TEMPORARY SHORING GUIDELINES

(10/1/2010)
REV 0

TEMPORARY SHORING

I. Overview

Excavation in close proximity to railroad tracks is unavoidable. This guideline is designed to assist in the preparation of shoring documents so that review time is limited.

This document is only a guideline and the preparer is still required to follow any agency-specific requirements including: AREMA, Railroads, OSHA, IDOT, FRA, or other governing agency in the jurisdiction. Note this document is only applicable to Metra-owned tracks.

These guidelines are provided as reference and may not be taken as authority to construct without prior written approval of the Metra. The Contractor must not begin construction of any component of the shoring system affecting Metra right-of-way until written approval has been received from Metra.

II. Submittals

To expedite shoring review the following items should be submitted with the review package.

- Design calculations stamped and signed by Illinois Licensed Structural Engineer
- Lateral pressure diagram
- Deflection calculations at top of wall and bracing locations including elastic deflection of the wall and the passive deflection of the resisting soil mass.
- Drawings or sketches of the proposed shoring consisting of:
    1. Plan view showing wall limits and distances from centerline of track (see attached example)
    2. Cross section (see attached example) showing excavation support system, top of rail elevation, distance from centerline of track to near face of excavation support, maximum excavation depth with elevations, elevation of bracing, tip elevation, etc.
    3. Connection details.
- Soil report and boring logs

III. Design

Excavation support shall be based on AREMA Manual for Railway Engineering, Chapter 8, Section 20 and Section 24.

Lateral Pressure from train loads shall be based on Cooper E 80 train load (Figure 1) and active earth pressure due to railroad surcharge shall be calculated using the Boussinesq Equation for strip load per AREMA 8-20.3.2.2 (Figure 2). Uniform surcharge (q) shall be based on an 8.5 foot long tie, 5 foot axle spacing and 80 kip axle load resulting in q=1.88ksf. See attached Table 1: Lateral Pressure from Train Load Example Calculation for additional variable designations

A simplified engineering analysis may be used, the railroad loading surcharge pressure may be assumed rectangular with width (P) equal to 0.8 of the maximum pressure as given by the appropriate railroad curve (Table 2: Lateral Pressure from Cooper E 80 train loads).

Temporary shoring on the Metra Electric Line may be designed for Cooper E 65 loading with approval from Metra.

All shoring systems must be analyzed for overturning, sliding and global stability.

Lateral live load deflection shall be limited to 3/8” for shoring located within 18’-0” of centerline of track and ½” for shoring located outside 18’-0”. The maximum allowable vertical of horizontal displacement of rail shall be ¼”.

Material allowable stresses based on AREMA shall be as follow:

- Structural Steel: 0.55Fy for compression in extreme fiber. (AREMA Table 15-1-11)
- Structural Steel: 0.35Fy for Shear. (AREMA Table 15-1-11)
- Sheet Pile Sections: 2/3 of yield strength of steel. (AREMA 8.20.5.7)
- Concrete: 1/3 of Compressive Strength. (AREMA 8.20.5.7)
- Anchor Rods: ½ of yield strength of steel. (AREMA 8.20.5.7)

No AISC allowable stress increase for temporary loading condition will be allowed.

IV. General Requirements

All components of the temporary shoring system are to be removed when the shoring is no longer needed. Track cross section and drainage facilities must be restored.

All Temporary shoring systems within the clearance envelope (see attached AREMA Minimum Railway Clearance sketch) shall be terminated below the top of rail.

An OSHA acceptable handrail is required around all excavation.

No cantilever shoring will be allowed within 12 feet of active rails.

No MSE walls will be allowed within the limits of E80 surcharge.

Cold formed piling will not be accepted within the limits of E80 surcharge.

Track deflection monitoring shall be implemented. Elevations of top of rail shall be taken at 50 foot intervals for a distance to extend 100 feet beyond the limits of excavation. Elevations shall be recorded at the following intervals: prior to shoring construction, at completion of shoring construction, following first train through area, daily there after and once shoring has been removed or as directed by the Engineer.

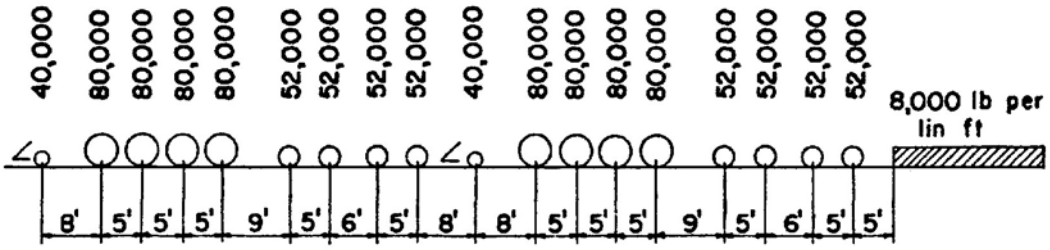


Figure 1: Cooper E 80 Load (AREMA Figure 15-1-2)

Boussinesq Equation: $P_S = (2q / \pi) (\beta + \sin\beta \sin^2\alpha - \sin\beta \cos^2\alpha)$ (per AREMA 8-20.3.2.2.a)

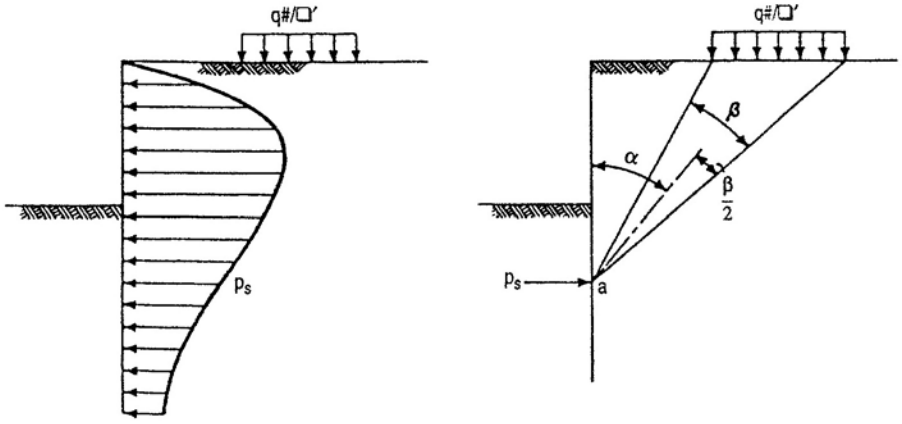
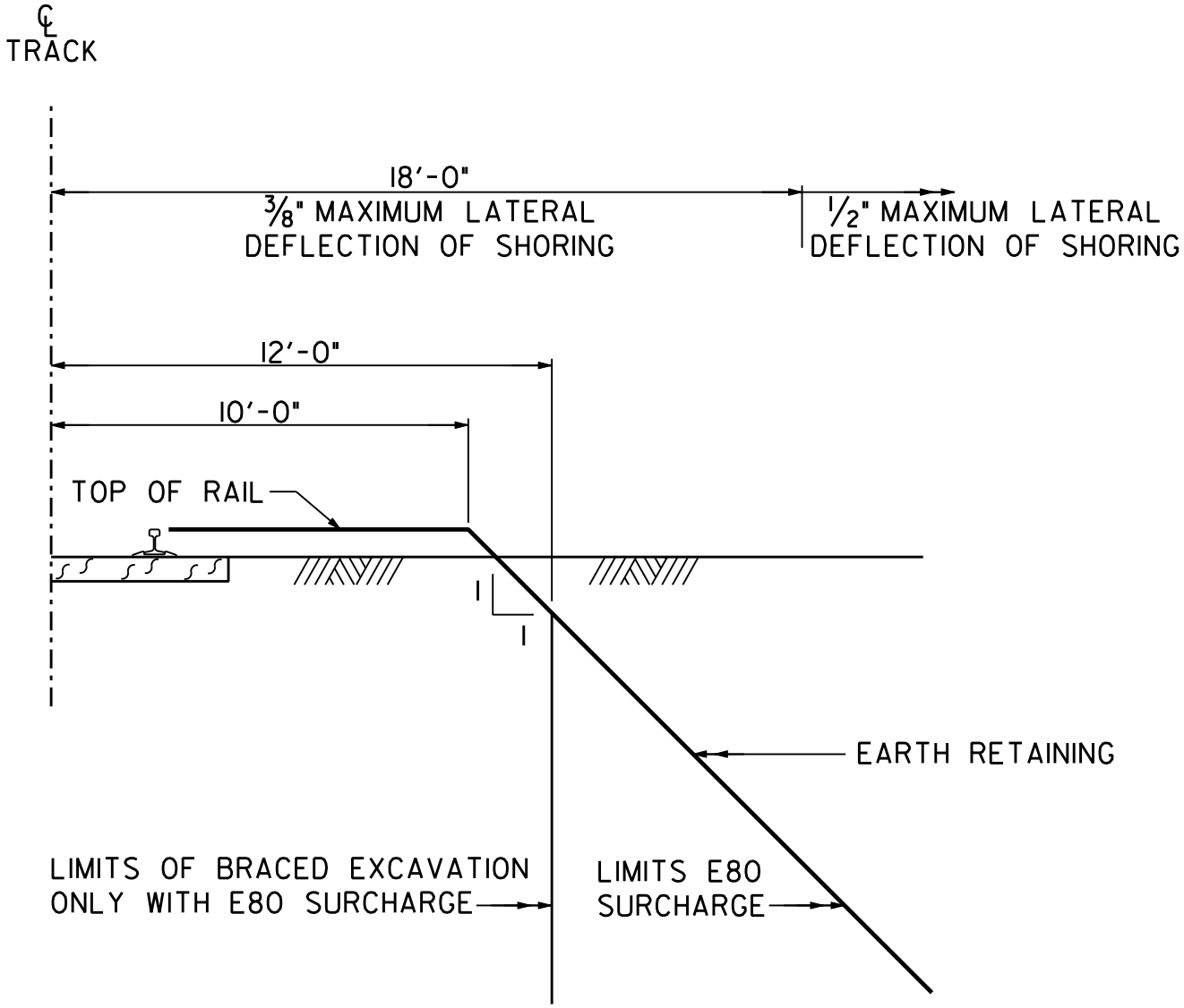


Figure 2: Pressure Distribution for Strip Load (AREMA Figure 8-20-2)



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GENERAL SHORING REQUIREMENTS

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1 OF 1

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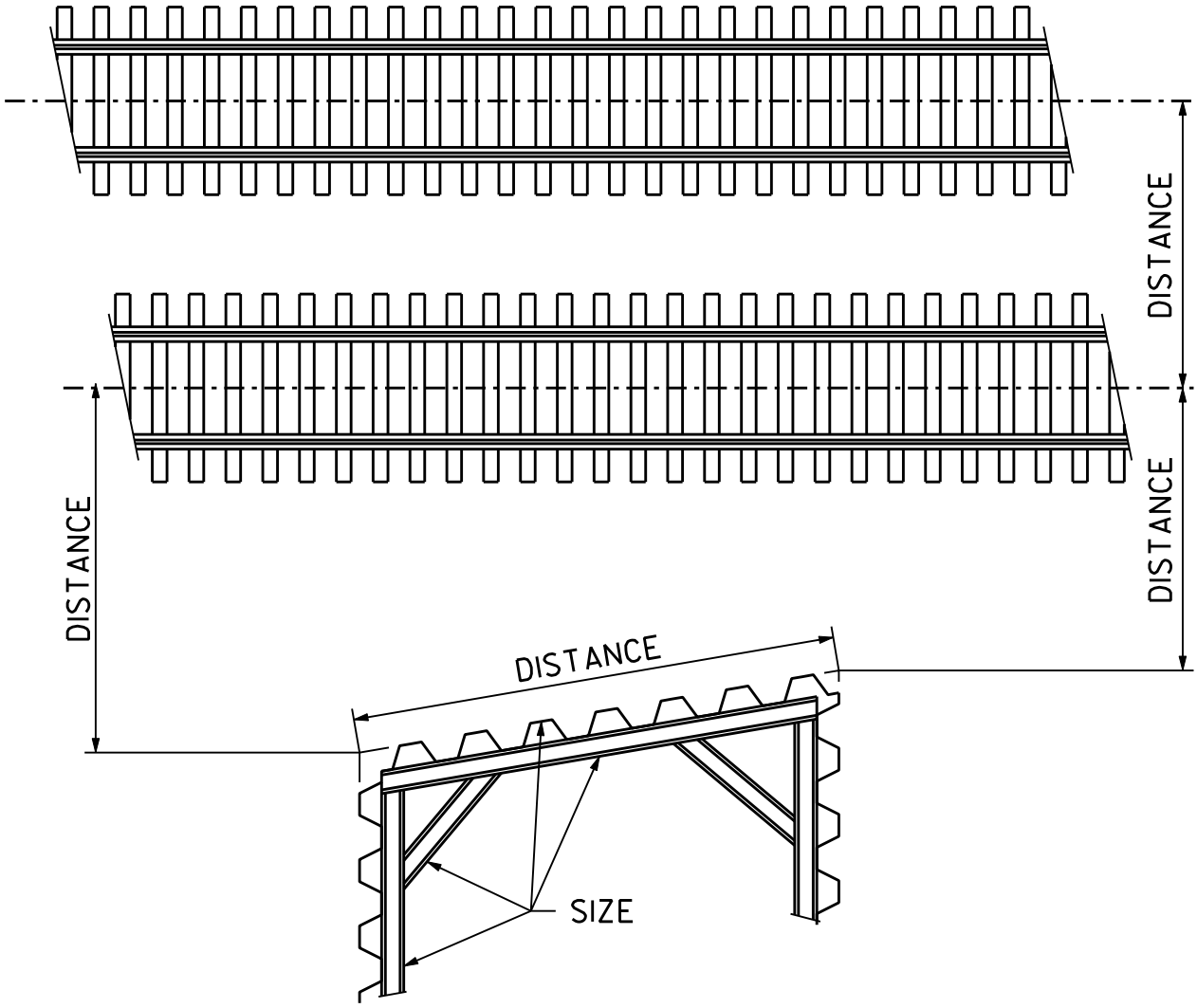

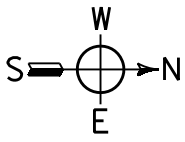

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EXAMPLE PLAN VIEW

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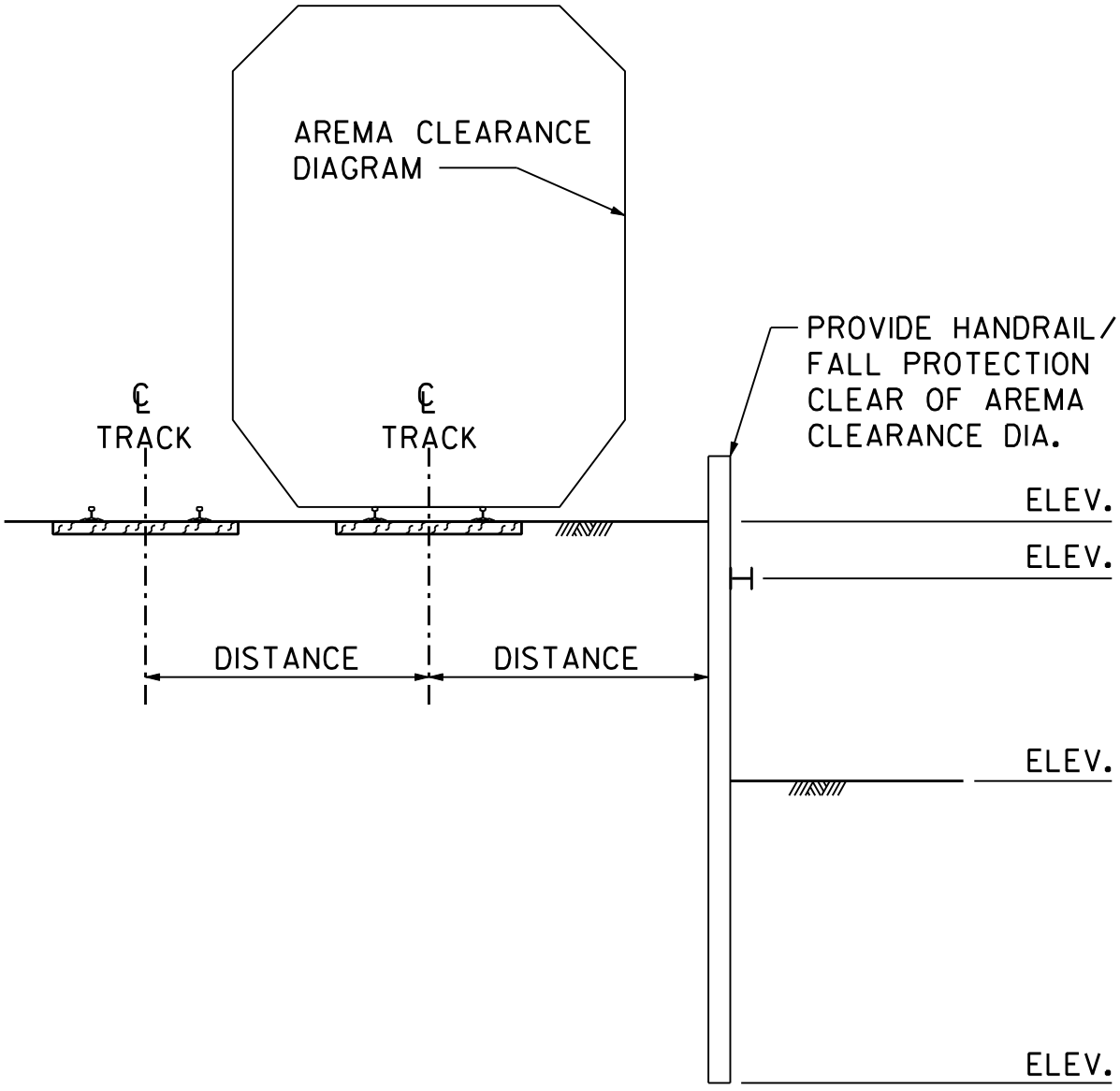
1 OF 1



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EXAMPLE CROSS-SECTION

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1 OF 1

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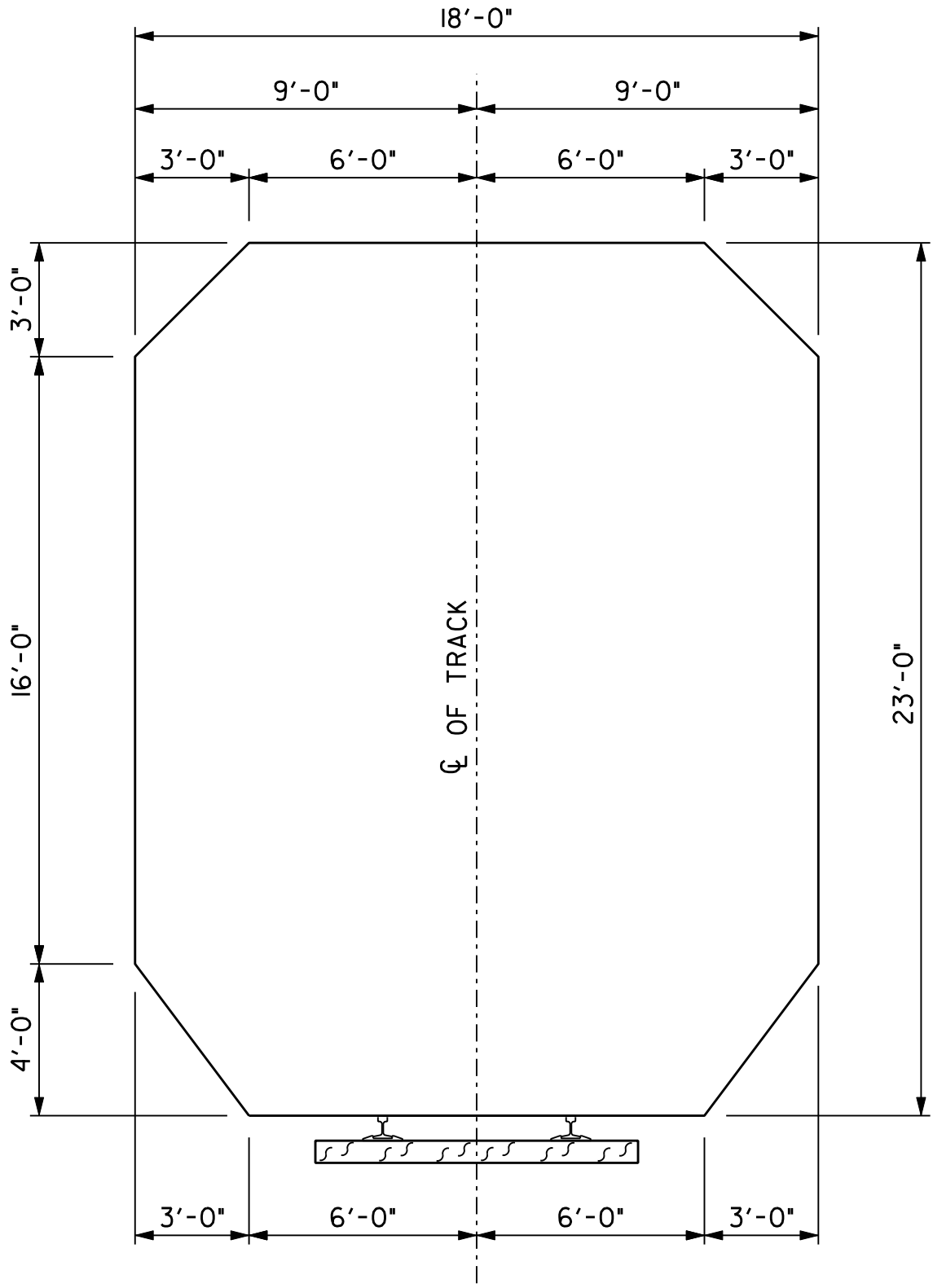

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AREMA MINIMUM RAILWAY CLEARANCE

SHEET

1 OF 1

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	Track 1			Track 2			
	Axle load	80 kips		Axle load	80 kips		
	TL	8.5 ft		TL	8.5 ft		
	CLT	10 ft		CLT	23 ft		
	q	1.8824 ksf		q	1.8824 ksf		
H_S	β	α	P_S	β	α	P_S	**P_S total**
(ft)	(rad)	(rad)	(ksf)	(rad)	(rad)	(ksf)	**(ksf)**
1	0.1021	1.4497	0.2410	0.0166	1.5258	0.0397	**0.2807**
2	0.1953	1.3337	0.4409	0.0330	1.4810	0.0785	**0.5194**
3	0.2734	1.2266	0.5775	0.0490	1.4366	0.1153	**0.6928**
4	0.3341	1.1301	0.6504	0.0644	1.3928	0.1495	**0.7999**
5	0.3783	1.0442	0.6723	0.0791	1.3498	0.1805	**0.8528**
6	0.4081	0.9682	0.6591	0.0930	1.3076	0.2076	**0.8668**
7	0.4265	0.9009	0.6247	0.1059	1.2664	0.2307	**0.8554**
8	0.4360	0.8412	0.5789	0.1177	1.2264	0.2497	**0.8287**
9	0.4390	0.7880	0.5287	0.1285	1.1875	0.2647	**0.7933**
10	0.4371	0.7404	0.4781	0.1382	1.1500	0.2757	**0.7538**
11	0.4317	0.6975	0.4297	0.1469	1.1137	0.2831	**0.7128**
12	0.4241	0.6589	0.3847	0.1545	1.0787	0.2872	**0.6720**
13	0.4148	0.6238	0.3437	0.1611	1.0451	0.2885	**0.6322**
14	0.4045	0.5920	0.3068	0.1668	1.0128	0.2872	**0.5941**
15	0.3937	0.5629	0.2739	0.1715	0.9818	0.2839	**0.5578**
16	0.3826	0.5363	0.2447	0.1755	0.9521	0.2788	**0.5235**
17	0.3715	0.5119	0.2189	0.1787	0.9237	0.2723	**0.4912**
18	0.3604	0.4894	0.1961	0.1812	0.8964	0.2648	**0.4609**
19	0.3496	0.4687	0.1760	0.1831	0.8703	0.2564	**0.4324**
20	0.3391	0.4495	0.1583	0.1845	0.8454	0.2474	**0.4057**
21	0.3289	0.4317	0.1426	0.1854	0.8215	0.2381	**0.3807**
22	0.3191	0.4152	0.1288	0.1858	0.7987	0.2285	**0.3573**
23	0.3097	0.3998	0.1166	0.1858	0.7769	0.2189	**0.3355**
24	0.3007	0.3855	0.1058	0.1855	0.7560	0.2093	**0.3151**
25	0.2920	0.3721	0.0961	0.1849	0.7360	0.1999	**0.2960**
26	0.2837	0.3595	0.0876	0.1841	0.7168	0.1906	**0.2782**
27	0.2758	0.3477	0.0800	0.1830	0.6985	0.1816	**0.2616**
28	0.2682	0.3367	0.0731	0.1818	0.6809	0.1729	**0.2460**
29	0.2610	0.3262	0.0671	0.1803	0.6641	0.1645	**0.2315**
30	0.2541	0.3164	0.0616	0.1788	0.6480	0.1564	**0.2180**
31	0.2475	0.3071	0.0567	0.1771	0.6325	0.1487	**0.2054**
32	0.2412	0.2984	0.0523	0.1754	0.6177	0.1414	**0.1936**
33	0.2351	0.2901	0.0483	0.1736	0.6035	0.1343	**0.1826**

Variable designation

$P_S = (2q/\pi)(\beta+\sin\beta\sin^2\alpha-\sin\beta\cos^2\alpha)$ Active Pressure from surcharge loading AREMA 8-20.3.2.2.a

B = $\text{atan}[(CLT+TL/2)/H_S] - \text{atan}[(CLT-TL/2)/H_S]$ in radians

A = $\beta/2+\text{atan}[(CLT-TL/2)/H_S]$ in radians

q = 80 kips / (5' x TL) uniform surcharge load from trains

CLT = Distance from near face of retaining wall to centerline of track (feet)

TL = Tie length (8.5 feet)

H_S = Depth below applied surcharge loading (feet)

Table 1: Lateral Pressure from Train Load Example Calculations

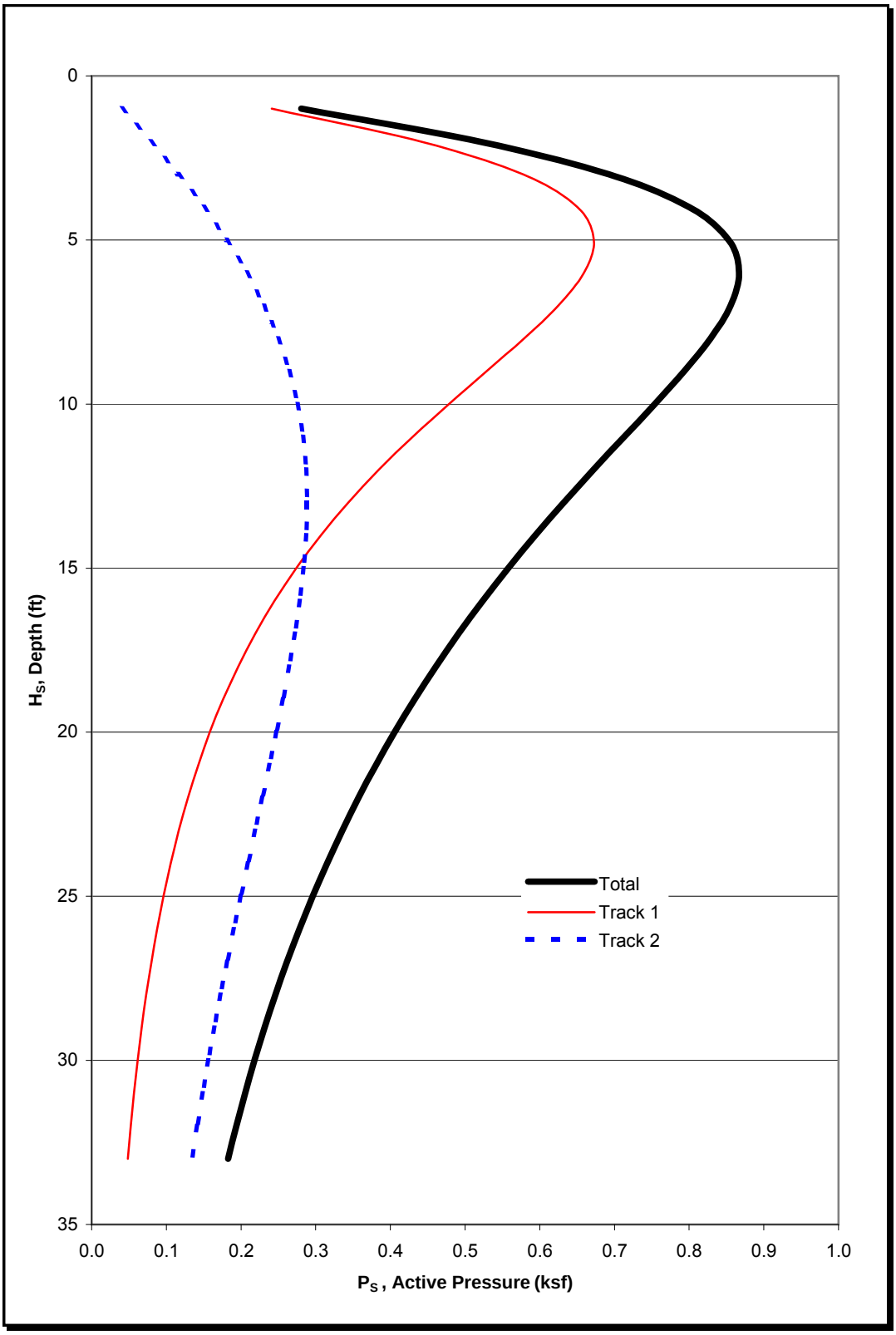

Figure 3: Lateral Pressure from Train Load Example Calculations

	CLT, Distance from near face of retaining wall to centerline of track (ft)																		
H_S	8	9	10	11	12	14	16	18	20	23	26	29	32	35	39	43	47	51	55
1	0.416	0.310	0.241	0.193	0.159	0.113	0.085	0.066	0.053	0.040	0.031	0.025	0.020	0.017	0.014	0.011	0.009	0.008	0.007
2	0.700	0.550	0.441	0.361	0.301	0.218	0.165	0.130	0.104	0.078	0.061	0.049	0.040	0.034	0.027	0.022	0.019	0.016	0.014
3	0.828	0.691	0.577	0.486	0.413	0.307	0.237	0.188	0.152	0.115	0.090	0.073	0.060	0.050	0.040	0.033	0.028	0.023	0.020
4	**0.846**	**0.746**	0.650	0.565	0.492	0.378	0.297	0.239	0.196	0.150	0.118	0.095	0.078	0.066	0.053	0.044	0.037	0.031	0.027
5	0.803	0.742	**0.672**	0.603	0.538	0.429	0.345	0.282	0.233	0.180	0.143	0.116	0.096	0.081	0.066	0.054	0.045	0.039	0.033
6	0.732	0.703	0.659	**0.608**	**0.556**	0.460	0.380	0.315	0.265	0.208	0.166	0.136	0.113	0.095	0.078	0.064	0.054	0.046	0.040
7	0.653	0.647	0.625	0.592	0.554	0.474	0.402	0.340	0.290	0.231	0.187	0.154	0.129	0.109	0.089	0.074	0.062	0.053	0.046
8	0.576	0.585	0.579	0.561	0.536	**0.475**	0.413	0.357	0.309	0.250	0.205	0.170	0.143	0.122	0.100	0.083	0.070	0.060	0.052
9	0.504	0.523	0.529	0.523	0.509	0.466	**0.416**	0.366	0.322	0.265	0.219	0.184	0.156	0.133	0.110	0.092	0.078	0.067	0.058
10	0.439	0.464	0.478	0.482	0.477	0.450	0.411	**0.369**	0.329	0.276	0.232	0.196	0.167	0.144	0.119	0.100	0.085	0.073	0.063
11	0.382	0.411	0.430	0.440	0.442	0.428	0.401	0.367	**0.332**	0.283	0.241	0.206	0.177	0.153	0.127	0.108	0.092	0.079	0.069
12	0.333	0.363	0.385	0.399	0.406	0.404	0.386	0.360	0.331	0.287	0.248	0.214	0.185	0.161	0.135	0.115	0.098	0.085	0.074
13	0.290	0.320	0.344	0.361	0.372	0.378	0.369	0.350	0.327	**0.288**	0.252	0.220	0.192	0.168	0.142	0.121	0.104	0.090	0.079
14	0.253	0.283	0.307	0.326	0.339	0.352	0.350	0.338	0.319	0.287	0.255	0.224	0.197	0.174	0.148	0.127	0.110	0.095	0.084
15	0.222	0.250	0.274	0.294	0.309	0.327	0.331	0.324	0.310	0.284	**0.255**	0.227	0.202	0.179	0.153	0.132	0.115	0.100	0.088
16	0.195	0.221	0.245	0.265	0.281	0.302	0.311	0.309	0.300	0.279	0.254	0.228	0.205	0.183	0.158	0.137	0.119	0.104	0.092
17	0.172	0.196	0.219	0.239	0.255	0.279	0.291	0.293	0.288	0.272	0.251	**0.228**	0.206	0.186	0.161	0.141	0.123	0.108	0.096
18	0.152	0.175	0.196	0.215	0.232	0.257	0.272	0.278	0.276	0.265	0.247	0.227	**0.207**	0.188	0.164	0.144	0.127	0.112	0.099
19	0.135	0.156	0.176	0.194	0.211	0.237	0.254	0.262	0.264	0.256	0.242	0.225	0.207	0.189	0.167	0.147	0.130	0.115	0.102
20	0.120	0.139	0.158	0.176	0.192	0.218	0.236	0.247	0.251	0.247	0.237	0.222	0.206	**0.189**	0.168	0.149	0.133	0.118	0.105
21	0.107	0.125	0.143	0.159	0.175	0.201	0.220	0.232	0.238	0.238	0.230	0.218	0.204	0.189	0.169	0.151	0.135	0.121	0.108
22	0.096	0.112	0.129	0.145	0.159	0.185	0.205	0.218	0.226	0.229	0.224	0.214	0.201	0.188	**0.170**	0.153	0.137	0.123	0.110
23	0.086	0.101	0.117	0.131	0.145	0.170	0.190	0.205	0.214	0.219	0.216	0.209	0.198	0.186	0.170	0.153	0.138	0.125	0.112
24	0.077	0.092	0.106	0.120	0.133	0.157	0.177	0.192	0.202	0.209	0.209	0.204	0.195	0.184	0.169	0.154	0.139	0.126	0.114
25	0.070	0.083	0.096	0.109	0.122	0.145	0.165	0.180	0.191	0.200	0.202	0.198	0.191	0.182	0.168	**0.154**	0.140	0.128	0.116
26	0.063	0.075	0.088	0.100	0.112	0.134	0.153	0.169	0.180	0.191	0.194	0.192	0.187	0.179	0.167	0.154	0.141	0.128	0.117
27	0.057	0.069	0.080	0.091	0.103	0.124	0.143	0.158	0.170	0.182	0.187	0.186	0.182	0.176	0.165	0.153	**0.141**	0.129	0.118
28	0.052	0.063	0.073	0.084	0.094	0.115	0.133	0.148	0.160	0.173	0.179	0.180	0.178	0.173	0.163	0.152	0.141	0.130	0.119
29	0.048	0.057	0.067	0.077	0.087	0.106	0.124	0.139	0.151	0.164	0.172	0.174	0.173	0.169	0.161	0.151	0.140	**0.130**	0.120
30	0.044	0.052	0.062	0.071	0.080	0.099	0.115	0.130	0.143	0.156	0.165	0.168	0.168	0.165	0.158	0.149	0.140	0.130	0.120
31	0.040	0.048	0.057	0.065	0.074	0.092	0.108	0.122	0.135	0.149	0.158	0.162	0.163	0.161	0.156	0.148	0.139	0.129	0.120
32	0.037	0.044	0.052	0.060	0.069	0.085	0.101	0.115	0.127	0.141	0.151	0.156	0.158	0.157	0.153	0.146	0.138	0.129	**0.120**
33	0.034	0.041	0.048	0.056	0.064	0.079	0.094	0.108	0.120	0.134	0.145	0.151	0.153	0.153	0.150	0.144	0.136	0.128	0.120

Depth (ft)

Table 2: Lateral Pressure from Cooper E 80 Train Loads (ksf)

note boxed value represents the maximum pressure for each value of CLT