/360.0$ = 41.67 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0003
- overall deflection (construction + composite stage) : 21.15 mm

TSC Beam/Girder Design

Project **Y-1** 2025-05-08 14:55:42

Member 094_29TB3 Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 1775×900×12×16(110)

- height H = 1775.0 mm
- width B = 900.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 16.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 12.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3000.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Pin

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	8	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 40777 N/m
- live load W_c = 2500.0 N/m^2

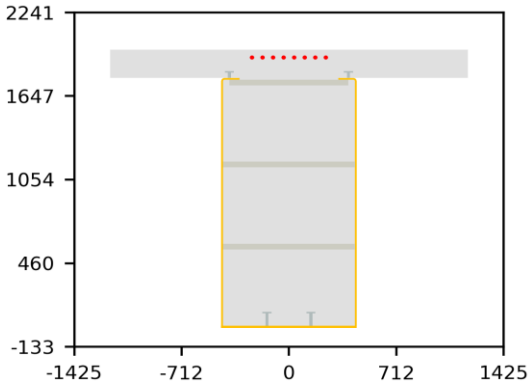
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 15000 N/m^2
- additional dead load W_{ud} = 6750 N/m^2
- required moment $M_{u,pos}$ = 4386 kN·m
- required moment $M_{u,neg}$ = 6733 kN·m
- required shear V_u = 2461 kN

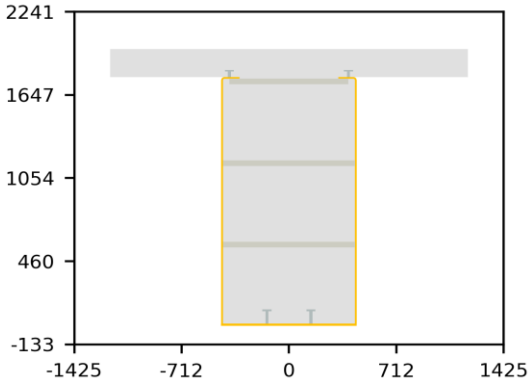
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 58968 mm^2
- centroid from bottom flange C_{yb} = 713 mm
- moment of inertia I_{xs} = 2207130 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 30929 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 20794 cm^3
- plastic section modulus Z_x = 31886 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, λ_p = 0.38√(E_s/F_y) = 9.24, λ_r = 0.95√($k_c E_s/F_L$) = 16.34 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 174.9, $\lambda_{p,singly\ sym.}$ = 41.89, λ_r = 5.70√(E_s/F_y) = 138.63 ⇒ Slender

<negative bending>

- web: $\lambda = h_c/t_w$ = 116.27, $\lambda_{p,singly\ sym.}$ = 123.93, λ_r = 5.70√(E_s/F_y) = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 54.75, λ_p = 1.12√(E_s/F_y) = 27.24, λ_r = 1.40√(E_s/F_y) = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.14 ⇒ **O.K.**

- required moment $M_{c,pos}$ = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L^2 x 9/128 = 861 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 5959 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 6744 kN·m
  - compression flange buckling $M_{nc,fb} = R_{pg}[F_y - (0.3F_y)(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{pf})]S_{x,tf}$ = 6622 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.23 ⇒ **O.K.**

- required moment $M_{c,neg}$ = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L^2/8 = 1531 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 6643 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 10979 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 9050 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.37 ⇒ **O.K.**

- required shear strength V_c = (α_D(W_s + $W_d B_{slab}$) + $\alpha_L W_c B_{slab}$) x L x5/8 = 638 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6F_y(2Ht_w)C_v = 1720.86 kN
  where, shear coefficient C_v = 0.21

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(5) Deflection:

<vertical displ.> δ_c = 1.42 mm < limit value = L/360.0 = 33.33 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 1747.0 mm

- web: $\lambda = h_{input}/t_w$ = 145.58, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 145.58, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Slender
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 54.75, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle} \text{x} 0.5B_{angle})$ = 446.76 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row} Q_n L_{pos}/S_{stud} + Q_{nh} L_{pos}/S_{angle}$ = 7486.84 kN
  where, entire positive moment region $L_{pos,ent}$ = 9000 mm ⇒ moment 0 ~ max. region L_{pos} = 4500 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row} Q_n L_{neg}/S_{stud} + Q_{nh} L_{neg}/S_{angle}$ = 3892.08 kN
  where, entire negative moment region $L_{neg,ent}$ = 3000 mm ⇒ moment 0 ~ max. region L_{pos} = 3000 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.49 ⇒ **Possible**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 15300.0 kN
- tensile stenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 20933.64 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 1.34 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab} f_{yr,slab}$ = 2906.2 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.27 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 4386 kN·m
- (yield) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{y,pos}$ = 16013.8 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.94 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 6733 kN·m
- (Slender) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{cr,pos}$ = 7178.6 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.3 ⇒ **O.K.**

- required shear strength V_u = 2461.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 8166.42 kN

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(6) Deflection

<Short-term> Vertical displacement 0.51 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 13891148 cm^4
- effecitive stiffness EI_{eff} = 0.8EI_{pos} + 0.2EI_{neg} = 18041981 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 1.92 mm

<Long-term> Vertical displacement 4 mm ≤ L/360.0 = 33.33 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0003
- overall deflection (construction + composite stage) : 5.84 mm

TSC Beam/Girder Design

Project **Y-1** 2025-06-20 14:22:17

Member 112_212TB1A Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 975×600×9×9(110)

- height H = 975.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 9.0 mm
- thk. t_w = 9.0 mm
- thk. t_{bf} = 9.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 15.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3000.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Pin

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	5	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 15116 N/m
- live load W_c = 2500.0 N/m^2

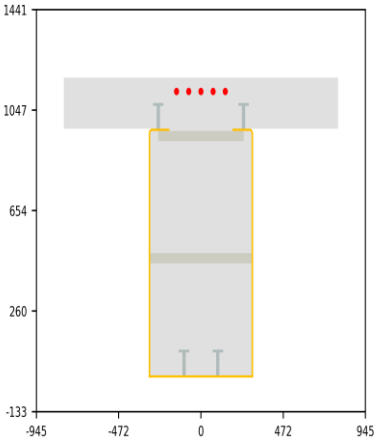
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 15000 N/m^2
- additional dead load W_{ud} = 6750 N/m^2
- required moment $M_{u,pos}$ = 2323 kN·m
- required moment $M_{u,neg}$ = 3659 kN·m
- required shear V_u = 1237 kN

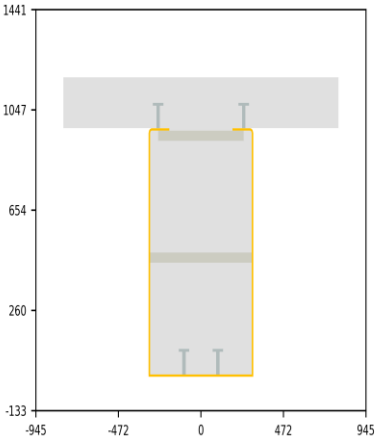
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 24606 mm^2
- centroid from bottom flange C_{yb} = 420 mm
- moment of inertia I_{xs} = 292553 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 6959 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 5274 cm^3
- plastic section modulus Z_x = 7523 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 12.72, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 17.2 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 121.25, $\lambda_{p,singly\ sym.}$ = 50.01, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 91.42, $\lambda_{p,singly\ sym.}$ = 107.01, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 64.67, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.51 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 744 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1464 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 1872 kN·m
  - compression flange buckling $M_{nc,fb} = [R_{pc} M_y - (R_{pc} M_{yc} - F_L S_{x,tf}(\lambda - \lambda_{pf})/(\lambda_{rf} - \lambda_{bf})]$ = 1626 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.79 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 1323 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1685 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 2470 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 1940 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.33 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 441 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6$F_y(2Ht_w)C_v$ = 1328.92 kN

  where, shear coefficient C_v = 0.4

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(5) Deflection:

<vertical displ.> δ_c = 13.04 mm < limit value = L/360.0 = 41.67 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 478.5 mm

- web: $\lambda = h_{input}/t_w$ = 53.17, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 53.17, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 64.67, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Noncompact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle}\text{x}0.5B_{angle})$ = 296.82 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row}Q_n L_{pos}/S_{stud} + Q_{nh}L_{pos}/S_{angle}$ = 7901.68 kN
  where, entire positive moment region $L_{pos,ent}$ = 11250 mm ⇒ moment 0 ~ max. region L_{pos} = 5625 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row}Q_n L_{neg}/S_{stud} + Q_{nh}L_{neg}/S_{angle}$ = 4419.56 kN
  where, entire negative moment region $L_{neg,ent}$ = 3750 mm ⇒ moment 0 ~ max. region L_{pos} = 3750 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.9 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 15300.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 8735.13 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 2.43 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab}f_{yr,slab}$ = 1816.1 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.43 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 2323 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 5404.02 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.89 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 3659 kN·m
- (Noncompact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{ply,pos}$ = 4094.21 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.37 ⇒ **O.K.**

- required shear strength V_u = 1237.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 3364.34 kN

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(6) Deflection

<Short-term> Vertical displacement 4.31 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 2479796 cm^4
- effecitive stiffness EI_{eff} = 0.8EI_{pos} + 0.2EI_{neg} = 4149288 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 17.36 mm

<Long-term> Vertical displacement 19 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0005
- overall deflection (construction + composite stage) : 32.88 mm

TSC Beam/Girder Design

Project **Y-1** 2025-06-20 14:22:09

Member 113_212TB2 Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 775×600×12×12(110)

- height H = 775.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 12.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 15.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3000.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Fixed

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	2	40	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 12480 N/m
- live load W_c = 2500.0 N/m^2

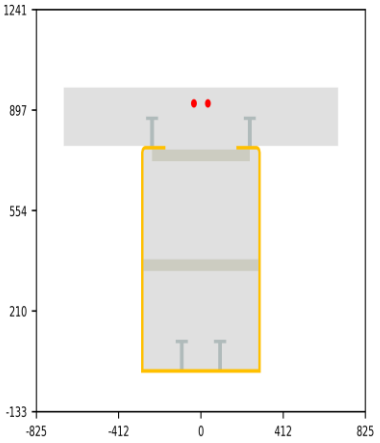
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 15000 N/m^2
- additional dead load W_{ud} = 6750 N/m^2
- required moment $M_{u,pos}$ = 1086 kN·m
- required moment $M_{u,neg}$ = 2603 kN·m
- required shear V_u = 974 kN

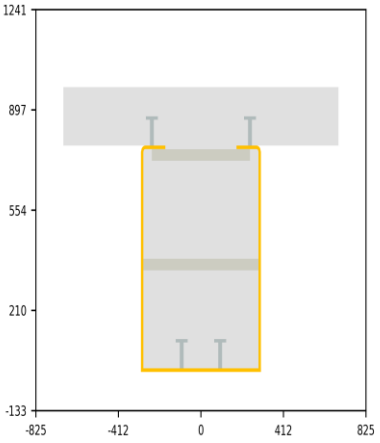
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 27864 mm^2
- centroid from bottom flange C_{yb} = 325 mm
- moment of inertia I_{xs} = 217077 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 6677 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 4824 cm^3
- plastic section modulus Z_x = 6921 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 19.64 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 72.99, $\lambda_{p,singly\ sym.}$ = 48.29, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 52.18, $\lambda_{p,singly\ sym.}$ = 123.05, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.0, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.46 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 694 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1522 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 1712 kN·m
  - compression flange buckling $M_{nc,fb}$ = [$R_{pc} M_y$ - ($R_{pc} M_{yc}$ - $F_L S_{x,tf}(\lambda$ - $\lambda_{pf})/(\lambda_{rf}$ - $\lambda_{bf})$] = 1691 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.8 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 1234 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1541 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 2370 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 2025 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.12 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 411 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6$F_y(2Ht_w)C_v$ = 3408.39 kN

  where, shear coefficient C_v = 0.96

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(5) Deflection:

<vertical displ.> δ_c = 15.99 mm < limit value = L/360.0 = 41.67 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 375.5 mm

- web: $\lambda = h_{input}/t_w$ = 31.29, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 31.29, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.0, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle}\text{x}0.5B_{angle})$ = 293.76 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row}Q_n L_{pos}/S_{stud} + Q_{nh}L_{pos}/S_{angle}$ = 6092.72 kN
  where, entire positive moment region $L_{pos,ent}$ = 8661 mm ⇒ moment 0 ~ max. region L_{pos} = 4330 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row}Q_n L_{neg}/S_{stud} + Q_{nh}L_{neg}/S_{angle}$ = 4484.48 kN
  where, entire negative moment region $L_{neg,ent}$ = 6339 mm ⇒ moment 0 ~ max. region L_{pos} = 3169 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.62 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 15300.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 9891.72 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 6.17 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab}f_{yr,slab}$ = 726.55 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.23 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 1086 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 4727.26 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.88 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 2603 kN·m
- (compact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 2964.37 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.27 ⇒ **O.K.**

- required shear strength V_u = 974.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 3565.62 kN

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(6) Deflection

<Short-term> Vertical displacement 2.48 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 1571618 cm^4
- effecitive stiffness EI_{eff} = 0.6EI_{pos} + 0.4EI_{neg} = 3469508 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 18.47 mm

<Long-term> Vertical displacement 8 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0004
- overall deflection (construction + composite stage) : 24.79 mm

TSC Beam/Girder Design

Project **Y-1** 2025-06-20 14:22:14

Member 114_212TB2A Code: KDS 41 Series 2022

1. Design Conditions

(1) steel section: TSC-NI/NO 775×600×12×12(110)

- height H = 775.0 mm
- width B = 600.0 mm
- thk. t_{tf} = 12.0 mm
- thk. t_w = 12.0 mm
- thk. t_{bf} = 12.0 mm
- width B_{tf} = 110.0 mm

(2) composite beam section:

- length L = 15.0 m
- slab thk. D_s = 200.0 mm
- effective slab width B_{eff} = 3000.0 mm
- boundary(construction): Fixed-Pin
- boundary(composite): Fixed-Pin

(3) reinforcement bars:

- slab

Yield S.	Diameter	EA	Distance	Location
550	29	5	40	End
550	29	2	100	End

(4) Applied loads:

<load factor>

- construction: α_D = 1.2, α_L = 1.6
- composite: α_D = 1.2, α_L = 1.6

<construction stage>

- dead load(slab) W_d = 4704 N/m^2
- dead load(TSC) W_s = 12480 N/m
- live load W_c = 2500.0 N/m^2

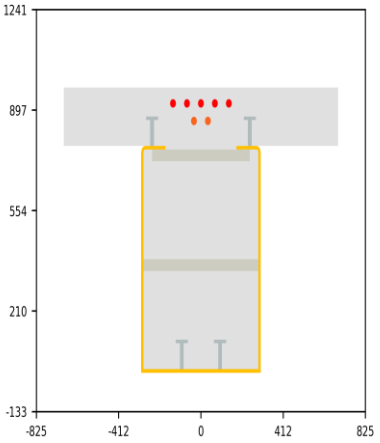
<composite stage>

- floor finishing load W_f = 0 N/m^2
- live load W_l = 15000 N/m^2
- additional dead load W_{ud} = 6750 N/m^2
- required moment $M_{u,pos}$ = 2229 kN·m
- required moment $M_{u,neg}$ = 3354 kN·m
- required shear V_u = 1193 kN

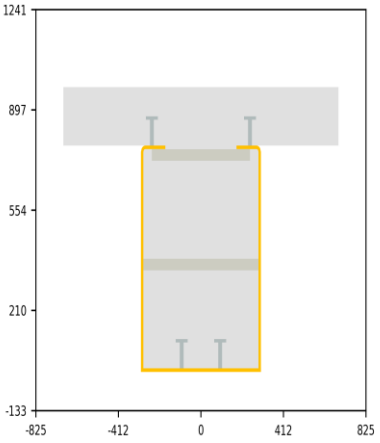
(5) Material properties:

- Concrete: E_c = 27537 MPa, f_{ck} = 30.0 MPa
- Steel: E_s = 210000 MPa, F_y = 355 MPa

<Beam section-End (mm)>



<Beam section-Center (mm)>



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(6) Shear connectors: **Headed studs**

- $F_{u,ac}$ = 400 MPa, diameter = 19 mm R_g = 1.0 R_p = 0.75
- M_{pos} region: n_{row} = 2, spacing S_{stud} = 200 mm
- M_{neg} region: n_{row} = 2, spacing S_{stud} = 200 mm

2. Construction Stage

(1) Sectional properties of u-shaped steel:

- area A_s = 27864 mm^2
- centroid from bottom flange C_{yb} = 325 mm
- moment of inertia I_{xs} = 217077 cm^4
- elastic section modulus to bot. flange $S_{x,bf}$ = 6677 cm^3
- elestic section modulus to top flange $S_{x,tf}$ = 4824 cm^3
- plastic section modulus Z_x = 6921 cm^3

(2) Classification of steel section:

<positive bending>

- top flange: $\lambda = b_{tf,in/out}/t_{tf}$ = 9.67, $\lambda_p = 0.38\sqrt{(E_s/F_y)}$ = 9.24, $\lambda_r = 0.95\sqrt{(k_c E_s/F_L)}$ = 19.64 ⇒ Noncompact
- web: $\lambda = h_c/t_w$ = 72.99, $\lambda_{p,singly\ sym.}$ = 48.29, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Noncompact

<negative bending>

- web: $\lambda = h_c/t_w$ = 52.18, $\lambda_{p,singly\ sym.}$ = 123.05, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.0, $\lambda_p = 1.12\sqrt{(E_s/F_y)}$ = 27.24, $\lambda_r = 1.40\sqrt{(E_s/F_y)}$ = 36.24 ⇒ Slender

(3) Flexural strength:

<positive moment> $M_{c,pos} / \Phi_b M_{nc,pos}$ = 0.46 ⇒ **O.K.**

- required moment $M_{c,pos} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2 x 9/128 = 694 kN·m
- design strength: $\Phi_b M_{nc,pos}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1522 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{x,tf}$ = 1712 kN·m
  - compression flange buckling $M_{nc,fb}$ = [$R_{pc} M_y$ - ($R_{pc} M_{yc}$ - $F_L S_{x,tf}(\lambda$ - $\lambda_{pf})/(\lambda_{rf}$ - $\lambda_{bf})$] = 1691 kN·m
  - tension flange yielding $M_{nc,fyt}$ = -
  - lateral torsional buckling $M_{nc,LTB}$ = -

<negative moment> $M_{c,neg} / \Phi_b M_{nc,neg}$ = 0.8 ⇒ **O.K.**

- required moment $M_{c,neg} = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L^2/8 = 1234 kN·m
- design strength: $\Phi_b M_{nc,neg}$ = 0.9 x min($M_{nc,fy}$, $M_{nc,fb}$, $M_{nc,fyt}$, $M_{nc,LTB}$) = 1541 kN·m
  - compression flange yielding $M_{nc,fy} = R_{pc} F_y S_{s,bf}$ = 2370 kN·m
  - compression flange buckling $M_{nc,fb} = F_y S_{eff}$ = 2025 kN·m
  - lateral torsional buckling $M_{nc,LTB}$ = -

(4) Shear strength:

<shear ratio> $V_c / \Phi_v V_{nc}$ = 0.12 ⇒ **O.K.**

- required shear strength $V_c = (\alpha_D(W_s + W_d B_{slab}) + \alpha_L W_c B_{slab})$ x L x5/8 = 411 kN
- design strength $\Phi_v V_{nc}$ = 0.9 x 0.6$F_y(2Ht_w)C_v$ = 3408.39 kN

  where, shear coefficient C_v = 0.96

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(5) Deflection:

<vertical displ.> δ_c = 15.99 mm < limit value = L/360.0 = 41.67 mm ⇒ **O.K.**

3. Composite Stage

(1) Classification of steel section:

<positive bending> Effective height of web h_{input} = 375.5 mm

- web: $\lambda = h_{input}/t_w$ = 31.29, $\lambda_p = 3.76\sqrt{(E_s/F_y)}$ = 91.45 ⇒ Compact

<negative bending>

- web: $\lambda = h_{input}/t_w$ = 31.29, $\lambda_p = 3.00\sqrt{(E_s/F_y)}$ = 72.97, $\lambda_r = 5.70\sqrt{(E_s/F_y)}$ = 138.63 ⇒ Compact
- bottom flange: $\lambda = b_{bf}/t_{bf}$ = 48.0, $\lambda_p = 2.26\sqrt{(E_s/F_y)}$ = 54.97, $\lambda_r = 3.00\sqrt{(E_s/F_y)}$ = 72.97 ⇒ Compact

(2) Shear connector strength: **Headed studs**

- nominal strength: $Q_n = 0.5A_{sa}\sqrt{(f_{ck}E_c)} \le R_g R_p A_{sa} F_{u,ac}$ = 85.06 kN
- strength of horizontal angles (width 40 mm, spacing 600 mm): $Q_{nh} = 0.85f_{ck}(L_{a,angle}\text{x}0.5B_{angle})$ = 293.76 kN
- (positive moment region)sum of shear strength $V_{q,pos} = n_{row}Q_n L_{pos}/S_{stud} + Q_{nh}L_{pos}/S_{angle}$ = 7871.08 kN
  where, entire positive moment region $L_{pos,ent}$ = 11250 mm ⇒ moment 0 ~ max. region L_{pos} = 5625 mm
- (negative moment region)sum of shear strength $V_{q,neg} = n_{row}Q_n L_{neg}/S_{stud} + Q_{nh}L_{neg}/S_{angle}$ = 4407.32 kN
  where, entire negative moment region $L_{neg,ent}$ = 3750 mm ⇒ moment 0 ~ max. region L_{pos} = 3750 mm

(3) Composite ratio:

<positive moment> $CR_{pos} = V_{q,pos}/\min\{V_{c,cr}, V_{s,cr}\}$ = 0.8 ⇒ **O.K.**

- compressive strength of slab $V_{c,cr} = 0.85f_{ck}B_{eff}D_s$ = 15300.0 kN
- tensile strenth of steel section $V_{s,cr} = A_s F_y A_{sr,beam} f_{yr,beam}$ = 9891.72 kN

<negative moment> $CR_{neg} = V_{q,neg}/V_{sr,cr}$ = 1.73 ⇒ **O.K.**

- tensile strength of slab re-bars $V_{sr,cr} = A_{sr,slab}f_{yr,slab}$ = 2542.6499999999996 kN

(4) Flexural strength

<Positive moment> moment ratio $M_{u,pos}/\Phi_b M_{n,pos}$ = 0.44 ⇒ **O.K.**

- required moment $M_{u,pos}$ = 2229 kN·m
- (plastic) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 5037.8 kN·m

<Negative moment> moment ratio $M_{u,neg}/\Phi_b M_{n,neg}$ = 0.84 ⇒ **O.K.**

- required moment $M_{u,neg}$ = 3354 kN·m
- (compact) design moment strength $\Phi_b M_{n,pos} = \Phi_b M_{pl,pos}$ = 4006.02 kN·m

(5) Shear strength shear strength ratio $V_u/\Phi_v V_n$ = 0.33 ⇒ **O.K.**

- required shear strength V_u = 1193.0 kN
- design shear strength $\Phi_v V_n = 0.9\text{x}0.6F_y A_w$ = 3565.62 kN

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(6) Deflection

<Short-term> Vertical displacement 7.36 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- transformed moment of inertia I_{tr} = 1571618 cm^4
- effecitive stiffness EI_{eff} = 0.8EI_{pos} + 0.2EI_{neg} = 2429646 kN-m^2
- effective I_{eff} = 0.75x(I_s + √(CR)(I_{tr} - I_s))
- overall deflection (construction + composite stage) : 23.36 mm

<Long-term> Vertical displacement 30 mm ≤ L/360.0 = 41.67 mm ⇒ **O.K.**

- years : 20.0
- relative humidity : 70.0%
- cement type 1 (wet curing)
- compressive strain due to creep and shrinkage: 0.0006
- overall deflection (construction + composite stage) : 46.67 mm