INDIANA DEPARTMENT OF TRANSPORTATION

Driving Indiana's Economic Growth

Design Memorandum No. 08-08
Technical Advisory

May 16, 2008

TO: **All Design, Operations, and District Personnel, and Consultants**

FROM: ***/s/ Richard L. VanCleave***
Richard L. VanCleave
Design Policy Engineer
Office of Roadway Engineering Services

SUBJECT: **High-Tension Cable Barrier System**

ADDS: ***Indiana Design Manual*** **Sections 17-3.14 and 49-4.06**

EFFECTIVE: **September 4, 2008, Letting**

A. Introduction

A High-Tension Cable Barrier System (CBS) should be considered in the median of a high-speed roadway where fatal median-crossover crashes have been reported or are anticipated.

B. Warrants

A CBS is a flexible median barrier with a larger lateral deflection during a vehicle impact than a semi-flexible barrier such as a double-faced W-beam or thrie-beam guardrail. The lateral deflection of a CBS is 6.6 ft to 9.2 ft (2 to 2.8 m). A CBS may be used in a median of at least 36 ft (11 m) width if the barrier is located close to the center of the median. It should not be located in a ditch bottom or flow line, so as to avoid potential drainage problems.

A National Cooperative Highway Research Program *Report 350* Test Level 4 (TL-4) CBS, if warranted, should be specified for an Interstate route. A TL-3 CBS, if warranted, should be specified for a non-Interstate route.

See the INDOT *Standard Drawings* for information on locating a CBS in a median which includes a bridge support, existing concrete barrier or guardrail, impact attenuator, or other safety hardware.

C. Advantages

1. A CBS can be installed in an existing median with a minimum of site work as one of the most cost-effective choices of median barrier.

   The cost of a CBS is almost the same as that of double-faced W-beam guardrail. Compared to double-faced W-beam guardrail, the repairs to a CBS are relatively simple, faster, and should not require driving posts or replacing rails.

2. Vehicle containment and redirection are effective over a wide range of vehicle sizes and installation conditions. Deceleration forces upon vehicle occupants are low.

3. A vehicle impact results in less damage to the vehicle and barrier, and results in less injury to vehicle occupants. The cable often remains at the proper height after an impact that damages several posts. A CBS can sustain multiple impacts and still remain effective.

4. The posts are installed in sleeves in the ground to facilitate removal and replacement.

5. Its open design does not generate drifting of sand or snow on or alongside the roadway.

6. Once maintenance crews have developed the skills to rapidly repair a CBS, maintenance costs can be reduced.

D. Disadvantages

1. A comparatively long length of CBS is non-functional, and is therefore in need of repair following a vehicle impact.

2. A large clear area is needed behind the barrier to accommodate the design lateral deflection distance.

3. A CBS has reduced effectiveness on the inside of a horizontal curve.

4. There is little installation tolerance in obtaining the specified barrier height.

5. Maintenance is often required.

E. Design Considerations

1. Deflection. A CBS redirects an impacting vehicle after sufficient tension is developed in the cable, with the posts in the impact area offering only slight resistance. A deflection distance of 10 ft (3 m) should be provided. The clearance between the cable and the opposing traffic's median edge of travel lane should be at least 10 ft (3 m).

   The use of a CBS where it is likely to be impacted frequently, such as on the outside of a sharp horizontal curve, is not recommended.

2. Slope Requirement. A CBS should not be constructed on a slope steeper than 6:1. The approach should be relatively flat, without a curb or a ditch.

3. Transverse Location in Median. The post offset from the centerline of a median V ditch should desirably be at least 8 ft (2.4 m), or minimally within 1 ft (0.3 m) of the centerline. The post offset from the edge of a median flat-ditch bottom should desirably be at least 8 ft (2.4 m) or minimally within 1 ft (0.3 m) of the ditch line. The post offset from the edge of paved shoulder should desirably be at least 12 ft (3.6 m) to avoid nuisance impacts. The desirable conditions described above require a minimum medium width of 48 to 52 ft (14.5 to 15.8 m) for proper placement of a CBS assuming that the paved shoulder and flat-bottom ditch widths are each 4 ft (1.2 m).

4. Line Post and Anchor Foundations. Each end of a CBS run must be anchored. The designer should initially prepare a layout plan and request a geotechnical investigation of soil conditions for approximate locations of the safety terminals and representative locations of the intermediate line-post foundations. The geotechnical-investigation findings should be incorporated into the contract documents. End-anchor and line-post-foundation sizes are determined by soil classification, condition, temperature extremes, etc.

5. Line-Post-Foundation Size. The foundation for an intermediate line post should have a minimum depth of 3.5 ft (1.1 m) and a minimum diameter of 14 in. (350 mm), with the foundation top flush with the ground level.

6. CBS Run Length. The recommended minimum run length is 1000 ft (300 m). The recommended maximum run length is 10,000 ft (3000 m) between anchors.

   The number of median crossovers for emergency vehicles should correspond to that required with a concrete or thrie-beam median barrier.

7. Clearance to Rigid Obstacle. The lateral clearance to a rigid obstacle such as a bridge pier, sign support, utility pole, tree, etc., should be 10 ft (3 m).

8. Placing CBS in the Vicinity of Another Barrier. If the side slopes are not steeper than 6:1 and another barrier is parallel to the roadway, the CBS can be tapered on a 50:1 or flatter taper. The end terminal should be placed behind the other barrier. A minimum lateral clearance of 10 ft (3 m) from the end treatment of the parallel barrier is recommended. If the other barrier is flared, the CBS may be connected to W-beam or thrie-beam guardrail using an attachment to the guardrail end terminal that is available from the manufacturer.

9. Placing CBS in Vicinity of Inlet or Dike. If a drainage inlet, dike, etc., is encountered and cannot be adjusted to the proper grade, the CBS alignment should be gradually transitioned around it to ensure that the correct cable height above the ground line will be maintained. The horizontal transition should be on a taper of 50:1 or flatter.

10 CBS at Crossover. For a CBS termination at a median crossover, the CBS end terminal (end anchor) should be located beyond the tangent points of the crossover, preferably 3 to 5 ft (1 to 1.5 m) from the tangent point.

11 Changing Offset of CBS in a Median from Being Closer to One Roadway to Being Closer to the Opposing-Traffic Roadway. If a CBS requires a change of lateral offset, the end anchors of the CBS should be overlapped for the minimum distance between the anchors in each direction as described below. The minimum distance for the anchor located at the incoming end should be at least the runout length, L_R, used for calculating the guardrail length of need. An overlap distance of 500 ft (150 m) should be used for a median width up to 60 ft (18 m), a design speed of 70 mph (110 km/h), and AADT > 6000. For the anchor located at the outgoing end, the minimum overlap distance should be two times the anchor length. Changing the lateral offset of a CBS at the anchor located at the outgoing end is the preferable method.

12 Locating the End Anchor of CBS in the Vicinity of Impact Attenuator. If a CBS is terminated in the vicinity of an impact attenuator, the entire end-anchor length should be located at the distance shown on the INDOT *Standard Drawings* behind and clear of the concrete attenuator pad.

F. Contract-Documents Requirements

1. Plans. The longitudinal and transverse CBS locations should be shown on the plans. A geotechnical investigation of the soil conditions will be required for the approximate locations of the safety terminal and the representative locations of the intermediate line-post foundations at the respective sites throughout the entire length of the proposed barrier installation. The geotechnical-investigation results should be incorporated into the contract documents.

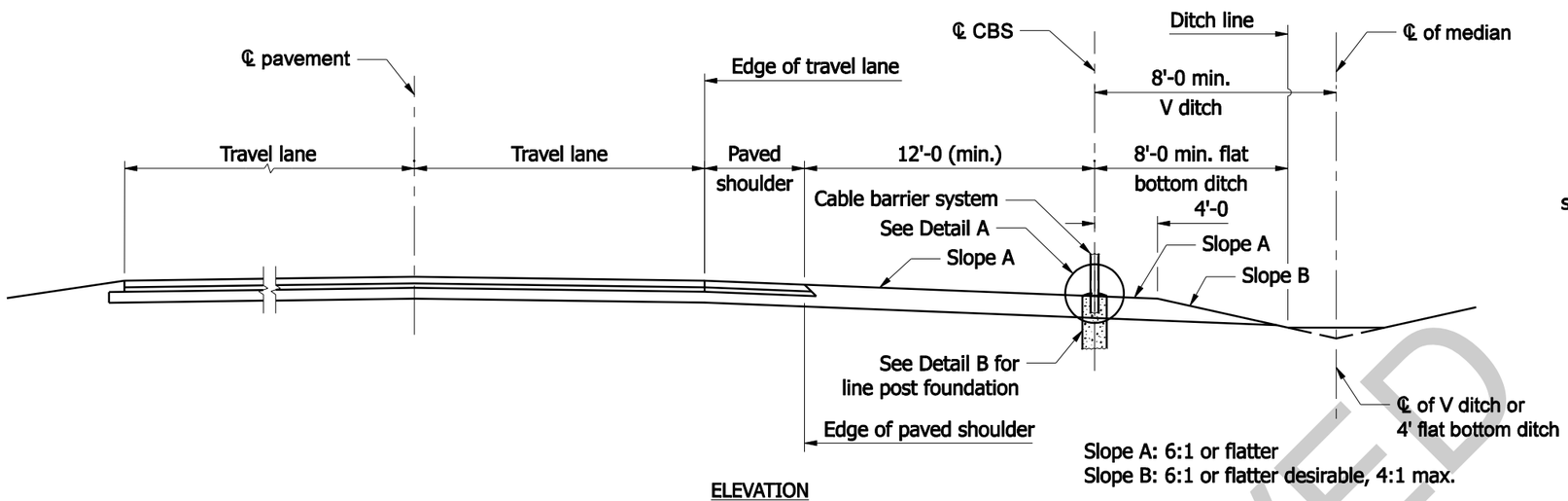
2. Quantities. The length of each end terminal should be included in the quantities for CBS. A safety terminal should be included for each end of each CBS run. One spare-parts set should be included. The plans should show all necessary linear-grading work to be done in the median. The quantities should be included in a pay item for linear grading. A traffic-control plan should be included, along with a pay item for maintaining traffic.

3. Recurring Special Provision and Recurring Plan Detail. Recurring Special Provision 627-R-546 and Recurring Plan Detail 627-R-546d, attached hereto, should be called for beginning with the July 9, 2008, letting, and through the August 2010, letting.

   The recurring special provision must be reviewed to verify that it is adequate to provide for the installation of a CBS. If necessary, a unique special provision must be written to incorporate contract-specific requirements.

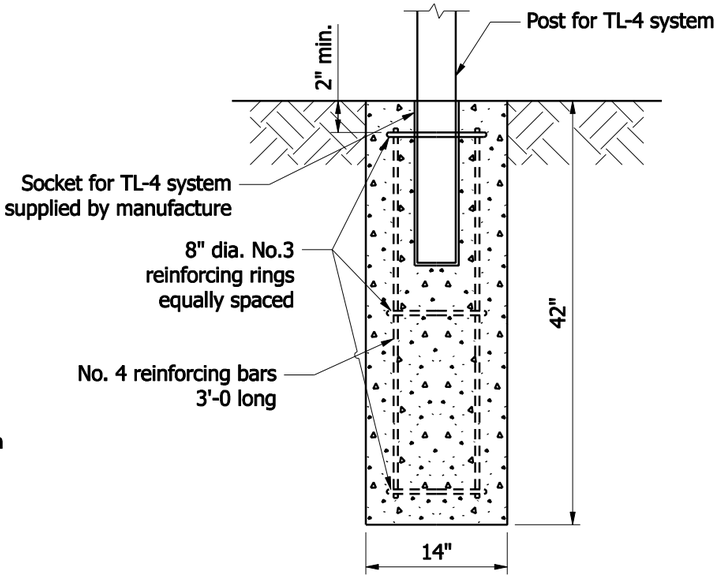
4. Pay Items. The code numbers, pay items, and pay units are as follows:

627-09326	Cable Barrier System, Type TL-3	LFT (m)
627-09330	Safety Terminal, Type TL-3	Each
627-09328	Cable Barrier System, Type TL-3, Spare Parts	Each
627-09327	Cable Barrier System, TL- 4	LFT (m)
627-09331	Safety Terminal, TL- 4	Each
627-09329	Cable Barrier System, TL-4, Spare Parts	Each



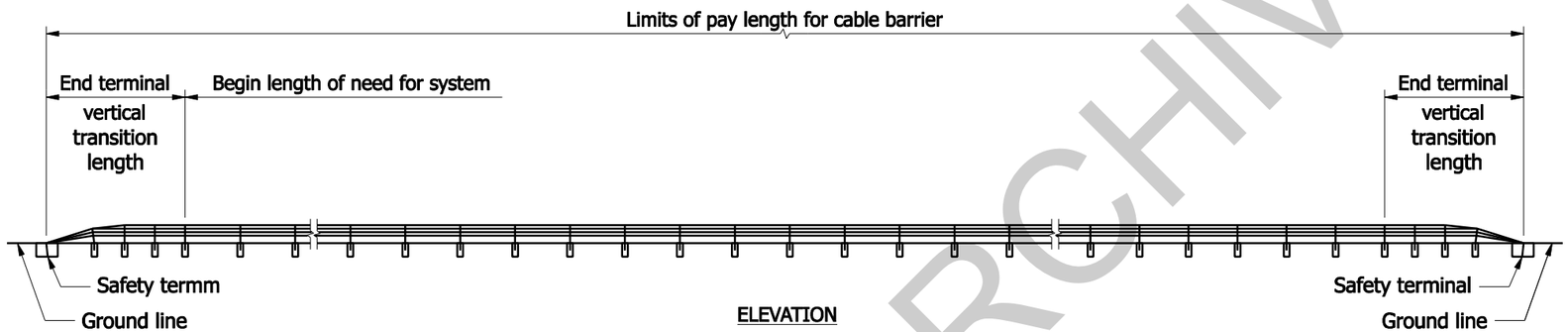
ELEVATION

LOCATION OF CBS IN MEDIAN



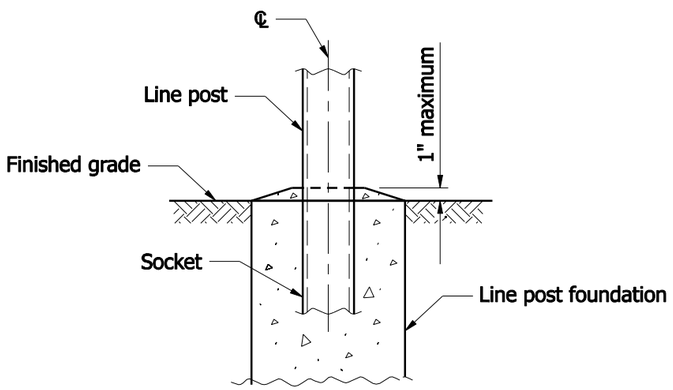
DETAIL B

MINIMUM SIZE AND MINIMUM REQUIRED REINFORCEMENT FOR LINE POST FOUNDATION FOR CBS TL-4 SYSTEM



ELEVATION

TYPICAL CBS LAYOUT



DETAIL A

NOTES:

1. CBS: Cable Barrier System.
2. Cable barrier placement detail shown on this drawing is applicable to median with a maximum paved shoulder width of 4 ft. and the following median widths:
   a. A minimum median width of 48 ft. for a V ditch
   b. A minimum median width of 52 ft. for a 4 ft. wide flat bottom ditch.
3. CBS horizontal alignment transitions shall be made on a 50:1 or flatter taper.

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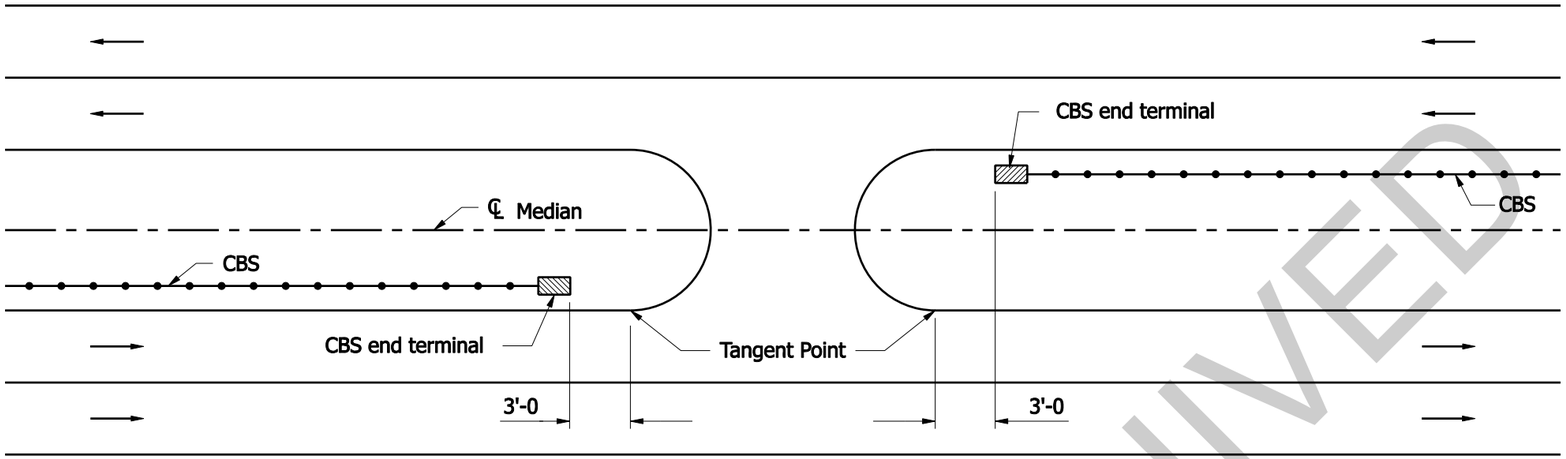
LOCATION OF CBS IN MEDIAN

1-01-09



LOCATION OF CBS END TERMINAL AT MEDIAN CROSSOVER

NOTES:

1. CBS: Cable Barrier System.
2. For location of CBS, See Sheet 1 of 6.

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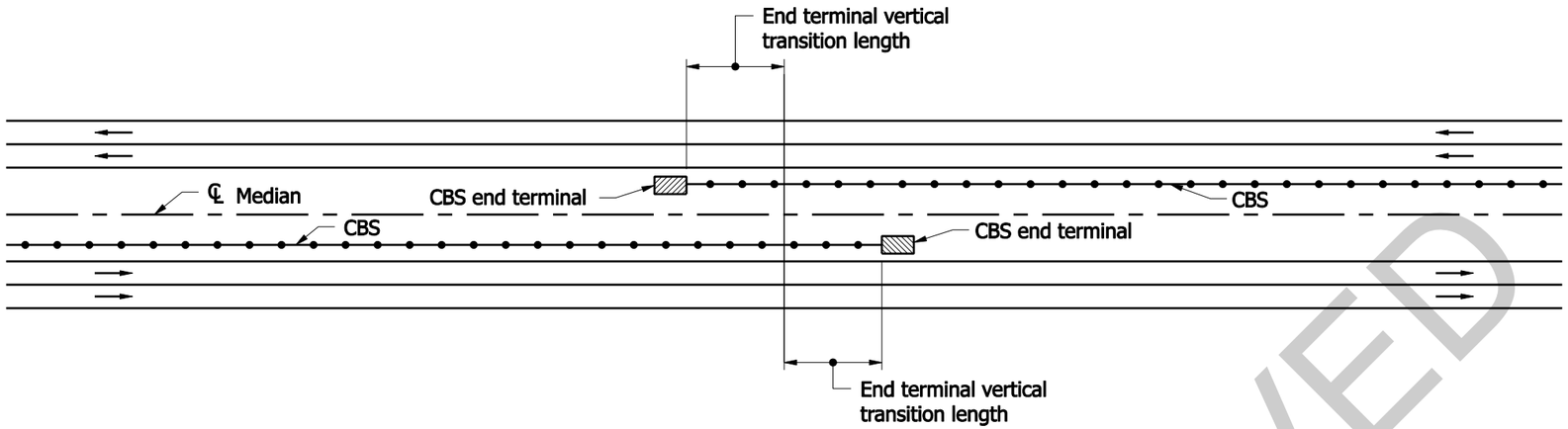
LOCATION OF CBS END TERMINAL
AT MEDIAN CROSSOVER

1-01-08

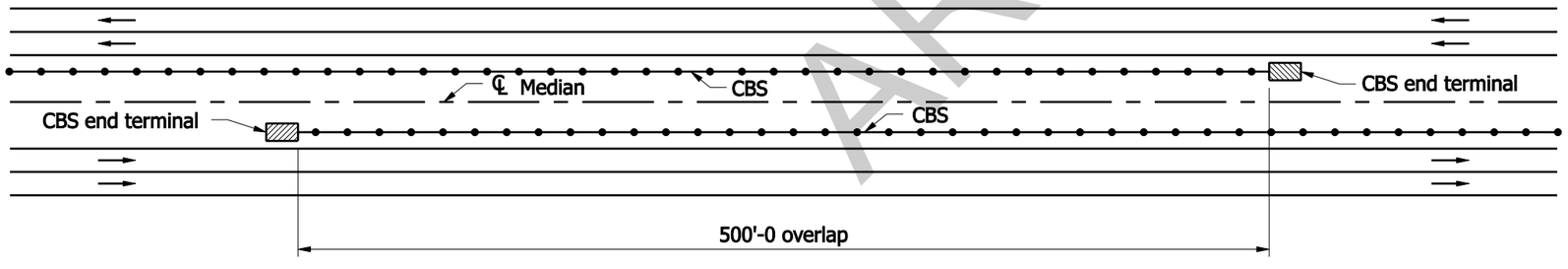
E 627-R-546d 2 of 6

NOTES:

1. CBS: Cable Barrier System.
2. For location of CBS, See Sheet 1 of 6.



CHANGING LOCATION OF CBS TRAFFIC SIDE TO OPPOSITE SIDE OF MEDIAN (DESIRABLE)



CHANGING LOCATION OF CBS TRAFFIC SIDE TO OPPOSITE SIDE OF MEDIAN (ALTERNATE)

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CHANGING LOCATION OF CBS TRAFFIC SIDE TO OPPOSITE SIDE OF MEDIAN

1-01-08

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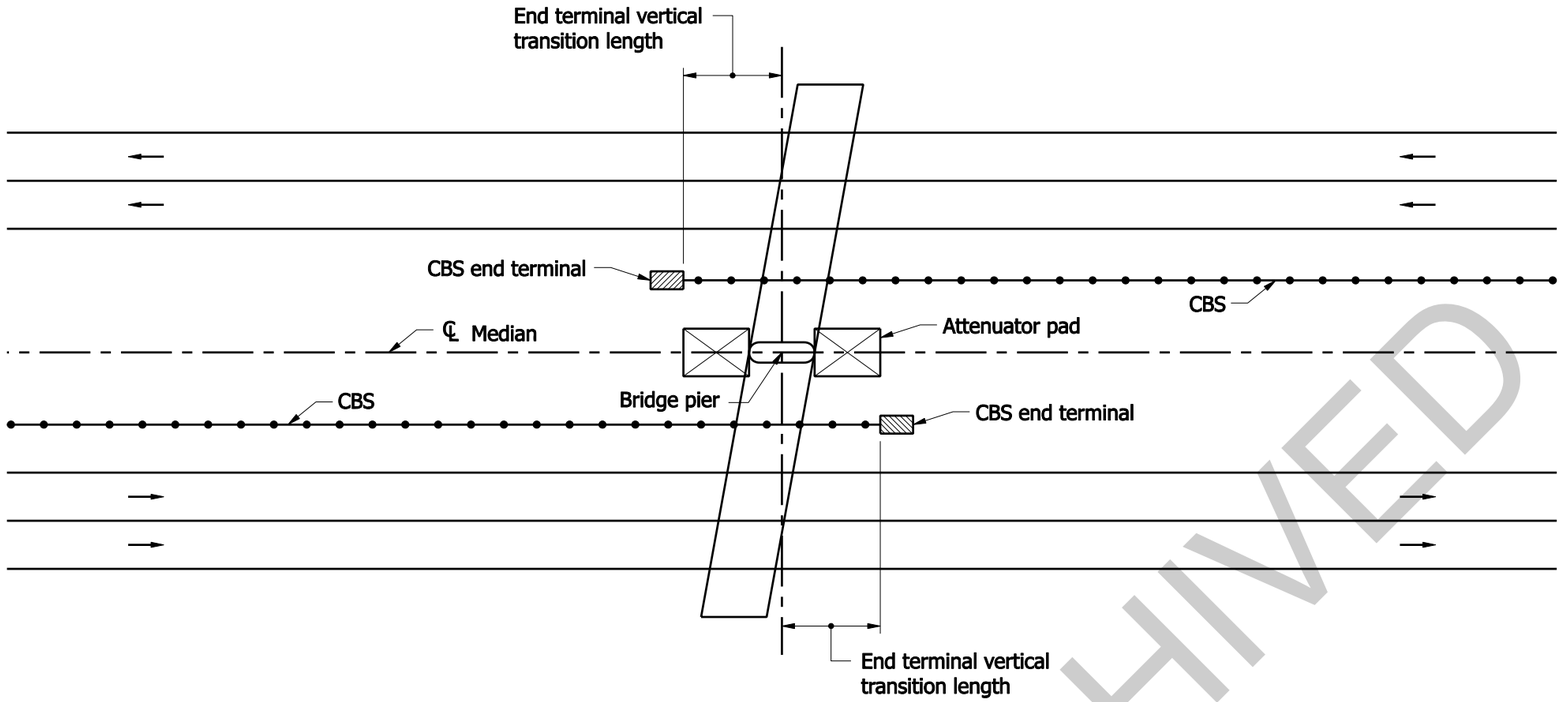
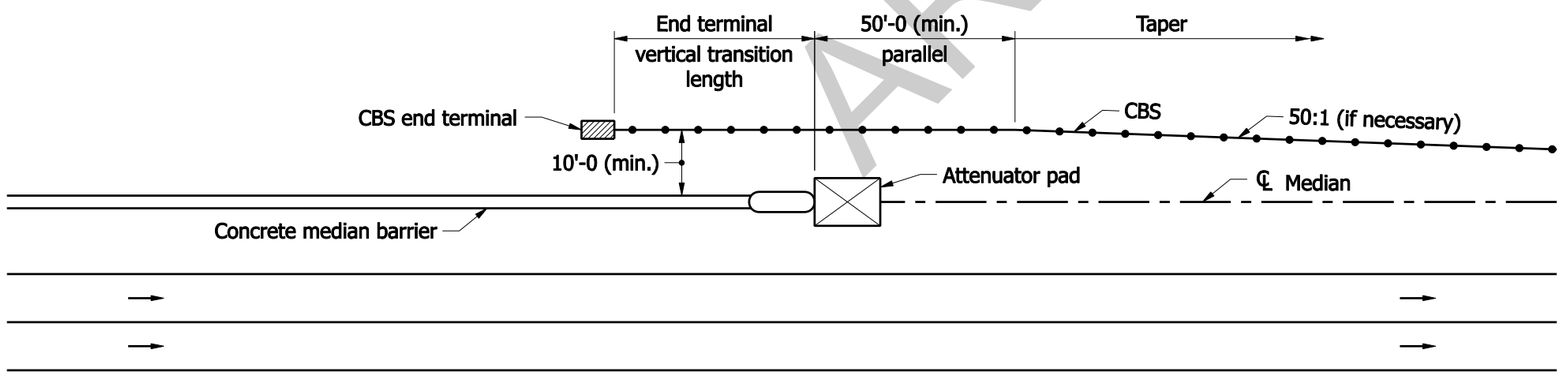


CBS AT MEDIAN BRIDGE PIER WITH ATTENUATOR



CBS AT CONCRETE MEDIAN BARRIER WITH ATTENUATOR

NOTES:

1. CBS: Cable Barrier System.
2. For location of CBS, See Sheet 1 of 6.

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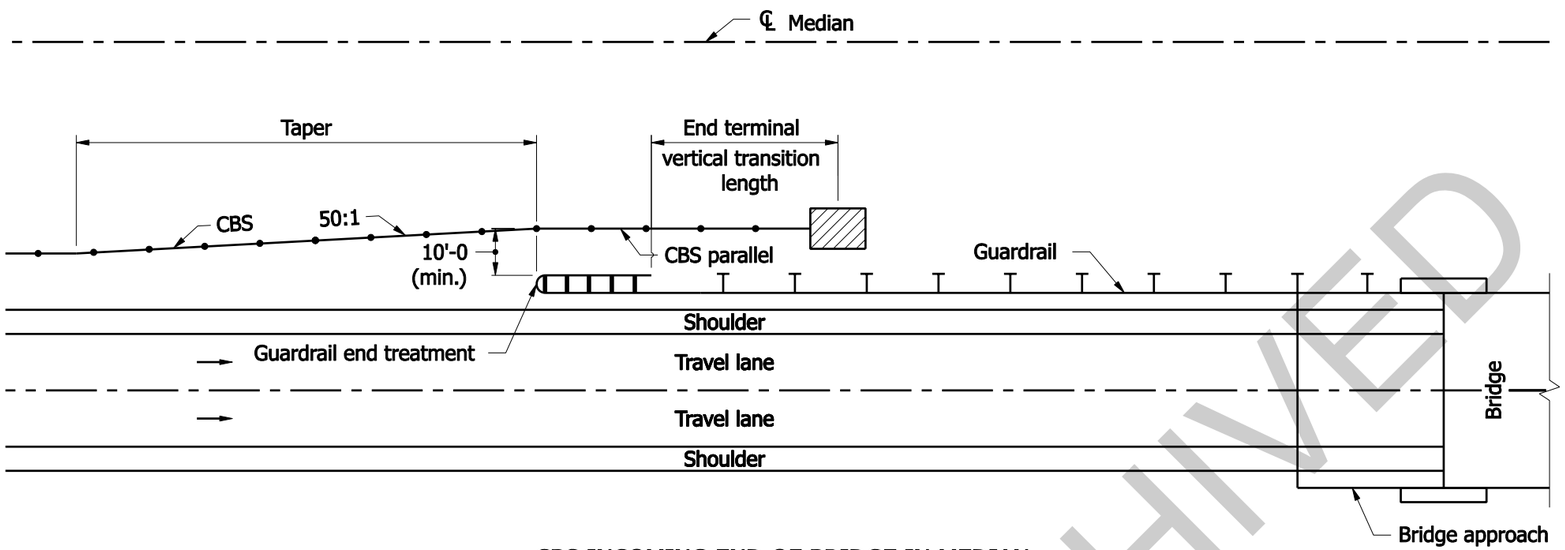
CBS AT MEDIAN BRIDGE PIER

1-01-08

E 627-R-546d 4 of 6



CBS INCOMING END OF BRIDGE IN MEDIAN

NOTES:

1. CBS: Cable Barrier System.
2. For location of CBS, See Sheet 1 of 6.

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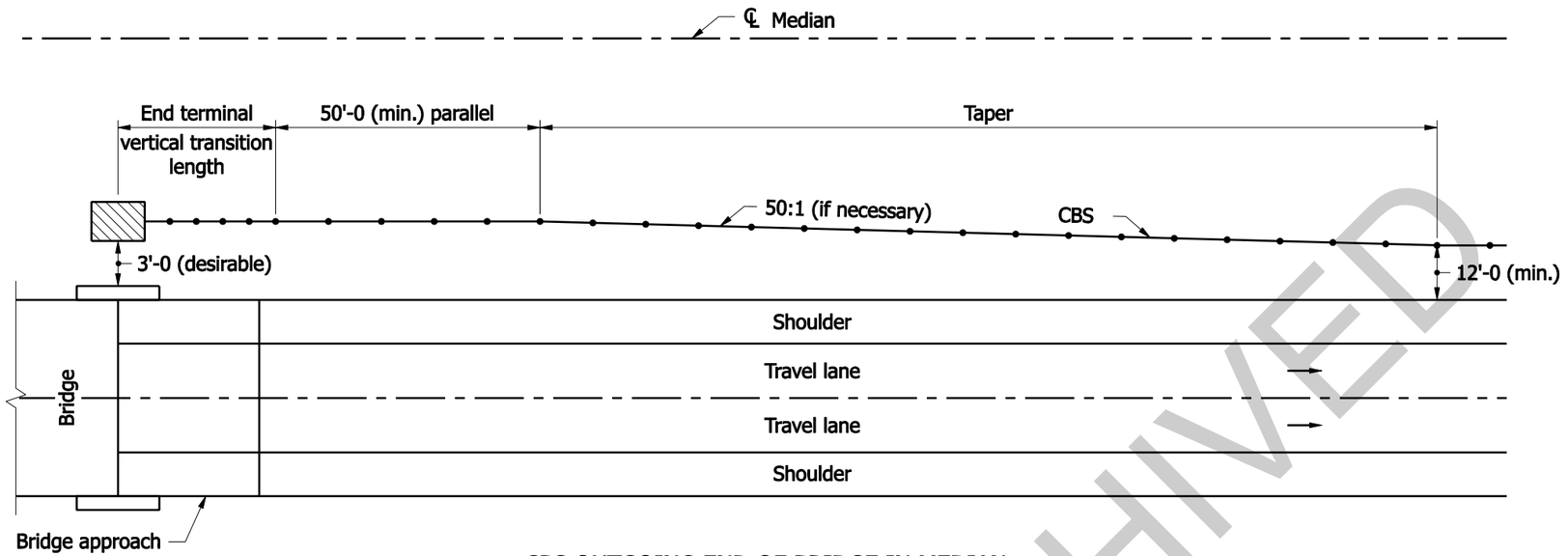
CBS INCOMING END OF BRIDGE
IN MEDIAN

1-01-08

E 627-R-546d 5 of 6

NOTES:

1. CBS: Cable Barrier System.
2. For location of CBS, See Sheet 1 of 6.



CBS OUTGOING END OF BRIDGE IN MEDIAN

INDIANA DEPARTMENT OF TRANSPORTATION

CBS OUTGOING END OF BRIDGE IN MEDIAN

627-R-546 CABLE BARRIER SYSTEM

(Revised 07-02-08)

The Standard Specifications are revised as follows:

SECTION 627, BEGIN LINE 1, INSERT AS FOLLOWS:

SECTION 627 – CABLE BARRIER SYSTEM

627.01 Description

This work shall consist of furnishing and installing a high-tension cable barrier system in accordance with 105.03.

627.02 General Requirements

The cable barrier system shall consist of four pre-stretched, individually anchored wire ropes in tension between safety terminals and held in position by intermediate line posts. The system shall be selected from the Department's list of approved Cable Barrier Systems. The Contractor shall use the selected system for the entire contract.

The Department will make geotechnical information available for the approximate locations of the safety terminals and representative locations of the intermediate line posts. The Contractor shall be responsible for obtaining any additional geotechnical information required by the cable barrier system manufacturer to complete design of line post and safety terminal foundations or other components of the system.

The Contractor shall provide the following to the Engineer a minimum of 14 days prior to installation of the system:

(a) A copy of the FHWA acceptance letter for the cable barrier system.

(b) Two copies of the manufacturer's product brochure, specifications and installation and maintenance manuals.

(c) Four copies of erection drawings clearly depicting installation details, including safety terminals, terminal transitions, intermediate line posts and cables.

(d) A copy of the design drawings and calculations for safety terminal and intermediate line post foundations for the soil conditions on the project. Design drawings and calculations shall be stamped by a professional engineer.

(e) Documentation that the Contractor's work force on the project has received training by the manufacturer in the proper installation of the system, including safety terminals, intermediate line posts, cables and tensioning of cables.

Safety terminal foundations shall at a minimum be designed to resist movement in the soil due to system tensioning and impacts to the system at the NCHRP 350 test level specified. Design of the safety terminal foundations shall include a factor of safety of 1.5 for overturning and pullout.

If all cables are to be anchored to a single foundation, the design of safety terminal foundations and cable connections shall be based on a minimum total equivalent horizontal static load of 50,000 lbf (222.4 kN) and the commensurate vertical component associated with the net cable angle from horizontal.

If cables are to be anchored in multiple foundations, the design of safety terminal foundations and cable connections shall be based on a minimum equivalent horizontal static load of 15,000 lbf (66.7 kN) per cable and the commensurate vertical component associated with this force and each cable's angle from horizontal.

Threaded terminals shall be of the swaged or wedge lock type. Only one field-installed swage connection will be allowed per cable per run. All other swage connections shall be factory installed.

Intermediate line post spacing shall be such that the maximum reported NCHRP crash test dynamic deflection is no greater than 10 ft (3.0 m), but in no case shall the post spacing be greater than 20 ft (6.0 m). Post spacing may be adjusted, as allowed by the manufacturer, to avoid conflicts with utilities, drainage structures, underdrain outlets and other permanent obstructions.

Intermediate line posts shall be of a socket tube and post design where the socket is part of the line post foundation and line posts are inserted into the socket. Posts shall have a means of holding the wire ropes at the design height. The post and socket design shall include a means of excluding debris from entering the socket.

Foundations for intermediate line post sockets shall be cast-in-place concrete a minimum of 3'-6" (1070 mm) deep and a minimum of 14 in. (350 mm) in diameter centered about the socket. Concrete foundations shall be reinforced as recommended by the manufacturer, but in no case shall the reinforcement be less than shown in the plans.

A minimum of 8 in.^{2} (5000 mm^2) of retroreflective sheeting shall be applied on the side facing approaching traffic of each line post in cable height transition sections and to every fourth intermediate line post in full height cable sections. The color of the sheeting shall match the color of the nearest adjacent traffic pavement marking.

MATERIALS

627.03 Materials

Materials shall be in accordance with the following:

Concrete, Class A.....702
Reinforcing Steel.....910.01

Cables shall meet the manufacturer's specifications. In addition, cables shall be 3/4 in. (19 mm) 3 X 7 zinc-coated wire rope in accordance with AASHTO M 30-02 (2006) Type 1, Class A and shall have a minimum breaking strength of 39,000 lbf (173.5 kN). Wire rope shall be pre-stretched to exhibit a minimum modulus of elasticity of 11,805,000 psi (81393 Mpa).

Intermediate line posts shall meet the manufacturer's specifications. In addition, posts shall be zinc-coated steel meeting the requirements of ASTM A-36 and AASHTO M 111M / M 111-04 after fabrication.

Threaded terminals, turnbuckles and anchor fittings shall meet the requirements of ANSI B1.13M and be zinc-coated in accordance with AASHTO M232-06 (M 232M) after fabrication and shall develop a minimum breaking strength of 36,800 lbf (160.1 kN). Turnbuckles may be either the open or closed body type and shall allow for a minimum of 6 in. (150 mm) of penetration from each end. Anchor fittings at the termination of each cable barrier run shall be of the same size and type used in connection to the turnbuckles.

Concrete for safety terminal and intermediate line post foundations shall be Class A.

Retroreflective sheeting shall be in accordance with AASHTO M-268 Type IV for adhesive sheeting.

A Type A certification in accordance with 916 shall be provided with each spool of wire rope cable prior to installation. The certification shall include the thickness of zinc coating, the minimum breaking strength, the modulus of elasticity and the force applied to pre-stretch the wire rope.

A Type C certification in accordance with 916 shall be provided for intermediate line posts, threaded terminals, turnbuckles, anchor fittings and retroreflective sheeting prior to installation.

CONSTRUCTION REQUIREMENTS

627.04 Construction

All site work, including grading and placing of fill shall be completed and approved by the Engineer prior to installation of the cable barrier system.

Installation of the cable barrier system shall be in accordance with the manufacturer's recommendations and these specifications.

The top of cast-in-place concrete safety terminal foundations and intermediate line post foundations shall be finished no lower than flush with final grade and no higher than 1 in. (25 mm) above final grade. Intermediate line post foundations shall be installed such that line posts will be plumb when installed in the socket. Safety terminal foundation concrete shall be cured for a minimum of 168 hr in accordance with 702.22 prior to tensioning of wire ropes.

A D2 delineator with post shall be placed in accordance with 804 in front of each safety terminal foundation.

Turnbuckles and other fittings shall be placed so as not to interfere with each other or with the intermediate line posts.

A manufacturer's representative shall be present during tensioning of the system. Tensioning shall be done in accordance with the manufacturer's specifications and using a tension chart provided by the manufacturer. The tension testing device shall be calibrated no more than one month prior to beginning tensioning and a copy of the calibration shall be provided to the Engineer. The temperature of the bottom wire rope shall be measured and recorded and used to determine the required tension values for the wire ropes from the manufacturer's chart. A copy of the chart shall be provided to the Engineer prior to tensioning.

The Contractor shall maintain a tensioning log in a format acceptable to the Engineer to record, at a minimum, the following:

(a) The date tensioning is performed
(b) The ambient air temperature at the time of tensioning
(c) The temperature of the bottom wire rope at the time of tensioning
(d) The model and serial number of the tension testing device used
(e) The location of each safety terminal in the run being tensioned
(f) The location where tensioning is being performed
(g) A diagram showing the number assigned to each of the four wire ropes
(h) The wire rope number being tensioned
(i) The maximum stress applied to each wire rope
(j) The final stress applied to each wire rope

The tensioning log shall be signed by the person overseeing the tensioning and submitted to the Engineer upon completion of each day's tensioning.

The tension in the cable barrier system shall be tested and retensioned as necessary no sooner than 15 days after initial tensioning. Retensioning shall be performed when the test indicates that tension is less than 90% of the manufacturer's recommended tension for the given cable temperature.

A tensioning log for all runs retensioned shall be completed and signed by the person overseeing the tensioning and submitted to the Engineer upon completion of each day's retensioning.

The Department may have non-inspection personnel on-site during the project to observe the installation of the cable barrier system. The Contractor shall provide for the manufacturer's representative to be on-site to instruct Department personnel in the proper installation and repair procedures for the system.

The Contractor shall repair any portion of a cable barrier system, including wire ropes, intermediate line posts, safety terminals, retroreflective sheeting and hardware that is damaged as a direct result of traffic during the life of the contract. Damage shall be repaired within seven days of notification by the Engineer. Responsibility for repairs will be in accordance with 107.18.

The Contractor may request final inspection and final acceptance of completed runs of cable barrier in accordance with 105.15(a).

The Contractor shall provide a spare parts package for the selected cable barrier system. The spare parts package shall include sufficient quantity of the following parts to replace 10% of the total number of like parts required in the original contract quantities.

(a) Intermediate line posts and all associated hardware.
(b) Intermediate line post sockets and all associated hardware.
(c) Retroreflective sheeting.

In addition, the spare parts package shall include the following.

(a) One of each of the manufacturer's tools required to replace intermediate line posts.
(b) One tension testing device as produced by or recommended by the manufacturer.
(c) One complete set of manufacturer's installation and repair manuals.

Prior to final acceptance of the contract, the spare parts package shall be delivered to a location within the District to be determined by the Engineer.

627.05 Method of Measurement

Cable barrier system will be measured by the linear foot (meter) for the type specified, complete in place. Measurement will be made between the centers of the two safety terminal foundations at the extreme ends of each run.

Safety terminals will be measured per each for the type specified, complete in place. One safety terminal will include all foundations and hardware necessary to anchor all 4 wire ropes at one end of a cable barrier run.

Safety terminal foundations, intermediate line posts, line post foundations, cable tensioning and retroreflective sheeting will not be measured separately for payment.

D2 delineators will be measured in accordance with 804.06.

Spare parts package will be measured per each, complete and delivered to the Department.

627.06 Basis of Payment

Cable barrier system will be paid for at the contract unit price per linear foot (meter) for the type specified.

Safety terminals will be paid for at the contract unit price per each for the type specified.

D2 delineators will be paid in accordance with 804.07.

Spare parts package will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	***Pay Unit Symbol***
Cable Barrier System, Type TL- _____ (test level)	*LFT (m)*
Cable Barrier System, Type TL- _____, Spare Parts (test level)	*EACH*
Safety Terminal, Type TL-_____ (test level)	*EACH*

The cost of wire rope cables, intermediate line posts, line post foundations, cable tensioning, retroreflective sheeting and all equipment, parts and labor, including the cost of the manufacturer's representative, necessary to furnish and install the cable barrier system shall be included in the cost of the pay item for cable barrier system.

The cost of safety terminal foundations, including reinforcing steel and all necessary cable anchor hardware, shall be included in the cost of the pay item for safety terminal.

The cost of obtaining any necessary additional geotechnical information and the cost of designing the safety terminal foundations shall be included in the cost of the pay item for safety terminal.

The cost of spare parts package shall include all costs necessary to deliver the spare parts to the designated location in the District.