

Federal Lands Highway Post-Construction Safety Reviews

Final Report

January 2004

Introduction

The FLH Safety Team has conducted one in-depth safety review of projects across the three Federal Lands Divisions every other year. During the December 2002 FLH Safety Team meeting, the team identified the need to perform post-construction field reviews on completed FLH projects. The objective of the post-construction field reviews is to evaluate safety features, including geometrics and the roadside, of completed projects and identify any site conditions that may negatively affect safety in an effort to implement the necessary changes to improve safety. Upon completion of the project reviews in all three Divisions, inspection reports were analyzed to determine if there are common inconsistencies with safety features and performance. The noted safety deficiencies and associated recommendations may be used to develop design guidelines for context sensitive design projects as a tool to aid designers in designing roadway geometrics and selecting roadside hardware under challenging environmental conditions, as well as to train construction personnel to identify and correct common mistakes.

Background of Field Reviews

The FLH team targeted for review completed projects that varied in scope: such as rehabilitation, reconstruction, and new construction projects; functional characteristics of the facility; terrain; and traffic. Projects completed within the last three years were reviewed, including locations exhibiting an unusual accident history. The post-construction safety reviews at the three divisions were conducted as follows:

In May 2003, the post-construction safety reviews were performed on projects administered by Eastern Federal Lands (EFL). Participants included the following from EFL: Scott Whittemore, Highway Safety Engineer; James Asirifi, Highway Engineer (Safety); Russell Garcia, Highway Engineer (Project Development); Jameel Saddiqi; Highway Engineer (Construction). The team also consisted of the following from Central Federal Lands (CFL): Greg Schertz, Safety Team Leader, and Cathy Satterfield, Highway Safety Engineer. The following projects were reviewed:

- US 421/ Blue Ridge Parkway Interchange: grading, drainage, paving, bridge, retaining walls, signing, and striping improvements in Watauga County, North Carolina.
- BLRI 2Q12: Resurfacing, restoration, rehabilitation work along the Blue Ridge Parkway in Buncombe County, North Carolina.
- GRSM 1A27,B18: Guardrail replacement and shoulder work improvements along Newfound Gap Road in Sevier County, Tennessee.

In June 2003, the post-construction safety reviews were performed on projects administered by Western Federal Lands (WFL). Participants included the following from WFL: Tori Kinne, Highway Safety Engineer; Jacinda Russell, PDP (Safety); George Fekaris, Design Operations Engineer; Gary Wrightman, Scott Blower, Tom Sutton, Western Federal Lands Project Engineers; and Brent Redenius Assistant Project Engineer. The rest of the team consisted of Scott Whittemore, EFL Highway Safety Engineer; and Cathy Satterfield, CFL Highway Safety Engineer. The following projects were reviewed:

- Mt Hood Meadows Access Road: grading, base, paving, drainage and bridge construction in Hood River County, Oregon.
- Jordan Road Improvement Project: bridge, grading, drainage, base and paving in Jefferson County, Oregon.

- Cascade Lakes Highway: paving and durable markings improvements in Deschutes County, Oregon.
- Canyonville-Trail Highway: grading, drainage, base, and paving improvements in Douglas County, Oregon.

In July 2003, the post-construction safety reviews were performed on projects administered by Central Federal Lands. Participants from CFL included: Cathy Satterfield, Highway Safety Engineer; Kevin Black, Construction Operations Engineer; Christine Black, Design Team Leader. The rest of the team consisted of Tori Kinne, WFL Highway Safety Engineer, and James Asirifi, EFL Highway Engineer (Safety). The following projects were reviewed:

- El Portal Road, Yosemite National Park: Design-Build Project consisting of drainage, retaining walls, guardwalls and road reconstruction in Mariposa County, California.
- Auburn-Forest Hill: Urban reconstruction; grading, drainage, resurfacing and retaining walls in Placer County, California.
- Wentworth Springs Road: grading, drainage, resurfacing and guardrails in El Dorado County, California.
- Marysville Road: Rehabilitation, reconstruction and asphalt recycling in Yuba County, California.

Findings and Conclusions

The findings and conclusions of inconsistencies found during the post construction reviews are as follows:

1. **Missed Opportunities for Improving Safety.** Roadside hardware including guardrail/guardwall end treatment and transitions, permanent signing and striping, and pedestrian crossings within the project limits need further consideration during the scoping process to avoid missed opportunities for safety improvements. An example of a missed opportunity found was ending the project limit at a bridge approach to avoid updating the bridge rail connection to steel-backed timber (SBT) guardrail to meet current crashworthy requirements. Also, many times it seems the decision has been made prior to scoping that existing guardrail will be replaced with new, without evaluating the need to improve terminal sections to meet current crash test standards and evaluating length of need for additional guardrail. Therefore, further consideration of safety during the design scoping process, including MUTCD compliant signing and striping and crashworthy roadside hardware, should be made a priority.
2. **Selection and Installation of Barriers.** During the reviews, inconsistencies were found in the selection and installation of roadside barriers. On some projects, non-crashworthy guardwall ends were terminated within a few feet of the travel lane; in many cases there was room to extend and offset them further. In other instances, a few of the guardrail terminals did not have proper grading, creating a potential obstacle along the roadside. There were several Steel-Backed Timber Flared Anchor Terminal (FAT) sections installed incorrectly. Per the standard drawing, the FAT section is to be turned down in the final two or three rail sections, depending on whether it is a FAT-20 or FAT-30 terminal, respectively. However, many installations were turned down at substandard height prior to the terminal sections. Lastly, in several cases the

guardrail placed at intersecting roadways did not completely incorporate the Cable Releasing Terminal (CRT) design. There appears to be possible confusion from both Design and Construction.

Where Construction personnel added guardrail, it was questionable whether those locations were the most appropriate and whether the length of need was considered. In addition, there may be confusion in interpreting guardrail standard drawing 617-10 and 617-18 regarding the height of the posts, since it shows a height for the “typical guardrail cross-section” which excludes the “alternate hole arrangement”. It was noted on some projects that where a post was skipped due to the presence of a paved spillway, the W-beam rail was not always doubled-up to account for the missing post. In addition, there were some instances where curbs were placed in front of the guardrail, particularly at the terminals. In summary, Construction personnel may be unclear interpreting some of the installation details in the guardrail standard drawings.

3. **Permanent Signing and Striping.** Discrepancies were also found in the permanent signing and striping on the reviewed projects. On certain projects, the striping was incorrectly applied in designed curve widening areas. This appears to be a design issue, as further detail may be necessary in the contract plans. Also, numerous uni-directional breakaway weathering steel sign supports were not oriented correctly with the major traffic direction. In addition, existing deteriorated and corroded steel with section loss was evident on several of the breakaway supports, which were not improved in the project. This deteriorated condition may negatively impact the safety breakaway support system. In addition to the deteriorated and corroded steel supports, wooden sign-posts installed within the clear zone without breakaway holes were observed.
4. **Design vs. Posted Speed.** Finally, our field reviews discovered inconsistencies in the selected design speed verses the actual posted/operating speed of the roadway. Several projects in the CFL review were designed for low speeds (from 25 to 40 mph), but are currently posted at 55 mph. Safety might be improved if appropriate design speeds had been chosen. Due to this discrepancy, there are many horizontal curves that should be signed but were not. It was uncertain whether these low speeds were selected to avoid the need for design exceptions, or the selected design speed was at the request of the partnering agencies. On one project reviewed, the signing plan showed higher posted speeds than the design speed, and the existing signing was posted even higher. It should be noted the posted speed was observed to be consistent with the 85th percentile speed, or operating speed.

Recommendations

In reviewing the findings and conclusions of the post-construction safety reviews, the FLH Safety team recommends the following changes to improve safety on FLH projects:

1. **Improve Safety Awareness During Scoping Process.** Currently, the Design Scoping Report (DSR) contains only one safety question in the report, “Describe any apparent problems with sight distance, clear zone, bridge clearances, roadside hazards, pedestrian or animal crossings, unusual traffic conditions, etc.”. In performing the project scoping field reviews, awareness to safety may be increased if more detailed questioning is provided. To improve consideration of

incorporating safety improvements in a project, the Safety team recommends the replacement of the current safety question in the DSR with the following:

- A. Are clear zone requirements met along all roadways within the project limits, for adjacent and opposing traffic?
- B. Are roadside/median barriers and sign supports crashworthy if located within the clear zone?
- C. Is there adequate sight distance along the roadway or at intersections?
- D. Are permanent signing and pavement markings clearly understood and visible?
- E. Are existing pavement edge drop-offs, and future drop-offs created by the project, less than 2-inches in height?
- F. If the scope of the project is 3-R and the profile of the roadway(s) is raised, will roadside and median barriers be the correct height?

In addition to modifying the scoping report questions, it is recommended to pursue the purchase of a retroreflectometer for each division to measure retroreflectivity of signing within the project limits during project scoping field reviews.

2. **Provide Roadside Safety Training for Design and Construction Staff.** The review of completed projects revealed the need to increase knowledge of roadside barrier design and installation issues for Design and Construction personnel. Therefore it is recommended to pursue the AASHTO Roadside Design Guide training course for both Project Development and Construction staff in all three divisions so barrier designs and installations will consider the current guidelines, including NCHRP 350 requirements. In addition to the Roadside Design Guide Course, two other NHI sponsored courses are recommended: “Design, Construction, and Maintenance of Highway Safety Appurtenances and Features”, and “Safety and Operational Effects of Geometric Design Features for 2-Lane Rural Highways”. The review re-emphasized the need for an FLH Barrier Design Guide that will incorporate the Roadside Design Guide principles with the design policy set forth in the Project Development Design Manual (PDDM). The guide would improve the appropriate selection, design, and installation of roadside barriers for the unique environmental constraints our projects encounter.
3. **Improve FLH Standard and Detail Drawings.** In addition to perceived unfamiliarity with current roadside design requirements, other improvements to FLH Standard and Detail drawings are recommended for clarity of use by both Design and Construction. The following changes are recommended in the Standards and Details:
 - **Curbs and Guardrails.** Typically, curbs are not desirable in combination with guardrail and, when used, curb height is limited to a maximum of 4 inches (100mm) and the face of the guardrail must be flush with the curb. For curbs higher than 4 inches (100mm), the guardrail system should be stiffened by adding another rail (nesting) or by adding a rubrail

underneath the normal rail. Curbs are particularly of concern in the terminal section of guardrail, including the CRT design where there is no block out. If the curb must be continued beyond the end of the guardrail, a special design is needed to relocate the curb away from the terminal. A new standard drawing to show this application is recommended.

- **Guardrail at Intersecting Roadways.** In areas where the Cable Releasing Terminal (CRT) guardrail system was placed at intersecting roadways the cable anchor along the mainline was typically not installed. Also, the breakaway design of the guardrail posts was not incorporated. We recommend that Standard drawings 617-21 and M617-21 be revised to include the in-line anchor system.
- **Guardrail Height.** There appears to be confusion related to the height of the G4 W Beam Guardrail for both steel and wood posts. The source of the confusion appears to be on standard drawing numbers 617-10 and 617-18, where the “TYPICAL GUARDRAIL CROSS SECTION” does not graphically show the “ALTERNATE HOLE ARRANGEMENT”, which indicates the post is installed 2-inches higher than the rail to accommodate future overlays. We recommend revising these standard drawings to clarify the appropriate height.
- **Special Situations.** Whenever a post is skipped, for a paved spillway for example, the W-beam rail should be doubled-up (nested) at that post and one rail length on either side to account for the missing post. We recommend Standard drawing 617-24 be used in all situations where nesting of rails is necessary, and not limit drawing for use with minor structures and pipe culverts.
- **SBT Terminals.** We recommend eliminating the use of the SBT FAT-20 (and the metric version FAT-6), as allowing this end rail section to be terminated above grade within the clear zone is hazardous. Also, it is recommended to eliminate the 5-foot flat area behind the end of the terminal section, as it is more critical to flare the terminal section as far from the travel way as possible, since the terminal section does not meet NCHRP 350 requirements for crashworthiness.
- **Approach Roads and Driveways.** Develop new FLH Standard drawings for driveway entrances, entitled “Road Connections”, with one drawing to be applied where the mainline roadway posted speed is less than 45 mph, and the second drawing for when the mainline posted speed is 45 mph or higher. These drawings are necessary to ensure the construction of crashworthy sideslope connections as discussed in the Roadside Design Guide.
- **Curve Widening.** On certain projects, striping was applied incorrectly in designed curve widening areas. It appears this was not a simple process for the striping equipment and that more data points are needed in the plans to apply centerline striping correctly. Therefore, it is recommended that a standard drawing be developed to adequately explain the proper striping for widened curves.
- **Breakaway Sign Supports.** Standard drawings that shows the correct details for drilling breakaway holes in 4” x 6” and greater size wood supports as well as proper installation of

steel sign supports, should be developed. The drawings need to address the following: correct orientation of the breakaway assembly with the major direction of traffic or the use of multi-directional breakaway devices, and the use of hinges on signs with multiple support posts to allow the intended breakaway safety mechanism of the support system to function properly.

Upon completion of the new and revised Standard and Detail Drawings, the FLH Safety team will inform the Project Development and Construction staff of these changes. This may be done by email notification to these employees describing the changes, as well as educating staff at the annual Winter Construction Conference, and similar forum to Project Development.

4. **Revise Process for Setting Design Speeds.** Several projects were designed at lower design speeds than the speed limit that is now posted. There are several reasons why this may occur on a project, including the varying terrain than can occur over the length of a project, the fact that many States and Counties base the posted speed on operating speeds of modern vehicles rather than the 1930's vehicles which the AASHTO design speeds are based on, and the unique environmental challenges that our FLH projects encounter. Therefore, it is not uncommon for design exceptions to occur in the required roadway geometric criteria. The process to mitigate substandard criteria is to document these deficiencies, and provide justification for design exceptions so as all stakeholders in the project are aware and the risks are acceptable. It is recommended that a clear policy be developed and documented in the PDDM to select a design speed that takes into consideration the operating and posted speed of the facility. This policy would consider the varying design and posted speeds along sections of a project and work with the various stakeholders to reconcile the issue. The policy should then be followed in Project Development, with the FLH Safety Team acting as a resource to assist in addressing and mitigating these issues on a project-by-project basis.
5. **Develop Crashworthy Roadside Features.** During the project reviews, the team observed several non-crashworthy devices that were offset within a few feet of the travel way. These included road closure gate posts, cattle guards, and turned-down guardrail terminals, which were often located along high speed roads (50 mph design speed in the case of the Blue Ridge Parkway). It is recommended to pursue research and potential crash testing for a crashworthy road closure gate and cattle guard. Another future research area by the Safety team may be an aesthetic crash cushion in lieu of a turned-down, or buried beneath an earth berm, barrier terminal when located inside the required clear zone. Aesthetic crash cushions should be discussed with our partners to determine if there is a mutual desire for use on projects.

It is recommended to share these findings and conclusions of the post-construction project reviews with FLH Design and Construction personnel. FLH Safety Engineers should coordinate with their respective Professional Development staff and offer the Roadside Design Guide training course locally to encourage the maximum number of participants. In addition, the current revision effort by the FLH Safety Team to update our library of Standard and Detail Drawings for safety-related items should include the recommended revisions and additions noted in this report. FLH Safety Engineers will continue to advise the PS&E Design and Construction Branches on safety matters, with particular emphasis on early safety consideration in the planning and design of projects.



Severely rusted breakaway bond plate connection needs replacement. Also, the bond plate height is greater than 4-inches from the concrete footing.



Weathering steel sign post installed without breakaway design.



Entrance gate post within clear zone (approximately 2-feet from travel lane) is non-crashworthy



Incorrect placement of Object Marker.
Object Marker about 3 meters off shoulder.



4" x 6" wood posts installed without breakaway holes in posts within the clear zone, and are not considered to be crashworthy.



Guardwall terminating at a tree, within clear zone for opposing traffic.



Rock protruding into the roadway. Guardwall ties into protruding rock.
Typical problem of environmental challenges
during project design and construction.



Terminating the barrier beyond the clear zone with earth berm is desirable
provided the roadway and terrain are suitable. Care should
be taken not to make the berm a hazard.



Example of improper signing as the warning sign is above a regulatory sign on the same Post. Also note the pavement drop-off is greater than 2 inches.



Curb in front of Slotted Rail Terminal (SRT) which negatively affects performance of the terminal section.



Timber guardrail standard height is not maintained up to the FAT-30 terminal section.



Incorrect striping at curve widening area. Place the centerline striping midway between the edges of the widened travel way. In other words, the distance from the edge of pavement to the edgeline should remain constant along the travel way.



Guardrail improvements could have been made by extending the rail.



Guardrail approach transition to bridge railing is not crashworthy. Offset of guardrail in front of bridge is a potential hazard for opposing traffic.