

Section 30 - Sign and VMS/DMS Support Structures (Overhead and Cantilever)

30.1 General Design Criteria

3.1.1 Design Specifications

The 2001 (4th) Edition of the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*, with the latest interim.

The 2007 Edition of the *NJDOT General Design Criteria and Standard Drawings for Overhead And Cantilever Sign Support Structures* (Referred to as Standard Drawings) is available for use in a project which includes fixed-message sign support structures. It has been reviewed to verify adherence to loading criteria that are specified in the *AASHTO Standard Specifications* referenced above. See Subsection 30.6 for more information.

The 2009 Edition of the *NJDOT General Design Criteria and Standard Drawings for Cantilever and Butterfly Dynamic Message Sign Support Structures* (referred to as DMS Standard Drawings) is available for use in a project which includes cantilever and butterfly Dynamic Message Sign (DMS) support structures.

See Subsection 30.2 for additional criteria concerning support structures for variable/dynamic message signs (VMS/DMS) if the *DMS Standard Drawings* are not applicable.

See Section 31 of this Manual for criteria concerning Bridge Mounted Sign Support Structures.

The Design shall verify the availability of steel pipe sizes, especially the 26" diameter pipe, in planning a structural configuration.

30.1.2 Functional Requirements

Vertical Clearance for Sign Support Structures:

The minimum vertical underclearance shall conform to Table 3.3.2 of this Manual. As indicated on the *Standard Drawings*, the minimum vertical underclearance for overhead and cantilever sign support structures shall be 17 ft. 9 inches.

30.1.3 Wind Load

A Design Wind Speed of 80 mph was used to develop the *Standard Drawings*.

The use of the 80 mph wind speed is based on the criteria specified in Appendix C of the above *AASHTO Specifications* for Wind Pressure determination.

30.1.4 Allowable Stress

The allowable stresses utilized for aluminum alloy ancillary members are in accordance with the publication titled "*Aluminum Design Manual - Specifications and Guidelines for Aluminum Structures*."

Do not use of aluminum arm truss and post members.

30.1.5 Fatigue Resistance

The 2007 *Standard Drawings* have been analyzed to verify that both the Overhead and Cantilever structures meet Fatigue Category II criteria as identified in Section 11 of the above referenced *AASHTO Specifications*.

30.2 Variable/Dynamic Message Sign (VMS/DMS) Support Structures – Design Guidance

1. Initially, the *Standard Drawings* shall be studied to determine if member sizes therein can be used for VMS/DMS support structure member selection.
2. The VMS/DMS signs shall be placed outside traffic lanes if possible to allow the use of front-access type cabinets. The use of walk-in type cabinets is required whenever a VMS/DMS is over traffic lanes. Generally walk-in type cabinets are 4 feet deep and 8.5 feet high. NJDOT ITS Unit should be contacted regarding the type, size and weight of VMS/DMS cabinets, and provision of maintenance walkway.
3. The following guidance shall be followed in designing and developing contract documents for the construction of VMS/DMS sign support structures:
 - A strength design and fatigue analysis shall be performed to determine adequate member sizes using three dimensional modeling. For Cantilever sign structures, all joints shall be assumed to be rigid. The greatest sign area shall initially be considered for use.
 - Potential use of fixed-message signs, on a project to project basis, will be permitted on overhead VMS/DMS sign support structures only. Accordingly, the General Notes for overhead VMS/DMS sign support structures shall indicate the sign area for which the VMS/DMS Structure has been designed, and the sign design area that can be accommodated by the remaining truss area.
 - To accommodate the potential future placement of fixed-message signs, the minimum height of the overhead truss, that is to be considered for the placement of the VMS/DMS cabinet, shall be 26'-3" to the centerline of the truss. This is considerate of a fixed-message sign design height of 15' and the 17'-9" minimum vertical underclearance to the lower limit, and the sign lighting system or maintenance walkway. If a sign lighting system or maintenance walkway is not erected, the minimum vertical underclearance shall be to the bottom of the fixed-message sign panel.
 - VMS/DMS cabinets shall be centered vertically between the upper and lower truss chord members.
 - The horizontal distance from the centerline of the truss chords to the center of gravity of the VMS/DMS cabinet shall be minimized.
 - Cantilever VMS/DMS sign support structures shall be designed to accommodate one VMS/DMS cabinet only. A note to this effect shall be provided in the General Notes portion of the contract plans.
4. If it is determined that support structures cannot be provided by use of the *Standard Drawings* or *DMS Standard Drawings*, the design of Overhead, Cantilever, and butterfly VMS/DMS structures shall conform to the following publications and to the criteria stated below:
 - The *AASHTO Standard Specifications* referenced above with the latest interim.
 - American Welding Society AWS D1.1 - Structural Welding Code - Steel (Current Edition)
 - VMS/DMS support structures shall be designed for strength, fatigue and deflection.

- Section 3 of the *AASHTO Standard Specifications* may be used to identify loading criteria, except for wind pressures which is to be determined in accordance with the Appendix C using a Design Wind Speed of 80 mph.
- Wind Drag Coefficient (C_d):
 $C_d = 1.20$ for horizontal wind pressure on VMS/DMS, and 1.70 for vertical wind load on VMS/DMS, such as truck-induced gusts;
Refer to the *AASHTO Standard Specifications* Table C-2 (or Table 3-6) for Wind Drag Coefficient for other members

- Fatigue Category II. See Subpart 5 below for clarification of fatigue analysis parameters.
- Deflection Criteria:

For the overhead support structures, the maximum deflection shall be limited to 2 ½ inches per 100 feet of the span length.

For the single-member-arm cantilever support structures, each applicable wind load range described in Subpart 5. should be applied separately and the largest vertical or horizontal deflection range should be limited to 8 inches.

The 8 inch range is defined as the sum of the potential upward and downward or potential horizontal axis displacement of the cantilever structure.

This criteria is included to minimize potential vibration damage to the VMS/DMS, ensure motorist visibility, and to reduce motorist concerns.

Deflection shall also be in accordance with Section 10 of the *AASHTO Standard Specifications*.

Permanent truss camber equal to 1/1000 of the truss span length, shall be provided in addition to the dead load camber for both overhead and cantilever support structures.

5. Natural wind gusts, truck induced gusts and galloping shall be applied in conducting a fatigue analysis. The following guidance may be followed for this analysis:
 - Apply each load separately to the sign structure model, as determined by the chords and posts, and design the strut to chord connections based upon the forces in the strut and the chord at each wind load range.
 - Fatigue resistance categories for the gusset plate/chord connection and other welded details shall be based on details listed in Table 11-2 of the *AASHTO Standard Specifications*.
 - The Fatigue Importance Factors (I_F) that shall be used for the fatigue analysis (Fatigue Category II) shall be as follows:
 - Galloping - 0.65
 - Natural Wind Gusts - 0.75
 - Truck Induced Gusts - 0.89
 - For cantilever and butterfly VMS/DMS support structures, all three phenomena shall be applied. For the overhead VMS/DMS support structure, the natural wind gusts and truck induced gusts phenomena need be applied.
 - Truck induced gusts shall be applied to any 12 ft length of the bottom face of the VMS/DMS cabinet, and to the projected area of the bottom chords, the lighting system/walkway and any miscellaneous attachments, to create the

maximum stress range, excluding any portion of the structure not located directly above the traffic lane

- Gusset plates should be designed for actual bending stresses and checked against allowable stresses.

6. Upon completion of the initial fatigue analysis, if member sizes are determined to be inadequate, new sizes shall be selected and a new analysis shall be made.

All detailing of finalized member size shall conform to the truss and tower configuration of the Standard Drawings. This will avoid the introduction of unique detailing to fabricators who provide support structures for Department projects.

30.3 Truss Chord Bolted Connections/Anchor Bolt Installations

1. Erection procedures contained in the *NJDOT Standard Specifications for Road and Bridge Construction*, concerning installation of sign support structures, shall be adhered to in developing contract documents.
2. Truss chord bolted connections shall be installed in accordance with the criteria stated in Section 11.5.6 of the *AASHTO LRFD Bridge Construction Specifications*.
3. The *NJDOT Standard Drawings* include Tables that specify bolt tension values to which high strength bolts and anchor bolts are to be installed. These Tables should be referenced when reviewing Working Drawings.

30.4 Foundations

1. At least one boring for each footing location is required (see Section 34).
2. Foundation conditions may require foundation types other than those indicated on the *Standard Drawings* and VMS/DMS Standard Drawings. In such a case, the Standard Contract Plans shall be modified accordingly. A foundation report shall be included in the Preliminary Plan submission in any case (see Section 34 of this Manual). This report can simply state, when warranted, that a study of the borings confirms that footings indicated on the Standard Plans are satisfactory for use in the design without any changes.
3. Subsurface utilities which cannot be relocated, or other special conditions, may require individual footing designs.
4. Acquisition of property is sometimes a long term process. Footings should be redesigned on an individual basis if taking of property outside of right of way can be avoided.
5. Top of concrete pedestals shall not project higher than 4 inches above finished ground line.
6. Foundation designs should be provided in furnishing of contract drawings for VMS/DMS structures.
7. Refer to Subsection 16.3 of this Manual for guidance concerning bottom of footing locations.
8. When alternate Foundation Designs, such as drilled shafts, are considered, refer to Tables 30.1 and 30.2 for Overhead Sign Supports and for Cantilever Sign Supports, respectively for application of loads.
9. For the foundation design of Cantilever and Butterfly VMS/DMS support structures, other than spread footing as shown in the *Standard Drawings*, use

Tables 30.3 and 30.4 for application of loads. These loads are per design criteria, including weight and size of VMS/DMS cabinet, as shown on the VMS/DMS Standard Drawings.

10. According to the Section 13 of the *AASHTO Standard Specifications*, design of foundations shall be based on the 17th Edition of the *AASHTO Standard Specifications for Highway Bridges* for the design requirements not addressed in the above mentioned section.

30.5 Plan Submissions

1. Preliminary bridge plans will be required for sign support structures in accordance with Section 6 of this Manual. This submission shall include: Key Plan to Structures, Elevation of Structures, Foundation Report and Boring Logs, and Estimated Construction Cost.
2. If changes are made on any of the Standard Contract Plans to suit the conditions of a particular project, such as the foundation, then half-size copies of those plans that were changed, shall be included with the Preliminary plan submission. Changes shall be indicated in red.
3. Working drawings to be prepared by the contractor and approved or certified by the Designer are required by the *NJDOT Standard Specifications for Road and Bridge Construction*.

30.6 Standard Drawings

1. *Standard drawings* for sign support structures are available for use in a project. They may be obtained from the NJDOT Engineering Documents Unit or downloaded from the NJDOT website (<http://www.state.nj.us/transportation>).
2. Unless as permitted herein, no changes in design criteria or details shall be made on the *Standard Drawings* without prior authorization.
3. The Design Unit should verify, during the Preliminary Design, locations where the sign panels are to be of the 100% reflectorized area type.

Otherwise, the use of a track lighting system is to be planned for. Suitable notes are included on the *Standard Drawings* to permit the use of track lighting system.
4. For the permanent record, the design calculations submitted at the Final Submission shall include a list of the Standard Design Instruction Drawings used in preparing the contract plans.
5. The design guidance in Subsection 30.2 for VMS/DMS support structures may be applied to an individual design for fixed-message sign support structures, except wind drag coefficient (C_d).

30.7 Structure Numbers

Structure numbers (7 digit) for the individual sign structures will be assigned during the Final Plan review (similar to the structure numbers for bridges as per Section 35). Temporary identification numbers used during the design phase shall be changed accordingly in the tabulations and contract pay items.

30.8 General Criteria and Miscellaneous Requirements

1. In the furnishing of sign panels for overhead and cantilever sign support structures, the size of the panels shall be such that the panel shall project a minimum of 6 inches above and below the respective top and bottom chord.
2. The proposed approximate quantities for Foundation Excavation, Concrete Footings and Reinforcement Steel in Structures shall reflect the summation of, respectively, all the overhead and cantilever sign structures that are within a contract. The location of sign panels shall be measured from the centerline of an end post.
3. Each sign support structure shall be listed individually in numerical order for each type that is in a contract. Refer to Subsection 30.7 for assigning of structure numbers.
4. Contract Pay Items for Lighting and Electrical work are usually included with the Roadway Items of work.

Table 30.1 - Overhead Sign Support**Loads At Bottom of Baseplate**

SS (%)	Span (ft)	Height (ft)	Pdl,max (kips)	Pdl,min (kips)	Pwind (kips)	Pice,max (kips)	Pice,min (kips)	Hwind (kips)	Ht,wind (kips)	Mt,wind (kips-ft)
40%	45.00	25.00	4.33	2.39	30.85	2.65	0.40	4.03	0.60	29.1
60%	45.00	25.00	4.65	2.44	42.53	2.84	0.43	5.48	0.81	49.97
70%	45.00	25.00	4.81	2.47	48.75	2.94	0.44	6.25	0.98	47.30
80%	45.00	25.00	4.97	2.49	54.64	3.03	0.45	6.98	1.10	53.30
40%	45.00	30.00	4.65	2.72	39.14	2.72	0.47	5.21	0.60	36.34
60%	45.00	30.00	5.22	3.08	52.80	2.92	0.58	7.16	0.81	51.21
70%	45.00	30.00	5.38	3.11	60.35	3.01	0.59	8.13	0.98	59.13
80%	45.00	30.00	5.54	3.13	67.50	3.11	0.61	9.04	1.10	66.62
40%	45.00	40.00	5.29	2.72	47.14	2.81	0.62	6.22	0.60	43.60
60%	45.00	40.00	5.61	3.46	64.16	3.00	0.66	8.26	0.81	61.45
70%	45.00	40.00	6.07	3.84	71.53	3.16	0.78	9.26	0.98	70.95
80%	45.00	40.00	6.23	3.87	79.96	3.26	0.80	10.29	1.10	79.95
40%	55.00	25.00	4.88	2.57	36.50	3.10	0.40	4.74	0.72	34.83
60%	55.00	25.00	5.26	2.61	50.93	3.33	0.43	6.52	1.03	49.51
70%	55.00	25.00	5.45	2.64	58.01	3.45	0.45	7.40	1.18	56.73
80%	55.00	25.00	5.82	2.94	63.61	3.55	0.55	8.37	1.32	63.94
40%	55.00	30.00	5.20	2.88	46.21	3.17	0.47	6.09	0.72	43.54
60%	55.00	30.00	5.83	3.26	62.98	3.41	0.59	8.47	1.03	61.89
70%	55.00	30.00	6.02	3.29	71.58	3.52	0.61	9.56	1.18	70.91
80%	55.00	30.00	6.46	3.62	78.47	3.68	0.73	10.60	1.32	79.93
40%	55.00	40.00	5.83	3.58	55.38	3.26	0.64	7.21	0.72	52.24
60%	55.00	40.00	6.52	3.99	74.64	3.55	0.78	9.64	1.03	74.27
70%	55.00	40.00	6.71	4.03	84.77	3.66	0.80	10.87	1.18	85.09
80%	55.00	40.00	7.19	4.43	92.96	3.80	0.93	12.28	1.32	95.91
40%	65.00	25.00	5.41	2.70	42.1	3.55	0.40	5.43	0.84	40.54
60%	65.00	25.00	5.86	2.77	58.97	3.82	0.44	7.52	1.20	57.70
70%	65.00	25.00	6.36	3.19	65.37	3.95	0.58	8.65	1.37	66.30
80%	65.00	25.00	6.58	3.23	73.30	4.09	0.61	9.67	1.55	74.68
40%	65.00	30.00	5.97	3.34	52.28	3.62	0.55	7.1	0.84	50.67
60%	65.00	30.00	6.42	3.42	72.74	3.88	0.60	9.71	1.20	72.13
70%	65.00	30.00	6.98	3.88	80.65	4.08	0.77	10.95	1.37	82.87
80%	65.00	30.00	7.21	3.92	90.39	4.21	0.79	12.23	1.55	93.35
40%	65.00	40.00	6.36	3.73	63.54	3.70	0.64	8.19	0.84	68.79
60%	65.00	40.00	7.40	4.53	84.45	4.04	0.91	11.21	1.20	86.56
70%	65.00	40.00	7.72	4.70	95.51	4.19	0.98	12.71	1.37	99.44
80%	65.00	40.00	7.94	4.74	106.88	4.30	1.00	14.12	1.55	112.02
40%	75.00	25.00	6.11	3.04	48.18	4.04	0.47	6.23	0.96	47.09
60%	75.00	25.00	6.93	3.55	65.06	4.35	0.65	8.67	1.38	66.46
70%	75.00	25.00	7.17	3.59	74.00	4.50	0.67	9.83	1.57	75.97
80%	75.00	25.00	7.43	3.63	82.94	4.65	0.7	10.98	1.77	85.48
40%	75.00	30.00	6.67	3.70	59.65	4.11	0.63	8.10	0.96	58.86
60%	75.00	30.00	7.55	4.23	80.27	4.47	0.83	10.98	1.38	83.07
70%	75.00	30.00	7.80	4.28	91.24	4.62	0.86	12.43	1.57	94.96
80%	75.00	30.00	8.68	4.95	102.22	4.77	0.89	13.87	1.77	106.85

Table 30.1 - Overhead Sign Support**Loads At Bottom of Baseplate**

SS (%)	Span (ft)	Height (ft)	Pdl,max (kips)	Pdl,min (kips)	Pwind (kips)	Pice,max (kips)	Pice,min (kips)	Hwind (kips)	Ht,wind (kips)	Mt,wind (kips-ft)
40%	75.00	40.00	7.36	4.43	70.72	2.24	0.83	9.23	0.98	70.62
60%	75.00	40.00	8.28	5.06	95.07	4.58	1.05	12.71	1.38	99.68
70%	75.00	40.00	8.53	5.10	107.82	4.73	1.07	14.34	1.57	113.96
80%	75.00	40.00	9.63	6.00	120.69	4.87	1.10	15.97	1.77	128.22
40%	85.00	25.00	6.96	3.53	54.41	4.57	0.58	7.06	1.12	53.92
60%	85.00	25.00	8.07	4.33	72.73	4.95	0.85	9.81	1.57	75.71
70%	85.00	25.00	8.35	4.38	82.39	5.12	0.89	11.07	1.78	86.15
80%	85.00	25.00	8.82	4.69	90.30	5.30	1.01	12.30	2.00	96.62
40%	85.00	30.00	7.56	4.23	67.36	4.65	0.77	9.15	1.12	67.40
60%	85.00	30.00	8.7	5.02	89.69	5.08	1.04	12.40	1.57	94.64
70%	85.00	30.00	9.21	5.42	99.30	5.24	1.19	14.11	1.78	107.69
80%	85.00	30.00	9.49	5.47	110.90	5.40	1.22	15.71	2.00	120.78
40%	85.00	40.00	8.25	5.98	79.80	4.78	0.97	10.41	1.12	80.87
60%	85.00	40.00	9.43	5.85	106.11	5.18	1.26	14.30	1.57	113.56
70%	85.00	40.00	10.57	6.77	119.98	5.34	1.29	16.10	1.78	129.24
80%	85.00	40.00	10.85	6.83	133.87	5.51	1.33	17.89	2.00	144.94
40%	95.00	25.00	8.20	4.56	59.07	5.11	0.86	8.01	1.26	60.96
60%	95.00	25.00	8.83	4.67	80.57	5.48	0.93	10.83	1.74	84.18
70%	95.00	25.00	9.74	5.46	88.65	5.74	1.18	12.26	1.99	96.25
80%	95.00	25.00	10.56	6.04	101.26	5.92	1.22	13.96	2.29	110.30
40%	95.00	30.00	8.59	4.94	74.49	5.19	0.94	10.22	1.26	76.20
60%	95.00	30.00	9.69	5.71	97.14	5.59	1.24	13.81	1.74	105.22
70%	95.00	30.00	10.41	6.25	108.91	5.83	1.39	15.65	1.99	120.30
80%	95.00	30.00	11.45	7.04	124.26	6.01	1.43	17.79	2.29	137.90
40%	95.00	40.00	9.57	6.08	86.53	5.30	1.27	11.78	1.26	91.44
60%	95.00	40.00	11.04	7.07	117.36	5.70	1.35	15.76	1.74	126.27
70%	95.00	40.00	11.77	7.60	130.48	5.94	1.50	17.83	1.99	144.38
80%	95.00	40.00	12.59	8.30	145.43	6.15	1.69	20.10	2.29	165.48
40%	105.00	25.00	8.71	4.71	64.43	5.53	0.86	8.72	1.38	66.73
60%	105.00	25.00	10.06	5.63	85.82	6.02	1.17	11.87	1.93	93.09
70%	105.00	25.00	10.92	6.22	99.40	6.22	1.21	13.71	2.24	108.23
80%	105.00	25.00	12.26	7.42	108.71	6.54	1.50	15.37	2.53	121.90
40%	105.00	30.00	9.34	5.40	79.50	5.64	1.05	11.03	1.38	83.42
60%	105.00	30.00	10.73	6.42	105.47	6.11	1.90	15.17	1.93	116.36
70%	105.00	30.00	11.80	7.22	121.99	6.30	1.43	17.47	2.24	135.30
80%	105.00	30.00	13.14	8.43	133.34	6.74	1.72	19.55	2.53	155.38
40%	105.00	40.00	10.07	6.24	94.21	5.74	1.28	12.77	1.38	101.11
60%	105.00	40.00	12.09	7.78	121.34	6.22	1.50	17.29	1.93	138.62
70%	105.00	40.00	12.94	8.49	142.78	6.44	1.69	19.74	2.24	162.36
80%	105.00	40.00	14.30	9.70	156.13	6.76	1.98	22.09	2.53	182.86
40%	115.00	25.00	10.14	5.90	68.82	6.11	1.18	9.57	1.54	74.12
60%	115.00	25.00	11.98	7.27	92.25	6.68	1.53	13.08	2.14	103.08
70%	115.00	25.00	12.86	7.87	106.33	6.90	1.57	15.04	2.45	119.23
80%	115.00	25.00	13.23	7.94	118.38	7.12	1.63	16.72	2.76	133.05

Table 30.1 - Overhead Sign Support**Loads At Bottom of Baseplate**

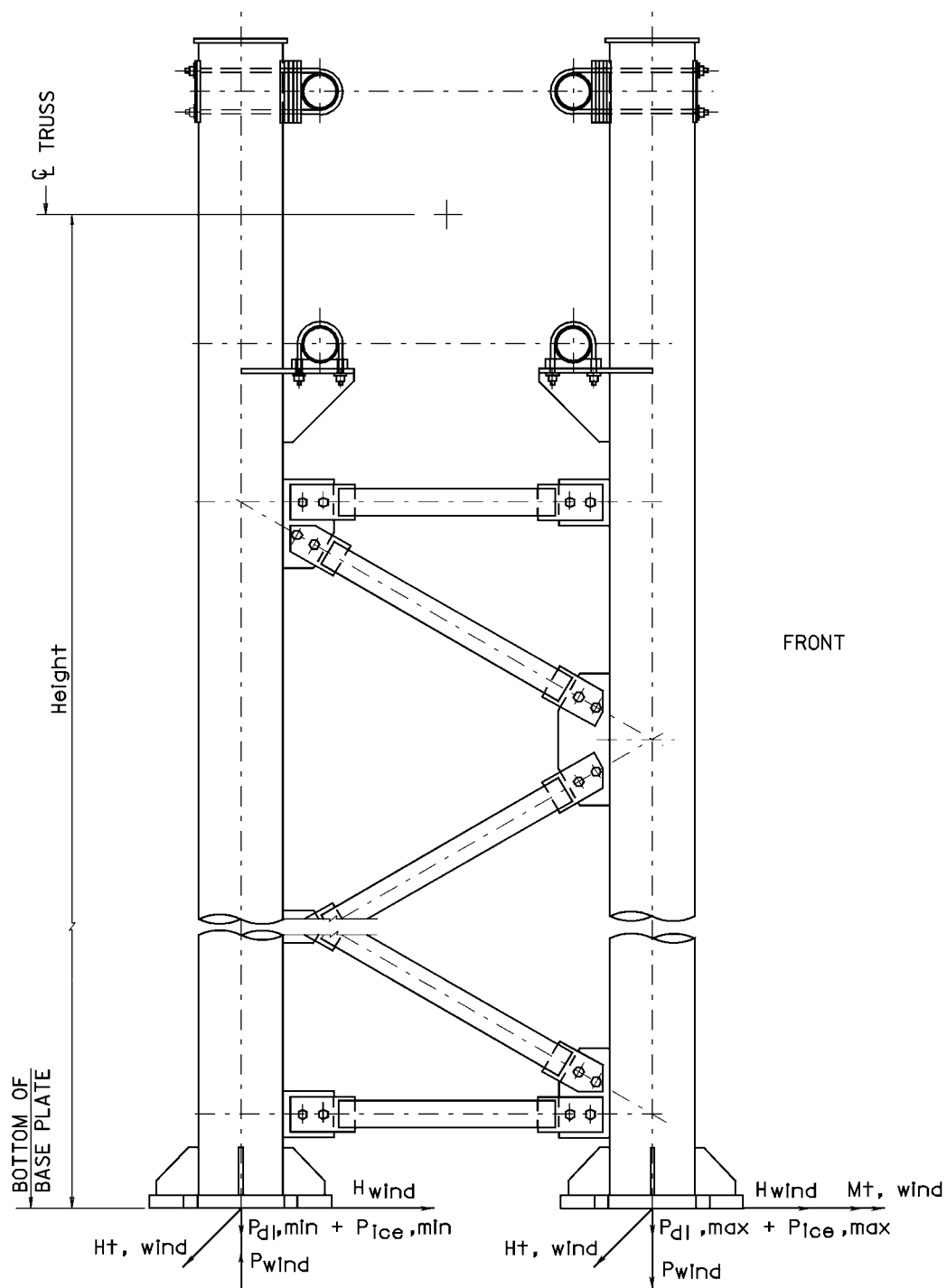
SS (%)	Span (ft)	Height (ft)	Pdl,max (kips)	Pdl,min (kips)	Pwind (kips)	Pice,max (kips)	Pice,min (kips)	Hwind (kips)	Ht,wind (kips)	Mt,wind (kips-ft)
40%	115.00	30.00	10.58	6.34	86.61	6.21	1.28	12.16	1.54	92.66
60%	115.00	30.00	12.65	8.07	113.34	6.77	1.75	16.69	2.14	128.86
70%	115.00	30.00	13.74	8.88	130.49	6.98	1.80	19.14	2.47	149.05
80%	115.00	30.00	14.10	8.96	145.17	7.20	1.85	21.25	2.76	166.30
40%	115.00	40.00	11.30	7.18	102.53	6.30	1.51	14.04	1.54	111.19
60%	115.00	40.00	13.56	9.09	130.75	6.90	2.02	18.86	2.14	155.24
70%	115.00	40.00	14.89	10.15	152.81	7.12	2.07	21.63	2.47	178.86
80%	115.00	40.00	15.25	10.23	169.96	7.34	2.12	24.00	2.76	199.56
40%	125.00	25.00	12.02	7.55	74.37	6.72	1.53	10.60	1.71	82.50
60%	125.00	25.00	13.33	8.23	101.95	7.20	1.63	14.43	2.37	114.21
70%	125.00	25.00	13.73	8.30	114.99	7.44	1.67	16.25	2.68	129.21
80%	125.00	25.00	14.37	8.79	125.04	7.65	1.85	18.15	2.99	140.06
40%	125.00	30.00	12.69	8.34	91.58	6.81	1.75	13.57	1.71	103.25
60%	125.00	30.00	14.21	9.24	125.16	7.28	1.85	18.38	2.37	142.77
70%	125.00	30.00	14.60	9.33	141.03	7.52	1.90	20.66	2.68	161.45
80%	125.00	30.00	15.41	9.97	152.56	7.76	2.10	22.83	2.99	180.16
40%	125.00	40.00	14.05	9.70	110.66	6.92	1.86	15.49	1.71	123.89
60%	125.00	40.00	15.36	10.52	146.58	7.41	2.12	20.77	2.37	171.30
70%	125.00	40.00	15.75	10.61	165.14	7.65	2.17	23.33	2.68	193.75
80%	125.00	40.00	16.52	11.22	179.70	7.88	2.36	26.03	2.99	216.20
40%	135.00	25.00	12.66	7.86	79.67	7.16	1.56	11.33	1.84	88.67
60%	135.00	25.00	14.97	10.30	107.91	7.83	1.99	15.69	2.58	124.56
70%	135.00	25.00	16.07	10.40	121.24	8.08	2.04	15.60	2.91	140.27
80%	135.00	25.00	16.73	10.89	130.48	8.30	2.23	19.59	3.23	156.00
40%	135.00	30.00	13.34	8.65	98.03	7.24	1.79	14.50	1.84	110.84
60%	135.00	30.00	16.53	11.33	130.48	7.91	2.22	19.96	2.58	155.70
70%	135.00	30.00	17.37	11.98	144.67	8.16	2.43	22.24	2.91	175.35
80%	135.00	30.00	17.78	12.08	160.51	8.41	2.49	24.13	3.23	194.99
40%	135.00	40.00	14.69	10.01	118.40	7.35	1.90	16.53	1.84	133.00
60%	135.00	40.00	17.68	12.61	155.24	8.04	2.49	22.54	2.58	186.85
70%	135.00	40.00	18.48	13.23	170.55	8.28	2.68	25.37	2.91	210.42
80%	135.00	40.00	18.90	13.33	189.10	8.53	2.75	28.06	3.23	233.99
40%	145.00	25.00	16.05	11.04	86.49	8.07	2.24	12.63	2.06	99.30
60%	145.00	25.00	17.47	11.76	116.30	8.62	2.36	16.89	2.79	134.46
70%	145.00	25.00	18.16	12.25	127.38	8.85	2.55	18.99	3.13	151.04
80%	145.00	25.00	18.61	12.35	141.10	9.12	2.61	21.00	3.48	167.63
40%	145.00	30.00	16.72	11.84	106.38	8.15	2.47	16.11	2.06	124.13
60%	145.00	30.00	18.35	12.77	142.70	8.69	2.60	21.69	2.79	168.07
70%	145.00	30.00	19.25	13.44	155.51	8.96	2.81	23.88	3.13	188.80
80%	145.00	30.00	19.66	13.55	172.24	9.23	2.86	26.40	3.48	209.54
40%	145.00	40.00	18.08	13.20	128.39	8.26	2.58	18.35	2.06	148.95
60%	145.00	40.00	19.50	14.06	167.21	8.82	2.87	24.24	2.79	201.68
70%	145.00	40.00	20.30	14.69	183.25	9.08	3.07	29.21	3.13	226.56
80%	145.00	40.00	20.77	14.81	202.83	9.34	3.14	30.05	3.48	251.45

Table 30.1 - Overhead Sign Support**Loads At Bottom of Baseplate**

SS (%)	Span (ft)	Height (ft)	Pdl,max (kips)	Pdl,min (kips)	Pwind (kips)	Pice,max (kips)	Pice,min (kips)	Hwind (kips)	Ht,wind (kips)	Mt,wind (kips-ft)
40%	155.00	25.00	14.92	11.57	91.97	8.56	2.33	13.41	2.19	105.77
60%	155.00	25.00	20.03	14.23	119.52	9.27	2.93	18.27	3.01	145.18
70%	155.00	25.00	20.51	14.35	133.43	9.56	3.00	20.37	3.37	162.44
80%	155.00	25.00	20.98	14.47	147.34	9.84	3.07	22.46	3.73	179.70
40%	155.00	30.00	18.30	13.10	113.06	8.63	2.57	17.10	2.19	130.21
60%	155.00	30.00	21.09	15.43	146.00	9.38	3.19	22.99	3.01	181.48
70%	155.00	30.00	21.56	15.55	162.98	9.66	3.26	25.61	3.37	203.05
80%	155.00	30.00	22.34	16.13	176.06	9.93	3.47	28.34	3.73	224.62
40%	155.00	40.00	19.47	14.39	130.51	8.76	2.84	19.30	2.19	158.64
60%	155.00	40.00	20.12	16.60	172.18	9.48	3.43	26.21	2.19	217.77
70%	155.00	40.00	22.59	16.72	192.07	9.76	3.50	29.16	2.19	243.65
80%	155.00	40.00	23.44	17.37	207.56	10.03	3.72	30.26	2.19	269.54
40%	165.00	25.00	19.69	14.16	97.30	9.19	2.75	14.54	2.39	115.04
60%	165.00	25.00	20.95	14.79	126.65	9.76	3.02	19.35	3.19	154.03
70%	165.00	25.00	22.26	15.82	140.08	10.18	3.30	21.69	3.59	173.35
80%	165.00	25.00	23.07	16.42	154.52	10.46	3.54	23.82	3.97	191.44
40%	165.00	30.00	20.57	15.17	119.61	9.27	2.98	18.51	2.39	143.80
60%	165.00	30.00	22.00	15.99	154.71	9.87	3.29	24.33	3.19	192.54
70%	165.00	30.00	23.30	17.02	171.14	10.29	3.59	27.27	3.59	216.70
80%	165.00	30.00	24.11	17.61	184.63	10.56	3.80	30.13	3.97	239.30
40%	165.00	40.00	21.73	16.42	140.26	9.39	3.26	20.91	2.39	172.55
60%	165.00	40.00	23.02	17.16	183.38	9.96	3.53	27.72	3.19	230.04
70%	165.00	40.00	24.72	18.72	197.59	10.37	3.97	30.17	3.59	260.05
80%	165.00	40.00	25.21	18.85	217.66	10.66	4.06	3.47	3.97	287.16

Notes:

1. Refer to the following sketch for the location of the load applications for the Overhead Sign Support Structure.
2. The Tables are for fixed-message sign support structures only.



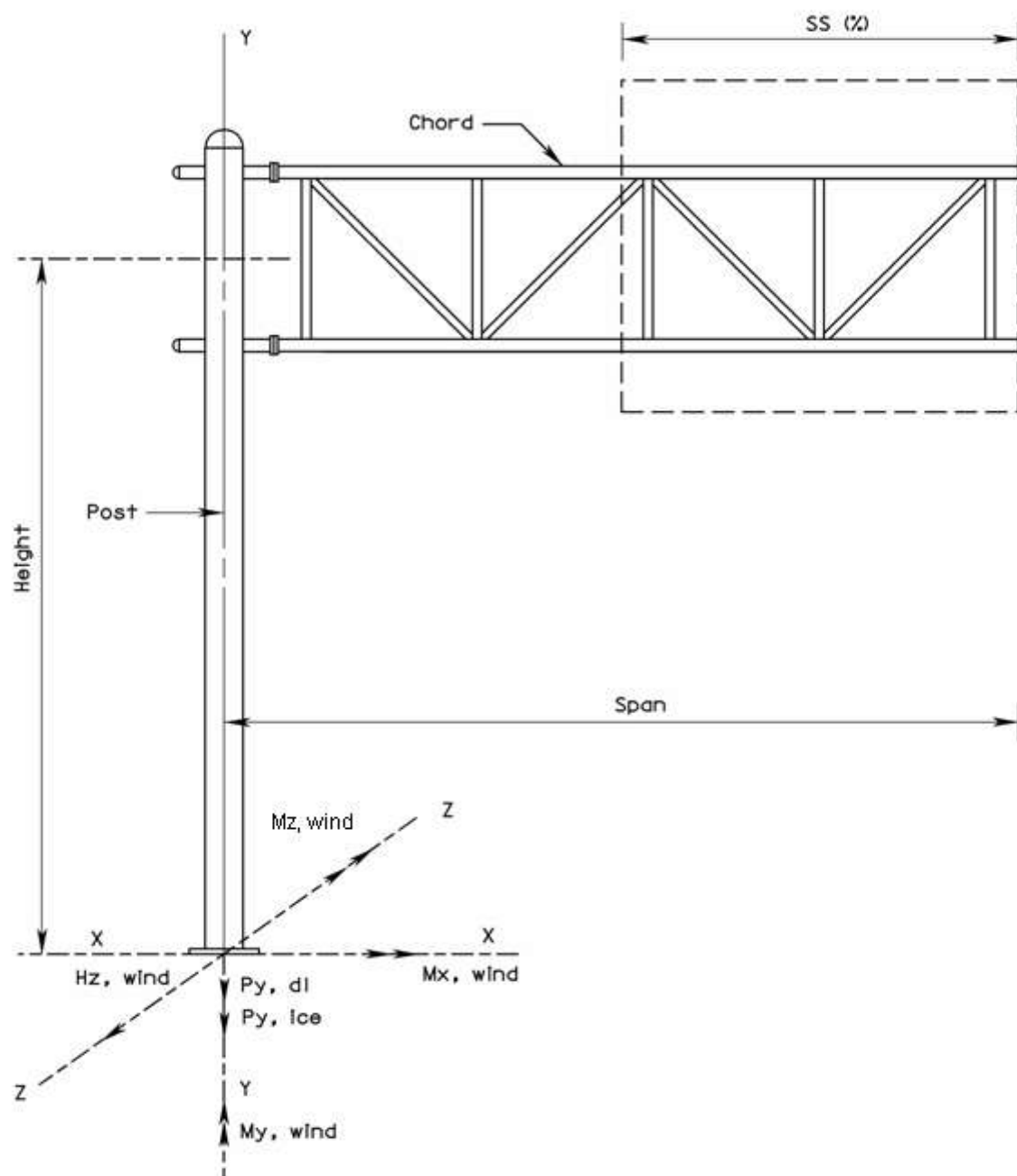
TOWER ELEVATION

Table 30.2 - Cantilever Sign Support**Loads At Bottom of Baseplate**

SS (%)	Span (ft)	Height (ft)	Hz, wind (kips)	Py,dl (kips)	Py,ice (kips)	Mx,wind (kips-ft)	My,wind (kips-ft)	Mz,dl (kips-ft)
40%	20.00	25.00	5.30	4.86	1.92	133.73	68.29	30.23
50%	20.00	25.00	6.25	5.91	2.05	157.78	77.81	37.59
60%	20.00	25.00	7.13	6.06	2.14	180.89	85.61	38.90
70%	20.00	25.00	8.08	6.52	2.27	204.98	91.67	39.93
80%	20.00	25.00	9.46	6.67	2.36	241.37	101.98	40.65
40%	30.00	25.00	8.41	8.64	3.08	213.04	158.02	89.68
50%	30.00	25.00	9.70	9.97	3.24	246.90	178.51	109.65
60%	30.00	25.00	11.56	10.51	3.42	294.99	206.55	112.62
70%	30.00	25.00	12.89	10.73	3.55	329.71	220.23	114.90
80%	30.00	25.00	14.28	11.27	3.73	365.41	229.99	116.57
40%	40.00	25.00	12.10	13.68	4.49	308.26	302.37	209.78
50%	40.00	25.00	13.86	16.09	4.71	353.76	339.12	251.64
60%	40.00	25.00	15.56	17.38	4.89	398.38	369.23	256.87
70%	40.00	25.00	17.26	17.68	5.06	442.99	392.66	260.94
80%	40.00	25.00	19.11	17.97	5.24	491.39	412.80	263.85
40%	20.00	30.00	5.49	5.72	2.04	170.28	68.27	30.24
50%	20.00	30.00	6.37	6.45	2.13	199.17	77.81	37.59
60%	20.00	30.00	7.33	6.99	2.28	229.51	85.60	38.91
70%	20.00	30.00	8.21	7.14	2.36	258.42	91.67	39.93
80%	20.00	30.00	9.68	7.67	2.51	305.38	101.98	40.67
40%	30.00	30.00	8.56	9.30	3.28	268.73	158.02	89.68
50%	30.00	30.00	9.93	11.04	3.40	312.46	178.48	109.68
60%	30.00	30.00	11.81	11.65	3.59	372.83	206.54	112.65
70%	30.00	30.00	13.13	11.87	3.72	416.26	220.22	114.94
80%	30.00	30.00	14.54	12.49	3.91	461.15	229.99	116.61
40%	40.00	30.00	12.36	14.89	4.67	389.60	302.31	209.84
50%	40.00	30.00	14.06	18.20	4.84	445.37	339.12	251.64
60%	40.00	30.00	15.76	18.50	5.02	501.13	369.23	256.87
70%	40.00	30.00	17.46	19.99	5.20	556.90	392.66	260.94
80%	40.00	30.00	19.30	20.29	5.38	617.40	412.80	263.85
40%	20.00	40.00	5.70	6.72	2.19	208.68	68.25	30.25
50%	20.00	40.00	6.58	7.46	2.28	243.37	77.80	37.60
60%	20.00	40.00	7.56	8.06	2.43	280.08	85.59	38.92
70%	20.00	40.00	8.44	8.21	2.52	314.79	91.66	39.94
80%	20.00	40.00	9.93	8.82	2.68	371.46	101.97	40.68
40%	30.00	40.00	8.81	10.46	3.35	327.36	157.99	89.71
50%	30.00	40.00	10.19	12.25	3.58	380.15	178.46	109.70
60%	30.00	40.00	11.99	12.48	3.71	450.92	206.54	112.65
70%	30.00	40.00	13.41	13.16	3.91	505.04	220.21	114.97
80%	30.00	40.00	14.73	14.81	4.04	557.19	229.99	116.61
40%	40.00	40.00	12.55	17.22	4.80	471.33	302.31	209.84
50%	40.00	40.00	14.25	19.30	4.98	538.25	339.12	251.64
60%	40.00	40.00	15.95	21.03	5.15	605.17	369.23	256.87
70%	40.00	40.00	17.65	21.30	5.33	672.09	392.66	260.94
80%	40.00	40.00	19.50	22.98	5.51	744.94	412.80	263.85

Notes:

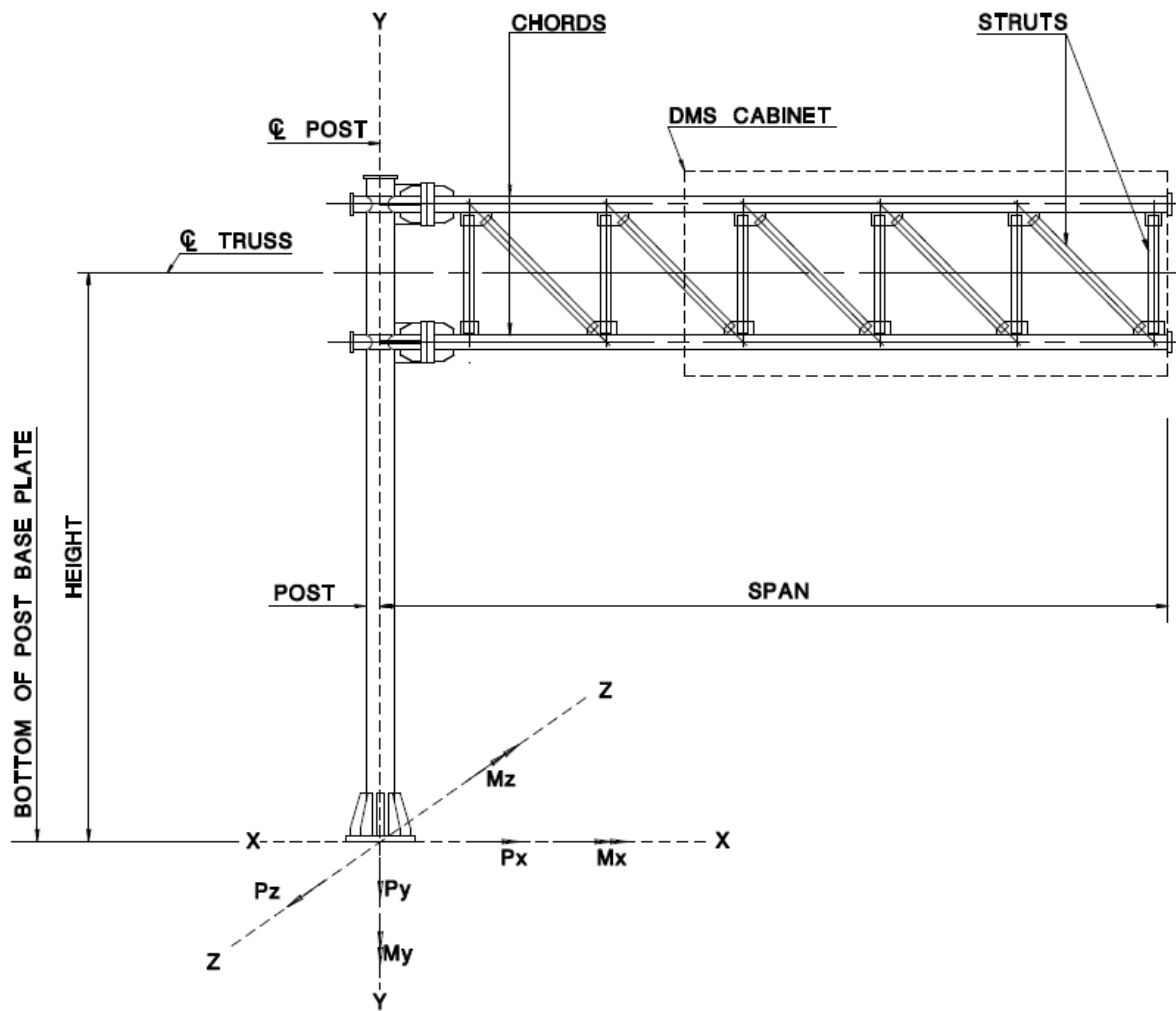
1. Refer to the following sketch for the location of the load applications for the Cantilever Sign Support Structures.
2. The Table is for fixed-message sign support structures only.



Cantilever Sign

Table 30.3 - Cantilever VMS/DMS Support
Loads At Bottom of Baseplate

Span (ft)	Height (ft)	Group load	Px (kips)	Py (kips)	Pz (kips)	Mx (kip-ft)	My (kip-ft)	Mz (kip-ft)
25	25	I	0.00	12.86	0.00	17.19	0.00	128.87
		II	1.52	12.86	7.27	220.32	92.45	168.40
		III	0.93	16.76	4.08	134.82	47.13	196.83
30	25	I	0.00	15.39	0.00	17.14	0.00	180.05
		II	1.80	15.39	8.68	259.98	130.51	227.44
		III	1.08	19.95	4.86	156.94	66.15	269.06
40	25	I	0.00	20.18	0.00	20.07	0.00	356.44
		II	2.15	20.18	10.15	308.06	227.13	410.90
		III	1.39	26.02	5.87	193.64	117.34	507.64
25	30	I	0.00	14.18	0.00	17.08	0.00	128.84
		II	1.68	14.18	8.16	281.33	102.01	180.98
		III	1.01	18.26	4.65	168.64	51.75	203.55
30	30	I	0.00	16.01	0.00	17.28	0.00	181.45
		II	1.99	16.01	9.61	333.09	144.00	242.99
		III	1.19	20.68	5.39	196.73	73.18	279.18
40	30	I	0.00	23.36	0.00	20.06	0.00	356.61
		II	2.34	23.36	11.17	389.27	249.23	427.66
		III	1.46	29.30	6.43	237.64	128.22	516.77
25	40	I	0.00	15.43	0.00	17.38	0.00	131.08
		II	1.74	15.43	8.48	371.21	102.96	200.93
		III	1.07	19.71	4.93	220.57	52.58	217.70
30	40	I	0.00	17.78	0.00	17.44	0.00	183.61
		II	2.06	17.78	10.01	438.76	145.24	266.09
		III	1.25	22.67	5.75	257.32	74.04	294.84
40	40	I	0.00	26.94	0.00	20.29	0.00	360.80
		II	2.41	26.94	11.51	509.71	250.57	455.46
		III	1.52	33.08	6.72	307.41	129.37	537.36

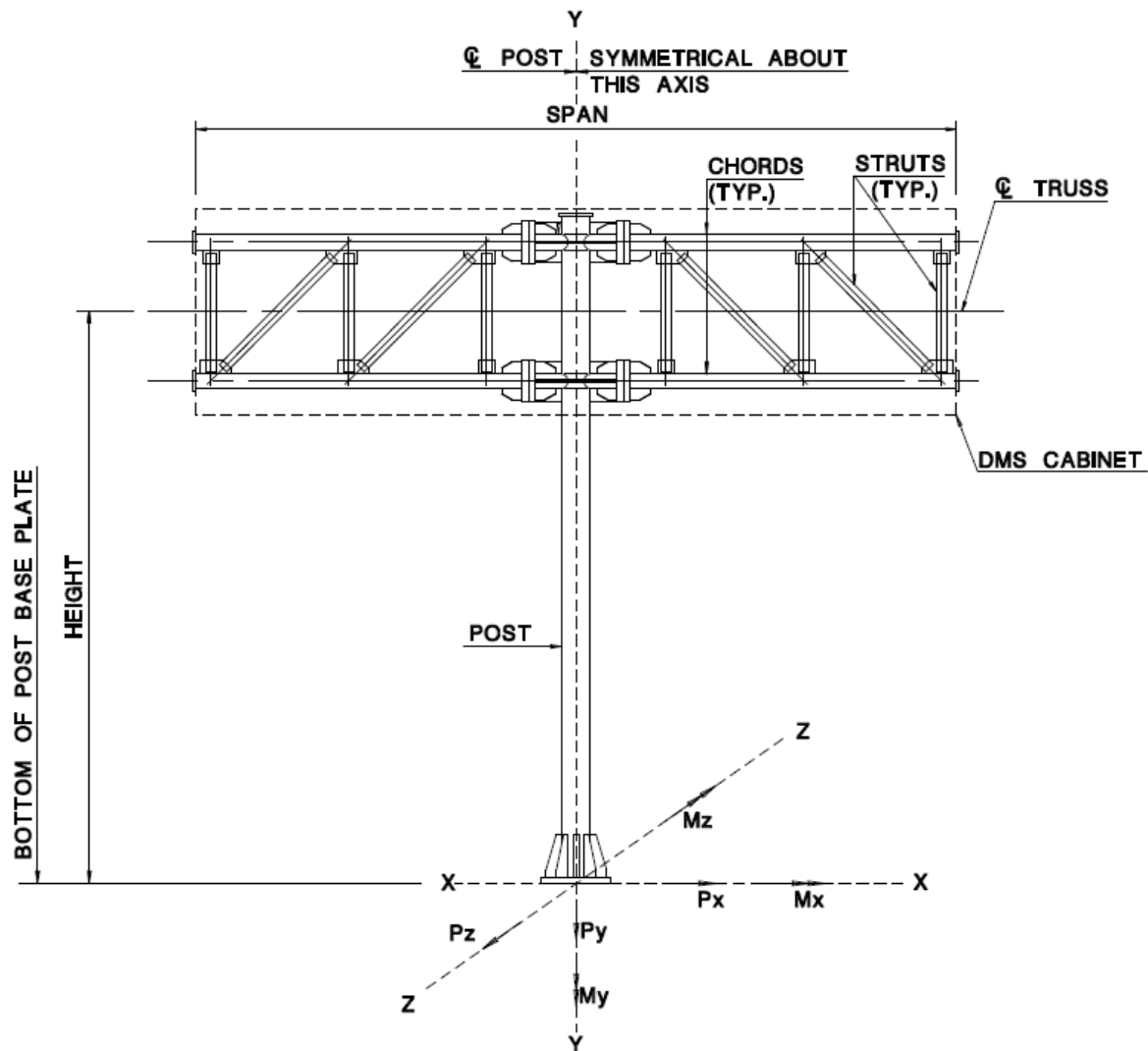


Cantilever VMS/DMS

Table 30.4 - Butterfly VMS/DMS Support

Loads At Bottom of Baseplate

Span (ft)	Height (ft)	Group load	Px (kips)	Py (kips)	Pz (kips)	Mx (kip-ft)	My (kip-ft)	Mz (kip-ft)
26.1	25	I	0.00	12.97	0.00	16.59	0.00	0.00
		II	1.62	12.97	8.12	241.58	34.90	44.86
		III	0.88	17.15	4.46	143.96	17.47	23.72
26.1	30	I	0.00	13.53	0.00	16.78	0.00	0.48
		II	1.80	13.53	8.99	310.29	38.30	58.19
		III	0.99	17.79	4.96	181.16	19.17	30.64
26.1	40	I	0.00	15.55	0.00	16.80	0.00	0.00
		II	1.88	15.55	9.40	409.03	38.46	78.42
		III	1.07	20.11	5.35	237.46	19.25	42.40



Butterfly VMS/DMS