Design of Concrete Barrier as Right- or Left-Side Guardrail: Survey of State Practice

Requested by
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Executive Summary

Background

Using concrete barrier in place of metal beam guardrail could offer a more rigid, less maintenance-intensive barrier on California roadsides. The California Department of Transportation (Caltrans) is investigating the use of concrete barrier as guardrail that is typically placed on the right side of a highway but may also be placed on the left side. Concrete guardrail as described for this purpose may be tested, applied for or under development under Manual for Assessing Safety Hardware (MASH) crash testing criteria.

Caltrans' March 2019 Traffic Safety Systems Guidance provides some detail about the intent of use when installing concrete barrier as varying lengths of guardrail. This detail has been used on a case-by-case basis as a construction detail to install concrete barrier as guardrail to the right of travel lanes, but the detail has not been accepted as a standard for this application.

To determine the current state of practice for using concrete barrier in this application, Caltrans is seeking design standards, specifications and policies from state departments of transportation (DOTs) and other agencies with experience using concrete barrier as right- or left-side guardrail. To assist Caltrans in this information-gathering effort, CTC & Associates surveyed a select group of state DOTs and contacted other transportation agencies for insight into the use of concrete barrier as guardrail. A limited literature search of publicly available sources about this topic supplemented the findings of the survey and consultations with subject matter experts.

Summary of Findings

This Preliminary Investigation gathered information in three areas:

- Survey of state practice.
- Consultation with experts.
- Related research and resources.

Survey of State Practice

An online survey was distributed to selected state DOTs expected to have experience with concrete barrier used as guardrail on the right or left side of the travel lane:

- Colorado.
- Florida.
- Georgia.
- Illinois.
- Indiana.
- Iowa.
- Michigan.
- New Hampshire.
- New York.
- Oregon.
- Texas.
- Utah.
- Virginia.
- Washington.

Transportation agencies from three states responded to the survey: Florida, Texas and Washington. Both Florida and Washington State DOTs use concrete barrier as guardrail. The Texas DOT respondent reported that the agency does install concrete barrier at roadside locations, and in many instances, guardrail could be used. However, the agency does not have a policy for when to use concrete barriers. Designers select the longitudinal barrier for roadside applications and may choose concrete barrier for various reasons, including reduced maintenance costs or restricted deflection distance.

Survey results from Florida and Washington State DOTs are summarized in case studies that include the following information:

- Date the agency began using concrete barrier as right- or left-side guardrail.
- Formal policy for using concrete barrier as right- or left-side guardrail.
- Side of the travel lane that the concrete guardrail is installed (right side, left side, or both right and left sides).
- Details about the foundation used for concrete barrier.
- Maintenance requirements.
- Standard plans for concrete barriers used as right- or left-side guardrail.

Highlights of this information are summarized in Table ES1.

Table ES1. Agency Use of Concrete Barrier as Right- or Left-Side Guardrail

Topic Area	Florida DOT	Washington State DOT
Implementation Date	1985	Unknown
Formal Policy for Use	No	Yes (see Supporting Documents, page 9)
Location of Concrete Guardrail	Typically installed on the right side of the travel lane.	Typically installed on the right and left sides of the travel lane.
Foundation	Plans available for shoulder barrier and wall shielding barrier.	Plans available for cast-in-place (CIP) barriers, including barriers with a 2'10" reveal and barriers with a 3'6" reveal (high-performance).
Maintenance Requirements	• No formal maintenance evaluation, in part because no notable issues have been reported. • Barrier “seems to be very robust.”	• Weathering of steel pin and loop connections in precast sections has required replacements. • Agency currently investigating the need to formalize its approach to assessing condition of weathered or damaged barrier.
Standard Plans	Yes (see Supporting Documents, page 8)	Yes (see Supporting Documents, page 9)

Consultation With Experts

Four other agencies were contacted for their insight and experience with using concrete barrier as guardrail:

- Federal Highway Administration (FHWA).
- Midwest Roadside Safety Facility (Midwest States Pooled Fund).
- North Texas Tollway Authority.
- Texas Transportation Institute (Roadside Safety Pooled Fund).

Federal Highway Administration

Menna Yassin, highway safety engineer on the Safety Design Team at FHWA, noted that many states use concrete barrier along roadsides, generally because the practice is seen as a lower-maintenance alternative. Yassin was familiar with a Washington State DOT application using concrete barrier instead of guardrail because of its low-maintenance requirements and suggested contacting the agency for this barrier system's specifications and plans.

Midwest Roadside Safety Facility

Robert Bielenberg, manager of the Midwest States Pooled Fund Program at the Midwest Roadside Safety Facility, said that he is not involved in state agency decisions for placing barriers that the center researches and develops. These decisions, he added, are typically based on cost, flexibility and frequency that the barrier is hit. Bielenberg referred to several barriers that could be used as guardrail—single slope, safety shapes, New Jersey, F-shape and stepped face—and suggested searching state DOT web sites for standards and specifications.

North Texas Tollway Authority

Elizabeth Tovarnak-Mow, assistant executive director of infrastructure at North Texas Tollway Authority, reported that the agency does use concrete barrier on its tollways; she suggested contacting Mark Bouma, technical oversight leader at North Texas Tollway Authority, for more information about agency practices. Bouma did not respond to follow-up requests.

Texas Transportation Institute

Chiara Silvestri Dobrovolny, associate research scientist at Texas Transportation Institute, recommended searching the MASH database on the Roadside Safety Pooled Fund web site for examples of MASH-tested roadside concrete barriers. This search yielded performance information and guidance for five relevant barriers:

- 40-foot-long keyed-in single slope barrier.
- 75-foot-long keyed-in single slope barrier.
- TL-4 36-inch single slope barrier on mechanically stabilized earth (MSE) wall.
- TL-5 42-inch New Jersey barrier on MSE wall.
- Single slope barrier.

Related Research and Resources

Supplementing the survey and consultation results are documents sourced through a limited literature search. These resources include two FHWA online resources listing longitudinal barriers. One list describes barriers that have been issued an FHWA eligibility letter based on American Association of State Highway and Transportation Officials (AASHTO) MASH criteria; barriers on the second list have been issued an FHWA eligibility letter based on National Cooperative Highway Research Program (NCHRP) 350 testing criteria.

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Standards, specifications and guidance for concrete barriers are presented from several states. Many of the standards and plans address subgrade and base preparation along with construction and installation requirements. In a discussion of concrete barrier applications, a 2019 Illinois DOT manual addresses barrier selection criteria, including test levels, deflection and maintenance requirements. Also included is a comparison of the advantages and disadvantages of various barrier systems along with examples of typical use. A 2016 Indiana

DOT report evaluates the in-service safety performance of concrete barriers, steel W-beam guardrails and high-tension cable barriers using cross-sectional analysis based on crash data.

Gaps in Findings

Only three state DOTs participated in the online survey, and only two of these agencies provided details about their agencies' practices and policies for using concrete barrier as guardrail on the right or left side of the travel lane. In addition, most subject matter experts contacted for this Preliminary Investigation had limited or no experience with the use of concrete barrier as guardrail. Reaching out to state DOTs that did not participate in the survey and other transportation research organizations and agencies could provide relevant information about experience and practices using concrete barriers in these applications.

Next Steps

Moving forward, Caltrans could consider:

- Following up with:
    - Texas DOT for more information about the agency's use of concrete barrier as guardrail, specifically the factors that designers consider when determining whether concrete barriers are more appropriate for a specific roadside application.
    - Mark Bouma of North Texas Tollway Authority for information about the agency's use of concrete barrier on state tollways.
- Examining the MASH database on the Roadside Safety Pooled Fund web site for performance information about MASH-tested roadside concrete barriers.
- Reviewing the concrete barrier standards and plans provided by survey respondents and sourced through the limited literature search for relevance to Caltrans' needs.

Detailed Findings

Background

The California Department of Transportation (Caltrans) is interested in collecting information on the current state of practice for the use of concrete barrier as guardrail that is typically placed on the right side of a highway but may also be placed on the left side. Specifically, Caltrans is seeking design plans or standards and any policies, specifications or criteria that would allow for the use of a concrete barrier to replace metal beam guardrail as a more rigid, less maintenance-intensive barrier. Concrete guardrail as described for this purpose may be tested, applied for or under development under Manual for Assessing Safety Hardware (MASH) crash testing criteria.

Caltrans' March 2019 Traffic Safety Systems Guidance provides some detail about the intent of use when installing concrete barrier as varying lengths of guardrail. This detail has been used on a case-by-case basis as a construction detail to install concrete barrier as guardrail to the right of travel lanes, but has not been accepted as a standard for this application.

Caltrans is seeking information from state departments of transportation (DOTs) and other agencies with experience designing and installing concrete barrier as right- or left-side guardrail. To assist Caltrans in this information-gathering effort, CTC & Associates surveyed a selected group of state DOTs about their agencies' experience with using concrete barrier as guardrail and related practices. In addition, four other agencies were contacted that were expected to have knowledge of or experience with the use of concrete barrier as guardrail:

- Federal Highway Administration (FHWA).
- Midwest Roadside Safety Facility (Midwest States Pooled Fund).
- North Texas Tollway Authority.
- Texas Transportation Institute (Roadside Safety Pooled Fund).

A limited literature search of publicly available sources about the use of concrete barrier as guardrail supplemented the survey findings and discussions with subject matter experts. Results from these efforts are presented in this Preliminary Investigation in three areas:

- Survey of state practice.
- Consultation with experts.
- Related research and resources.

Survey of State Practice

An online survey was distributed to selected state DOTs expected to have experience with concrete barrier used as guardrail on the right or left side of the travel lane. The survey questions are provided in Appendix A. The full text of survey responses is presented in a supplement to this report.

The following state DOTs received the survey:

- Colorado.
- Florida.
- Georgia.
- Illinois.
- Indiana.
- Iowa.
- Michigan.
- New Hampshire.
- New York.
- Oregon.
- Texas.
- Utah.
- Virginia.
- Washington.

Three state transportation agencies responded to the survey: Florida, Texas and Washington State DOTs. Respondents from two of these agencies—Florida and Washington State DOTs—reported that their agencies use concrete barrier as guardrail on the right or left side of the travel lane. Both respondents provided additional details about concrete barrier practices and policies.

The Texas DOT respondent reported that the agency does use concrete barrier on the roadside and that in many instances when concrete barrier is installed, guardrail could be used. However, the agency doesn't have a policy for using concrete barrier in this application. Instead, designers choose the longitudinal barrier for each application; concrete barrier may be chosen for various reasons, including reduced maintenance costs or restricted deflection distance. No further details were provided by the respondent.

Below are case studies that summarize Florida and Washington State DOTs' practices and policies for using concrete barrier as guardrail. Each case study includes the following information:

- Date the agency began using concrete barrier as right- or left-side guardrail.
- Formal policy for using concrete barrier as right- or left-side guardrail.
- Side of the travel lane that the concrete guardrail is installed (right side, left side, or both right and left sides).
- Details about the foundation used for concrete barrier.
- Maintenance requirements.
- Standard plans for concrete barriers used as right- or left-side guardrail.

Following each case study is a Supporting Documents section that includes agency policies and guidance that were provided by the respondent or sourced through a limited literature search.

Florida Department of Transportation

Topic Area	Description
Implementation Date	1985
Formal Policy for Use	No
Location	Typically installed on the right side of the travel lane.
Foundation	Plans available for shoulder barrier and wall shielding barrier (see Supporting Documents below).
Maintenance Requirements	No formal evaluation of maintenance has been conducted, in part because no notable issues have been reported. The respondent added that the barrier "seems to be very robust."
Standard Plans	Yes (see Supporting Documents below)

Supporting Documents

Index 521-001: Concrete Barrier, Standard Plans Instructions, FY 2019-20, Florida Department of Transportation, October 2019.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/design/standardplans/2020/spi/spi-521-001.pdf?sfvrsn=53e0ac62_2
This section provides concrete barrier design assumptions, limitations and plan content requirements for shoulder and wall shielding barriers, including shielding hazards, end treatments and barrier end connections/continuations.

Chapter 215, Roadside Safety, Florida DOT Design Manual, Florida Department of Transportation, January 2019.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/roadway/fdm/2019/2019fdm215roadsidesafety.pdf?sfvrsn=f02156e0_4
Section 215.4.1.3, Rigid Barrier (beginning on page 32), provides information about rigid barriers that include concrete barriers used for roadway applications and links to standard plans.

Concrete Barrier, FY 2019-20 Standard Plans, Index 521-001, Florida Department of Transportation, November 2018.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/design/standardplans/2020/idx/521-001.pdf?sfvrsn=89fa9556_2
Standard plans are provided for shoulder barrier (beginning on page 13) and wall shielding barrier (beginning on page 23). General notes include the following:

- Subgrade: Compact the top layer of subgrade with Type B Stabilization, LBR 40 (12 in.).
- Footing Bottom Concrete Cover: At the bottom of barrier footings shown throughout this Index, up to 2 inches of additional concrete cover is permitted beyond what is shown herein to accommodate soil grade irregularities.
- Finish Grade Elevation: At the barrier face location, the finish grade pavement has a vertical position tolerance of ±0.5 inch from the locations shown herein, relative to the barrier elevation. Maintain visually smooth and even pavement at the barrier face, per the approval of the Engineer.

Concrete Barrier Wall, Florida Department of Transportation, July 2014.
https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/content2/roadway/ds/15/idx/00410.pdf?sfvrsn=4c73927b_0
Plan sheets on pages 3 and 10 of the PDF show the design standards for shoulder barrier walls.

Washington State Department of Transportation

Topic Area	Description
Implementation Date	Unknown
Formal Policy for Use	Yes
Location	Typically installed on the right and left sides of the travel lane.
Foundation	Plans available for cast-in-place (CIP) barriers, including barriers with a 2'10" reveal and barriers with a 3'6" reveal (high-performance) (see Supporting Documents below).

Topic Area	Description
Maintenance Requirements	• Weathering of steel pin and loop connections in precast sections has required replacements. • Agency is currently investigating the need to formalize its approach to assessing condition of weathered or damaged barrier.
Standard Plans	Yes (see Supporting Documents below)

Supporting Documents

Chapter 1610, Traffic Barriers, WSDOT Design Manual, Washington State Department of Transportation, December 2019.
https://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/1610.pdf
Section 1610.06 (beginning on page 32 of the PDF) presents Washington State DOT's policy for using concrete barrier. Considerations for installing concrete barriers include:

- For slopes with a horizontal-to-vertical (H:V) steepness of 10H:1V or flatter, concrete barrier can be used anywhere outside of the shoulder.
- Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.
- When considering concrete barrier use in areas where drainage and environmental issues (such as stormwater, wildlife or endangered species) might be adversely impacted, contact the HQ Hydraulics Office and/or the appropriate environmental offices for guidance. Also, refer to Section 1610.02 [Barrier Impacts, beginning on page 2 of the PDF].

Three concrete barrier types are discussed: single slope, New Jersey and F-shape. Other general topics include design considerations, placement considerations and barrier deflection.

Standard Plan C-80.10-01: Single-Slope Concrete Barrier (Cast-In-Place) Dual-Faced, Washington State Department of Transportation, June 2014.
https://www.wsdot.wa.gov/publications/fulltext/Standards/english/PDF/C80.10-01_e.pdf.
Standard plans are provided for foundations of CIP barriers, including barriers with a 2'10" reveal and barriers with a 3'6" reveal (high-performance).

Section C: Concrete Barrier, Standard Plans, Washington State Department of Transportation, undated.
https://www.wsdot.wa.gov/Design/Standards (Scroll to Section C (Concrete Barrier))
This web page provides links to numerous precast and CIP standard plans.

Consultation With Experts

We contacted the following experts from transportation agencies and research organizations known to have knowledge of or experience with the use of concrete barrier as guardrail:

- FHWA.
- Midwest Roadside Safety Facility.
- North Texas Tollway Authority.
- Texas Transportation Institute.

Below are summaries of email and phone conversations with these subject matter experts.

Federal Highway Administration

Contact: Menna Yassin, Highway Safety Engineer, Safety Design Team, Federal Highway Administration, 202-366-2833, menna.yassin@dot.gov.

Menna Yassin, highway safety engineer on the Safety Design Team at FHWA, noted that many states use concrete barrier along their roadsides for various reasons, generally because the practice is seen as a lower-maintenance alternative. Yassin was familiar with an instance where Washington State DOT used concrete barrier instead of guardrail because it required lower maintenance, and recommended contacting the agency for specifications and plans.

Midwest Roadside Safety Facility

Contact: Robert Bielenberg, Manager, Midwest States Pooled Fund Program, Midwest Roadside Safety Facility, Nebraska Transportation Center, 402-472-9064, rbielenberg2@unl.edu.

Robert Bielenberg, manager of the Midwest States Pooled Fund Program at the Midwest Roadside Safety Facility, said that he doesn't get involved in state agency decisions of where to place the barriers that the center researches and develops. Bielenberg indicated that these decisions are typically based on cost, flexibility and frequency that the barrier is hit.

Bielenberg mentioned different types of barriers that could be used as guardrail, including single slope, safety shapes, New Jersey, F-shape and stepped face. He suggested searching state DOT sites for standards and specifications, adding that shape, reinforcement and footing conditions will vary. Bielenberg also recommended reviewing different MASH test levels.

Related Resource:

> **MwRSF Pleased With Test of Concrete Barrier**, Karl Vogel, College of Engineering, University of Nebraska–Lincoln, April 2016.
> https://engineering.unl.edu/mwrsf-pleased-test-concrete-barrier/
> This article describes the successful testing of a 49-inch single slope concrete roadside barrier at the Midwest Roadside Safety Facility.

North Texas Tollway Authority

Contact: Elizabeth Tovarnak-Mow, Assistant Executive Director of Infrastructure, North Texas Tollway Authority, emow@ntta.org.

North Texas Tollway Authority does use concrete barrier on its tollways, according to Elizabeth Tovarnak-Mow, assistant executive director of infrastructure at the agency. She referred us to Mark Bouma, technical oversight leader at North Texas Tollway Authority, for more information about agency practices. Bouma did not respond to our inquiries.

Texas Transportation Institute

Contact: Chiara Silvestri Dobrovolny, Associate Research Scientist, Texas Transportation Institute, 979-317-2687, c-silvestri@tti.tamu.edu.

Chiara Silvestri Dobrovolny, associate research scientist at Texas Transportation Institute, directed us to the MASH database (available at https://www.roadsidepooledfund.org/mash-implementation/search/) to search for roadside barriers and compare performance and deflection with metal guardrail systems. She added that not all barriers have been included in the database.

The following resource briefly describes the Roadside Safety Pooled Fund program. Following this description are examples of MASH-tested concrete barriers available at the web site.

> **Roadside Safety Pooled Fund**, Texas Transportation Institute, Transportation Pooled Fund Program, Federal Highway Administration, undated.
> https://www.roadsidepooledfund.org/
> MASH database: https://www.roadsidepooledfund.org/mash-implementation/search/
> *Lead state*: Washington State Department of Transportation
> The Roadside Safety Pooled Fund was organized to "establish an ongoing roadside safety research program that meets the research and functional needs of participating states in a cost-effective and timely manner." As the pooled fund's web site indicates, "[s]pecific research activities addressed within the program include the design, analysis, testing and evaluation of crashworthy structures, and the development of guidelines for the use, selection and placement of these structures. Crashworthy structures addressed include bridge rails, guardrails, transitions, median barriers, portable concrete barriers, end treatments, crash cushions, culverts, breakaway support structures (e.g., sign supports, luminaire supports, mailboxes) and work zone traffic control devices."

MASH-Tested Concrete Barriers

40-Foot Long Keyed-In Single Slope Barrier
https://www.roadsidepooledfund.org/?p=5688

Report Number(s): 610221-01

Description: 42-inch tall, keyed-in single slope barrier with 40-foot-long section length

Test Level: 4

Barrier Type: Single slope

MASH Test Number: 4-12

Proprietary/Nonproprietary: Nonproprietary

Pass/Fail: Pass

Sponsor: Roadside Safety Research Program Pooled Fund

Test Article Description:

Height: 42 inches

Top Base: 8 inches

Bottom Base: 24 inches

Ground Connection: Embedded

Related Resource:

MASH Test 4-12 on Keyed-In Single Slope Barrier With 40-Ft Segment Length, Washington State Department of Transportation, October 2018.
https://www.roadsidepooledfund.org/mash-testing-of-keyed-in-single-slope-barrier-610221-01/
From the abstract: This report provides details of the keyed-in single-slope barrier with the 40-[foot] segment, detailed documentation of the crash test results, and an assessment of the performance of the barrier for MASH Test 4-12 evaluation criteria. Based on the results of the test, the keyed-in single-slope barrier with the unconnected 40-[foot] segment performed acceptably for MASH Test 4-12.

75-Foot Long Keyed-In Single Slope Barrier
https://www.roadsidepooledfund.org/longitudinal-barrier/single-slope-concrete-barrier-in-1-inch-aspahlt/

Report Number(s): 0-6946-1

Description: 42-inch tall SSCB [single slope concrete barrier] with 1-inch ACP [asphalt concrete pavement] lateral support

Test Level: 4

Barrier Type: Single slope

MASH Test Number: 4-12

Proprietary/Nonproprietary: Nonproprietary

Pass/Fail: Pass

Sponsor: Texas DOT

Test Article Description:

Height: 42 inches

Top Base: 8 inches

Bottom Base: 24 inches

Ground Connection: Embedded

Related Resource:

MASH Evaluation of TxDOT Roadside Safety Features—Phase I, Roger P. Bligh, Wanda L. Menges and Darrell L. Kuhn, Texas Department of Transportation, January 2018.
https://www.roadsidepooledfund.org/wp-content/uploads/2017/11/0-6946-1.pdf
The 75-foot-long keyed-in single slope barrier is discussed in Chapter 3 (beginning on page 17 of the report, page 35 of the PDF). The following summary remarks are presented in Section 8.2 (page 139 of the report, page 157 of the PDF):

> The TxDOT [Texas DOT] 42-inch SSCB with 1-inch ACP lateral support contained and redirected the 10000S vehicle. The vehicle did not penetrate, underride or override the installation. No lateral deflection was noted during the test. No detached elements, fragments or other debris was present to penetrate or show potential for penetrating the occupant compartment or to present hazard to others in the area. The 10000S vehicle remained upright during and after the collision event.
>
> The TxDOT 42-inch tall SSCB with 1-inch ACP lateral support performed acceptably for MASH Test 4-12.

Recommendations for implementation are given in Section 9.2 (page 143 of the report, page 161 of the PDF).

TL-4 36-Inch Single Slope Barrier on MSE [Mechanically Stabilized Earth] Wall
https://www.roadsidepooledfund.org/longitudinal-barrier/tl-4-36%e2%80%b3-f-shape-barrier-on-mse-wall/

Report Number(s): NCHRP Project 22-20(2)

Description: 36-inch-tall single slope barrier on a 10-foot-high MSE wall with unreinforced concrete bearing pad

Test Level: 4

Barrier Type: Single slope

MASH Test Number: 4-12

Proprietary/Nonproprietary: Nonproprietary

Pass/Fail: Pass

Sponsor: National Cooperative Highway Research Program (NCHRP)

Test Article Description:

Height: 36 inches

Top Base: 7.5 inches

Bottom Base: 24 inches

Ground Connection: Embedded

Related Resource:

Project in Progress: NCHRP Project 22-20(2): Design Guidelines for TL-3 Through TL-5 Roadside Barrier Systems Placed on Mechanically Stabilized Earth (MSE) Retaining Walls), start date: May 2010, completion date: May 2017.
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2735

Note: While the status lists this research as completed and a final report delivered to American Association of State Highway and Transportation Officials (AASHTO), a report does not appear to be publicly available and this research continues to be listed as “active.”

From the project objective: The objective of this research is to develop, in a format suitable for consideration by AASHTO, recommended guidelines for designing roadside barrier systems placed on MSE retaining structures to resist vehicular impact loadings varying from passenger vehicles to heavy trucks. To extend the work done under Project 22-20, this project will consist of engineering analyses, computer modeling and bogie testing for Test Levels 3 through 5 and will include full-scale crash testing of a tractor-van trailer (TL-5) into a barrier placed atop an MSE retaining wall. The guidelines should address Test Levels 3 through 5. Specific considerations include defining appropriate design loads, developing procedures for sizing the traffic barrier foundation and designing the MSE wall when traffic barriers are required.

TL-5 42-Inch New Jersey Barrier on MSE Wall

https://www.roadsidepooledfund.org/longitudinal-barrier/mse-wall/

Report Number(s): NCHRP Project 22-20(2)

Description: 42-inch-tall New Jersey barrier on a 10-foot-high MSE wall with unreinforced concrete bearing pad

Test Level: 5

Barrier Type: New Jersey

MASH Test Number: 5-12

Proprietary/Nonproprietary: Nonproprietary

Pass/Fail: Pass

Sponsor: NCHRP

Test Article Description:

Height: 42 inches

Top Base: 11.75 inches

Bottom Base: 25.5 inches

Ground Connection: Embedded

Related Resource:

Project in Progress: NCHRP Project 22-20(2): Design Guidelines for TL-3 Through TL-5 Roadside Barrier Systems Placed on Mechanically Stabilized Earth (MSE) Retaining Walls, start date: May 2010, completion date: May 2017.
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2735

Note: While the status lists this research as completed and a final report delivered to AASHTO, a report does not appear to be publicly available and this research continues to be listed as “active.”

From the project objective: The objective of this research is to develop, in a format suitable for consideration by AASHTO, recommended guidelines for designing roadside barrier systems placed on MSE retaining structures to resist vehicular impact loadings varying from passenger vehicles to heavy trucks. To extend the work done under Project 22-20, this project will consist of engineering analyses, computer modeling and bogie testing for Test Levels 3 through 5 and will include full-scale crash testing of a tractor-van trailer (TL-5) into a barrier placed atop an MSE retaining wall. The guidelines should address Test Levels 3 through 5. Specific considerations include defining appropriate design loads, developing procedures for sizing the traffic barrier foundation and designing the MSE wall when traffic barriers are required.

Single Slope Barrier

https://www.roadsidepooledfund.org/longitudinal-barrier/single-slope-barrier/

Report Number(s): 405160-13-1

Description: Offset 2 feet from 1.5:1 slope

Test Level: 3

Eligibility Letter: B225

Barrier Type: Single slope (10.8 degrees)

Barrier Type: Single slope

MASH Test Number: 3-11

Proprietary/Nonproprietary: Nonproprietary

Pass/Fail: Pass

Sponsor: Roadside Safety Research Program Pooled Fund

Test Article Description:

Height: 32 inches

Top Base: 8 inches

Bottom Base: 24 inches

Ground Connection: Embedded

Related Resources:

Development and Testing of a Concrete Barrier Design for Use in Front of Slope or on MSE Wall, Nauman M. Sheikh, Roger P. Bligh and Wanda L. Menges, Washington State Department of Transportation, August 2009.
https://roadsidepooled.wpengine.com/wp-content/uploads/2016/10/405160-13-1_Report.pdf
From the abstract: The objective of this research was to restrict lateral deflection of a concrete barrier when placed adjacent to steep slopes or on top of Mechanically Stabilized Earth (MSE) walls, without using a concrete moment slab. The final design was required to incorporate 20-[foot]-long single slope barrier segments with grouted rebar grid connection. The researchers first evaluated the performance of the free-standing barrier with grouted rebar-grid connection using a smaller scale bogie impact test and simulation analysis. It was determined that the grouted rebar-grid connection did not provide enough strength to restrict lateral deflections.

The researchers then evaluated restricting the deflection of the barrier by embedding it 10 inches in soil. The barrier was placed in front of a 1.5H:1V slope. The offset of the barrier from the slope break point was restricted to 2 [feet]. Another phase of bogie testing and simulation analysis was performed to evaluate the performance of the grouted rebar grid connection in the embedded configuration. Results of the simulation analysis showed that the embedded barrier system will result in acceptably reduced lateral deflections.

A 100-[foot]-long installation of the embedded single-slope barrier in front of a 1.5H:1V slope was subsequently crash-tested under Manual for Assessing Safety Hardware (MASH) criteria. The design performed acceptably according to the requirements of MASH and the maximum static barrier deflection was 5.5 inches. While the barrier was tested in front of a 1.5H:1V slope, due to a relatively small lateral deflection, it is also recommended for use on top of MSE walls as long as a minimum 2-[foot] lateral offset is maintained between the back of the barrier and the wall.

FHWA Eligibility Letter B225: Single Slope Concrete Barrier Placed in Front of Steep Slope, Federal Highway Administration, November 2011.
https://roadsidepooled.wpengine.com/wp-content/uploads/2016/10/405160-13-1_FHWAeligibilityLetter_b225.pdf
This eligibility letter includes details of the single slope concrete barrier.

Related Research and Resources

State Research, Guidance and Plans

Multiple States

Longitudinal Barriers, Office of Safety, Federal Highway Administration, July 2019.
https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=long
Longitudinal barriers in this list have been issued an FHWA eligibility letter based on AASHTO MASH criteria. Concrete barriers include the single slope concrete barrier reviewed by Washington State DOT.

Longitudinal Barriers—NCHRP 350, Office of Safety, Federal Highway Administration, October 2018.
https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing-archived.cfm?code=long&filter=
Roadside safety hardware at this web site has been issued an FHWA eligibility letter based on NCHRP 350 testing criteria. Example hardware includes various concrete barriers.

Colorado

Guardrail Type 9 Single Slope Barrier, Colorado Department of Transportation, July 2018.
https://www.codot.gov/business/designsupport/standard-plans/copy_of_2012-m-standards-plans/2012-m-standards-pdfs/m-606-15/m-606-15
These plan sheets show details of a concrete barrier with single slope sides.

Guardrail Type 7 F-Shape Barrier, Colorado Department of Transportation, August 2013.
https://www.codot.gov/business/designsupport/standard-plans/copy_of_2012-m-standards-plans/2012-m-standards-pdfs/34-guardrail-type-7-f-shape-barrier/m-606-13-guardrail-type-7-f-shape-barrier
These plan sheets show details of an F-shape concrete barrier. General notes provide anchorage information and foundation requirements.

Precast Type 7 Concrete Barrier, Colorado Department of Transportation, July 2012.
https://www.codot.gov/business/designsupport/standard-plans/copy_of_2012-m-standards-plans/2012-m-standards-pdfs/35-precast-type-7-concrete-barrier/m-606-14-precast-type-7-concrete-barrier
These plan sheets show details of rebar and pin and loop connections.

Georgia

Section 621, Concrete Barrier, Standard Specifications: Construction of Transportation Systems, Georgia Department of Transportation, April 2013.
http://www.dot.ga.gov/PartnerSmart/Business/Source/specs/ss621.pdf
From the introduction:

> This work includes constructing portland cement concrete barriers according to these specifications and in conformance with the lines, grades, type and typical sections shown on the Plans, or established by the Engineer. This specification may require barriers suitable for medians or side installation on both roadways and bridges.

Subgrade and base preparation are discussed along with construction and installation requirements.

Illinois

Chapter 38, Roadside Safety, Bureau of Design and Environment Manual, Illinois Department of Transportation, November 2019.
http://www.idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Split/Design-And-Environment/BDE-Manual/Chapter%2038%20Roadside%20Safety.pdf
Concrete barrier applications and barrier height are briefly discussed in Section 38-5.01(b) (page 50 of the PDF). Section 38-5.02 (page 51 of the PDF) addresses selection criteria, including test levels, deflection and maintenance requirements. Figure 38-5.A (page 53 of the PDF) compares the advantages and disadvantages of various barrier systems, with examples of typical use.

Traffic Barrier Guidelines, Illinois State Toll Highway Authority, March 2019.
https://www.illinoistollway.com/documents/20184/473059/TrafficBarrierGuidelines_Mar2019.pdf/e48b7a64-8f0b-450b-abcf-6c6b460d5279?version=1.4
Applications for concrete barrier are addressed in Section 13 (beginning on page 115 of the report, page 123 of the PDF) including installation requirements for single face reinforced concrete barrier. Guidance recommends using concrete barriers "in lieu of guardrail, when a higher test level is desired due to the severity of an obstacle."

Section C–Guardrail/Median Barrier, Illinois Tollway Standard Drawing Revisions*,* Illinois State Toll Highway Authority, March 2019.
https://www.illinoistollway.com/documents/20184/753196/Section+C-+Guardrail_Mar2019.pdf/843c1222-23df-464f-b124-2d81720d6d58?version=1.1
This document summarizes the modifications to various guardrail and median barrier plan sheets. Revisions to single face reinforced concrete barriers are presented in Standards C-3, C-5, C-15, C-16 and C-17.

Indiana

Performance Assessment of Road Barriers in Indiana, Yaotian Zou and Andrew P. Tarko, Indiana Department of Transportation, March 2016.
https://gibraltarglobal.com/wp-content/uploads/2018/02/Road-Barriers-Assessment-in-Indiana.pdf
From the abstract: The objective of this study was to evaluate the in-service safety performance of three types of road barriers (concrete barriers, steel W-beam guardrails and high-tension cable barriers) in Indiana using cross-sectional analysis based on crash data. The quantitative evaluation was comprised of three components: 1) the effect of the road, barrier scenarios and traffic on the barrier-relevant (BR) crash frequency, 2) the effect of the road and the barrier scenarios on the BR harmful events, and 3) the effect of the BR events and other conditions on the injury outcomes.

Iowa

Standard Road Plans—BA Series, Iowa Department of Transportation, 2019.
https://iowadot.gov/design/stdplne_ba
Links to several concrete barrier plans and other roadside safety hardware are provided on this web page.

Massachusetts

F Shape Concrete Barrier for Permanent Use, Engineering Directive, Massachusetts Department of Transportation, June 2018.
https://www.mass.gov/files/documents/2018/06/25/E-18-001.pdf
This engineering directive provides standard details for precast F-shape concrete barrier in permanent installations. *From the engineering directive*:

> Effective immediately, the standard details for F Shape Concrete Barrier contained in the MassDOT [Massachusetts DOT] Highway Division Construction Standard Details and listed below apply to Precast Concrete Barrier only. These standard details no longer apply to Cast-in-Place Concrete Barrier. Any use of a Cast-in-Place Concrete Barrier system on a MassDOT project or on a MassDOT owned facility must conform to the performance requirements contained in the 2016 edition of the Manual for Assessing Safety Hardware (MASH).

Michigan

Concrete Barriers, Road Standard Plans, Michigan Department of Transportation, April 2018.
https://mdotcf.state.mi.us/public/design/files/englishstandardplans/files/standard_plan_distribution.pdf
Standard plans for concrete barrier (Standard Plan R-49-G) begin on page 15 of the PDF.

New Hampshire

Standard Plans for Road Construction, Bureau of Highway Design, New Hampshire Department of Transportation, 2010.
https://www.nh.gov/dot/org/projectdevelopment/highwaydesign/standardplans/
This web page provides links to standard plans for various NCHRP 350 compliant concrete barriers, including precast 42-inch F-shape (double-faced) (GR-15) and single slope (GR-19) barriers.

New York

New York State Standard Sheets, Office of Design, New York State Department of Transportation, May 2013.
https://www.dot.ny.gov/main/business-center/engineering/cadd-info/drawings/standard-sheets-us-repository/2013_May_02_USC_book.pdf
Standard plan sheets are provided for CIP (page 111 of the PDF), precast (page 112 of the PDF) and machine-formed (page 113 of the PDF) concrete barriers.

Oregon

Section 4.6, Guardrail and Concrete Barrier, ODOT Highway Design Manual, Oregon Department of Transportation, 2012.
https://www.oregon.gov/ODOT/Engineering/Documents_RoadwayEng/HDM_04-Cross-Sections.pdf
Single slope barrier, CIP and slip form barrier are discussed in this section, beginning on page 34 of the PDF. The section also includes a link to standard drawings for concrete barriers (RD500 series).

Related Resource:

RD500 Series: Concrete Barrier, Oregon Standard Drawings, Oregon Department of Transportation, undated.
https://www.oregon.gov/ODOT/Engineering/Pages/Drawings-Roadway.aspx
This web page provides links to standard drawings for various concrete barriers.

Texas

Roadway Standards, Design Division, Texas Department of Transportation, 2019.
https://www.dot.state.tx.us/insdtdot/orgchart/cmd/cserve/standard/rdwylse.htm
(Scroll to Barrier (Rigid))
This web page lists standard plans for various precast and CIP concrete barriers, including F-shape and single slope.

Utah

Concrete Barrier Shoulder Installation, Standard Drawing Number BA 1C, Utah Department of Transportation, 2012.
https://www.udot.utah.gov/main/uconowner.gf?n=8265111353579979
This standard drawing provides guidance for installing precast and CIP concrete barriers along the shoulder of the road.

Barrier Systems on MSE Walls, Catherine Higgins, Utah Department of Transportation, September 2011.
https://blog.udot.utah.gov/2011/09/barrier-systems-on-mse-walls/
This article discusses research on barrier systems performing as safety devices on MSE walls. Two barrier types were tested: Jersey and a vertical barrier. Study results were used to modify new Load and Resistance Factor Design specifications for barrier systems on MSE walls.

Contacts

CTC contacted the individuals below to gather information for this investigation.

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Appendix A: Survey Questions

The following survey was distributed to selected state DOTs expected to have knowledge of or experience with the use of concrete barrier as guardrail on the right or left side of the travel lane.

Use of Concrete Barrier as Right- or Left-Side Guardrail

(Required) Does your agency use concrete barrier as guardrail on the right or left side of the travel lane?

- No (directs the respondent to **Agencies Not Using Concrete Barrier as Right- or Left-Side Guardrail**)
- Yes (directs the respondent to **Agencies Using Concrete Barrier as Right- or Left-Side Guardrail**)

Agencies Not Using Concrete Barrier as Right- or Left-Side Guardrail

Is your agency considering use of concrete barrier as right- or left-side guardrail?

- No
- Yes (please briefly describe your agency's discussions or plans)

Note: After responding to the question above, the respondent is directed to the Wrap-Up section of the survey.

Agencies Using Concrete Barrier as Right- or Left-Side Guardrail

1. How long has your agency used concrete barrier as right- or left-side guardrail?
2. Does your agency have a formal policy for its use of concrete barrier as right- or left-side guardrail?
   - No
   - Yes (please provide a link to this policy or send any files not available online to chris.kline@ctcandassociates.com)
3. Typically, on which side of the travel lane is the concrete guardrail installed?
   - Right side
   - Left side
   - Right and left sides
4. Please provide details of the foundation used for these concrete guardrails.

   4A. If available, please provide links to documentation that describes the foundation used for concrete guardrail installations; send any files not available online to chris.kline@ctcandassociates.com.
5. Please describe your agency's experience with maintaining these concrete guardrails.

6. Does your agency have standard plans for concrete barriers used as right- or left-side guardrail?
    - No
    - Yes (please provide a link to these plans or send any files not available online to chris.kline@ctcandassociates.com)
7. Please provide links to other documents you have not already provided that are associated with your agency's use of concrete barrier as right- or left-side guardrail. Send any files not available online to chris.kline@ctcandassociates.com.

Wrap-Up

Please use this space to provide any comments or additional information about your previous responses.