Subject: ACTION: Crash Testing of Bridge Railings May 30, 1997

From: Chief, Federal-Aid and Design Division

To: Regional Administrators
Federal Lands Highway Program Administrator

On August 28, 1986 and on August 13, 1990, the Office of Engineering sent you listings of bridge railing designs that were considered acceptable for use on Federal-aid projects by virtue of their crash test performance. As noted in the transmittal memoranda, some of these railings had been tested under the National Cooperative Highway Research Program (NCHRP) Report 230 and some under the 1989 "AASHTO Guide Specifications for Bridge Railings". Since the FHWA has now adopted NCHRP Report 350 as the guideline for testing all roadside hardware, including bridge railings, we reviewed these listings and assigned each railing on the lists a rating that we consider approximately equivalent to one of the six test levels suggested in NCHRP Report 350. These "equivalency" listings, along with a third listing which identified additional bridge railings tested after the 1990 memorandum, were included in a paper we presented to the AASHTO Highway Subcommittee on Bridges and Structures on May 14, 1996. A copy of this position paper, without the originally accompanying lists, is attached for your reference.

Also attached are revised copies of the three lists with sketches for each cited design. We have added several additional railings to the third list. Please note that those railings which were specifically tested to NCHRP Report 350 criteria are now identified in bold type, whereas those assigned an equivalent test level based on earlier testing guidelines are shown in regular type. The equivalent test levels are conservative and may be subject to further evaluation in some cases as additional NCHRP Report 350 tests are run on these railings or on similar systems.

Recognizing that these lists are not rationally organized and that the quality of many of the accompanying sketches is poor, we wish to consolidate and reorganize the three lists into a single list and provide a drawing of each bridge rail that is similar in detail to the drawings in the AASHTO-AGC-ARTBA "Guide for Standardized Highway Barrier Hardware" (SB-series drawings). To aid us in this effort we would appreciate your doing the following:

- Tell us which States within your region are currently using which of the railing designs identified on the three lists.

- Provide us with a set of drawings of each of the railings on the lists that are used in your Region. Where there are duplications or slight variations of nominally the same railing used by different agencies, only one drawing for that type of railing need be sent. However, we would appreciate a brief verbal description of any differences and an assessment of their significance.

- Tell us of any railings <u>not</u> on one of the lists that any State within your Region plans to use on the NHS after September 30, 1998. We would also appreciate receiving

drawings of these railings and information on any crash tests that have been run on these designs.

Information on railings developed and tested for use on Federal Lands Highways will be requested from that office.

Responses by July 15 would be appreciated. When we have received the requested information, a consolidated listing with drawings will be sent to each field office, and we will keep this listing current as additional designs are tested. Please address any questions regarding this effort to Mr. Richard Powers at (202) 366-1320.

(original signed by Dwight A. Horne)

Dwight A. Horne

4 Attachments

BRIDGE RAILING DESIGN AND TESTING

A Discussion with the
AASHTO Highway Subcommittee on Bridges and Structures
Technical Committee (T-7) for Guardrail and Bridge Rail

May 14, 1996

Until the late 1980's, designers relied on precedent, the information contained in the most recent edition of the AASHTO "Standard Specifications for Highway Bridges", and their judgement to design a bridge railing appropriate for a given site. The Standard Specifications, as they still do, called for the application of a 10-Kip static load at key locations on the railing as well as some dimensional requirements for the openings between rail elements and other cross section geometry. Full-scale crash testing was not required, although a design that "passed" crash testing could be used even if it did not meet the static loading and/or geometric design criteria. The test requirements generally accepted by highway agencies at the time were contained in the National Cooperative Highway Research Program (NCHRP) Report 230, "Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances," 1981. (Two earlier publications with this title, NCHRP Report 153,1974, and Transportation Research Circular Number 191, 1978, and the Highway Research Board publication, Highway Research Correlation Service Circular 482, "Proposed Full-Scale Testing Procedures for Guardrails," 1962, also provided testing guidance.)

In the late 1970's and early 1980's, actual tests were run on several commonly-used railings that had been designed under the static loading procedures. The results were unexpected: several of the railings failed quite dramatically and it was shown that static design loadings were not sufficient to ensure adequate railing performance. As a result of these findings, Mr. R.D. Morgan , FHWA's Executive Director , issued a policy memorandum on August 28, 1986, that stated that railings on bridges on Federal-aid projects must be (or have been) crash tested and meet the acceptance criteria in NCHRP Report 230 or equivalent acceptance procedures. Included with that memorandum was a list of 22 railings that were considered crashworthy based on previous testing.

In 1989 AASHTO published its "Guide Specifications for Bridge Railings", a document that not only specified tests to be run, but categorized them into three separate performance levels. This publication also included a selection procedure for determining an appropriate performance level for a given site. The crash test matrix included in the Guide Specifications differed in several areas from the NCHRP Report 230 test matrices, and its use by State highway agencies was (and remains) optional.

On August 13, 1990, the FHWA issued a second memorandum listing 25 additional railings that had met the requirements in NCHRP Report 230 or one of the performance levels in the AASHTO Guide Specifications. This memorandum also stated that the FHWA considered any railing that was acceptable based on NCHRP Report 230 testing could also be considered

acceptable at least as a PL-1

railing as described in the Guide Specifications. In addition, it indicated that any SL-1 railing (as developed by Southwest Research Institute and reported in NCHRP Report 239, "Multiple-Service-Level Highway Bridge Railing Selection Procedures", November 1981) could also be considered equivalent to a PL-1 railing.

NCHRP Report 230 was superseded by NCHRP Report 350, "Recommended Procedures for the Safety Performance Evaluation of Highway Features", in 1993. This document includes six different Test Levels, all of which differ in some ways from the previous Report 230 basic test matrix as well as from the Performance Levels contained in the Guide Specifications. No selection procedures for the use of a specific test level are included in Report 350. And finally, to add to the conflicting guidance for selecting an appropriate bridge railing, AASHTO issued its 1994 "LRFD [Load and Resistance Factor Design] Bridge Design Specifications"as an alternate to the long-standing "Standard Specifications for Highway Bridges". Section 13 of the new publication contains recommendations on railing designs and a crash test matrix that differs from NCHRP Report 350 and the AASHTO Guide Specifications.

FHWA's current position can be summarized as follows:

- All bridge railings installed on NHS projects let to contract after August 16, 1998, shall meet the acceptance criteria contained in NCHRP Report 350 or an FHWA recognized successor to those criteria. The minimum acceptable bridge railing will be a TL-3 (MSL-2 until August 1998) unless supported by a rational selection procedure. Acceptability under NCHRP Report 350 and a rational selection procedure are defined below.

- Railings that have been found acceptable under the crash testing and acceptance criteria in NCHRP Report 230, the AASHTO Guide Specifications for Bridge Railings, or the AASHTO LRFD Bridge Design Specifications will be considered as meeting the requirements of NCHRP Report 350 without further testing as indicated in the following table.

RAILING LEVEL EQUIVALENCY TABLE

BRIDGE RAILING TESTING CRITERIA	**ACCEPTANCE EQUIVALENCIES**					
NCHRP Report 350	TL-1	TL-2	TL-3	TL-4	TL-5	TL-6
NCHRP Report 230		MSL-1 MSL-2*		MSL-3		
AASHTO Guide Specifications		PL-1		PL-2	PL-3	

AASHTO LRFD Bridge Specifications		PL-1		PL-2	PL-3	

* This is the performance level usually cited when describing a barrier as tested under NCHRP Report 230. It is close to a TL-3 but adequate TL-3 performance cannot be assured without a pickup truck test.

- The FHWA strongly suggests that the AASHTO adopt the test level definitions in NCHRP Report 350.

- The FHWA strongly recommends that all future testing of bridge railings be conducted in accordance with the recommendations in Report 350 or an FHWA-recognized successor to Report 350.

- The FHWA strongly encourages the AASHTO to support the ongoing NCHRP efforts to develop railing level selection procedures and, after appropriate review and, if needed, adjustment, adopt railing level selection procedures.

- Until the AASHTO adopts a new railing level selection procedure the FHWA will accept the procedures in the "Guide Specifications for Bridge Railings" or a rational, experience-based, cost-beneficial, consistently-applied procedure proposed by a State.

- Exceptions to the items in this position, which are expected to be rare, will be considered on their merits on a case-by-case basis.

Attached is a list of the railings that are considered acceptable under the guidelines in NCHRP Report 350 or the presumed equivalent guidelines indicated in the Railing Level Equivalency Table. This list will be supplemented with sketches of each railing soon. Omission of a railing from this list may be the result of an oversight or a judgement that a particular railing is unlikely to be used. Therefore, the list should not be considered all-inclusive. As is currently the case, any railing that is essentially the same as one that was successfully tested, even though not identical, may often be considered acceptable as well.

J. H. Hatton
FHWA HNG-10
7 May 96

EQUIVALENT TEST LEVELS FOR CRASH-TESTED BRIDGE RAILINGS - PART 1

1-1	NCHRP 239 SL-1 Thrie beam, wood posts	TL-2
1-2	NCHRP 239 SL-1 Thrie beam, steel posts	TL-2
1-3	Texas Type 6 (tubular w-beam)	TL-2
1-4	Aluminum Tru-beam (modified AASHTO BR5)	TL-2
1-5	AASHTO BR2 (California Type 9)	TL-2
1-6	Ohio Box Beam Rail (w-beam backed with box beam)	TL-2
1-7	Modified Kansas Corral (open concrete beam and post)	TL-2
1-8	Oklahoma Modified TR-1 (open concrete beam and post)	TL-2
1-9	Oregon 2-Tube Curb-Mounted Rail	TL-2
1-10	North Carolina Standard 1 Bar Metal Rail	TL-2
1-11	Texas T101 Bridge Rail	TL-3
1-12	Nebraska Tubular Thrie Beam	TL-3
1-13	California Type 20 (NJ Safety Shape with Rail)	TL-3
1-14	Nevada Safety Shape Parapet (NJ Shape with Rail)	TL-3
1-15	New Jersey Concrete Safety Shape	TL-4
1-16	F Profile Concrete Safety Shape	TL-4
1-17	NJ Turnpike Heavy Vehicle Barrier	TL-5
1-18	Texas T5 Modified	TL-6

EQUIVALENT TEST LEVELS FOR CRASH-TESTED BRIDGE RAILINGS - PART 2

2-1	Oregon Side-Mounted Thrie Beam	TL-2
2-2	Texas T202 Concrete Beam and Post	TL-2
2-3	Federal Lands Modified Kansas Corral	TL-2
2-4	Nebraska Concrete Beam and Post	TL-2
2-5	Iowa Concrete Beam and Post	TL-2
2-6	California Type 115	TL-2
2-7	Washington 10 gage Thrie Beam Retrofit	TL-2
2-8	California Thrie Beam	TL-2
2-9	Glu-Lam Wood Rail on Timber Deck	TL-2
2-10	Texas 411 Aesthetic Concrete Baluster	TL-2
2-11	Texas T421 Aesthetic Steel Pipe Bridge Rail	TL-2
2-12	Aesthetic Stone Masonry-Faced Concrete	TL-3
2-13	Missouri Thrie Beam and Channel	TL-3
2-14	Wyoming Curb-Mounted 2-Tube (Two Designs)	**TL-3**
	(see Acceptance letter B-37)	**TL-4**
2-15	Michigan 10 gage Retrofit on curb/sidewalk	TL-4
2-16	Iowa Concrete Block Retrofit	TL-4
2-17	32-in Vertical Concrete Parapet	TL-4
2-18	Pre-cast NJ or F-Shape bolted to deck (see Acceptance letters B-5 and B-5A)	TL-4
2-19	Illinois 2399 2-Rail on Curb	TL-4
2-20	42-in Vertical Concrete Parapet	TL-5
2-21	42-in F Shape Concrete Barrier	TL-5
2-22	Texas Type HT (Modified T5)	TL-5
2-23	Modified Texas C202 Bridge Rail	TL-5

Attachment 3

EQUIVALENT TEST LEVELS FOR CRASH-TESTED BRIDGE RAILINGS - PART 3

Railings for Timber Bridges:

3-1	Timber rail-System 1	TL-2
3-2	Timber rail-System 2	TL-2
3-3	Timber rail-System 3	TL-2
3-4	Steel System-Thrie beam on steel posts	TL-2
3-5	Curb System- Glu-Lam timber rail w/ curb	TL-2
3-6	Shoe Box System-Glu-Lam rail w/out curb	TL-2
3-7	TBC-8000-Thrie-beam w/ stiffened steel posts	TL-4
3-8	**GC-8000 Glu-Lam timber rail w/ curb** **TL-4** (see Acceptance letter B-31 for 3-4 through 3-8 designs)	

Railings for Concrete Bridges:

3-9	Texas C411 42" Concrete Baluster Rail	TL-2
3-10	BW Parkway Smooth Stone Bridge Rail	TL-2
3-11	West Virginia W-beam Retrofit Railing for Concrete Baluster designs	TL-2
3-12	Foothills Parkway Aluminum Bridge Rail	TL-2
3-13	GW Parkway Steel Tri-Rail on curb	TL-2
3-14	Natchez Trace Concrete Bridgerail (post and beam)	TL-2
3-15	Washington, D. C. Historic Bridgerail (curb-mounted retrofit)	TL-2
3-16	BR27D-two steel rails on 18" concrete parapet w/ curb and sidewalk	TL-2
3-17	BR27D-flush-mounted	TL-2
3-18	BR27C-single steel rail on 24" concrete parapet w/ curb and sidewalk	TL-4
3-19	BR27C-flush-mounted	TL-4
3-20	Nebraska Open Concrete Bridgerail (modified from earlier TL-2 design)	TL-4
3-21	Missouri 30" NJ Concrete Barrier (to test effect of 3" overlay on standard height)	TL-4
3-22	Illinois Side-mounted railing	TL-4
3-23	New England Transportation Consortium (NETC) 2-rail curb-mounted railing (see Acceptance letter B-50)	TL-4
3-24	Delaware Thrie-beam Retrofit Railing (curb-mounted)	TL-4
3-25	**Wyoming 2-tube steel railing on curb** (see Acceptance letter B-37)	**TL-4**
3-26	**Minnesota Combination Bridge Rail**	**TL-4**
3-27	Single Slope Concrete Bridge Rail (see Acceptance letter B-45A)	TL-4