SIGN AND PAVEMENT MARKING DESIGN

FIELD REVIEW

The initial field review is one of the most important steps in the design of any signing and marking project. This is when the designer collects and reviews the information necessary to ensure a complete, comprehensive and cohesive system is developed. The field review allows the designer to also determine traffic patterns including lane drops, lane reductions, lane transitions, lane continuity, turn lanes, etc. Any change in traffic patterns will effect signing and marking.

The installation or modification of highway signs can often have impacts well beyond the roadway corridor being studied. Prior to the field investigation, it is important for the designer to have a clear understanding of the project objective. This means discussing the project with the team leader, reviewing the Design Request (DR), and contacting the DR's author in the District Traffic office and meeting in the field if necessary. The goal of the designer should be to ensure that any changes made do not cause inconsistency or confusion in the signing system. This also presents the opportunity to identify any existing problems that can be fixed as a part of the construction project.

Prepare a Base Map

Field data collection and conceptual design are made easier if a base map is prepared. Good sources of mapping are recent Highway Design Projects in the area or aerial mapping from Project Planning Division. If this is not available, there are other options available. The "Grid Maps" are available in electronic format from the Cartography Section, and they make a good base map. If more detail is required, it may be necessary to digitize a set of old plans and then perform a thorough field check. If less information will suffice, a schematic or "Stick Diagram" can be constructed from maps, the video log, and the field review.

The level of detail required for the plan will vary depending on the project. In fact, many Areawide and Shop Forces projects do not require scaled drawings, provided that sufficient location and construction information is given on the plans. In general, new construction plans are designed on base mapping provided by Highway Design Division.

Information to Collect

Signing: Initial Site Visit

Once the project objective is known, the signing requirements and impacts can be estimated. For every change, impacts to signs and messages beyond the immediate project area need to be considered in addition to the actual project construction. For example, removing a supplemental sign may impact a supplemental sign on a neighboring approach roadway.

1. Collect sign size, support type and size, position, and location (i.e. station and offset) information for all signs within the corridor. Even if your project is not modifying warning, or regulatory information, these signs may influence your choice of sign location. Always take pictures and make note of any signs needing replacement; these can always be included in your plan set. Take note of any other structures like light and signal poles that can be used for banding the signs.

2. Always take pictures of the job site! This may eliminate a field visit later.

3. By this point, the designer should have a good feel for the number and location of signs to be installed on the project. For each one, identify two or three possible locations in the field. Take note of lateral clearance problems, availability of electric service and barrier types at these locations, since these will influence your choice of final location and support type. Wherever possible, it is preferred to locate new signs behind existing traffic barrier.

4. If a potential site is behind barrier, measure the entire approach length in front of the sign location, the lateral distance from the sign support to the barrier, the distance from the travel lane to the barrier, and the shoulder width. The length of need must be checked to

ensure adequate protection of non-breakaway supports.

5. Look for drainage facilities and utilities that will influence the selection of proposed locations.

6. Check that the selected locations meet MUTCD guidelines for sign spacing.

7. Identify the location and offset of all ditches near your sign locations. Sign foundations should never be located in the centerline (bottom) of a ditch.

8. Check the sign messages on all approaches to the corridor. The final system should have consistent messages on all signs approaching the system as well on the system itself.

9. Drive the entire corridor and look for opportunities to reduce the total number of signs. Check for unnecessary or unwarranted signs and look for sign messages that can be combined with others in your plan.

Signing: Subsequent Site Visits

For most projects, it will be necessary to make a second site visit. Follow-up visits will usually be necessary to finalize locations, get cross section information, check barrier locations, and check roadside clearances. This is because the sign sizes are not known at the initial visit and often change throughout the course of the design. On smaller jobs, the roadside elevations can be taken at the initial site visit, however this is not always practical on large jobs.

Pavement Markings

The primary purpose of taking a pavement marking inventory is to identify changes in the traffic pattern so that the appropriate changes may be made on the design plans. The field review should collect information regarding existing pavement markings and lane usage. The markings should be noted for turn lanes, auxiliary lanes, lane reductions, and lane drops. This should include the presence of lane lines, center lines, edge lines, dotted lines, transverse lines, channelizing lines, stop lines, arrows, words, and symbols. This information will be important in verifying that the overall treatment is consistent with current standards for both signing and marking. It is also important to note marked crosswalks, two way left turn lanes, raised pavement markers (RPM's), shoulder rumble strips, and raised rumble strips used for warning conditions.

Data Collection Methods

Sign Sizes

Sheet aluminum signs generally have to be measured to determine size. Extruded aluminum signs, however, can be "counted" based on the panels they are constructed from. Each panel is either 6" or 12" tall, with 6" panels generally located at the top when they are used. Note, 6" panels should be used only for special purposes. Each panel also has bolt holes along the bottom edge, and these are also 12" apart. When signs are even foot widths (i.e. 12'-0"), the holes are offset 6" from each edge. Where signs are half-foot widths (i.e. 12'-6"), the holes are offset 3" from each edge. Once again, half-foot widths should be used only for special purposes.

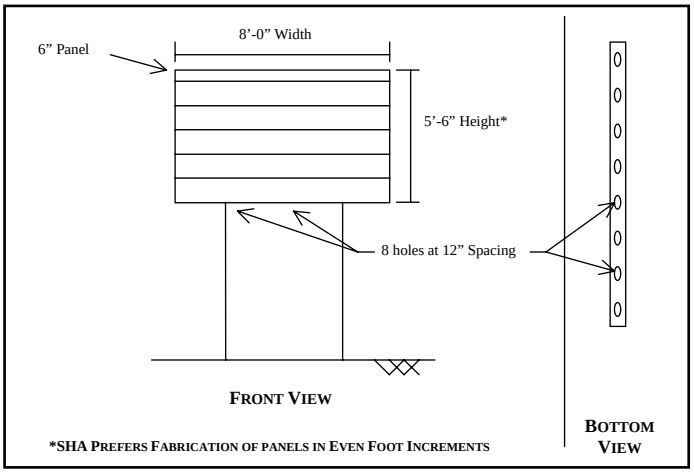


Figure 1 - Extruded Aluminum Sign

Elevations

Elevations are required to determine ground mounted support sizes and lengths as well as overhead structure clearances. This is usually a two-person process involving a survey rod and a lock-level, however for new construction this information is available from the profiles, cross sections, and typical sections. The person holding the level usually stands on the edge of shoulder

and takes measurements at the edge of shoulder, edge of travel lane, and the top and bottom of roadside slopes and ditches. The first measurement, taken at the edge of shoulder, is used to calculate the "eye height" of the observer, and will be used to calculate elevations and slopes. A measurement should be taken at the edge of travel lane for the purposes of estimating the elevation of the high point on the roadway. Curved sections of roadway may be super-elevated and should have elevations at both shoulders where practical.

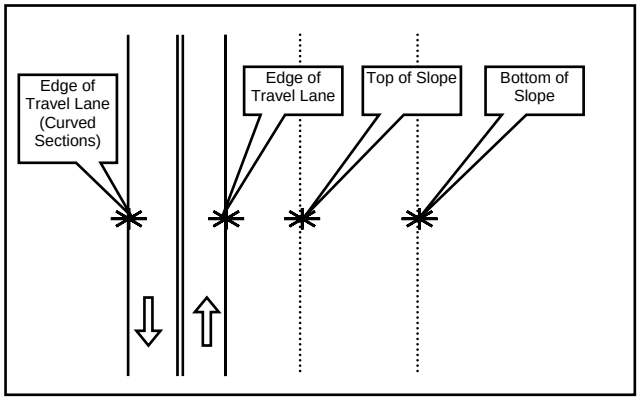


Figure 2 - Typical Elevation Requirements

Consider the following example, where the elevation of a ditch is being calculated. The observer has already taken readings for eye height at 5.2 Feet, top of slope at 7.2 Feet, and bottom of slope at 9.2 Feet. He is now trying to determine the elevation of the top of slope and ditch. Since there are no known elevations, it would be common to assume that the edge of shoulder is at an elevation of 100 Feet. This would put the observer's eye at 105.2 Feet and the ditch at 105.2' – 9.2' = 96 Feet, and the top of ditch at 105.2' – 7.2' = 98 Feet.

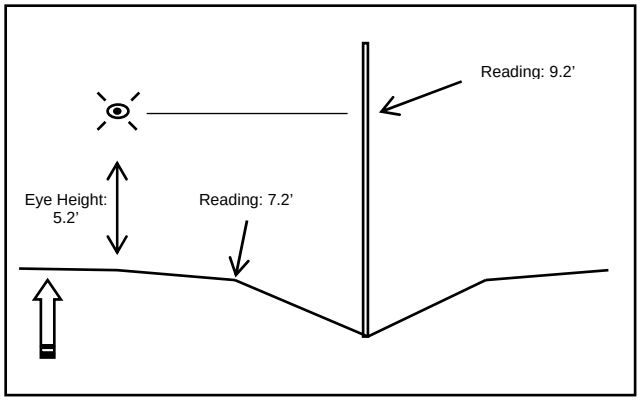


Figure 3 - Roadside Elevation Readings

CONCEPTUAL PLANS

Developing a Concept

The conceptual plan is developed before the actual design of any signs is begun. The designer will develop what he feels is the desired layout prior to the "Post-It Note" plan review, when his recommendations will be reviewed. The concept review is an important step in the design process, because it sets the foundation for the messages and sign types to be used and then gathers comments and input from all interested parties early in the design process. The designer, the designer's team leader, director's staff and the district traffic office as a minimum usually attend the Concept Review. Depending on the complexity and level of input desired, it is also helpful to have the Division Chief, Assistant Division Chief, representatives from another design team, design consultant (where applicable), and the Highway Design Division Lead present.

The Goal of the Concept Plan

Prior to the concept stage, the base mapping should have been obtained and a roll map produced. Information from the field review should be drawn on the plan, including existing signs, existing traffic barrier, existing markings, and lane usage. Where possible, information that may influence the selection of final locations should also be included.

The concept plan should lay down on paper what the designer feels is the desired and preferred system of signs and proposed traffic patterns. The focus should be on the location, order, presentation, and coordination of sign messages, both within and outside the project limits. The concept does not need to address exact details of what sign sizes will fit in the field, however obvious problems should be noted and addressed. At this stage, the designer should choose between overhead and ground mounting of the signs as this may influence other signs in the system. It should also be indicated if there are changes in the traffic pattern, as this will influence the signing.

The Signing "System"

Signs are designed to operate as part of a system that makes use of driver memory and learning to reinforce messages and improve understanding and reaction. The conceptual plan should address the design on a system, or a "Big Picture", level to ensure continuity with existing messages and treatments. The development of a concept plan usually involves the following steps.

A. Guide Signs

1. ***Note the Area Type:*** Urban, suburban, and rural characteristics often influence the type, size, frequency and support structures for signs along a roadway.

2. ***Identify Routes and Destinations***: Identify the primary routes, road names, primary destinations, supplemental destinations, and services that need to be signed. This information will be available from the field review, maps, neighboring roadways, and the district traffic office. A list of Maryland's Control Cities by route number is in the Guidelines section of the Appendix. The control cities along interstates may also be found in *List of Control Cities for Use in Guide Signs on Interstate Highways* from AASHTO.

3. ***Identify Problem Areas***: Check the roadway for unusual circumstances that may cause driver confusion or difficulty. These include lane drops, lane reductions, splits, and confusing geometry. The design must address these situations.

4. ***Choose a Scheme or System***: The selection of a scheme or system type will depend on roadway classification and configuration. Typical configurations include the conventional 1 Mile, ½ Mile, Exit Direction trio or may include Sequential signs and diagrammatic signs. Lower classification roadways, such as two lane and local roadways, will usually be adequately covered by route markers, distance/destination signs and mid-block Street Name Signs.

5. ***Sketch and Locate Proposed Signs***: Using the scheme chosen above and the messages identified in Step 2 as a guide, make hand

sketches of the proposed signs and locate them approximately on the plan. Most often this is done with a roll map and "Post-It Notes".

6. ***Check Opportunities to Reduce Clutter***: When the initial layout is complete, re-evaluate the concept looking for logical ways to eliminate signs, combine signs, and reduce costs. This process should always keep the needs of the driver as a primary objective.

B. Warning and Regulatory Signs

7. ***Place Warning Signs***: Identify where warning signs are needed and sketch them on the plan. While it is not necessary to address every warning sign at the concept level, it is important to consider unusual situations such as lane reductions, lane drops, sharp curves, low design speed ramps, etc. Refer to the MUTCD and MUTCD Supplement for application of these signs.

8. ***Place Regulatory Signs***: Similar to warning signs, it is not necessary to address all regulatory signs at the concept review. It is sufficient to identify what types will be used and what criteria will be used for most cases. It is usually important to identify one way and wrong way treatments, lane use control signs, stop/yield signs, and the post interchange sequence (speed limit and route marker).

9. ***Place Route Markers, Service Signs, and Others:*** If they have not already been addressed, review the application of route markers and service signs. This is also the time to review the need for any other signs, such as historic signs and attractions signs.

Reducing Clutter

There are many demands competing for the installation of highway signing. In addition to the standard compliment of regulatory, warning, and guide signs, there are programs for service signs, logo signs, supplemental generator signs, historical markers, historic signs, and more recently an attractions signs program. A designer should be concerned with preventing signs from being lost in a background of visual clutter.

The latest edition of the MUTCD states "a conservative use of regulatory and warning signs is recommended as these signs, if used to excess, tend to lose their effectiveness. On the other hand, a frequent display of route markers and directional signs to keep the driver informed of his location and course will not lessen their value".

One of the purposes of the conceptual plan is to check that new projects not only recognize this problem, but also attempt to reduce it. In this type of environment, it is important to prioritize information into what the driver needs to know and what other people would like the driver to know. Reasonable accommodations should be made to install signs that are not necessary to the drivers safety, however this should not be done at the expense of the basic principles of human abilities and time-distance relationships.

Reviewing the Concept

The concept review is the time for all interested parties to finalize what will and what will not be signed. It is a critical point for input from the District Traffic Office and, if necessary, the Director's Office. The concept will define the information that needs to be presented to motorists, which will play a key role in the final design process.

The exact type of review necessary will depend on the project size and scope. Obviously, if the project is replacing a single sign knock-down, a formal meeting is not necessary. This type of review can take place by fax, mail or e-mail. For larger projects involving new construction or signing replacements, a concept review can take several hours.

Review Items

A reviewer should consider the following items when participating in the review of a concept plan:

1. Check that the level of signing is appropriate for the facility in question. Keep in mind that the level of signing for a Freeway differs significantly from a two-lane highway.

2. Check route numbers, route names, and destinations. They should be accurate and consistent with other signing in the area.

3. Check that supplemental destinations are addressed where needed.

4. Check service signs for applicability and consistency. Make sure that logo and generic signs do not address the same service at an interchange.

5. Check unexpected or unusual circumstances and see that they are adequately signed. This should include lane drops, lane reductions, turn restrictions, confusing geometry, etc.

SIGN SIZE AND DESIGN

The MUTCD and Maryland's Supplement to the MUTCD describe standard signs and outline criteria for their application. The MUTCD also gives general criteria governing the design of guide signs. The Maryland Standard Sign Book should be used for all standard signs. The purpose of this section is to give guidance on the design of signs and application of the rules from the MUTCD as well as Maryland SHA practice.

Sign Legibility

Sign legibility will play a key role in designing the sign layout. It helps to determine the required text size for different driving scenarios. Historically, sign legibility distance has been estimated at 50 feet per inch of letter height, which was based on research done in the 1930's. More recently, the MUTCD states that 40 feet of legibility distance per inch of letter height should be used. Thus, a sign with 8" letters would be legible to drivers at 320 feet distance under the new criteria and 400 feet using the old criteria. Further, the MUTCD recommends that 1-inch letter height per 33 feet of legibility distance could be beneficial. Table 1 summarizes legibility distances for common letter heights.

Table 1 - Sign Legibility Distance

LETTER HEIGHT (INCHES)	LEGIBILITY DISTANCE (FEET)		
	50 FT/IN	40 FT/IN	33 FT/IN
4	200	160	132
6	300	240	198
8	400	320	264
10	500	400	330
12	600	480	396
15	750	600	495

An important concept related to how *long* a driver needs to see a sign is Decision Sight Distance. The AASHTO "Green Book" defines this as "the distance required for a driver to detect an unexpected or otherwise difficult-to-perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard or its threat potential, select an appropriate speed and path, and initiate and complete the required safety maneuver safely and efficiently". Decision Sight Distances are inherently longer than other sight distance criteria because they allow time for a driver to comprehend the information presented by the roadway environment (i.e. the sign or hazard) and make a judgment regarding course of action.

An application of these criteria would be in the placement of an Exit Direction sign along a freeway. MUTCD guidelines recommend that Exit Direction signs be placed ground-mounted at the beginning of the deceleration lane and overhead at the theoretical gore. If the deceleration lane is less than 300 Feet, then the Exit Direction sign should only be placed overhead at the theoretical gore. For a 60 MPH urban interstate, the recommended Decision Sight Distance is 1,275 Feet. If the deceleration lane is a typical 600 Feet length, then the driver can see the sign about 1,350 Feet prior to the physical gore. A vehicle traveling at the design speed will have over 15 seconds to read the sign and make a decision on exiting the highway, and select speed and path as necessary.

Sign Layout

The first step in sign layout is determining the class of facility the sign will be used along. This will be used to select letter heights from the charts in section 2-E of the MUTCD. For warning and regulatory signs, letter heights range from 1½ in. on parking signs to 8 in. on some warning signs depending on visibility needs. Once a letter height has been selected, the MUTCD offers the following guidelines for legend design.

- The minimum height of legend for expressway signs is 8 inches.
- The spacing between lines of copy should be approximately three-fourths of the average upper case letter height for adjacent lines of copy.
- Spacing between lines of copy and the top and bottom borders should be approximately equal to the average letter height of the adjacent line of copy.

- Spacing between legend and vertical borders should be approximately equal to the largest letter.

- Spacing between legend and symbols, for example a shield and a cardinal direction, should be equal to the capital letter height.

Sign layout is an iterative process that can be broken down into 6 steps. Given that signs are generally fabricated in heights and widths of even 12" multiples, strict application of the above spacing recommendations does not usually produce a design that can be used for fabrication. It is usually necessary to adjust the inter-line and edge spacing to obtain a workable design. This process is usually performed within Microstation and using SHA's SIGNTOOL program, which makes alternative layouts easy to develop. A typical design process would involve the following steps:

1. Select appropriate letter heights for the legend and symbols.
2. Using TEDD's CADD Standards manual, place all of the legend and symbols. Designers are referred to the Signtool Users Manual and the CADD Standards Manual for information regarding the proper use of Microstation and SIGNTOOL software.
3. Space the various lines of legend according to the spacing guidelines given above.
4. Place a border, allowing for legend to border spacing equal to the capital letter height.
5. Check the computed height and width against manufacturing capabilities. Generally, the sign shop fabricates extruded signs in even foot multiples (both height and width).
6. Using the spacing recommendations as a guideline, additional space can be added or possibly deleted to develop the required height and/or width.

When selecting the border width, use Table 2 as a guide. Border width and corner radius are selected based on the smallest sign dimension, either height or width.

General Principles

There are many general principals, or possibly rules of thumb, which are applied to sign design on a daily basis. Some important ones to always keep in mind are:

- When designing for a cloverleaf interchange, the top destination should be for the closer exit ramp and the bottom destination for the further or second ramp.

- For diamond interchanges, the top destination should be the one requiring a left turn and the bottom destination a right turn at the top of the ramp.

- Where possible, road names should be included on guide signs. Long road names present a good opportunity to use a combined sign.

- Where EXIT ONLY panels will be constructed on extruded panels, maintain 12" multiples for the height.

- 20"/15" letters should be used for all exit direction signs on Freeways. For Freeway-to-Freeway interchanges, a full compliment (1-MILE, ½-MILE, Exit Direction) of 20"/15" signs will be used.

- Be careful when applying lane designation arrows to choice lanes. Motorists are sometimes confused when the number of arrows pointing is fewer than the actual number of lanes, and vice-versa.

- When designing guide signs for left exits in lieu of diagrammatic signs, the action messages starting with the furthest sign should be "LEFT X MILE", "LEFT EXIT", "NEXT LEFT", followed by the exit direction sign. The action message shall have black legend and border on a fluorescent yellow background.

- The exit panels for left exit guide signs are left justified on top and the cardinal direction is placed on the left of the route shield.

- Don't center all lines of a multi-line message. Where the road name, destination, or other message is more than one line, the second

line is indented, not centered. The vertical space between two lines of a split message is reduced in relation to other spacing. Never split a single destination or roadway into more than two lines.

Table 2 - Sign Border Dimensions

Smallest Side Dimension (Feet)	Corner Radius (Inches)	Width (Inches)
2	3	1 1/8
3	3	1 1/8
4	6	1 1/8
5	6	2
6	9	2
7	9	2
8 +	12	2

Table 3 - Standard Capital Letter Heights (Series B,C,D, and E)

Standard Letter Heights (Inches)	
3	8
4	9
5	10
6	12
7	16

Table 4 - Standard Emod Letter Heights

Initial Upper Case	Lower Case
6	4.5
8	6
10.67	8
13.33	10
16	12
20	15

Sign Layout Example

As an example sign layout, consider an Advance Guide Sign located along I 70 in Washington County. The MUTCD recommends the following letter sizes for Freeway guide signs:

Table 5 - Letter Heights for Design Example

LEGEND	SIZE
Exit Panel (word/number)	10”/15”
Shield	36”
Destination (Upper/Lower)	16”/12”
Distance (number/word)	15”/10”
Fractions (Numeral/Overall)	10”/15”

Referring to the sign layout guidelines mentioned earlier, an initial layout might produce the following spacing:

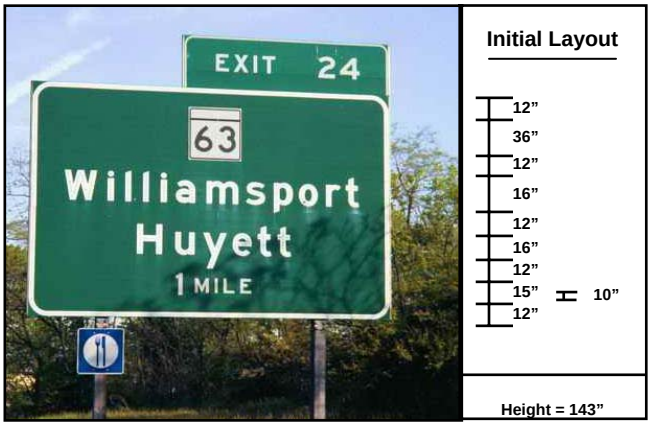


Figure 4 - Initial Layout for Design Example

A quick application of the above rules led us to choose 12” for the inter-line and edge spacing. The total height calculated, 143” should be modified to an overall total of 12’-0” (or 144”). In this situation, a logical location to add the required additional inch would be between “Huyett” and “1 MILE”, where the lowercase “y” hangs below the line.

Refining your Design

A refining technique for improving sign legibility is to reduce spacing between associated messages and increase spacing between route – destination – information messages.

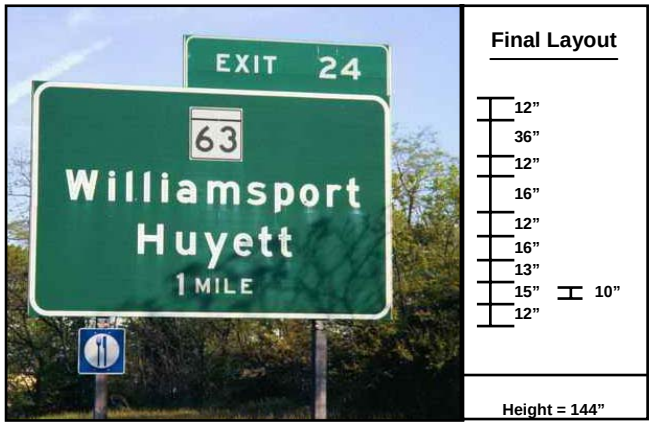


Figure 5 - Final Layout for Design Example

Combining Messages

The goal of sign designers should be to install the fewest signs necessary to provide motorists with required informational needs. Combining messages is one way to reduce the required number of signs while grouping messages having a common theme. Cloverleaf interchanges are frequently designed with an overhead structure containing both the Exit Direction sign for one interchange ramp and a second "¼ MILE" sign for the subsequent ramp. Since these ramps often serve a common route number or route name, these messages can be combined to produce a single sign. This may allow the structure size to be reduced, reduces the total number of signs along the highway, or creates room for a different sign to be installed. In either case, care should be taken not to overload the driver with information. The MUTCD's rules regarding legend and number of destinations per interchange still apply. Two of the primary objectives of combining messages are:

Group messages to provide motorists with a more effective and concise presentation.

Reduce the total number of highway signs and minimize driver information overload.

Message Dividers

Message dividers are most commonly used to separate road names, points of interest, destinations, and services on distance and destination signs. They also are used on combined guide signs, where road names are used on the primary guide signs or to separate action messages for different ramps. Figure 6 and Figure 7 show example message divider applications.

These signs are governed by the following rules:

- The divider color and dimensions are the same as the sign border. See Table 2 for border dimensions.
- Where a partial divider is used, it is 2/3 of the sign height for vertical dividers or sign width for horizontal dividers. This is also referred to as a $^{2}/_{3}$-bar.
- Where distance/destination panels are stacked, a divider (usually white) is used between the different colored backgrounds. An exception to this is EXIT ONLY panels, where both a black and white border is used to separate the yellow panels from green panels.
- Message dividers should imply the degree of association between various items. For example, if services are associated with a particular point of interest, no divider is used. If the services are separate but available at the same exit, then a divider is used.

Figure 6 – Typical Message Divider

Figure 7 - Typical Message Divider

Reverse Sign Colors

When additional conspicuity is desired for supplemental or service signs, SHA has experimented with the use of reverse sign colors. This means using blue or green legend on a white background instead of white on blue or green. These signs should only be used at the discretion of the Office of Traffic and Safety when there is a direct conflict with the MUTCD.

Figure 8 - Reverse Sign Colors

Arrows

The MUTCD and the FHWA Standard Highway Signs book define three standard arrows, the "UP" and "Down" arrows, intended for use on interstate guide signs, and the "Standard Arrow" which can be used on all signs. In addition, Maryland SHA also uses several curve and turn arrows which have been developed for unique situations. The SHA Standard Sign Book gives dimensions and details for all arrows used in Maryland.

Interstate "UP" arrows are used to designate exiting or turning movements on exit direction signs. They are known as Type A Arrows in the Standard Signs Book and are known as the UP arrow in the FHWA Standard Highway Signs Book. Interstate "Down" arrows (also called "lane designation" and "C-1" arrows) tell motorists what lanes to use to reach a particular destination or follow a specific route. They are commonly used for "EXIT ONLY" signs and at freeway splits. These arrows are intended to point at the center of the lane to which they refer. If the lane designation arrow needs to be rotated to signify a message applying to an adjacent lane, the rotation is typically 5^{o} and in any case should not exceed 10^{o}. These arrows are not to be used for "UP" arrows.

The "Standard Arrow" is used for all other signs, including distance/destination, warning, and regulatory applications. Dimensions for standard letter heights are given in the Appendix of the sign book, however non-standard sizes can be scaled for application to warning and regulatory signs. The MUTCD recommends that the width across the barbs of an arrow be equal to the capital letter height.

Other arrows shown in the Standard Sign Book can be employed to more accurately reflect roadway geometry. These include:

- Single Line Curve
- Single Line Turn
- SLARO1 (Curve)
- SLARO2 (Turn)
- LARO/LARO2

These arrows should be considered only when the application of FWHA standard arrows would not provide motorists with sufficient guidance.

Diagrammatic Signs

Diagrammatic signs are a special category of signs in the MUTCD that are intended to graphically depict roadway conditions ahead. They are commonly used to indicate freeway splits, left exits, choice lanes, route discontinuity, and lane drops. In addition to visualizing the roadway geometry,

diagrammatic signs can be combined with EXIT ONLY panels to show lane drop situations and can clearly identify left exits. These signs tend to be extremely large (the one along southbound I-270 is the largest sign in Maryland), and as such are found mainly along Interstates and Freeways. The MUTCD section on freeway signing gives criteria governing the design of diagrammatic signs and specifies dimensions for lane widths, lane line widths, and arrowhead sizes. It is important to note that the manual specifically states that these signs SHALL NOT be used at cloverleaf interchanges.

Figure 9 - Typical Diagrammatic Sign

Sign Lighting

Book of Standards References
Sign/Luminaire Supports Mounting – Structures
Mounting for Sign / Luminaires – Overhead Structures
Lighting Control Cabinet

Maryland policy is to provide sign lighting for all overhead signs. Sign Lighting Maintenance Systems are the preferred method of sign lighting no matter what type of facility and level of signing. However, traditional sign lighting is used in certain situations. Maintenance systems vary depending on the manufacturer, however the goal is to allow all maintenance activities to take place off the traveled roadway. This provides quicker access to hardware, reduces Maintenance of Traffic costs, and eliminates the need for lane closures. Maintenance systems are used for guide signs located above the travel lanes and shoulders. This includes both overhead and cantilever trusses, however, if the maintenance system does not provide benefits for MOT then approval to install without should be obtained. For traditional lighting, the luminaires are mounted on steel beam supports that are attached to the overhead truss (see for an example). See also the lighting design section of this manual.

The basic elements of sign lighting design are:

1. Selecting the number and wattage of luminaires.
2. Identifying a power source.
3. Determine Circuitry.
4. Maintenance Considerations

Figure 10 – Sign Lighting Maintenance System

Luminaire Selection

The number and wattage of luminaires is based on the sign height and width. TEDD has a standard Sign Lighting Schedule, which is included in the Appendix. This chart has been developed for Mercury Vapor lamps and luminaires, which are currently the standard for sign lighting.

Power Sources

Signs are typically powered from the roadway lighting circuits, where roadway lighting is present and spare capacity exists. Connections to existing circuits can be made in the base of light poles, or

spare circuits can be run from an existing cabinet to the signs. In either case, the existing circuits should be reviewed to ensure sufficient spare capacity exists.

Where there is no roadway lighting, a separate cabinet will be necessary for the sign lighting. For most situations, a Pole Mounted Lighting Cabinet (Spec. Section 816) will be sufficient to power the sign lighting. A remote service consists of an enclosure, a 60 amp Main breaker, 2-20 amp circuit breakers, and a photocell. This is sufficient to provide 2 circuits operating at 240V, which can power 1 or 2 signs. Where the total load is more than 32 Amps, the cost of multiple Pole Mounted Cabinets versus a Base Mounted Lighting Cabinet should be examined. Where a Pole Mounted Cabinet is insufficient, it will be necessary to install a Base Mounted Cabinet. The decision between a Base Mounted and Pole Mounted Cabinet is a cost trade-off between supplying individual Pole Mounted Cabinets at $1,500 to $2,000 each against a Base Mounted Cabinet at $7,500 to $10,000 each, plus additional trenching and cable to reach a central location. Refer to Spec. Section 807, Electrical Service Equipment, for utility connection information.

Determine Circuitry

Sign lighting design is a balance between total circuit load and circuit voltage drop. The three rules governing lighting circuit design are: sign lights should be run from two different circuits, the total voltage drop in each circuit should be less than or equal to NEC guidelines (5% of the source voltage currently), and the maximum circuit load in amperes is determined by NEC guidelines (currently 80% of the circuit breaker trip size for roadway lighting). For connections to existing roadway lighting, it is important to determine if there is sufficient capacity in both the cabinet and the circuits that will be used. Where a remote service is used, it is important to check the total load, because they are not intended to handle large lighting systems.

More information regarding sign lighting and circuit design can be obtained from the lighting section of this manual.

Maintenance Considerations

Sign lighting maintenance is a key concern given the costs that are associated with roadway work and Maintenance of Traffic (MOT). Not long ago, SHA tracked the costs of changing bulbs for a sign on the Capital Beltway. That particular job required less than $1,000 in new bulbs, but over $10,000 in MOT costs for lane closures. As a result, SHA has developed the following guidelines aimed at reducing these costs over the life of the sign.

1. Overhead sign bridges shall have sign lighting maintenance systems.
2. Where possible and practical, cantilever signs should be designed to be situated above the shoulder, not the travel lanes so that maintenance systems may be omitted.
3. Cantilever signs over travel lanes shall have sign lighting maintenance systems.

The goal of these guidelines is to locate guide signs over the shoulder wherever possible and where this makes sense from an engineering point of view. Obviously, this cannot apply to all situations. While advance guide signs and exit direction signs perform the same over the shoulder versus over the travel lanes, exit only and lane designation signs (i.e. those signs with down arrows) need to be pointing at the center of the appropriate lane. Another situation requiring judgment would be the inside of curves, where a sign located over the shoulder may not have sufficient sight distance for motorists.

Considering Construction and Fabrication

Fabrication

There are different processes by which signs are fabricated depending on what type of sign is being made. The process used affects not only the cost of construction, but also what can and cannot be made.

In Maryland, larger signs are constructed on an extruded aluminum background, and legend is fastened using rivets. In this method, sometimes referred to as De-mountable Copy, legend is fabricated individually on sheet aluminum and then riveted to the extruded panels. This is done for all of the sign legend, including letters, route markers, arrows, and any other symbol which may be used

on guide signs. Minor copy changes can then be made in the field using only a drill and a rivet gun. In addition to copy changes, the use of extruded panels allows modification to part of a sign without replacing the entire sign. Since the typical green background of larger signs is directly applied to each individual extruded panel before the panels are assembled to make the sign, panels can be added or removed simply by unbolting the extrusions in the field.

Smaller signs and signs involving artwork typically use silk screening as part of the fabrication process. This involves making a master screen or template and using it to apply ink to the reflective sheeting background. The master is made using a photographic process and a full scale mock up, which allows one screen to be used for the production of many signs. Each color of legend must be applied in a separate process (and using a separate screen), allowing dry time between colors. Screening offers a high degree of consistency and quality while producing a large number of signs in a short time frame.

Direct applied (adhesive backed) sign legend is usually used with sheet aluminum signs and can be used in conjunction with silk screening. It is typically used for legend, which cannot be mass-produced, such as road names and destinations.

Construction

Guide sign legend can be modified when the sign has de-mountable copy as discussed earlier and when the sign is in relatively good condition. Instead of replacing an entire sign, it makes more sense to replace just the weathered, damaged, or inaccurate portion of a sign. Copy changes are an economical way to modify signs, however, designers should be careful when doing so:

- Over time, the sheeting behind copy weathers at a different rate than sheeting that is exposed to sunlight and the elements. This can produce ghost images after legend is modified. When this occurs, replacement or a sheet aluminum overlay should be considered.

- Making substantial changes is time consuming. Where signs are mounted over the travel lanes, changes should be limited to a short line or a few symbols. For substantial changes, consider a sheet overlay instead. Sheet overlays are less expensive to fabricate than extruded signs, and can be installed quickly, minimizing lane closure time and crew exposure.

- While lane closures are introduced, look at the option of upgrading not only the sign, but also sign lighting such as a sign lighting maintenance system or other adjacent signs

- Button copy is an older type of legend where the letter is made of plastic and round reflectors are mounted on top of the letter to provide reflectivity. Background sheeting on these signs is usually Engineering Grade, an older type with relatively low reflectivity. Button copy can be modified, however it is most times impractical, and designers should avoid mixing both types of copy. A sheet aluminum overlay may be the best means of modification, but it is preferred to replace these signs where practical.

SIGN SUPPORTS

Mounting Hardware

Book of Standards References
Wood Sign Supports Sign Mounting
Wood Sign Supports Route Marker Assemblies
Extruded Aluminum Details/ Sign Panels

The type of hardware used for sign mounting depends primarily on the aluminum panels the sign is constructed from. Extruded aluminum panels are typically attached to supports using post clips that are held in place by bolts that run through the channel at the back of each extrusion. These clips can attach directly to the flanges of steel I-beam supports, or can attach to aluminum angles that are bolted to wood supports. Sheet aluminum signs are typically bolted directly to the sign post, however larger sheet signs come in 4-foot wide panels that must be assembled prior to installation.

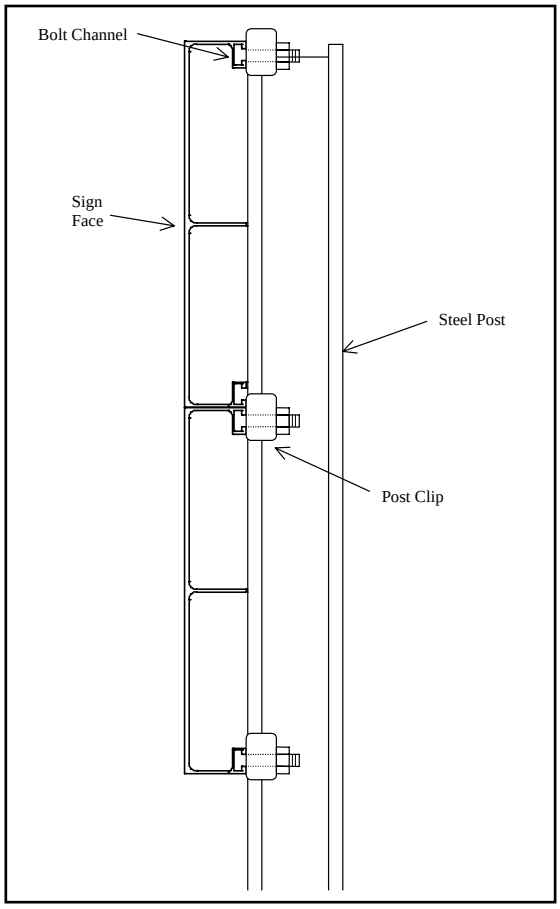


Figure 11 - Typical Extruded Panel

Selecting a Support

There are two decisions that must be made in selecting a sign support. First, it must be determined whether the installation will be overhead or ground mounted. Then, within each category, an appropriate and economical selection must be made. Maryland's policy is to use overhead guide signs where there are three or more lanes per direction. In most other situations, ground mounted signs will suffice, however, overhead signs may also be used to improve visibility or provide additional emphasis in problem situations. With the exception of special situations, warning, regulatory, and route marker signs are always ground mounted.

Overhead Structures

Book of Standards References
Overhead Sign Structures General Notes
Single Plane Cantilever Sign Structures
Box Truss Cantilever Sign Structures
Cantilever Sign Structure Foundation
Overhead Span Sign Structures

The decision to use overhead structures is based on the factors outlined in the Overhead Sign Installations section of the MUTCD (Section 2A.17). If it is decided that guide signs will be installed overhead, then a choice must be made between Overhead Structures and Cantilever Structures for each location. Overhead Structures have two roadside supports (also referred to as End Frames) and typically span over all lanes in a given direction. Cantilever Structures have one end frame (or roadside support) and typically span over zero to two lanes.

Choosing the Right Structure

This decision requires some judgment, as there are issues of function, cost and maintenance that are important. Overhead structures cost more to install and maintain, however the sign function and driver needs must be the first priority. Each situation needs to be evaluated on an individual basis, to ensure that information is presented in the most appropriate manner. The following questions, which are listed in priority order, should be asked in making this decision:

1. Does the type of sign or site conditions (i.e. sight distance, etc…) require that the sign be at a particular location over the travel lanes? This is true for exit only, lane designation, and diagrammatic signs.

2. If the installation is ONE sign, can it be located over the shoulder and still function properly? This is true for most advance guide and exit direction signs.

3. Will the total sign width (for 2 or more signs, include space between signs) fit on a typical cantilever span (Usually 10 to 45 feet)? The span length calculation must include the shoulder setback and the required sign position above the roadway.

Overhead Structures

Overhead structure spans are measured from centerline to centerline of the end frames. Typical span lengths range from 70 feet to 120 feet in length, however longer structures have been designed in some situations. The Administration requires the use of a minimum 70-foot span even if a shorter span would suffice. Most new spans are designed as a box truss, however tri—chords are used on occasion. Box truss spans allow signs to be attached on both sides of the span (i.e. both directions of traffic) and can support two span sections with a common center support on divided highways.

When determining the span length, consideration should be given to clear recovery areas, ditches, steep slopes, etc. It may be better to increase the span length than introduce a hazard in the recovery area. On divided highways, the center support should be located as close as possible to the center of the median, to allow for future roadway widening.

The following criteria must be met for the Design Sign Area of an Overhead Sign Structure:

1. Design sign must extend, at a minimum, the width of the roadway.

2. For actual signs beginning or ending outside the limits of the roadway, the design sign shall extend to the limit of the sign.

3. Design sign height shall be the height of the tallest actual sign on the structure. An exit panel already shall be considered in addition to the main design sign panel.

4. Design chart sign size of standards shall be equal or greater than calculated design sign size.

5. The centerline of the design sign shall be placed at the centerline of the truss. The exit panel will be on top of the design sign.

Figure 12 - Tri-Chord Truss

Figure 13 - Box Chord Truss

Cantilever Structures

Cantilevers are typically used to hold one or two signs, depending on the sign area. They have only one support, and spans are measured from centerline of end frame to end of truss. Typical spans range from 10 to 45 feet. Factors influencing the Design Sign Area and span length are:

1. Design sign height shall be 1.25 times the height of the tallest sign.

2. The design sign width shall be the width of the actual sign. When two signs are required, the design sign width shall be the out limits of the actual signs including the space between the signs.

3. An exit panel in addition to design sign of main panel shall be included in the design. The centerline of the design sign shall be placed at the centerline of the truss. The exit panel will be on top of the design sign.

4. Design chart sign size of standards shall be equal or greater than the calculated design sign size.

5. Sign position over roadway.

6. Roadside features (curbs, shoulders, sidewalks, etc…).

Cantilever structures also come in several truss arrangements, however Maryland most commonly uses the box and plane trusses. (See Figure 14 and Figure 15).

Figure 14 - Typical Box Truss Cantilever

Figure 15 - Typical Plane Truss Cantilever

Requesting Structure Design

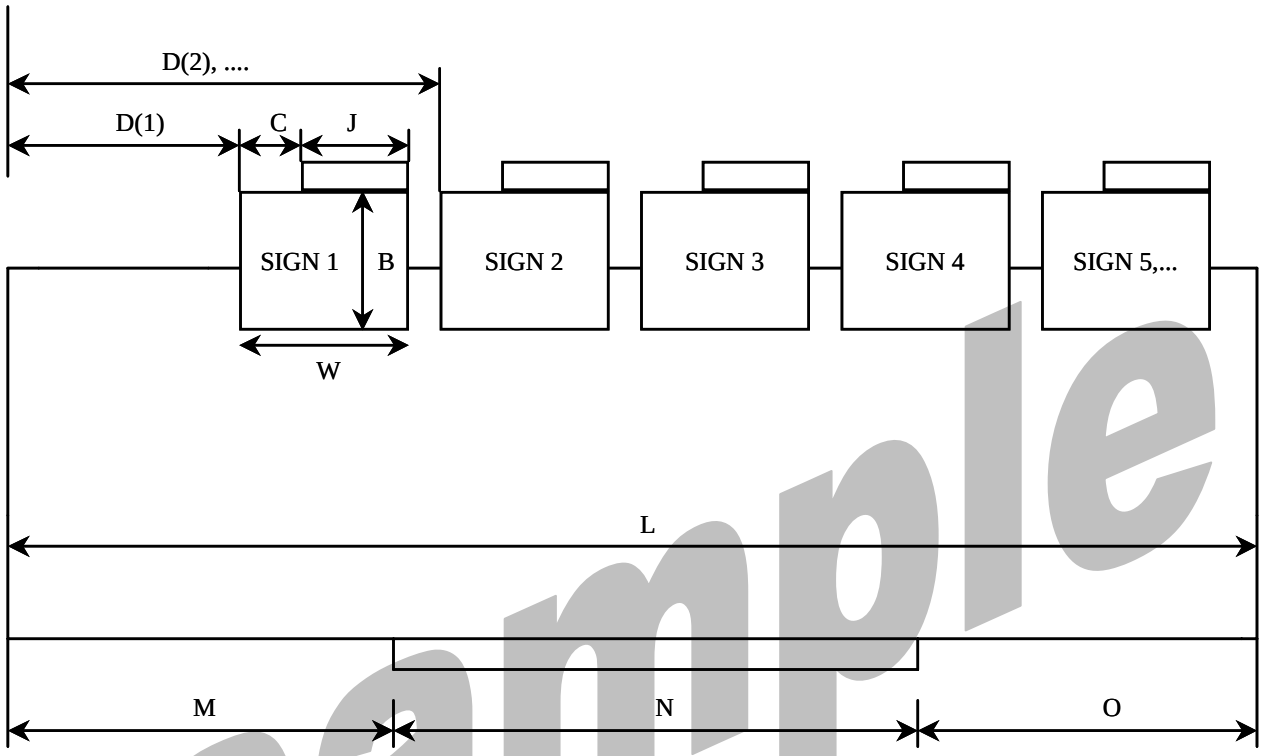
Structure design can be requested once the designer knows the sign size, roadside elevations,

and the horizontal location of the sign over the travel lanes. This is done by filling out the Structure Input Sheets with cross sections, which are included in the TEDD Document Manager and sending them to the Structural Design Team. Depending on the individual project, all the information necessary to complete the forms can be obtained from either the Field Review or the Highway Plans and Cross Sections. See figures 16, 17 and 18 for examples of the forms used for new structures.

One item designers need to be careful of is the positioning of the sign above the roadway, which will be guided by the function of the sign. Lane designation signs will need to be positioned with down arrows pointing to the center of the lane they refer to. Other signs have more flexibility. When the location is known, the designer can then calculate the distance from the center of the structure end frame to the edge of the sign. This is the exposed arm length (LA) on the Cantilever Input Sheet and Sign Offset (D) on the Overhead Input Sheet.

When signs are being changed on an existing structure, the structural capacity must also be checked. The structure verification form, also a part of Document Manager, should be used to supply the Structures Section with the information necessary to analyze the structure. On this form, the designer fills out the information pertaining to the size and location of all existing and proposed signs on the structure and any information regarding the contract under which it was installed. See Figure 19 for the form used for existing structures.

SPAN INPUT PROGRAM



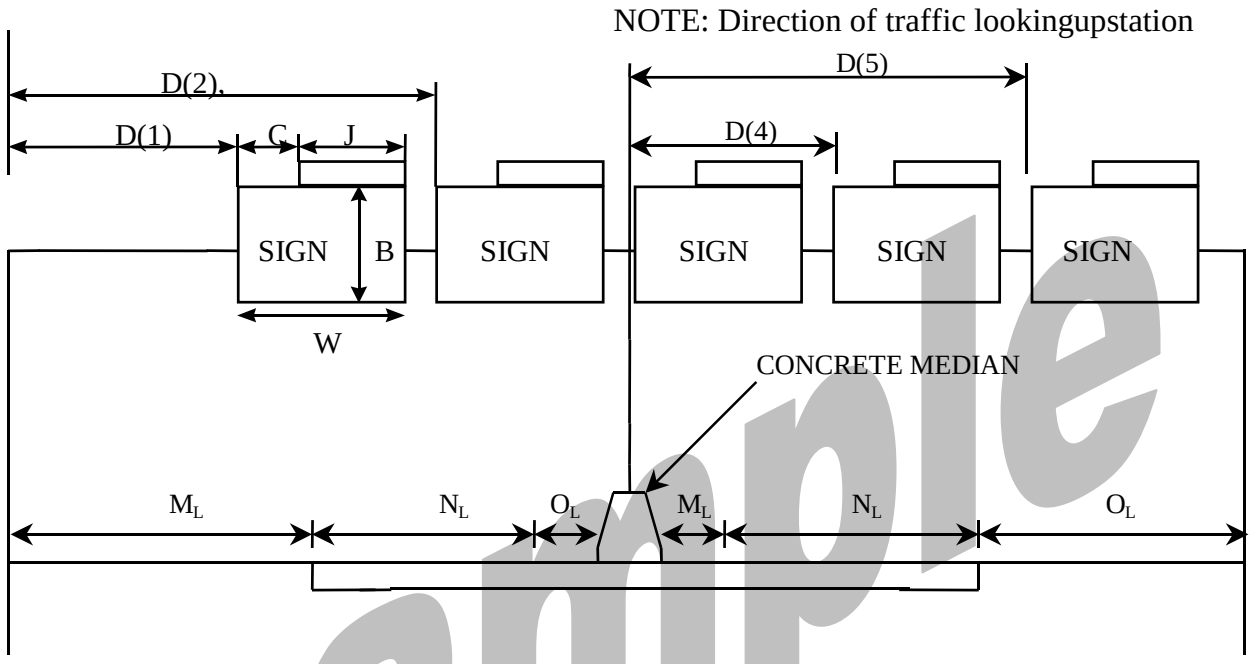
Date: _____
Project: _____
Contract Number: _____ Designer: _____
Structure Number: _____

Left Support Over(-)/Under(+) Roadway: _____
Right Support Over(-)/Under(+) Roadway: _____
Length of Span: _____
Number of Signs: _____
Offset from Left Support to Road Edge (M): _____
Offset from Right Support to Road Edge (N): _____
Road Width (O): _____

D(1)	D(2)	D(3)	D(4)	D(5)	D(6)
B(1)	B(2)	B(3)	B(4)	B(5)	B(6)
W(1)	W(2)	W(3)	W(4)	W(5)	W(6)
C(1)	C(2)	C(3)	C(4)	C(5)	C(6)
J(1)	J(2)	J(3)	J(4)	J(5)	J(6)

Figure 16 – Structure Input Sheet for New Structures with Two End Frames

SPAN INPUT PROGRAM



Date: _____
Project: _____
Contract Number: _____ Designer: _____
Structure Number: _____

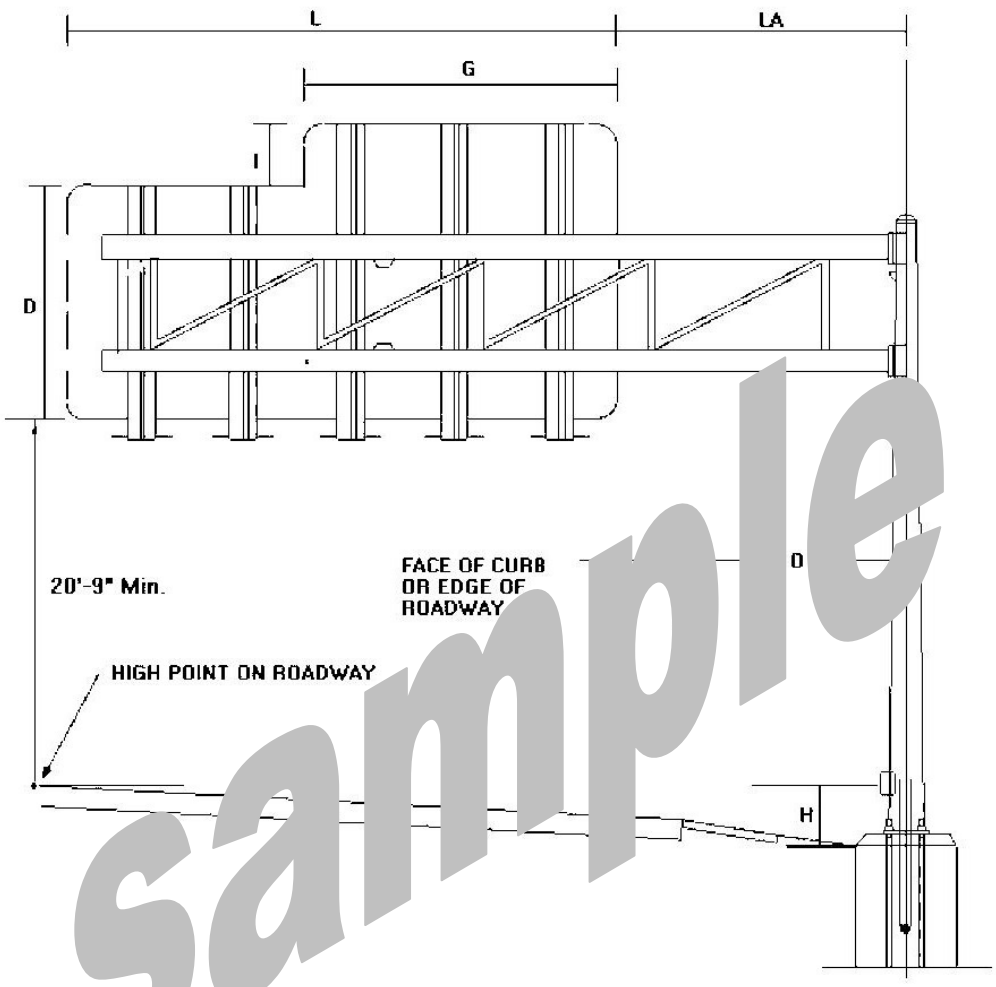
Left Support Over(-)/Under(+) Roadway: _____
Right Support Over(-)/Under(+) Roadway: _____
Length of Span: _____
Number of Signs: _____
Offset from Left Support to Road Edge (M): _____
Offset from Right Support to Road Edge (N): _____
Road Width (O): _____

D(1)	D(2)	D(3)	D(4)	D(5)	D(6)
B(1)	B(2)	B(3)	B(4)	B(5)	B(6)
W(1)	W(2)	W(3)	W(4)	W(5)	W(6)
C(1)	C(2)	C(3)	C(4)	C(5)	C(6)
J(1)	J(2)	J(3)	J(4)	J(5)	J(6)

Figure 17 – Structure Input Sheet for New Structures with Three End Frames

DocMgr

CANTILEVER INPUT SHEET



Date	Date
Location	Location
Contract Number	Contract Number
Structure Number	Structure Number
Designer	Designer
Sign Depth (D)	D
Sign Length (L)	L
Exposed Arm (LA)	LA
Over(-)/Under(+) Road (H)	H
Edge Road To Support (O)	O
Barrier Wall Mounted (Y/N)	Y/N
Exit Panel Justification (Left/Right)	Left/Right
Exit Panel Dimensions	G: G I: I

Figure 18 – Structure Input Sheet for New Cantilever Structures

M E M O R A N D U M

TO: Woody Hood, Chief
Traffic Engineering Design Division

DATE:

THROUGH: Navin Patel, P.E., Chief
Structural Design Section

FROM: Cheryl Schreiber, Acting Assistant Division Chief
Traffic Engineering Design Division

SUBJECT: Structure Verification for Adding, Deleting or Modifying Signs on Existing Structures.
Route:
County:
Contract No:
Structure Numbers or Location: _____

DESCRIPTION:*(Reason for project, requested by, etc.)*

Struct #	Sign Panel Letter	Near or Far Side	Roadway Clearance**	Existing Area-Per Panel WxH	Loc. on Span*	Proposed Area WxH	Loc. on Span*	*Struct. Design Area W x H*	*Design Wind Load (MPH)*	*CSR*

The above noted structures have been checked and verified. Those noted with a Combined Stress Ratio of greater than one are inadequate.

Please submit picture of recent existing signs and drawings of new replacement signs.

NOTE: All existing sign sizes and locations on the structure to be checked must be included in above table.
Italics and underlined to be filled out by Structure Design Section
Once checked, copy must be given to sign designer.
* Measured from left post to center of sign on overhead spans
* Measured from post to center of sign for cantilever structures
** Distance: Lowest luminaire support bottom to highest point of roadway

By: Sign Designer | Checked By: Structural Designer | Approved, Navin Patel, P.E.

Figure 19 – Structure Verification Form for Existing Structures

Ground Mounted Supports

Book of Standards References
Galvanized Steel Beam Sign Posts Foundation Details – Type A, B and C
Galvanized Steel Beam Sign Posts
Wood Sign Supports
Ground Mounted Sign Details
Wood Sign Posts Vertical And Lateral Clearance
Extruded Aluminum Details
Sign Banding Details
Special Sign Supports
Breakaway Base Support System for Highway Signs
Breakaway Poles Adjustment For Ground Slopes

SHA uses two types of ground mounted supports, steel and wood. Wood supports are used for warning, regulatory and smaller guide signs, and steel supports are used for larger installations. Both support types are available as either breakaway or non-breakaway, but anything that is not protected by some form of traffic barrier (see Roadside Hazards section below) should be breakaway unless it's located beyond the clear zone. The Book of Standards shows what modifications are necessary to make both steel and wood supports meet breakaway requirements. The preferred sign location is outside of the clear zone. If this condition cannot be met, the sign should be placed as far from the roadway as possible.

Ground Mounted Selection

There are a number of factors influencing the selection of ground-mounted supports. Wood supports are the most economical, however, breakaway modifications have a significant impact on the allowable sign area. Most standard signs fit on wood supports as given in SHA Standard 812.04. The general process for selecting ground supports is as follows:

1. Based on MUTCD guidelines, select an appropriate location for the sign.

2. Check for existing traffic barrier nearby. If so, use non-breakaway wood or steel. Be careful to ensure that the existing barrier will provide adequate protection in terms of length of need.

3. If no barrier is available and the sign is within the clear zone, check the breakaway wood support charts in the Appendix for the appropriate district.

4. If breakaway wood supports are insufficient or will not work, use the steel support charts in the Appendix to select the appropriate breakaway steel supports.

Standard Signs

Warning, regulatory and route marker signs are installed on breakaway wood supports. These installations have been standardized in the table on SHA Standard 812.04, where the number and size of posts are given for each standard sign blank.

below the ground, from the ground to the bottom of the sign and the sign height.

Wood Supports

Supports are sized based on sign area, mounting height, and post length. When using the design tables for wood supports, post length is measured from the ground line to the center of the sign, as shown in Figure 20. Once the post length "L" is known, the tables in the Appendix can be used to determine the required supports. Note, that the actual length of wood required is the total distance

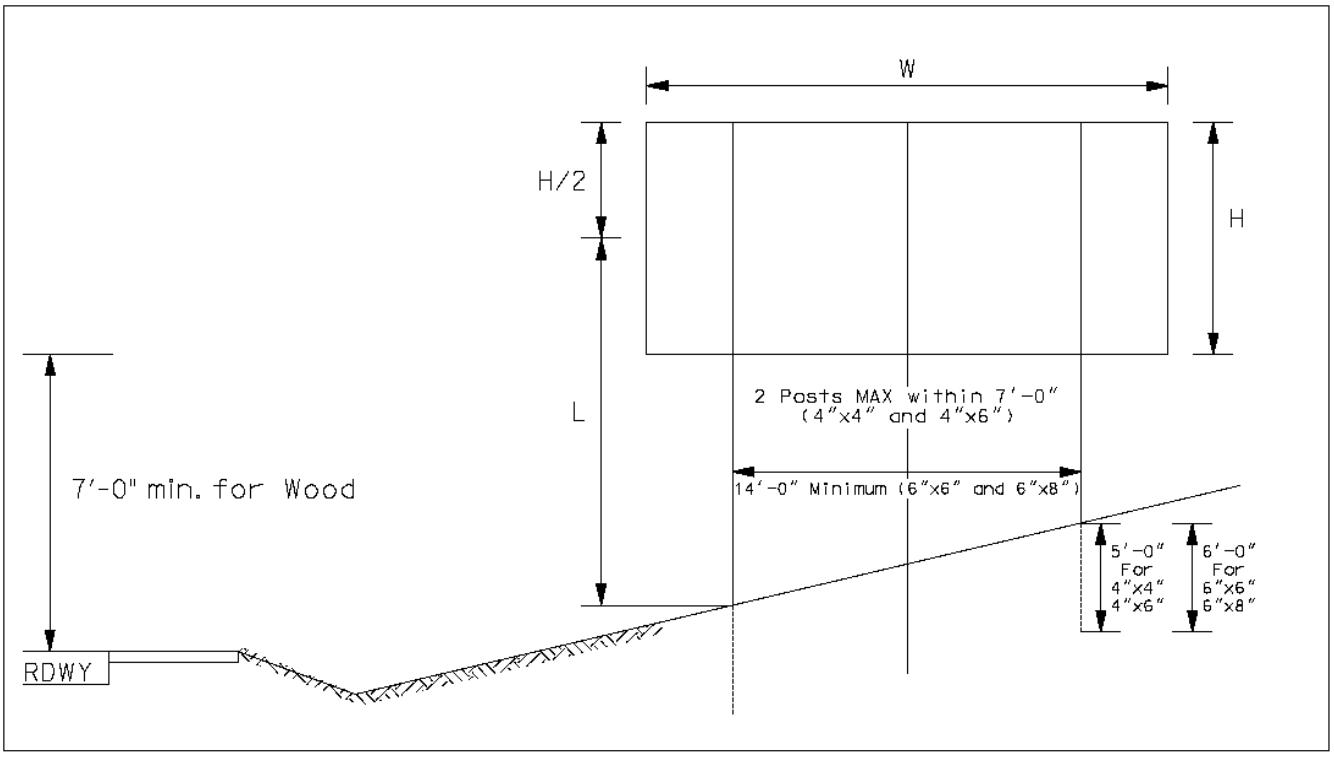


Figure 20 - Wood Support Selection

Steel Supports

Larger ground mounted signs require steel supports. This includes signs that are too large and signs that are too narrow to install on 6x6 or 6x8 wood posts because of the 7-foot spacing requirement. Steel supports are sized in the same manner as wood supports, with the exception that the post length, which for steel is referred to as L_{MAX}, is measured from the ground line to the bottom of the sign. In addition, steel supports must meet the following guidelines:

- Breakaway steel supports require a minimum ground to breakaway hinge distance of 7'-0" in order for the breakaway to operate properly. (See Figure 21)
- On cut-slopes, the farthest edge of the sign should be a minimum of 2'-0" above the ground line. This may force an increase in L_{MAX}.
- Generally avoid installing large signs on a single steel support.

Support Spacing

Sign supports are spaced laterally based on sign width, without regard for material. Standard post clear spacing for two and three post installations are given in Figure 22 and Figure 23. It is important to note, however, that post spacing must be adjusted occasionally to maintain federal breakaway requirements. In order to meet breakaway requirements, supports should be designed to meet the following:

- For steel supports, a single post spaced with a clear distance of 7 feet or more from another post, shall have a weight no greater than 44 pounds per foot. The total weight below the hinges but above the shear plate of the breakaway base, shall be less than 600 pounds (a W6x15 weighs 15 pounds per foot). Also, for multidirectional breakaway, two I-beams shall not be placed within 7'-0", per manufacturer's requirements. Two W6x9 supports for breakaway system "B" are not to be installed. Instead, single square tube posts may be installed if design CD allows for sign widths up to 7'-0". Further, hinge plates are not required for single post installations.

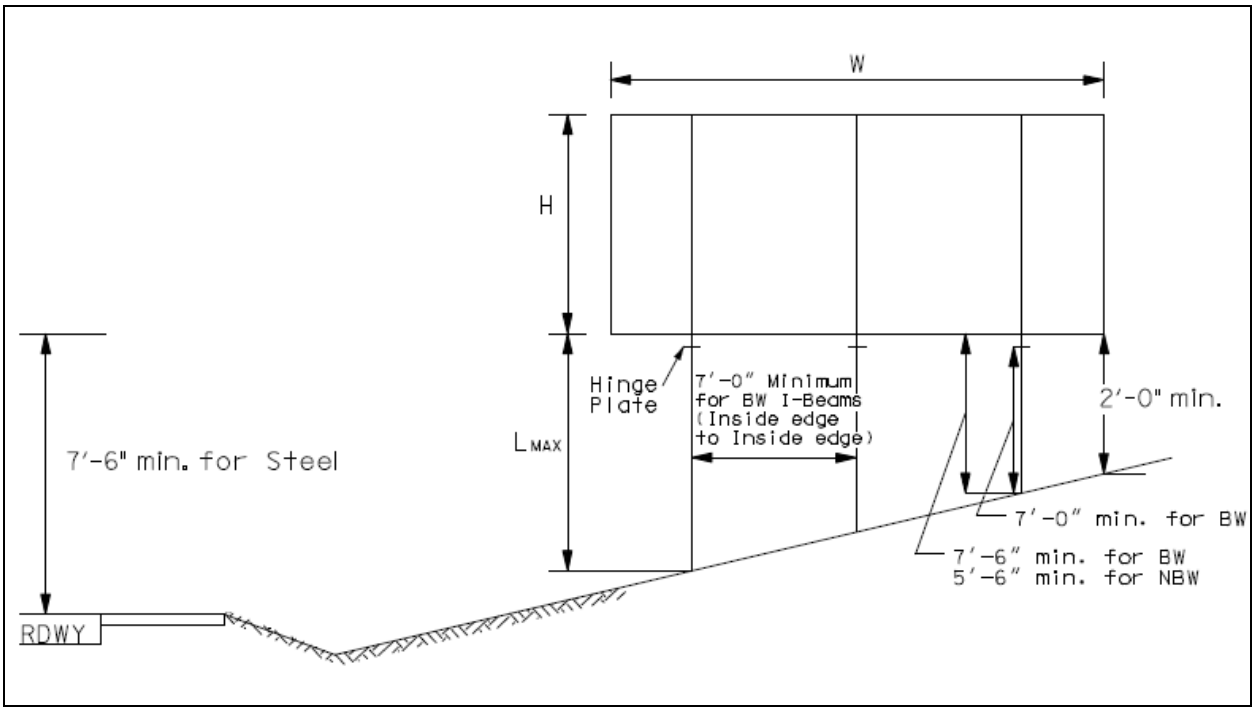


Figure 21 - Steel Support Selection

- All supports 4”x6” or greater shall be drilled per standards.
- No more than two (2) 4”x4” or drilled 4”x6” wood posts are permitted within a 7’-0” distance, regardless of the spacing between the supports.
- The minimum clear spacing (edge of post to edge of post) between all drilled 6”x6” and drilled 6”x8” posts is 7’-0”.
- The hinge plate for breakaway steel supports is located 7’-0” to 7’-2 ¾” above the ground. Supplemental panels must be mounted above the hinge plate, because they will prevent them from operating properly. Where necessary, an angle bracket can be used to hang a single plate, such as a generic service logo, below the hinge plates
- NOTE: Standard sign support spacing is based on the distance from center of support to center of support. Therefore, for each steel support size there is a corresponding minimum sign width to achieve the standard spacing. For example, the minimum sign width for two W6x15 I-beams is 12.5 ft.

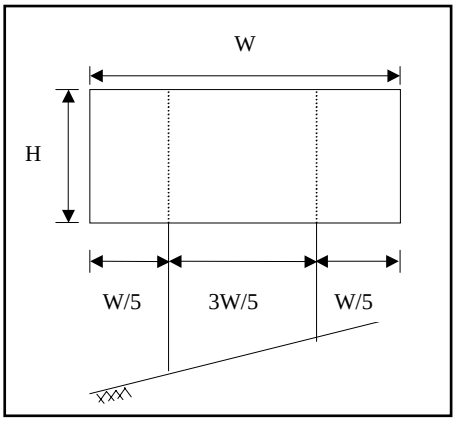


Figure 22 – Standard Sign Support Spacing (Two Supports)

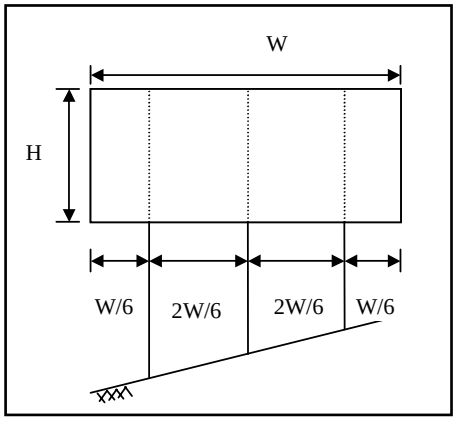


Figure 23 – Standard Sign Support Spacing (Three Supports)

Figure 24 – Breakaway Steel Support

Where problems are encountered, designers should consider the following possibilities:

- Increase the sign width to accommodate breakaway spacing.
- Locate traffic barrier nearby and mount on non-breakaway posts.
- Over-design the supports. (i.e. use steel supports instead of wood).
- For additional options see Structural Design Team.

Supports on Steep Slopes

As defined in the AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals* and the Maryland SHA Standard for Breakaway Poles Adjustment for Ground Slopes, "To avoid undercarriage snagging on convex ground profiles, the top of the footing shall not project more than 4" above any 60" chord aligned perpendicular to the edge of the roadway between a point on the ground surface on one side of the support to a point on the ground surface on the other side of the support." Based on this requirement, a 30" foundation is limited to a 10:1 slope, a 36" foundation is limited to a 12:1 slope, and a 42" foundation is limited to a 13:1 slope. Special considerations have to be made if the slope exceeds these values. The following steps should be taken when this occurs:

1. Determine if there is another suitable location to install the supports where the roadside slope is acceptable and the surrounding terrain is graded, where there is an existing roadside barrier, on an existing structure or similar non-accessible areas.

2. Determine if grading can be performed to obtain a desirable slope. A 10:1 slope is required in advance of the foundation.

3. Consider the use of a modified foundation:

    a. To be used on a maximum 7:1 slope for a 30" foundation, a maximum 8:1 slope for 36" foundations and a maximum 9:1 slope for 42" foundations; a portion of the exposed corner of the footing on the lower slope side can be removed as per MD801.04-01.

    b. To be used on a maximum 3:1 slope for 30" foundations and a maximum 4:1 slope for both 36" and 42" foundations; a modified saw tooth foundation can be used as per MD801.04-02.

4. Determine if new roadside barrier can be installed. As a result, non-breakaway foundations can be used.

5. Redesign the sign to be placed on smaller supports.

Additional steps should be taken to ensure that a breakaway support would fail in a safe and predictable manner when struck by a vehicle. First, it is important to keep in mind that breakaway supports are designed for impact at a bumper height of 20 inches. To maintain this height, signs should not be located near ditches or on a back slope near the drainage channel where vehicles could be funneled into the sign or become airborne. To prevent the chances of an errant vehicle becoming airborne on a fill slope, slopes can be rounded to create a more traversable terrain.

It is also important to determine an appropriate clear zone based on the steep slope. Non-breakaway foundations can be used if they are installed outside of 1.3 times the clear zone.

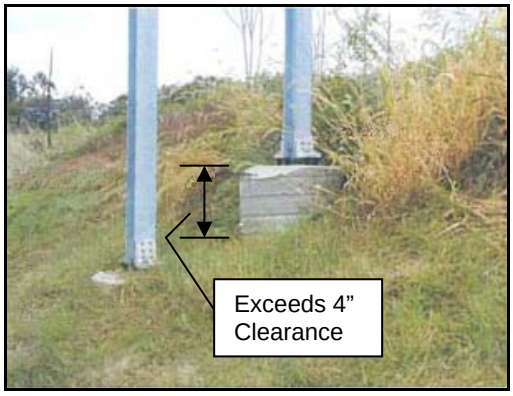


Figure 25 – Improper Supports on Steep Slopes

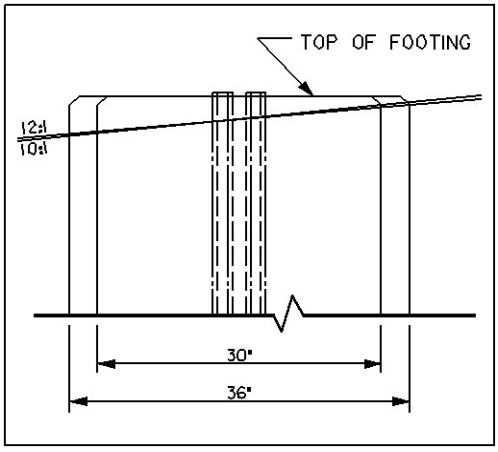


Figure 26 – Slope Limits for Foundations

Other Small Sign Supports

Maryland SHA most commonly uses either wood or steel sign supports for the installation of small signs. A variety of other small support types exist which may be more appropriate for certain situations. These include square tube, round tube, and posts made from alternative materials such as fiberglass. These posts are grouped into two categories, yielding and breakaway, depending on how they meet breakaway requirements. Care should be used when using these types of supports, provide a minimum 7' ground clearance and a minimum 9' clearance to the top of the sign to avoid impact with the windshield of a car.

Yielding supports are designed so that the post will bend at the base when struck by a vehicle, causing the sign to hit the ground and pass underneath the impacting vehicle. They are typically smaller metal supports, such as Square Tube, buried directly in the ground without the use of a separate base. These supports have been known to snag on the underside of cars, pulling the post from the ground.

Breakaway supports are designed to break away at the base when struck by a vehicle. They may be weakened to cause fracture or installed with a separate anchor base and post, which are designed to separate under vehicle impact. This type of support includes some Square Tube installations as well as fiberglass and other post types.

Roadside Hazards

Book of Standards References
Traffic Barrier End Treatments
Concrete Jersey Shape and F Shape Traffic Barrier
Traffic Barrier W Beam and Thrie Beam
Post Mounted Delineators and Barrier Markers

Any objects that are located along the roadside and are not shielded from the driver present a hazard to the motorist. This includes trees, utility poles, sign supports, light supports, and traffic barrier. The AASHTO Roadside Design Guide defines the clear zone concept as an unencumbered roadside recovery area. This distance is typically 30 Feet for a freeway, and may vary based on design speed and traffic volumes. Clear Zone distances can be looked up in the Clear Zone Distances table of the Roadside Design Guide and should be used as a guide in determining what objects need to be protected with barrier.

Any sign supports located within the clear zone of a roadway must either meet federal breakaway requirements or be protected by traffic barrier. For ground-mounted supports, breakaway modifications are detailed in the Book of Standards. All overhead and cantilever installations within the clear zone must be protected by traffic barrier.

Traffic Barrier Design

The design of traffic barrier is outlined in Chapter 5 of the Roadside Design Guide as well as in the Highway Design Division's Guidelines for Traffic Barrier Placement and End Treatment Design. The process generally involves the following steps:

1. **Determine Clear Zone Distance**. This is selected from Table 3.1 of the Roadside Design Guide and/or Table No.1 of the HDD guideline and is based on Design Speed, traffic volumes and roadside slope.

2. **Determine if barrier is warranted**. If the support is within the clear zone and is not breakaway, barrier is required. For ground mounted sign supports, breakaway modifications can be added per the Book of Standards.

3. **Check if existing barrier can be extended to protect the support**.

4. **Determine Lateral Offset of Barrier**. Traffic barrier is typically installed 2 feet from the edge of paved shoulder. When practical, barrier should be installed beyond 12 feet on fill slopes (6:1 or steeper) and as far out as possible on cut slopes. The offset from face of barrier to face of sign support or foundation, typically 8 feet for single post installations, is determined by the dynamic deflection distance of the barrier.

5. **Calculate Length of Need**. This is done using the formulas given in the Roadside Design Guide and the HDD's guideline.

6. **Select an appropriate end treatment**.

When designing traffic barrier, it is important to consider the following:

- It is important to check fixed objects for hazard potential to vehicles traveling in **BOTH** directions. This is especially true for two lane highways and divided highway medians. This will influence choice of end treatment and single versus double face traffic barrier.

- Where traffic in the reverse direction is not a concern, the departure section of traffic barrier typically extends 25 Feet past the sign support and terminates with a Trail End Anchorage (sometimes called a Boxing Glove).

End Treatments

The selection of an appropriate end treatment is a critical component of barrier design. The end treatment is designed to prevent vehicles from spearing, riding on top of the barrier, and rolling over. When selecting an end treatment, the following items should be considered:

- Wherever possible, barrier should be extended and the end buried in the back slope of cut sections, as detailed in the Book of Standards. This is economical and safe and should be considered as a first option for all installations. Typically, an extension of 200 to 300 additional feet is justifiable.

- Many end treatments require roadside grading of 10:1 or flatter. Be sure to check slopes and make the appropriate adjustments.

- It is important to use the correct end treatment for a given situation. Roadside end treatments are not intended to be struck from both front and back, and should not be used in medians where they may be struck from behind by opposing vehicles.

- Enclosed and enveloped treatments are acceptable for median applications.

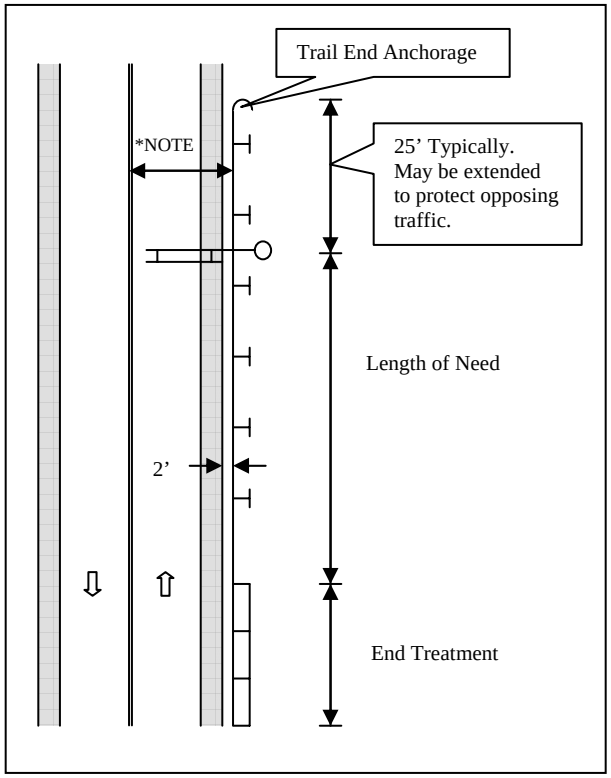


Figure 27 - Typical Traffic Barrier Installation

*NOTE: Check the clear zone distance from opposing direction of travel for undivided highways. Extend barrier and install crash worthy end treatment in place of the trail end anchorage if required.

Delineation Design

Book of Standards References
Post Mounted Delineators
Barrier Markers
Placement of Delineators and Markers
Accel/Decel Lane Delineation
Ramp Delineation

Delineation devices are effective aids for night driving and are to be considered as guidance rather than warning devices. Delineation devices are used along continuous sections of highway,

through locations where there are changes in horizontal alignment, and at pavement width transitions and other potentially hazardous locations. Refer to the SHA Roadway Delineation Policy and Book of Standards for more guidance.

The most common types of roadway delineation devices are: pavement markings, raised pavement markers (RPM's), post, W-beam traffic barrier and barrier wall mounted delineators, chevron alignment signs, and object (hazard) markers. Delineators shall be yellow in color when placed on the left, median-side of the road, and white when placed on the right shoulder-side of the road.

DO NOT FORGET TO ADD DELINEATORS TO A PROJECT. Delineators are paid for per each and are not incidental to the price of the barrier of which they are to be mounted. Therefore, delineators must be included on the plans and as a separate pay item in the estimate.

Pavement Markings, Raised Pavement Markers (RPM's)

See the following section regarding Materials.

Post Mounted Delineators

These delineators consist of flexible posts with reflective sheeting, as well as wood snow stakes and u-channel mounted reflectors. Placement of delineation is based upon roadway classification, need and at locations such as intersections, channelizing islands, spot hazards, horizontal curvature, crossovers, auxiliary and turn lanes, lane drops/merges, narrow bridges, narrowed roadway sections, etc.

Single yellow delineators (or snow stakes) should be provided along the left side of expressway and freeway roadways during winter months. Single white delineators shall be provided along the right side of expressway and freeway roadways if RPMs and/or highway lighting is not present. If RPMs are continuously placed on lane lines and/or highway lighting is present, right side delineators are optional and left side delineators can be removed during non-winter months.

For non-expressway and non-freeway type divided highways, left and right side delineators are optional if RPMs and/or highway lighting are present. In the absence of RPMs and/or highway lighting on these roadways, right side delineation should be placed in rural areas if speeds are 50 mph or greater; left side delineation is optional.

The spacing of delineators along expressway and freeway roadways, when used, shall be 264 feet, except that snow stakes may be spaced at 528 feet. On accel/decel and C/D roads double delineators shall be used with spacing of 100 feet.

Figure 28 – Single Yellow Delineator

Figure 29 – Double White Delineator

W-Beam Traffic Barrier Delineators

W-beam traffic barriers within 6 feet of the shoulder (or road edge if no shoulder is present) along either side of one-way roadways or on the right hand side of two-way roadways shall be provided with delineators, or "rail riders." Along tangent sections in excess of 500 feet in length, the spacing of delineators shall be 100 feet. For tangent sections less than 500 feet in length and curves of less than 1,000-foot radius, the spacing of delineators shall be 50 feet.

Figure 30 – Top Mounted Yellow W-Beam Marker

Barrier Wall Delineation (Barrier Markers)

Barrier walls within 15 feet of the roadway (travel lane) along either side of one way roadways shall be provided with barrier markers. The spacing of barrier markers shall be 100 feet along tangent sections of roadway and 75 or 50 feet along curves having a radius of less than 1000 feet and less than 300', respectively. Double delineators should be used for accel/decel and C/D roads as shown in the photo below.

Figure 31 – Top and Side Mounted White Barrier Wall Markers

Lateral Clearance of Signs

Book of Standards References
Galvanized Steel Beam Sign Post Service Panel Attachments and Vertical and Lateral Clearance

- The lateral clearance from edge of roadway to near edge of sign should be consistent with the roadway type and use.
- Preferred sign location is outside of the clear zone. If this condition cannot be met, the sign should be placed as far from the roadway as possible.
- For freeways and expressways, minimum lateral clearance should be 12 feet minimum and 30 feet maximum from edge of traveled roadway.
- Edge of sign 6 feet from face of W-beam traffic barrier and from edge of shoulder.
- In urban areas, 6 feet preferred minimum and 2 feet minimum from face of curb.

MATERIALS

Reflective Sheeting

The use of reflective sheeting on highway signs improves nighttime visibility and gives drivers more time to read, comprehend and react to roadway information. The actual performance of a given sheeting is a function of sheeting type and sheeting manufacturer.

There are nine (9) types of sheeting used for traffic control. The Standard Sign Book gives sheeting types for all standard signs. Sheeting types are defined by ASTM D-4956 and are given the designations Type I through Type IX. A summary of these types along with descriptions and typical applications is as follows:

Type I: This is an enclosed lens glass-bead sheeting that is commonly referred to as "Engineering Grade". This type of sheeting has the lowest reflective properties of all categories.

Type II: This is another type of enclosed lens glass-bead sheeting commonly referred to as "Super Engineering Grade". Typical applications would be for highway signs, delineators, and Work Zone Traffic Control. This type of sheeting is used on No Parking, No Stopping, No Standing, and Hiker-Biker signs.

Type III: This is an encapsulated glass-bead sheeting commonly referred to as "High Intensity". Typical applications are for highway signs, delineators, and Work Zone Traffic Control. This type of sheeting is Maryland's standard, and is used for all signing except for work zone signs and certain warning and regulatory signs.

Type IV: This is a non-metallic microprismatic sheeting also referred to as "High Intensity". Typical applications would be for highway signs, delineators, and work zone traffic control.

Type V: This is a metallic microprismatic sheeting, also referred to as "Super-High Intensity". This material is typically used on delineators.

Type VI: This is a vinyl microprismatic sheeting typically used for roll-up signs and on traffic cones.

Type VII: Commonly referred to as "Super High Intensity," this non-metallic microprismatic retroreflective sheeting has the highest retroreflective characteristics at long and medium road distances. This is the SHA standard material for work zone signs. Other typical applications for this type of sheeting are permanent highway signing, construction zone devices, and delineators.

Type VIII: This non-metallic microprismatic retroreflective element material is commonly referred to as "Super High Intensity". It is a retroreflective sheeting having the highest retroreflective characteristics at long and medium road distances. Applications for this material are permanent highway signing, construction zone devices, and delineators; however, this type of sheeting is typically not used by SHA.

Type IX: This non-metallic microprismatic retroreflective element material is commonly referred to as "Very High Intensity". It is a retroreflective sheeting having the highest retroreflective characteristics at short road distances. . This type of sheeting is used for Stop, Yield, Chevrons, Turn Warning, Do Not Enter, and Wrong Way signs.

Prismatic Sheeting: This is a high performance sheeting offering excellent visibility at wide viewing angles that is utilized in Type IV thru Type IX sheeting. Trade names for this type of sheeting include Diamond Grade, Long Distance Performance (LDP), which is used for Work Zone signs, and Visual Impact Performance (VIP), which is used for

Turn Warning, Do Not Enter, and Wrong Way signs.

Color

Sign color is dictated by the guidelines specified in the MUTCD and the Maryland Supplement to the MUTCD for all signs including but not limited to regulatory, warning, guide, services, recreational, and emergency. Recent updates to State standards include the use of Fluorescent Yellow for all warning messages and Fluorescent Yellow Green for school zone related signing and school crosswalks signs.

Night Driving

The mechanics of nighttime visibility differ somewhat from daytime conditions in that the available light levels are a function of vehicle headlights, roadway lighting, sign lighting, ambient lighting from surrounding land uses, and sign sheeting material. The interaction of light between vehicle headlight, sign (or sign sheeting) and driver is referred to as retroreflection. In American Society for Testing and Materials (ASTM) standard E-808, retroreflection is defined as "reflection in which reflected rays are preferentially returned in directions close to the opposite of the direction of the incident rays". In other words, light from vehicular headlights is intentionally directed back at the approaching vehicle. Two of the primary measures of light and sheeting performance, called Observation Angle and Entrance Angle, are depicted in Figures 32 and 33.

Both Observation Angle and Entrance Angle are used to determine the performance criteria for sign sheeting. Each point along the roadway, for example 250 Feet in advance of a warning sign, corresponds to an Entrance and Observation Angle Pair. The performance of sign sheeting is measured by taking luminance measurements at standard angles (typically Observation Angles of 0.2^o or 0.5^o and Entrance Angles of -4^o and 30^o). When these criteria are exceeded under driving conditions, the sign may appear either "dull" or completely black depending on the sheeting type (Type I through IX), manufacturer, and condition. Some situations where this is of concern include Keep Right (R4-7) signs, which are commonly placed at a 15^o angle and Added Lane (W4-3), or Merge (W4-1) signs at the end of a loop ramp. In both of these situations, the angle of approaching vehicles may reduce nighttime visibility of these signs for some approaches.

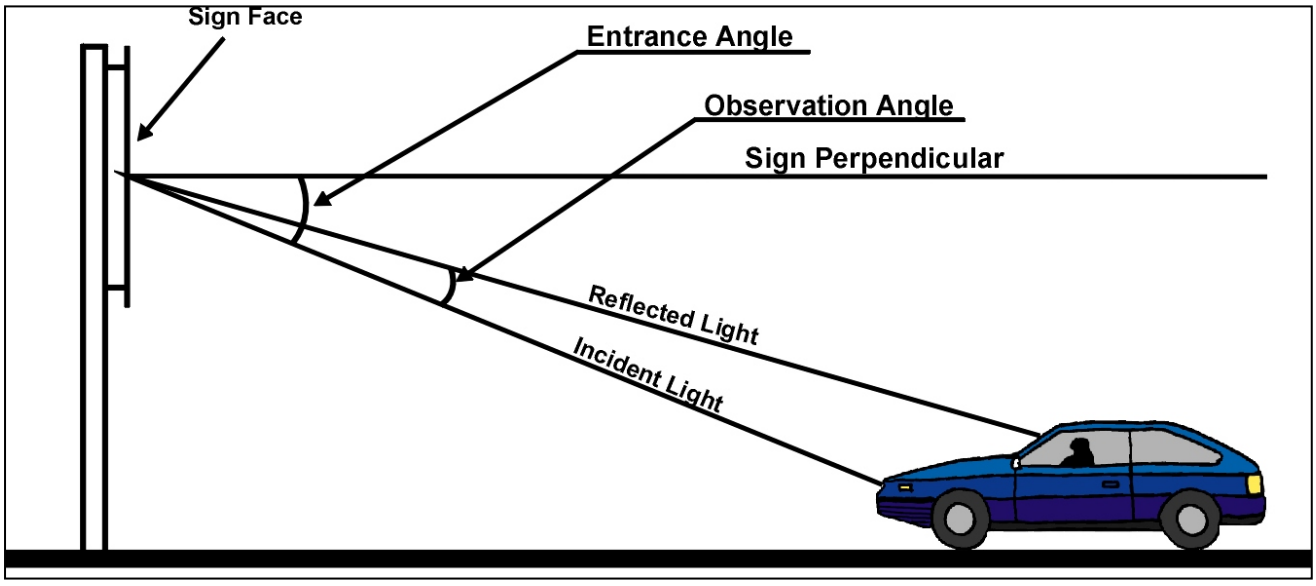


Figure 32 - Observation and Entrance Angle

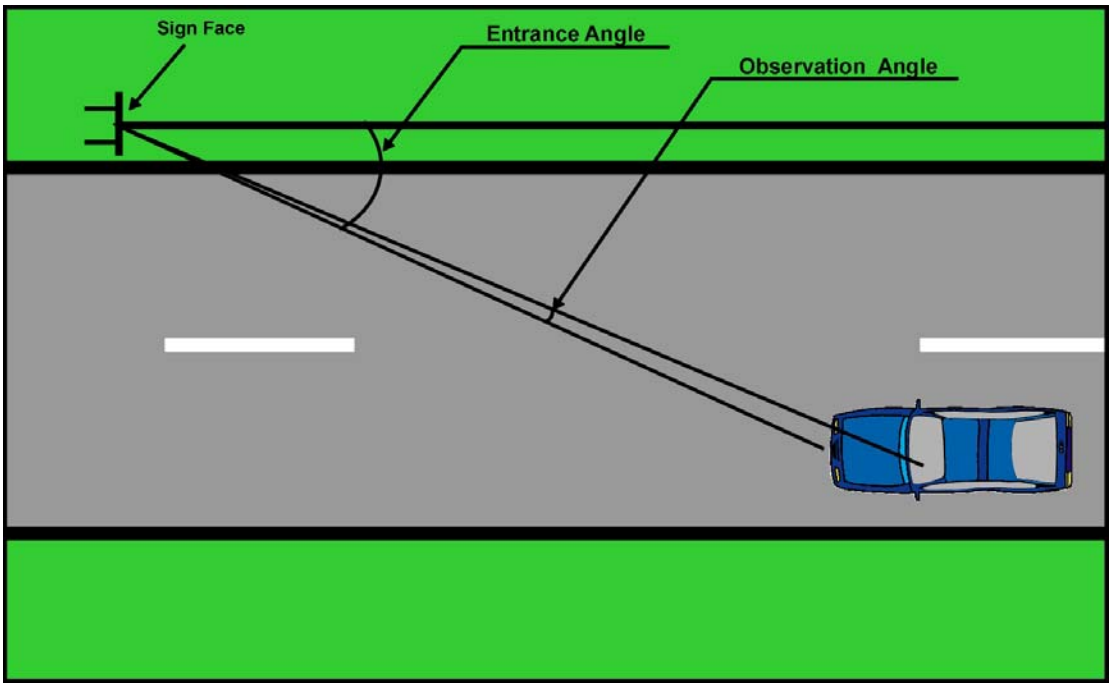


Figure 33 - Observation and Entrance Angle

Aluminum Backing

Signs are constructed as reflective sheeting on an aluminum backing material. In the case of standard warning and regulatory signs, the legend is typically silk screened or "inked" onto a background consisting of reflective sheeting mounted on sheet aluminum. Maryland uses two types of aluminum backing material for sign construction, depending on the purpose:

Sheet Aluminum:

Sheet aluminum is used for standard warning and regulatory signs, and for most guide signs with a surface area less than 40 square feet. It is also used for temporary signs that are mounted on skids or wood posts and for overlaying existing signs. The 40 square foot criteria is a rule of thumb based on support type and manufacturing considerations. The primary consideration is that sheet aluminum cannot be mounted on steel supports using Maryland Standards; therefore any sign requiring steel supports must be made from extruded aluminum.

Extruded Aluminum:

Extruded aluminum is used for all large guide signs and non-standard warning and regulatory signs over 40 square feet. Extruded panels are available in 6 inch and 12 inch heights that are cut to width and bolted together to build the correct sign height. For signs constructed by the SHA Sign Shop, heights should be designed to even multiples of 12", as 6" panels are not kept in stock. Details regarding the construction and dimensions of extruded panels are given in the book of standards.

Pavement Markings

Pavement markings covered in this chapter include lines and markings applied to the pavement, raised pavement markers and special pavement treatments such as rumble strips, tubular markers, contrast markings and colored raised pavement markers. The design criteria and standardization of application are covered in the MUTCD and the Maryland Supplement To The MUTCD (MSMUTCD). Pavement marking material selection is specified in the MSHA Pavement Marking Policy.

The traveled portions of a highway are defined by pavement markings such as centerlines, lane lines, edge lines, channelizing lines, etc. Typical application details are included in the MUTCD and the MSMUTCD. On state highways the approval of the Asst. District Engineer-Traffic or the Director of Office of Traffic & Safety is required to make any modifications to pavement markings that would change the functional operation of the roadway.

Materials:

Generally all markings applied on state highways are reflectorized. The black markings typically used for covering existing markings and as contrast markings are non-reflectorized. The MSMUTCD and the MSHA Pavement Marking Policy dictate the widths and patterns of pavement markings. Pavement markings come in various compositions and each have different characteristics, costs, application methods, durability and maintenance. Following is an outline describing the different typical permanent pavement marking material:

Waterborne Paint: Waterborne paints are typically used as permanent markings for conventional roadways with low ADT. They may also be used for re-striping over existing longitudinal pavement marking materials. The service life of waterborne paints is 6 months to 1 year however longer service lives have been experienced in some areas. Thermoplastic: Thermoplastic pavement markings are durable markings applied primarily on new asphalt surfaces. They may be applied for all longitudinal lines along high ADT roadways and for multi-lane or divided highways other than Interstates/Freeways with low ADT. The service life of thermoplastic markings is 1.5 to 3 years. Specially formulated thermo may be applied as a thin retrace over existing pavement markings. The service life of the retrace is 1.5 to 2 years with the typical cost reduced.

Epoxy: Epoxy pavement markings are durable markings applied on new asphalt. They may be applied for all longitudinal lines along high ADT roadways and for multi-lane or divided highways other than Interstates/Freeways with low ADT. The service life of epoxy markings is 1 to 3 years. This may be the material of choice where sections of the roadway have both concrete and asphalt pavements.

Preformed Patterned Tape: Patterned tape markings are durable markings in-laid in new asphalt surfaces and applied with a primer on Portland Cement Concrete surfaces. They are applied for all longitudinal lines on expressways, freeways and multi-lane or divided highways other than Interstates/Freeways with high ADT. When used on Portland Cement Concrete, contrast patterned tape is applied for lane lines for an increased visibility. The service life of patterned tapes is 4 to 6 years. These markings typically have a high initial cost. However, their greater durability and visibility compared to other durable markings make them desirable for high volume freeway applications where retracing is expensive and is very disruptive to traffic flow.

Preformed Heat Applied Thermoplastic: Preformed heat applied thermoplastic markings are applied using a propane torch for transverse markings, raised rumble strips, and for arrows, letters, numbers and symbols. These markings can be applied on pavement surfaces above freezing temperature. The material can be fused onto itself with a propane torch for routine maintenance. This material provides very good durability where cross shear resistance is required for stop line and crosswalk applications. The typical cost for the material is about 25% more than preformed tapes.

Permanent Preformed Pavement Marking Tape: Preformed tapes are made from plastic and installed using a primer adhesive. They are not as durable as preformed thermoplastic. They are used primarily for short longitudinal line applications, transverse markings for low ADT roadways and for arrows, letters, numbers and symbols. High-end tape materials using ceramic particles provide the same performance characteristics as preformed thermoplastic but are proprietary materials.

Plowable Raised Pavement Markers (RPMs): Plowable markers supplement lane lines, and channelizing lines approaching gore areas. They delineate the lanes during inclement weather and under low ambient light conditions. The plowable markers typically used along state highways are

raised type on a cast iron casting. The casting is epoxied in a grooved pavement slot to provide resistance to being removed by snow plowing.

Figure 34 – Raised Pavement Marker

Recessed Raised Pavement Markers (RRPMs): Recessed markers also supplement lane lines, and channelizing lines approaching gore areas. They delineate the lanes during inclement weather and under low ambient light conditions. Recessed pavement markers are typically installed in the heavily plowed western area of the state (All of District 6). The installation consists of grooving the pavement surface longitudinally and installing a reflector unit within the groove. An epoxy adhesive (rapid setting, low viscosity, water resistant type) shall be used to hold the reflector unit in place.

Figure 35 – Recessed Raised Pavement Marker

Special Pavement Treatments:

Rumble Strips: Rumble strips are bands of raised material or indentations formed or grooved in the traveled way or shoulders. Rumble strips call the motorist's attention to standard warning or regulatory devices or otherwise alert drivers by transmitting sound and vibration through the vehicle. Locations where rumble strips have been used include shoulders along freeways, ends of freeways, approaches to roundabouts and in advance of sharp curves where other devices have not provided a significant reduction in off the road accidents.

Traveled way rumble strips are ¾ inch or less in height if raised or 1 inch or less in depth if indented and generally extend across the travel lanes. There are significant disadvantages to the use of rumble strips across travel lanes. These include:

- An abrupt rise or depression in the roadway can present problems to bicyclists and motorcyclists. Provisions should be made for cyclists to traverse through or around rumble strips.
- Nearby residents may be subjected to continuous noise and vibration in the residential areas prompting citizen's complaints.
- All motorists are subjected to the noise and vibration where only a few are in need of the affect to be alerted.
- Motorists may make unusual maneuvers to avoid rumble strips.

Shoulder rumble strips are usually 1 inch or less in depth and less than 3 feet wide indented along the roadway shoulder. They can be grooves rolled into the hot mix as part of a resurfacing project. The use of shoulder rumble strips may reduce drift-off-road accidents along freeways. They are not suitable as a riding surface for bicycles. Where bicycles are permitted adequate (4'-5') of clear shoulder width should be provided between the rumble strips and the outer edge of the shoulder.

Contrast Treatment: Contrast treatment of the pavement surface is used to provide lane guidance

information to motorists. Typically for concrete pavements, the shoulders are built with a darker color than the travel lanes. Similarly, black non-reflective stripes can supplement lane lines to enhance visibility of the markings. These contrast treatments are typically used for lightly textured pavement surfaces and relieve the washout effect of the markings during dusk, dawn and under direct sunlight. Contrasting black markings should be the same width and placed longitudinally preceding the lane markings.