



## **OVERHEAD AND DYNAMIC MESSAGE SIGN FOUNDATIONS:**

### **Description**

Sign foundations include foundations for overhead and dynamic message signs (DMS) supported by metal poles or upright trusses. Sign foundations consist of footings with pedestals or drilled piers with or without grade beams or wings, conduit and anchor rod assemblies. Construct sign foundations in accordance with the contract and accepted submittals. Define "cantilever sign" as an overhead cantilever sign support in accordance with Figure 1-1 of the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

### **Materials**

Use sign foundation materials that meet the *Foundations and Anchor Rod Assemblies for Metal Poles* provision.

### **Assumed Subsurface Conditions**

Assume the following soil parameters and groundwater elevation for sign foundations unless these subsurface conditions are not applicable to sign locations:

- (A) Unit weight ( $\gamma$ ) = 120 lb/cf,
- (B) Friction angle ( $\phi$ ) = 30°,
- (C) Cohesion ( $c$ ) = 0 lb/sf, and
- (D) Groundwater 7 ft below finished grade.

A subsurface investigation is required if the Engineer determines these assumed subsurface conditions do not apply to a sign location and the sign cannot be moved. Subsurface conditions requiring a subsurface investigation include but are not limited to weathered or hard rock, boulders, very soft or loose soil, muck or shallow groundwater. No extension of completion date or time will be allowed for subsurface investigations.

### **Subsurface Investigations**

Use a prequalified geotechnical consultant to perform one standard penetration test (SPT) boring in accordance with ASTM D1586 at each sign location requiring a subsurface investigation. Rough grade sign locations to within 2 ft of finished grade before beginning drilling. Drill borings to 2 drilled pier diameters below anticipated pier tip elevations or refusal, whichever is higher.

Use the computer software gINT version 8.0 or later manufactured by Bentley Systems, Inc. with the current NCDOT gINT library and data template to produce SPT boring logs. Provide boring logs sealed by a geologist or engineer licensed in the state of North Carolina.

### **Sign Foundation Designs**

Design sign foundations for the wind zone and clearances shown in the plans and the slope of finished grade at each sign location. Use the assumed soil parameters and groundwater elevation above for sign foundation designs unless a subsurface investigation is required. For sign locations requiring a subsurface investigation, design sign foundations for the subsurface conditions at each sign location. Design footings, pedestals, drilled piers, grade beams and wings in accordance with the 4<sup>th</sup> Edition of the *AASHTO Standard Specifications for Structural*

*Supports for Highway Signs, Luminaires and Traffic Signals.* In some instances, conflicts with drainage structures may dictate sign foundation types.

Design footings in accordance with Section 4.4 of the *AASHTO Standard Specifications for Highway Bridges*. Do not use an allowable bearing pressure of more than 3,000 lb/sf for footings.

Design drilled piers for side resistance only in accordance with Section 4.6 of the *AASHTO Standard Specifications for Highway Bridges* except reduce ultimate side resistance by 25% for uplift. Use the computer software LPILE version 5.0 or later manufactured by Ensoft, Inc. to analyze drilled piers. Provide drilled pier designs with a horizontal deflection of less than 1" at top of piers. For cantilever signs with single drilled pier foundations supporting metal poles, use wings to resist torsion forces. Provide drilled pier designs with a factor of safety of at least 2.0 for torsion.

For drilled pier sign foundations supporting upright trusses, use dual drilled piers connected with a grade beam having a moment of inertia approximately equal to that of either pier. The Broms' method is acceptable to analyze drilled piers with grade beams instead of LPILE. Use a safety factor of at least 3.5 for the Broms' design method in accordance with C13.6.1.1 of the *AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Submit boring logs, if any, working drawings and design calculations for acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, required foundation dimensions and elevations and typical sections with reinforcement, conduit and anchor rod assembly details. Include all boring logs, design calculations and LPILE output for sign foundation design submittals. Have sign foundations designed, detailed and sealed by an engineer licensed in the state of North Carolina.

**Construction Methods**

Construct footings, pedestals, drilled piers, grade beams and wings and install anchor rod assemblies for sign foundations in accordance with the *Foundations and Anchor Rod Assemblies for Metal Poles* provision.

**Measurement and Payment**

*Overhead Footings* will be measured and paid in cubic yards. Sign foundations will be measured as the cubic yards of foundation concrete for footings, pedestals, drilled piers, grade beams and wings shown on the accepted submittals. The contract unit price for *Overhead Footings* will be full compensation for providing labor, tools, equipment and foundation materials, stabilizing or shoring excavations and supplying concrete, reinforcing steel, conduit, anchor rod assemblies and any incidentals necessary to construct sign foundations. Subsurface investigations required by the Engineer will be paid as extra work in accordance with Article 104-7 of the *Standard Specifications*.

Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Overhead Footings	Cubic Yard

OVERHEAD SIGN SUPPORTS



DESCRIPTION

Design, fabricate, furnish and erect various types of overhead sign assemblies with maintenance walkways, when specified in the plans, in accordance with the requirements of the plans. Fabricate supporting structures using tubular members of either aluminum or steel. Tubular members made of aluminum are not allowed for Dynamic Message Sign (DMS) structures. Only one type of material may be used throughout the project. The types of overhead sign assemblies included in this specification are span structures, cantilever structures, and sign structures attached to bridges.

MATERIALS

Structural Steel.....	Section 1072
Overhead Structures.....	Section 1096
Signing Materials .....	Section 1092
Organic Zinc Repair Paint .....	Article 1080-9
Reinforcing Steel .....	Section 1070

CONSTRUCTION METHODS

A. General

Fabricate overhead sign assemblies in accordance with the details shown in the approved working drawings and the requirements of these specifications.

No welding, cutting, or drilling in any manner will be permitted in the field, unless approved by the Engineer.

Drill bolt holes and slots to finished size. Holes may also be punched to finished size, provided the diameter of the punched holes is at least twice the thickness of the metal being punched. Flame cutting of bolt holes and slots will not be permitted.

Erect sign panels in accordance with the requirements for Type A or B signs as indicated in the plans or roadway standard drawings. Field drill two holes per connection in the Z bars for attaching signs to overhead structures. Use two bolts at each connection.

Use two coats of a zinc-rich paint to touch up minor scars on all galvanized materials.

B. Shop Drawings

Design the overhead sign supports, including foundations, prior to fabrication. Submit computations and working drawings for the designs to the Engineer for review and acceptance.

Have a professional engineer registered in the State of North Carolina perform the computations and render a set of sealed, signed, and dated drawings detailing the construction of each structure.

Submit to the Engineer for review and acceptance complete design and fabrication details for each overhead sign assembly, including foundations and brackets for supporting the signs, maintenance walkways (when specified in the plans), electrical control boxes, and lighting luminaires. Base design upon the revised structure line drawings, wind load area and the wind speed shown in the plans, and in accordance with the "Standard Specifications for Structural Structures for Highway Signs, Luminaires and Traffic Signals".

Submit thirteen (13) copies of completely detailed working drawings and one (1) copy of the design computations including all design assumptions for each overhead sign assembly to the Engineer for approval prior to fabrication. Working drawings include complete design and fabrication details (including foundations); provisions for attaching signs, maintenance walkways (when applicable), lighting luminaires to supporting structures; applicable material specifications, and any other sign information necessary for procuring and replacing any part of the complete overhead sign assembly.

Allow 40 days for initial working drawing review after the Engineer receives them. If revisions to working drawings are required, additional time will be required for review and approval of final working drawings.

Approval of working drawings by the Engineer will not relieve the Contractor of responsibility for the correctness of the drawings, or for the fit of all shop and field connections and anchors.

### C. Design and Fabrication

The following criteria governs the design of overhead sign assemblies:

Design shall be in accordance with the Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 4<sup>th</sup> Edition, 2001, and the latest Interim Specifications.

Within this Specification, there are several design criteria that are owner specified. They include:

- The wind pressure map that is developed from the 3-second gust speeds, as provided in Article 3.8, shall be used.
- Overhead cantilever sign structures shall include galloping loads (exclude four-chord horizontal trusses), truck-induced gust loading and natural wind gust loading in the fatigue design, as provided for in Article 11.7.1, 11.7.4 and 11.7.3 respectively.
- The natural wind gust speed in North Carolina shall be assumed to be 5 meters per second or 11.6 mph for inland areas, and 7 meters per second or 15.7 mph for coastal areas. The coastal area shall be defined as any area within 2 miles from the

waterfront facing the ocean or sound and all area where the design basic wind speed is above 120 mph, as shown in Figure 3-2.

- The fatigue importance category used in the design, for each type of structure, as provided for in Article 11.6, Fatigue Importance Factors, shall be Category II unless otherwise shown on the contract plans.
- Wind drag coefficient for Dynamic Message Sign enclosures shall be 1.7.

The following Specification interpretations or criteria shall be used in the design of overhead sign assemblies:

- For design of supporting upright posts or columns, the effective length factor for columns “K”, as provided for in Appendix B, Section B.5, shall be taken as the following, unless otherwise approved by the Engineer:

Case 1 For a single upright post of cantilever or span type overhead sign structure, the effective column length factor, “K”, shall be taken as 2.0.

Case 2 For twin post truss-type upright post with the post connected to one chord of a horizontal truss, the effective column length factor for that column shall be taken as 2.0.

Case 3 For twin post truss-type upright post with the post connected to two truss chords of a horizontal tri-chord or box truss, the effective column length factor for that column shall be taken as 1.65

- For twin post truss-type upright post, the unbraced length shall be from the chord to post connection to the top of base plate.
- For twin post truss-type upright post, that is subject to axial compression, bending moment, shear, and torsion the post shall satisfy Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals Equations 5-17, 5-18 and 5-19. To reduce the effects of secondary bending, in lieu of Equation 5-18, the following equation may be used:

$$\frac{f_a}{F_a} + \frac{f_b}{\left(1 - \frac{0.6f_a}{F_e}\right)F_b} + \left(\frac{f_v}{F_v}\right) \leq 1.0$$

Where

$f_a$  = Computed axial compression stress at base of post

- The base plate thickness for all uprights and poles shall be a minimum of 2" but not less than that determined by the following criteria and design.

Case 1 Circular or rectangular solid base plates with the upright pole welded to the top surface of base plate with full penetration butt weld, and where no stiffeners are provided. A base plate with a small center hole, which is less than 1/5 of the upright diameter, and located concentrically with the upright pole, may be considered as a solid base plate.

The magnitude of bending moment in the base plate, induced by the anchoring force of each anchor bolt shall be,  $M = (P \times D_1) / 2$ .

Case 2 Circular or rectangular base plate with the upright pole socketed into and attached to the base plate with two lines of fillet weld, and where no stiffeners are provided, or any base plate with a center hole that is larger in diameter than 1/5 of the upright diameter

The magnitude of bending moment induced by the anchoring force of each anchor bolt shall be  $M = P \times D_2$ .

- $M_1$ , bending moment at the critical section of the base plate induced by one anchor bolt
  - $P$ , anchoring force of each anchor bolt
  - $D_1$ , horizontal distance between the center of the anchor bolt and the outer face of the upright, or the difference between the radius of the bolt circle and the outside radius of the upright
  - $D_2$ , horizontal distance between the face of the upright and the face of the anchor bolt nut
- The critical section shall be located at the face of the anchor bolt and perpendicular to the radius of the bolt circle. The overlapped part of two adjacent critical sections shall be considered ineffective.
  - The thickness of base plate of Case 1 shall not be less than that calculated based on formula for Case 2.
  - Uprights, foundations, and trusses that support overhead signs or dynamic message signs shall be designed in accordance with the Overhead Sign Foundation Special Provision for the effects of torsion. Torsion shall be considered from dead load eccentricity of these attachments, as well as for attachments such as walkways, supporting brackets, lights, etc., that add to the torsion in the assembly. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.

- Uprights, foundations, and trusses that support overhead mounted signs or dynamic message signs shall be designed for the proposed sign wind area and future wind areas. The design shall consider the effect of torsion induced by the eccentric force location of the center of wind force above (or below) the center of the supporting truss. Truss vertical and horizontal truss diagonals in particular and any other assembly members shall be appropriately sized for these loads.

Fabricate all overhead sign assemblies, including foundations in accordance with the details shown in the approved shop drawings and with the requirements of these specifications.

Fabricate the span and cantilever supporting structures using tubular members of either aluminum or steel, using only one type of material throughout the project. Sign support structures that are to be attached to bridges may be fabricated using other structural shapes.

Horizontal components of the supporting structures for overhead signs may be of a truss design or a design using singular (monotube) horizontal members to support the sign panels. Singular (monotube) horizontal members will not be allowed for DMS signs. Truss or singular member centerline must coincide with centerline of sign design area shown on the structure line drawing. Provide permanent camber in addition to dead load camber in accordance with the "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals". Indicate on the shop drawings the amount of camber provided and the method employed in the fabrication of the support to obtain the camber.

For all U-bolt connections of hanger beams to overhead assembly truss chords, provide all U-bolts with a flat washer, a lock washer and double nuts at each end of the U-bolts. All double nuts that are on any U-bolt shall be the same thickness and weight. When assembled, the double nuts shall be brought tight against each other by the use of two wrenches.

Use cantilever sign structures that meet the following design criteria:

- a. Do not exceed an  $L/150$  vertical dead load deflection at the end of the arm due to distortions in the arm and vertical support, where  $L$  is the length of the arm from the center of the vertical support to the outer edge of the sign.
- b. Do not exceed an  $L/40$  horizontal deflection at the end of the arm due to distortions in the arm and vertical support, as a result of design wind load.

Attach the overhead sign assemblies to concrete foundations by the use of galvanized anchor bolts with galvanized nuts, flat washers, and lock washers. For cantilever structure use a minimum of eight anchor bolts. Provide anchor bolts that have an anchor plate with nut at the end to be embedded in concrete.

Fabricate attachment assemblies for mounting signs in a manner that allows easy removal of sign panels for repair. Provide adequate supporting frames for mounting the lighting luminaires in the positions shown in the plans or approved shop drawings for all overhead sign assemblies to be illuminated.

### **MAINTENANCE WALKWAYS**

When plans require maintenance walkways, provide maintenance walkways with an open, skid-resistant surface, and safety railings on all overhead structures unless specifically stated otherwise in the plans. Requirements for design and fabrication of the walkways are shown in the plans. Provide a walkway that is continuous and extends from 3 feet (1m) outside the edge of pavement over the shoulder to the farthest edge of any sign on the structure. If a sign is to be located such that it extends more than three feet outside the edge of pavement, extend the walkway for the full length of that sign. Provide walkways with a safety railing along the front side that can be folded, when not in use, to a horizontal position that will not obscure the signs.

To accommodate lighting luminaires, (when required by the plans), extend supports for the walkways in front of the walkway and railing. If external ballast is required, make provisions adjacent to the walkway and between the walkway and sign to accommodate ballast boxes for lighting circuits in a manner readily accessible from the walkway. Provide ballast box, brackets, and fastening devices which will withstand the loading requirements for the walkway, and mount so that the top of the box will be flush with the top of the walkway.

The walkway sections are to be connected rigidly where sections join to avoid an uneven walking surface. Attach the walkway directly to the walkway brackets.

Install a 4-inch x 4-inch safety angle in back of and parallel to the walkway and extend it the entire length of the walkway, except in the area occupied by ballast boxes. Design the safety angle to withstand a loading in keeping with the walkway.

Fabricate folding safety railing in lengths not exceeding 10 feet and install for the full length of the walkway. Join each folding safety railing post to walkway supports through a hinge support of appropriate design that will rotate freely. Provide a hinge support that has a locking or latching device and holds the railing in a steady manner, free of movement while in the raised position. Maximum allowable displacement from vertical at the top of the railing will be 1 inch.

Install fixed safety railing along the sign side of the walkway from the beginning of the walkway to the edge of the first sign. Provide fixed safety rails between signs when they are greater than 12 inches apart. Provide one fixed safety rail below any sign having a clearance between the bottom of the sign and the walkway grating of greater than 24 inches and less than 42 inches. Provide two fixed rails when the clearance between the bottom of a sign and the walkway exceeds 42 inches.



Provide a walkway in which the open ends have a galvanized steel coil safety chain attached on one end near the top of the safety railing, and on the other end to the walkway hanger, or other fixed member of the structure. When the railing is folded, the chain must not hang below the walkway bracket.

Where offsets in the walkway and safety railing are necessitated by variable luminaires provide safety chains between the offset handrail sections.

### **Anchor Rod Assembly**

Attach the overhead sign structure to concrete foundations by the use of straight galvanized anchor bolts with galvanized heavy hex nuts and flat washers. The rods and nuts shall be galvanized in accordance with AASHTO M232. The washers shall be galvanized in accordance with AASHTO M298 Class C. For cantilever structures, use a minimum of eight anchor rods. Provide anchor rods that have an anchor plate with nut at the end to be embedded in concrete.

Ensure material used in steel anchor rods conforms to AASHTO M 314 or ASTM F1554, and the specified yield strength does not exceed 55,000 psi. Compute the required projection of the anchor rod above the foundation top. Compute the total projection based on the following:

- Provide between 3 and 5 threads of anchor rod projection above the top nut after tightening is complete. Avoid any additional projection, or a normal depth socket torque wrench shall not be used on top nuts.
- Include the sum of the thickness of top nut, top nut flat washer or top nut beveled washers, base plate, leveling nut flat washer or leveling nut beveled washers, leveling nut.
- Set the maximum distance between the bottom of the leveling nut and the foundation top to one nut height to avoid excessive bending stresses in the anchor rod under service conditions.
- Do not use lock washers.

### **ANCHOR ROD NUT TIGHTENING REQUIREMENTS**

#### **Prior to installation:**

1. Protect the anchor rod threads from damage prior to and during installation.
2. Prior to installation of the rods in the foundation, turn nuts onto and off the rods, well past the elevation of the bottom of the leveling nuts. Turn by the effort of one worker using an ordinary wrench without a cheater bar. Report to the Engineer thread damage requiring unusually large effort.

**During installation:**

1. Place leveling nuts (bottom nuts) on the anchor rod.
2. Place leveling nut washers on top of the anchor rod leveling nuts.
3. Place a rigid template on top of the leveling nuts to check the level of the nuts. If the anchor nut and washer cannot be brought into firm contact with the template, then beveled washers shall be used.
4. Verify that the distance between the bottom of the leveling nut and the top of the concrete foundation is no more than one anchor rod diameter. If an upright is required to be back-raked, then the distance between the bottom of the leveling nut and the top of the concrete foundation shall be no more than one anchor rod diameter, averaged over the anchor rod group.
5. Place the base plate and structural element to which it is attached. However, do not attach to the upright element, during tightening of the anchor nuts, cantilever beams or arms with span in excess of 10 feet. Luminaire arms and fixtures may be attached prior to standing the pole on the foundation.
6. Place top nut washers.
7. Do not use lock washers.
8. Lubricate threads and bearing surfaces of top nuts. Lubricant shall be beeswax, stick paraffin, or other lubricant approved by the Engineer.
9. Place top nuts. If the anchor nut and washer cannot be brought into firm contact with the base plate, then beveled washers shall be used.
10. Tighten top nuts to snug-tight. A snug-tight condition is defined as the washer and nut being in full contact with the base plate, and the application of the full effort of a workman on a 12-inch wrench. Turn top nuts in increments following a star pattern (using at least two full tightening cycles).

11. To ensure proper pretensioning, after all top nuts have been brought to snug-tight condition, repeat the procedure on the leveling nuts. Turn leveling nuts in increments following a star pattern (using at least two full tightening cycles).
12. At this point, verify if beveled washers are required. Beveled washers shall be required under the leveling nut or top nut if any face of the base plate has a slope greater than 1:20 and / or any nut can not be brought into firm contact with the base plate.
13. Before further nut turning, mark the reference position of the nut in the snug-tight condition with a suitable marking (ink or paint that is not water-soluble). Mark on the corner at the intersection of two flats with a corresponding reference mark on the base plate at each nut. After tightening, verify the nut rotation.
14. Achieve pretensioning by turn-of-nut method. Turn the top nuts to 1/6 of a turn. Do so in a star pattern using at least two full-tightening cycles.
15. After installation, ensure that firm contact exists between the anchor rod nuts, washers, and base plate on any anchor rod installed.
16. For overhead sign assemblies: The span type truss or the cantilever truss may be placed on the uprights or attached to the upright at this time. For signal support structures: The span wires or mast arms may be attached to the upright at this time.
17. After a period of no less than 4 days, and no more than 2 weeks, and in the presence of the Engineer, use a torque wrench to verify that a torque at least equal to 600 foot-pounds is provided on each top nut. For cantilever structures, verify the torque after erection of the remainder of the structure and any heavy attachments to the structure.
18. If any top nut torque reveals less than 600 foot-pounds of effort is required to move the nut, then tighten the nut to no less than 600 foot-pounds.
19. Calibrate the torque indicator, and obtain corresponding certification, for all torque wrenches used for anchor nut tightening. The calibration and certification shall have occurred no more than 12 months prior to use of the torque wrench. Torque wrenches that were calibrated and certified more than twelve months prior to anchor nut tightening shall be re-calibrated and re-certified prior to use. Provide the Engineer a certification of such calibration.

20. Because inspection or re-tightening of the leveling nuts would be prevented, and to reduce moisture retention and associated corrosion, grout shall not be allowed under the base plate.

**COMPENSATION**

The work covered by this section will be paid for at the contract lump sum for each Overhead Structure “\_\_\_\_\_”. Such price will be full compensation for all work covered by this specification includes all design, fabrication, construction, transportation, and erection of the complete overhead sign structure, supporting structure, hardware, lighting support brackets, preparing and furnishing shop drawings, and attaching the signs to the overhead assembly.

Payment will be made under:

- Supports, Overhead Sign Structure @ Station 26+40 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 27+40 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 33+60 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 35+40 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 41+60 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 50+00 -L REV-.....Lump Sum
- Supports, Overhead Sign Structure @ Station 75+00 -L REV-.....Lump Sum