20.3.2 ACTIVE EARTH PRESSURE DUE TO SURCHARGE LOADS (1993)

20.3.2.1 Uniform Load q

The active earth pressure due to a uniform surcharge load q (pounds per square foot) is:

$$p_u = K_A q$$

which is represented by area II, Figure 8-20-1.

20.3.2.2 Strip Load q

a. A continuous strip of surcharge load q (pounds per square foot) parallel to the bulkhead is shown in Figure 8-20-2. The intensity of pressure at a given point may be computed by:

$$p_s = \frac{2q}{\pi}(\beta + \sin\beta\sin^2\alpha - \sin\beta\cos^2\alpha)$$

Consolidated Rail Corporation
2001 Market Street -12B
PO Box 41412
Philadelphia, Pennsylvania 19101-1412

A letter size plan showing the location, size, construction details, and access to the requested crossing should accompany the letter of application. The plan shall be fully detailed and dimensioned with all Conrail facilities shown and referenced. The sponsor shall state the purpose for which the crossing is needed and the expected life of the crossing. All application fees, construction, maintenance, protection and removal costs shall be at the sole cost and expense of the sponsor. The roadbed and all other Conrail facilities will be restored to the original condition subject to the approval of Conrail's designated representative.

SHEETING AND SHORING REQUIREMENTS

The following items are to be included in the design and construction procedures for all permanent and temporary facilities adjacent to Conrail tracks:

1) Footings for all piers, columns, walls or other facilities shall be located and designed so that any temporary sheeting and shoring for support of adjacent track or tracks during construction shall not be closer than ten (10) feet (3.0 m) from the centerline of the nearest track.
2) When excavation for construction of the above mentioned facilities is within the theoretical railroad embankment line (see Conrail Drawing SK-1, attached), interlocking steel sheet piling, driven prior to excavation, must be used to protect track stability. The use of trench boxes or similar devices is not acceptable. Soldier piling and lagging will be considered for supporting adjacent track(s) only when its use is approved by Conrail. Consideration for the use of soldier piling and lagging shall be made if the required penetration of steel sheet piling cannot be obtained and when dry, non-running, stable material will be encountered.
3) The sheeting shall be designed to support all lateral forces caused by the earth, railroad and other surcharge loads. The railroad loading to be applied is an E-80 loading. This loading consists of 80 Kip (356 KN) axles spaced five (5) feet (1.5 m) on centers. The lateral forces acting on the sheeting shall be computed as follows:

   a. The Rankine Theory shall be used to compute the active earth pressure due to the weight of the soil.

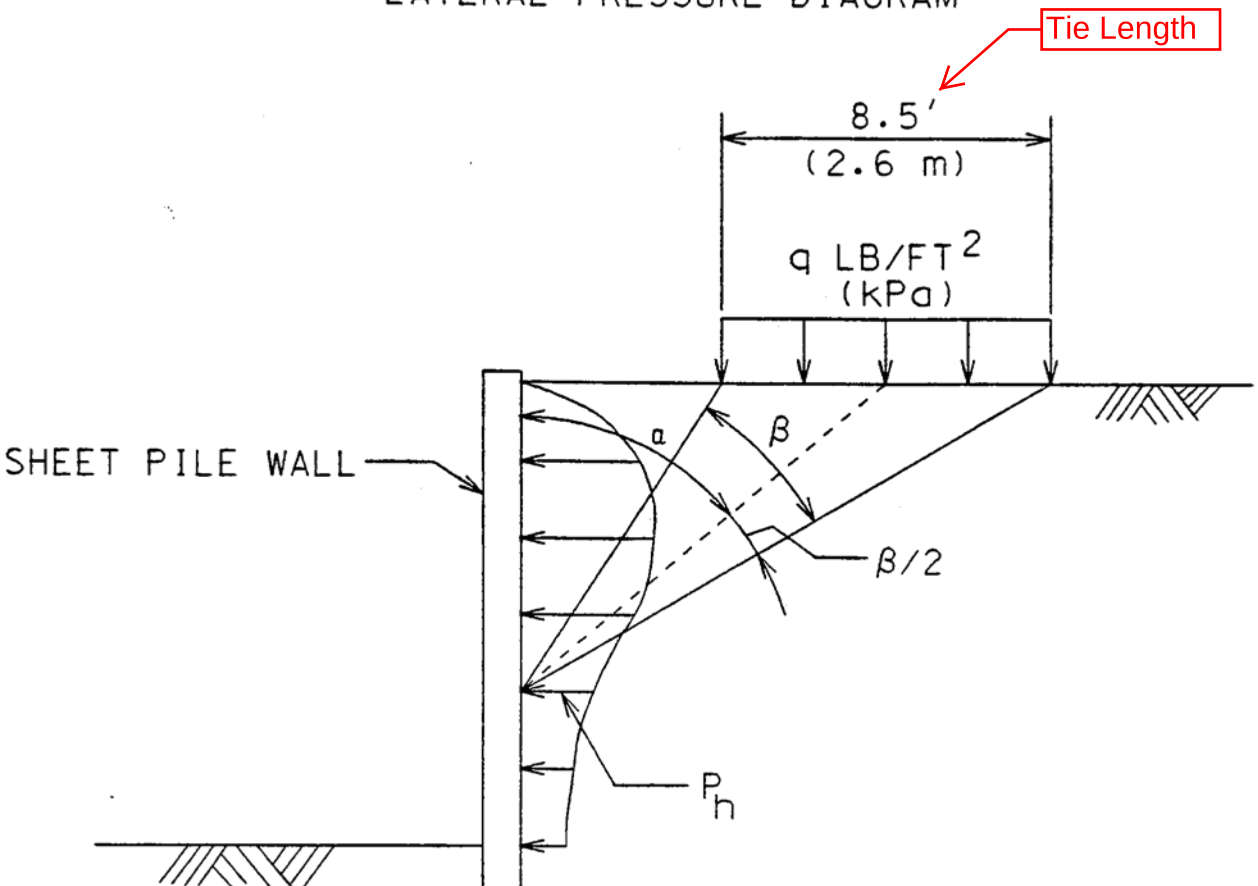
   b. The Boussinesq analysis shall be used to determine the lateral pressure caused by the railroad loading. The load on the track shall be taken as a strip load with a width equal to the length of the ties (8'-6" or 2.6 m). The vertical surcharge, q (psf), caused by each axle, shall be uniform and equal to the axle weight divided by the tie length and the axle spacing (5'-0" or 1.5 m). For an E-80 loading, this results in: $q = 80{,}000 / (8.5 \times 5) = 1882$ psf (90.1 KPa). The horizontal pressure due to the live load surcharge at any point on the sheet piling wall is Ph and can be calculated by the following: $Ph = (2q/\pi)(\beta - \sin\beta \cos 2\alpha)$ (see Conrail Drawing SK-2, attached).
4) Deflection design criteria is as follows:

   a. 1/2" (1.27 cm) maximum deflection for sheet piling ten (10) feet (3.0 m) from centerline of the nearest track.

   b. 1" (2.54 cm) maximum deflection for sheet piling greater than ten (10) (3.0 m) feet from centerline of the nearest track.

   c. Use K (at-rest earth pressure) for design of all braced and tie-back excavations.

LATERAL PRESSURE DIAGRAM



$P_h = (2q/\pi)(\beta - \sin\beta \cos 2a)$

P_h = PRESSURE AT ANY GIVEN POINT

q = STRIP LOAD SURCHARGE

a = ANGLE IN DEGREES

β = ANGLE IN RADIANS

LATERAL PRESSURE DUE TO STRIP LOAD

CONRAIL

OFFICE OF CHIEF ENGINEER - D & C

FEB 1, 1995 DWG. NO.: SK-2

LATERAL PRESSURES FROM COOPERS E-80 TRAIN LOADS

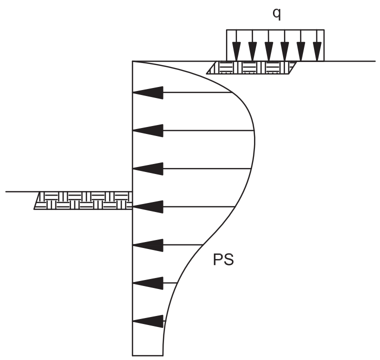
THE BOUSSINESQ EQUATION FOR STRIP LOADS IS SHOWN IN THE AREMA MANUAL FOR RAILWAY ENGINEERING, CHAPTER 8, SECTION 20.3.2.2

BOUSSINESQ EQUATION:

$PS = (2q/\pi) * (\beta - (SIN(\beta) * COS(2\alpha)))$

WHERE:

PS	=	ACTIVE PRESSURE FROM SURCHARGE LOADING
β	=	ATAN((CLT+TL/2) / HS) - ATAN((CLT-TL/2) / HS) IN RADIANS
α	=	β/2 + ATAN((CLT-TL/2) / HS) IN RADIANS
q	=	UNIFORM SURCHARGE LOAD FROM TRAINS = 80 KIPS/ (5) (TL)
CLT	=	DISTANCE FROM FACE OF RETAINING WALL TO CENTERLINE OF TRACK
TL	=	TIE LENGTH = 8.5' STANDARD
HS	=	DEPTH BELOW APPLIED SURCHARGE LOADING



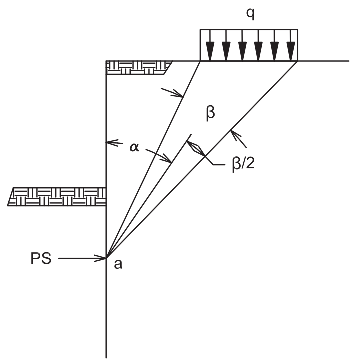


Table 1 - Lateral Pressure from E-80 Train Loads

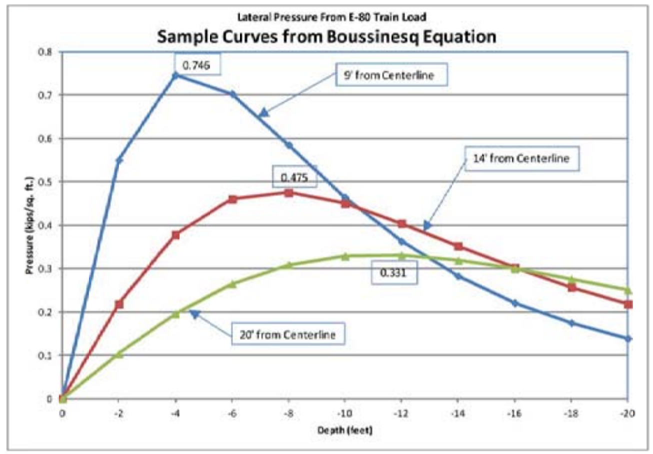
(From Boussinesq Equation)

"CLT" (Distance From Centerline of Track in Feet); Depth (Feet)

"CLT"	0	-2	-4	-6	-8	-10	-12	-14	-16	-18	-20
8	0	0.7	0.846	0.732	0.576	0.439	0.333	0.253	0.195	0.152	0.12
9	0	0.55	0.746	0.703	0.585	0.464	0.363	0.283	0.221	0.175	0.139
10	0	0.44	0.65	0.659	0.579	0.478	0.385	0.307	0.245	0.196	0.158
11	0	0.36	0.565	0.608	0.561	0.482	0.99	0.326	0.265	0.215	0.176
12	0	0.301	0.492	0.556	0.536	0.477	0.406	0.339	0.281	0.232	0.192
14	0	0.218	0.378	0.46	0.475	0.45	0.404	0.352	0.302	0.257	0.218
16	0	0.165	0.297	0.38	0.413	0.411	0.386	0.35	0.311	0.272	0.236
18	0	0.13	0.239	0.315	0.357	0.369	0.36	0.338	0.309	0.278	0.247
20	0	0.104	0.196	0.265	0.309	0.329	0.331	0.319	0.3	0.276	0.251
23	0	0.078	0.15	0.208	0.25	0.276	0.287	0.287	0.279	0.265	0.247
26	0	0.061	0.118	0.166	0.205	0.232	0.248	0.255	0.254	0.247	0.237
29	0	0.049	0.095	0.136	0.17	0.196	0.214	0.224	0.228	0.227	0.222
32	0	0.04	0.078	0.113	0.143	0.167	0.185	0.197	0.205	0.207	0.206
35	0	0.034	0.066	0.095	0.122	0.144	0.161	0.174	0.183	0.188	0.189
39	0	0.027	0.053	0.078	0.1	0.119	0.135	0.148	0.158	0.164	0.168
43	0	0.022	0.044	0.064	0.083	0.1	0.115	0.127	0.137	0.144	0.149
47	0	0.019	0.037	0.054	0.07	0.085	0.098	0.11	0.119	0.127	0.133
51	0	0.016	0.031	0.046	0.06	0.073	0.085	0.095	0.104	0.112	0.118
55	0	0.014	0.027	0.04	0.052	0.063	0.074	0.084	0.092	0.099	0.105

All pressures shown are in kips per sq. ft.

Boxed values represent the maximum pressure ordinate for each value of "CLT".



NOTES:

1. TABLE 1 PROVIDES THE RESULTANT LATERAL PRESSURES FOR VARIOUS DEPTHS AND DISTANCES FROM THE CENTERLINE OF TRACK. THREE REPRESENTATIVE PRESSURE CURVES ARE ALSO SHOWN ON THE PROVIDED SAMPLE CURVES FROM BOUSSINESQ EQUATION.
2. FOR A SIMPLIFIED ENGINEERING ANALYSIS, THE RAILROAD LOADING SURCHARGE PRESSURE MAY BE ASSUMED RECTANGULAR WITH WIDTH (P) EQUAL TO 0.8 OF THE MAXIMUM PRESSURE ORDINATE AS GIVEN BY THE APPROPRIATE RAILROAD CURVE.
3. WORK THIS DRAWING WITH PUBLIC PROJECTS MANUAL APPENDIX H, SECTION H.I.6 (OVERHEAD BRIDGE) OR SECTION H.2.8 (UNDERPASS BRIDGE).

REVISIONS

DATE	LTR.	DESCRIPTION

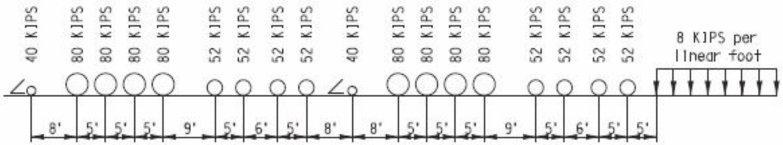
NORFOLK SOUTHERN®

PUBLIC PROJECTS MANUAL
TYPICAL DRAWINGS

SHOREING DESIGN GUIDE

REF. NO.: SEC 3 - MISC 1

DATE: JULY 1, 2013 | DRAWING NO.: 5



COOPER E80 LOAD

SCALE: (NOT TO SCALE)

Vertical pressure q shall be based on a distribution width Ld.
Ld is the length of tie plus H_1.
H_1 is the height from the bottom of tie to the top of shoring.
H_2 is the depth of point being evaluated with the Boussinesq equation.
S is a distance perpendicular from centerline of track to the face of shoring.
D is from top of shoring to one foot below dredge line.
Zp is the minimum embedment depth.
Length of tie is 9 feet
q is the intensity of strip load due to E80 Railroad live load
and shall be calculated as follows:

For $H_1 = 0$ Ld = length of tie; therefore, $q = \frac{80{,}000 \text{ lb}}{(5 \text{ feet})(9 \text{ feet})} = 1{,}778$ psf

For $H_1 > 0$ Ld = length of tie + H_1; therefore, $q = \frac{80{,}000 \text{ lb}}{(5 \text{ feet})(Ld)}$

CASE 1: Lateral live load pressure Ps, due to E80 loading for track parallel to shoring system is calculated using the Boussinesq Strip Load Equation.

$$Ps = \frac{2q}{\pi}(\beta + \sin\beta \sin^2\alpha - \sin\beta \cos^2\alpha)$$

The above equation can be simplified into the following equivalent form:

$$Ps = \frac{2q}{\pi}[\beta - \sin\beta \cos(2\alpha)]$$

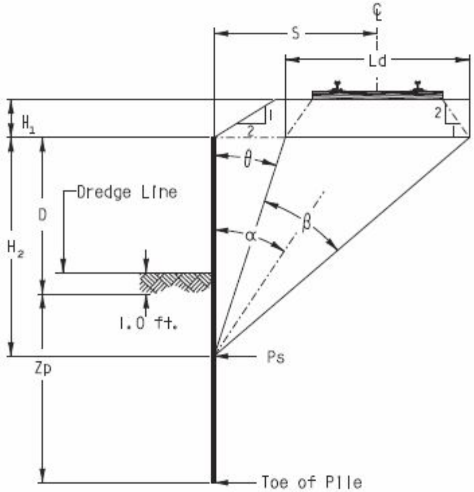
α and β are angles measured in radians, $\alpha = \theta + \frac{\beta}{2}$

CASE 2: Live load pressure due to E80 loading for track at a right angle to the shoring system can be calcuated using the following equation.

$$Ps = K_A q$$

where $K_A = \tan^2(45 - \frac{\phi}{2})$

ϕ is the angle of internal friction in degrees



PLAN

SCALE: (NOT TO SCALE)

REVISIONS		
DATE	LTR.	DESCRIPTION
/		
/		
/		
/		
/		
/		

DESIGN BY: PGP | DRAWN BY: JFS | CHECKED BY: AA

APPROVED:

K.H. Jennison
BNSF - ASSISTANT DIRECTOR STRUCTURES DESIGN

George J. Meyer 9-1-04
UPRR - MGR SPECIAL PROJECTS STRUCTURES DESIGN

BRIDGE SHORING STANDARDS

LIVE LOAD PRESSURE DUE TO COOPER E80

FILE OWNER: UPRR | DATE:
PLAN NO.: 710001 | SHEET: 1 OF 1

PLOTTED: $$$$DATE$$$$ $TIME

Figure 2