4.8 *SURCHARGE LOADS*

A surcharge load is any load which is imposed upon the surface of the soil close enough to the excavation to cause a lateral pressure to act on the system in addition to the basic earth pressure. Groundwater will also cause an additional pressure, but it is not a surcharge load.

Examples of surcharge loads are spoil embankments adjacent to the trench, streets or highways, construction machinery or material stockpiles, adjacent buildings or structures, and railroads.

4.8.1 Minimum Construction Surcharge Load

The minimum lateral construction surcharge of 72 psf (σ_h) shall be applied to the shoring system to a depth of 10 feet (Hs) below the shoring system or to the excavation line whichever is less. See Figure 4-47. This is the minimum surcharge loading that shall be applied to any shoring system regardless of whether or not the system is actually subjected to a surcharge loading. Surcharge loads which produce lateral pressures greater than 72 psf would be used in lieu of this prescribed minimum.

This surcharge is intended to provide for the normal construction loads imposed by small vehicles, equipment, or materials, and workmen on the area adjacent to the trench or excavation. It should be added to all basic earth pressure diagrams. This minimum surcharge can be compared to a soil having parameters of γ= 109 pcf and Ka = 0.33 for a depth of 2 feet [(0.33)(109)(2) = 72 psf]

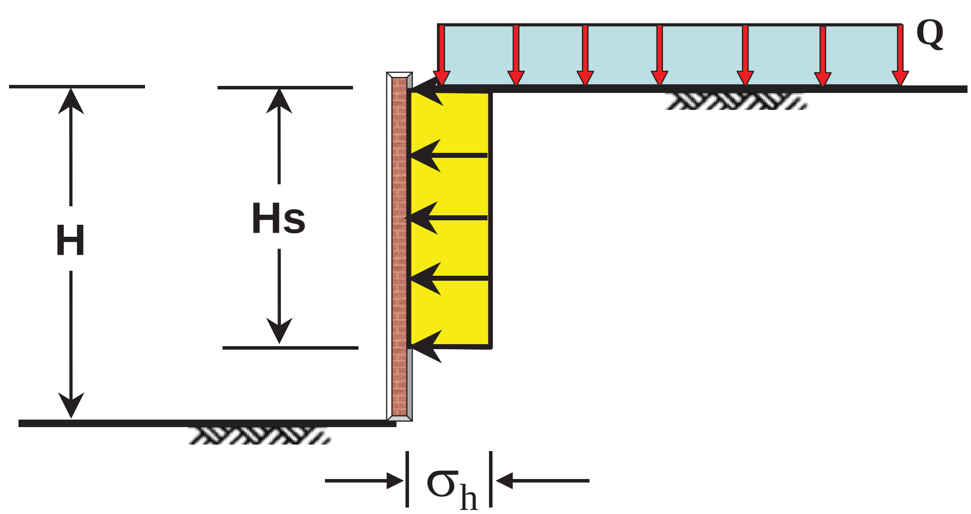


Figure 4-47. Minimum Lateral Surcharge Load

4.8.2 Uniform Surcharge Loads

Where a uniform surcharge is present, a constant horizontal earth pressure must be added to the basic lateral earth pressure. This constant earth pressure may be taken as:

$$\sigma_h = (K)(Q) \quad \text{Eq. 4-66}$$

Where:

σ_h = constant horizontal earth pressure due to uniform surcharge

K = coefficient of lateral earth pressure due to surcharge for the following conditions:

- Use K_a for active earth pressure.
- Use K_o for at-rest earth pressure.

Q = uniform surcharge applied to the wall backfill surface within the limits of the active failure wedge.

4.8.3 Boussinesq Loads

Typically, there are three (3) types of Boussinesq Loads. They are as follows:

4.8.3.1 Strip Load

Strip loads are loads such as highways and railroads that are generally parallel to the wall.

The general equation for determining the pressure at distance h below the ground line is (See Figure 4-48):

$$\sigma_h = \frac{2Q}{\pi}\left[\beta_R - \sin\beta\cos(2\alpha)\right] \qquad \text{Eq. 4-67}$$

Where β_R is in radians.

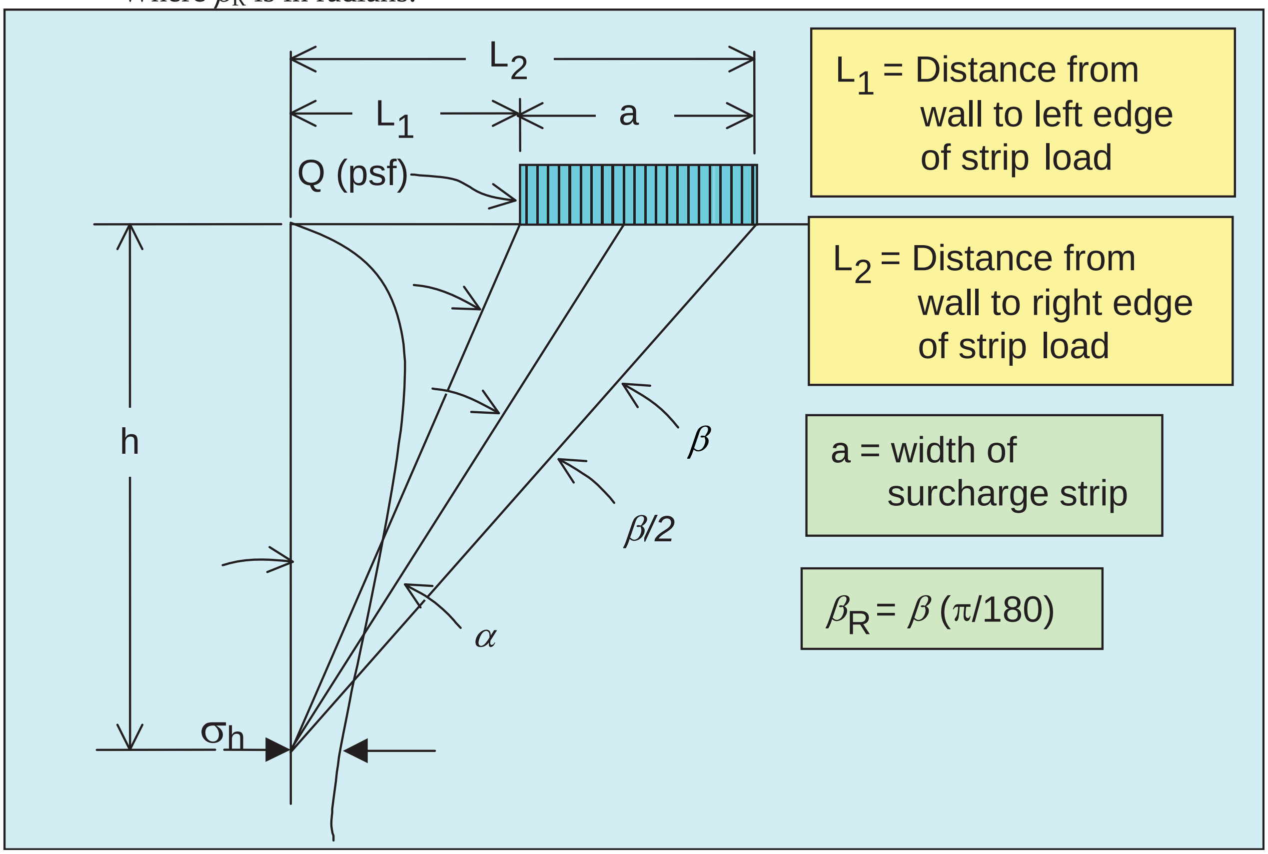


Figure 4-48. Boussinesq Type Strip Load

4.8.3.2 Line Load

A line load is a load such as a continuous wall footing of narrow width or similar load generally parallel to the wall. K-Railing could be considered to be a line load.

The general equation for determining the pressure at distance h below the ground line is: (See Figure 4-49)

For m ≤ 0.4:

$$\sigma_h = \frac{Q_l}{H}\frac{0.2n}{\left(0.16+n^2\right)^2} \qquad \text{Eq. 4-68}$$

For m > 0.4

$$\sigma_h = 1.28\frac{Q_l}{H}\frac{m^2 n}{\left(m^2+n^2\right)^2} \qquad \text{Eq. 4-69}$$

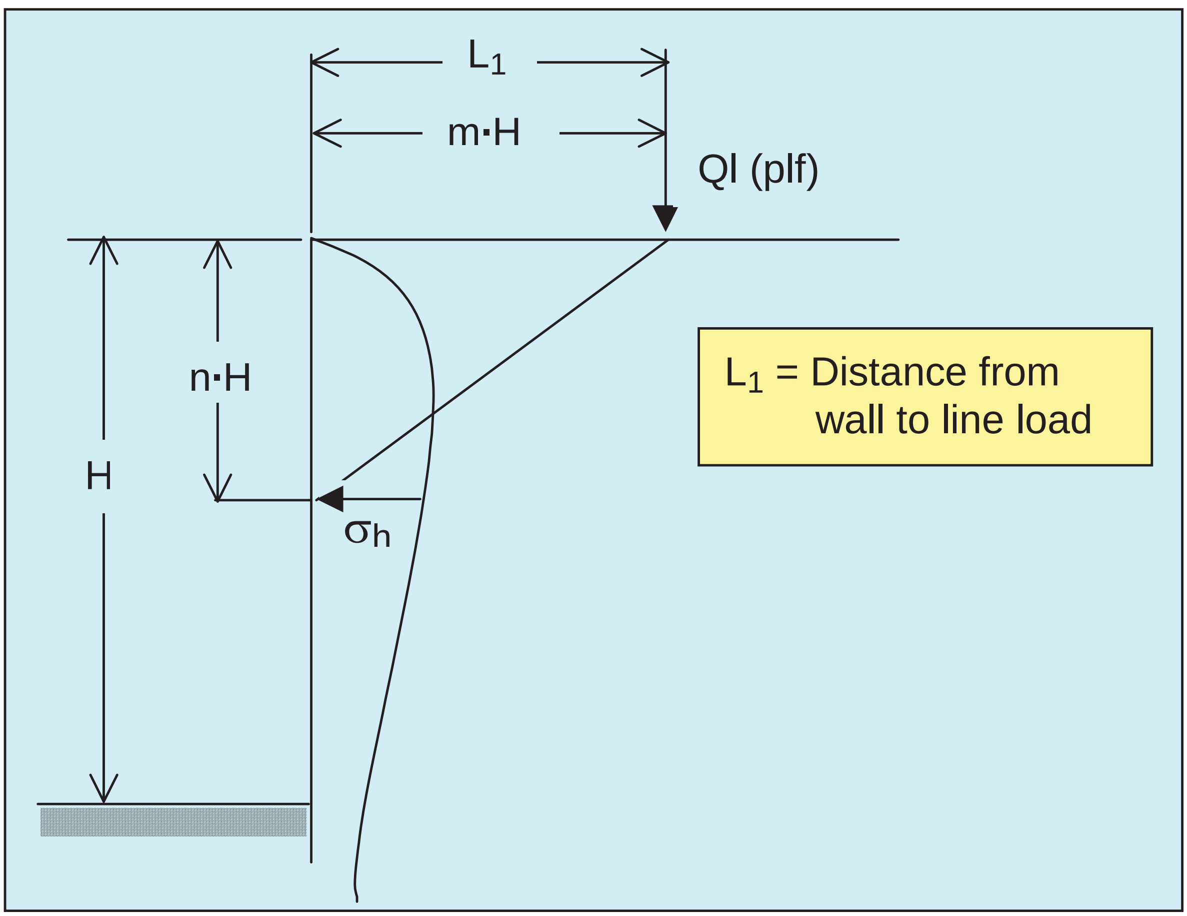


Figure 4-49. Boussinesq Type Line Load

4.8.3.3 Point Load

Point loads are loads such as outrigger loads from a concrete pump or crane. A wheel load from a concrete truck may also be considered a point load when the concrete truck is adjacent an excavation and in the process of the unloading. The truck could be positioned either parallel or perpendicular to the excavation.

The general equation for determining the pressure at distance h below the ground line is: (See Figure 4-50)

For m ≤ 0.4:

$$\sigma_h = 0.28 \frac{Q_p}{H^2} \frac{n^2}{(0.16 + n^2)^3} \qquad \text{Eq. 4-70}$$

For m > 0.4

$$\sigma_h = 1.77 \frac{Q_p}{H^2} \frac{m^2 n^2}{(m^2 + n^2)^3} \qquad \text{Eq. 4-71}$$

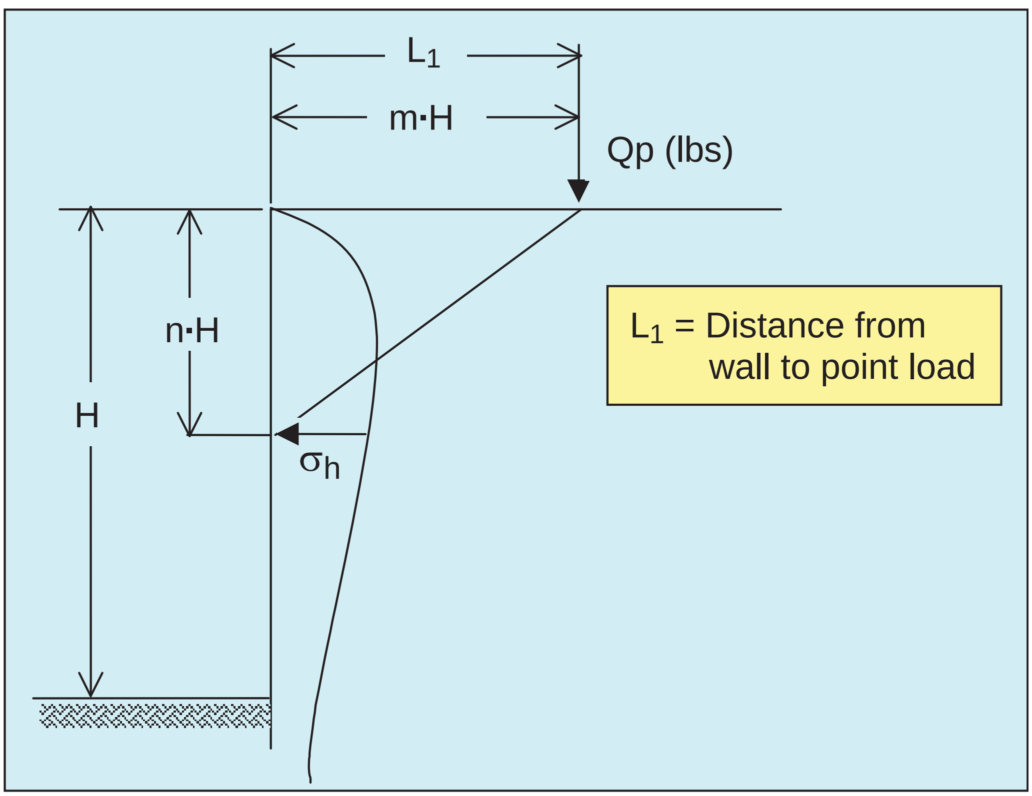


Figure 4-50. Boussinesq Type Point Load

In addition, σ_h is further adjusted by the following when the point is further away from the line closest to the point load: (see Figure 4-51)

$$\sigma_h' = \sigma_h \cos^2[(1.1)\theta] \qquad \text{Eq. 4-72}$$

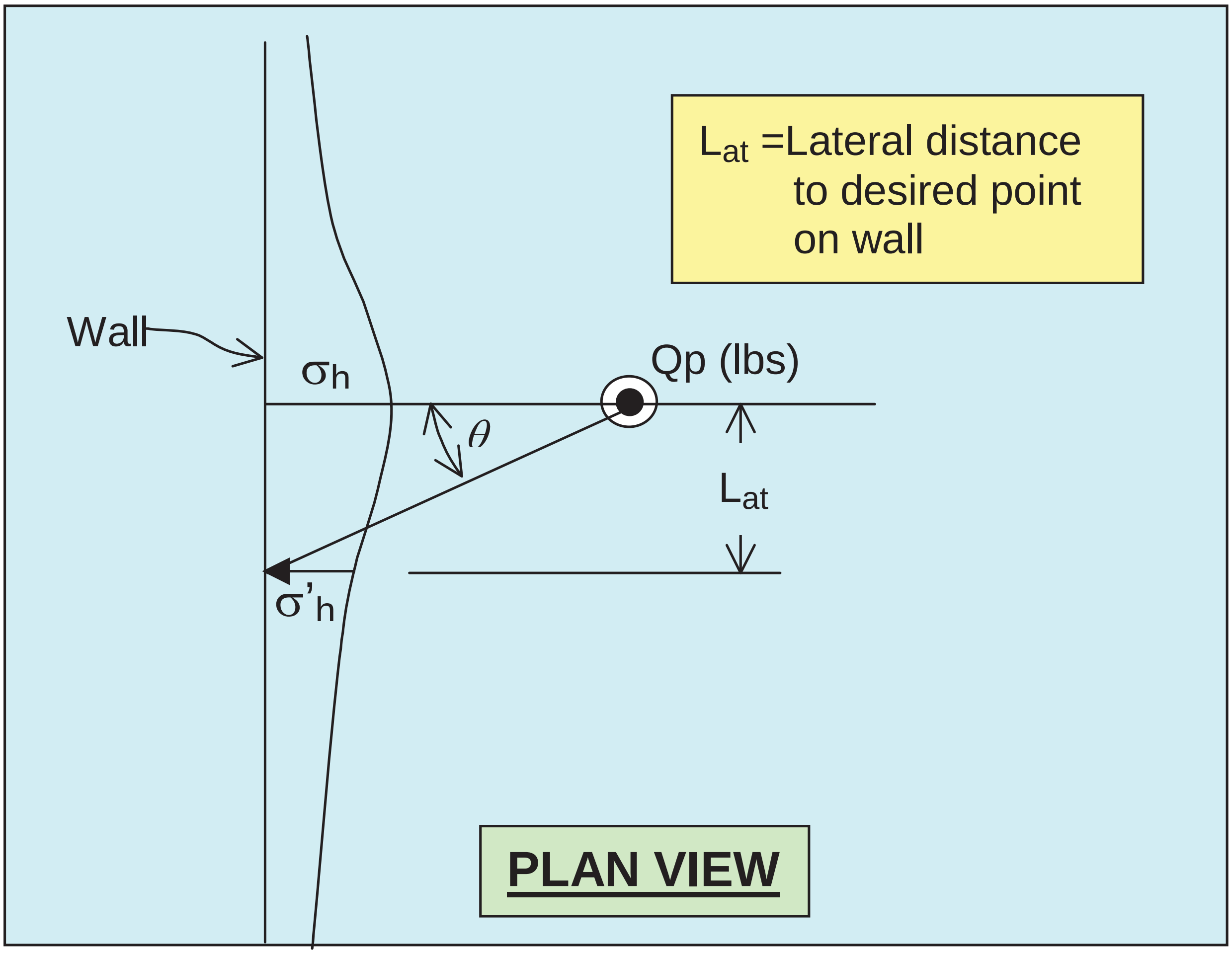


Figure 4-51. Boussinesq Type Point Load with Lateral Offset

4.8.4 Traffic Loads

Traffic near an excavation is one of the more commonly occurring surcharge loads. Trying to analyze every possible scenario would be time consuming and not very practical. For normal situations, a surcharge load of 300 psf spread over the width of the traveled way should be sufficient.

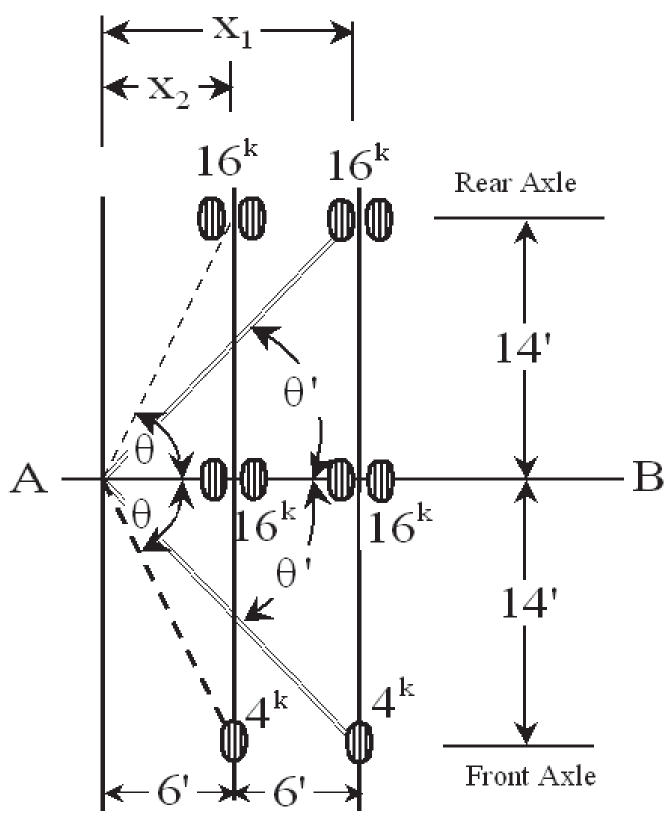
The following example compares the pressure diagrams for a HS20 truck. (using point loads) centered in a 12' lane to a load of Q = 300 psf (using the Boussinesq Strip method). The depth of excavation is 10'.

$$x_1 = m_1 H$$
$$\therefore m_1 = 12/10 = 1.2$$

$$x_2 = m_2 H$$
$$\therefore m_2 = 6/10 = 0.6$$

$$n = depth/H$$

Depth	n
2’	0.2
4’	0.4
6’	0.6
8’	0.8
10’	1.0



For line AB, see Eq. 4-71. For loads at an angle to AB, see Eq. 4-72.

Front and rear right wheels: $\theta = 66.8°, \therefore \cos^2[(1.1)(66.8°)] = 0.08$

Front and rear left wheels: $\theta = 49.4°, \therefore \cos^2[(1.1)(49.4°)] = 0.34$

1.) Right rear wheels: $\sigma_h = \dfrac{(0.08)(1.77)(16{,}000)(0.6^2)(n^2)}{10^2(0.6^2 + n^2)^3}$

2.) Left rear wheels: $\sigma_h = \dfrac{(0.34)(1.77)(16{,}000)(1.2^2)(n^2)}{10^2(1.2^2 + n^2)^3}$

3.) Right center wheels: $\sigma_h = \dfrac{(1.77)(16{,}000)(0.6^2)(n^2)}{10^2(0.6^2 + n^2)^3}$

4.) Left center wheels: $\sigma_h = \dfrac{(1.77)(16{,}000)(1.2^2)(n^2)}{10^2(1.2^2 + n^2)^3}$

5.) Right front wheels: $\sigma_h = \dfrac{(0.08)(1.77)(4{,}000)(0.6^2)(n^2)}{10^2(0.6^2 + n^2)^3}$

6.) Left front wheels: $\sigma_h = \dfrac{(0.34)(1.77)(4{,}000)(1.2^2)(n^2)}{10^2(1.2^2 + n^2)^3}$

Combine and simplify similar equations:

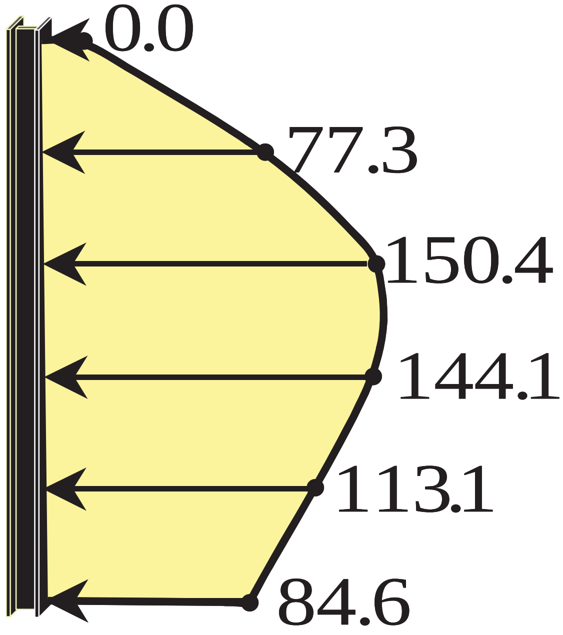
a.) $\sigma_H = \dfrac{(112.2)(n^2)}{(0.36 + n^2)^3}$

b.) $\sigma_H = \dfrac{(581.1)(n^2)}{(1.44 + n^2)^3}$

Depth	n	a.) σ_H	b.) σ_H	$\sum \sigma_H$
0’	0.0	0.0	0.0	0.0
2’	0.2	70.1	7.2	77.3
4’	0.4	127.7	22.7	150.4
6’	0.6	108.2	35.9	144.1
8’	0.8	71.8	41.3	113.1
10’	1.0	44.6	40.0	84.6

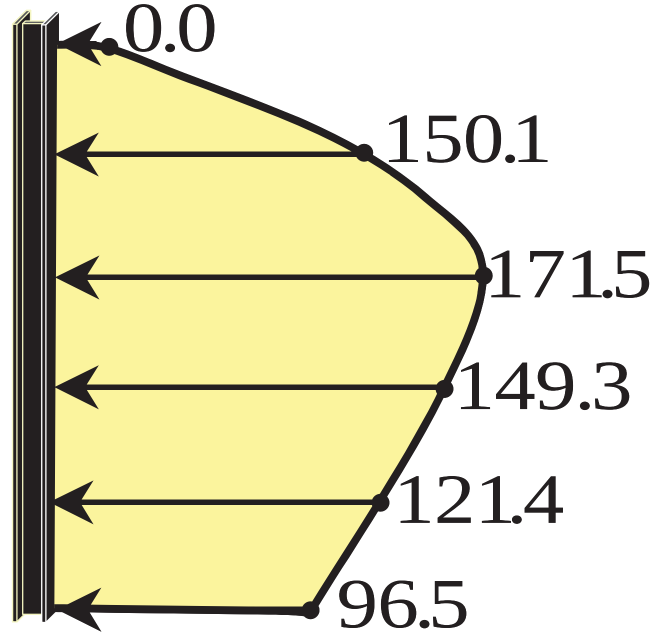
HS20 Truck

(Point loading without impact)



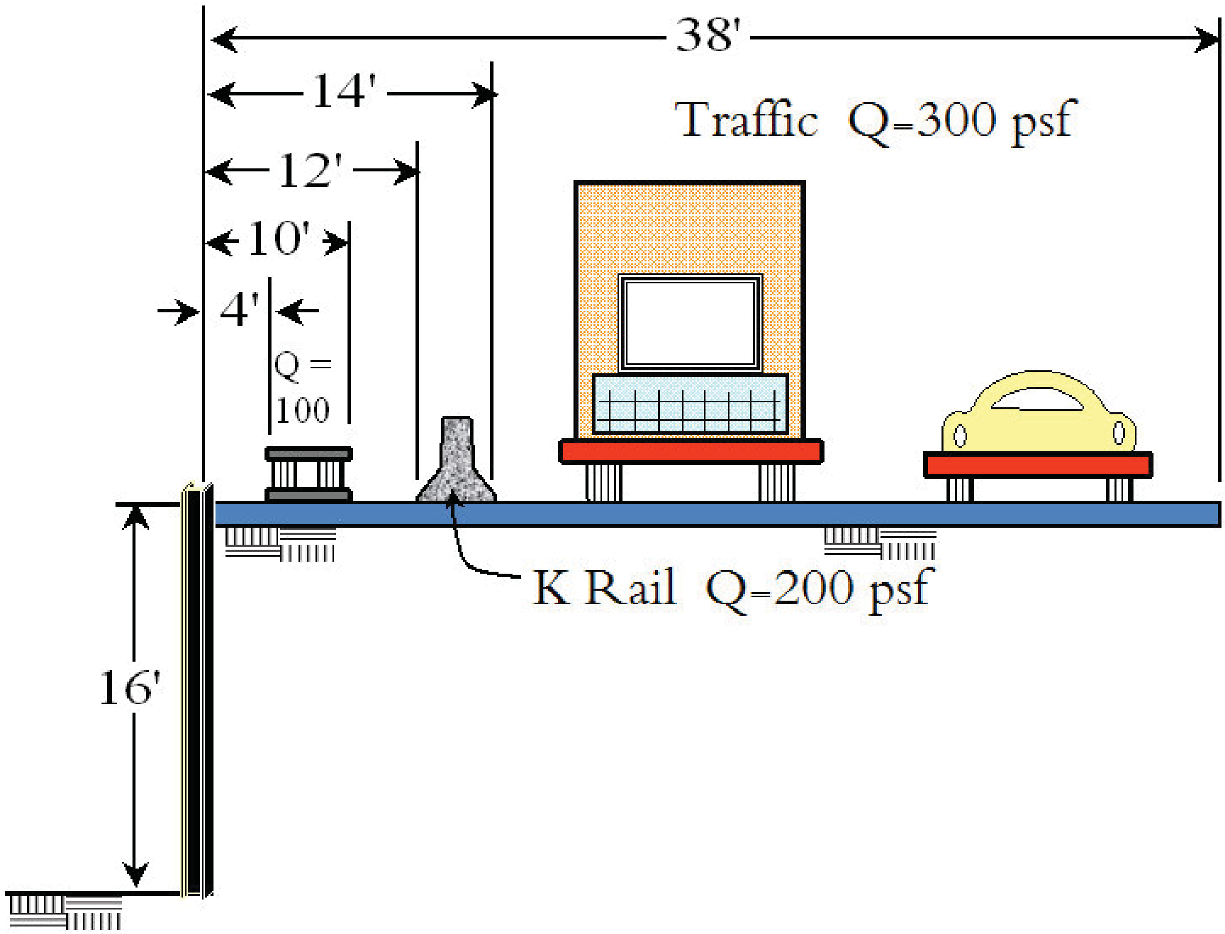
12' Strip

(Q = 300 psf)



CONCLUSION: Strip load of Q = 300 psf compares favorably to a point load evaluation for HS20 truck loadings.

4.8.4.1 Example 4-7 Sample Problem – Surcharge Loads



Example 4-7. Surcharge Loads

Surcharge Lateral Pressures (psf)

Depth	Q = 100	Q = 200	Q = 300	Sum
0.1	1.9	0.3	1.7	72*
1	17.9	3.0	17.1	72*
2	30.2	5.8	33.8	72*
4	35.7	10.1	63.7	109.5
6	29.5	12.3	87.1	128.9
8	21.9	12.7	103.3	137.9
10	15.9	11.9	112.6	140.4
12	11.5	10.5	116.4	138.4
14	8.5	9.0	116.1	133.6
16	6.3	7.6	112.9	126.8

* Minimum construction surcharge load.

Add soil pressures of surcharge loads to derive combined pressure diagram.

4.8.5 Alternate Surcharge Loading (Traffic)

An acceptable alternative to the Boussinesq analysis described below consists of imposing imaginary surcharges behind the shoring system such that the resulting pressure diagram is a rectangle extending to the computed depth of the shoring system and of a uniform width of 100 psf. Generally, alternative surcharge loadings are limited to traffic and light equipment surcharge loads. Other loadings due to structures, or stockpiles of soil, materials or heavy equipment will need to be considered separately.

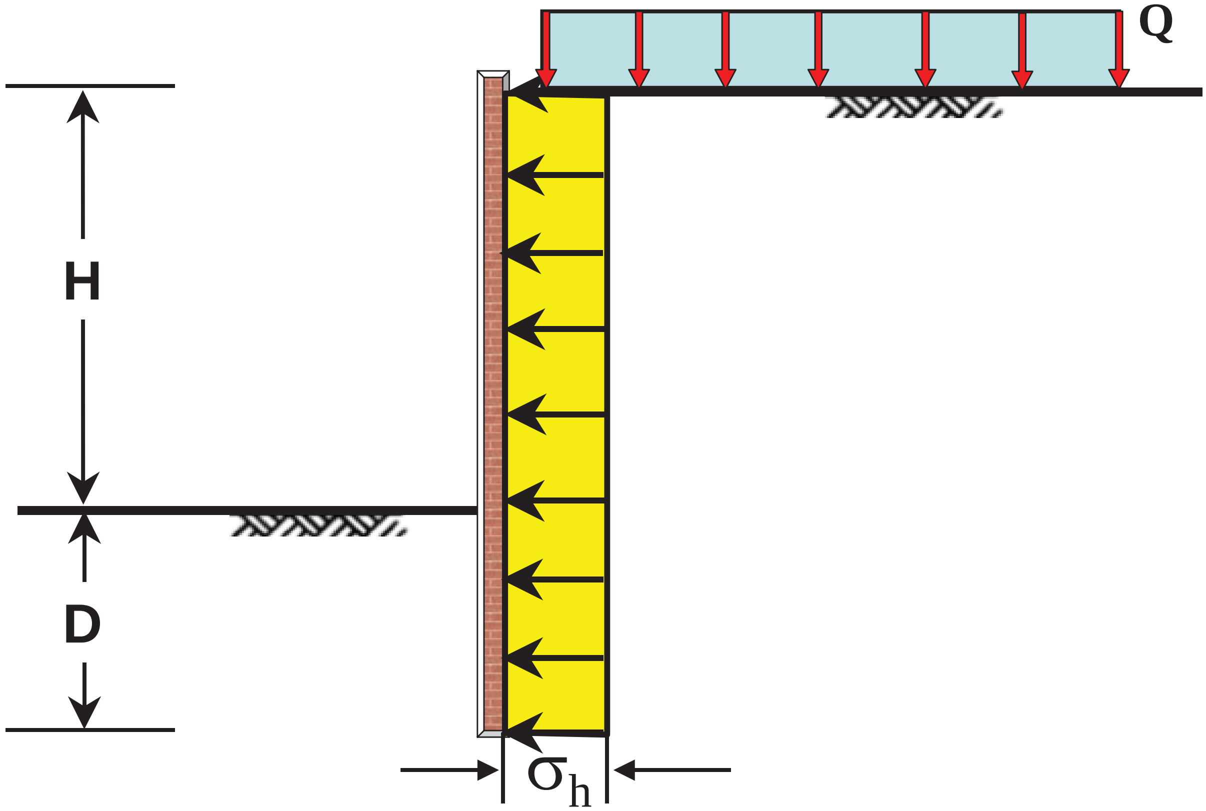


Figure 4-52. Alternate Traffic Surcharge Loading