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CHAPTER 7

APPURTENCES

7.01

ROADSIDE SAFETY BARRIERS

7.01.01 (revised 10-21-2013)

References

A. Guide for Selecting, Locating, and Designing Traffic Barriers, AASHTO 1977

B. A Guide to Standardized Highway Barrier Rail Hardware, AASHTO-AGC-ARTBA Joint Committee, 1995

C. A Supplement to A Guide for Selecting, Designing and Locating Traffic Barriers, Texas Transportation Institute and FHWA, March 1980


In addition, there are a number of National Cooperative Highway Research Program (NCHRP) research publications and reports of the major research and testing agencies that are available either within the Design Division or in the Transportation Library.

7.01.02 (revised 10-22-99)

Application of Section 7.01

In writing this portion of Chapter 7 it should be noted that the concepts presented will not necessarily be considered as absolutes to be rigidly adhered to, but will be considered as an aid to enhance the engineering judgement of the designer. Even when the word "should" is used, it is recognized that there may be circumstances unique to a situation that will suggest, or even dictate, alteration of a recommended treatment.

It is also intended that the barrier treatments recommended will be applicable to state trunkline projects and not necessarily to local government projects, except as local agencies wish to incorporate them.

7.01.03 (revised 10-22-99)

History of Guardrail and Barrier in Michigan

The practice of placing an artificial obstruction to prevent an errant vehicle from going down a steep embankment or into an area of water probably originated in the 1920's in the form of a line of posts placed at the edge of the shoulder. At some point in time the system was improved by the addition of connecting planks, which in turn were replaced by a more maintenance-free system of two steel cables. This design is illustrated on the old E-4-A-75 Series of standard plans. Following World War II some metal beam designs were introduced. One that found limited use in Michigan was the Tuthill Highway Guard, a convex smooth steel beam, 12" wide, fastened to spring steel supports, which were mounted on either wood or steel posts. In the early 1950's the concept of a metal beam was further refined with the introduction of the W-beam with the two corrugations that are essentially what we are familiar with today.
7.01.03 (continued)

History of Guardrail and Barrier in Michigan

Initially, the W-beam was not galvanized and had to be painted. The next step was to galvanize it for more economical maintenance.

The first installations of W-beam rail involved attaching the beam element directly to posts placed 12'-6" on centers, at a top of rail height of 24". This design later became known as our Beam Guardrail - Type A. Research and crash testing in the late 1950's and early 1960's, principally by the state of California and by General Motors at its Milford Proving Grounds, produced the recommendations of closer post spacing, (6'-3"), blocking out the beam from the post, and a higher top of rail mounting height. This resulted in Michigan's development of our Beam Guardrail - Type C in 1965, and Beam Guardrail - Type B in 1966. The most recent significant change in guardrail type in Michigan occurred in 1984 with the adoption of thrie beam, now called Guardrail, Type T.

Until 1995, four basic end treatments had been used in conjunction with steel beam guardrail. Initially, a curved end shoe was placed on both ends of the run. The concept of turning down or burying the ending to form an anchorage was developed about 1966. The first standard plan to be approved by what was then the Federal Bureau of Public Roads was issued in 1968. A variation of the turned down ending, featuring the elimination of the first two posts (so the ending would collapse under impact) appeared in 1971 with the issuance of Standard Plan III-65A.

The Breakaway Cable Terminal (BCT) ending was adopted in 1973 with the issuance of Standard Plan III-58A. After 22 years as the standard guardrail terminal in most states, the FHWA disallowed further installation of the BCT on the National Highway System (NHS) after December 31, 1995. This, along with the adoption of new crash testing criteria (NCHRP 350) ended the use of the BCT as well as other traditional un-patented endings.

7.01.03 (continued)

This initiated the development and use of a number of proprietary terminals. The Department has divided these terminals into two basic categories of flared gating terminals and tangent terminals. Current standard designs are described in Section 7.01.25 along with other designs previously used.

Development of concrete barrier in this country, principally concrete median barrier having the concave safety shape, is generally attributed jointly to General Motors and to the state of New Jersey, both of whom conceived shapes that bear their names. Michigan's first concrete barrier was on the DeQuindre Yard bridge, on I-94 in Detroit, in 1965. Although the New Jersey shape was used in this initial installation, the GM shape was adopted as standard. In 1976 the New Jersey shape was adopted as standard.

7.01.04

Section deleted
Basic Concepts for Roadside Control

The following are basic concepts and design options for the use or non-use of roadside barriers. The primary sources of information for roadside control are found in the AASHTO documents listed in Section 7.01.01, "References".

A. A collision with a roadside barrier is considered a crash, because the barrier itself is a roadside obstacle.

B. A roadside barrier may increase the frequency of crashes, therefore a barrier should only be installed if it will reduce the severity of potential crashes.

C. When considering the design options for roadside treatment and the progression of design options basic concepts for roadside control should be as follows.

1. Remove the obstacle or redesign it so it can be safely traversed.

2. Relocate the obstacle to a point where it is less likely to be struck.

3. Reduce impact severity by using an appropriate breakaway or traversable device.

4. Redirect a vehicle by shielding the obstacle with a longitudinal traffic barrier and/or crash cushion.

5. Delineate the obstacle if the above alternatives are not appropriate.

D. Generally, a roadside barrier should be placed as far from the traveled way as conditions will permit. See Section 7.01.30G.

E. Standard Plan R-59-Series depicts guardrail at approaches to bridges, both over and under. It is intended for new construction, where it is possible to grade approach fill sections to accommodate the flared ending. Generally, the more flare that can be achieved, the shorter the rail needs to be to afford the desired protection.

F. Longer runs of parallel barrier may be required on upgrading projects, where less than ideal existing conditions preclude the use of flares as called for by Standard Plan R-59-Series.

G. To uniformly compute the length of need for roadside barriers, a guardrail worksheet has been developed and should be used on both new and upgrading projects. Computation methods used on this worksheet complies with the guidelines described in the Roadside Design Guide. It still remains important that all designers become familiar with the "Guide" to understand the design process. For determining the length of need when non traversable embankments are the only obstacles of concern, see Section 7.01.30.

The worksheet shall be used by all designers, including consulting firms performing work for the Department, to compute guardrail length of needs.

The designer should fill in all data and compute each individual barrier run. This will assure proper compliance to standards and allow each barrier run calculation to be documented and checked for accuracy.

Construction field offices should be sent the completed worksheets for reference during project construction.

The worksheet does not cover all situations which may occur in the field, although it is expected to cover most installations. Any situation not covered by the worksheet shall be similarly documented, along with a sketch providing the details of the guardrail installation.

Guardrail Worksheet

The guardrail worksheet is shown on the following pages.
GUARDRAIL WORKSHEET
FOR APPROACH TERMINALS ON R-51-SERIES AND R-82-SERIES

ROUTE  __________________________  CONTROL SECTION  __________  JOB #  _________

DESIGNED BY  __________  DATE  __________  CHECKED BY  __________  DATE  __________

APPROX. STATION OR M.P.  __________  DESCRIPTION  __________________________

GUARDRAIL RUN #  __________

IF STATIONING IS NOT AVAILABLE, LOCATE TO NEAREST FIXED OBJECT

NOTE: TYPE 1 TERMINAL ILLUSTRATED

\[ X = \frac{L_H - \left( \frac{b}{a} \right) (L_I) - (L_2 \cdot d)}{L_H - \left( \frac{b}{a} \right) L_R} \]

\[ X = \frac{L_H - \left( \frac{b}{a} \right) L_R}{L_H - \left( \frac{b}{a} \right) (L_I)} \]

\[ Z = (X - L_I - 25) \left( \frac{b}{a} \right) + L_2 \]

\[ Z = L_2 \text{ (For Type 2 Terminals)} \]

LENGTH OF NEED  ............................... \( X = \)  ____

RUNOUT LENGTH (7.01.19)  .................................. \( L_R = \)  ____

GUARDRAIL TAPER RATE (R-59-SERIES)  .................. \( \frac{b}{a} = \)  ____

E.O.P. TO FACE OF BARRIER (DESIGNED) ...................... \( L_2 = \)  ____

CLEAR ZONE (7.01.11)  ............................ \( L_C = \)  ____ \( L_1 = \)  ____ (25' MIN.)

E.O.P. TO ROADSIDE FEATURE (MEASURED) ........... \( L_3 = \)  ____

EFFECTIVE TURNED OUT DISTANCE OF ANCHORAGE  .... \( d = \)  ____ STATION AT A  ____

LATERAL EXTENT OF ROADSIDE FEATURE (MEASURED) \( L_H = \)  ____ STATION AT B  ____

LATERAL OFFSET AT END OF FLARE  ...................... \( Z = \)  ____

NOTE: DISTANCE OF OBJECT FROM BACK OF BARRIER MUST BE GREATER THAN THE MAXIMUM DEFLECTION (7.01.20):

\[ L_H \leq L_C \]

REFER TO STANDARD PLAN R-59-SERIES AND DESIGN MANUAL
SECTION 7.01.30 FOR GUARDRAIL AT EMBANKMENTS
PROPOSED TREATMENT

CALCULATIONS OR NOTES

PAY ITEMS

<table>
<thead>
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<th>Item</th>
<th>Quantity</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>FT</td>
<td>___</td>
<td>GUARDRAIL, TYPE ___</td>
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<tr>
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<td>___</td>
<td>GUARDRAIL ANCHORAGE, BRIDGE, DET ___</td>
</tr>
<tr>
<td>FT</td>
<td>___</td>
<td>BRIDGE RAILING, THRIE BEAM RETROFIT</td>
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<td>___</td>
<td>GUARDRAIL APPROACH TERMINAL, TYPE ___</td>
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<td>GUARDRAIL DEPARTING TERMINAL, TYPE ___</td>
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<tr>
<td>CYD</td>
<td>___</td>
<td>EMBANKMENT, LM</td>
</tr>
<tr>
<td>EACH</td>
<td>___</td>
<td>GUARDRAIL TERMINAL END SHOE (WHEN SPECIFIED)</td>
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* FOR THIS PAY ITEM, THE GUARDRAIL APPROACH TERMINAL, TYPE ___ PORTION OF LENGTH OF NEED (X) MUST BE DEDUCTED

<table>
<thead>
<tr>
<th>GUARDRAIL APPROACH TERMINAL</th>
<th>TYPE 1</th>
<th>TYPE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUARDRAIL TYPE B</td>
<td>25'</td>
<td>37.5'</td>
</tr>
<tr>
<td>GUARDRAIL TYPE T</td>
<td>31.25'</td>
<td>43.75'</td>
</tr>
</tbody>
</table>

PAY LENGTHS MUST BE DIVISIBLE BY 12.5', ROUND TO NEXT HIGHEST RAIL LENGTH.


7.01.10 (revised 10-21-2013)

Clear Zone – History

For a number of years road designers and safety authorities considered 30’ a desirable requirement for a safe roadside free of obstacles. This was based upon a study by General Motors in the early 1960’s which revealed that of 211 cases at the proving grounds involving vehicles leaving the road, 80% did not travel more than 29’ from the edge of pavement. The 1967 “Yellow Book” (Highway Design and Operational Practices Related to Highway Safety, AASHTO), page 20, rounded this distance off to 30’. The 2nd edition of the “Yellow Book”, published in 1974, reiterated the 30’ distance, but called for an application of engineering judgement by emphasizing that the “30’ distance is not a “magic number” (page 38). The 1977 Barrier Guide defined clear zone, in the glossary on page iv, as “That roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. Establishment of a minimum width clear zone implies that rigid objects and certain other features with clearances less than the minimum width should be removed, relocated to an inaccessible position outside the minimum clear zone, or remodeled to make safely traversable, breakaway, or shielded.”

The 1977 Barrier Guide introduced the concept that rate of sideslope, speed of traffic, horizontal curvature, and ADT would affect the width of clear zone. The 30’ width was retained for 60 mph speed in combination with flat side slopes, tangent roadway alignment, and ADT exceeding 6,000. However, a graph on page 16 adjusts this basic 30’ for traffic speed and rate of sideslope. These adjustments are both up or down (wider or narrower) for either descending or ascending slope. A formula on page 17 further adjusts the clear zone for horizontal curvature. Finally, a procedure shown on pages 60-65 adjusts the clear zone downward (narrower) for ADT’s below 6,000. The Supplement to the 1977 Barrier Guide expanded on the clear zone criteria that begins on page 15 of the Barrier Guide by including a series of tables prepared by the state of Illinois that show clear zone requirements for various degrees of curve. These criteria have been criticized by a number of states because of the extreme clear zone widths, particularly for the combination of sharp curve, higher speed, high traffic volume and steep slope.

In anticipation of a proposed revision of the 1977 Barrier Guide, FHWA in April 1986 afforded the states a measure of relief with respect to clear zone requirements. It provided a formula for a curve correction factor that is based upon increasing the value for clear zone for a tangent section, obtained from the Barrier Guide. This new formula is more reasonable than the formula on page 17 of the Barrier Guide. It was adopted by the Department in July 1986. In 1989 the Roadside Design Guide was issued by AASHTO and adopted by MDOT as a guide. Updates to the Roadside Design Guide were published in 1996, 2002, 2006 and 2011.

7.01.11 (revised 9-21-2015)

Current Clear Zone Criteria

Virtually everyone agrees that a flat, smooth, unobstructed area adjacent to the driving lanes is highly desirable and significantly improves roadside safety. The only point of contention is how wide to make this area. The designer needs to understand that the clear zone distance is not an absolute number. Some designers have erroneously believed, that in all cases, the need for protecting motorists ends at the selected clear zone distance.

7.01.10 (continued)
7.01.11 (continued)

Current Clear Zone Criteria

The Department measures the clear zone from the outer edge of the through lane. When determining clear zones in auxiliary lane areas, use the volume of the through lanes and the freeway design speed to obtain the clear zone distance. The resulting clear zone distance should be measured from the outer edge of the through lane and is not to be less than 23 ft out from the outer edge of the auxiliary lane.

The Roadside Design Guide defines the clear zone as a variable distance from the traveled way, depending on design speed, ADT, and embankment slope rate and direction.

The Clear Zone Distances Table presents a range of values that can be used for specific conditions. These numbers are based on limited data that was gathered under non-typical conditions and extrapolated to account for sloped roadsides. Also the values obtained from the Clear Zone Distances Table are based on an assumption of constant side slope throughout the clear zone. They must not be perceived as absolute. In situations where the side slope changes within the calculated clear zone, the clear zone must be recalculated based upon a weighted average calculation. An example of this procedure is shown in Section 13.02.08 of this manual.

Application of the values in the Clear Zone Distances Table is dependent on the extent of work and the roadway classification. The higher values should be used on new construction, reconstruction and on all freeways.

7.01.11 (continued)

When evaluating existing conditions and when designing rehabilitation projects, we should attempt to use the higher values; however, economics, existing field conditions, and other restraints may justify using the lower values.

Clear zone for 3R-nonfreeway projects must be selective and generally “fit” conditions within the existing right-of-way and character of the road. Some roadside improvements that should be considered may include removal, relocation, or shielding of such obstacles as culvert headwalls, utility poles, and bridge supports that are within the selective clear zone.

The designer should also be aware that current clear zone distances and 3R guidelines serve as general guidance for Heritage Routes (See Section 3.09). Narrow pavement, narrow shoulders, winding and/or rolling alignment, steep side slopes, roadside obstacles and narrow right-of-way are common characteristics of Heritage Routes that sometimes prevent the use of even the lower range of the Clear Zone table. Where economic or environmental concerns are great, and there is no history of crash concentration, shorter clear zone distances may be considered to preserve the characteristics of the Heritage Route. Some areas of concern may be addressed with appropriate traffic signing. When distances below the ranges offered in the Clear Zone Distances Table are used, the rationale for the alternative treatment should be noted in the project file.

Tree removal should be considered as stated in Section 3.09.03C. Some alternatives are also offered in the next two sections (7.01.11A and 7.01.11B).
7.01.11 (continued)

Current Clear Zone Criteria

A. Treatment/Consideration of Obstacles Outside the Calculated Project Clear Zone

Occasionally, there may be opportunities to improve the roadside safety on a project for a small cost by addressing a few obstacles outside the determined clear zone. Examples of these opportunities are as follows:

1. When installing landscape items: Since we have control over the location of new items, we can provide additional protection to the motorist by applying a more generous clear area to these items. For instance, our freeway guideline for a long time has been to plant trees at least 50 feet off the edge of traffic lanes.

2. When isolated trees, volunteer growth, utility poles, etc. are present: Depending on aesthetic concerns, it may be possible to offer the motorist a very generous clear area (beyond that required by the Clear Zone Distances tables) by simply removing or relocating a few isolated obstacles.

3. Obstacles near the bottom of a ditch are more likely to be hit by an errant vehicle since the ditch tends to funnel the vehicle. Relocating the obstacle further up the back slope, or even slightly up the front slope (closer to road but still outside the clear zone limit), would usually be preferable.

4. A clear runout area beyond the toe of a traversable (smooth and free of fixed objects) but non-recoverable (between 1:4 and 1:3) foreslope is desirable since vehicles traversing this steep slope are likely to continue to the bottom. The extent of this clear runout area can be determined by subtracting the distance between the edge of traveled way and the breakpoint of recoverable foreslope from the clear zone distance. This distance should be at least 10' if feasible.

7.01.11 (continued)

B. Treatment/Consideration of Obstacles Inside the Calculated Project Clear Zone

Where the following conditions exist, it may be necessary to retain trees that otherwise would be considered for removal.

1. At landscaped areas, parks, recreation or residential areas or where the functional and/or aesthetic values will be lost.

2. Exceptional or unique trees (because of their size, species, or historic value).

3. On designated heritage roads and low speed roads (including low speed urban areas).

4. At locations where cumulative loss of trees would result in a significant change in character of the roadside landscape.

5. Behind nontraversable backslopes.

6. Behind vertical curbs, particularly in low speed areas.

7. Where shrubs and/or ornamental trees exist that would have a mature diameter of 4" or less at 4'-6" above ground line.

8. Where removal would adversely affect endangered/threatened species, wetland, water quality, or result in significant erosion/sedimentation problems.
### 7.01.11 (continued)

**Current Clear Zone Criteria**

#### C. Clear Zone Distance Chart

**CLEAR ZONE DISTANCES**
**(IN FEET FROM EDGE OF DRIVING LANE)**

<table>
<thead>
<tr>
<th>DESIGN SPEED</th>
<th>DESIGN ADT</th>
<th>FILL SLOPES</th>
<th>CUT SLOPES</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1:6 OR FLATTER</td>
<td>1:5 TO 1:4</td>
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<tr>
<td>40 mph or Less</td>
<td>under 750</td>
<td>7 - 10</td>
<td>7 - 10</td>
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<tr>
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<td>750 - 1500</td>
<td>14 - 16</td>
<td>16 - 20</td>
</tr>
<tr>
<td></td>
<td>1500 - 6000</td>
<td>16 - 18</td>
<td>20 - 26</td>
</tr>
<tr>
<td></td>
<td>over 6000</td>
<td>20 - 22</td>
<td>24 - 28</td>
</tr>
<tr>
<td>55 mph</td>
<td>under 750</td>
<td>12 - 14</td>
<td>14 - 18</td>
</tr>
<tr>
<td></td>
<td>750 - 1500</td>
<td>16 - 18</td>
<td>20 - 24</td>
</tr>
<tr>
<td></td>
<td>1500 - 6000</td>
<td>20 - 22</td>
<td>24 - 30</td>
</tr>
<tr>
<td></td>
<td>over 6000</td>
<td>22 - 24</td>
<td>26 - 32*</td>
</tr>
<tr>
<td>60 mph</td>
<td>under 750</td>
<td>16 - 18</td>
<td>20 - 24</td>
</tr>
<tr>
<td></td>
<td>1500 - 6000</td>
<td>26 - 30</td>
<td>32 - 40*</td>
</tr>
<tr>
<td></td>
<td>over 6000</td>
<td>30 - 32*</td>
<td>36 - 44*</td>
</tr>
<tr>
<td>≥ 65 mph</td>
<td>under 750</td>
<td>18 - 20</td>
<td>20 - 26</td>
</tr>
<tr>
<td></td>
<td>750 - 1500</td>
<td>24 - 26</td>
<td>28 - 36*</td>
</tr>
<tr>
<td></td>
<td>1500 - 6000</td>
<td>28 - 32*</td>
<td>34 - 42*</td>
</tr>
<tr>
<td></td>
<td>over 6000</td>
<td>30 - 34*</td>
<td>38 - 46*</td>
</tr>
</tbody>
</table>

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear zone distances greater than 30 feet as indicated. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or designs indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1:3 slopes, fixed objects should not be present in the vicinity of the toe of these slopes.
7.01.11 (continued)

Current Clear Zone Criteria

D. Curve Correction Factors Table

The Curve Correction Factors Table shown below shall be applied to horizontal curves with radii less than or equal to 2950 ft. The curve correction factor (Kcz) shall be applied to the outside of curve only. The inside portion of the curve will be treated as a tangent section.

<table>
<thead>
<tr>
<th>CURVE CORRECTION FACTORS (Kcz)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Radius</strong> (ft)</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>2950</td>
</tr>
<tr>
<td>2300</td>
</tr>
<tr>
<td>1970</td>
</tr>
<tr>
<td>1640</td>
</tr>
<tr>
<td>1475</td>
</tr>
<tr>
<td>1315</td>
</tr>
<tr>
<td>1150</td>
</tr>
<tr>
<td>985</td>
</tr>
<tr>
<td>820</td>
</tr>
<tr>
<td>660</td>
</tr>
<tr>
<td>495</td>
</tr>
<tr>
<td>330</td>
</tr>
</tbody>
</table>

7.01.11 (continued)

E. Other Controlling Factors

For free access highways, the clear zone should ideally be the same as for controlled access highways, but often this is impossible as it would require complete reconstruction of the highway, and destruction of the existing roadside features. Clear zone may often be restricted by drives, intersections, ditches, narrow R.O.W., and other features. While it may be argued that the dynamics of a vehicle running off the road are no different on a free access road than they are on a limited access facility, it remains as a fact of life that there will always be obstacles of some description on free access roads - mailboxes, driveway embankments, trees, buildings, etc. Enormous numbers of these obstacles occur on the trunkline system.

Continued efforts should be made to reduce these obstacles as finances permit, even though some cannot be removed without great difficulty, because of socio-environmental considerations, e.g., mature shade trees in a west-facing front yard. However safety considerations should overrule, and if need be, even these mature shade trees may have to be removed.

The designer should note that the presence of an up-slope significantly reduces the clear zone width required. It is therefore seldom necessary to remove a tree or to shield an obstacle that is located at the top of a cut-slope if the elevation of the top of slope is approximately 5'-0" to 6'-0" higher than the edge of pavement. These situations should always be checked, however.
7.01.12 (revised 1-20-2010)

Types of Guardrail Used in Michigan

There are seven principal types of steel beam guardrail in addition to cable guardrail found on Michigan highways. The term "Current Use" means "currently proposed for use", not necessarily what may be found existing in the field.

A. Type A (Standard Plan R-60-Series)

Description: W-beam attached directly to posts, Terminal End Shoes on ends. 12'-6" post spacing, 28" height to top of rail.

Current Use:
1. Cul-de-sacs
2. Limited to locations not exposed to through traffic.

B. Type B (Standard Plan R-60-Series)

Description: W-beam guardrail, 8" offset blocks. 6'-3" post spacing, 28" height to top of rail.

Current Use:
1. Basic type for all free access trunklines.
2. On local roads when part of a state trunkline project.

C. Type BD (Standard Plan R-60-Series)

Description: Type B with W-beam on both sides of the post, 8" offset blocks.

Current Use:
1. Limited use in medians on free access highways when median barrier is recommended.

D. Type C (old Standard Plan III-60E)

Description: Upper beam blocked out (similar to Type B) but has a lower beam attached directly to the post. 6'-3" post spacing, 32" height to top of rail.

Current Use:
1. Repairing runs of existing Type C (ask for copy of old standard for use as a Special Detail).

E. Type CD (old Standard Plan III-60E)

Description: Similar to Type C except beam elements are installed on both sides of the post.

Current Use:
1. Repairing runs of existing Type CD (ask for copy of old standard for use as Special Detail).

F. Type T (Standard Plan R-60-Series)

Description: Offset thrie beam rail, 8" offset blocks, 6'-3" post spacing, 34" height to top of rail.

Current Use:
1. Standard guardrail for new freeway construction (including ramps).
2. Updating existing freeways and ramps when the entire run of guardrail is being removed and replaced.
7.01.12 (continued)

Types of Guardrail used in Michigan

G. Type TD (Standard Plan R-60-Series)

Description: Similar to Type T except beam elements and offset blocks are installed on both sides of the post.

Current Use:
1. In freeway medians over 30’ wide when median barrier is recommended. Used to update existing freeway medians when there is a significant length of guardrail being replaced or where none was constructed initially, but barrier is now recommended.

H. Cable Barrier (See Section 7.0155C)

Description: Three or four steel cables mounted on steel posts, anchored and tensioned.

Current Use:
1. Medians where crash history indicates cross median crashes and rigid barrier is not warranted.
2. Special situations where up to 90 degree impacts can be expected and larger deflections can be tolerated.

7.01.13

Curved Beam Elements

Curved steel beam elements having a radius of 150’ or less must be shop bent. Designers should try to be as accurate as possible when specifying a radius for curved rail, as it is time consuming and expensive returning elements to the shop for re-bending. When shop bent rail will be required, the following note should be included on the plans: "Shop bent curved guardrail elements shall not be ordered until the radius has been field verified by the Engineer."

7.01.14 (revised 12-22-2011)

Guardrail Surface Finish

A. Galvanized

For a short time in the early to mid-1950's, the first steel W-beam guardrail was not galvanized and therefore had to be painted. Subsequently, galvanized beam elements were supplied and have been used ever since except, of course, for the use of weathering steel. The galvanizing coating is considered to have a service life of at least 25 years under average conditions before exhibiting significant rusting. Some of the earlier accepted galvanized rails were "pre-galvanized" and had very thin zinc coatings. These have rusted at a considerably premature age. From that time, a heavier galvanizing was applied by hot dip method after forming. This exhibited good durability. The industry asked for reconsideration of the pre-galvanized method in 1995. The Construction Field Services Division performed a study to determine the weather resistance of pre-galvanized rail. The results of an accelerated weathering simulation were acceptable. The specifications now allow for either method of galvanizing.

B. Unpainted Corrosion-Resistant

Atmospheric corrosion resistant guardrail (sometimes referred to as "weathering" or "rusty steel" guardrail) was first installed in Michigan, at 3 test sites, in 1963. It was adopted as standard by the Department in late 1971. If galvanized beam was desired, and it was in certain locations where visibility was especially needed, then it had to be specified on the plans and in the pay item. The theory behind the development of this material was that, being uncoated, it would oxidize rather quickly to a uniform brown color, the chemistry of the steel causing the surface rust to be dense and adherent. After the initial surface rust had formed, it was thought that further oxidation would proceed very slowly as the oxides would form a protective coating, making painting unnecessary. Initially, the
7.01.14B (continued)

Guardrail Surface Finish

Buffered endings were galvanized, but in 1976 it was decided to specify corrosion resistant steel for them as well. In early 1980 a moratorium was placed on the use of weathering steel, requiring all new guardrail be galvanized according to the former requirements. The moratorium was prompted by the discovery that, when chloride contamination occurred, oxidation of the metal did not slow up after the initial rusting, and crevice corrosion accelerated the attack on the overlapped surfaces. Concerns were expressed that the useful life of the rail would be considerably less than that originally anticipated. The moratorium led to a permanent discontinuation of the use of weathering steel.

C. Corrosion-Resistant Guardrail Replacement Policy

The Engineering Operations Committee, meeting on January 20, 1989, decided that all existing corrosion resistant, or "rusty steel", guardrail encountered on proposed Interstate resurfacing or reconstruction projects should be removed and replaced as part of the project. On projects involving bridges only, the nominal provisions of the approach guardrail anchorage shall be replaced if the rail elements are rusty steel. Where guardrail at the bridge approaches is part of a more extensive installation, the decision to replace will be made on the merits of the specific project. See Section 7.01.44 for upgrading local roads.

7.01.15 (revised 8-29-2011)

Guardrail Terminals

The following guardrail terminal details are in current use for new construction and where specified for updating:

7.01.15 (continued)

A. Guardrail Approach Terminal, Type 1B (Standard Plan R-61-Series)

Current Use:
1. On approach end of Guardrail, Type B, on one-way roadways.
2. On both ends of Guardrail, Type B, on two-way roadways.

B. Guardrail Approach Terminal, Type 1T (Standard Plan R-61-Series)

Current Use:
1. On approach end of Guardrail, Type T, on one-way roadways.
2. On both ends of Guardrail, Type T, on two-way roadways.

C. Guardrail Approach Terminal, Type 2B (Standard Plan R-62-Series)

Current Use:
1. Same as Type 1B when grading limits prohibit proper offset for Type 1B.

D. Guardrail Approach Terminal, Type 2T (Standard Plan R-62-Series)

Current Use:
1. Same as Type 1T when grading limits prohibit proper offset for Type 1T.

E. Guardrail Departing Terminal, Type B (Standard Plan R-66-Series)

Current Use:
1. Departing end of Guardrail, Type B, on one-way roadways.
2. Departing end of Guardrail, Type B, on two-way roadways when located outside the clear zone.

F. Guardrail Departing Terminal, Type T (Standard Plan R-66-Series)

Current Use:
1. Departing end of Guardrail, Type T, on one-way roadways.
2. Departing end of Guardrail, Type T, on two-way roadways when located outside the clear zone.
7.01.16

Guardrail Attachment to Bridges and Walls

The following guardrail anchorage details are in current use for new construction and where specified for upgrading and are detailed on Standard Plans R-67-Series, B-22-Series, B-23-Series:

A. Guardrail Anchorage, Bridge, Detail T-1 (Standard Plan R-67-Series)

Current Use: (Two uses detailed)
1. Use when connecting Guardrail, Type T to Bridge Barrier Railing, Type 4 without expansion at backwall.
2. Use when connecting Guardrail, Type T to Bridge Barrier Railing, Type 4 with expansion at backwall.

B. Guardrail Anchorage, Bridge, Detail T-2 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type B to Bridge Barrier Railing, Type 4 without expansion at backwall.

C. Guardrail Anchorage, Bridge, Detail T-3 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type T to Bridge Barrier Railing, Type 5 without expansion at backwall.

E. Guardrail Anchorages, Bridge, Detail T-5 (Standard Plan R-67-Series)

Current Use: (Two uses detailed)
1. Use when connecting Guardrail, Type B to Bridge Barrier Railing, Type 4 with expansion at backwall.
2. Use when connecting Guardrail, Type B to Fillerwalls.

F. Guardrail Anchorages, Bridge, Detail T-6 (Standard Plan R-67-Series)

Current Use:
1. Use when connecting Guardrail, Type T to Fillerwalls.

G. Guardrail Anchorages, Bridge, Detail A-1 (Standard Plans B-22-Series and B-23-Series)

Current Use:
1. Use when connecting Guardrail, Type T to Bridge Railing, Thrie Beam Retrofit.

H. Guardrail Anchorages, Bridge, Detail A-2 (Standard Plans B-22-Series and B-23-Series)

Current Use:
1. Use when connecting Guardrail, Type B to Bridge Railing, Thrie Beam Retrofit.

I. Need for Additional Expansion

The Guardrail Anchorage, Bridge details on Standard Plan R-67-Series will accommodate thermal deck movement up to about 4". If the expected thermal deck movement will exceed 4", the Road designer should consult with the Bridge designer to decide the method for providing the additional expansion required in the guardrail.
7.01.17 (revised 2-18-2014)

Strength Requirements of Steel Beam Guardrail

The Standard Specifications reference material requirements for steel beam guardrail and associated hardware to AASHTO Specification M 180, which requires 70,000 psi tensile strength in the base metal.

Crash testing of roadside safety devices, such as guardrail and other barriers, is standardized according to procedures outlined in National Cooperative Highway Research Program Report 350 (NCHRP 350) and the Manual for Assessing Safety Hardware (MASH), respectively. MASH contains the current guidelines for testing and evaluating roadside safety devices, thereby superseding NCHRP 350. As of January 1, 2011, newly tested or modified roadside safety devices must be evaluated using MASH criteria. However, all safety hardware accepted prior to adoption of MASH using NCHRP 350 criteria may remain in place and may continue to be manufactured and installed. As a result, it is acceptable to install new roadside safety devices that meet NCHRP 350 or MASH. MDOT-approved roadside safety hardware not accepted under NCHRP 350 or MASH with no suitable alternatives may remain in place and may continue to be installed.

<table>
<thead>
<tr>
<th>NCHRP 350 Test Level</th>
<th>Vehicle</th>
<th>Impact Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Nominal Speed (km/h)</td>
</tr>
<tr>
<td>1</td>
<td>2000P (2000 kg pick up truck)</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>2000P (2000 kg pick up truck)</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>2000P (2000 kg pick up truck)</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>8000S (8000 kg single unit truck)</td>
<td>80</td>
</tr>
<tr>
<td>5</td>
<td>3600V (3600 kg tractor van trailer)</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>3600T (3600 kg tractor tanker-type trailer)</td>
<td>80</td>
</tr>
</tbody>
</table>

7.01.17 (continued)

There are up to six test levels in NCHRP 350 and MASH, respectively, depending on the feature being evaluated. All six test levels apply to longitudinal barriers. Test levels 2 and 3 apply to breakaway features and test levels 1, 2, and 3 apply to crash cushions and end treatments.

Fundamentally, guardrail is intended to redirect the impacting vehicle, not stop it. Energy absorption and vehicle deceleration are the functions of an impact attenuator (or a Type 2 terminal, under certain conditions). For this reason, 25 degrees is the maximum angle used in testing for guardrail strength.

The designer will occasionally encounter situations where a broad area must be shielded. These may be areas wide enough to allow a vehicle to exceed 25 degrees in approach angle and too wide to make an impact attenuator feasible. These situations must be studied. The solution will usually involve guardrail placed in a curving configuration or the use of cable barrier if there is room for the deflection that is characteristic of a cable barrier.
### Strength Requirements of Steel Beam Guardrail

<table>
<thead>
<tr>
<th>MASH Test Level</th>
<th>Test Vehicle Designation and Type</th>
<th>Impact Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Vehicle Weight Kg (lbs)</td>
</tr>
<tr>
<td>1</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td>2</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td>3</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td>4</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td></td>
<td>10,000S (Single Unit Truck)</td>
<td>10,000 (22,000)</td>
</tr>
<tr>
<td>5</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td></td>
<td>36,000V (Tractor-Van Trailer)</td>
<td>36,000 (79,300)</td>
</tr>
<tr>
<td>6</td>
<td>1,100C (Passenger Car)</td>
<td>1,100 (2,420)</td>
</tr>
<tr>
<td></td>
<td>2,270P (Pickup Truck)</td>
<td>2,270 (5,000)</td>
</tr>
<tr>
<td></td>
<td>36,000T (Tractor-Tank Trailer)</td>
<td>36,000 (79,300)</td>
</tr>
</tbody>
</table>

### Suggested Shy Line Offset Values

Shy line offset is the distance from the edge of traveled way in which a roadside object will not be perceived as an obstacle or result in the driver reducing speed or changing the vehicle's path of travel.

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>Shy Line Offset (L_s) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>12</td>
</tr>
<tr>
<td>75</td>
<td>10</td>
</tr>
<tr>
<td>70</td>
<td>9</td>
</tr>
<tr>
<td>60</td>
<td>8</td>
</tr>
<tr>
<td>55</td>
<td>7</td>
</tr>
<tr>
<td>50</td>
<td>6.5</td>
</tr>
<tr>
<td>45</td>
<td>6</td>
</tr>
<tr>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>30</td>
<td>4</td>
</tr>
</tbody>
</table>
**Suggested Runout Lengths for Barrier Design**

Runout length is the distance from the object being shielded to the point the vehicle is assumed to depart from the roadway.

<table>
<thead>
<tr>
<th>Traffic Volume (ADT) veh/day</th>
<th>Over 10,000</th>
<th>Over 5,000-10,000</th>
<th>1000-5000</th>
<th>Under 1000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Speed (mph)</strong></td>
<td><strong>Runout Length L&lt;sub&gt;R&lt;/sub&gt; (ft)</strong></td>
<td><strong>Runout Length L&lt;sub&gt;R&lt;/sub&gt; (ft)</strong></td>
<td><strong>Runout Length L&lt;sub&gt;R&lt;/sub&gt; (ft)</strong></td>
<td><strong>Runout Length L&lt;sub&gt;R&lt;/sub&gt; (ft)</strong></td>
</tr>
<tr>
<td>70</td>
<td>360</td>
<td>330</td>
<td>290</td>
<td>250</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
<td>250</td>
<td>210</td>
<td>200</td>
</tr>
<tr>
<td>50</td>
<td>230</td>
<td>190</td>
<td>160</td>
<td>150</td>
</tr>
<tr>
<td>40</td>
<td>160</td>
<td>130</td>
<td>110</td>
<td>100</td>
</tr>
<tr>
<td>30</td>
<td>110</td>
<td>90</td>
<td>80</td>
<td>70</td>
</tr>
</tbody>
</table>

**Guardrail Deflection**

Being flexible barriers, both steel beam guardrail and cable guardrail are expected to deflect under impact. This deflection is a result of deformation of the beam element or stretching of the steel cable, fracturing of the post (if wood) or bending of the post (if steel), and lateral displacement of the post in the soil. It is therefore necessary that room for deflection be provided between the back of the rail system (back of posts) and the object or area being shielded. For design purposes, use the chart at the end of this section for the expected deflections of the various barrier systems.

It should be noted that the above deflection distances are not well-defined values, and that deflections may vary for different soil types and moisture content, thawed or frozen ground, different types of anchorages, and differing lengths of installation. If specific site conditions are such that it is predictable that greater deflection values may occur, and space for deflection is restricted, then shorter post spacing or deeper embedment of posts should be considered. Shorter post spacing is only effective, however, if the full effect of proper post embedment is realized. See Section 7.01.41D, "8'-0" Posts". See also Section 5.5.2, 2011 AASHTO Roadside Design Guide.

<table>
<thead>
<tr>
<th>Guardrail</th>
<th>Post Spacing</th>
<th>Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type T</td>
<td>1'-6¾&quot;</td>
<td>1'-2&quot;</td>
</tr>
<tr>
<td>Type T</td>
<td>3'-1½&quot;</td>
<td>1'-8&quot;</td>
</tr>
<tr>
<td>Type T</td>
<td>6'-3&quot;</td>
<td>2'-0&quot;</td>
</tr>
<tr>
<td>Type C</td>
<td>6'-3&quot;</td>
<td>2'-0&quot;</td>
</tr>
<tr>
<td>Type B</td>
<td>3'-1½&quot;</td>
<td>2'-0&quot;</td>
</tr>
<tr>
<td>Type B</td>
<td>6'-3&quot;</td>
<td>3'-0&quot;</td>
</tr>
<tr>
<td>3-Cable</td>
<td>8'-0&quot;</td>
<td>11'-6&quot;</td>
</tr>
</tbody>
</table>

The Zone of Intrusion (ZOI) is the region measured above and behind the face of a barrier system where an impacting vehicle or any major part of the system may extend during an impact. For a typical TL-3 system, the ZOI extends between 18" and 30" behind the traffic side face of the barrier. Where practical, the designer should keep objects out of this area. See Section 5.5.2, 2011 AASHTO Roadside Design Guide, for additional ZOI guidance.
7.01.21 (revised 10-21-2013)

Guardrail Strength Transitions

Sudden and significant changes in lateral stiffness of a barrier system may cause an impacting vehicle to pocket, if it proceeds from a weaker system to a stronger system. A gradual modification of the deflection characteristics of the barrier is therefore needed. This may be achieved by closer post spacing, heavier barrier elements, larger posts or a combination of these. Illustrated below is a typical transition from Guardrail, Type B to a concrete barrier, filler wall, or barrier railing. The 2011 AASHTO, Roadside Design Guide (page 7-15) advocates that the transition length between joining barrier types should be approximately 10 to 12 times the difference in dynamic deflection. For a difference in deflection of 12", the transition stiffening length should occur in one effective beam element length or 12'-6". See Section 7.01.20 for dynamic deflections.

7.01.22 (10-22-99)

Minimum Guardrail Lengths and Gaps

A free-standing section of guardrail (one not attached to a bridge or other structure) should be at least 100' in length. Greater lengths are recommended; lesser lengths maybe acceptable under low speed conditions. A gap of less than approximately 200' between barrier installations should be avoided. Usually this will require filling in the gap with connecting barrier. An exception would be the unique situation where an approach and trailing ending, separated by a gap, can be buried in a cut slope, and the consequences of a vehicle encroaching on the cut slope would be less than hitting the guardrail filling the gap.

7.01.23 (revised 10-21-2013)

Function of Guardrail Components

It is essential that the designer understand the function of the various components of a guardrail system and some of the principles underlying barrier design details.

Beam height - The 28" top of rail height of single beam systems is a compromise between satisfying the conflicting demand of meeting the centers of gravity of heavier, higher cars and of smaller, lower cars. The use of a second beam element (Type C), or of a wider beam element (Type T), permits the 32" and 34" top of rail heights that cover a broader range of center of gravity heights.
7.01.23 (continued)

Function of Guardrail Components

**Offset block** - Serves two principal purposes, 1) locates beam farther from the post to minimize the possibility of wheel snagging on the post and pocketing in the guardrail, and 2) maintains top of rail height momentarily longer as the post rotates backward under impact, reducing the probability of the vehicle vaulting over the rail. (See page 5-16, 2011 AASHTO, *Roadside Design Guide*).

**Round washer** - Provides an even bearing surface around holes that are often field-drilled and rough.

**Post bolt washer** - To prevent the head of the post bolt from pulling through the beam element. Recent recommendations, nationally, have been to delete the washer, on new construction, to allow the rail to strip off the posts and thus not go down under impact. Washers are now recommended only on the end post of the SRT, or on the end post in a Departing End Terminal.

**Rail splice** - Splices, of course, are unavoidable. They should be at least as strong as the rail itself; all eight connection bolts (twelve in thrie beam) are needed to distribute the load throughout the rail section. Lapped splices are usually such that the outer rail overlaps in the downstream direction, to prevent vehicle snagging.

7.01.24

Accommodation of Expansion

Provision must be made for the movement of guardrail beam elements caused by thermal expansion and contraction. The movement in rail elements is accomplished by means of oblong slots at the splices. Additional expansion at structures is obtained by means of longer slots in the Special End Shoes and Thrie Beam Expansion Section illustrated on Standard Plan R-67-Series (see Section 7.01.16I).
Guardrail Approach Terminals

Crashworthy end treatments are critical to guardrail installations. An approach terminal is designed to redirect an impacting vehicle and to reduce the occurrences of a vehicle being penetrated, rolled, or vaulted in an end on hit. The following section describes the characteristics and uses of approved standard treatments.

A. Type 1 Terminals

Type 1 Guardrail Approach Terminals are flared gating terminals. This is the preferred design when grading limits allow for the appropriate 4'-0" offset of the terminal end from the tangent extension of the standard line of guardrail run. When the Type 1 terminal is called for on plans by reference to Standard Plan R-61-Series, the contractor may use one of two terminal options. Descriptions of the current approved options are described in this section.

1. Slotted Rail Terminal (SRT)

The SRT was adopted by the Department in 1995 when FHWA mandated the discontinued use of the BCT. It subsequently became the first guardrail terminal to pass the NHCRP Report 350 crash test criteria.

The concept of a slotted rail terminal consists of longitudinal slots cut into the W-beam rail element to control the location of dynamic buckling thus reducing the potential for impact or penetration of the occupant compartment by the buckled rail element.

The SRT was originally intended as a retrofit or replacement for the BCT ending.

The SRT uses many of the same components used in the BCT. It also uses features common to other end treatments such as the yoke and strut and controlled release terminal (CRT) posts. The parabolic flare of the SRT is identical to that of the BCT, simplifying the retrofit of existing terminals.

2. Flared Energy Absorbing Terminal (FLEAT)

FLEAT was adopted in 1998 after it passed NCHRP Report 350 crash testing. Among other reasons, it was chosen as an alternate for the SRT because of the similarities in the components and installation configuration of the two systems. In addition to these similarities to the SRT and other flared terminals, the FLEAT includes an energy absorbing impact head. Unlike the SRT, the 4'-0" offset of the FLEAT is a straight taper rather than a parabolic flare.

3. Minimum Offset

The Type 1 Terminal is designed to have a minimum offset of 4'-0", measured from the tangent line of the guardrail run. Whenever conditions allow, the line of guardrail designed in advance of the terminal should be flared to further increase the total offset of the terminal from the traveled lane. On curved roadways the offset is measured from the circular extension of the standard rail alignment along the curve.

Sometimes on certain minor trunklines and a great number of local roads, the end post may have to be placed on the slope beyond the shoulder hinge point, in which case care should be taken that the terminal end shoe and the steel sleeves are not left "high" nor placed too low.

B. Type 2 Terminals

Type 2 terminals are tangent, energy absorbing terminals. They are used when proper grading cannot be achieved to accommodate the 4'-0" offset called for with the Type 1 terminals. When the Type 2 terminal is called for on plans by reference to Standard Plan R-62-Series, the contractor may use one of two terminal options. Descriptions of the currently approved options are described in the following sections.
7.01.25B (continued)

Guardrail Approach Terminals

1. Extruder Terminal (ET)

The ET was installed experimentally by the Department in 1993 and was used occasionally when special situations called for a non flared terminal. In 1995 the ET became the first non-flared terminal to meet the NCHRP Report 350 crash test criteria. Frequent use of the ET led to its upgraded status as a standard plan in 1997. It features an impact head that, when hit head on, flattens the guardrail beam element as the head translates down the terminal rail. The flattened rail is then extruded away from the impacting vehicle.

2. Beam Eating Steel Terminal (BEST)

At the same time the ET was originally approved as a standard, the BEST was chosen as an approved alternate option. Its status as a standard was short lived when the SKT (see succeeding section) replaced it months after its adoption. The BEST featured an impact head that shredded and flattened the rail before extruding it. The developers and patent holders of the BEST discontinued marketing and production of this product shortly after they developed and patented the SKT.

3. Sequential Kinking Terminal (SKT)

The SKT was successfully crash tested in 1997 and adopted by the Department as a standard Type 2 terminal alternate in 1998, replacing the BEST. The materials and configuration of the SKT were more compatible with the ET. Like the FLEAT, its impact head includes a deflector plate that produces sequential kinks in the beam element before extruding it away from the impacting vehicle.

4. Minimum Offset

The original intent of the Type 2 terminals was to provide endings that required no offset. This was the orientation used in the crash tested system. It was later determined by the FHWA that a 12” offset would be acceptable without further testing. This minimal offset was adopted in Standard Plan R-62-Series in order to minimize the number of nuisance accidents that may occur when the impact head was located close to or encroaching on the shoulder.

C. Function of the Various Guardrail Terminal Components

It is important that designers, as well as construction and maintenance personnel, understand the function of the components that make up Guardrail terminals:

**Bearing plate** - Distributes the forces in the cable to the wooden end post and steel sleeve. The slotted bearing plate design featured in the SRT, allows the bearing plate to separate from the cable upon breaking of the wooden end post.

**Terminal End Shoe** - This feature of the SRT absorbs some of the impact forces, spreading them over a wider area, to reduce the potential for the end of the beam element to penetrate the vehicle passenger compartment.
Guardrail Approach Terminals

**Impact head** - The impact head or extruder head absorbs energy in an end on hit. Like the terminal end shoe, it spreads the forces over a wider area.

In addition, the rail element passes through the head and is extruded away from the impacting vehicle. The FLEAT and the SKT head contains a deflector plate that creates sequential kinks in the rail as it passes through. The ET head flattens the rail as it passes through. The bending or flattening dissipates energy while preventing rail penetration into the vehicle.

**Cable** - For downstream impacts, transfers tensile forces from the beam to the base of the end post, allowing the full redirective strength of the rail system to be developed at the third post. For ending impacts the cable is released and serves no purpose.

**Channel Strut** - This strut and yoke distributes the load from the tensioned cable between the first and second post. The strut also contributes to the collapse of the second post during an end on impact.

**Controlled release terminal (CRT) post** - CRT posts are 6” x 8” wood posts with two 3½” diameter holes drilled through the post. One hole is placed at the ground line and the other 1'-4” below the ground, to facilitate fracture of the post during end-on impacts.

**Holes in the two end posts** - These holes are used to weaken the end posts and to allow them to break off close to the ground, when the guardrail ending is struck by an end impacting vehicle. The guardrail ending will likely collapse, thereby reducing spearing and vaulting. The holes have no function for downstream impacts.

**Pipe Insert** - No function for ending impacts. For downstream impacts, distributes vertical component of forces in the cable to the post.

**Slotted Rail Element (SRT)** - The first two panels of rail in the SRT are slotted to provide controlled dynamic buckling. Rail buckling in the SRT is controlled by the length and location of the slots. The controlled buckling of the rail element reduces the potential for the rail to directly impact or penetrate the vehicle occupant compartment.

**Slot guard (SRT)** - Slot guards are installed on the SRT at the downstream end of each set of rail slots. It prevents the bumper or other parts of the impacting vehicle from intruding into and extending the slots.

**Soil plate** - Inhibits movement of the post in the soil; aids in keeping the post from pulling out of the ground.

**Steel sleeves** - For ending impacts, reduces tendency for the post to rotate in the soil; aids in resisting movement so the post will break off at the weakening hole. For downstream impacts, distributes loads from the post to the soil.
7.01.25 (continued)

Guardrail Approach Terminals

D. Guardrail Full Strength Point

When a standard guardrail terminal is used, the length of need is calculated to a point where the guardrail run develops the full strength of the system. This point on the approach end is considered to be the third post from the end (page 5-51, 2011 AASHTO, Roadside Design Guide).

E. Clear Area Behind Guardrail Terminals

When determining the length of need of a guardrail run, the designer should verify that there will be no obstacle behind or to the behind side of a guardrail terminal that would prevent gating.

This is especially true with the Type 1 terminal since it is specifically designed to gate.

The area behind should be traversable for the vehicle after it passes through the terminal. The minimum recovery area behind and beyond a terminal should be an obstacle free area approximately 75' long and 20' wide. If it appears that the area behind will not be traversable, then the guardrail run will probably have to be extended to a point where the area behind the terminal is clear.

F. Burying Ending in a Backslope

Occasionally high cut slopes adjacent to the traveled roadway do not provide sufficient clear area behind a Type 1 terminal to allow gating.

The designer should consider terminating the guardrail inside the backslope. The designer or project manager can obtain a special detail for this treatment from the Design Standards Unit.

G. Slope Under Guardrail Terminals

The area under the terminal should be graded to a 1:10 slope or flatter from the edge of the traveled lane to the shoulder hinge point (2'-0" behind the face of the post). See the appropriate guardrail approach terminal Standard Plans for grading details.
Guardrail Flare

When designing guardrail, the designer should take advantage of opportunities to flare the installation. This reduces the required length of need. It also places the guardrail terminal farther from the traveled lane, thus reducing the potential for nuisance hits.

A. Flare Rate

Historically, 1:15 has been the preferred flare rate for guardrail in Michigan. Other maximum flare rates for semi-rigid barriers are listed on page 5-48 of the 2011 AASHTO, *Roadside Design Guide* and on Standard Plan R-59-Series according to design speed. Flatter flare rates listed by AASHTO for barrier inside the shy line should only be used where it will not increase the length of the guardrail run.

B. Uniform Flare from Structures

Guardrail may need to be flared inward to meet the bridge barrier railing of bridges with narrow shoulders. When the guardrail length at a structure is increased, such as for an embankment, a uniform guardrail flare rate (not flatter than 1:30) may be substituted for the combined short parallel section and the two flared sections. The Illustration at right shows this situation on a left approach rail. When the shielded area in advance of the bridge rail is a steep embankment, the length of need is determined as outlined in Standard Plan R-59-Series. A uniform flare can then be constructed from the end of the tangent length of barrier at the bridge rail (L1) to the first post of the guardrail terminal at offset distance "z".
7.01.30 (revised 8-18-2014)

Guardrail at Embankments

As a general rule, a barrier should be placed to protect a vehicle from going down an embankment only if the barrier itself is the least severe of the two features. Such a comparison must of necessity be very subjective because of the many variables involved. The Department generally follows the criterion that, if the fill slope is 1:3 or flatter, no barrier is required. For slopes of 1:3 or flatter, the height of fill does not increase severity.

A. Height-Slope Guidelines

The economics of earthwork obviously dictate that all slopes cannot be 1:6, regardless of fill height. As the fill becomes higher, more consideration must be given to steepening the slopes, which in turn may call for a decision relative to placing a barrier.

Slopes intended to be traversable, i.e., one flat enough that a barrier can be omitted but still perhaps 1:3, should be relatively free of discontinuities that might "trip up" a vehicle. Plans should note that half-buried boulders and large rocks should be removed as part of the final trimming operation.
7.01.30 (continued)

Guardrail at Embankments

B. Location on Fill Sections (New Construction)

The following shoulder sections with guardrail are shown to clarify and standardize the location of guardrail. Divided highway sections illustrate guardrail on left and right shoulders of each roadway.

* See Section 6.05.04D for paved shoulder widening at guardrail sections.
** The 2' offset from face of guardrail to edge of shoulder should not be used if the paved shoulder width is at least 12'.
7.01.30 (continued)

Guardrail at Embankments

C. Maximum Height of 1:2 Slope Without Barrier

Barrier is not warranted on 1:2 fill slopes up to about 5’ height. See Section 7.01.30A, Height-Slope Guidelines.

D. Flattening Slopes to Eliminate Guardrail

On limited access projects, guardrail may be eliminated if the fill slopes are flattened to 1:4 or flatter. In order to eliminate guardrail on free access projects, the fill slope should also be flattened to 1:4 or flatter, unless additional R.O.W. would be required. If there are no obstacles or severe inclined slopes within the clear zone or at the toe of the fill slope, a 1:3 slope or flatter may then be considered.

E. Length of Barrier at Embankments (New Construction)

When determining the length of barrier required to shield an embankment slope (does not apply to barn roof sections), the designer must first determine the beginning of the 1:4 slope and where the slope steepens to 1:3. Using Standard Plan R-59-Series, which shows flared installations, the limits of the endings can be determined. Field personnel should check the length and slope rate of the fill section and make any necessary adjustments; sometimes the length will be adequate, but it may be necessary to “slide” the barrier one way or the other to fit actual conditions.

7.01.30 (continued)

F. Length of Barrier at Embankments (Upgrading Projects)

When a flared guardrail installation is not feasible and a parallel guardrail installation must be used, the following chart and diagram should be used to determine the length of barrier needed in advance of a 1:3 slope.

<table>
<thead>
<tr>
<th>HEIGHT OF FILL AT 1:3 (ft)</th>
<th>LENGTH OF NEED IN ADVANCE OF 1:3 (ft)</th>
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<td>OVER TO</td>
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**GUARDRAIL AT EMBANKMENTS (PARALLEL INSTALLATIONS)**

**NOTE:** All lengths are in feet.

- SEE SPECIFIC GUARDRAIL ENDING STANDARD FOR POST NUMBER
- LENGTH OF NEED IN ADVANCE OF 1:3
- "HEIGHT OF FILL" MEASURED FROM WHERE SLOPE BEGINS TO TRANSITION FROM 1:3 TO 1:2
- SLOPE TRANSITION FROM 1:3 TO 1:2
- FILL SLOPE

**DIRECTION OF TRAFFIC**
7.01.30 (continued)

Guardrail at Embankments

G. Placing Beam Guardrail on a Downslope

Usually the greater the distance from the roadway that a barrier can be placed, the less chance there is of it being struck and less barrier length will be needed to shield the object. However, placing a barrier on a downslope close to the shoulder hinge point (approximately 12'-0" or less) introduces the potential for the barrier to be less effective because of the tendency for a vehicle, leaving the shoulder, to vault over it. The following guidelines therefore apply:

1. Beam guardrail may be placed on a slope, beyond the shoulder point, if the slope is 1:10 or flatter.

2. Generally, a 1:10 or flatter slope should not be constructed specifically to locate the barrier farther out.

3. Usually, the placement of guardrail on a 1:6 slope is not recommended. There has been one crash test where guardrail was placed on a 1:6 slope, 18 feet off the shoulder point that satisfactorily redirected a vehicle. However, a flatter slope is more desirable. The placing of guardrail on 1:6 slopes should be confined to the applications specified in Section 7.01.32F.

H. Guardrail Placed near Intersecting Streets and Driveways

An intersecting street or driveway located near a roadside object or feature may prevent installation of the full length of barrier required along the main road. An example of this would be a bridge on a main road with an intersecting driveway located near the bridge.

The preferred solution is to close or relocate the intersecting street or driveway in order to install the full length of barrier required along the main road. A crash cushion or other impact attenuating devices may be used to shield a fixed object such as a bridge railing end, however, this may not provide the length of need required to shield other roadside objects or features in the vicinity.

When closing or relocating the intersecting driveway or street is not feasible, two possible solutions are given in the accompanying sketches. A second guardrail run in advance of the intersecting street or driveway should be considered when the vehicle's runout path does not intersect guardrail, or when the runout path intersects the departing terminal or the first 12.5 feet of the approach terminal attached to the curved run of guardrail. See Special Detail 21 for installing a curved guardrail run near an intersecting street or driveway. Also, graphical design methods are suggested when utilizing the proposed solutions depicted in the accompanying sketches.

Site-specific constraints must be taken into consideration when designing guardrail near intersecting streets and driveways. Examples of these constraints include limited intersection sight distance, right-of-way limitations, and the presence of multiple intersecting driveways in close proximity to each other. In addition, the use of excessively short advanced guardrail runs should be avoided. Questions regarding guardrail installations near intersecting streets and driveways should be directed to the Geometric Design Unit of the Design Division.
7.01.30 (continued)

Guardrail at Embankments

VEHICLE’S RUNOUT PATH SHOULD INTERSECT GUARDRAIL (EXCLUDING THE DEPARTING TERMINAL OR THE FIRST 12.5' OF THE APPROACH TERMINAL ATTACHED TO THE CURVED RUN OF GUARDRAIL)

CURVED RUN OF GUARDRAIL

ADVANCED RUN OF GUARDRAIL SHOULD BE CONSIDERED WHEN THE VEHICLE’S RUNOUT PATH DOES NOT INTERSECT THE CURVED RUN OF GUARDRAIL, OR WHEN THE RUNOUT PATH INTERSECTS THE DEPARTING TERMINAL OR FIRST 12.5’ OF THE APPROACH TERMINAL ATTACHED TO THE CURVED RUN OF GUARDRAIL.

CURVED RUN OF GUARDRAIL

ADVANCED RUN OF GUARDRAIL
7.01.31 (revised 10-21-2013)

Shielding Bodies of Water

Warrants for shielding streams or permanent bodies of water are judgment decisions based on location and depth of water and likelihood of encroachment (page 5-9, 2011 AASHTO, Roadside Design Guide). Streams or permanent bodies of water more than 2'-0" in depth will usually require shielding by a barrier if within the clear zone (page 18, 1977 AASHTO, Guide for Selecting, Locating and Designing Traffic Barriers). Barrier may also be required for bodies of water beyond the clear zone if, in the judgement of the designer, there is greater than usual potential for an errant vehicle to enter the water. An exception may be water close to the road for a considerable distance (a causeway is a case in point). In this case, speeds may have been correspondingly reduced because the roadside might be heavily used for recreational access to the water and for fishing. An intermittent barrier leaves many exposed endings to treat and space may not be available for proper flaring of the ends. After all factors are taken into consideration, it may be decided that the disadvantages of a barrier outweigh the advantages.

7.01.32 (revised 10-20-2008)

Barrier at Bridge Approaches (Over and Under)

Besides shielding embankments, the other most common use of a roadside barrier is shielding massive structural components. These fall into two general categories, the overpassing structure (approaches and railings) and the under passing structure (piers, drainage structures, and abutments).

A. Attachment to Barriers and Closer Post Spacings

Guardrail beam elements fastened to concrete structures should overlap the concrete sufficiently to place the end bolts onto the concrete a minimum of 3'-6". This distance is considered necessary to prevent the concrete from shattering and the bolts from pulling loose under impact.

All of the guardrail anchorage, bridge attachments specified on Standard Plans R-67-Series, B-22-Series and B-23-Series increase in lateral stiffness. This is done to keep an impacting vehicle from displacing the guardrail and pocketing against the rigid bridge structure. The transition for lateral stiffness of guardrail is described in Section 7.01.21. Additionally, Standard Plans B-22-Series and B-23-Series use heavier 10 gage (0.138") thrie beam elements to increase barrier strength.
7.01.32 (continued)

Barrier at Bridge Approaches (Over and Under)

B. Relationships Between Bridge Sidewalk and Approach Guardrail

If the bridge approaches are continuously curbed, and the design speed is 40 mph or higher, place the approach guardrail in conjunction with the curb as described in Section 7.01.34. Then carry the rail across the bridge in line with the approach rail, affixed to the sidewalk with metal brackets. If the design speed is 35 mph or less, place the guardrail in general alignment with the bridge railing and connected to it.

If the approaches are not curbed, regardless of traffic speed, place the guardrail at the edge of shoulder, connected to the bridge railing.

7.01.32 (continued)

C. Barrier at the Trailing End of Overpassing Structures

Standard Plan R-59-Series does not show guardrail on the trailing end of bridges carrying one-way traffic. This is because, assuming a 15 degree angle of departure, an errant vehicle can be assumed as being in the area where the "approach" fill slope will be 1:3 or flatter. When a slope steeper than 1:3 occurs, shielding may be required.

Where a roadway carries two-way traffic, approach guardrail is provided because the departing end for one direction is the approach end for the other. The designer should determine if the opposite side railing is within the clear zone, measured from the centerline.

If one or more downspout headers are required on the departing end of a one-way bridge, it will be necessary to shield it with guardrail. This guardrail should extend a minimum length of the Guardrail Departing Terminal beyond the last downspout header.

When a major railing or bridge reconstruction project is programmed, existing 12" high approach curbs on the departing ends of one-way bridges should be removed and replaced with a reduced height curb, unless shielding with guardrail will be required. See current Standard Plan R-32-Series for Bridge Approach Curb & Gutter, Detail 1A.
7.01.32 (continued)

Barrier at Bridge Approaches (Over and Under)

D. Shielding Requirements at Bridge Underpasses

The clear zone criteria presented in Section 7.01.11 is the primary source of information used in determining whether bridge columns or abutments require shielding. Because a clear zone distance cannot always be determined precisely, it may happen that a fixed object thought to be outside the clear zone may need shielding. When this occurs, the designer must determine a method to shield them. Accepted methods for shielding are specified on the standard plans. If the only requirement is to shield the bridge pier or abutment, the barrier length should be calculated using the information found in Section 7.01.05G.

Current bridges are usually designed with longer spans, so that bridge columns and abutments can be placed outside the clear zone. Even when spans are increased, not all bridge columns and abutments can be located outside clear zones. An example might be where a widened clear zone results from a bridge being located over a curved roadway.

Currently, the approach bridge fill, behind the abutment, is designed to have a 1:6 slope facing oncoming traffic on the road below. However, when the approach slope is not 1:6 or flatter, additional barrier may be required to obtain the required runout length used in the above formula.

7.01.32 (continued)

E. Guardrail Median Object Protection

Standard Plan R-56-Series illustrates an enclosed guardrail system for shielding objects such as bridge piers and sign supports in medians 36’ to less than 70’ in width. The system encloses the median objects between two parallel runs of thrie beam guardrail converged and terminated at each end with a Type 3 approach terminal (Standard Plan R-63-Series). This design replaces the past versions of Standard Plan R-56-Series featuring the Minnesota Bullnose design. The current standard also provides details for a direct connection to filler walls. This connection detail requires construction of concrete end walls and reduces the overall guardrail length required.

Standard Plan R-56-Series also details a treatment for shielding the opening between twin-bridge approaches. For wider medians at twin bridge approaches, the guardrail configuration specified on Standard Plan R-59-Series should be used.
7.01.32 (continued)

**Barrier at Bridge Approaches**
**(Over and Under)**

**F. Bridge Columns and Foundations in 70’ Medians**

Bridge columns and sign support foundations located in the center of 70’ medians were once considered outside the clear zone. Shielding is now required and should be included in any programmed project upgrading.

The treatment for shielding columns and foundations for new construction and reconstruction projects should be according to the enclosed system designs shown on Standard Plan R-56-Series, Guardrail Median Object Protection.

In addition to the enclosed systems discussed in the previous section, an open system is detailed in Standard Plan R-56-Series for other than new construction and reconstruction projects with 70’ medians and existing fill slope rates of 1:6 or flatter. This detail features twin parallel guardrail runs that shield the median objects independently for each direction of traffic. This option offers the advantage of better accessibility for maintenance equipment to service the median or sign foundations. It is intended only for the conditions stated above.

7.01.33 (revised 10-21-2013)

**Maintaining Guardrail Strength When One or More Posts Must Be Omitted**

**A. Downspout Headers**

Standard Plan R-32-Series, under “Notes”, advises field personnel to determine the location of proposed guardrail posts prior to locating the spillway or downspout header(s). If this is done, there will be no conflict. There are occasions however, when miscalculation in construction layout or when upgrading guardrail, that an existing downspout header will prevent a post from being placed at the proper spacing. Downspout headers that were constructed prior to 1970 and according to Standard Plan E-4-A-144 series, are an example. These downspouts had deeper throats and were designed to fit 12'-6” post spacing. When a post cannot be properly placed, Standard Plan R-72-Series, “W-Beam Backed Guardrail Installations” should be used.

**B. Wide Culverts**

Maintaining the continuity of the barrier strength is also necessary when a run of guardrail spans a wide culvert and the proper embedment of a guardrail post(s) cannot be obtained. When the spanning of a wide culvert requires the omission of one or two posts, Standard Plan R-72-Series, "W-Beam backed Guardrail Installations" should be used. Where no barrier wall exists and the span is over 18'-9", Standard Plan R-73-Series, "Guardrail over Box or Slab Culverts" may be used.
Maintaining Guardrail Strength When One or More Posts Must Be Omitted

C. Placing Guardrail in Rock

Rock formations, which occur more frequently in the Upper Peninsula, may prevent the full embedment of guardrail posts. When only a partial embedment of posts can be obtained, backing the guardrail according to the method illustrated in Standard Plan R-72-Series is an option to individually drilling each hole. If the number of post locations in the influence of the rock formation would force the length of the backed guardrail section to exceed that allowed in the standard, the affected posts holes will have to be drilled. If the depth of soil overlying the rock formation is 18" or greater, the hole diameter required for steel posts is 8" (12" for wood) and full post embedment depth is required. If the depth of soil overlying the rock formation is less than 18", the hole diameter required for steel posts is 21" (23" for wood) and a 24" embedment depth into the rock is required. A strong-post W-beam guardrail exhibits better performance if the post is allowed to rotate in the soil. Thus, the post should not be placed in the center of the hole, but at the front, so the backfill is behind the back of the post. This work should be included by special provision.
**7.01.33 (continued)**

**Maintaining Guardrail Strength When One or More Posts Must Be Omitted**

**D. Guardrail Posts through Paved Surfaces**

Guardrail posts embedded into paved surfaces present a problem similar to that of guardrail posts in rock formations. The paved surface will not allow the posts to rotate in their embedment (to distribute vehicle loads through the post into the embedment material) prior to breaking. Thus, an area of pavement around the post known as "leave out" must be omitted to allow the post to rotate. For both steel and wood posts, the size of the leave out should be an area of about 15" x 15" (square or round). The most critical measurement is the distance from the back of post to the back edge of the leave out, which should be a minimum of 7". After post installation, patching material is generally placed around the guardrail post in the "leave out" area. This work should be included by special provision.

**7.01.33 (continued)**

**E. Additional Blockouts on Guardrail Posts**

Double blockouts (16" deep) may be used to increase the post offset to avoid obstacles such as curbs. Except at terminals, there is no limit to the number of posts in a guardrail run that use double blockouts. Under special circumstances, one or two posts in a run of guardrail may employ as many as four blockouts (up to 36") to provide proper clearance. There should be no voids between blockouts when using double or multiple blockouts. Furthermore, for aesthetic reasons, double or multiple blockouts should be installed without creating sudden changes in guardrail alignment.

When using double or multiple blockouts, steps must be taken to prevent the placement of guardrail posts on steep fill slopes beyond the shoulder hinge point. Placing conventional length guardrail posts on steep fill slopes may result in posts having insufficient soil embedment depth, thereby reducing the post's strength to resist overturning. See **Section 7.01.41.D, 8'-0" Posts**, for guardrail post length requirements when placing guardrail at or near the shoulder hinge line.
Guardrail in Conjunction with Curb

When a vehicle strikes a curb, the trajectory of that vehicle depends upon several variables including the size and suspension characteristics of the vehicle, its speed and angle of impact, and the height and shape of the curb itself. Generally, the use of curb on high speed roadways (design speed greater than 50 mph) is discouraged.

If guardrail/curb combinations are used when design speeds are less than 45 mph, the curb height should be 6" or less, with the face of guardrail being located either flush with the face of curb or at least 8' behind it.

For design speeds of 45 mph or 50 mph, a 6" curb (or less) may be used if the guardrail is located flush with the face of curb. If an offset from the curb is desired, the curb height should be 4" or less with the guardrail being located at least 13' behind the curb.

If guardrail/curb combinations are necessary when the design speed is greater than 50 mph, a mountable curb (Type D curb or valley gutter) should be used, and the curb height should be 4" or less, with the face of guardrail being located flush with the face of curb.

When guardrail is located flush with the face of curb, the rail height should be measured from the front edge of the gutter pan, which is the point on the gutter pan that is closest to the edge of the traveled lane. At greater distances (typically 8'-0" to 13'-0") the rail height should be measured from the ground just in front of the guardrail.
7.01.40  
Guard Posts for Roadside Control

Barrier systems should not be used merely for roadside control. Where it is impractical to use curb for this purpose, wooden posts without connecting beam elements will suffice. These posts should be weakened by adding two 3½” diameter holes, through the 8” face and 6” apart, with the bottom one about 1” above the ground. The holes should be perpendicular to traffic. Posts may be about 5'-0” apart or as necessary to control traffic in the specific situation. See Standard Plan R-74-Series.

7.01.41 (revised 10-20-2008)  
Upgrading and Replacement of Guardrail

The upgrading and replacement of existing guardrail runs is a leading construction item in Michigan. Two principle reasons for updating are an obsolete design or because of changed conditions, e.g., a guardrail made too low by resurfacing the shoulder.

A. Guidelines for Upgrading or Replacing Guardrail

1. If entire runs of guardrail must be replaced because the guardrail is out of specifications or cannot be adjusted to meet specifications, then the guardrail should be replaced following the current MDOT recommendations as called for in Section 7.01.12.

2. Height adjustment may be made on existing guardrail posts that pass a thorough inspection for soundness. Existing beam elements should be evaluated for expected life and may be used if they meet current design standards. If the existing guardrail cannot be made to meet these conditions, then the entire run should be replaced with new guardrail using the recommended type from Section 7.01.12.
Upgrading and Replacement of Guardrail

3. When replacement of the existing guardrail on freeway ramps is necessary, use Type T. If a continuous guardrail run is needed up to and along the crossroad, transition the Type T to Type B at a point 50'-0" minimum from the edge of the crossroad for a "T" type ramp terminal. For a continuous run through a free-flow ramp, transition to Type B opposite the 2'-0" point in the gore. This should be done at both on and off ramp terminals. The transition to Type B is to provide as much sight distance as possible at the ramp terminals.

4. Height adjustments may be made to Type T guardrail meeting the conditions stated in 2 of this section. If the existing posts are too low to allow the thrie beam rail to be placed at the proper height, then new Type T should be installed.

The placing of the upper bolt shall not be closer than 2" from top of wood or steel posts. See the following illustrations.
7.01.41A (continued)

Upgrading and Replacement of Guardrail

B. Upgrading Guardrail Terminals

A 1999 federal mandate required the replacement of Breakaway Cable Terminals (BCT) on 3R projects on the NHS. Along with a 1995 mandate that required the replacement of blunt ends and turned down endings, this expedites the elimination of all guardrail terminals that do not meet the crash test criteria of NCHRP Report 350.

BCT’s shall be upgraded to current standard terminals on all 3R projects on the NHS and all NHS projects that include guardrail work. See Standard Plans R-61-Series and R-62-Series for details of approved terminals. Existing BCTs on Non-NHS projects that include guardrail work shall be upgraded to current standard terminals except existing BCTs on Non-NHS 3R projects will not require replacement if they are in good condition, properly installed and preceded by a flared guardrail run. This is summarized in the following table:

<table>
<thead>
<tr>
<th>BCT Replacement Policy</th>
<th>NHS</th>
<th></th>
<th></th>
<th></th>
<th>Non NHS</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3R</td>
<td>New or Reconstruct</td>
<td>3R</td>
<td>New or Reconstruct</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Guardrail Work Included</td>
<td>No Guardrail Work Included</td>
<td>Guardrail Work Included</td>
<td>No Guardrail Work Included</td>
<td>Guardrail Work Included</td>
<td>No Guardrail Work Included</td>
<td>Guardrail Work Included</td>
<td>No Guardrail Work Included</td>
</tr>
<tr>
<td>Existing flared installation.</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>No Upgrade required</td>
<td>No Upgrade required</td>
<td>Upgrade</td>
<td>No Upgrade required</td>
<td></td>
</tr>
<tr>
<td>Existing non-flared installation.</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>No Upgrade required</td>
<td>Upgrade</td>
<td>Upgrade</td>
<td>No Upgrade required</td>
<td></td>
</tr>
</tbody>
</table>
7.01.41B (continued)

Upgrading and Replacement of Guardrail

These guidelines do not apply to Capital Preventive Maintenance (CPM) projects. Safety Criteria for CPM projects are covered under a separate agreement with the FHWA.

Maintenance forces are to replace a damaged BCT with an approved terminal from Standard Plan R-61 or R-62-Series.

C. Intermixing Wood and Steel Posts

At the present time, the Standard Specifications permit the use of either wood or steel guardrail posts. Both types of posts may be randomly intermixed in making repairs on Types A, B, and T guardrail, but, for appearance, complete runs being reconstructed should utilize only one type of post. Wood and steel posts for types BD and TD cannot be intermixed because of post size.

Posts in terminals shall be the same as those specified on Standard Plans R-61-Series, R-62-Series, R-63-Series and R-66-Series. When the repair of an existing bullnose installation is necessary, wood posts shall be used.

D. 8'-0" Posts

Guardrail upgrading on local roads and trunklines sometimes requires setting the posts at the shoulder hinge line rather than 2'-0" (shoulder hinge point to front face of post) onto the shoulder as specified on Standard Plan R-60-Series. Most of the time this condition occurs on a fill, which means that the soil support behind the post will be reduced because of the close proximity of the slope. In these cases, 8'-0" long posts should be specified. If the ground does not fall away behind the guardrail, then conventional length posts are sufficient.

7.01.41B (continued)

E. Allowable Variation from Standard Height

When evaluating existing guardrail to determine upgrading needs, variation from standard barrier height is a consideration. A variation of 3" from the standard height is allowable. This is considered a functional variation. Closer tolerances are expected for construction purposes. If an existing guardrail is of the proper type, and after all phases of the proposed project are complete, e.g., shoulder resurfacing, etc., the guardrail height should be within this limit. If any work must be done on it at all, however, then the run should be brought up to standard. Before allowing such a run of guardrail to remain untouched, it should pass a thorough inspection for the soundness of posts and the expected remaining life of the beam elements. The timing of future road improvements should also be a consideration.

F. Unpainted Corrosion Resistant Beam Elements

See Section 7.01.14B. The Engineering Operations Committee meeting on January 20, 1989 decided that all existing corrosion resistant, or "rusty steel", guardrail encountered on proposed Interstate resurfacing or reconstruction projects should be removed and replaced as part of the project.

On projects involving bridges only, the nominal provisions of approach guardrail (guardrail anchorage to bridge and approach terminal) shall be replaced if the rail elements are rusty steel. Where guardrail at the bridge approaches is part of a more extensive installation, the decision to replace will be made on the merits of the specific project.
7.01.41 (continued)

Upgrading and Replacement of Guardrail

G. Thick Shoulder Lifts

Rehabilitation of rural freeways often entails placing a new concrete pavement on top of the old, or placing a thick HMA overlay. This procedure also raises the shoulder elevation, thus causing the existing guardrail to be too low. When this occurs, the designer is reminded that provisions should be made to either reconstruct or upgrade the guardrail.

If reconstruction of the guardrail must precede the pavement lift by a year or so; the designer may be tempted to call for longer than normal posts, leaving them with tops protruding so that they will be long enough to fit the ultimate installation. This should not be done; crash test films frequently show the impacting vehicle laying over on the rail and sliding along it. Protruding post tops would thus have a detrimental effect on smooth redirection of the vehicle.

H. Type A Guardrail Parallel to Continuous Abutment, Twin Overpassing Structures

It was practice for a number of years to place Type A guardrail in front of the opening between twin overpassing structures, parallel to the continuous abutment and about 4'-0" in back of it. Current standards provide either a length or a configuration of guardrail that eliminates the need for this transverse section of barrier. On an updating project, if this transverse barrier is still in place and in good condition, it may be left as a deterrent to persons or animals who could accidentally fall over the backwall. If the condition of the barrier warrants removal, it should be removed and not replaced.

7.01.41 (continued)

I. Replacing with Thrie Beam Guardrail

Even though Type T (thrie beam) is the current "standard" guardrail for use on freeways, Type B or Type C guardrails do not need to be replaced on freeways, if there are no physical deficiencies.

7.01.43

Guidelines for Bridge Railing Replacement and Attached Approach and Trailing Guardrails

See Chapter 12 of the Bridge Design Manual.

7.01.44 (revised 10-22-99)

Guardrail Upgrading on Local Roads

A. Guardrail Upgrading Guidelines on Local Roads (In Conjunction with Freeway Work)

In conjunction with work programmed on a freeway, the Department may have occasion to upgrade guardrail on roads that are under local jurisdiction. Generally, the guardrail will be constructed to "trunkline standards" with respect to the type of guardrail and the type of ending. Depending on site conditions, the location and configuration of the guardrail used on local roads may not necessarily be to "trunkline standards".

The Department attempts to prevent errant local road traffic from encroaching on the freeway and its appurtenances. The following guidelines have been established for upgrading guardrail on local roads over and under freeways.
**ROAD DESIGN MANUAL**

**ROAD DESIGN**

7.01.44A (continued)

**Guardrail Upgrading on Local Roads**

1. If the major work is on the crossroad, the approach guardrail will be upgraded. For ADT less than 2000 and the operating speed 50 mph or less, 200' of approach guardrail can be considered as satisfying the runout length \( (L_R) \) from the bridge railing end, pier or abutment. See table for runout length \( (L_R) \) in Section 7.01.19. If the ADT on the crossroad exceeds 2,000 or the operating speed exceeds 50 mph, the type of guardrail shall be as specified in Section 7.01.12 and the lengths computed using the worksheet in Section 7.01.05F. If the total length of the existing run is not more than 100' longer than the computed length, then the entire run should be constructed. If the run is considerably longer, then simply connect the upgraded guardrail to the existing guardrail at the 200' cut-off point.

2. If the major work is on the freeway, then no guardrail upgrading need be done on local roads, over or under, except in interchange areas. The limits of upgrading the guardrail in interchange areas should be between the crossroad ramp terminals.

3. When the major work is on the freeway, upgrading older local road bridge railings with guardrail retrofits or new railings will not be required. See Chapter 12 of the Bridge Design Manual for instructions on bridge rail upgrading.

4. A typical urban depressed freeway will generally not require a guardrail installation or upgrading because the local street is probably at grade with the service streets on each side of the freeway and the bridge railing endings are a short distance from the edge of the intersecting service streets. These local streets are usually curbed and traffic is restricted to speeds less than 50 mph (usually 25 mph to 35 mph). In addition, low crash frequency and possible obstruction to vision also works against the use of guardrail in this situation. This is not to prohibit the use of a barrier at such approaches if different circumstances suggest the need.

**B. Cul-de-sacs**

Provide 75' of Type A guardrail at cul-de-sacs when a rural freeway intersects a local road and no grade separation is provided. See Section 12.07.03 for a typical cul-de-sac. Terminal end shoes are placed at each end. The purpose of this guardrail is to alert the motorist using the local road that the road is not continuous.

**C. Guardrail at Urban Service Road "T"**

It was practice for many years to place a short section of guardrail adjacent to the fence opposite local streets dead-ending into urban service roads. This guardrail serves very little purpose because it will not stop a high-speed vehicle going through the intersection from the local street, and it is an additional obstacle for a vehicle to hit while traveling on the service road. It is therefore being omitted on new construction. Instead, a directional arrow sign is usually placed at the fence, and shrubs may be planted behind the fence to act as a screen or visual barrier.
7.01.44 (continued)

Guardrail Upgrading on Local Roads

D. Cable on Chain Link Fence

Cable on chain link fence consists of attaching 2 steel cables to a chain link fence. This treatment may be useful in urban freeway areas where a local street ends at a service road and where a chain link fence is located parallel between the freeway and service road. Its possible use might be at locations where there is greater than usual potential for an errant vehicle to go down onto the freeway. Details are available from the Standards Unit.

7.01.45 (revised 10-21-13)

Alternative Barrier End Treatments

All the terminals discussed in this section have been crash tested as recommended by NCHRP Report 350 and approved by FHWA. As with all terminals where penetration behind and beyond the barrier can be expected, a traversable area, free of fixed objects, is recommended to aid post-crash vehicle stability. Alternative endings should be considered where restrictive site conditions exist, such as bi-directional traffic or two-sided directional traffic, and where the designer is unable to obtain the required offset, length, etc.

Note that this is not a comprehensive list of all alternative barrier end treatments, and future developments in the roadside safety industry will likely result in the availability of additional barrier end treatments. Consult with the Geometric Design Unit, Design Division, for additional information regarding alternative barrier end treatments.

7.01.45 (continued)

A. X-Tension / X-MAS

The X-Tension and X-MAS (X-Tension Median Attenuator System), respectively, are guardrail terminals manufactured by Barrier Systems (a Lindsay Corporation company), Vacaville, California. Both guardrail terminals are NCHRP 350, Test Level 3 compliant. The X-Tension may be installed as a flared or a tangent guardrail terminal for ending single-sided guardrail. The X-MAS is available for terminating double-sided guardrail.

The X-Tension and X-MAS terminals are non-gating terminals, so the beginning length of need point starts at the first guardrail post. As a result, the X-Tension and X-MAS may be desirable at locations where a redirective, non-gating guardrail terminal is considered advantageous due to site-specific conditions.

Detailed information on design, installation, and maintenance is available from the Geometric Design Unit, Design Division.

B. X-TENuator

The X-TENuator is an NCHRP 350, Test Level 3 compliant crash cushion manufactured by Barrier Systems (a Lindsay Corporation company), Vacaville, California. The X-TENuator may be used for both permanent and temporary applications, and may be used to terminate single-sided guardrail, double-sided guardrail, and concrete barriers. The X-TENuator is approximately 24'-9" long, and requires a concrete or asphalt base pad for installation. While the X-TENuator has a relatively low installation cost compared to other crash cushions, this device is considered to be a sacrificial unit that generally requires complete removal and replacement after a vehicular impact.
Alternative Barrier End Treatments

The X-TENuator may be desirable for restrictive site conditions, such as shielding concrete barrier or bridge railing endings at locations that prevent the installation of a traditional guardrail bridge anchorage and guardrail approach terminal. Designers should note that the X-TENuator requires 12'-6" of longitudinal clear space behind the unit on both sides of the object being shielded in order for the side panels of the X-TENuator to slide back and telescope when the unit is impacted.

Detailed information on design and installation is available from the Geometric Design Unit, Design Division.

C. QuadTrend™

The QuadTrend system is a proprietary terminal manufactured by Energy Absorption Systems Inc. This device is for one-sided directional traffic and is intended for shielding concrete barrier endings, bridge railing endings, abutments, etc. This device can be attached directly to a rigid ending without a guardrail strength transition. Detailed design, construction and maintenance information is available from the Geometric Unit, Design Division.

D. BEAT-SSCC

The BEAT-SSCC (Box Beam Bursting Energy Absorbing Terminal Single-Sided Crash Cushion) is an NCHRP 350, Test Level 3 compliant terminal manufactured by Road Systems Inc., Big Springs, Texas.

The BEAT-SSCC may be used for both permanent and temporary applications, and is intended for use as a single-sided terminal for shielding concrete barrier, bridge abutments/piers, and certain types of bridge railings. The BEAT-SSCC is available in the following lengths: 28’, 32’, 36’, 40’, and 44’. The BEAT-SSCC is available with driven (ground-mounted) posts or with surface-mounted posts for installation on a concrete surface. While the BEAT-SSCC has a relatively low installation cost compared to other crash cushions, this device is considered to be a sacrificial unit that generally requires complete removal and replacement after a vehicular impact.

The BEAT-SSCC may be desirable for restrictive site conditions, such as shielding concrete barrier or bridge railing endings at locations that prevent the installation of a traditional guardrail bridge anchorage and guardrail approach terminal.

Detailed information on design and installation is available from the Geometric Design Unit, Design Division.
Temporary Beam Guardrail

Temporary beam guardrail consists of a W-beam attached directly to posts at 12'-6" spacing. Materials, including posts, may be of salvaged origin, and removal is included in the pay item. It is used on construction projects where traffic is maintained along the existing road. While temporary concrete barrier is now used to a great extent, temporary guardrail only costs about half as much and is more conveniently available in the northern outstate area. Temporary beam guardrail is called for on plans when so requested by the Region/TSC. Specific locations are seldom shown on plans, but a lump sum quantity is shown for the entire project on the Note Sheet, as follows:

Guardrail, Type __, Temp ____ ft
(To be used to protect traffic as directed by the Engineer)

Do not estimate less than 200' total for a project, in order to avoid a very small quantity and an exorbitant unit price.

Temporary beam guardrail usually is not placed less than 6'-0" from the edge of traffic-carrying lanes. It may be used in areas where the pavement is located 20'-0" or less from the edge of excavations that exceed 5'-0" in depth, and which have a vertical face or slope of 1:2 or steeper.

If possible, endings of Temporary Beam Guardrail should be curved away from traffic, much like temporary concrete barrier.
Warrants for Median Barriers on Freeways

Double thrie and double W-beam steel guardrail (semi-rigid), concrete median barrier (rigid) and Cable (Flexible) are considered equally suitable for reducing cross-median crashes. However, each has its application and each has its advantages and disadvantages. The designer should be knowledgeable of these when making decisions relative to which type of barrier to call for. The most desirable system is the one that satisfies the performance requirement and costs the least to install and maintain. Section 5.2 of the 2011 AASHTO Roadside Design Guide summarizes the major factors which should be considered before making a final selection. The current median barrier warrants formulated for placing barrier in freeway medians were developed by the former Traffic and Safety Division, accepted by the Barrier Advisory Committee and approved by the Engineering Operations Committee at their February 4, 1992 meeting. The warrant table is shown below:

![Diagram of median barrier on freeways with traffic volumes and median width.

**Warranted** if major reconstruction.

**Warranted** without major reconstruction.

Average daily traffic (thousand) based on a 5 year projection.
7.01.55 (revised 10-21-2013)

Median Barrier Types

Median barriers, when used, are employed almost exclusively on controlled access highways. If the road is free access, openings would have to be provided at intersections and crossovers. This means that the barrier must be terminated at these points with a crash worthy end treatment. The lengths of the end treatments must be added to the length of the opening thus increasing the length of unprotected median, as the end treatments provide only marginal median crossover protection.

Generally, the initial installation cost of concrete median barrier is about 10-15% more than a double-sided metal guardrail. (However, this comparison does not include the possible additional cost of drainage alterations, etc., that might be required in conjunction with concrete barrier.)

Advantages and disadvantages for the three barrier systems are as follows:

A. Concrete Median Barrier

Advantages

1. Very low maintenance.
2. Relatively good visibility.
3. Less vehicle damage at low angles of impact.
4. Easier on which to affix glare screen (glare screen can be integrally cast)

Disadvantages:

1. Greater “snow fence” effect (wind cannot pass through)
2. Traps blowing paper and trash
3. Usually requires some form of internal drainage

B. Double Steel Beam Guardrail

Advantages

1. May be used in the wider medians (median width not a factor)
2. Less “snow fence” effect than concrete barrier
3. Lateral drainage can flow under
4. Performs better than concrete barrier for high angle impacts

Disadvantages:

1. Maintenance repair usually required after a hit
2. Harder to install in rock
3. No durable glare screen available for mounting on top

C. Cable Barrier

General Guidelines

- Cable median barrier is recommended on divided roadways where:
  1. Median crossover crashes have been reported, and
  2. Median barrier is not warranted based on Section 7.01.54 of the Michigan Road Design Manual.
- Median width should be a minimum of 30 feet.
- Median slopes shall be 1:4 or flatter.
- The cable barrier shall be placed at a location that permits the system to deflect unimpeded during a vehicular impact. The cable barrier shall not interfere with opposing traffic or other roadside objects during a vehicular impact. If a single run of cable barrier cannot satisfy the offset requirements, dual runs should be used.
- At locations where both NCHRP 350, TL-3 and TL-4 cable systems may be installed, NCHRP 350, TL-4 cable systems are preferred.
7.01.55C (continued)

Median Barrier Types

- The length of need (LON) for cable median barrier is based on engineering judgment. Consult with the Geometric Unit of the Design Division for additional information.
- Due to the advantages high-tension cable systems possess, high-tension cable systems are preferred over low-tension cable systems.

Approved Cable Median Barrier Systems

The following cable barrier systems are approved for use as median barrier. Questions regarding cable median barriers should be directed to the Geometric Unit of the Design Division.

A. Low-Tension Three-Cable Median Barrier (Type M Cable Barrier per Standard Plan R-70-Series)

This is a non-proprietary cable system that is described in the 2011 AASHTO Roadside Design Guide and MDOT Standard Plan R-70-Series. This design has been adopted by various agencies throughout the nation. The cable system and the end terminals have been successfully tested to NCHRP 350, TL-3.

**Advantages:**

1. Non-proprietary, usually less expensive than proprietary items
2. May be used on curved roadways with radii as low as 110 feet

**Disadvantages:**

1. Generally requires more maintenance than high-tension cable systems
2. System is usually inoperative after an impact (i.e., requires immediate inspection and maintenance after an impact)
3. Larger impact deflection compared to high-tension cable systems
4. Maximum length between terminals is considerably smaller than high-tension cable systems

### Table 1:

<table>
<thead>
<tr>
<th>DESIGN CRITERIA FOR LOW-TENSION THREE-CABLE MEDIAN BARRIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Flare Rate</td>
</tr>
<tr>
<td>Minimum Design Deflection Distance</td>
</tr>
<tr>
<td>Minimum Offset Between Median Ditch Line and Cable Barrier (Single Runs Only)</td>
</tr>
<tr>
<td>Maximum Length Between Terminals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Post Spacing and Roadway Curvature Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>RADIUS POST SPACING</td>
</tr>
<tr>
<td>Less than 110 feet</td>
</tr>
<tr>
<td>110 feet to 219 feet</td>
</tr>
<tr>
<td>220 feet to 699 feet</td>
</tr>
<tr>
<td>700 feet or more and Tangent Sections</td>
</tr>
</tbody>
</table>
7.01.55C (continued)

Median Barrier Types

B. High-Tension Cable Median Barrier

CASS Cable System
The CASS cable system is a proprietary, high-tension cable barrier manufactured by Trinity Industries, Inc. The system is available with either C-shaped or I-shaped steel posts, driven into the ground or installed in concrete post foundations with a sleeve of steel. I-shaped steel posts can be spaced farther apart than C-shaped posts, thereby requiring fewer posts and lowering the overall installation cost. However, it is necessary to use C-shaped posts along curved roadways with radii less than 1,300 feet. C-shaped and I-shaped steel posts may not be intermixed on an individual run of cable barrier.

Three ¾” diameter pre-stretched cables are placed in a slot at the top of the post and kept apart by spacers of recycled plastic. The cables are tensioned according to cable temperature.

The CASS cable system is available in both NCHRP 350, TL-3 and NCHRP 350, TL-4 versions rated for 1:6 slopes or flatter. CASS is also available in an NCHRP 350, TL-3 version rated for 1:4 slopes or flatter. In addition, the CASS cable terminal (CCT) is an NCHRP 350, TL-3 compliant end terminal for use with the CASS cable system.

Gibraltar Cable System
The Gibraltar cable system is a proprietary, high-tension cable barrier manufactured by Gibraltar Cable Barrier Systems, LP. The system consists of steel posts, driven into the ground or installed in concrete post foundations with a sleeve of steel. Gibraltar manufactures both three-cable and four-cable systems. ¾” diameter prestretched cables are attached to the posts and kept at the appropriate height by devices called "hairpins," which are unique to Gibraltar. The cables are tensioned according to cable temperature.

The Gibraltar cable system is available in both NCHRP 350, TL-3 and NCHRP 350, TL-4 versions rated for 1:6 slopes or flatter. Gibraltar also manufactures an NCHRP 350, TL-3 cable system rated for 1:4 slopes or flatter. In addition, the Gibraltar cable terminal is an NCHRP 350, TL-3 compliant end terminal for use with the Gibraltar cable system.

Brifen Cable System
The Brifen cable system is a proprietary, high-tension cable barrier manufactured by Brifen USA, Inc. The system consists of steel posts, driven into the ground or installed in concrete post foundations with a sleeve of steel, and four ¾” pre-stretched cables. Three of the four cables are woven on alternating sides of sequential posts over the entire segment length. The cables are tensioned according to cable temperature.

The Brifen cable system is available in both NCHRP 350, TL-3 and NCHRP 350, TL-4 versions rated for 1:6 slopes or flatter. Brifen is also available in an NCHRP 350, TL-3 version rated for 1:4 slopes or flatter. In addition, the Brifen WRGT end terminal is an NCHRP 350, TL-3 compliant end terminal for use with the Brifen cable system.

Safence Cable System
The Safence cable system is a proprietary, high-tension cable barrier manufactured by Safence, Inc. The system consists of steel posts, driven into the ground or installed in concrete post foundations with a sleeve of steel. Safence manufactures both three-cable and four-cable systems. ¾” diameter pre-stretched cables are placed in a slot at the top of the post and kept apart by spacers of recycled plastic. The cables are tensioned according to cable temperature.

The Safence cable system is available in both NCHRP 350, TL-3 and NCHRP 350, TL-4 versions rated for 1:6 slopes or flatter. In addition, the Safence cable terminal is an NCHRP 350, TL-3 compliant end terminal for use with the Safence cable system.
7.01.55C (continued)

Median Barrier Types

**Advantages:**

1. Typically impact deflection is 10 feet or less
2. Generally requires less maintenance than low-tension cable systems
3. Compared to low-tension cable barrier, high-tension cable barrier has a much higher probability of remaining operative after an impact

**Disadvantages:**

1. Systems are proprietary; more expensive than low-tension cable systems
2. System may be inoperative after an impact (i.e., usually requires immediate inspection and maintenance after an impact)
3. System is limited to curved roadways with radii of 650 feet and greater

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### Table 2: DESIGN CRITERIA FOR HIGH-TENSION CABLE MEDIAN BARRIER

<table>
<thead>
<tr>
<th><strong>Maximum Flare Rate</strong></th>
<th>30:1</th>
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<tbody>
<tr>
<td><strong>Minimum Design Deflection Distance</strong></td>
<td>12 feet</td>
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<tr>
<td><strong>Minimum Offset Between Median Ditch Line and Cable Barrier (Single Runs Only)</strong></td>
<td>10 feet</td>
</tr>
<tr>
<td><strong>Maximum Length Between Terminals</strong></td>
<td>26,400 feet (5 miles)</td>
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<tr>
<td><strong>Post Spacing and Roadway Curvature Requirements</strong></td>
<td><strong>RADIUS</strong></td>
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<tr>
<td></td>
<td>Less than 650 feet</td>
</tr>
<tr>
<td></td>
<td>650 feet and greater</td>
</tr>
</tbody>
</table>
7.01.55C (continued)

Median Barrier Types
7.01.55C (continued)

Median Barrier Types

MEDIAN SLOPES 1:4 OR FLATTER

FOR CABLE SYSTEMS RATED FOR INSTALLATION ON 1:4 SLOPES
MEDIAN SLOPES 1:6 OR FLATTER ON ONE SIDE AND STEEPER THAN 1:6 ON THE OTHER

LOW TENSION CABLE BARRIER OR HIGH TENSION SYSTEMS RATED FOR 1:6 SLOPES OF FLATTER
Median Barrier Types

DUAL RUNS ON MEDIAN SLOPES 16 OR FLATTER
Median Barrier Types
7.01.55C (continued)

Median Barrier Types
7.01.55C (continued)

Median Barrier Types
7.01.55C (continued)

Median Barrier Types

OPTION 1

* EITHER OPTION IS ACCEPTABLE

OPTION 2

RECOMMENDED CABLE BARRIER PLACEMENT ON CURVED ROADWAYS

R < 5720' WITH INCREASING EMBANKMENT HEIGHT OR MEDIAN SLOPES STEEPER THAN 1:4
7.01.55C (continued)

Median Barrier Types

RECOMMENDED CABLE BARRIER PLACEMENT ON CURVED ROADWAYS

\[ 5.000' \leq R \leq 11.460' \]

\[ R < 5.000' \text{ with equal embankment height and } 1:4 \text{ or flatter median slopes} \]
Concrete Median Barriers

A. GM Shape

The first concrete barrier shape used in Michigan was developed by General Motors. Sections of the GM barrier shape still remain in use, but is no longer being built on new construction projects. It was replaced by the New Jersey shape on Standard Plan II-49D in 1976.

The key design parameter for a safety shape barrier is the distance from the ground to the slope break point because this determines how much the vehicle suspension will be compressed. The higher slope break (1'-1") of the GM shape causes less sheet metal damage, but it has more potential for an impacting vehicle to ride up on the barrier. There would be nothing wrong with a vertical-faced barrier except that the slightest vehicle contact will result in sheet metal damage. A vertical wall, of course, is more difficult to construct if slip-form methods are used.

At its June 2, 2000 meeting, the Engineering Operations Committee approved a Department policy that calls for replacement of existing GM barrier as warranted by the condition of the existing barrier and crash history.

B. New Jersey Shape

The New Jersey shape is Michigan's current standard shape. It has a 3" high vertical face at the toe. This is an allowance for future resurfacing. The 10" radius at the change in vertical slope has no safety purpose; it is for aesthetic purposes only. The standard 10" top width was determined as necessary to provide the same overturning moment as the previously used G.M. barrier, and to reduce the probability of fracture under heavy impact. It should be emphasized that the New Jersey shaped barrier should not be built with a 6" top width and, in fact, has never been standard in Michigan.
Concrete Median Barriers

C. Innovative Concrete Median Barriers

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required that each State Transportation Agency construct innovative median barrier (IMB) amounting to at least 2½ percent of their total yearly installation for each of the next six calendar years. Shown below and on the right side of this page are two concrete median barriers used in Michigan that FHWA approved as qualified IMB.

Concrete barrier normally can be ended by attaching a combination of a bridge guardrail anchorage (Standard Plan R-67-Series), conventional guardrail, and a guardrail approach terminal (see Standard Plans R-61 & R-62-Series). The same criteria for calculating the length of need should be used with the concrete barrier included in the length of need. The minimum length of anchorage and ending guardrail are specified on Standard Plan R-54-Series.

In the case of ending a concrete median barrier, the approach side can be ended with guardrail as long as the barrier is ended with all portions of the barrier system being located outside the clear zone area for the opposing traffic.

Where the minimum length and lateral clearance cannot be obtained, a more expensive alternative for ending the concrete barrier would be to use a QuadTrend system or some type of impact attenuator. (See Sections 7.01.45C and 7.02.)
7.01.58 (revised 10-22-99)

**Two Types of Concrete Median Barrier Footings**

Designers should note that the standard plan for concrete median barrier (R-49-Series) specifies a Type A and a Type B. Type A has an integrally cast footing whereas Type B is doweled to a separately cast footing or concrete shoulder. When Type A barrier is called for on the plans the contractor has the option of casting the base integrally with footing or constructing the barrier in the same manner as Type B without any extra payment. Type B is payment for the upper portion of the barrier and is doweled onto an existing separately cast footing or concrete shoulder. If the designer wants to designate that the barrier be cast on a separate footing, they should note this on the plans or in a special provision, but still pay for it as Type A barrier.

7.01.59 (revised 10-22-99)

**Concrete Glare Screen**

Concrete glare screen, as opposed to glare screen made of other materials, is now used exclusively in Michigan when a glare screen is needed in conjunction with a concrete median barrier. Glare screen is called for routinely whenever the concrete median barrier is on a curve and whenever the concrete median barrier is used on new urban type construction. See Section 7.03.

7.01.60 (continued)

2. Is the median ditch shallow enough and the slopes gentle enough to permit safe traversal? If the open ditch must be filled in and enclosed drainage provided, then the median must be completely reconstructed.

3. If enclosed drainage is decided upon, are roadway grades sufficient to drain surface water?

When flat (0 - 0.1%) grades are encountered, it may be necessary to use metal slotted drain adjacent to concrete median barrier. When slotted drain is used, only about 50% of the length of flat grade actually needs the slotted drain (placed intermittently).

7.01.65 (revised 10-20-2008)

**Concrete Median Barrier Between Roadways of Different Elevations**

Superelevation on divided highways may cause the median shoulders to be at different elevations. When this occurs, one side will be higher than normal resulting in the median barrier being asymmetrical. The barrier must be specially detailed on the plans. The New Jersey shape should be used, and the high side should be created by extending the upper slope as high as necessary to match the other, normal, side. The plans should not refer to the New Jersey shape as such, except in the context that it is modified.

A 2'-0" difference in elevation is about the maximum that would allow the barrier to be slip-formed in one pass. It greatly assists construction personnel and the contractor if the plans show surface elevations at the toe of the barrier.

Shown on the next page is a typical example of such a median barrier, used on I-696. Note that the axis is vertical, rather than perpendicular to the plane of the shoulders.

7.01.60

**Retrofitting Concrete Median Barrier**

It is usually difficult and costly constructing a concrete median barrier where no median barrier had existed previously and especially where the median is drained by open ditch. Factors which the designer must consider are:

1. Where will the median barrier be placed? If located at the center of the median, the clear recovery area remaining is equal for both roadways; if constructed adjacent to one shoulder, recovery area is unequal for the two directions.
Concrete Median Barrier Between Roadways of Different Elevations

CONCRETE MEDIAN BARRIER WITH UNEVEN ROADWAYS
Concrete Barrier, Single Face

Single face concrete barrier was developed to shield roadside objects or features from one side only. One such situation is found on depressed expressways, where the right side approaches to bridge piers need shielding from only one side. The Metro Region favors the use of a concrete barrier over the use of steel beam guardrail in these locations. The major justification for its use is the virtual absence of the need for maintenance. The results are less exposure to risk for maintenance personnel and the elimination of a damaged system being exposed to the motoring public between an impact and the completed repair.

If the normal width shoulder can be maintained and a concrete barrier safety shape is needed, it should be placed in front of the underpass bridge piers. Otherwise the concrete safety shape should be transitioned to the vertical face of the pier column as specified on Standard Plan R-54-Series. Because single face concrete barrier is most commonly used on urban depressed expressways, the approach ending is usually buried in the adjacent cut slope. See Standard Plan R-54-Series. If the approach end cannot be buried in a backslope, it should be shielded with a minimum of a Guardrail Anchorage, Bridge and a guardrail approach terminal.

The use of single face concrete barrier will usually be requested at the plan review meeting and will usually be restricted to the depressed urban freeway situation. Its use in rural areas is generally discouraged because of the cost factor, the "snow fence" effect, and drainage problems created by concentrating runoff at one or few locations on high fills. However, the single face concrete safety shape might be considered between two consecutive bridges having safety shape concrete railings that are approximately 200' apart or less.

Temporary Barrier

Temporary barrier was introduced in Michigan around 1972, with temporary concrete barrier being the first type of temporary barrier available. Since that time, the use of temporary barrier in construction work zones has steadily increased. Temporary barrier serves a dual purpose: it shields hazards originating from construction practices and protects construction and maintenance personnel from the inherent hazard of closely adjacent moving traffic.

Presently, three crashworthy temporary barrier types are available for use; temporary concrete barrier, temporary steel barrier, and portable water-filled barrier. Each temporary barrier type has unique features and limitations. Therefore, it is important to determine which barrier types are acceptable for use on each project based on site-specific conditions.

A. Temporary Concrete Barrier (TCB)

TCB sections were initially precast. Then, a cast-in-place or slip-formed barrier similar to permanent barrier was allowed. Current designs meeting or exceeding NCHRP 350, TL-3 or MASH, TL-3 criteria and having FHWA acceptance are now required. TCB is the most commonly used temporary barrier type on Michigan roadways.
B. Temporary Steel Barrier (TSB)

TSB sections are fabricated entirely of galvanized steel. Each TSB manufacturer has a unique design with a specific brand name assigned to each design. TSB used by the Department must meet or exceed NCHRP 350, TL-3 or MASH, TL-3 criteria and have FHWA acceptance.

TSB is typically much lighter than TCB. As a result, TSB is typically easier to transport, install, and disassemble compared to TCB. Various TSB designs are available with tested impact deflections and performance characteristics comparable to TCB. However, the purchase cost of TSB is typically more than TCB.

Some TSB manufacturers can provide TSB sections equipped with casters for ease of movement on paved surfaces. Casters on TSB sections are retractable, raised or lowered, either by a hand crank or compressed air mechanism. When the casters are raised, the bottom of the TSB section comes in contact with the underlying pavement and functions as a standard TSB section. When the casters are lowered, the casters allow the TSB section to be maneuvered in any direction. Casters and their respective mechanisms are located within TSB sections, and are typically installed at the manufacturing facility during fabrication of TSB sections.

Some TSB designs require the pinning of TSB sections to the underlying pavement. Generally, TSB pins can be easily removed and the resulting holes in the pavement are filled with epoxy.

C. Portable Water Filled Barrier

Portable water filled barrier consists of plastic sections, alternating white and work zone safety orange for high visibility, that are filled with water after the sections have been assembled. Portable water-filled barrier used by the Department must meet or exceed NCHRP 350, TL-3 or MASH, TL-3 criteria and have FHWA acceptance.

When empty, portable water filled barrier sections are the lightest of all temporary barrier types. Consequently, they are relatively easy to transport, install, and disassemble. Due to their light weight, cranes or heavy equipment typically are not needed to install and disassemble empty barrier sections. The process of filling the barrier sections with water and emptying them is also simple and efficient.

Portable water filled barrier may be used year round, provided that manufacturer-approved and Department compliant anti-freeze agents are used in the appropriate doses to prevent the water from freezing inside the barrier sections.

The use of portable water filled barrier is very limited due to excessive impact deflection. Crash tests have shown that portable water-filled barrier designs typically deflect more than TCB or TSB when impacted. One specific portable water-filled barrier system deflected over 22 feet, laterally, when subjected to NCHRP 350, TL-3 crash testing.

Portable water filled barrier should only be used in cases where sufficient space is available for the barrier to deflect when impacted while providing adequate work zone protection.
D. Temporary Barrier Quantities and Specifications

When computing quantities of temporary barrier, the designer should review the staging plans and determine the maximum length of each barrier type required at any one time on the project.

Contact the Geometric Design Unit (Design Division) for current specifications and special provisions regarding temporary barrier.

1. Temporary Concrete Barrier (TCB) and Temporary Steel Barrier (TSB)

On most projects, standard TSB may be used as an alternative to standard TCB, and the Contractor may be given the choice of furnishing TCB or TSB. The option of furnishing standard TSB as an alternative to standard TCB can be provided by special provision without the use of a separate pay item. However, if TSB equipped with casters is required, a separate special provision and pay item is needed for furnishing TSB equipped with casters.

Standard pay items should be used for operating, adjusting, and relocating standard TCB or TSB, since the same pay items apply to both standard TCB and standard TSB.

Note that different pay items and special provisions are used for standard temporary barrier and limited deflection temporary barrier (furnishing, operating, adjusting, and relocating).

2. Portable Water Filled Barrier

The pay item "Portable Water Filled Barrier, Furn" is used for furnishing portable water filled barrier.

The pay item "Portable Water Filled Barrier, Oper" is used for operating, maintaining, cleaning, relocating, filling/emptying the barrier sections, and removal of portable water filled barrier.

Please note that additional pay items and quantities typically are not used for adjusting or relocating portable water filled barrier. Any costs associated with adjusting or relocating portable water filled barrier are included as part of the "Portable Water Filled Barrier, Oper" pay item, and are not paid for separately.
Ending Temporary Barrier

A. Temporary Concrete Barrier and Temporary Steel Barrier

The methods for ending temporary concrete barrier and temporary steel barrier are specified on Standard Plan R-126 Series.

B. Portable Water Filled Barrier

When the barrier ending is located within the clear zone, a crashworthy end treatment that is compatible with the portable water filled barrier must be installed. The crashworthy end treatment must meet or exceed the requirements of NCHRP 350, TL-3 or MASH, TL-3 and have FHWA acceptance.

Some portable water filled barriers are designed such that the barrier itself is a crashworthy end treatment. In which case, when the barrier ending is located within the clear zone, a separate crashworthy end treatment is not required.

Payment for furnishing, operating, and relocating crashworthy end treatments for portable water filled barrier endings is included as part of the "Portable Water Filled Barrier, Furn" and "Portable Water Filled Barrier, Oper" pay items, and is not paid for separately.

Temporary Barrier at Bridge Deck and Railing Reconstruction

Temporary barrier is frequently used on bridge railing replacement projects. Its use, however, is not feasible if it results in lane widths of less than 10'-0", nor if the duration of need is short. In the latter event, alternatives are plastic drums, traffic signals at each end of the work site, or a detour. It may be noted that use of barrier on a bridge produces three points of constriction at about the same location: a narrower shoulder, introduction of the bridge railing, and the funneling down created by the barrier itself. If possible, it is better if these constrictions and driver decision points can be spread out along the approach roadway.

Bridge deck reconstruction usually requires more work area than bridge railing reconstruction, and will frequently result in bi-directional traffic control on a single lane. Temporary barrier is commonly used in this application and a detail showing placement is specified on Standard Plan R-126-Series. Maintaining traffic provisions should be included in the plans.
Temporary Barrier Adjacent to a Precipitous Drop-off

There are occasions, notably when reconstructing a bridge by part width, when maintaining traffic constraints will force the placement of temporary barrier immediately adjacent to a precipitous drop-off situation. This creates a potential for the line of barrier to be displaced under impact, when there may be inadequate room available for displacement. When this condition occurs, special barrier types and/or hardware are needed to ensure that the barrier will function properly.

Standard temporary barrier is usually adequate when the lateral offset between the toe of the barrier on the construction side and the drop-off is 26” or greater. However, when there is less than 26” laterally between the toe of the barrier on the construction side and the drop-off, limited deflection temporary barrier meeting the requirements of Standard Plan R-53-Series or an approved alternative is required.

If designers reference barrier offset from the toe of the barrier on the traffic side to the drop off, then limited deflection temporary concrete barrier should be specified for offsets less than 4’-6”, as opposed to the “A” distance specified in Standard Plan R-53-Series. This is required since current MDOT specifications allow a wide variety of standard temporary barriers to be used, and the bottom width of standard temporary barrier can be as wide as 28”. Therefore, when referencing barrier offset from the toe of the barrier on the traffic side to the drop-off, the 4’-6” minimum offset for standard temporary barrier would ensure that the “A” distance specified in Standard Plan R-53-Series is at least 26” with any standard temporary barrier permitted under current MDOT specifications.

Note that any alternatives to Standard Plan R-53-Series must meet current crash testing criteria and must also be adequate for installation at each location taking site-specific features and constraints into consideration, including, but not limited to, proposed barrier offset from the drop-off, underlying surface type, and expansion joints in the underlying surface. In general, portable water filled barrier should not be placed adjacent to or near a precipitous drop-off, unless there is sufficient room between the barrier and the drop-off for the barrier to deflect during an impact.

When using limited deflection temporary barrier meeting Standard Plan R-53-Series, designers will need to select the appropriate detail for use at each location. Designers will need to determine the proposed offset between the barrier and the drop-off at each location, and the underlying surface type and condition at each location. In addition, when placing limited deflection temporary barrier over a bridge deck, designers may need to determine the number of expansion joints in the bridge deck, and the amount of thermal expansion/contraction expected at each joint.
7.01.70 (continued)

A. Detail 1, Standard Plan R-53-Series: Box Beam Stiffened Method

Of all the details in Standard Plan R-53-Series, Detail 1 requires the least amount of pinning to the underlying surface. With Detail 1, pinning to the underlying surface is only required to secure the ends of the limited deflection temporary barrier, as shown in Standard Plan R-53-Series. Therefore, Detail 1 is desirable in cases where pinning the barrier to the underlying surface needs to be minimized to reduce the possibility of damaging the underlying surface. For example, placing limited deflection temporary barrier over a new bridge deck or an existing bridge deck that will be left in place after construction.

When using Detail 1 on bridge decks, designers should extend the limited deflection temporary barrier beyond the limits of the bridge deck to ensure that all required pinning to the underlying surface occurs off the bridge deck.

Detail 1 may be placed over all bridge deck expansion joints, regardless of the number of joints in the deck or the amount of thermal expansion/contraction expected at each joint.

A minimum offset of 12" between the toe of the barrier on the construction side and the drop-off must be provided when using Detail 1. Other details must be considered if a minimum 12" offset cannot be provided.

7.01.70 (continued)

B. Detail 2, Standard Plan R-53-Series: Staked Method

Detail 2 should be considered when a limited deflection temporary barrier is required over an HMA roadway, and the barrier must be placed less than 12" from the toe of the barrier on the construction side to the drop-off. Note that a minimum barrier offset of 6", between the toe of the barrier on the construction side and the drop-off, must be provided in order to use Detail 2.

Since Detail 2 requires the use of 3'-4" long stakes that extend considerably into the ground, designers should examine the proposed installation site and verify that underground utilities or obstructions will not be impacted by the stakes. Designers may need to relocate the barrier and/or consider other options if underground utilities or obstructions are going to be impacted by Detail 2.
7.01.70 (continued)

C. Detail 3A, Standard Plan R-53 Series:
    Through Bolt Method on Concrete
    Bridge Deck

Detail 3A should be considered when a limited
deflection temporary barrier is required over a
concrete bridge deck, and the barrier must be
placed less than 12” from the toe of the barrier
on the construction side to the drop-off. With
Detail 3A, the toe of the barrier on the
construction side can be placed up to the
edge of the drop-off, but must not be placed
beyond the edge of the drop-off.

In general, Detail 3A is preferred over Detail
4A (Drilled and Grouted Method) on concrete
bridge decks. However, designers must avoid
using Detail 3A on bridge decks with
corrugated metal decking, since the metal
decking will present difficulties with anchor
bolt installation.

Detail 3A must not be used on concrete bridge
decks with an HMA overlay, since the anchor
bolts in Detail 3A lack the additional
reinforcement needed to withstand higher
bending moments induced during an impact in
the anchor bolts at the top of the concrete
surface.

Since drilling through bridge decks may be
undesirable or prohibited on some bridges,
designers should consult with the Technical
Section of Bridge Field Services before using
Detail 3A.

7.01.70 (continued)

D. Detail 3B, Standard Plan R-53-Series:
    Through Bolt Method on Concrete
    Bridge Deck with an HMA Overlay

Detail 3B should be considered when a limited
deflection temporary barrier is required over a
concrete bridge deck with an HMA overlay,
and the barrier must be placed less than 12”
from the toe of the barrier on the construction
side to the drop-off. With Detail 3B, the toe of
the barrier on the construction side can be
placed up to the edge of the drop-off, but must
not be placed beyond the edge of the drop-off.

Detail 3B is required when an HMA overlay is
present over a concrete bridge deck, since a
steel tube is needed around each anchor bolt
for additional reinforcement due to higher
bending moments induced during an impact in
the anchor bolt at the top of the concrete
surface. This is the reason why Detail 3A must
not be used on concrete bridge decks with an
HMA overlay.

Designers must avoid using Detail 3B on
bridge decks with corrugated metal decking,
since the metal decking will present difficulties
with anchor bolt installation.

Since drilling through bridge decks may be
undesirable or prohibited on some bridges,
designers should consult with the Technical
Section of Bridge Field Services before using
Detail 3B.
7.01.70 (continued)

E. Detail 4A, Standard Plan R-53-Series: Drilled and Grouted Method on Concrete Roadway or Concrete Bridge Deck

Detail 4A should be considered when a limited deflection temporary barrier is required over a concrete roadway or concrete bridge deck, and the barrier must be placed less than 12” from the toe of the barrier on the construction side to the drop-off. With Detail 4A, the toe of the barrier on the construction side can be placed up to the edge of the drop-off, but must not be placed beyond the edge of the drop-off.

Designers may consider using Detail 4A on concrete bridge decks with corrugated bridge decking. However, Detail 4A cannot be used on concrete bridge decks with an HMA overlay.

Since drilling through bridge decks may be undesirable or prohibited on some bridges, designers should consult with the Technical Section of Bridge Field Services before using Detail 4A on a bridge deck.

F. Detail 4B, Standard Plan R-53-Series: Drilled and Grouted Method on Concrete Roadways with an HMA Overlay

Detail 4B should be considered when a limited deflection temporary barrier is required over a concrete roadway with an HMA overlay, and the barrier must be placed less than 12” from the toe of the barrier on the construction side to the drop-off. With Detail 4A, the toe of the barrier on the construction side can be placed up to the edge of the drop-off, but must not be placed beyond the edge of the drop-off.

Detail 4B is intended for exclusive use on concrete roadways with an HMA overlay, and cannot be used on bridge decks.

G. Placing Limited Deflection Temporary Barrier Over Bridge Deck Expansion Joints

Detail 1 may be placed over all bridge deck expansion joints, regardless of the number of joints in the deck or the amount of thermal expansion/contraction expected at each joint. However, Details 3A, 3B, and 4A have certain limitations when placed over bridge deck expansion joints.

Details 3A, 3B, and 4A may be used over bridge deck expansion joints with an expected thermal expansion/contraction up to 1.5”, provided the expansion joint guidelines specified in Standard Plan R-53 Series are followed during installation. No special hardware is needed with Details 3A, 3B, and 4A when the expected thermal expansion/contraction does not exceed 1.5”.

Special hardware must be used when placing Details 3A, 3B, and 4A over expansion joints with an expected thermal expansion/contraction greater than 1.5”, up to 4”. In this case, a Type J1/J2 assembly, as shown in Standard Plan R-53 Series, must be placed over the expansion joint to accommodate the expected thermal expansion/contraction. Designers should note that a separate pay item is used for Type J1/J2 assemblies. Therefore, designers will need to include the appropriate pay item for the Type J1/J2 assembly and estimate the quantity of Type J1/J2 assemblies required on each project.

Note that Details 3A, 3B, and 4A must never be used over bridge deck expansion joints with an expected thermal expansion/contraction greater than 4”. 
Concrete Filler Walls

Concrete filler walls between pier columns serve as a continuous barrier to prevent an impacting vehicle from snagging on the pier columns. They are used when the shoulder width does not allow the approach barrier system to be carried under the structure at the normal offset from the edge of pavement. When filler walls are used, the approach barrier system, if non-rigid, should be anchored to the filler wall. See Standard Plans R-55-Series and R-67-Series.

Concrete filler walls constructed between about 1976 and 1982 were 33" high. The height was increased in June 1983 to 42" to allow for future heavy resurfacing. Some difficulty is being experienced connecting the current thrie beam guardrail anchorage to these older 33" high filler walls if there has been (or will be) a thick-lift resurfacing. When this occurs, provide for a filler wall extension with a minimum height of 1'-8" reinforced, and adhesive anchored to the existing filler wall with steel bars. Use horizontal sleeves in the new concrete for the guardrail attachment bolts. The approach guardrail should be aligned to allow the holes that must be drilled into the existing filler wall to be as far from the top edge as possible, to lessen the possibility of spalling during the drilling operation.

Sometimes the toe header for the bridge slope paving is behind the pier columns. This condition should be noted at the plan review meeting. When it occurs, a separate footing must be provided for the filler wall.

In the past, there have been occasional attempts to cast a concrete safety shape into the filler wall in the area of the pier. This usually results in a concrete "toe" being placed, having the 55 degree slope of the safety shape, but the wall being vertical, like the conventional filler wall. It seems to work out better to simply transition the approach barrier system into the vertical face of the filler wall, and not try to cast a semblance of a safety shape that will only break away from the remainder of the structure over time.

The top of the filler wall should be constructed parallel with the grade of the road, rather than level. This gives the top lines of the approach barrier and filler wall a continuous appearance. Even though the angle between the vertical columns and the top of the filler wall will be something other than 90 degrees, its appearance will be less noticeable.

A filler wall end block shall be constructed when the connecting guardrail anchorage has one or more of the posts that can not be installed full depth. See Standard Plan R-55-Series.
IMPACT ATTENUATORS

Questions regarding impact attenuators should be directed to the Geometric Unit of the Design Division.
GLARE SCREEN

7.03.02 (revised 10-22-99)

General

Glare screen was first used on median barriers within the limits of curves, where the headlight glare from vehicles rounding the curve would be momentarily aimed directly at on-coming vehicles in the opposite roadway. Various materials were tried, with expanded metal mesh finding favor in Michigan. Expanded metal mesh, while effective as a glare screen, is fragile and susceptible to damage by vehicle contact, fatigue, corrosion and wind. It thus requires almost constant maintenance. Its principal advantage is that it can be rather easily mounted on metal beam guardrail.

To overcome the shortcoming of expanded metal mesh, plastic paddles, or "Glarefoils", were developed around 1976. Varying in height from about 2'-0" to 4'-0" and made of polyethylene, they are fastened to metal brackets attached to concrete median barrier. Of hollow, oval cross-section, they are oriented at 45° to the line of barrier in such a manner that the line of sight is screened between the opposing directions of traffic, yet wind currents can pass through. Michigan's experience with plastic paddles has been mixed; they are more durable than expanded metal mesh, but they still require considerable maintenance. Plastic paddles may be considered if a temporary glare screen is required on temporary concrete median barrier, but we currently do not consider it for permanent installation.

7.03.02 (continued)

Concrete glare screen came into use in Michigan in 1973 as an "add on" to previously placed concrete median barrier. It soon became apparent that it was an economical, almost maintenance-free structure that, by comparison, ruled out further consideration of the other glare screen materials and designs. As techniques developed for slip-forming higher and almost vertical concrete walls, Standard Plan III-76D came out in 1978 requiring that, whenever glare screen was to be constructed in conjunction with a concrete median barrier, the wall must be cast monolithically, 51" high. Not only does this requirement achieve economy of construction, it lends strength and additional height to the concrete barrier as well. If concrete glare screen has a disadvantage, it is because it cannot be used in conjunction with steel beam guardrail.

7.03.03 (revised 12-22-2011)

Criterion for Use

It is current practice to place concrete glare screen on concrete median barrier whenever new concrete median barrier is constructed in urban areas. In rural areas the use of a glare screen will be as recommended on a project-by-project basis by the Geometric Unit, Design Division. (The terms "urban" and "rural" here refer to the characteristics of surrounding development, not the relationship of the project to city limit signs.)
ROAD DESIGN MANUAL
ROAD DESIGN

7.04

PAVEMENT MARKINGS

7.04.01 (revised 10-22-99)

General

Pavement markings, both permanent and temporary, are included in the contracts of virtually every project in the lower peninsula and about half of those in the upper peninsula. The inclusion of pavement markings on the remaining projects will be determined by the Region/TSC. The only type of project not requiring the pavement markings to be included (either by contract or by work order) are where the existing markings are not altered or obliterated.

When there are no construction projects scheduled, annual pavement marking is accomplished through region-wide contracts or by state forces.

7.04.02 (revised 10-20-2008)

Temporary Pavement Markings

Temporary pavement markings usually consist of 4" wide strips of reflectorized, white or yellow, adhesive-backed tape, 4'-0" long with 46' gaps. There are two types designated in the pay items, "R" and "NR," standing for Removable and Non-Removable. Temporary markings must be removable if they are applied to the ultimate pavement surface; they need not be removed if they are applied to a lower course of HMA pavement that will be covered by another course of material.

Reflectorized tape does not adhere well to rough surfaces, such as seal coats or an open-graded HMA mat. Paint is used in these cases to replace the reflectorized tape. If paint is used for temporary marking, the pay item should reflect the word "temporary," e.g., "Pavt Mrkg, Type NR, Paint, 4 inch (color), Temp."

7.04.02 (continued)

Temporary Raised Pavement Markers (TRPM) consist of either flexible retro-reflective strips (with or without a plastic shield) or a solid plastic device with a retro-reflective face. Types of TRPMs and their applications are listed in section 812 of the current Standard Specifications for Construction.

7.04.03 (revised 10-22-99)

Pavement Marking Quantities

The Region/TSC Traffic and Safety Engineer will usually furnish Design quantities of each type of pavement marking required for the project. These quantities are normally given after the Plan Review Meeting and may be near design completion. If the pavement marking is complicated, a pavement marking layout sheet(s) should be included in the plans. The quantities are typically shown under "Miscellaneous Quantities" on the Note Sheet.

7.04.04

Removing Permanent Pavement Markings

Inappropriate permanent pavement markings must be removed before any change is made in traffic patterns. This may be done using air or water blasting, sand blasting, grinding, scraping, or chemicals. Painting over is not considered to meet the requirements for removal. Payment for removing pavement markings, when necessary, will only be made for Type NR markings.

7.04.05

Statutory Participating Cities

Statutory participating cities are exempt from participating in the cost of permanent pavement markings.
**Witness, Log and Layout**

Most projects call for the placement and/or replacement of permanent pavement markings. To ensure the markings are laid out properly the Designer must include information in the plans or proposal to allow a Contractor to do so.

Markings are placed or replaced using one or a combination of the following methods:

- A log of previously witnessed markings
- Pavement marking plan sheets
- Reference to standard plans (only if the standard can be placed in the field)

When there is a need for the Contractor to witness and log any existing pavement markings, the pay item “Witness, Log, Layout, $1,000.00”, must be included in the contract. This item must be used when any portion of the pavement markings must be witnessed and logged by the Contractor or Sub-Contractor prior to the pavement being removed.
TRAFFIC SIGNS AND ROADWAY Delineators

7.05.01 (revised 12-22-2011)

Traffic Signs

The Department has jurisdiction over traffic operational signs (As opposed to local street name signs which are the property and responsibility of the local jurisdiction, and occupy the R.O.W. by permission). The responsibility for preparing any required freeway signing plans will be that of the Design Division – Traffic Sign Unit and/or its traffic signing consultant. The preparation of signing plans for non-freeway is the responsibility of the Region/TSC or a per-qualified signing consult. Design's responsibility will usually be limited to coordinating the signing plans with the project plans.

When a project involves completely new construction or reconstruction, the signing plans should be included as part of the project plans. If the project will be built under one contract, e.g., a two-lane, free access roadway, then the signing will be included with the road plans either as plan sheets or computerized log sheets. If a contiguous section of freeway is being built under several contracts, it is possible that the signing work will be done with a separate contract. Even if this happens, some foundation and sign base work may be included in the road and bridge contracts. The Design Unit should contact the Region/TSC Operations Engineer early in the project development stage to determine if signing will be a part of the project. Also a copy of the correspondence should be given to Design Division – Traffic Sign Unit. If the signing contract is being done with a separate contract, the Design Unit should also contact the Traffic Sign Unit to confirm that all items are included in their respective contracts.

7.05.01 (continued)

As mentioned above, signing plans will generally be prepared by the Design Division – Traffic Sign Unit or Region/TSC Traffic & Safety. There may be occasions, however, where time constraints will necessitate Design completing the final drafting of signing plans from preliminary layouts furnished by the Region/TSC. Design should contact the Reflective Systems Unit, if the Region/TSC has not submitted special provisions and support standards with plans. The role that the Traffic Sign Unit, plays is one of review and coordination between the Region/TSC and Design.

Salvaged signs remain the property of the Department and components will be re-used, whenever possible, by Maintenance and the sign shops.

For signing on detours see Section 12.05.

7.05.02 (revised 10-22-2014)

Delineators

See Standard Plan R-127-Series, "Delineator Installations" for information on both rigid-post and flexible-post delineators.

The contract items of “Delineator Reflector”, “Post, Delineator”, and/or “Delineator, Reflective Sheeting”, and “Post, Flexible Delineator” shall be used on all 3R/4R road construction projects for divided highways and freeways. Inclusion of these items should also be considered on divided highway and freeway CPM projects depending on the condition of existing devices and the pavement remaining service life.

The rigid delineator measurements and payments are for Delineator Reflector, measured as "each" (Delineator Reflector-Double is counted as two each) and Post, Delineator, also measured as “each”.
Delineators

The designer should make an estimate of each type of Delineator reflector, based on the patterns specified on the standard plan. These quantities are shown in the Miscellaneous Estimate on the plans, as follows:

- Delineator Reflector - Single Crystal
- Delineator Reflector - Single Yellow
- Delineator Reflector - Single Green
- Delineator Reflector - Double Crystal
- Delineator Reflector - Double Yellow
- Delineator Reflector - Single Crystal with Red
- Delineator Reflector - Single Yellow with Red

Delineator Reflector Total

The flexible delineator measurements and payments are for Delineator, Reflective Sheeting of the size and color specified, measured as "each", and for Post, Flexible, Delineator, also measured as "each".

The designer should make an estimate of each type of Delineator, Reflective Sheeting, based on the patterns shown on the standard plan. These quantities are shown in the Miscellaneous Estimate on the plans, as follows:

- Delineator, Reflective Sheeting, 3 inch by 6 inch, White
- Delineator, Reflective Sheeting, 3 inch by 12 inch, White
- Delineator, Reflective Sheeting, 4 inch by 8 inch, White
- Delineator, Reflective Sheeting, 3 inch by 6 inch, Yellow
- Delineator, Reflective Sheeting, 3 inch by 12 inch, Yellow
- Delineator, Reflective Sheeting, 4 inch by 8 inch, Green
- Delineator, Reflective Sheeting, 3 inch by 6 inch, Green
- Delineator, Reflective Sheeting, 3 inch by 12 inch, Green
- Delineator, Reflective Sheeting, 4 inch by 8 inch, Red

Delineators with Red are to be used where red delineators are attached to the back of delineators on ramps to face possible wrong-way traffic movements.
7.06

FENCING

7.06.01

References

A. Standard Plan R-97-Series, High Tensile Eight Wire Fence
B. Standard Plan R-98-Series, Chain Link Fence (Using Tension Wire)
C. Standard Plan R-101-Series, Woven Wire Fence
D. Standard Plan R-102-Series, Installation of Woven Wire Fence (At Structures)
E. An Informational Guide on Fencing Controlled Access Highways, AASHTO, October 1967. (This is the latest edition published.)
F. Construction Manual, MDOT, Section 6.21

7.06.02

Purpose of Fence

Reference "E", above, states, "Fencing along a highway is a means of preventing unwanted and likely hazardous intrusion of animals, people, vehicles, machines, etc., from outside the right-of-way line into the vicinity of moving traffic." In the early days of the development of our highway system it was considered the responsibility of the abutting property owner to keep livestock within bounds. If someone's horse got out on the road and was hit, it was the owner's fault and owner's loss. Today, with higher vehicle speeds and controlled access operation, the driver has the expectation that the road will be clear of roadside interference. It therefore has become increasingly the highway agency's responsibility to safeguard against unwarranted intrusion on the highway.

7.06.02 (continued)

Only controlled access highways are routinely and continuously fenced. Exceptions, on such highways, are where it can be definitely established that a fence is not necessary, such as in areas of precipitous slopes or natural barriers.

7.06.03 (revised 8-18-2014)

Types of Fence

The following types of fence are used for the applications indicated:

A. Woven Wire Fence

Woven wire fence, nominally about 4'-0" high, is the predominant fence used in rural areas. Steel posts are used, unless the fence is in swampy soil, in which case wood posts are used. The type of post, whether wood or steel, must be indicated in the pay item, which means that the designer must estimate where swampy soils will be encountered along the R.O.W. line. Normally, steel posts are less expensive than wood, so a contractor will want to use steel if possible. There have been cases where the contractor has asked to use wood posts throughout a project, and this has been allowed.

B. Chain Link Fence

Chain link fence is predominantly used in urban areas. Sometimes a project will require both woven wire and chain link fence, if the character of the adjacent development is both rural and urban. If this is the case, the change over point should be selected at a convenient location at or near the end of the urbanized section and not necessarily at the city limits.
7.06.03 (continued)

Types of Fence

C. High Tensile Eight Wire Fence

High Tensile Eight Wire Fence, as a right-of-way fence, is a substitute for woven wire fence. It is thought to be more economical to construct because it consists of individual strands of wire and has no vertical tie wires. It is considered to be more economical to maintain because a broken wire can be spliced with a patented device and re-tensioned, an obvious advantage when compared with the rehabilitation of a broken down or cut woven wire fence. Designers should consult with the Region/TSC and determine at the time of the plan review meeting whether high tensile eight wire fence should be used.

7.06.04

Location of Fence

Fence is ordinarily constructed 1'-0" inside the R.O.W. line. This is in accordance with an old common law custom that the owner of the fence should be able to theoretically construct and maintain it without setting foot on the neighbor's property.

On urban freeways, where fence is used between the freeway and the parallel service road, the location of the "R.O.W. line" between the two is often undefined. Usually, the fence will be placed at a determined distance from the inside service road curb, which may be as little as 3' to as much as 20' to 25'. The wider margin allows greater flexibility for landscaping and plantings, but the municipality must be willing to accept the greater maintenance responsibility. The fence should not be set back at a greater distance if the reason for doing so is to justify paving the area. See details of a typical fence installation between a service road and urban freeway in Section 12.01.05.

7.06.04 (continued)

In rural areas, the R.O.W. line will often coincide with a quarter or section line, which also may have formerly been a property boundary when the area was farmed. These old fence lines frequently became a depository for stone piles and/or were allowed to grow into a tree line. The question of whether to remove the trees and stone piles, or to place the fence inside the R.O.W. line to avoid the costly removal, has been faced repeatedly over the years. Department practice is, if at all possible, to remove the debris and vegetation sufficient to place the fence 1'-0" inside the R.O.W. line. However, it must be remembered that a fencing contractor is not equipped, nor does the contractor have the personnel, to do extensive clearing. While clearing of the line is included in the price paid for fencing, it is customary to allow the fence to veer around a large tree to avoid having to remove it.

When chain link fence is used on urban freeways, the gapping out for ramps and the fence overlap should be accomplished as shown on the next page.
7.06.04 (continued)

Location of Fence

![Diagram showing the location of fence around a road network.]

- SERVICE ROAD
- EXPRESSWAY
- CHAIN LINK FENCE
- TOE OF SLOPE
- ON RAMP
- OFF RAMP

(1) USE LESS THAN 100' ONLY WHEN REQUIRED TO SATISFY MINIMUM OFFSET FROM ADJACENT EXPRESSWAY LANES OR CORE AREAS.

(2) MINIMUM OFFSETS FROM EXPRESSWAY HAVE PRIORITY.
7.06.05

Use of Barbed Wire

In rural areas subject to stock grazing, woven wire fence has traditionally been topped with a single strand of barbed wire. This was done to discourage farm animals from leaning over the fence and breaking it down. However, there are areas where it is obvious that grazing will never occur, e.g., across state and federal forest lands. When this condition occurs, the barbed wire should be omitted, for economy.

Barbed wire is seldom used in conjunction with 4’ and 6’ chain link fence. (See Section 7.06.10) It may be used on top of 8’ and 10’ chain link fence adjacent to areas where special security measures are required, as around an industrial plant. In these cases the number of strands, and the direction they will be angled, will be as requested by the adjacent property owner, and may be part of the R.O.W. agreement.

7.06.06 (continued)

Chain link fence may cause a special problem at airports that are large enough to use radar, as the fence fabric has been known to cause ghost images on radar screens. Whenever new fence is contemplated adjacent to a major airport, the designer should coordinate the proposed project with the Federal Aviation Administration. It may be necessary to use a non-metallic fence through the area off the end of the runways.

There are also occasions when a woven fence is warranted because of the surrounding rural topography but the adjacent property owner may specifically request chain link fence. On one project where this occurred, in the Metro area, an agreement was worked out whereby the Department furnished the fencing materials and the property owner erected it at their own cost.

When the R.O.W. corridor has been purchased well in advance of construction, and subsequent residential areas have developed adjacent to the R.O.W., it is not unusual for the property owners to place their own chain link fence on the R.O.W. line, in their backyard. When the time comes to fence the freeway R.O.W., the question arises, “should a second chain link fence be erected 1'-0” from the existing fence so that the Department has complete ownership of the R.O.W. fence?” While this has been done, it creates an unsightly trash collector, it makes both fences difficult to maintain, and it is unnecessarily costly. The new fence should simply tie into the existing fence at its ends, assuming that the existing fence is in good condition. If it is not in good condition, then an agreement should be sought with the property owner to remove the existing fence and allow it to be replaced by the freeway R.O.W. fence. 

7.06.06

Chain Link Fence

Both 4’ and 6’ chain link fence are used, with the higher fence favored adjacent to platted subdivisions. To avoid intermittent stretches of varying heights of fence, the designer should attempt to limit any one run of either 4’ or 6’ height to a minimum of 660’ or 40 rods.

Initially, chain link fence was constructed on our projects using a pipe top rail. In 1973 the standard plan was changed to provide a tension wire that would replace the top rail on new construction. If the scope of a project includes alteration or updating of chain link fence that has a top rail, the fence should be modified to provide the tension wire, and the top rail should be removed.
7.06.07 (revised 10-22-99)

Gates in Chain Link Fence

Gates should be provided in chain link fence to provide access for maintenance equipment, e.g., mowers, cranes for servicing pumphouses, etc. Width of gates should be a minimum of 8'. The exact location and width of gates will be determined by Region/TSC personnel at the time of the plan review meeting.

Gates should preferably swing in toward the freeway, and not out onto the service road where an open gate could be struck by service road traffic. If the service road shoulder slope is continued upward past the fence it could cause problems opening the gate unless the earth is graded out somewhat to accommodate the arc of the gate swing.

7.06.08 (revised 2-27-2012)

Fencing Clear Vision Areas

Clear vision areas are usually fenced, but it is not a rule that they must be. There are situations where the property owner may wish to maintain the clear vision triangle as mowed lawn, in which case a fence across the corner would detract from the overall appearance and inhibit trimming and mowing. In these cases, the omission of the fence will be a consideration in the negotiation with the property owner, and safeguards to protect the integrity of the clear vision area will be included in the legal documents. These safeguards will include prohibition against parking equipment and vehicles in the area, and keeping trees trimmed high so that there is a clear line of sight. The designer should set up fencing of clear vision areas on the plans unless informed by the Development Services Division to omit it at specific locations.

7.06.09

Fencing Scenic Strips

Scenic strips located adjacent to limited access R.O.W. are usually fenced along the back and sides, but not along the regular R.O.W. line in front of the strip. Occasionally a scenic strip was acquired after the R.O.W. was fenced, in which case the area may be completely enclosed by fence. If for some reason this happens, a gate should be provided in the regular R.O.W. fence to provide vehicular access to the scenic strip. No driveway should be provided, however.

7.06.10 (revised 12-22-2011)

Fencing Borrow Area Lakes and Retention Basins

Borrow areas that have been excavated deep enough to form lakes should be fenced with 6' chain link fence, unless ownership is to be transferred to private interests who do not want the fence. Use 6' chain link fence with three strands of barbed wire on top. Show the fence located at least 10' to 15' from the water’s edge to enable a vehicle to drive between the lake or pond and the fence. A vehicular gate should be provided. Lakes transferred to the jurisdiction of the Michigan Department of Environmental Quality (MDEQ) should be fenced.

Retention basins that can be expected to have 2'-0" or more of standing water for more than a day or two should likewise be fenced.
7.06.11

Fence Between Twin Overpassing Structures

When twin independent structures (without a common backwall) carry a freeway over a crossroad, and there is no interchange, the median should be fenced on each side of the crossroad to prevent or inhibit vehicle or animal entry. The fence should preferably line up with the abutment walls.

7.06.12

Guardrail in Conjunction With Fence

There have been occasions in the past where there has been a reluctance to place guardrail in front of a fence. It should be remembered that guardrail does not serve the function of fence, nor does fence serve the function of guardrail, so if both are needed, both should be constructed. As a matter of practicality, however, the fence should be placed sufficiently behind the guardrail, if possible, to allow room for the expected guardrail deflection. See Section 7.01.20.

7.06.13 (revised 2-27-2012)

Temporary Fence

The Development Services Division does not pay for fencing as part of the limited access R.O.W. agreement with property owners. (On free access R.O.W., fencing is paid for as part of the property settlement by the Development Services Division.) This means that a problem could be created through areas of stock grazing in that it could leave pasture land unfenced for months during the construction of the project. A General Plan Note is placed on the Note Sheet that says, "Permanent right-of-way fence shall be constructed as the first operation in cases where the right-of-way cuts across stock grazing areas. Temporary fencing, when ordered by the Engineer, will be paid for at the contract unit price for "Fence, Temp".

7.06.13 (continued)

Temporary fencing is used when it is not possible to construct the permanent fence until necessary grading is completed. This may be in muck storage areas, areas of grading permits, etc. Quantities of Temporary Fence are estimated on the basis of 3% of the total fencing for the project, with a minimum of 1320' or 80 rods. This quantity is shown in the Miscellaneous Estimate, on the Note Sheet. Removal of temporary fence is not paid for separately.

In the event that grading and surfacing are let as separate projects, the R.O.W. fence will, of course, be included in the grading contract, with the above provisions included.

7.06.14 (revised 12-22-2011)

Protective Fence

Protective Fence is woven wire or plastic fence that is placed around deep excavations such as those required for bridges, pumphouses, and other structures. It is used primarily to protect pedestrians and animals, as directed by the Engineer, but may even be used to protect trees. The road plans should, on urban freeway projects, set up an amount of Protective Fence equal to the length of the project in feet, labeling it as "estimated". On other urban projects and on rural projects, call for the item if requested at the plan review meeting.

If the pumphouse or structure is to be let separately, Protective Fence should be included in the plans for that structure. On package projects, coordination will be required between Road and Bridge Design to determine which plans will show the fence required to enclose "bathtub" construction.
Removing Fence

Payment for fencing includes the cost of clearing and cleaning the fence line, which includes any old fencing that may be there, except in areas where Clearing for Fence is a pay item. Removal of old fencing that is not coincidental with the construction of new fence should be paid for under the item "Fence, Rem".

When tying highway fencing to an existing intersecting private fence that has had to be interrupted by the construction, necessary corner bracing should be added to the private fence, as required. The plans should call attention to this requirement, which should not be paid for separately.

If fence removal is required, but the quantity is unknown, it is permissible to include the removal in compensation for another pay item.

Screening Fence

Construction of a screening or privacy fence is not a common undertaking of the Department, but it has been done. One that was constructed in East Lansing was wood, having 8' high panels, manufactured commercially. An existing chain link fence was removed and the screening fence placed generally along the former fence line. The screening fence overlapped the chain link fence at the ends by about 3', and the details called for a maximum allowable space underneath of 6", with a 2" space as average. Post were set in concrete 3'-6" deep. The pay item was "8' Screening Fence", measured in linear feet.
7.07

NOISE BARRIERS

7.07.01 (revised 12-22-2011)

References


D. MDOT Noise Barrier Policy (guidelines for highway noise barriers), January 1978 and January 1982

7.07.02 (revised 12-22-2011)

General

The concept of traffic noise attenuation became an integral part of highway planning and design in 1976 when FHWA first issued Procedures for Abatement of Highway Traffic Noise and Construction Noise (currently 23 CFR 772). This regulation established two types of noise mitigation projects, which are continued to the present.

噪声衰减主要限制在高速公路，虽然在州内有少数的免费道路有修建土堤声屏障。通常，免费道路的入口点所需开孔的距离太近，因此不实际安装声屏障。

Responsibilities for noise barrier investigation, evaluation, and design are generally divided as shown in the following chart:

<table>
<thead>
<tr>
<th>Technical investigation and analysis</th>
<th>Instrumentation and Data Systems Unit, Construction Field Services Division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Impact Statement</td>
<td>Bureau of Planning, Transportation Planning Services Division</td>
</tr>
<tr>
<td>Choice of noise barrier type, general details of design</td>
<td>Roadside Development Design Unit, Design Division</td>
</tr>
<tr>
<td>Noise barrier structural analysis</td>
<td>Bridge Design Special Assignment Unit, Design Division</td>
</tr>
<tr>
<td>Noise barrier design details</td>
<td>Road Design Unit, Region/TSC</td>
</tr>
</tbody>
</table>
7.07.03 Technical Aspect of Sound Transmission

The sound pressure level (SPL) is equal to 20 times the logarithm of the ratio of the sound pressure measured to the reference sound pressure. The reference sound pressure is 20 x 10 Pascal. The unit of SPL is the decibel. The sound is also A weighted so that the measurement is similar to the frequency response of the human ear. The unit is abbreviated dbA.

Because decibels are in logarithms, doubling the sound pressure only raises the decibel level 3 dbA. Also, an apparent doubling of the sound level to the human ear occurs when the decibel level is increased by 10 dbA. The human ear can perceive a difference at 1 dbA when sound levels are presented on a comparative basis. However, the human ear cannot detect a change in highway noise level until the change amounts to about 3 dbA.

7.07.04 Current Requirements and Practices

23 CFR 772 (current issue is dated October 1997) requires highway noise to be analyzed in each environmental document. If the predicted design year noise level is greater than the stated FHWA noise level guidelines, then the affected residential properties or special sites must be analyzed for possible noise abatement in conjunction with the highway improvement.

The Department has established noise guidelines for Type II noise barrier projects. These guidelines have received FHWA approval.

The Department was also instrumental in obtaining vehicle noise legislation. In 1978, Section 707 of the Michigan Vehicle Code was changed to limit the level of noise that a car, truck, or motorcycle can produce on a roadway. The Department assists local enforcement agencies in administering that law, and makes periodic noise measurements to insure contractor compliance with construction noise specifications.
Process for Type I Projects

Type I projects are initiated by the environmental document prepared for each highway improvement project, whether it be an EIS or FONSI, with the Construction Field Services Division preparing the entire noise portion of the document. All homes are analyzed, even those that are widely scattered, though it is recognized that there is not enough money available to treat individual homes with a noise barrier. (Individual homes may be granted an exception to allow them to be treated, however, by adding insulation, solid core doors, storm windows, or air conditioning that would allow the residence to remain closed during hotter weather, thereby reducing interior noise levels.)

Existing subdivisions are examined, the number of homes counted in the first, second, third, etc. rows back from the highway, and the cost of shielding these homes is estimated. The Department's noise policy requires that at least a 6 dBA reduction be achieved in the noise level for attenuation measures to be considered worthwhile. They also set Leq = 67 dBA as the guideline for maximum sound level in a residential area. (Leq is the average intensity of sound in the 30th high hour, or at level of service "C", whichever is worse. Level of service "C" is considered the theoretical worst traffic condition for noise; beyond it the movement of traffic starts to break down, with a corresponding reduction in noise levels generated.)

A public meeting or hearing is then held. The Department, however, relies upon input from the local unit of government, rather than the public at large, in making the final determination relative to constructing a noise barrier. Even though all the data may point to the need for a noise barrier, if the public hearing reveals that the people as a whole do not want it, the Department will not build it.

Process for Type II Projects

The construction of Type II noise barrier projects is entirely dependent upon the funding annually set aside for this purpose. The same federal funds that are used for Interstate preservation and capacity improvements also provide funding for noise abatement. Obviously, there is much more potential barrier construction classified as Type II than Type I, as Type II encompasses the entire trunkline system, not just new projects. It is significant when considering Type II projects to know whether or not the highway preceded the construction of a subdivision, or vice versa, as it then becomes a question of whether or not the builders and buyers of homes did so with full knowledge of the highway-related environment. The Department uses the date on which a subdivision was platted, or the date the area was zoned residential, as this date is easily determined and undisputed.

An inventory has been made of the noise levels at all the residential sites along Michigan freeways. There are 1,135 such sites. These are ranked by predicted (as of 1981) noise levels, length of area and "who was there first", and a priority factor is computed. Priority #1 covers those situations where the highway came after the homes, Priority #2 covers those situations where the homes came after the highway.

Mitigation measures are then proposed, an informal public meeting is held, and, as in the Type I process, the Department takes its cue from the local governmental agency whether or not to proceed with the noise barrier. It can be seen that, with 1,135 sites, and treating two or three each year, most will never be treated.
Design Considerations for Noise Barriers

Of the various types of possible noise barriers that could be used, the Roadside Development Design Unit attempts to select the one that best fits the community and the site. For example, if there are existing large plantings that would be on the highway side of a noise barrier, a metal wall would probably be much more suitable than an earth berm, because the metal wall can be jogged in and out around the trees whereas an earth berm would probably require removal of the trees. On the other hand, if R.O.W. is sufficiently wide, trees are not a problem, and earth is available nearby, an earth berm would probably be most economical. (Required heights are lower for an earth berm than they are for walls.) The Roadside Development unit will work closely with the Road design unit in choosing details of the noise barrier.

While various density materials are suitable for use as noise barriers, a minimum density of about 4 pounds per square foot is required to adequately prevent sound transmission through the material.

Construction Field Services Division will ask for a survey of the R.O.W. fence, then will furnish the height and length requirements for the noise barrier, along with elevations of the top of the barrier throughout its length. This information is included in the Environmental Clearance.

The noise barrier should be longer (on each end) than the area to be shielded by a factor of 4 times the distance between the highway and the observer, i.e., the nearest activity to be shielded. This approximates a 45 degree angle from the observer to the end of the wall, and results in an overlap.

Types of Noise Barriers Used in Michigan

Michigan has used 7 basic types of noise barriers: earth mound, concrete panels in H-beam slots, brick, metal, wood, concrete stab-in panels, and concrete block. These are briefly discussed as follows:

A. **Earth mound** - This is the first preference if R.O.W. is available, earth can be obtained at reasonable cost, and utilities are not affected. A major drawback is that it requires considerable space. The requirements for an earth mound are contained in Reference "B", Section 7.07.01.

B. **Concrete panels in H-beam slots** - Concrete or steel H-beam posts are embedded in the soil, then precast and post-tensioned concrete panels, perhaps 4' high by 20' long by 6" thick are inserted in the slots formed by opposing posts, one panel on top of the other. Frequently random designs are incorporated in the panels by means of form liners, or the plastic concrete may be raked on one side to give a texture that appears darker, by contrast, than smooth concrete. A variation previously used involved colored panels 18" high by 10' long by 4" thick. The panel ends must rest upon a footing, and the bottom of the lowest panel must be below ground line so noise cannot pass underneath. These panels are very durable but are susceptible to painting of graffiti if the concrete is smooth or raked.
Types of Noise Barriers Used in Michigan

C. **Brick** - Brick has proven to be a popular noise wall material, especially in an urban setting. If close to the highway, a 30" high concrete base wall may be cast, with a 4" thick clay brick wall on top, utilizing brick pilasters on the residence side for rigidity and strength. If the wall is somewhat back from the highway, the concrete base wall will be omitted and the wall constructed entirely of brick (though brick also requires a footing). A range of colors are available.

D. **Metal** - Metal noise walls are an outgrowth of metal building construction. Their principal advantage is that they can be painted to almost any desired color, e.g., brown, if earth tones are desired. They can be easily jogged to change alignment or can be built through or near trees that need to be saved, and the height can be easily varied for visual effect. They probably require more maintenance than a concrete wall, but they are less expensive initially as they do not require full-length footings. Different color selections and textures are available.

E. **Wood** - One of our earliest noise walls was built of wood. Initially, there were visual problems because of the blotchy effect of the creosote preservative, and warpage of the boards created cracks that allowed the sound to go through the wall. Techniques now call for water-borne and Penta preservatives, and panels are constructed of 2" x 6" lumber with double walled treated plywood. These panels may be 2' x 10', or 2' x 12'. Advantages of wood are that it is comparatively light, allowing its use for sound walls on top of bridge railings, and it does not require full length footings.

F. **Stab-in concrete panels** - As the term implies, stab-in noise walls are composed of precast concrete panels that have stability by virtue of having about one-third of their length embedded in the ground, thus eliminating the need for supporting H-beam columns. The panels are usually heavier than the simple panels described in "B", preceding, and have tongue and grooved edges to allow sealing of the joints. They require no foundation, and the height of the panels can be staggered. However, the required depth of embedment is not compatible with a concentration of underground utilities.

G. **Concrete block** - Concrete block is a rather economical alternate to other forms of concrete noise walls. Blocks can be made rough on one side and smooth on the other, or can be alternated to achieve a pattern. It is essential that water be kept out of the core holes, otherwise it will freeze and break off the block faces. One wall has been constructed with a concrete block bottom and a wood wall higher up. Concrete block walls require full length footings. A wide range of colors and textures are available.

Landscape Treatment

Landscape plans, prepared by the Roadside Development Design Unit, should be a part of every noise barrier project.
7.08

MAILBOX POSTS

7.08.01 (revised 10-21-2013)

References

A. Standard Plan R-74-Series, Bumper & Parking Rails, and Misc. Wood Posts

B. Roadside Design Guide, AASHTO, 2011, Chapter 11

7.08.02 (revised 10-21-2013)

General

Typically, the post supported rural mailbox is private property that occupies the R.O.W. by permission. During construction activities, the Department assumes the responsibility for maintaining serviceability of existing mailboxes. After construction activities are completed, the Department or its contractor will place a department approved support at the permanent location, remove the mailbox from the old support and attach it firmly to the new post, and dispose of the old support. The property owner shall be given the option of disposing of the old support. Existing newspaper boxes are removed and stored for the property owner’s future installation and are not paid for separately.

Even though the authority to regulate mailbox installations is not well defined, the property owner should be discouraged from reconstructing unusual mailbox installations. Crash tests seem to show that the mailboxes that remain attached to the post go down under impact and away from the vehicle. Attaching several boxes to one large horizontal support is discouraged by Chapter 11 of the Roadside Design Guide, AASHTO, 2011. Department standard plans now show a mailbox post having a smaller cross-sectional area than previously. Alternate mailbox support designs meeting the performance criteria of NCHRP Report 350 or MASH may be used as approved by the Engineer.

7.08.03 (revised 10-21-2013)

Design Considerations

As a part of the design, the number of existing mailboxes should be determined and used as a basis for estimating the number of mailbox posts to be placed on the project. Sometimes this can be determined from the plans if buildings are included in the topography shown, but this method is usually not as accurate as actually counting those in the field. The photolog is a reliable source of this information. Internet mapping websites can also be used.

Placement of mailboxes in a curb and gutter section may pose questions, particularly if a curb is being constructed where it did not exist before. If it is a vertical curb, the posts must be within arm’s reach of the face of curb; the question then is, are existing boxes concentrated on one side only, or on both sides of the road? If the curb is a roll curb, then the boxes can either be directly behind the curb or at the far edge of shoulder. Either location has advantages and disadvantages. If immediately behind the curb, the post may interfere with the movement of vehicles on the shoulder, pedestrians, and bicyclists, as well as snow removal on the shoulder. If placed at the far edge of the shoulder, the shoulder should be strong enough and wide enough for the delivery vehicle to get completely off the road. Snow removal may not always be complete to the point that the shoulder area is clear, back to the boxes. Generally, however, it has been our practice to place the boxes, in a roll curbed section, at the back of the shoulder, particularly if the purpose of the roll curb and paved shoulder is to provide a bicycle path. Traffic volume and speed are considerations that will influence the location of mailboxes in a roll curb and gutter section.
7.09

CONCRETE STEPS

7.09.01

General

Concrete steps, with a pipe handrail, are not built as part of a highway project as frequently as they once were. Before designers were as conscious of safety and clear zones as they are now, it was not uncommon to construct concrete steps on a cut backslope to facilitate a property owner’s access to a mailbox. This would not normally be done anymore, because the concrete structure would probably be located within the clear zone. Steps are, of course, constructed to facilitate frequent access up or down steep slopes. Before a decision is made to provide steps for this purpose, the designer should be satisfied that the structure is indeed outside the clear zone. In the rare case that concrete steps are included in a project, consult the Roadside Development Unit for step details and requirements.