

CENTRAL CANTILEVER

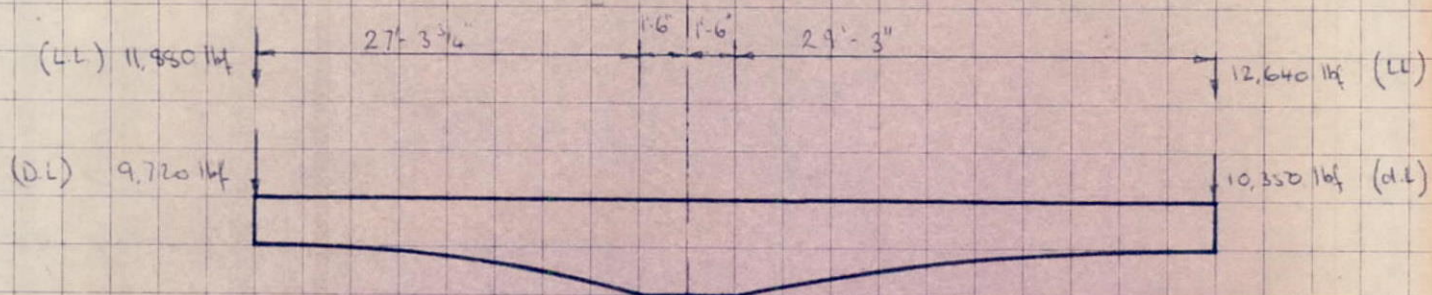
The prestressed unit is designed and then analysed in detail for stress conditions. The unit is checked for ultimate strength.

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DESIGN OF CENTRAL CANTILEVER, Unit 3



Long Cantilevers

$$\text{Dead Load Moment} = \underline{5,564,870 \text{ lb.in.}}$$

$$\text{Live Load Moment} = 23,000 \times 29.25 \times 12 + 766 (29.25)^2 \times \frac{12}{2}$$

$$= \underline{12,005,165 \text{ lb.in.}}$$

$$\text{Dead Load stresses, } \sigma_{\text{top}} = \frac{5,564,870}{14,660} = \underline{-380 \text{ p.s.i.}}$$

$$\sigma_{\text{bot}} = \frac{5,564,870}{14,033} = \underline{+397 \text{ p.s.i.}}$$

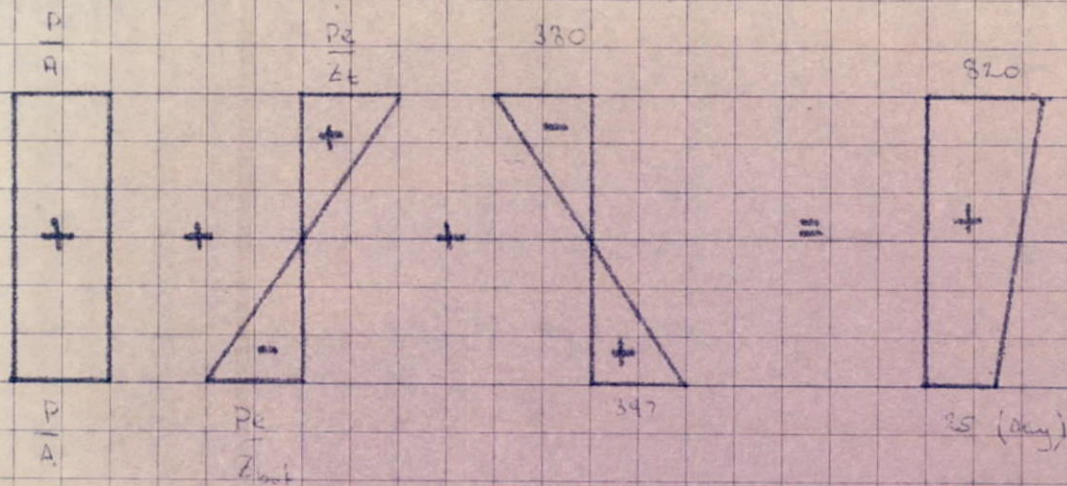
Live Load stresses,

$$\sigma_{\text{top}} = \frac{12,005,200}{14,660} = \underline{-819 \text{ p.s.i.}}$$

$$\sigma_{\text{bot}} = \frac{12,005,200}{14,033} = \underline{+855 \text{ p.s.i.}}$$

Prestressing

4.03



Equations:

$$\frac{P}{A} + \frac{Pe}{Z_t} - 380 = 820 \quad \text{--- (1)}$$

$$\frac{P}{A} - \frac{Pe}{Z_{bot}} + 397 = 25 \quad \text{--- (2)}$$

① $\times Z_{top}$ + ② $\times Z_{bot}$ and simplify :-

$$P = \frac{(1200 \times Z_t - 372 \times Z_b) A}{Z_t + Z_b}$$

$$\begin{aligned} Z_t &= 14660 \text{ in}^3 \\ Z_b &= 14033 \text{ in}^3 \\ A &= 2467 \text{ in}^2 \end{aligned}$$

$$P = \underline{1,063,710 \text{ lbf.}}$$

Sub in ①

$$\underline{e = 10.57 \text{ ins}}$$

ie 6.06' from top face

Stress on end section ($x = 16.25'$)

$$e = 5.42 - 6.06 = -0.64''$$

$$\frac{Pe}{Z_t} = - \frac{1,063,000(0.64)}{1480} = -344$$

$$\frac{Pe}{Z_{bot}} = \frac{Pe}{1300} = +523$$

$$\frac{P}{A} = \frac{P}{700} = +1519$$

O.K. $\left\{ \begin{aligned} \sigma_{top} &= -344 + 1519 = +1174 \text{ p.s.i.} \\ \sigma_{bot} &= +523 + 1519 = +2042 \text{ p.s.i.} \end{aligned} \right.$

(a) Steel Creepstress relieved $\frac{1}{2}$ " ϕ strand10,000 p.s.i.(b) Elastic deformation

$$\frac{E_s}{E_c} = \frac{28 \times 10^6}{5.25 \times 10^6} = 5.35$$

 σ_c , stress in adjacent concrete, i.e. at 6.06" from top face,

$$\sigma_c = 25 + (820 - 25) \frac{28.65}{34} = +695 \text{ p.s.i.}$$

$$\therefore \text{loss} = 5.35 \times 695 = \rightarrow$$

3,720 p.s.i.(c) Concrete Shrinkage

$$300 \times 10^{-6} \times 28 \times 10^6$$

8,400 p.s.i.(d) Concrete Creep

$$0.33 \times 10^{-6} \times 28 \times 10^6 \times 695$$

6,420 p.s.i.Total Losses 28,540 p.s.i.

$$\text{Required Final } P = 1,063,000 \text{ lbf.}$$

$$\text{Stress} = \frac{1,063,000}{56 \times 0.144} = 132,000 \text{ p.s.i.}$$

$$\text{Then } \sigma_{\text{initial}} = 132,000 + 28,540 = 160,540 \text{ p.s.i.}$$

$$\text{and } P_{\text{initial}} = 160,540 \times 0.144 \times 56 = 1,278,000 \text{ lbf.}$$

$$\% \text{ loss} = \frac{28,540}{160,540} = \underline{\underline{17.8\%}}$$

$$P / \text{strand} = \frac{1,278,000}{56} = \underline{\underline{23,000 \text{ lbf.}}}$$

$$\% \text{ elastic loss} = \frac{3,720}{160,540} = \underline{\underline{2.25\%}}$$

It is appreciated that % losses increase towards the smaller sections, but there is a more than proportionate reserve of stress in these sections. (see analysis)

Short Cantilever

4.05

$$\text{Dead load Moment} = 4,828,700 \text{ lb.in.}$$

$$\text{Dead Load Stresses} \quad \sigma_{\text{top}} = \frac{M}{14,660} = -330 \text{ p.s.i.}$$

$$\sigma_{\text{bot}} = +344 \text{ p.s.i.}$$

$$\frac{P}{A} = +430 \text{ p.s.i.}$$

$$\frac{P_e}{Z_t} = +774 \text{ p.s.i.}$$

$$\frac{P_e}{Z_b} = -800 \text{ p.s.i.}$$

$$\sigma_{\text{top}} = -330 + 430 + 774 = +874 \text{ p.s.i.}$$

$$\sigma_{\text{bot}} = +344 + 430 - 800 = -26 \text{ p.s.i.}$$

The -ve stress σ_{bot} is small and will become +ve when the suspended span is loaded and is therefore only temporary and will be accepted. The live loadings for this span are smaller than for the long span and so there is plenty of reserve strength.

check Transfer stresses, allowing for Jacking Pockets.

$$P_{\text{transfer}} = 1,278,000 \times \frac{97.75}{100} = 1,249,000 \text{ lbf.}$$

$$A = 2,312 \text{ in}^2$$

$$Z_t = 13,104 \text{ in}^3$$

$$Z_b = 13,001 \text{ in}^3$$

$$\frac{P}{A} = +542 \text{ p.s.i.}$$

$$A$$

$$\frac{P_e}{Z_t} = -1011 \text{ p.s.i.}$$

$$Z_{\text{bot}}$$

$$\frac{P_e}{Z_{\text{top}}} = +1000 \text{ p.s.i.}$$

$$Z_{\text{top}}$$

$$\frac{DL}{Z_{\text{bot}}} = +371 \text{ p.s.i.}$$

$$Z_{\text{bot}}$$

$$\frac{DL}{Z_{\text{top}}} = -367 \text{ p.s.i.}$$

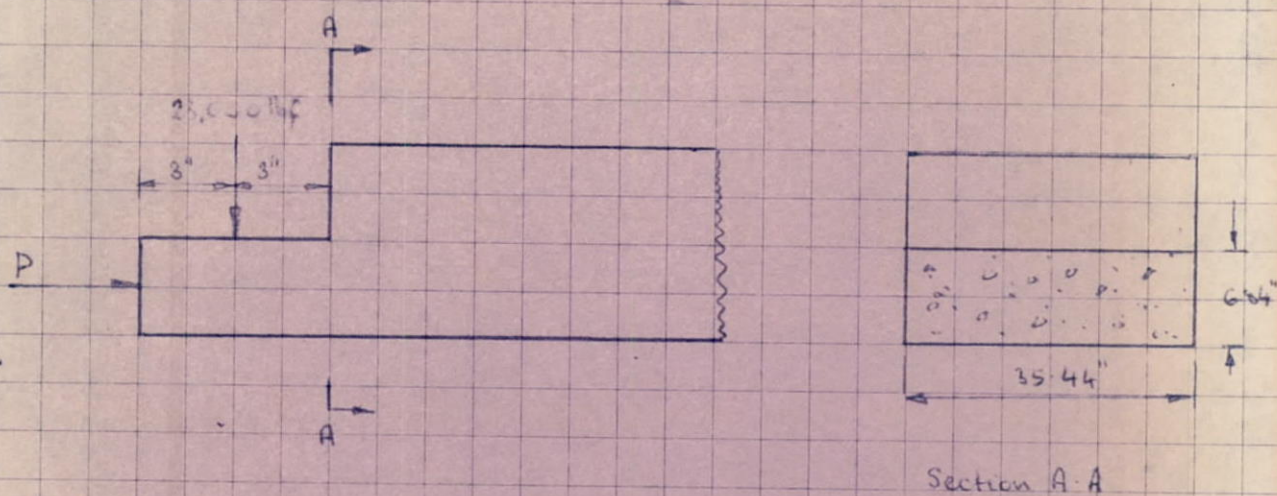
$$Z_{\text{top}}$$

$$\sigma_{\text{top}} = +542 + 1000 - 367 = +1175 \text{ p.s.i.}$$

$$\sigma_{\text{bot}} = +542 - 1011 + 371 = -98 \text{ p.s.i.}$$

Transfer Stresses O.K.

Check Shear Stresses on End Section



16 strands in lower section then $P = \frac{16}{56} \times 1,063,000 = 320,000 \text{ lbf}$.

But only $\frac{3}{4}$ of P is developed at section A-A - $P_A = 63,000 \text{ lbf}$.

Principal stress equation -

$$\sigma_p = \frac{P_A}{2A} - \left[\sigma_a^2 + \left(\frac{P}{2A} \right)^2 \right]^{1/2}$$

where σ_p = allowable principal stress = -175 psi

σ_a = allowable shear stress =

$$A = 35.44 \times 6.94 = 249 \text{ in}^2$$

$$\frac{P_A}{A} = 255 \text{ psi}$$

Expressing equation and sub

$$(-175)^2 = \left(\frac{255}{4} \right)^2 + \sigma_a^2$$

Substitute -

$$-175 = \frac{255}{4} - \left[\right]^{1/2}$$

Square

$$(353)^2 = -(\sigma_a^2 + (173)^2)$$

$$\sigma_a = +304 \text{ psi}$$

$$\text{Allowable Shear Force} = \frac{35.44^2 \times 304 \times 4 \times 6.94^3}{35.44 \times 3.42 \times 6.94 \times 12} = 49,100 \text{ lbf}$$

Actual shear force = 23,000 lbf < Allowable shear force.

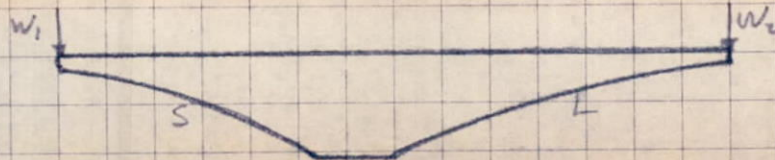
Only nominal reinforcement required in joint.

CENTRAL CANTILEVER

LIVE LOAD

STRESSES

4.07



$W_1, W_2 =$ (wt of suspended span + reaction due to live load)

$W_1 = 21,600 \text{ lb} \quad W_2 = 22,990 \text{ lb}$

$M_{ss} = W_1 \cdot x$

live load over central cantilever, $w = 766 \text{ lb/ft}$

$M_{LL} = \frac{wx^2}{2}$

CURVE

CURVE

X ft	x ft	x ² ft ²	M _{LL} lb-ft	M _{ss} lb-ft	M _{LL} + M _{ss}	C _{top} lb/in ²	C _{bottom} lb/in ²
10	1	144	4,596	259,200	263,796	126.8	190.4
18	3	1,296	41,364	777,600	818,964	345.8	506.8
20	5	3,600	114,900	1,296,000	1,410,900	520.2	742.5
22	7	7,056	225,204	1,814,400	2,039,604	654.8	900.2
24	9	11,664	372,276	2,332,800	2,705,076	754.3	1,002.3
26	11	17,424	556,116	2,851,200	3,407,316	822.9	1,056.7
28	13	24,336	776,724	3,369,600	4,146,324	865.9	1,075.0
30	15	32,400	1,034,100	3,888,000	4,922,100	886.6	1,066.1
32	17	41,616	1,328,244	4,406,400	5,734,644	890.1	1,038.9
34	19	51,984	1,659,156	4,924,800	6,583,956	878.4	997.9
36	21	63,504	2,026,836	5,443,200	7,470,036	854.5	947.3
38	23	76,176	2,431,284	5,961,600	8,392,884	821.8	891.8
40	25	90,000	2,872,500	6,480,000	9,352,500	782.0	833.2
42	27	104,976	3,350,484	6,998,400	10,348,884	738.5	774.6
42.86	27.565	104,396	3,491,556	7,144,200	10,635,756	725.5	757.9
44	29	121,104	3,865,336	8,000,520	11,865,756	809.4	845.5
44	27.5	108,940	3,475,725	7,556,700	11,032,425	842.8	890.2
42	25.5	93,026	2,928,549	7,034,940	10,023,489	887.1	950.9
40	23.5	79,534	2,539,141	6,483,180	9,022,321	924.3	1,009.0
38	21.5	66,504	2,124,501	5,931,420	8,055,921	954.4	1,063.5
36	19.5	54,756	1,747,629	5,379,660	7,127,289	974.4	1,111.5
34	17.5	44,100	1,407,525	4,827,900	6,235,425	982.1	1,149.5
32	15.5	34,596	1,104,189	4,276,140	5,380,329	974.7	1,173.3
30	13.5	26,244	837,621	3,724,380	4,562,001	948.0	1,176.0
28	11.5	19,044	607,821	3,172,620	3,780,441	895.0	1,151.1
26	9.5	12,996	414,789	2,620,860	3,035,649	827.5	1,093.5
24	7.5	8,100	258,525	2,069,100	2,327,625	724.0	987.9
22	5.5	4,356	139,029	1,517,240	1,656,369	587.2	826.2
20	3.5	1,764	56,301	965,580	1,021,881	411.4	595.9
18	1.5	324	10,341	413,820	424,161	193.1	287.1

CURVE L (unbraced cantilever)

Station	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123	125	127	129	131	133	135	137	139	141	143	145	147	149	151	153	155	157	159	161	163	165	167	169	171	173	175	177	179	181	183	185	187	189	191	193	195	197	199	201	203	205	207	209	211	213	215	217	219	221	223	225	227	229	231	233	235	237	239	241	243	245	247	249	251	253	255	257	259	261	263	265	267	269	271	273	275	277	279	281	283	285	287	289	291	293	295	297	299	301	303	305	307	309	311	313	315	317	319	321	323	325	327	329	331	333	335	337	339	341	343	345	347	349	351	353	355	357	359	361	363	365	367	369	371	373	375	377	379	381	383	385	387	389	391	393	395	397	399	401	403	405	407	409	411	413	415	417	419	421	423	425	427	429	431	433	435	437	439	441	443	445	447	449	451	453	455	457	459	461	463	465	467	469	471	473	475	477	479	481	483	485	487	489	491	493	495	497	499	501	503	505	507	509	511	513	515	517	519	521	523	525	527	529	531	533	535	537	539	541	543	545	547	549	551	553	555	557	559	561	563	565	567	569	571	573	575	577	579	581	583	585	587	589	591	593	595	597	599	601	603	605	607	609	611	613	615	617	619	621	623	625	627	629	631	633	635	637	639	641	643	645	647	649	651	653	655	657	659	661	663	665	667	669	671	673	675	677	679	681	683	685	687	689	691	693	695	697	699	701	703	705	707	709	711	713	715	717	719	721	723	725	727	729	731	733	735	737	739	741	743	745	747	749	751	753	755	757	759	761	763	765	767	769	771	773	775	777	779	781	783	785	787	789	791	793	795	797	799	801	803	805	807	809	811	813	815	817	819	821	823	825	827	829	831	833	835	837	839	841	843	845	847	849	851	853	855	857	859	861	863	865	867	869	871	873	875	877	879	881	883	885	887	889	891	893	895	897	899	901	903	905	907	909	911	913	915	917	919	921	923	925	927	929	931	933	935	937	939	941	943	945	947	949	951	953	955	957	959	961	963	965	967	969	971	973	975	977	979	981	983	985	987	989	991	993	995	997	999	1001	1003	1005	1007	1009	1011	1013	1015	1017	1019	1021	1023	1025	1027	1029	1031	1033	1035	1037	1039	1041	1043	1045	1047	1049	1051	1053	1055	1057	1059	1061	1063	1065	1067	1069	1071	1073	1075	1077	1079	1081	1083	1085	1087	1089	1091	1093	1095	1097	1099	1101	1103	1105	1107	1109	1111	1113	1115	1117	1119	1121	1123	1125	1127	1129	1131	1133	1135	1137	1139	1141	1143	1145	1147	1149	1151	1153	1155	1157	1159	1161	1163	1165	1167	1169	1171	1173	1175	1177	1179	1181	1183	1185	1187	1189	1191	1193	1195	1197	1199	1201	1203	1205	1207	1209	1211	1213	1215	1217	1219	1221	1223	1225	1227	1229	1231	1233	1235	1237	1239	1241	1243	1245	1247	1249	1251	1253	1255	1257	1259	1261	1263	1265	1267	1269	1271	1273	1275	1277	1279	1281	1283	1285	1287	1289	1291	1293	1295	1297	1299	1301	1303	1305	1307	1309	1311	1313	1315	1317	1319	1321	1323	1325	1327	1329	1331	1333	1335	1337	1339	1341	1343	1345	1347	1349	1351	1353	1355	1357	1359	1361	1363	1365	1367	1369	1371	1373	1375	1377	1379	1381	1383	1385	1387	1389	1391	1393	1395	1397	1399	1401	1403	1405	1407	1409	1411	1413	1415	1417	1419	1421	1423	1425	1427	1429	1431	1433	1435	1437	1439	1441	1443	1445	1447	1449	1451	1453	1455	1457	1459	1461	1463	1465	1467	1469	1471	1473	1475	1477	1479	1481	1483	1485	1487	1489	1491	1493	1495	1497	1499	1501	1503	1505	1507	1509	1511	1513	1515	1517	1519	1521	1523	1525	1527	1529	1531	1533	1535	1537	1539	1541	1543	1545	1547	1549	1551	1553	1555	1557	1559	1561	1563	1565	1567	1569	1571	1573	1575	1577	1579	1581	1583	1585	1587	1589	1591	1593	1595	1597	1599	1601	1603	1605	1607	1609	1611	1613	1615	1617	1619	1621	1623	1625	1627	1629	1631	1633	1635	1637	1639	1641	1643	1645	1647	1649	1651	1653	1655	1657	1659	1661	1663	1665	1667	1669	1671	1673	1675	1677	1679	1681	1683	1685	1687	1689	1691	1693	1695	1697	1699	1701	1703	1705	1707	1709	1711	1713	1715	1717	1719	1721	1723	1725	1727	1729	1731	1733	1735	1737	1739	1741	1743	1745	1747	1749	1751	1753	1755	1757	1759	1761	1763	1765	1767	1769	1771	1773	1775	1777	1779	1781	1783	1785	1787	1789	1791	1793	1795	1797	1799	1801	1803	1805	1807	1809	1811	1813	1815	1817	1819	1821	1823	1825	1827	1829	1831	1833	1835	1837	1839	1841	1843	1845	1847	1849	1851	1853	1855	1857	1859	1861	1863	1865	1867	1869	1871	1873	1875	1877	1879	1881	1883	1885	1887	1889	1891	1893	1895	1897	1899	1901	1903	1905	1907	1909	1911	1913	1915	1917	1919	1921	1923	1925	1927	1929	1931	1933	1935	1937	1939	1941	1943	1945	1947	1949	1951	1953	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041	2043	2045	2047	2049	2051	2053	2055	2057	2059	2061	2063	2065	2067	2069	2071	2073	2075	2077	2079	2081	2083	2085	2087	2089	2091	2093	2095	2097	2099	2101	2103	2105	2107	2109	2111	2113	2115	2117	2119	2121	2123	2125	2127	2129	2131	2133	2135	2137	2139	2141	2143	2145	2147	2149	2151	2153	2155	2157	2159	2161	2163	2165	2167	2169	2171	2173	2175	2177	2179	2181	2183	2185	2187	2189	2191	2193	2195	2197	2199	2201	2203	2205	2207	2209	2211	2213	2215	2217	2219	2221	2223	2225	2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Dead Load
Bending Moments
(lb.in)

Curve S of
Central Cantilever
(Unit 3)

Distance from Support (ft)	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75	77	79	81	83	85	87	89	91	93	95	97	99	101	103	105	107	109	111	113	115	117	119	121	123	125	127	129	131	133	135	137	139	141	143	145	147	149	151	153	155	157	159	161	163	165	167	169	171	173	175	177	179	181	183	185	187	189	191	193	195	197	199	201	203	205	207	209	211	213	215	217	219	221	223	225	227	229	231	233	235	237	239	241	243	245	247	249	251	253	255	257	259	261	263	265	267	269	271	273	275	277	279	281	283	285	287	289	291	293	295	297	299	301	303	305	307	309	311	313	315	317	319	321	323	325	327	329	331	333	335	337	339	341	343	345	347	349	351	353	355	357	359	361	363	365	367	369	371	373	375	377	379	381	383	385	387	389	391	393	395	397	399	401	403	405	407	409	411	413	415	417	419	421	423	425	427	429	431	433	435	437	439	441	443	445	447	449	451	453	455	457	459	461	463	465	467	469	471	473	475	477	479	481	483	485	487	489	491	493	495	497	499	501	503	505	507	509	511	513	515	517	519	521	523	525	527	529	531	533	535	537	539	541	543	545	547	549	551	553	555	557	559	561	563	565	567	569	571	573	575	577	579	581	583	585	587	589	591	593	595	597	599	601	603	605	607	609	611	613	615	617	619	621	623	625	627	629	631	633	635	637	639	641	643	645	647	649	651	653	655	657	659	661	663	665	667	669	671	673	675	677	679	681	683	685	687	689	691	693	695	697	699	701	703	705	707	709	711	713	715	717	719	721	723	725	727	729	731	733	735	737	739	741	743	745	747	749	751	753	755	757	759	761	763	765	767	769	771	773	775	777	779	781	783	785	787	789	791	793	795	797	799	801	803	805	807	809	811	813	815	817	819	821	823	825	827	829	831	833	835	837	839	841	843	845	847	849	851	853	855	857	859	861	863	865	867	869	871	873	875	877	879	881	883	885	887	889	891	893	895	897	899	901	903	905	907	909	911	913	915	917	919	921	923	925	927	929	931	933	935	937	939	941	943	945	947	949	951	953	955	957	959	961	963	965	967	969	971	973	975	977	979	981	983	985	987	989	991	993	995	997	999	1001	1003	1005	1007	1009	1011	1013	1015	1017	1019	1021	1023	1025	1027	1029	1031	1033	1035	1037	1039	1041	1043	1045	1047	1049	1051	1053	1055	1057	1059	1061	1063	1065	1067	1069	1071	1073	1075	1077	1079	1081	1083	1085	1087	1089	1091	1093	1095	1097	1099	1101	1103	1105	1107	1109	1111	1113	1115	1117	1119	1121	1123	1125	1127	1129	1131	1133	1135	1137	1139	1141	1143	1145	1147	1149	1151	1153	1155	1157	1159	1161	1163	1165	1167	1169	1171	1173	1175	1177	1179	1181	1183	1185	1187	1189	1191	1193	1195	1197	1199	1201	1203	1205	1207	1209	1211	1213	1215	1217	1219	1221	1223	1225	1227	1229	1231	1233	1235	1237	1239	1241	1243	1245	1247	1249	1251	1253	1255	1257	1259	1261	1263	1265	1267	1269	1271	1273	1275	1277	1279	1281	1283	1285	1287	1289	1291	1293	1295	1297	1299	1301	1303	1305	1307	1309	1311	1313	1315	1317	1319	1321	1323	1325	1327	1329	1331	1333	1335	1337	1339	1341	1343	1345	1347	1349	1351	1353	1355	1357	1359	1361	1363	1365	1367	1369	1371	1373	1375	1377	1379	1381	1383	1385	1387	1389	1391	1393	1395	1397	1399	1401	1403	1405	1407	1409	1411	1413	1415	1417	1419	1421	1423	1425	1427	1429	1431	1433	1435	1437	1439	1441	1443	1445	1447	1449	1451	1453	1455	1457	1459	1461	1463	1465	1467	1469	1471	1473	1475	1477	1479	1481	1483	1485	1487	1489	1491	1493	1495	1497	1499	1501	1503	1505	1507	1509	1511	1513	1515	1517	1519	1521	1523	1525	1527	1529	1531	1533	1535	1537	1539	1541	1543	1545	1547	1549	1551	1553	1555	1557	1559	1561	1563	1565	1567	1569	1571	1573	1575	1577	1579	1581	1583	1585	1587	1589	1591	1593	1595	1597	1599	1601	1603	1605	1607	1609	1611	1613	1615	1617	1619	1621	1623	1625	1627	1629	1631	1633	1635	1637	1639	1641	1643	1645	1647	1649	1651	1653	1655	1657	1659	1661	1663	1665	1667	1669	1671	1673	1675	1677	1679	1681	1683	1685	1687	1689	1691	1693	1695	1697	1699	1701	1703	1705	1707	1709	1711	1713	1715	1717	1719	1721	1723	1725	1727	1729	1731	1733	1735	1737	1739	1741	1743	1745	1747	1749	1751	1753	1755	1757	1759	1761	1763	1765	1767	1769	1771	1773	1775	1777	1779	1781	1783	1785	1787	1789	1791	1793	1795	1797	1799	1801	1803	1805	1807	1809	1811	1813	1815	1817	1819	1821	1823	1825	1827	1829	1831	1833	1835	1837	1839	1841	1843	1845	1847	1849	1851	1853	1855	1857	1859	1861	1863	1865	1867	1869	1871	1873	1875	1877	1879	1881	1883	1885	1887	1889	1891	1893	1895	1897	1899	1901	1903	1905	1907	1909	1911	1913	1915	1917	1919	1921	1923	1925	1927	1929	1931	1933	1935	1937	1939	1941	1943	1945	1947	1949	1951	1953	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	2013	2015	2017	2019	2021	2023	2025	2027	2029	2031	2033	2035	2037	2039	2041	2043	2045	2047	2049	2051	2053	2055	2057	2059	2061	2063	2065	2067	2069	2071	2073	2075	2077	2079	2081	2083	2085	2087	2089	2091	2093	2095	2097	2099	2101	2103	2105	2107	2109	2111	2113	2115	2117	2119	2121	2123	2125	2127	2129	2131	2133	2135	2137	2139	2141	2143	2145	2147	2149	2151	2153	2155	2157	2159	2161	2163	2165	2167	2169	2171	2173	2175	2177	2179	2181	2183	2185	2187	2189	2191	2193	2195	2197	2199	2201	2203	2205	2207	2209	2211	2213	2215	2217	2219	2221	2223	2225	2227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CURVE S			CURVE L	
x	B.M. calculated	B.M. interpolated	B.M. calculated	B.M. interpolated
16	—	8,958	—	—
17	17,915	—	1088	—
18	—	45,355	—	14,625
19	72,794	—	28,161	—
20	—	119,960	—	60,635
21	167,125	—	93,168	—
22	—	235,491	—	145,751
23	303,857	—	198,294	—
24	—	395,156	—	272,652
25	486,454	—	346,910	—
26	—	602,714	—	424,391
27	718,973	—	501,872	—
28	—	863,471	—	644,794
29	1,067,968	—	787,715	—
30	—	1,180,681	—	938,107
31	1,353,394	—	1,088,444	—
32	—	1,560,209	—	1,268,426
33	1,767,023	—	1,449,353	—
34	—	2,010,604	—	1,662,732
35	2,254,184	—	1,876,171	—
36	—	2,538,619	—	2,125,757
37	2,823,054	—	2,575,403	—
38	—	3,152,988	—	2,665,061
39	3,482,921	—	2,954,718	—
40	—	3,863,626	—	3,288,608
41	4,244,331	—	3,622,497	—
42	—	4,814,456	—	4,005,351
43	—	—	4,888,205	—
44	—	—	—	4,825,341
45	—	—	5,262,477	—
42.565	5,099,519	5,099,519	—	—
45.5	—	—	5,499,175	5,499,175

STRESSES IN TOP OF CENTRAL CANTILEVER ~ Table C _{Top}

4.11

		1	2	3	4	5	6
	X ft	D.L. stresses	$P_0/2A_0$	P/A	$1+2+3$	L.L. stress	$4+5$
CURVE S	16.0	-4.3	-275.9	1483.3	1203.1	-126.8	1076.3
	18.0	-19.1	-40.4	1395.1	1335.6	-345.8	989.8
	20.0	-44.2	+164.6	1302.4	1422.8	-520.2	902.6
	22.0	-75.6	344.7	1208.1	1477.2	-654.8	822.4
	24.0	-110.2	+42.1	1113.4	1495.3	-754.3	741.0
	26.0	-145.6	5.9	1014.9	1387.2 1387.2	-822.9	405.7
	28.0	-180.3	70.5	929.6	1450.8	-865.9	584.9
	30.0	-212.7	767.9	843.3	1398.5	-886.6	511.9
	32.0	-242.2	816.1	762.7	1330.3	-890.1	440.2
	34.0	-263.3	832.5	687.1	1251.3	-878.4	372.9
	36.0	-290.4	837.8	617.5	1164.9	-854.5	310.4
	38.0	-308.7	828.2	554.1	1073.9	-821.8	252.1
	40.0	-323.1	807.1	496.4	980.4	-782.0	198.4
	42.0	-343.6	776.0	444.6	877.0	-738.5	138.5
	42.5625	-347.8	776.4	430.9	859.5	-725.5	134.0
CURVE L	45.5	-375.1	776.4	430.9	832.2	-804.4	22.8
	44.0	-367.6	780.9	465.4	886.7	-842.8	43.9
	42.0	-354.5	815.7	516.4	977.6	-887.1	90.5
	40.0	-336.9	832.1	571.4	1067.1	-924.3	142.8
	38.0	-315.7	835.7	632.8	1155.8	-954.4	201.4
	36.0	-290.6	831.2	698.8	1239.4	-974.4	265.0
	34.0	-261.9	807.0	770.1	1315.2	-982.1	333.1
	32.0	-229.9	766.4	846.4	1382.9	-974.7	408.2
	30.0	-194.9	703.8	926.8	1435.7	-948.0	487.7
	28.0	-152.7	611.5	1006.3	1465.1	-895.0	570.0
	26.0	-115.7	512.9	1098.4	1495.6	-824.5	668.1
	24.0	-84.8	380.3	1186.7	1482.2	-724.0	758.2
	22.0	-51.7	218.0	1275.4	1442.3	-587.2	855.1
	20.0	-24.4	34.2	1362.6	1372.4	-411.4	961.0
	18.0	-6.7	-174.2	1446.6	1265.7	-193.1	1072.6

STRESSES IN BOTTOM OF CENTRAL CHANTLEVER ~ Table D Bottom.

4.12

	1	2	3	4	5	6
X	D.L. stresses	$P_2 / 2 \text{ bottom}$	P / A	$1 + 2 + 3$	L.L. stress	$4 + 5$
16	+ 6.5	+ 414.4	1483.3	+ 1903	+ 190.4	+ 2093
18	+ 28.0	+ 59.1	1395.1	+ 1482	+ 505.8	+ 1987
20	+ 62.8	- 233.7	1302.4	+ 1131	+ 742.5	+ 1873
22	+ 103.9	- 473.9	1208.1	+ 838	+ 960.2	+ 1798
24	+ 146.4	- 653.8	1113.4	+ 606	+ 1202.3	+ 1608
26	+ 186.9	- 844.6	1019.9	+ 421	+ 1056.7	+ 1477
28	+ 223.9	- 870.9	924.6	+ 282	+ 1075.0	+ 1357
30	+ 255.7	- 923.2	843.3	+ 175	+ 1066.1	+ 1241
32	+ 282.6	- 945.5	762.4	+ 99	+ 1038.9	+ 1137
34	+ 304.7	- 945.7	687.1	+ 46	+ 998.9	+ 1043
36	+ 321.9	- 928.8	617.5	+ 10	+ 948.3	+ 957
38	+ 335.0	- 899.1	554.1	- 10	+ 891.8	+ 881
40	+ 344.2	- 859.9	+ 46.4	- 19	+ 833.2	+ 614
42	+ 360.3	- 813.9	+ 44.6	- 9	+ 774.6	+ 765
42.525	+ 363.4	- 800.6	430.9	- 7	+ 757.9	+ 750
45.5	+ 391.8	- 800.6	430.9	+ 23	+ 845.5	+ 908
44	+ 388.3	- 833.1	465.4	+ 20	+ 590.2	+ 910
42	+ 380.0	- 874.4	516.4	+ 22	+ 950.9	+ 972
40	+ 367.8	- 908.4	571.9	+ 30	+ 1009.0	+ 1039
38	+ 351.8	- 934.7	632.8	+ 49	+ 1063.5	+ 1112
36	+ 331.5	- 948.2	698.5	+ 91	+ 1114.5	+ 1192
34	+ 306.5	- 944.5	770.1	+ 132	+ 1179.5	+ 1281
32	+ 276.7	- 922.6	846.4	+ 191	+ 1173.3	+ 1364
30	+ 241.8	- 874.1	926.8	+ 293	+ 1176.0	+ 1469
28	+ 196.3	- 786.5	1006.3	+ 416	+ 1151.1	+ 1567
26	+ 152.9	- 677.8	1098.4	+ 574	+ 1093.5	+ 1667
24	+ 115.7	- 518.8	1186.7	+ 783	+ 987.9	+ 1770
22	+ 73.7	- 307.5	1275.4	+ 1040	+ 826.2	+ 1866
20	+ 35.4	- 49.6	1362.6	+ 1348	+ 595.9	+ 1943
18	+ 9.9	+ 259.0	1446.6	+ 1714	+ 287.1	+ 2001

CURVE

CURVE L

We require $M_u > 2(M_D + M_L)$

$$\text{Then } M_u > 2(5,332,892 + 12,005,165) \text{ lb.in}$$

$$\underline{\underline{M_u > 34,676,200 \text{ lb.in.}}}$$

The Section is very nearly rectangular (over column) with all tendons in tensile zone. The formula # 4 in CL 313, C.P.115 will therefore be used:-

$$M_u = f_m A_{st} (d_1 - 0.4 d_n)$$

where

- M_u = Ultimate failing Moment
- f_m = 246,000 lb/in² (Stress in tendons at failure. [here = f_u])
- A_{st} = 8.06 in² (Area of Steel tendons)
- d_1 = 28.94 in (Centroid of tendons to compression edge)
- d_n = $K_1 d_1$
- u_w = 7,500 p.s.i (28 day concrete strength)
- b = 60 in (width of compressive zone)

for Table 7, cl. 313 we require $\frac{246,000 \cdot 8.06}{7,500 \times 60 \times 28.94 \times \cancel{0.152}} = \frac{A_{st} \cdot f_u}{u_w \cdot b \cdot d_1}$

$$= 0.152$$

Then from table 7, $\frac{d_n}{d_1} = 0.38 = K_1$

Then $d_n = 0.38 \times 28.94 = 10.98 \text{ ins.}$

Then $M_u = 246,000 \times 8.06 (28.94 - 0.4 \times 10.98)$

$$\underline{\underline{M_u = 48,672,800 \text{ lb.in}}} \quad - \text{O.K.}$$

Percentage of Tendon steel.

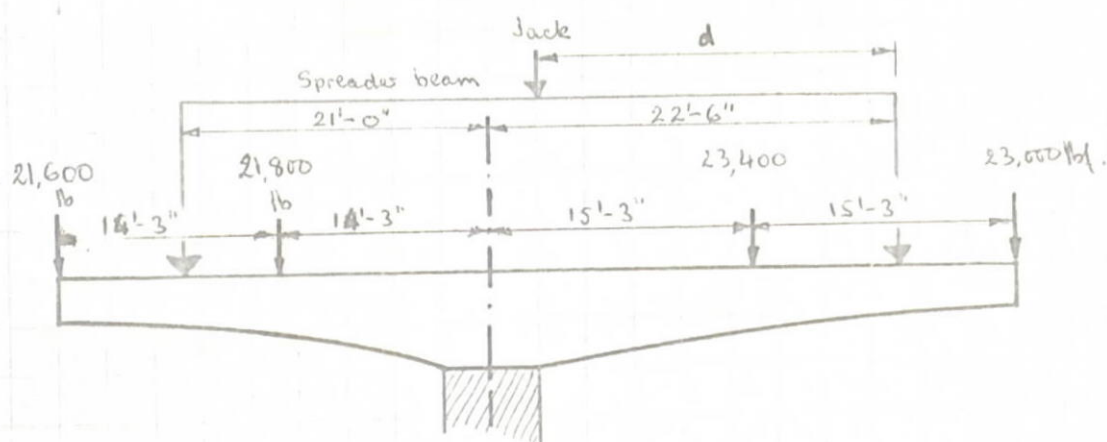
Clause 314, C.P.115 requires $\frac{A_{st}}{b \times d} \times 100 > \frac{15}{f_u}$

($b = 60$)
($d = 34$)
($f_u = 110 \text{ ksi}$)

$$\frac{A_{st}}{60 \times 34} = 0.39\% > \frac{15}{110} = 0.136 \quad - \text{O.K.}$$

WORKS TEST OF CENTRAL CANTILEVER

It is anticipated that Unit 3 will be tested at the casting works in accordance with M.O.T. Memorandum No T2/64



It is suggested the beam is loaded at the positions shown in red, being the approximate resultant of design loads from suspended span and cantilever live loads.

Position of Jacks:

$$\text{ratio of loads} = \frac{43,400}{46,400} = \frac{43'-6''}{43'-6''} \times 0.935$$

$$\text{Then } d = \frac{43.5}{1 + 0.935} \Delta 22.5' \text{ i.e. on beam } \ell.$$

Bending Moment at cantilever root.

$$M = P \times 18.5 \times 12 = 222 P \text{ lb.in where } P = \text{Jacking Load}$$

$$\text{Then } \sigma_{\text{top}} = \frac{222 P}{14660} = 0.015143 P$$

$$\text{We require 1) } \sigma_{\text{top}} \nlessgtr 0.1 \sigma_{\text{UT}} = -0.1 \times 6,500 = -650 \text{ p.s.i.}$$

$$\text{or 2) } \sigma_{\text{bot}} \nlessgtr 0.4 \sigma_{\text{UT}} (\text{tve}) = 0.4 \times 6,500 = +2,600 \text{ p.s.i.}$$

$$\text{for 1) } P = \frac{-650}{0.015143} = 42,924 \text{ lb.}$$

$$\text{for 2) } P = \frac{2,600 \times 14033}{222} =$$

Transfer stresses (see design)

$$\sigma_{top} = + 1175 \text{ p.s.i.}$$

$$\sigma_{bot} = - 100 \text{ p.s.i.}$$

The beam will be tested such that either 1) $\sigma_{top} = -0.1 U_t$
or 2) $\sigma_{bot} = 0.4 U_t$

$$\text{where } U_t = 6,500 \text{ p.s.i.}$$

$$\text{Whence :- } -0.1 U_t = -650 \text{ p.s.i.} ; \quad 0.4 U_t = +2600 \text{ p.s.i.}$$

It follows that range of stress passed through by $\sigma_{top} = 1175 - (-650) = \underline{1825 \text{ p.s.i.}}$

$$\sigma_{bot} = 2600 - (-100) = \underline{2,700 \text{ p.s.i.}}$$

$$\begin{aligned} \text{Moment required to produce } \sigma_{top}, M_t &= 1825 \times 13104 \\ &= 2,392,000 \text{ lb.in} \end{aligned}$$

$$\begin{aligned} \sigma_{bot}, M_b &= 2,700 \times 13001 \\ &= 3,510,000 \text{ lb.in} \end{aligned}$$

i.e. condition 1) is reached first and the beam will be tested to this limit.

$$\text{Jacking force } P = \frac{2,392,000}{222} = \underline{10,790 \text{ lb.}}$$

Deflection of Beams.

The deflection of a point on the end of the short cantilever 27'-0" from the root, is evaluated in tabular form overleaf according to Mohr II.

①	②	③	④	⑤	⑥	⑦
X ft	Moment arm L ins	M = P × L lb·ins	a width element ins	$\frac{aM}{I}$ lb/in ²	$\bar{y}$ in	$\frac{aM\bar{y}}{I}$ lb/in
26	24	2,590,000	36	2,669.2	125.25	334,317
28	48	5,179,000	24	2,814.9	149.25	420,124
30	72	7,769,000	24	3,335.1	173.25	577,806
32	96	10,358,000	24	3,516.3	197.25	693,590
34	120	12,948,000	24	3,474.3	221.25	768,689
36	144	15,538,000	24	3,293.4	245.25	807,706
38	168	18,127,000	24	3,038.7	269.25	818,170
40	192	20,716,800	24	2,746.9	293.25	805,528
42	216	23,306,000	18.75	1,914.0	317.25	607,217

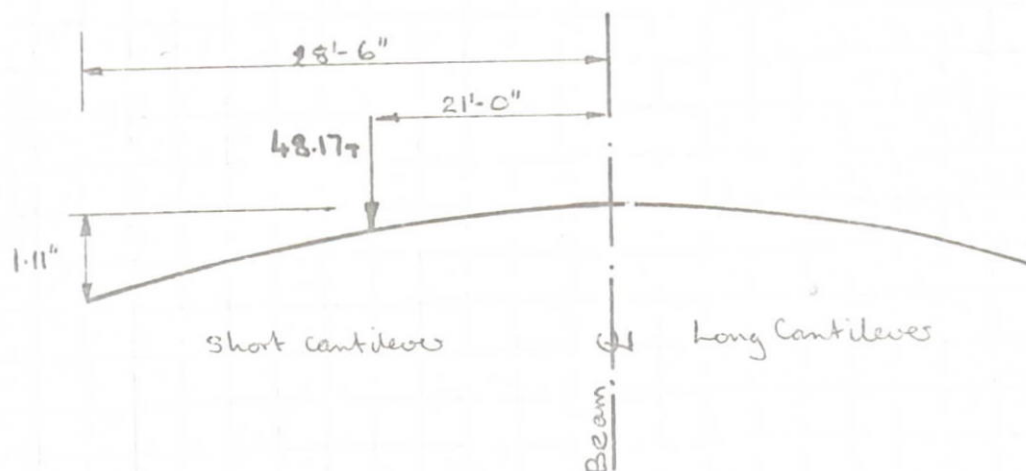
$$\Sigma \textcircled{7} = 5,833,147$$

Then deflection of point 27'0" from root, $\delta = \frac{\Sigma \textcircled{7}}{E_c}$

where $E_c = 5.25 \times 10^6$ lb/in² (we hope)

$$\delta = \frac{5,833,000}{5.25 \times 10^6} = 1.11 \text{ ins}$$

Summary



Maximum allowable load, as shown, 48.17
 expected deflection, as shown 1.11 ins