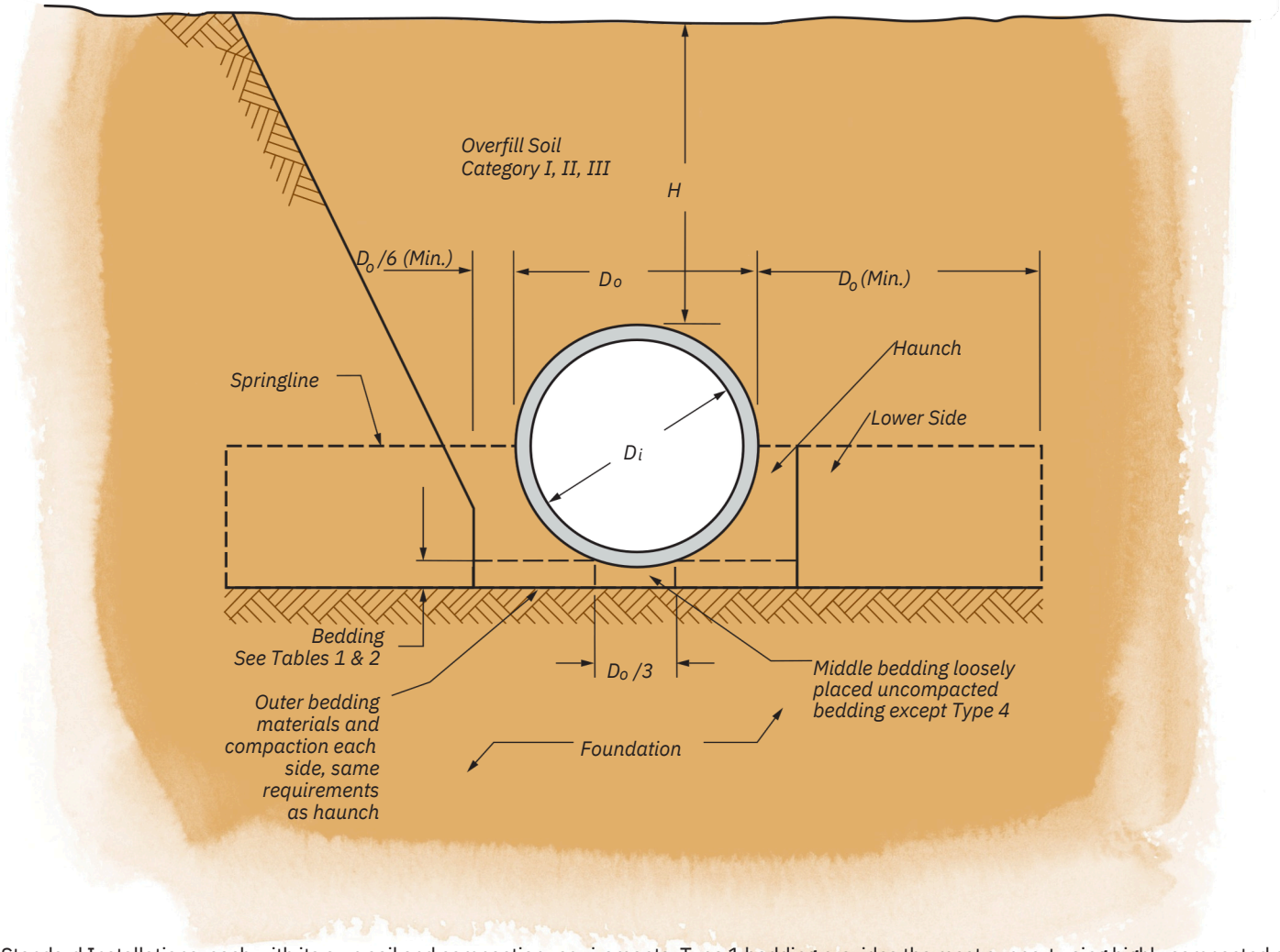
LRFD FILL HEIGHT TABLES

FOR CONCRETE PIPE

ACPA
American Concrete Pipe Association

Standard Trench/Embankment Installation

Concrete pipe should be installed in accordance with the AASHTO LRFD Bridge Construction Specifications, Section 27 or ASTM C1479. Figure 1 shows the basic pipe and soil terminology.



There are four types of Standard Installations, each with its own soil and compaction requirements. Type 1 bedding provides the most support using highly compacted granular material, while Type 4 provides for less support allowing the use of silts and clay soils with little or no compaction. These four choices provide flexibility and versatility for the designer and contractor, as well as performance and economy for the owner that are not available with other types of pipe.

The soil and compaction requirements are provided in Table 1. Table 2 shows the equivalent soil designations per the Unified Soil Classification System (USCS) and AASHTO.

To facilitate your selection of the proper reinforced concrete pipe using the most beneficial Standard Installation for the conditions at the site, fill height tables are provided on the following pages. The required 0.01 inch crack D-Loads in units of lbs per linear foot per foot of diameter are provided numerically and the class of pipe per ASTM C76 (AASHTO M 170) meeting this requirement is designated by color of the cell.

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Table 1: Standard Installation Soils and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D_o /24 minimum, not less than 3" (75 mm), If rock foundation, use or D_o/12 minimum, not less than 6" (150 mm)	95% Category I	90% Category I 95% Category II or 100% Category III
Type 2	D_o /24 minimum, not less than 3" (75 mm), If rock foundation, use or D_o/12 minimum, not less than 6" (150 mm)	90% Category I or 95% Category II	85% Category I 90% Category II or 95% Category III
Type 3	D_o /24 minimum, not less than 3" (75 mm), If rock foundation, use or D_o/12 minimum, not less than 6" (150 mm)	85% Category I 90% Category II or 95% Category III	85% Category I 90% Category II or 95% Category III
Type 4	No bedding required except if rock foundation, use D_o/12 minimum, not less than 6" (150 mm)	No compaction required, except if Category III, use 85%	No compaction required, except if Category III, use 85%

Reference: ASCE 15-17, "Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)", 2017.

Table 2: Equivalent USCS and AASHTO and Soil Classifications for Standard Installation Soil Designations

Representative Soil Types			Percent Compaction	
SIDD	USCS	AASHTO	Standard Proctor	Modified Proctor
Gravelly Sand (Category I)	SW, SP, GW, GP	A1, A3	100 95 90 85 80 61	95 90 85 80 75 59
Sandy Silt (Category II)	GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve	A2, A4	100 95 90 85 80 49	95 90 85 80 75 46
Silty Clay (Category III)	CL, MH, GC, SC	A5, A6	100 95 90 85 80 45	90 85 80 75 70 40
Not Allowed for Haunch or Bedding	CH	A7	100 95 90 45	90 85 80 40

Reference: ASCE 15-17, "Standard Practice for Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)", 2017.

Table 3: Reinforced Pipe Classes for 0.01 inch Crack Per ASTM C 76 (lbs/ft/ft)

Class I	≤800
Class II	≤1000
Class III	≤1350
Class IV	≤2000
Class V	≤3000
Special Design	> 3000

NOTES:

1. Compaction and soil symbols – i.e. "95% Category I" refers to Category I soil material with a minimum Standard Proctor compaction of 95%. See Table 2 for equivalent Modified Proctor values.
2. Soil in the outer bedding, haunch, and lower side zones shall be compacted to at least the same compaction as the majority of soil in the overfill zone.

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The following Fill Height Tables have been developed by the American Concrete Pipe Association (ACPA) using the indirect design method in accordance with Section 12.10.4.3 of the AASHTO LRFD Bridge Design Specification, 9th Edition, 2020.

Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

	Fill Height in Feet													
Pipe Size (in)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1612	1399	888	695	633	620	635	661	544	603	662	721	780	839
15	1546	1344	856	673	614	602	617	644	532	589	646	704	761	818
18	1462	1307	836	660	604	593	608	634	526	583	639	696	752	809
21	1309	1281	823	653	598	588	604	630	525	581	637	693	749	805
24	1287	1262	814	648	595	587	603	629	527	583	638	694	750	805
27	1442	1264	815	653	599	591	608	634	530	586	642	697	753	809
30	1581	1272	819	660	605	598	615	640	535	591	646	702	758	814
33	1443	1222	798	651	599	596	615	641	541	597	653	709	765	821
36	1329	1187	780	643	595	595	616	643	547	603	660	716	772	829
42	1151	1099	745	627	587	591	613	641	553	609	665	721	778	834
48	1019	961	713	614	582	589	612	641	560	616	673	729	785	841
54	969	919	689	604	578	589	613	643	569	625	681	737	794	850
60	994	890	670	596	577	590	615	646	578	634	691	747	804	860
66	946	865	657	589	576	592	618	651	588	644	701	758	814	871
72	881	844	647	584	578	595	622	656	598	655	712	769	826	883
78	827	823	637	582	579	597	625	659	606	663	720	777	834	892
84	782	805	629	580	580	600	628	664	615	672	729	786	843	901
90	744	789	622	580	582	603	632	668	712	681	738	795	853	910
96	712	749	616	580	585	606	637	673	718	690	747	805	862	920
102	685	723	623	587	592	614	645	682	727	774	757	814	872	929
108	662	711	629	595	600	623	654	691	736	783	766	824	882	940
114	642	715	636	603	609	631	663	700	745	793	842	834	892	950
120	625	720	642	609	617	640	672	709	755	802	852	844	903	961
126	611	726	649	617	625	649	681	719	764	812	862	913	913	971
132	599	731	651	625	634	658	690	728	774	822	872	924	976	983
138	589	736	645	633	643	667	699	738	784	832	883	934	987	994
144	580	742	651	642	652	676	709	747	794	843	893	945	998	1052

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D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

	Fill Height in Feet													
Pipe Size (in)	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	898	957	1016	1075	1134	1194	1253	1312	1371	1430	1489	1548	1607	1666
15	876	933	990	1048	1105	1163	1220	1277	1335	1392	1449	1507	1564	1621
18	865	921	978	1034	1091	1147	1203	1260	1316	1373	1429	1485	1542	1598
21	861	917	973	1029	1084	1140	1196	1252	1308	1364	1420	1476	1532	1588
24	861	917	972	1028	1084	1139	1195	1251	1306	1362	1418	1474	1529	1585
27	864	920	975	1031	1087	1142	1198	1254	1309	1365	1421	1476	1532	1588
30	870	925	981	1037	1093	1148	1204	1260	1316	1372	1427	1483	1539	1595
33	877	933	989	1045	1101	1157	1213	1269	1325	1381	1437	1493	1549	1605
36	885	941	998	1054	1110	1167	1223	1279	1335	1392	1448	1504	1561	1617
42	890	946	1002	1058	1115	1171	1227	1283	1339	1395	1451	1508	1564	1620
48	897	953	1010	1066	1122	1178	1234	1290	1346	1403	1459	1515	1571	1627
54	906	963	1019	1075	1131	1188	1244	1300	1356	1413	1469	1525	1581	1638
60	917	973	1029	1086	1142	1199	1255	1312	1368	1425	1481	1538	1594	1650
66	928	985	1041	1098	1155	1211	1268	1325	1381	1438	1495	1552	1608	1665
72	940	997	1054	1111	1168	1225	1282	1339	1396	1453	1510	1567	1624	1681
78	949	1006	1063	1120	1177	1234	1291	1348	1405	1462	1519	1576	1633	1690
84	958	1015	1072	1129	1186	1244	1301	1358	1415	1472	1529	1587	1644	1701
90	967	1024	1082	1139	1196	1254	1311	1368	1425	1483	1540	1597	1655	1712
96	977	1034	1092	1149	1207	1264	1322	1379	1436	1494	1551	1609	1666	1723
102	987	1045	1102	1160	1217	1275	1333	1390	1448	1505	1563	1620	1678	1736
108	997	1055	1113	1171	1228	1286	1344	1402	1459	1517	1575	1633	1690	1748
114	1008	1066	1124	1182	1240	1298	1356	1413	1471	1529	1587	1645	1703	1761
120	1019	1077	1135	1193	1251	1309	1367	1426	1484	1542	1600	1658	1716	1774
126	1030	1088	1146	1205	1263	1321	1380	1438	1496	1555	1613	1671	1730	1788
132	1041	1100	1158	1217	1275	1334	1392	1451	1509	1568	1626	1685	1743	1802
138	1052	1111	1170	1229	1287	1346	1405	1464	1522	1581	1640	1698	1757	1816
144	1064	1123	1182	1241	1300	1359	1418	1477	1536	1595	1654	1712	1771	1830

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Fill Height Tables are based on:

1. γ_s= 120 pcfs
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3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions
4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

	Fill Height in Feet													
Pipe Size (in)	29	30	31	32	33	34	35	36	37	38	39	40	41	42
12	1725	1784	1843	1902	1961	2020	2079	2139	2198	2257	2316	2375	2434	2493
15	1679	1736	1793	1851	1908	1965	2023	2080	2138	2195	2252	2310	2367	2424
18	1655	1711	1767	1824	1880	1937	1993	2049	2106	2162	2219	2275	2331	2388
21	1643	1699	1755	1811	1867	1923	1979	2035	2091	2147	2203	2258	2314	2370
24	1641	1696	1752	1808	1863	1919	1975	2030	2086	2142	2197	2253	2309	2365
27	1643	1699	1755	1810	1866	1922	1977	2033	2089	2144	2200	2256	2311	2367
30	1650	1706	1762	1818	1874	1929	1985	2041	2097	2152	2208	2264	2320	2376
33	1661	1717	1773	1829	1885	1941	1997	2053	2109	2165	2221	2277	2333	2389
36	1673	1730	1786	1842	1899	1955	2011	2067	2124	2180	2236	2293	2349	2405
42	1676	1732	1788	1845	1901	1957	2013	2069	2125	2181	2238	2294	2350.	2406
48	1683	1740	1796	1852	1908	1964	2020	2077	2133	2189	2245	2301	2357	2414
54	1694	1750	1807	1863	1919	1975	2032	2088	2144	2200	2257	2313	2369	2426
60	1707	1763	1820	1876	1933	1989	2046	2102	2159	2215	2271	2328	2384	2441
66	1722	1778	1835	1892	1948	2005	2062	2119	2175	2232	2289	2345	2402	2459
72	1738	1795	1852	1909	1966	2023	2080	2137	2194	2251	2308	2365	2422	2479
78	1748	1805	1862	1919	1976	2033	2090	2147	2204	2261	2318	2375	2432	2489
84	1758	1815	1872	1929	1987	2044	2101	2158	2215	2272	2330	2387	2444	2501
90	1769	1826	1884	1941	1998	2056	2113	2170	2227	2285	2342	2399	2457	2514
96	1781	1838	1896	1953	2011	2068	2125	2183	2240	2298	2355	2413	2470	2527
102	1793	1851	1908	1966	2024	2081	2139	2196	2254	2311	2369	2427	2484	2542
108	1806	1864	1921	1979	2037	2095	2152	2210	2268	2326	2383	2441	2499	2557
114	1819	1877	1935	1993	2051	2109	2167	2224	2282	2340	2398	2456	2514	2572
120	1832	1891	1949	2007	2065	2123	2181	2239	2297	2355	2414	2472	2530	2588
126	1846	1905	1963	2021	2079	2138	2196	2254	2313	2371	2429	2488	2546	2604
132	1860	1919	1977	2036	2094	2153	2211	2270	2328	2387	2446	2504	2563	2621
138	1875	1933	1992	2051	2110	2168	2227	2286	2345	2403	2462	2521	2579	2638
144	1889	1948	2007	2066	2125	2184	2243	2302	2361	2420	2479	2538	2597	2656

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1. γ_s = 120 pcfs
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4. A Type 1 installation requires greater soil stiffness from the surrounding soils than the Type 2, 3, and 4 installations, and is thus harder to achieve. Therefore, field verification of soil properties and compaction levels should be performed.

D-Load (lb/ft/ft) for Type 1 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

	Fill Height in Feet											
Pipe Size (in)	43	44	45	46	47	48	49	50	51	52	53	54
12	2552	2611	2670	2729	2788	2847	2906	2965	3024	3084	3143	3202
15	2482	2539	2596	2654	2711	2768	2826	2883	2940	2998	3055	3112
18	2444	2501	2557	2614	2670	2726	2783	2839	2896	2952	3008	3065
21	2426	2482	2538	2594	2650	2706	2762	2817	2873	2929	2985	3041
24	2420	2476	2532	2587	2643	2699	2754	2810	2866	2921	2977	3033
27	2423	2478	2534	2590	2645	2701	2757	2812	2868	2924	2979	3035
30	2431	2487	2543	2599	2654	2710	2766	2822	2878	2933	2989	3045
33	2445	2501	2557	2613	2669	2725	2781	2837	2893	2949	3005	3061
36	2462	2518	2574	2631	2687	2743	2799	2856	2912	2968	3025	3081
42	2462	2518	2575	2631	2687	2743	2799	2855	2911	2968	3024	3080
48	2470	2526	2582	2638	2694	2750	2807	2863	2919	2975	3031	3087
54	2482	2538	2594	2651	2707	2763	2819	2876	2932	2988	3044	3101
60	2497	2554	2610	2667	2723	2780	2836	2892	2949	3005	3062	3118
66	2515	2572	2629	2686	2742	2799	2856	2912	2969	3026	3082	3139
72	2536	2593	2650	2707	2764	2821	2878	2935	2992	3049	3106	3163
78	2546	2603	2661	2718	2775	2832	2889	2946	3003	3060	3117	3174
84	2558	2615	2673	2730	2787	2844	2901	2958	3016	3073	3130	3187
90	2571	2628	2686	2743	2800	2858	2915	2972	3030	3087	3144	3201
96	2585	2642	2700	2757	2815	2872	2929	2987	3044	3102	3159	3217
102	2599	2657	2715	2772	2830	2887	2945	3002	3060	3118	3175	3233
108	2614	2672	2730	2788	2845	2903	2961	3019	3076	3134	3192	3250
114	2630	2688	2746	2804	2862	2920	2978	3035	3093	3151	3209	3267
120	2646	2704	2762	2820	2879	2937	2995	3053	3111	3169	3227	3285
126	2663	2721	2779	2838	2896	2954	3013	3071	3129	3187	3246	3304
132	2680	2738	2797	2855	2914	2972	3031	3089	3148	3206	3265	3323
138	2697	2756	2814	2873	2932	2991	3049	3108	3167	3226	3284	3343
144	2715	2774	2833	2892	2950	3009	3068	3127	3186	3245	3304	3363

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1492	1322	880	727	694	705	741	788	704	781	858	934	1011	1087
15	1434	1272	851	707	676	688	724	771	691	766	841	915	990	1065
18	1358	1240	834	697	668	680	717	763	688	761	835	909	983	1056
21	1220	1218	824	692	665	678	715	762	689	763	836	909	983	1056
24	1202	1203	818	690	665	680	717	764	694	768	841	915	988	1062
27	1344	1205	819	694	668	684	721	768	696	769	842	915	989	1062
30	1471	1213	823	701	674	690	727	773	699	772	845	919	992	1065
33	1347	1168	805	693	669	688	727	773	704	777	850	923	996	1069
36	1244	1137	789	687	665	687	728	775	710	783	856	929	1003	1076
42	1084	1059	759	673	659	685	726	773	715	788	861	933	1006	1079
48	966	935	732	663	655	684	726	774	722	795	867	940	1013	1085
54	923	899	712	655	654	685	728	777	731	803	876	948	1021	1094
60	948	875	696	650	654	688	731	781	740	813	885	958	1031	1103
66	906	855	687	646	655	691	736	787	750	823	896	969	1041	1114
72	850	837	679	643	658	696	741	793	761	834	907	980	1053	1126
78	802	820	672	642	660	697	744	796	768	841	913	986	1059	1131
84	763	805	665	641	661	700	747	799	775	848	920	993	1065	1138
90	730	791	660	641	664	703	750	803	863	855	927	999	1072	1144
96	703	756	655	642	666	706	754	807	867	862	934	1006	1078	1151
102	679	734	662	649	674	714	761	814	875	937	941	1013	1086	1158
108	660	723	668	657	681	721	769	822	882	945	949	1021	1093	1165
114	643	729	675	665	689	729	776	830	890	952	1016	1028	1100	1172
120	629	734	682	670	697	737	784	837	898	960	1024	1036	1108	1180
126	617	740	689	678	705	744	792	845	905	968	1032	1097	1115	1187
132	607	745	691	686	712	752	800	853	913	976	1039	1105	1171	1195
138	599	751	686	694	720	760	808	861	921	983	1047	1112	1178	1203
144	592	757	692	701	728	768	816	869	929	991	1055	1120	1186	1253

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	1164	1240	1317	1393	1470	1547	1623	1700	1776	1853	1929	2006	2083	2159
15	1139	1214	1289	1363	1438	1513	1587	1662	1737	1811	1886	1961	2035	2110
18	1130	1204	1278	1351	1425	1499	1573	1647	1720	1794	1868	1942	2015	2089
21	1130	1203	1277	1350	1424	1497	1570	1644	1717	1791	1864	1938	2011	2085
24	1135	1209	1282	1356	1429	1503	1576	1650	1723	1797	1870	1944	2017	2091
27	1135	1208	1282	1355	1428	1501	1574	1648	1721	1794	1867	1940	2014	2087
30	1138	1211	1284	1357	1430	1503	1576	1649	1722	1796	1869	1942	2015	2088
33	1143	1216	1289	1362	1435	1508	1581	1654	1727	1800	1874	1947	2020	2093
36	1149	1222	1295	1369	1442	1515	1588	1662	1735	1808	1881	1954	2028	2101
42	1152	1225	1298	1370	1443	1516	1589	1662	1735	1807	1880	1953	2026	2099
48	1158	1231	1303	1376	1449	1521	1594	1667	1739	1812	1885	1957	2030	2102
54	1166	1239	1311	1384	1457	1529	1602	1674	1747	1820	1892	1965	2037	2110
60	1176	1249	1321	1394	1467	1539	1612	1684	1757	1830	1902	1975	2048	2120
66	1187	1260	1332	1405	1478	1551	1623	1696	1769	1842	1914	1987	2060	2133
72	1199	1272	1345	1418	1490	1563	1636	1709	1782	1855	1928	2001	2074	2147
78	1204	1277	1350	1422	1495	1568	1640	1713	1786	1858	1931	2004	2076	2149
84	1210	1283	1355	1428	1500	1573	1645	1718	1790	1863	1935	2008	2080	2153
90	1216	1289	1361	1433	1506	1578	1650	1723	1795	1867	1940	2012	2084	2157
96	1223	1295	1367	1439	1512	1584	1656	1728	1800	1873	1945	2017	2089	2161
102	1230	1302	1374	1446	1518	1590	1662	1734	1806	1878	1950	2022	2094	2166
108	1237	1309	1381	1453	1524	1596	1668	1740	1812	1884	1956	2028	2100	2172
114	1244	1316	1388	1459	1531	1603	1675	1747	1819	1890	1962	2034	2106	2178
120	1251	1323	1395	1467	1538	1610	1682	1754	1825	1897	1969	2041	2112	2184
126	1259	1330	1402	1474	1545	1617	1689	1760	1832	1904	1975	2047	2119	2190
132	1266	1338	1410	1481	1553	1624	1696	1768	1839	1911	1982	2054	2125	2197
138	1274	1346	1417	1489	1560	1632	1703	1775	1846	1918	1989	2061	2132	2204
144	1282	1353	1425	1496	1568	1639	1711	1782	1854	1925	1996	2068	2139	2211

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Fill Height Tables are based on:

1. γ_s= 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 2 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	29	30	31	32	33	34	35	36	37	38	39	40	41	42
12	2236	2312	2389	2465	2542	2618	2695	2772	2848	2925	3001	3078	3154	3231
15	2185	2259	2334	2409	2483	2558	2633	2707	2782	2857	2931	3006	3081	3155
18	2163	2237	2310	2384	2458	2532	2605	2679	2753	2827	2900	2974	3048	3122
21	2158	2231	2305	2378	2452	2525	2599	2672	2745	2819	2892	2966	3039	3113
24	2164	2238	2311	2385	2458	2532	2605	2679	2752	2826	2899	2973	3046	3120
27	2160	2233	2306	2380	2453	2526	2599	2672	2746	2819	2892	2965	3038	3112
30	2161	2234	2307	2380	2453	2526	2599	2673	2746	2819	2892	2965	3038	3111
33	2166	2239	2312	2385	2458	2531	2605	2678	2751	2824	2897	2970	3043	3116
36	2174	2247	2320	2394	2467	2540	2613	2687	2760	2833	2906	2979	3053	3126
42	2172	2244	2317	2390	2463	2536	2609	2681	2754	2827	2900	2973	3046	3118
48	2175	2248	2320	2393	2466	2538	2611	2684	2756	2829	2902	2974	3047	3119
54	2183	2255	2328	2400	2473	2546	2618	2691	2763	2836	2908	2981	3054	3126
60	2193	2266	2338	2411	2483	2556	2629	2701	2774	2847	2919	2992	3065	3137
66	2205	2278	2351	2424	2496	2569	2642	2715	2787	2860	2933	3006	3078	3151
72	2220	2293	2365	2438	2511	2584	2657	2730	2803	2876	2949	3022	3095	3168
78	2222	2295	2367	2440	2513	2585	2658	2731	2803	2876	2949	3021	3094	3167
84	2225	2298	2370	2443	2515	2588	2660	2733	2805	2878	2950	3023	3095	3168
90	2229	2301	2374	2446	2518	2591	2663	2735	2808	2880	2952	3025	3097	3169
96	2233	2306	2378	2450	2522	2594	2667	2739	2811	2883	2955	3028	3100	3172
102	2238	2311	2383	2455	2527	2599	2671	2743	2815	2887	2959	3031	3103	3175
108	2244	2316	2388	2460	2532	2604	2676	2748	2819	2891	2963	3035	3107	3179
114	2250	2322	2393	2465	2537	2609	2681	2753	2824	2896	2968	3040	3112	3184
120	2256	2328	2399	2471	2543	2615	2686	2758	2830	2902	2973	3045	3117	3189
126	2262	2334	2405	2477	2549	2620	2692	2764	2835	2907	2979	3050	3122	3194
132	2269	2340	2412	2483	2555	2627	2698	2770	2841	2913	2985	3056	3128	3199
138	2275	2347	2418	2490	2562	2633	2705	2776	2848	2919	2991	3062	3134	3205
144	2282	2354	2425	2497	2568	2640	2711	2783	2854	2925	2997	3068	3140	3211

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1518	1369	947	817	805	838	896	964	902	1000	1098	1196	1294	1392
15	1459	1318	916	794	783	815	872	939	880	975	1070	1165	1260	1355
18	1384	1285	897	781	772	804	860	926	870	963	1057	1150	1243	1337
21	1247	1263	886	775	767	799	855	921	867	959	1051	1144	1236	1329
24	1229	1248	879	772	765	798	854	920	868	960	1051	1143	1235	1327
27	1372	1251	881	778	770	804	860	925	872	963	1055	1147	1238	1330
30	1500	1260	887	786	777	812	868	933	878	970	1061	1153	1245	1337
33	1378	1218	871	780	775	813	871	936	886	978	1070	1162	1254	1345
36	1276	1189	857	776	774	815	875	941	895	987	1079	1172	1264	1356
42	1119	1113	829	765	770	815	875	942	903	995	1087	1179	1271	1363
48	1004	992	808	758	770	817	879	946	913	1005	1097	1189	1281	1373
54	963	958	791	753	771	822	884	953	926	1018	1109	1201	1293	1385
60	991	937	778	751	775	828	891	961	939	1031	1123	1216	1308	1400
66	952	920	772	751	779	835	900	970	954	1046	1138	1231	1323	1416
72	898	905	768	751	786	843	909	981	969	1062	1154	1247	1340	1433
78	853	890	762	752	790	847	913	985	977	1070	1162	1255	1348	1440
84	816	878	758	754	794	852	918	991	986	1079	1171	1263	1355	1448
90	786	866	755	756	798	857	924	996	1076	1088	1180	1272	1364	1456
96	760	833	753	759	803	862	930	1003	1083	1097	1189	1281	1373	1464
102	739	814	761	769	813	872	939	1012	1092	1174	1198	1290	1382	1473
108	722	805	770	778	822	882	949	1022	1102	1184	1208	1299	1391	1482
114	708	813	779	788	832	892	959	1032	1112	1194	1277	1309	1400	1492
120	696	821	788	796	842	902	969	1042	1121	1203	1287	1319	1410	1501
126	687	829	798	806	852	912	979	1052	1131	1213	1297	1382	1420	1511
132	679	837	802	816	863	922	989	1062	1141	1223	1307	1391	1477	1521
138	673	845	800	826	873	932	999	1072	1152	1233	1317	1401	1487	1531
144	669	853	808	837	883	943	1010	1082	1162	1244	1327	1411	1497	1583

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	15	16	17	18	19	20	21	22	23	24	25	26	27	28
12	1490	1588	1686	1784	1882	1980	2078	2176	2274	2372	2470	2568	2666	2764
15	1450	1545	1640	1735	1830	1925	2020	2115	2210	2305	2401	2496	2591	2686
18	1430	1523	1617	1710	1803	1897	1990	2083	2177	2270	2363	2457	2550	2643
21	1421	1513	1606	1698	1790	1883	1975	2068	2160	2252	2345	2437	2529	2622
24	1419	1511	1603	1695	1786	1878	1970	2062	2154	2246	2338	2430	2521	2613
27	1422	1514	1605	1697	1789	1880	1972	2064	2155	2247	2339	2431	2522	2614
30	1428	1520	1612	1704	1795	1887	1979	2071	2162	2254	2346	2437	2529	2621
33	1437	1529	1621	1713	1805	1897	1989	2081	2173	2265	2357	2449	2541	2633
36	1449	1541	1633	1726	1818	1910	2003	2095	2187	2280	2372	2464	2557	2649
42	1455	1547	1639	1731	1823	1915	2007	2098	2190	2282	2374	2466	2558	2650
48	1465	1556	1648	1740	1832	1924	2016	2108	2200	2291	2383	2475	2567	2659
54	1477	1569	1661	1753	1845	1937	2029	2121	2213	2305	2397	2489	2581	2673
60	1492	1584	1676	1768	1861	1953	2045	2137	2229	2321	2413	2506	2598	2690
66	1508	1601	1693	1786	1878	1970	2063	2155	2248	2340	2433	2525	2617	2710
72	1526	1619	1711	1804	1897	1990	2083	2175	2268	2361	2454	2547	2639	2732
78	1533	1625	1718	1810	1903	1995	2088	2180	2273	2365	2458	2550	2643	2735
84	1540	1632	1725	1817	1909	2001	2094	2186	2278	2370	2463	2555	2647	2740
90	1548	1640	1732	1824	1916	2008	2100	2192	2284	2377	2469	2561	2653	2745
96	1556	1648	1740	1832	1924	2016	2108	2199	2291	2383	2475	2567	2659	2751
102	1565	1657	1748	1840	1932	2024	2115	2207	2299	2390	2482	2574	2666	2757
108	1574	1666	1757	1849	1940	2032	2123	2215	2307	2398	2490	2581	2673	2764
114	1583	1675	1766	1857	1949	2040	2132	2223	2315	2406	2498	2589	2680	2772
120	1593	1684	1775	1866	1958	2049	2140	2232	2323	2414	2506	2597	2688	2780
126	1602	1693	1785	1876	1967	2058	2149	2241	2332	2423	2514	2605	2697	2788
132	1612	1703	1794	1885	1976	2067	2158	2250	2341	2432	2523	2614	2705	2796
138	1622	1713	1804	1895	1986	2077	2168	2259	2350	2441	2532	2623	2714	2805
144	1632	1722	1813	1904	1995	2086	2177	2268	2359	2450	2541	2632	2723	2814

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition - this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 3 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet							
Pipe Size (in)	29	30	31	32	33	34	35
12	2862	2960	3058	3156	3254	3352	3450
15	2781	2876	2971	3066	3161	3256	3351
18	2737	2830	2923	3017	3110	3203	3297
21	2714	2807	2899	2991	3084	3176	3268
24	2705	2797	2889	2981	3073	3165	3256
27	2706	2797	2889	2981	3072	3164	3256
30	2713	2804	2896	2988	3080	3171	3263
33	2725	2817	2909	3001	3093	3185	3277
36	2741	2833	2926	3018	3110	3203	3295
42	2742	2834	2926	3018	3110	3202	3294
48	2751	2843	2935	3026	3118	3210	3302
54	2765	2857	2948	3040	3132	3224	3316
60	2782	2874	2966	3058	3151	3243	3335
66	2802	2895	2987	3080	3172	3265	3357
72	2825	2918	3011	3103	3196	3289	3382
78	2828	2920	3013	3105	3198	3290	3383
84	2832	2924	3016	3109	3201	3293	3385
90	2837	2929	3021	3113	3205	3297	3389
96	2843	2934	3026	3118	3210	3302	3394
102	2849	2941	3032	3124	3216	3308	3399
108	2856	2947	3039	3131	3222	3314	3405
114	2863	2955	3046	3138	3229	3320	3412
120	2871	2962	3054	3145	3236	3328	3419
126	2879	2970	3061	3153	3244	3335	3426
132	2887	2979	3070	3161	3252	3343	3434
138	2896	2987	3078	3169	3260	3351	3442
144	2905	2996	3087	3178	3269	3360	3450

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition -this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 4 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Pipe Size (in)	Fill Height in Feet													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
12	1579	1481	1111	1032	1071	1154	1264	1383	1372	1521	1671	1820	1969	2119
15	1519	1426	1073	998	1036	1116	1221	1336	1326	1616	1612	1756	1899	2042
18	1443	1391	1050	978	1015	1093	1195	1307	1297	1580	1576	1715	1854	1994
21	1306	1366	1035	966	1002	1079	1179	1288	1279	1557	1552	1688	1825	1961
24	1288	1349	1025	959	994	1070	1168	1276	1267	1541	1535	1670	1804	1938
27	1431	1352	1025	960	993	1068	1165	1271	1259	1531	1524	1657	1790	1922
30	1560	1360	1029	965	995	1070	1166	1270	1254	1524	1517	1648	1780	1911
33	1437	1316	1010	955	988	1064	1160	1264	1252	1520	1512	1642	1773	1903
36	1336	1285	993	947	982	1060	1157	1260	1251	1518	1509	1639	1768	1898
42	1181	1211	966	935	976	1057	1153	1256	1252	1518	1508	1636	1764	1892
48	1068	1090	941	927	973	1056	1152	1255	1257	1522	1511	1638	1765	1892
54	1029	1058	925	921	973	1058	1154	1257	1264	1529	1516	1642	1768	1894
60	1059	1038	912	918	975	1062	1158	1261	1273	1538	1523	1649	1774	1899
66	1021	1022	906	917	978	1066	1163	1266	1282	1548	1532	1657	1781	1906
72	969	1008	902	917	984	1072	1169	1272	1292	1559	1541	1666	1790	1914
78	927	996	899	920	990	1079	1176	1280	1303	1570	1551	1675	1799	1923
84	893	986	898	925	997	1086	1184	1288	1315	1582	1562	1686	1810	1933
90	866	978	898	931	1004	1094	1192	1296	1408	1595	1574	1697	1820	1944
96	844	948	899	936	1012	1102	1201	1305	1417	1608	1585	1708	1831	1955
102	826	932	911	949	1024	1115	1214	1318	1429	1685	1597	1720	1843	1966
108	812	927	923	962	1037	1128	1226	1330	1441	1698	1609	1732	1855	1978
114	801	938	935	975	1050	1141	1239	1343	1454	1712	1682	1745	1867	1990
120	793	949	947	986	1063	1154	1252	1356	1467	1726	1694	1757	1879	2002
126	786	960	959	999	1076	1167	1265	1369	1480	1740	1707	1823	1892	2014
132	782	971	967	1013	1090	1180	1278	1382	1493	1754	1720	1836	1952	2027
138	779	982	968	1026	1103	1194	1292	1395	1506	1769	1733	1848	1965	2040
144	778	994	980	1039	1116	1207	1305	1409	1519	1783	1746	1861	1978	2095

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Fill Height Tables are based on:

1. γ_s = 120 pcfs
2. AASHTO HL-93 live load
3. Positive Projecting Embankment Condition -this gives conservative results in comparison to trench conditions

D-Load (lb/ft/ft) for Type 4 Bedding

Class I
Class II
Class III
Class IV
Class V
Special Design

Fill Height in Feet											
Pipe Size (in)	15	16	17	18	19	20	21	22	23	24	25
12	2268	2417	2566	2716	2865	3014	3163	3313	3462	3611	3760
15	2185	2329	2472	2615	2759	2902	3045	3189	3332	3475	3618
18	2133	2272	2412	2551	2690	2830	2969	3108	3247	3387	3526
21	2098	2234	2370	2507	2643	2780	2916	3053	3189	3326	3462
24	2073	2207	2341	2476	2610	2744	2879	3013	3147	3282	3416
27	2055	2188	2320	2453	2586	2718	2851	2984	3116	3249	3382
30	2042	2174	2305	2436	2568	2699	2830	2962	3093	3225	3356
33	2033	2164	2294	2424	2554	2685	2815	2945	3075	3206	3336
36	2027	2156	2286	2415	2544	2674	2803	2932	3062	3191	3321
42	2020	2148	2276	2404	2532	2660	2788	2916	3044	3171	3299
48	2018	2145	2272	2399	2526	2653	2780	2907	3033	3160	3287
54	2020	2146	2273	2399	2525	2651	2777	2903	3029	3155	3281
60	2025	2150	2276	2401	2526	2652	2777	2903	3028	3153	3279
66	2031	2156	2281	2406	2531	2655	2780	2905	3030	3155	3280
72	2039	2163	2288	2412	2536	2661	2785	2909	3034	3158	3283
78	2047	2171	2295	2419	2543	2667	2791	2915	3039	3163	3287
84	2057	2181	2304	2428	2552	2675	2799	2923	3046	3170	3294
90	2067	2190	2314	2437	2561	2684	2807	2931	3054	3178	3301
96	2078	2201	2324	2447	2570	2693	2817	2940	3063	3186	3309
102	2089	2212	2335	2458	2581	2704	2826	2949	3072	3195	3318
108	2100	2223	2346	2469	2591	2714	2837	2959	3082	3205	3328
114	2112	2235	2357	2480	2602	2725	2848	2970	3093	3215	3338
120	2124	2247	2369	2491	2614	2736	2859	2981	3103	3226	3348
126	2137	2259	2381	2503	2626	2748	2870	2992	3115	3237	3359
132	2149	2271	2393	2515	2638	2760	2882	3004	3126	3248	3370
138	2162	2284	2406	2528	2650	2772	2894	3016	3138	3260	3382
144	2174	2296	2418	2540	2662	2784	2906	3028	3150	3272	3393

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The preceding fill height tables are based on a concrete pipe installed in a positive projecting embankment installation with a soil unit weight of 120 lbs/ft^3 and HL-93 live load per the AASHTO LRFD Bridge Design specifications at the surface. Pipe outside diameters were based on a Wall C thickness since the larger outside diameters would represent the highest soil overburden load on the pipe. The required classes of pipe do not account for construction loads or any other load induced on the pipe prior to its completed installation, or live load in excess of HL-93.

Dimensions of Circular Concrete Pipe - Metric Units

Designated Internal Diameter mm	Actual Internal Diameter mm	Wall B		Wall C	
		Minimum Wall Thickness mm	Average Weight kg/m	Minimum Wall Thickness mm	Average Weight kg/m
300	305	50	162	69	197
375	381	57	216	76	262
450	457	63	253	82	335
525	533	69	327	88	417
600	610	75	430	94	505
675	686	82	500	100	602
750	762	88	598	107	708
825	838	94	695	113	821
900	914	100	832	119	940
975	991	113	923	125	1090
1050	1067	117	1057	132	1207
1200	1219	125	1324	144	1504
1350	1372	138	1589	157	1829
1500	1524	150	1927	169	2192
1650	1676	163	2295	182	2582
1800	1829	175	2695	194	2998
1950	1981	188	3125	207	3457
2100	2134	200	3585	219	3943
2250	2286	213	4078	232	4460
2400	2438	225	4598	244	5009
2550	2591	238	5179	257	5595
2700	2743	250	5752	269	6202
3000	3048	279	6344	298	7521
3600	3658	330	8104	349	10,540

Dimensions of Circular Concrete Pipe - Imperial Units

Internal Diameter Inches	Wall A		Wall B		Wall C	
	Minimum Wall Thickness Inches	Average Weight pounds per foot	Minimum Wall Thickness Inches	Average Weight pounds per foot	Minimum Wall Thickness Inches	Average Weight pounds per foot
12	1-3/4	79	2	93	2-3/4	133
15	1-7/8	103	2-1/4	127	3	177
18	2	131	2-1/2	168	3-1/4	226
21	2-1/4	171	2-3/4	214	3-1/2	281
24	2-1/2	217	3	264	3-3/4	341
27	2-5/8	255	3-1/4	322	4	406
30	2-3/4	295	3-1/2	384	4-1/4	476
33	2-7/8	336	3-3/4	451	4-1/2	552
36	3	383	4	524	4-3/4	633
42	3-1/2	520	4-1/2	686	5-1/4	811
48	4	683	5	867	5-3/4	1011
54	4-1/2	864	5-1/2	1068	6-1/4	1232
60	5	1064	6	1295	6-3/4	1473
66	5-1/2	1287	6-1/2	1542	7-1/4	1735
72	6	1532	7	1811	7-3/4	2023
78	6-1/2	1797	7-1/2	2100	8-1/4	2329
84	7	2085	8	2409	8-3/4	2656
90	7-1/2	2395	8-1/2	2740	9-1/4	3004
96	8	2710	9	3090	9-3/4	3374
102	8-1/2	3078	9-1/2	3480	10-1/4	3765
108	9	3446	10	3865	10-3/4	4178
114	9-1/2	3840	10-1/2	4278	11-1/4	4611
120	10	4263	11	4716	11-3/4	5066
126	10-1/2	4690	11-1/2	5175	12-1/4	5542
132	11	5148	12	5655	12-3/4	6040
138	11-1/2	5627	12-1/2	6156	13-1/4	6558
144	12	6126	13	6679	13-3/4	7098
150	12-1/2	6647	13-1/2	7223	14-1/4	7659
156	13	7190	14	7789	14-3/4	8242
162	13-1/2	7754	14-1/2	8375	15-1/4	8846
168	14	8339	15	8983	15-3/4	9471
174	14-1/2	8945	15-1/2	9612	16-1/4	10,117
180	15	9572	16	10,263	16-3/4	10,785

ACPA
American Concrete Pipe Association
E-mail: acpa@concretepipe.org
www.concretepipe.org