AASHTO LRFD Bridge Design Specifications

Cover Height Calculations by the National Corrugated Steel Pipe Association

Corrugated Steel Pipe

AASHTO Vehicle Loading

HL93 Truck	32 kips/axle
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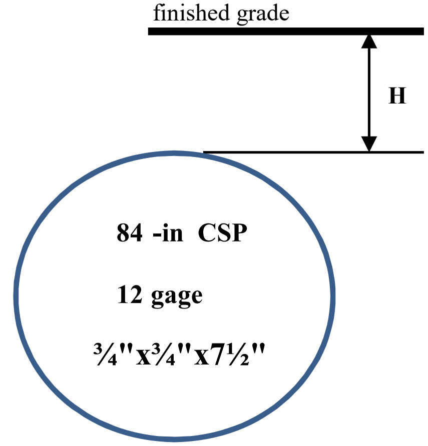
Fill Height Parameters	H (ft)
Maximum Cover Height	47
Minimum Cover Height	0.7
AASHTO Minimum Cover	1.0
Governing Minimum Cover	1.0

Corrugation Section Properties	
Thickness (in)	0.109
Area, A (in^2/ft)	1.184
Radius of Gyration, r (in)	0.2370
Moment of Inertia, I (in^4/in)	0.005537



Cover Height Investigated, H (ft) = 1.0

(1) Determine the factored vertical crown pressure, P_L (ksf)

$$P_L = \eta_{EV}\gamma_{EV}\,DL + [\eta_{LL}\gamma_{LL}(m)(IM)(LL) + 0.064]$$

η_{EV} (vertical earth pressure load modifier) = 1.00

γ_{EV} (vertical earth pressure load factor) = 1.95

η_{LL} (LL load modifier) = 1.0

γ_{LL} (LL load factor) = 1.75

The dynamic load allowance factor (IM) is a percentage increase in the live load to account for the rolling motion of the vehicle.

m (single-lane multiple presence factor) = 1.2

A design lane load of 0.064 ksf shall be added to the factored live load.

Vertical Earth Pressure, EV (ksf) $\quad EV = \gamma_s H \quad$ γ_S (soil density, kcf) = 0.120

EV = 0.12 ksf

Live load (LL) spreads with increasing depth of fill as a function of the live load distribution factor (LLDF = 1.15). Compute the depth at which wheels on adjacent axles interact (Figure A), and the depth at which wheels on the same axle interact (Figure B). Wheel loads shall be added as appropriate and applied over the total interaction dimension(s) for cover depths that exceed the interaction depth. Evaluate both the design truck and the design tandem to determine which configuration produces the maximum load.

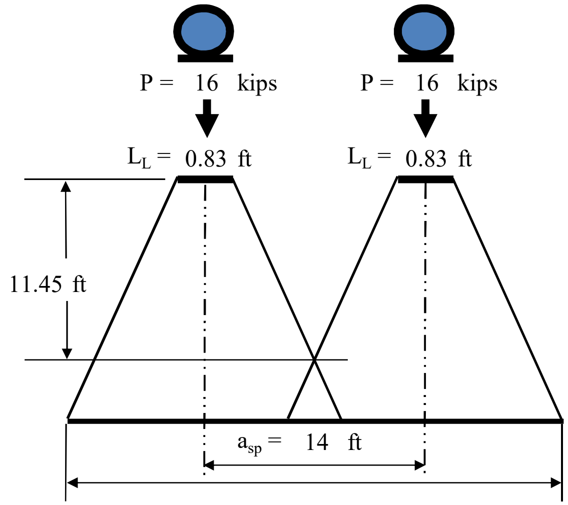
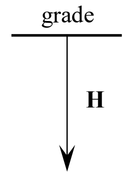


Figure A. Total Interaction Length

HL93 Truck

LL = 2.86 ksf



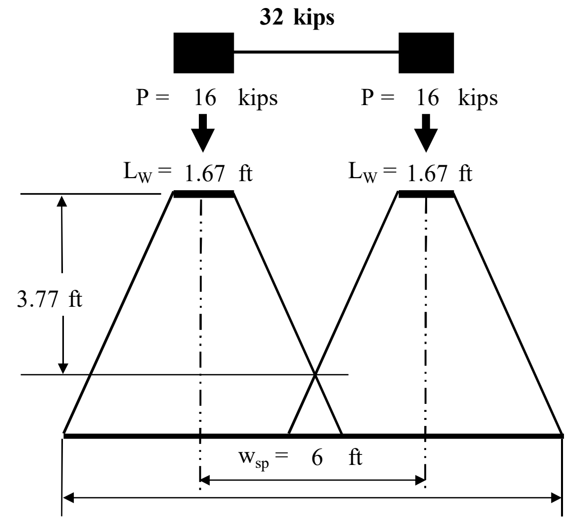


Figure B. Total Interaction Width

$H \leq 3.77$	$LL = P \div (L_W + 1.15H)(L_L + 1.15H)$
$H \leq 11.45$	$LL = 2P \div (L_W + 1.15H + w_{sp})(L_L + 1.15H)$
$H > 11.45$	$LL = 4P \div (L_W + 1.15H + w_{sp})(L_L + 1.15H + a_{sp})$

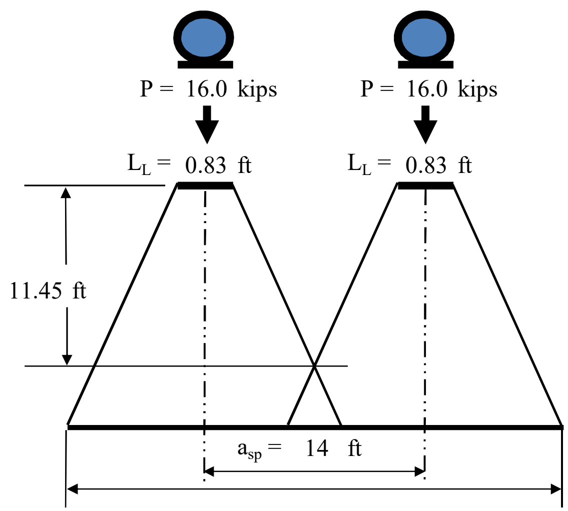
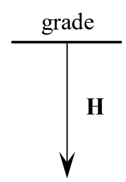


Figure A. Total Interaction Length

HL93 Truck

LL = 2.86 ksf



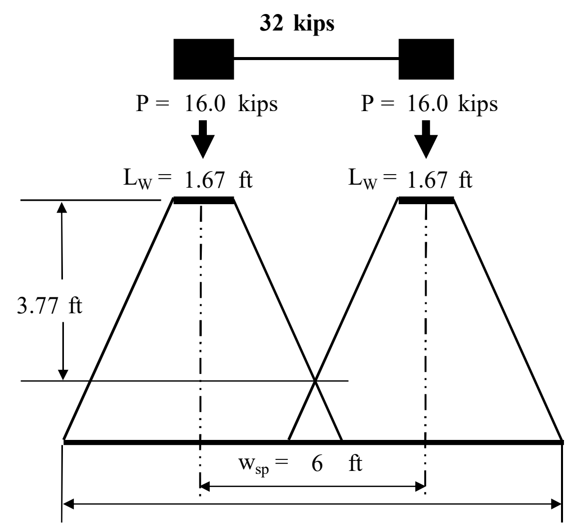


Figure B. Total Interaction Width

$H \leq 11.45$	$LL = P \div (L_W + 1.15H)(L_L + 1.15H)$
$H \leq 3.77$	$LL = 2P \div (L_W + 1.15H + w_{sp})(L_L + 1.15H)$
$H > 3.77$	$LL = 4P \div (L_W + 1.15H + w_{sp})(L_L + 1.15H + a_{sp})$

MAX LL = 2.86 ksf

Dynamic Load Allowance (IM) Impact Load (%) **$IM = 33(1.0 - 0.125H) \geq 0\%$**

IM = 28.88 % **The factor to be applied to the static load = 1.29**

$P_L = \eta_{EV}\gamma_{EV}\ EV + [\eta_{LL}\gamma_{LL}(m)(IM)(LL) + 0.064] =$ 8.05 ksf

(2) Determine factored thrust per unit length of wall, T_L (kpf) **$T_L = P_L(S/24)$** S, span of arch pipe (in) = 84

$T_L =$ 28.17 kpf

(3) Determine Critical Buckling Stress, f_{cr} (ksi)

(a) If $S < (r/k)(24E_m/F_u)^{1/2}$, then $f_{cr} = F_u - (F_u kS/r)^2/48E_m$

(b) If $S > (r/k)(24E_m/F_u)^{1/2}$, then $f_{cr} = 12E_m/(kS/r)^2$

E_m (ksi) =	29,000	r, radius of gyration (in) =	0.2370
F_y (ksi) =	33	k (soil stiffness factor) =	0.22
F_u (ksi) =	45	S, pipe arch span (in) =	84

$S < (r/k)(24E_m/F_u)^{1/2} =$ 133.975

Therefore use equation (a) above

$f_{cr} =$ 36.16 ksi

(4) Determine the Factored Axial Resistance to Buckling R_n (kpf) **$R_n = \phi_w F_y A$**

If the critical buckling stress is less than the actual yield stress then the resistance to buckling must be calculated using f_{cr} in place of F_y.

F_y (ksi) = 33 A = wall area (in^2/ft) = 1.184

$\phi_w = 1.0$

The actual yield strength is less than the critical buckling stress therefore use F_y (ksi) = 33.00

$R_n =$ 39.07 kpf greater than T_L, therefore OK

(5) Check Flexibility Factor, FF (in/kip) **$FF = S^2/E_m I$**

E_m (ksi) =	29,000	S, pipe arch span (in) =	84
I (in^4/in) =	0.005537	FF max allowed (in/kip) =	46.53
		Trench Installation Only	

FF actual (in/kip) = 43.94

The actual FF is less than the maximum allowed, therefore OK