



一个汽车后轮横向分布宽

$$\begin{aligned} 0.6/2 + H \tan 30^\circ &= 2.12 \text{ m} > 1.3/2 \text{ m} \\ &> 1.8/2 \text{ m} \end{aligned}$$

故横向分布宽度

$$a = (0.6/2 + H \tan 30^\circ) \times 2 + 1.3 = 5.537 \text{ m}$$

同理，纵向，汽车后轮着地长度0.2m

$$0.2/2 + H \tan 30^\circ = 1.919 \text{ m} > 1.4/2 \text{ m}$$

故

$$b = (0.2/2 + H \tan 30^\circ) \times 2 = 3.837 \text{ m}$$

$$\Sigma G = 140 \text{ kN}$$

$$\text{车辆荷载垂直压力 } q_{\text{车}} = \Sigma G / (a \times b) = 6.59 \text{ kN/m}^2$$

$$\text{车辆荷载水平压力 } e_{\text{车}} = q_{\text{车}} \tan^2(45^\circ - \varphi/2) = 2.20 \text{ kN/m}^2$$

### (三) 内力计算

#### 1、构件刚度比

$$K = (I_1/I_2) \times (h_p/L_p) = 1.13$$

#### 2、节点弯矩和轴向力计算

##### (1) a种荷载作用下 (图L-02)

$$\text{涵洞四角节点弯矩 } M_{aA} = M_{aB} = M_{aC} = M_{aD} = -1/(K+1) \cdot pL_p^2/12$$

$$\text{横梁内法向力 } N_{a1} = N_{a2} = 0$$

$$\text{侧墙内法向力 } N_{a3} = N_{a4} = pL_p/2$$

$$\text{恒载 } p = p_{\text{恒}} = 74.20 \text{ kN/m}^2$$

$$M_{aA} = M_{aB} = M_{aC} = M_{aD} = -126.40 \text{ kN} \cdot \text{m}$$

$$N_{a3} = N_{a4} = 244.86 \text{ kN}$$

$$\text{车辆荷载 } p = q_{\text{车}} = 6.59 \text{ kN/m}^2$$

$$M_{aA} = M_{aB} = M_{aC} = M_{aD} = -11.22 \text{ kN} \cdot \text{m}$$

$$N_{a3} = N_{a4} = 21.74 \text{ kN}$$

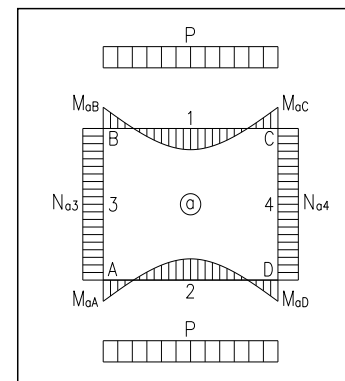


图 L-02

##### (2) b种荷载作用下 (图L-03)

$$M_{bA} = M_{bB} = M_{bC} = M_{bD} = -K/(K+1) \cdot ph_p^2/12$$

$$N_{b1} = N_{b2} = ph_p/2$$

$$N_{b3} = N_{b4} = 0$$

$$\text{恒载 } p = e_{p1} = 18.90 \text{ kN/m}^2$$

$$M_{bA} = M_{bB} = M_{bC} = M_{bD} = -18.46 \text{ kN} \cdot \text{m}$$

$$N_{b1} = N_{b2} = 44.42 \text{ kN}$$

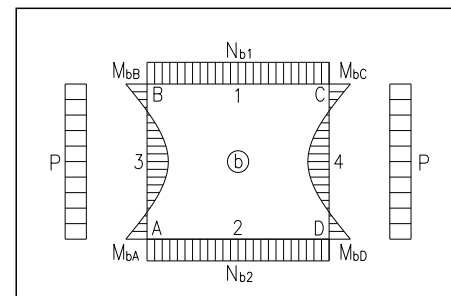


图 L-03

##### (3) c种荷载作用下 (图L-04)

$$M_{cA} = M_{cD} = -K(3K+8)/[(K+1)(K+3)] \cdot ph_p^2/60$$

$$M_{cB} = M_{cC} = -K(2K+7)/[(K+1)(K+3)] \cdot ph_p^2/60$$

$$N_{c1} = ph_p/6 + (M_{cA} - M_{cB})/h_p$$

$$N_{c2} = ph_p/3 - (M_{cA} - M_{cB})/h_p$$

$$N_{c3} = N_{c4} = 0$$

$$\text{恒载 } p = e_{p2} - e_{p1} = 32.40 \text{ kN/m}^2$$

$$M_{cA} = M_{cD} = -17.46 \text{ kN} \cdot \text{m}$$

$$M_{cB} = M_{cC} = -14.19 \text{ kN} \cdot \text{m}$$

$$N_{c1} = 24.69 \text{ kN}$$

$$N_{c2} = 51.45 \text{ kN}$$

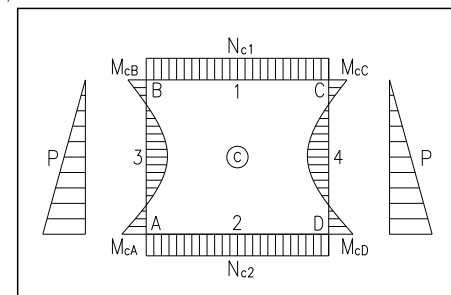


图 L-04

##### (4) d种荷载作用下 (图L-05)

$$M_{dA} = -[K(K+3)/6(K^2+4K+3) + (10K+2)/(15K+5)] \cdot ph_p^2/4$$

$$M_{dB} = -[K(K+3)/6(K^2+4K+3) - (5K+3)/(15K+5)] \cdot ph_p^2/4$$

$$M_{dC} = -[K(K+3)/6(K^2+4K+3) + (5K+3)/(15K+5)] \cdot ph_P^2/4$$

$$M_{dD} = -[K(K+3)/6(K^2+4K+3) - (10K+2)/(15K+5)] \cdot ph_P^2/4$$

$$N_{d1} = (M_{dD} - M_{dC})/h_P$$

$$N_{d2} = ph_P - (M_{dD} - M_{dC})/h_P$$

$$N_{d3} = -N_{d4} = -(M_{dB} - M_{dC})/L_P$$

$$p = e_{\text{车}} = 2.20 \quad \text{kN/m}^2$$

$$M_{dA} = -8.42 \quad \text{kN} \cdot \text{m}$$

$$M_{dB} = 3.71 \quad \text{kN} \cdot \text{m}$$

$$M_{dC} = -5.85 \quad \text{kN} \cdot \text{m}$$

$$M_{dD} = 6.28 \quad \text{kN} \cdot \text{m}$$

$$N_{d1} = 2.58 \quad \text{kN}$$

$$N_{d2} = 7.74 \quad \text{kN}$$

$$N_{d3} = -N_{d4} = -1.45 \quad \text{kN}$$

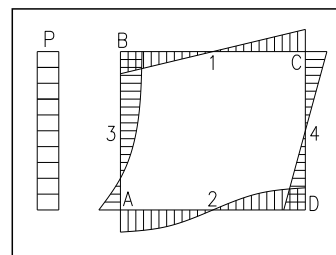


图 L-05

车辆荷载

(5) 节点弯矩、轴力计算及荷载效应组合汇总表

按《公路桥涵设计通用规范》(JTG D60—2004)第4.1.6条进行承载能力极限状态效应组合

| 荷载种类   |                 | M (kN·m)       |                |                |                | N (kN)         |                |                |                |
|--------|-----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|        |                 | M <sub>A</sub> | M <sub>B</sub> | M <sub>C</sub> | M <sub>D</sub> | N <sub>1</sub> | N <sub>2</sub> | N <sub>3</sub> | N <sub>4</sub> |
| 恒载     | a               | -126.40        | -126.40        | -126.40        | -126.40        | 0              | 0              | 244.86         | 244.86         |
|        | 1.2 × Σ 结构、土的重力 | -151.69        | -151.69        | -151.69        | -151.69        | 0              | 0              | 293.83         | 293.83         |
|        | b               | -18.46         | -18.46         | -18.46         | -18.46         | 44.42          | 44.42          | 0              | 0              |
|        | c               | -17.46         | -14.19         | -14.19         | -17.46         | 24.69          | 51.45          | 0              | 0              |
|        | 1.4 × Σ 土侧压力    | -50.29         | -45.72         | -45.72         | -50.29         | 96.74          | 134.22         | 0              | 0              |
| 车辆荷载   | a               | -11.22         | -11.22         | -11.22         | -11.22         | 0              | 0              | 21.74          | 21.74          |
|        | d               | -8.42          | 3.71           | -5.85          | 6.28           | 2.58           | 7.74           | -1.45          | 1.45           |
|        | 1.4 × Σ 汽车      | -27.51         | -10.53         | -23.91         | -6.93          | 3.61           | 10.84          | 28.41          | 32.47          |
| 荷载效应组合 |                 | -229.48        | -207.93        | -221.31        | -208.90        | 100.35         | 145.06         | 322.24         | 326.30         |

3、构件内力计算(跨中截面内力)

(1) 顶板 (图L-06)

$$x = L_P/2$$

$$P = 1.2p_{\text{恒}} + 1.4q_{\text{车}} = 98.26 \quad \text{kN}$$

$$N_x = N_1 = 100.35 \quad \text{kN}$$

$$M_x = M_B + N_3x - Px^2/2 = 320.43 \quad \text{kN} \cdot \text{m}$$

$$V_x = Px - N_3 = 2.03 \quad \text{kN}$$

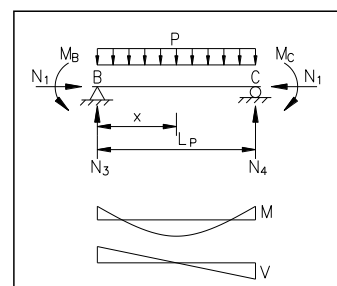


图 L-06

(2) 底板 (图L-07)

$$\omega_1 = 1.2p_{\text{恒}} + 1.4(q_{\text{车}} - 3e_{\text{车}}H_P^2/L_P^2)$$

$$= 93.59 \quad \text{kN/m}^2$$

$$\omega_2 = 1.2p_{\text{恒}} + 1.4(q_{\text{车}} + 3e_{\text{车}}H_P^2/L_P^2)$$

$$= 102.94 \quad \text{kN/m}^2$$

$$x = L_P/2$$

$$N_x = N_3 = 322.24 \quad \text{kN}$$

$$M_x = M_A + N_3x - \omega_1 \cdot x^2/2 - x^3(\omega_2 - \omega_1)/6L_P$$

$$= 315.86 \quad \text{kN} \cdot \text{m}$$

$$V_x = \omega_1x + x^2(\omega_2 - \omega_1)/2L_P - N_3$$

$$= -5.69 \quad \text{kN}$$

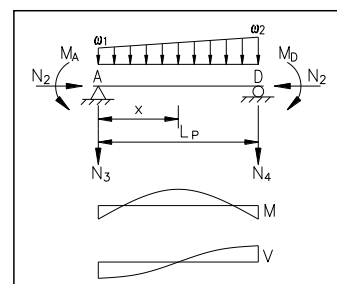


图 L-07

(3) 左侧墙 (图L-08)

$$\begin{aligned}
\omega_1 &= 1.4e_{p1} + 1.4e_{\text{左}} \\
&= 29.53 \quad \text{kN/m}^2 \\
\omega_2 &= 1.4e_{p2} + 1.4e_{\text{右}} \\
&= 74.89 \quad \text{kN/m}^2 \\
x &= h_p/2 \\
N_x = N_3 &= 322.24 \quad \text{kN} \\
M_x &= M_B + N_1 x - \omega_1 \cdot x^2/2 - x^3(\omega_2 - \omega_1)/6h_p \\
&= -74.53 \quad \text{kN} \cdot \text{m} \\
V_x &= \omega_1 x + x^2(\omega_2 - \omega_1)/2h_p - N_1 \\
&= -4.30 \quad \text{kN}
\end{aligned}$$

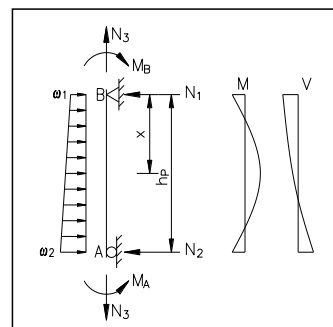


图 L-08

(4) 右侧墙 (图L-09)

$$\begin{aligned}
\omega_1 &= 1.4e_{p1} = 26.46 \quad \text{kN/m}^2 \\
\omega_2 &= 1.4e_{p2} = 71.82 \quad \text{kN/m}^2 \\
x &= h_p/2 \\
N_x = N_4 &= 326.30 \quad \text{kN} \\
M_x &= M_C + N_1 x - \omega_1 \cdot x^2/2 - x^3(\omega_2 - \omega_1)/6h_p \\
&= -79.42 \quad \text{kN} \cdot \text{m} \\
V_x &= \omega_1 x + x^2(\omega_2 - \omega_1)/2h_p - N_1 \\
&= -11.52 \quad \text{kN}
\end{aligned}$$

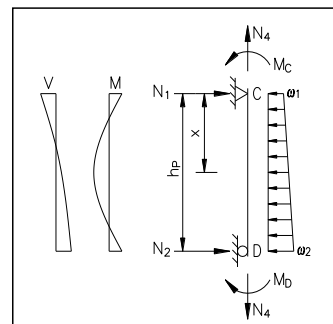


图 L-09

(5) 构件内力汇总表

| 构件    | $M_d$   | $N_d$  | $V_d$  | $M_d$  | $N_d$  | $V_d$  | $M_d$   | $N_d$  | $V_d$  |
|-------|---------|--------|--------|--------|--------|--------|---------|--------|--------|
| B - C | B       |        |        | B-C    |        |        | C       |        |        |
|       | -207.93 | 100.35 | 322.24 | 320.43 | 100.35 | 2.03   | -221.31 | 100.35 | 326.30 |
| A - D | A       |        |        | A-D    |        |        | D       |        |        |
|       | -229.48 | 145.06 | 322.24 | 315.86 | 145.06 | -5.69  | -208.90 | 145.06 | 326.30 |
| B - A | B       |        |        | B-A    |        |        | A       |        |        |
|       | -207.93 | 322.24 | 100.35 | -74.53 | 322.24 | -4.30  | -229.48 | 322.24 | 145.06 |
| C - D | C       |        |        | C-D    |        |        | D       |        |        |
|       | -221.31 | 326.30 | 100.35 | -79.42 | 326.30 | -11.52 | -208.90 | 326.30 | 145.06 |

#### (四) 截面设计

1、顶板 (B-C)

钢筋按左、右对称，用最不利荷载计算。

(1) 跨中

$$\begin{aligned}
l_0 &= 6.60 \text{ m}, & h &= 0.70 \text{ m}, & a &= 0.03 \text{ m}, & h_0 &= 0.67 \text{ m}, & b &= 1.00 \text{ m}, \\
M_d &= 320.43 \text{ kN} \cdot \text{m}, & N_d &= 100.35 \text{ kN}, & V_d &= 2.03 \text{ kN}
\end{aligned}$$

$$e_0 = M_d/N_d = 3.193 \text{ m}$$

$$i = h/12^{1/2} = 0.202 \text{ m}$$

长细比

$$l_0/i = 32.66 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7e_0/h_0 = 13.067 > 1.0, \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01l_0/h = 1.056 > 1.0, \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0/h)^2 \xi_1 \xi_2 h_0/1400e_0$$

$$\eta = 1.013$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 3.556 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$356.81 = 16100x(0.67 - x/2)$$

$$\text{解得} \quad x = 0.034 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.67 = 0.355 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = 0.001239 \text{ m}^2 = 1239.0 \text{ mm}^2$$

$$\mu = 100 A_s / (b h_0) = 0.18 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 360 \text{ mm}$  , 实际  $A_s = 1363.5 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 2021.5 \text{ kN} > r_0 V_d = 2.0 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 509.2 \text{ kN} > r_0 V_d = 2.0 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算, 仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

(2) 结点

$$l_0 = 6.60 \text{ m} , \quad h = \delta + C_1 = 0.95 \text{ m} , \quad a = 0.03 \text{ m} , \quad h_0 = 0.92 \text{ m} , \quad b = 1.00 \text{ m} ,$$

$$M_d = 221.31 \text{ kN} \cdot \text{m} , \quad N_d = 100.35 \text{ kN} , \quad V_d = 326.30 \text{ kN}$$

$$e_0 = M_d / N_d = 2.205 \text{ m}$$

$$i = h / 12^{1/2} = 0.274 \text{ m}$$

$$\text{长细比} \quad l_0 / i = 24.07 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7 e_0 / h_0 = 6.672 > 1.0 , \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01 l_0 / h = 1.081 > 1.0 , \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0 / h)^2 \xi_1 \xi_2 h_0 / 1400 e_0$$

$$\eta = 1.014$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 2.682 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$269.15 = 16100x(0.92 - x/2)$$

$$\text{解得} \quad x = 0.018 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.92 = 0.488 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = 0.0005421 \text{ m}^2 = 542.1 \text{ mm}^2$$

$$\mu = 100 A_s / (b h_0) = 0.06 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 260 \text{ mm}$  , 实际  $A_s = 1888.0 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 2775.8 \text{ kN} > r_0 V_d = 326.3 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 699.2 \text{ kN} > r_0 V_d = 326.3 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算, 仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

2、底板 (A-D)

钢筋按左、右对称, 用最不利荷载计算。

(1) 跨中

$$l_0 = 6.60 \text{ m} , \quad h = 0.70 \text{ m} , \quad a = 0.03 \text{ m} , \quad h_0 = 0.67 \text{ m} , \quad b = 1.00 \text{ m} ,$$

$$M_d = 315.86 \text{ kN} \cdot \text{m} , \quad N_d = 145.06 \text{ kN} , \quad V_d = 5.69 \text{ kN}$$

$$e_0 = M_d / N_d = 2.177 \text{ m}$$

$$i = h / 12^{1/2} = 0.202 \text{ m}$$

$$\text{长细比} \quad l_0/i = 32.66 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7e_0/h_0 = 8.975 > 1.0, \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01l_0/h = 1.056 > 1.0, \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0/h)^2 \xi_1 \xi_2 h_0 / 1400 e_0$$

$$\eta = 1.020$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 2.540 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$368.44 = 16100x (0.67 - x/2)$$

$$\text{解得} \quad x = 0.035 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.67 = 0.355 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = 0.0011657 \text{ m}^2 = 1165.7 \text{ mm}^2$$

$$\mu = 100 A_s / (b h_0) = 0.17 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 360 \text{ mm}$  , 实际  $A_s = 1363.5 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 2021.5 \text{ kN} > r_0 V_d = 5.7 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 509.2 \text{ kN} > r_0 V_d = 5.7 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算, 仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

(2) 结点

$$l_0 = 6.60 \text{ m}, \quad h = \delta + C_1 = 0.95 \text{ m}, \quad a = 0.03 \text{ m}, \quad h_0 = 0.92 \text{ m}, \quad b = 1.00 \text{ m},$$

$$M_d = 229.48 \text{ kN} \cdot \text{m}, \quad N_d = 145.06 \text{ kN}, \quad V_d = 322.24 \text{ kN}$$

$$e_0 = M_d / N_d = 1.582 \text{ m}$$

$$i = h/12^{1/2} = 0.274 \text{ m}$$

$$\text{长细比} \quad l_0/i = 24.07 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7e_0/h_0 = 4.843 > 1.0, \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01l_0/h = 1.081 > 1.0, \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0/h)^2 \xi_1 \xi_2 h_0 / 1400 e_0$$

$$\eta = 1.020$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 2.059 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$298.63 = 16100x (0.92 - x/2)$$

$$\text{解得} \quad x = 0.020 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.92 = 0.488 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = 0.0005088 \text{ m}^2 = 508.8 \text{ mm}^2$$

$$\mu = 100 A_s / (b h_0) = 0.06 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 260 \text{ mm}$  , 实际  $A_s = 1888.0 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 2775.8 \text{ kN} > r_0 V_d = 322.2 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 699.2 \text{ kN} > r_0 V_d = 322.2 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算，仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

### 3、左、右侧板 (B-A, C-D)

#### (1)板中

$$l_0 = 4.70 \text{ m}, \quad h = 0.60 \text{ m}, \quad a = 0.03 \text{ m}, \quad h_0 = 0.57 \text{ m}, \quad b = 1.00 \text{ m},$$

$$M_d = 79.42 \text{ kN} \cdot \text{m}, \quad N_d = 326.30 \text{ kN}, \quad V_d = 11.52 \text{ kN}$$

$$e_0 = M_d/N_d = 0.243 \text{ m}$$

$$i = h/12^{1/2} = 0.173 \text{ m}$$

$$\text{长细比} \quad l_0/i = 27.14 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7e_0/h_0 = 1.353 > 1.0, \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01l_0/h = 1.072 > 1.0, \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0/h)^2 \xi_1 \xi_2 h_0 / 1400 e_0$$

$$\eta = 1.103$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 0.538 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$175.67 = 16100 x (0.57 - x/2)$$

$$\text{解得} \quad x = 0.019 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.57 = 0.302 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = -3.54 \times 10^{-5} \text{ m}^2 \quad \Rightarrow \quad 35.4 \text{ mm}^2$$

$$\mu = 100 A_s / (b h_0) = -0.01 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 430 \text{ mm}$  , 实际  $A_s = 1141.6 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 1719.8 \text{ kN} > r_0 V_d = 11.5 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 433.2 \text{ kN} > r_0 V_d = 11.5 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算，仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

#### (2)结点

$$l_0 = 4.70 \text{ m}, \quad h = t + C_2 = 0.85 \text{ m}, \quad a = 0.03 \text{ m}, \quad h_0 = 0.82 \text{ m}, \quad b = 1.00 \text{ m},$$

$$M_d = 229.48 \text{ kN} \cdot \text{m}, \quad N_d = 322.24 \text{ kN}, \quad V_d = 145.06 \text{ kN}$$

$$e_0 = M_d/N_d = 0.712 \text{ m}$$

$$i = h/12^{1/2} = 0.245 \text{ m}$$

$$\text{长细比} \quad l_0/i = 19.15 > 17.5$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.3.10条

$$\xi_1 = 0.2 + 2.7e_0/h_0 = 2.545 > 1.0, \quad \text{取} \xi_1 = 1.00$$

$$\xi_2 = 1.15 - 0.01l_0/h = 1.095 > 1.0, \quad \text{取} \xi_2 = 1.00$$

$$\eta = 1 + (l_0/h)^2 \xi_1 \xi_2 h_0 / 1400 e_0$$

$$\eta = 1.025$$

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTJ D62—2004)第5.3.5条

$$e = \eta e_0 + h/2 - a = 1.125 \text{ m}$$

$$r_0 N_d e = f_{cd} b x (h_0 - x/2)$$

$$362.54 = 16100 x (0.82 - x/2)$$

$$\text{解得} \quad x = 0.028 \text{ m} \leq \xi_b h_0 = 0.53 \times 0.82 = 0.435 \text{ m}$$

故为大偏心受压构件。

$$A_s = (f_{cd} b x - r_0 N_d) / f_{sd} = 0.0003543 \text{ m}^2 = 354.3 \text{ mm}^2$$

$$\mu = 100A_s / (bh_0) = 0.04 \% < 0.2 \%$$

应按最小配筋率配置受拉钢筋。

选用  $\Phi 25 @ 290 \text{ mm}$  , 实际  $A_s = 1692.7 \text{ mm}^2$

$$0.51 \times 10^{-3} f_{cu,k}^{1/2} b h_0 = 2474.1 \text{ kN} > r_0 V_d = 145.1 \text{ kN}$$

故抗剪截面符合《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.9条的要求。

由《公路钢筋混凝土及预应力混凝土桥涵设计规范》(JTG D62—2004)第5.2.10条

$$0.50 \times 10^{-3} \alpha_2 f_{td} b h_0 = 623.2 \text{ kN} > r_0 V_d = 145.1 \text{ kN}$$

故可不进行斜截面抗剪承载力的验算, 仅需按(JTG D62—2004)第9.3.13条构造要求配置箍筋。

### (五)配筋图

见设计图纸。

### (六)基底应力验算

#### 1、荷载计算 (取单位涵长计算)

##### (1)恒载

$$\text{箱重力} \quad P_{\text{箱}} = 2\gamma_2 (\delta L + t h_0 + C_1 C_2) = 375.1 \text{ kN}$$

$$\text{基础重力} \quad P_{\text{基}} = \gamma_3 B d = 18.2 \text{ kN}$$

$$\text{填土重力} \quad P_{\text{土}} = \gamma_1 H L = 408.2 \text{ kN}$$

$$\text{水重力} \quad P_{\text{水}} = \gamma_{\text{水}} (L_0 h_0 - 2 C_1 C_2) = 238.8 \text{ kN}$$

##### (2)车辆荷载 (由图L-07)

$$\text{竖直力} \quad P_{\text{车}} = q_{\text{车}} L = 47.4 \text{ kN}$$

$$\text{水平力} \quad E_{\text{车}} = e_{\text{车}} (h+d) = 12.1 \text{ kN}$$

$$\text{弯矩} \quad M_{\text{车}} = E_{\text{车}} (h+d) / 2 = 33.2 \text{ kN} \cdot \text{m}$$

#### 2、基底应力

$$N = P_{\text{箱}} + P_{\text{基}} + P_{\text{土}} + P_{\text{水}} + P_{\text{车}} = 1087.8 \text{ kN}$$

$$M = M_{\text{车}} = 33.2 \text{ kN} \cdot \text{m}$$

由《公路桥涵地基与基础设计规范》(JTJ 024—85)第3.2.2-2式

$$\begin{aligned} \sigma &= N/A \pm M/W = N/B \pm 6M/B^2 \\ &= \frac{146.6}{139.7} \text{ kPa} < [\sigma_0] = 200 \text{ kPa} \end{aligned}$$

基底应力满足设计要求。