Orange Book Requirements to Enhance the Effectiveness of UDOT’s Pavement Preservation Program Considering a Balanced Perspective

Quality Improvement Team Report

February 2008

By
Federal Highway Administration – Utah Division
Utah Department of Transportation
Orange Book Safety Improvement Guidelines Quality Improvement Team Report

Scope:
Review Orange Book program, including the scoping and design processes. Evaluate and provide guidance within the design process to maximize pavement preservation activities while addressing critical safety needs in a cost effective manner.

Background:
UDOT preventive maintenance program follows the AASHTO definition as a “planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system (without substantially increasing structural capacity).” The Orange Book Program consists of contracted treatments to support the preventive maintenance program. Orange book contracts include:

- Thin functional overlays ≤ 1 ½ inches
- Rotomilling
- Surface seals
- Rejuvenation
- Lane leveling
- Crack sealing
- Concrete joint resealing & spall repair
- Concrete grinding
- Slab jacking and/or undersealing
- Minimal full depth repair

During the 1990s congress through legislation broadened the applicability of federal aid funds to preventive maintenance activities. Because federal funds are being utilized safety appurtenances along federal aid highways must meet current standards. The need to upgrade safety appurtenances began to compete with and in some cases override the ability to maintain pavements. In some areas, the cost to upgrade safety protective devices became so high that the proposed pavement preservation projects became infeasible. More and more safety issues were being addressed along the roadside utilizing pavement preservation funds, thus limiting the effectiveness of the program as a pavement preservation program.

While the safety issues are important, there was a need to balance those issues and maintain an effective pavement preservation program. In March and April of 2006 an attempt was made to achieve that balance. Under the direction of FHWA Utah Division and Utah Department of Transportation (UDOT), this team carried on from that work to develop safety improvement guidelines to be incorporated into the design process for Orange Book Projects. As a guiding document we used the FWHA memo regarding preventive maintenance eligibility dated October 8, 2004. That document indicates that “All preventive maintenance projects should consider appropriate ways to maintain or enhance the current level of safety and accessibility. Isolated or obvious deficiencies should always be addressed. Safety enhancements such as the installation or upgrading of
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guardrail and end treatments, installation or replacement of traffic signs and pavement markings, removal or shielding of roadside obstacles, mitigation of edge drop offs, the addition of paved or stabilization of unpaved shoulders, or installation of milled rumble strips should be encouraged and included in projects where they are determined to be a cost effective way to improve safety. To maintain preservation program flexibility, and in accordance with 23 U.S.C. 109(q), safety enhancements can be deferred and included within an operative safety management system or included in a future project in the STIP. In no way shall preventive maintenance type projects adversely impact the safety of the traveled way or its users.”

Safety Improvement Guidelines for Orange Book Projects:
The team addressed four main areas:

1. Safety items required to be addressed in all projects
2. Recommended Safety Items to be addressed on NHS and Non-NHS routes
3. Incorporation of identified safety issues into UDOT’s Safety Management System
4. Guidance regarding cost thresholds

Required Safety Items
Several safety-related issues are required to be addressed on all projects either by policy, regulation, directives or court settlement. These include:

• Pavement drop offs greater than 2 inches
• ADAAG Compliant Pedestrian Ramps (Stipulation of Settlement for case of Ronald Decker v. UDOT).
• Rumble Strips installed or re-ground (UDOT Rumble Strip Policy 06C-17)
• Replacement of turn-down guardrail terminals within the AASHTO clear zone with appropriate end section (FHWA Memo dated September 29, 1994).

NHS and Non-NHS Routes
A decision matrix was developed to address required and recommended safety improvements for NHS and non-NHS routes with design speeds less than and greater than 40 miles per hour. The decision matrix is based on requirements of the FHWA memo dated September 29, 1994.

Incorporation of identified safety issues into UDOT’s Safety Management System
In addition, the decision matrix addresses guardrail height or configuration and when they should be addressed. Since judging appropriate guardrail configuration including height, post spacing, block outs etc. can be difficult a checklist has been developed and included with the guidelines. This checklist identifying those deficiencies is submitted to the Division of Traffic and Safety for incorporation into the UDOT Safety Management System. With this data, The UDOT Division of Traffic and Safety can identify needs and develop cost estimates to plan future improvements addressing safety issues that are not addressed with the pavement preservation projects.
Guidance on Costs
When the costs for safety improvements exceed a particular threshold, additional funding should be sought from the UDOT Division of Traffic and Safety. Those items that are required should be completed regardless of whether the threshold has been reached or not. Exceptions to that should be based on engineering analysis coordinated with the UDOT Division of Traffic and Safety. If federal funds are involved in the project, concurrence from the FHWA Division Office will be required. Those items that should be considered but not required should be completed based on funding availability and a cost/benefit analysis. In some cases it may be appropriate to seek additional safety funding regardless of threshold amounts. The threshold amount was set at twenty percent to help define when safety items become a more significant driver of project needs.

Summary
The intent of the Safety Improvement Guidelines for Orange Book Projects is to provide guidance on those safety improvements that should be included with pavement preservation projects while allowing for and documenting good engineering judgment on those improvements that may not be required but should be considered. Pavement preservation projects should not be avoided, deferred, or shortened based on the need to repair or improve roadside safety hardware because pavement preservation in and of itself contributes to the overall safety of the roadway.

The complete guidance document is included with this report.

Team Participants
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Appendix

- Safety and ADA Improvement Guidelines for Orange Book Projects (3/04/08)
- Preventive Maintenance Eligibility FHWA Memo Dated October 8, 2004
- Traffic Barrier Safety Policy and Guidance FWA Memo Dated September 29, 1994
The Orange Book program is established first and foremost for the purpose of pavement preservation. But in addition to furthering the goal of pavement preservation, Orange Book projects present cost-effective opportunities to enhance safety. Pavement preservation projects should consider appropriate ways to maintain or enhance the current level of safety while not adversely impacting the safety of the traveled way or its users. These projects should not be avoided, deferred, or shortened based on the need to repair or improve roadside safety hardware.

This guideline outlines the circumstances where particular safety improvements should be either included or considered for inclusion in an Orange Book project.

**Items to be included in all applicable Orange Book projects:**

1. Pavement drop-offs greater than 2 inches
2. ADAAG compliant pedestrian ramps in accordance with the Stipulation of Settlement for the case of Ronald Decker v. UDOT. (See guideline for funding ADA ramp improvements.)
3. Rumble strips installed or re-ground in accordance with UDOT Rumble Strip Policy 06C-17.
4. Replacement of turn-down guardrail terminals within the AASHTO clear zone with an appropriate end section.

**Other items to be included in the Orange Book project according to the Orange Book Safety Improvement Decision Matrix:**

<table>
<thead>
<tr>
<th>Project Location</th>
<th>Posted Speed (mph)</th>
<th>Replacement of concrete sloped ends(1)</th>
<th>Correct blunt ends on bridges or barriers(2)</th>
<th>Correct guardrail height or configuration(3)</th>
<th>Correct substandard bridge transitions(4)</th>
<th>Correct concrete barrier height or configuration(5)</th>
<th>Other identified safety needs(6)</th>
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</thead>
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<tr>
<td>NHS (including interstate)</td>
<td>&gt; 40</td>
<td>Y</td>
<td>Y</td>
<td>C</td>
<td>Y</td>
<td>C</td>
<td>C</td>
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<tr>
<td></td>
<td>≤ 40</td>
<td>C</td>
<td>Y</td>
<td>C</td>
<td>Y</td>
<td>C</td>
<td>C</td>
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<td>Non-NHS</td>
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<td></td>
</tr>
</tbody>
</table>

**Legend:**

- Y = include this safety item in the project.
- C = Consider, based on budget, cost/benefit analysis, crash history, estimated risk of future crashes and in consultation with the Region Traffic Engineer.
Notes:

1. Replacement of concrete sloped ends within the AASHTO clear zone with an appropriate end section. (See Figure 1.)
2. Blunt ends on bridges or barriers within the AASHTO clear zone. (See Figure 2.)
3. Substandard height or configuration (elements and proper installation for crashworthiness) of guardrail. Steel block outs can remain if they are the only substandard item. (See Figure 3. and Table 1, Safety Hardware Deficiency List)
4. Bridge transitions that don’t meet at least NCHRP 230 (See Figure 4. UDOT Standard Drawing 735-1F dated 4/27/1999).
5. Substandard height or configuration of concrete barrier except if it:
   a. Meets at least NCHRP 230 (See Figure 5. UDOT Standard Drawing 735-1C dated 1/13/1998); and
   b. Is at least 29 inches high from pavement; and
   c. Not disturbed during project.
6. As identified in an Operational Safety Report or other safety study.

Use Table 1. Safety Hardware Deficiency List to identify any barrier or guardrail elements that may need repair or replacement and to document the deficiencies found so that those improvements not included in the Orange Book project can be included within UDOT’s Safety Management System for consideration in a future construction project as allowed by 23 U.S.C. 109(q). Submit the completed deficiency list to the Division of Traffic and Safety. Guardrail height determinations should be based on finished height after proposed project completion. The completed project should not adversely affect the safety of the traveled way.

If the estimated total cost of safety and ADA Ramp improvements exceeds 20 percent of the estimated project cost as a whole, submit application to UDOT Division of Traffic and Safety for supplemental funding to cover the cost of safety improvements beyond 20 percent. The required safety improvements (those from the list to include in all projects, and those marked by a “Y” in the Decision Matrix) must be included in the project with or without supplemental funding from the Division of Traffic and Safety. Exceptions to this should be based on engineering analysis coordinated with the division of Traffic and Safety. If federal funds are being used on the project, concurrence from the FHWA Division Office will be required. However, ADA ramp improvements may be postponed as long as the terms of the Stipulation of Settlement for Decker v. UDOT are otherwise met. Safety improvements marked “C” should be included based on funding availability and a benefit/cost analysis.
Figures and Table

Figure 1. – Concrete sloped end section.

Figures 2. – Blunt ends on barrier and a bridge.

Figure 3. – Substandard guardrail height.
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# Table 1. Safety Hardware Deficiently List

Write the number of deficiencies for each item  

<table>
<thead>
<tr>
<th>HWY</th>
<th>MP to</th>
</tr>
</thead>
</table>

**Concrete sloped end sections**

- Concrete sloped ends on highways posted 40 mph and less within clear zone as per UDOT standard.
- Concrete sloped ends on highways posted 45 mph and greater within clear zone as per UDOT standard.

**Blunt ends**

- Blunt ends on bridges or culvert head walls within clear zone as per UDOT standard.
- Blunt ends on barriers within clear zone as per UDOT standard.

**W-beam guardrail**

- Splices that don’t have eight bolts.
- Posts that don’t have a block-out.
- Posts that don’t have banding around each wood block-out and wood posts to prevent rotation.
- Feet of w-beam rail in front of hazard that isn’t properly stiffened to protect the hazard (See UDOT Barrier Installation Manual).
- Posts that don’t have adequate (1 foot or more) soil backing behind the post or are not longer that the standard length
- Object markers, delineators, or reflectors not installed properly on the guardrail.
- Steel posts (with steel block-outs) that don’t have back-up plates between the post and rail except at splice joints.
- Feet of guardrail that doesn’t have a top of rail height between 26 and 30 inches as per UDOT standard.
- Approaches to end terminals having substandard grading.
- Feet of guardrail where there is substandard grading in front of the guardrail.

Feet of new guardrail required to meet the length of need.
Table 1. Safety Hardware Deficiently List

**Write the number of deficiencies for each item**

**Transitions:**

___ 7/8-inch-high strength bolts (four minimum) not properly anchoring the transition connection plate and are not protruding greater than 0.5 inches above the nut.

___ Transitions not having 12.5 feet of double rail at the transition connection.

___ Posts missing OR not properly sized adjacent to the rigid object

___ Rub rails or curbing missing to prevent wheel snagging

**End treatments**

___ Texas turndowns or trailing end shoes within clear zone as per UDOT standard.

**Jersey style concrete barrier**

___ Feet of barrier not meeting at least NCHRP 230 OR less than 29 inches high from pavement OR disturbed during project

**Other identified safety items**

Conduct by: ____________________________ Date: ________________
Figure 4. UDOT Standard Drawing 735-1F
MEMORANDUM

U.S. Department of Transportation
Federal Highway Administration

Subject: ACTION: Preventive Maintenance Eligibility

Date: October 8, 2004

From: /s/ Original signed by:
King W. Gee
Associate Administrator for Infrastructure

To: Directors of Field Services
Division Administrators
Federal Lands Highway Division Engineers

Timely preventive maintenance and preservation activities are necessary to ensure proper performance of the transportation infrastructure. Experience has shown that when properly applied, preventive maintenance is a cost-effective way of extending the service life of highway facilities and therefore is eligible for Federal-aid funding. By using lower-cost system preservation methods, States can improve system conditions, minimize road construction impacts on the travelling public, and better manage their resources needed for long-term improvements such as reconstruction or expansion. Preventive maintenance offers State DOT's a way of increasing the return on their infrastructure investment.

During the 1990's, Congress incrementally broadened, through legislation, the applicability of Federal-aid funding to preventive maintenance activities. Congress' acknowledgement of preventive maintenance activities as an eligible activity on Federal-aid highways is a logical step that reinforces the importance of implementing a continuing preventive maintenance program. Each of these actions was conveyed to the field through a series of memoranda. This policy memorandum supersedes the related memoranda listed in the attachment.

The FHWA division offices have an important role in promoting system preservation and are encouraged to work closely with their State DOT counterparts to establish a program that identifies eligible preventive maintenance measures for all roadway assets on Federal-aid highways. The AASHTO defined preventive maintenance "as the planned strategy of cost effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without increasing structural capacity." Projects that address deficiencies in the pavement structure or increase the capacity of the facility are not considered preventive maintenance and should
be designed using appropriate 3R standards. Functionally, Federal-aid eligible preventive maintenance activities are those that address aging, oxidation, surface deterioration, and normal wear and tear from day-to-day performance and environmental conditions. Preventive maintenance activities extend the service life of the roadway asset or facility in a cost-effective manner.

Division offices should proactively work with their State partners to establish a preservation component, which is composed of various preventive maintenance activities and treatments. These include roadway activities such as joint repair, seal coats, pavement patching, thin overlays, shoulder repair, restoration of drainage systems, and bridge activities such as crack sealing, joint repair, seismic retrofit, scour countermeasures, and painting. Many other activities that heretofore have been considered routine maintenance may be considered Federal-aid eligible on an area-wide or system-wide basis as preventive maintenance (i.e., extending the service life). This might include such work items as regionwide projects for periodic sign face cleaning, cleaning of drainage facilities, corrosion protection, spray-applied sealant for bridge parapets and piers, etc. These typical preventive maintenance work items are not intended to be all-inclusive but are rather a limited list of examples.

The final eligibility determination should be the result of collaboration between the division and the State DOT. This determination should be based on sound engineering judgment and economic evaluation, allowing flexibility in determining cost-effective strategies for extending the service life of existing pavements, bridges, and essential highway appurtenances on Federal-aid highways.

All preventive maintenance projects should consider appropriate ways to maintain or enhance the current level of safety and accessibility. Isolated or obvious deficiencies should always be addressed. Safety enhancements such as the installation or upgrading of guardrail and end treatments, installation or replacement of traffic signs and pavement markings, removal or shielding of roadside obstacles, mitigation of edge drop offs, the addition of paved or stabilization of unpaved shoulders, or installation of milled rumble strips should be encouraged and included in projects where they are determined to be a cost effective way to improve safety. To maintain preservation program flexibility, and in accordance with 23 U.S.C. 109(q), safety enhancements can be deferred and included within an operative safety management system or included in a future project in the STIP. In no way shall preventive maintenance type projects adversely impact the safety of the traveled way or its users.

As with any Federal-aid project, adequate warning devices for highway-rail grade crossings within the project limits or near the terminus shall be installed and functioning properly per 23 CFR 646 before opening the project to unrestricted use by traffic. For projects on the NHS, all traffic barriers shall comply with the FHWA September 29, 1994, memorandum entitled Traffic Barrier Safety Policy and Guidance, signed by E. Dean Carlson. This work can be accomplished by force account or through other existing contracts prior to final acceptance.

The FHWA supports the increased flexibility for using Federal-aid funding for cost-effective preventive maintenance. The Maintenance Quality Action Team (MQAT) is developing technical guidance on preventive maintenance activities and transportation system preservation as a whole; that technical guidance is under development and will be issued in the near future. For further information please contact Christopher Newman of the Office of Asset Management, at
(202) 366-2023 or Christopher.newman@fhwa.dot.gov, or visit the Transportation System Preservation website at http://www.fhwa.dot.gov/preservation/

Attachment

Attachment: Memoranda Superseded by Preventive Maintenance Memorandum

- 01/27/04 Stewardship of Preservation and Maintenance
- 01/11/02 HBRRP Funds For Preventive Maintenance (23 U.S.C. 116(d))
- 10/30/98 Implementation of TEA-21 Interstate Maintenance Guidelines
- 08/19/98 Phase Construction for Safety Considerations
- 09/18/97 Transportation System Preservation
- 03/21/96 Preventive Maintenance Revision to 23 U.S.C. 116
- 10/12/93 Safety and Geometric Considerations for Interstate Maintenance Program Projects
- 06/14/93 Interstate Maintenance Program
- 07/27/92 Preventive Maintenance
- 05/21/92 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) Implementation Interstate Maintenance Program

Preventive Maintenance Questions and Answers

This page last modified on 03/26/07
Memorandum

Subject: ACTION: Traffic Barrier Safety Policy and Guidance

Date: September 29, 1994

From: Executive Director

To: Regional Administrators
Federal Lands Highway Program Administrator

Reviews and reports from the field show that some obsolete roadside hardware or poor practices thought to have been upgraded or eliminated as a result of the "Yellow Book" safety reviews of a generation ago, still remain on the Nation's main roadway systems. Recent trips to several States have also shown that continued attention to roadside safety is essential on new projects, particularly in the selection, location, and design of traffic barrier terminals.

We believe that roadside hardware selected by a highway agency to improve safety should do so, and that agencies must provide due care in not allowing inappropriate devices to remain indefinitely. Consequently, we expect the selection and maintenance of roadside safety hardware will be key elements of a State's safety management system, with the objective of assuring that current crashworthy designs will be employed where appropriate. To assist the States in the development of their design and maintenance policies and increase the safety of the National Highway System (NHS), with particular attention given to the Interstate component, the Federal Highway Administration (FHWA) has a responsibility to provide the latest technical information on safety hardware performance and to identify hardware designs and practices that are no longer acceptable for specific conditions. As an exercise of this responsibility, the following nationwide traffic barrier upgrading issues, most of which involve terminals, are identified as needing attention.

I. Replacement of Blunt End Terminals

The 1974 second edition of the American Association of State Highway and Transportation Officials' "Highway Design and Operational Practices Related to Highway Safety," commonly called the "Yellow Book," stated:

Equally important is proper treatment of the exposed end of the guardrail. The untreated or square approach end of a barrier is one of the more formidable roadside obstacles with which traffic must contend. The many spectacular accidents involving collisions with a guardrail end document this serious hazard.
After 20 years, we believe there should be no blunt ends on the leading edge of corrugated steel beam guardrail or median barrier within the clear zone of highways on the NHS. This includes stand-up ends anchored by a cable connected to a concrete deadman.

**Action:** Highway agencies should survey and replace any such blunt ends with crashworthy terminals. (See TA 5040.33, dated February 9, 1993, titled "Corrugated Steel Guardrail Terminals" for information on crashworthy terminals.) This replacement upgrading should be completed within 2 years from the date of this memorandum. Within the first 6 months of this period, the State should develop a plan and schedule for accomplishing the upgrading to the satisfaction of the FHWA Division Administrator.

II. Use of Turned-Down Terminals

The FHWA’s prohibition on the use of this type of end-anchor on high speed, high volume highways is contained in Mr. Willett’s September 7, 1990, memorandum titled “Guidelines for Application of the AASHTO Roadside Design Guide on Federal-Aid Highway Projects.” Originally applied to strong post W-beam guardrail and rigid barrier systems only, the prohibition is now extended to weak post W-beam guardrail as well. Recent testing has shown that a Modified Eccentric Loader Terminal (MEL) will perform as intended with this system, but that a transition design (see attachment) is necessary between the terminal and the barrier itself. The restriction on the use of turned-down ends does not apply to downstream terminals on freeways or other one-way roadways.

**Action:** A year from the date of this memorandum, turned-down ends will no longer be acceptable for installation on the approach end of roadside or median weak post W-beam barriers on high-speed, high-volume roads on the NHS. Units that have been damaged and must be replaced, should be upgraded with crashworthy terminals.

Existing turned-down ends within clear zones, including strong post designs and sloped concrete ends, should be replaced in conjunction with any significant roadway work in the same area. On the Interstate System, State highway agencies should develop a plan and schedule that will lead to the eventual replacement of all approach end turned-down terminals. This plan and schedule should evolve from each State’s safety management system and be submitted to the FHWA Division Administrator for concurrence.

III. Breakaway Cable Terminal (BCT)

Because the BCT does not pass high-speed, head-on tests at 100 km/h with the 820-kg car, several alternate designs have been developed. Of the various alternative designs, many agencies have adopted the MEL or a commercial proprietary design as their current standard, but some continue to install the BCT on new construction.
Action: A year from the date of this memorandum, the BCT will no longer be acceptable for installation on the approach end of barriers on high-speed, high-volume roads on the NHS. Where site conditions permit or are modified to permit, an eccentric loader terminal, a MELT or any other approved terminal may be used in lieu of the BCT. Where the necessary flare cannot be accommodated, a crashworthy terminal that can be installed without a flare would be the appropriate choice.

The FHWA does not recommend a wholesale replacement of existing BCTs. Units that must be replaced due to accident damage should be upgraded with a crashworthy terminal and any BCT installed without the specified flare should be replaced in conjunction with regularly scheduled roadway work in the same area.

IV. Terminal Replacement

It is the policy of some agencies to restore damaged features to their original condition or "replace in-kind." Opportunities to improve or upgrade a safety appurtenance occur when it becomes necessary to repair or replace a damaged or deteriorated device. In these situations, cost-effective analysis often favors upgrading or replacement for two reasons. First, because the repair or replacement costs must be incurred, a relatively minor commitment of resources above the costs for repair may result in accomplishing safety upgrading. Second, accident damage can constitute prior knowledge that a potentially hazardous situation exists, making a highway agency vulnerable to tort losses. A process that considers and implements safety improvements in a logical and cost-effective manner provides a good basis for defense in tort liability suits. Thus, upgrading obsolete hardware that fails to meet current standards when it is damaged could support a responsible practices tort defense and will reduce future exposure to potential tort losses.

Action: Approximately one fourth of the reported guardrail accidents involve terminals (upstream end). Therefore, on high-speed, high-volume roads on the NHS when damaged substandard terminals are being repaired or replaced, they should be replaced with crashworthy terminals.

This is being accomplished by some agencies through the establishment of contingency maintenance funds earmarked for the specific purpose of upgrading damaged roadside features.

V. Connection of Approach Guardrail to Bridge Rail

The 1967 "Yellow Book," stated:

To afford maximum protection and to develop the full strength of the rail in tension, all guardrail on the approaches to structures must be attached securely to the structure and provide a relatively smooth configuration on the traffic side.
Action: Any remaining unconnected bridge-approach guardrail on the NHS should be connected by an acceptable transition design. This effort should also be completed within 3 years from the date of this memorandum.

E. Dean Carlson

Attachment