
IN-SERVICE PERFORMANCE EVALUATION OF THE BULLNOSE MEDIAN BARRIER IN THE STATE OF IOWA

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ABSTRACT

This paper presents results of an in-service performance evaluation of the bullnose median barrier used in the state of Iowa. The data were collected in a four-county portion of Iowa during a 24-month data collection effort in 1997 to 1999. The collision performance was measured in terms of collision characteristics, occupant injury and barrier damage.

KEYWORD

Roadside safety, in-service performance evaluation, bullnose, median barrier.

INTRODUCTION

The bullnose is a W-beam barrier commonly used in the Midwest in the median of divided highways, to protect vehicles from hazards in the median like the gap between twin bridges or bridge piers. In Iowa, it consists of a standard G4(1W) on each side of the hazard and a five-foot radius breakaway end anchorage system (Iowa DOT Standard Road Plan RE-53 and RE-56) at each end. An example is shown in Figure 1.



Figure 1. Typical bullnose median treatment around bridge piers.

Wide medians are an integral part of modern highways. The median provides physical separation between streams of traffic and also provides an area where errant vehicles can regain control or stop without becoming involved in a serious collision. Although medians are usually kept free of hazardous fixed objects, there are functional elements of the highway that must be located within the median. High-mast lighting, bridge piers, openings between twin bridges and large sign bridge supports are some of the functional features located in the median that would present a hazard to an errant vehicle. These objects would be potentially hazardous if struck, so they must be shielded by guardrails if they are within the clearzone.

Several states including Minnesota, Iowa, Michigan and Colorado use a guardrail envelope to completely surround hazardous features of the median. These installations are often called bullnose median treatments. While the middle portion of the bullnose is simply a guardrail installed in the median, the ends of the bullnose must be specially designed in order to safely stop vehicles that strike the installation end-on.

The 1977 AASHTO Barrier Guide included an experimental design of a bullnose system.⁽¹⁾ In 1975 a bullnose system from the state of Minnesota with a 1.5-m radius nose was tested to determine if the device would safely stop an impacting vehicle.⁽²⁾⁽³⁾ This system has been widely used throughout the midwest including the state of Iowa.

Although the performance of the 1.5-m radius bullnose was judged to be adequate in an impact, the test was performed on flat and level terrain and the posts were installed in concrete. The Federal Highway Administration (FHWA) sponsored a research project to examine the performance of bullnose median treatments using realistic terrain and the latest crash test and evaluation procedures to determine if the bullnose performed adequately in more realistic conditions.⁽⁴⁾ This research determined that the performance of the standard 1.5-m radius design was very poor in V-shaped medians. The small car tended to underide the barrier in impacts on the nose of the device resulting in very severe collisions. On the other hand, large cars impacting at the third post from the nose tended to override the barrier. This result was also considered unacceptable. The research team experimented with a variety of potential improvements including using thrie-beam rails, modified thrie-beam blockouts, special nose plates and other items. While a device with a specially constructed nose section performed well in a small car impact, the improved device was never completely evaluated according to the crash test recommendations in place at the time.

Interest in developing a crashworthy bullnose median barrier has continued to the present day. Research is currently underway at the University of Nebraska to develop a bullnose median treatment that will satisfy the requirements of NCHRP Report 350.⁽⁵⁾ Designing a safe crashworthy system that can be used in typical median cross-sections has continued to be a challenging design problem.

While the previously discussed studies examine the crash test performance of the bullnose system, this paper examines the in-service performance of the bullnose median barrier in Iowa. All collisions involving bullnose median treatments in a four-county area in southeastern Iowa were investigated from 1 July 1997 until 30 June 1999.

The bullnose median treatment used in Iowa is based on the G4(1W) guardrail system. The G4(1W) is a blocked-out strong-post “W” beam guardrail using a 2.67 mm thick steel “W” rail section and posts spaced at 1905 mm. It is shown in Iowa DOT’s Standard Road Plan as RE-12A, and is a modified version of AASHTO’s SGR04b that uses 200x200mm wood posts with wood blocks.(6) The bullnose system itself, shown in Iowa DOT’s RE-53, is similar to the SEW10 shown in the AASHTO hardware guide.(7) It includes a 3.8-meter piece of W-beam guardrail bent to a 1.5-meter radius around a 152x152mm wood post (post one), with a 203x203 breakaway wood post on each side attached to an anchored cable assembly.

The data collection teams were notified about collisions from police and highway maintenance agencies in their respective data collection areas. Information from the police accident reports and maintenance cost-recovery reports were collected for each case where available. In addition to these official sources of information, the collision sites were visited and the damage to the guardrail was measured and documented with photographs. The bullnose collisions were divided into four categories: impacts with the nose (post one), near the nose (posts 2 or 3), with the bullnose transition (e.g., the flared section after post 3), and mid-length (e.g., the standard G4(1W) section). The following sections will address the performance of each part of the bullnose with respect to collision characteristics, occupant injury and barrier damage.

DATA COLLECTION AREA

GENERAL CHARACTERISTICS

The data collection area shown in Figure 2 was composed primarily of Cedar, Johnson, Linn and Scott Counties in southeastern Iowa. The data collection area contained three metropolitan areas (Cedar Rapids, Davenport and Iowa City), four interstate highways (74, 80, 380, 280 and 218), and roadways in a variety of functional classes. The area was selected based on Iowa DOT maintenance garage responsibility maps. The data collection area

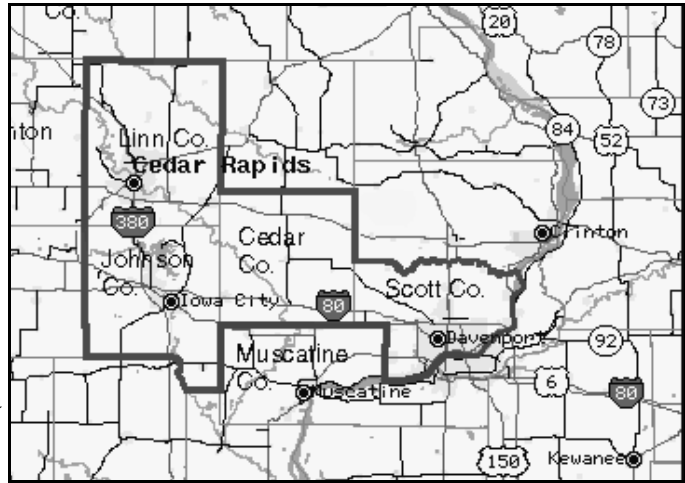


Figure 2. Iowa data collection area.

was chosen to coincide with the areas covered by each maintenance garage even when the coverage area crossed a political boundary. In addition to roadways in the four Counties, several roadway segments were included in other Counties to conform to the State DOT maintenance garage coverage areas. These additional routes included Route 30 and all State roadways south of Route 30 in Clinton County (added to Scott County) and Interstate 380 in Benton, Buchanan, and Blackhawk Counties (added to Linn County). The average traffic volume on each type of roadway and the number of kilometers of roadway in each County are shown in Table 1.

Table 1. Kilometers of State-maintained roadway and traffic volumes in the Iowa data collection area.

Roadway Type	Kilometers of Roadway						Average ADT veh/day	Vehicle km Traveled	
	Cedar km	Johnson km	Linn km	Scott km	Total km	%		10 ⁹ veh-km	%
Interstate	43	56	124	67	290	30	21,542	2.28	54
US Highway	93	68	24	179	364	37	9,810	1.30	31
State Highway	50	100	97	80	327	33	5,245	0.63	15
Total	186	224	245	326	981	100		4.21	100

The data collection area consisted of 981 km of State-maintained roadway with a total traffic demand of 4.21 billion vehicle-kilometers traveled per year. The interstate highways accounted for 30 percent of the highway mileage and

almost 55 percent of the traffic demand as shown in Table 1. In Iowa, bullnoses are only used on interstate highways.

POLICE REPORTS

The average severities of police-reported guardrail collisions that occurred on State-maintained roadways in the Iowa data collection area between 1989 and 1993 are shown in Table 2. On average, nearly 100 guardrail-related collisions occur each year in the four-county data collection area, almost 80 percent of them on the interstate system. Collisions on the interstate system resulted in property damage only (PDO) in nearly 70 percent of the collisions and severe injuries (A+K) in about 5 percent of the collisions. The Iowa police report form does not distinguish between types of guardrails, ends or transitions so it is not possible to separate the bullnose data from the statewide collision data.

Table 2. Average annual guardrail and guardrail terminal collisions on State-maintained roads in the Iowa data collection area (1989-1993).

Severity	Interstate		US/State		Total	
	No.	%	No.	%	No.	%
A+K	4	5	2	9	6	6
B+C	21	28	6	26	27	27
PDO	51	67	15	65	66	67
Total	76	100	23	100	99	100

All police agencies in Iowa use a uniform collision reporting form. The use of this standard form simplified coordinating information on the collision reports between law enforcement agencies. The State Police were regularly contacted by the data collection team to obtain police reports, since they responded to the majority of the collisions on the interstate system. Local police agencies were also surveyed periodically to ensure that all cases were identified. Reports were available from the police as soon as the investigating officer completed the paperwork. The State Police barracks were used as a secondary means of notification.

MAINTENANCE REPORTS

Iowa DOT attempts to recover the cost of guardrail repairs from the people who damaged the roadside hardware in a collision. For this reason, the DOT documents the materials, labor and equipment required to repair any State-owned property including guardrails and guardrail terminals. The police agencies normally notify the appropriate

DOT maintenance supervisor whenever a collision occurs that involves damage to roadside hardware. In the case of major damage, the maintenance supervisor is notified immediately, whereas for less severe collisions the maintenance supervisor is faxed a copy of the police report within a couple of days of the collision. Fortunately, there is excellent cooperation between the DOT maintenance garages and the local State Patrol. From the beginning, therefore, the collision damage is linked to the collision that caused the damage. DOT maintenance supervisors generally inspect each mile of roadway under their jurisdiction regularly, so damage that was not reported to the police is also identified.

Once the DOT has been notified about damaged roadside hardware, the maintenance supervisor schedules the repair of the hardware. When the repair is complete, a "Memorandum of Cost Report" is completed and submitted, which itemizes the materials, labor and equipment used to repair the damaged hardware. The Cost Memo is filled out whenever a roadside appurtenance is repaired as a result of a collision, even if the collision is not reported to the

police. The Cost Memo is filed so that if a collision is subsequently linked to the damage or the responsible party is identified the cost can be documented. For example, a collision report may be lost or not delivered in a timely manner due to clerical errors. In such a case the barrier may have already been repaired before the collision report is delivered to the DOT. Since the Cost Memo is always filled out, attaching a late or missing collision report is relatively easy. A cost report is not filled out for routine maintenance,



however, which sometimes might include minor damage to a guardrail that was never reported, such as that shown in Figure 3. **Figure 3. An example of minor guardrail damage.**

The maintenance supervisors were the primary agents for notification during the study. They called the data collection team whenever they became aware of a guardrail collision. The data collection team also made sure they

contacted each maintenance supervisor at least once a week to be sure that all cases were sampled.

INVENTORY DATA

Approximately 10 years ago, each Iowa DOT Resident Maintenance Engineer (now Area Engineer) developed an inventory of guardrails and guardrail terminals on State-maintained roads. There was, unfortunately, no standard format or content in these inventories, but some Area Engineers still use these inventories as a means of managing their roadside hardware inventories and scheduling maintenance work. For example, the Scott County inventory is updated every year and is used as a management tool for identifying installations that need routine maintenance or repair. The Johnson and Cedar Counties inventories for the interstate highways are still routinely used, although the other State-maintained roadway inventories have not been updated in a number of years. The Linn County inventory has not been updated in about five years. Table 3 shows the estimated number and total length of bullnose installations in the four-county data collection area based on the inventories. The inventory in Linn County was estimated by extrapolating the amount of hardware based on the number of kilometers of roadway and the ratios from the other Counties.

Table 3. Estimated length of bullnose median barriers on State-maintained roads in the four-county data collection area.

County	Bullnose Installations	Length (km)
Johnson/Cedar	130	3.8
Scott	146	6.2
Linn	92	3.4
Total	368	13.4

DISCUSSION

There were many advantages to performing an in-service evaluation in Iowa. First, the coordination and cooperation between the police agencies and the maintenance agencies is very good. This in turn makes it possible to receive notification from both the police and maintenance agencies, ensuring that cases were not missed. Iowa interstates have milepost markers every 80.5 m (0.05 miles), which makes it relatively easy to identify specific roadside hardware installations. This is exceptionally helpful for identifying minor collisions that were reported to the police but resulted in little or no damage. The roadside hardware standards used in Iowa are highly standardized and have been stable for many years, so there tends to be a large quantity of one or two types of hardware. The

quality of the installations also tended to be high for the same reason.

There was, however, one disadvantage to performing an in-service evaluation in Iowa. Roadways in the State, even interstates, experience relatively light traffic volumes so the data collection area had to be quite large in order to sample a sufficient number of cases. The data collection area required to obtain 42 bullnose collision cases in 24 months was very large and required nearly two hours to drive from one corner to the other.

COLLISION CHARACTERISTICS

Data from a total of 42 bullnose collisions were collected in the study area during the 24-month data collection period. Data for nine nose collisions, 12 near-nose collisions, 17 bullnose-transition collisions and four mid-length G4(1W) collisions were collected. Of these, 28 were reported to the police and 9 were reported only to a maintenance agency. Impact scenarios were determined based on physical evidence observed at the scene, like skid marks on the pavement, ruts in the soil and scraps on the guardrail. When the collision was reported to the police, the officer's sketch of the impact was also useful in determining the collision scenario.

The type of vehicle involved in the collision could only be determined in the 28 collisions that were reported to the police. The most common vehicles were passenger cars and pickups. One of the six nose cases, three of the eight near-nose cases, and seven of the eleven transition cases involved collisions by passenger cars, as shown in Table 4. Altogether, 39 percent of the cases involved passenger cars and 39 percent involved pickups. Overall, pickups, SUVs, and vans make up 50 percent of the bullnose collisions.

Table 4. Vehicle types involved in 28 police-reported bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Passenger car	1	17	3	38	7	64	0	0	11	39
Pickup truck	2	33	4	50	3	27	2	67	11	39
Sport utility vehicle	0	0	0	0	1	9	0	0	1	4
Van	1	17	0	0	0	0	1	33	2	7
Bus	0	0	0	0	0	0	0	0	0	0
Tractor-trailer truck	0	0	1	13	0	0	0	0	1	4
Other	2	33	0	0	0	0	0	0	2	7
Total	6		8		11		3		28	

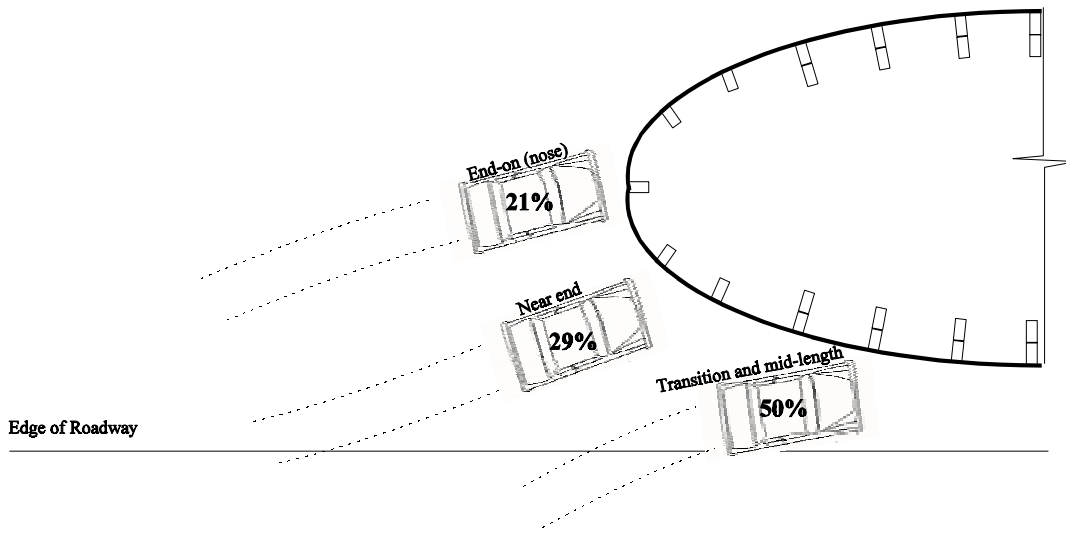
The events that preceded, followed and resulted from the guardrail impact in the 28 police-reported cases are shown in Table 5. The errant vehicle interacted with no other vehicles or objects prior to striking the guardrail in 74 percent of the cases. It interacted with another vehicle in the traffic stream in four of the cases and with a tree, pole or other roadside object in the remainder of the cases. In general it appears that most bullnose collisions are the first impact in the sequence of collision events and most often bullnose collisions are single-event scenarios.

Table 5. Events in 28 police-reported bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Events prior to impact										
None	6	100	6	75	6	55	3	100	21	74
Tree or pole	0	0	0	0	1	9	0	0	1	4
Other vehicle	0	0	2	25	2	18	0	0	4	14
Other roadside object	0	0	0	0	1	9	0	0	1	4
Unknown	0	0	0	0	1	9	0	0	1	4
Total	6		8		11		3		28	100
Result of impact										
Redirected/Gated	0	0	1	13	2	18	1	33	4	14
Stopped in Contact	2	33	3	38	3	27	0	0	8	28
Snagged/spun out	0	0	2	25	4	36	1	33	7	25
Hit from Behind	1	17	0	0	0	0	0	0	1	4
Override	1	17	1	13	1	9	1	33	4	14
Penetrated	1	17	1	13	1	9	0	0	3	11
Unknown	1	17	0	0	0	0	0	0	1	4
Total	6		8		11		3		28	100
Events following impact										
None	5	83	5	63	9	82	1	33	20	71
Tree or pole	0	0	1	13	1	9	0	0	2	7
Other vehicle	0	0	1	13	0	0	0	0	1	4
Other roadside object	0	0	0	0	1	9	1	33	2	7
Unknown	1	17	1	13	0	0	1	33	3	11
Total	6		8		11		3		28	100

The result of the impact with the guardrail is shown in the middle portion of Table 5. The vehicle was redirected in four of the 28 cases, and it stopped while still in contact with the guardrail in eight cases. There were seven cases where the vehicle snagged and spun out, four cases where it overrode the rail, and three cases where it penetrated the barrier. The result of the collision was acceptable (e.g., the vehicle was redirected or stopped) in only twelve of the 28 bullnose collisions (43 percent). Figure 4 summarizes the impact scenarios and their results.

The collision with the barrier was the last event in about 70 percent of the cases, as shown in the bottom portion of Table 5. There were two cases where the vehicle struck a tree after being redirected, two cases where it struck another roadside object, one case where it struck another vehicle, and three cases where the subsequent event could not be determined.



Scenario	No.	% of Scenario	% of Total
End-on impacts			
Redirected or stopped	2	33	7
Overrode or penetrated	2	33	7
Snagged, spun, or hit from behind	1	17	4
Unknown	1	17	4
All end-on impacts	6	100	21
Near-end impacts			
Redirected or stopped	4	50	14
Overrode or penetrated	2	25	7
Snagged, spun, or hit from behind	2	25	7
All near-end impacts	8	100	29
Transition impacts			
Redirected or stopped	5	46	18
Overrode or penetrated	2	18	7
Snagged, spun, or hit from behind	4	36	14
All transition impacts	11	100	39
Mid-length impacts			
Redirected or stopped	1	33	4
Overrode or penetrated	1	33	4
Snagged, spun, or hit from behind	1	33	4
All mid-length impacts	3	100	11
All bullnose impacts	28		100

Figure 4. Impact scenario and results in 28 bullnose collisions.

UNREPORTED COLLISIONS

A 35.8 km portion of an interstate in the Iowa data collection area was closely monitored during the 24 months of data collection. This control segment contained twelve bullnose installations and experienced average daily traffic (ADT) volumes of about 32,000 vehicles per day. In addition to collecting information about all collisions reported to the police or maintenance agencies, the data collection team surveyed every bullnose installation on the 35.8-km long control segment approximately once every month in order to record any minor damage. Such damage generally consisted of paint scraps and black marks from tires (e.g., very minor damage) as well as dents in the guardrail, collapsed end sections, or slightly bent posts (e.g., minor damage).

There was evidence of at least 40 bullnose collision events on the twelve bullnoses in the control segment as shown in Tables 6 and 7. Of these 40 presumed collision events, only one (three percent) was reported to the police. The data suggest that 95 percent of the collisions with bullnose median barriers in the State of Iowa are not reported to the police or DOT. Presumably, if the driver left the scene without a police report being filed or maintenance personnel being notified, no one was injured and the vehicle was still operable after the collision. These collisions represent guardrail successes, since they shielded an errant vehicle from some more hazardous roadside feature without causing occupant injuries or serious property damage. The proportion of reported and unreported collisions for the bullnose median barriers is similar to that for the BCT guardrail terminal.(8)

Table 6. Reported and unreported bullnose collisions on a 35.8-km segment of an interstate in Johnson County, Iowa from 1 July 1997 to 30 June 1999.

Collision Type	No.	%
Unreported Events		
Very minor damage	26	65
Minor damage	12	30
Reported Events		
Maintenance only	1	2.5
Police and maintenance	0	0
Police only	1	2.5
Total	40	100

Table 7. Reported and unreported bullnose collisions on the Iowa control section.

Collision Type	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Police-reported	0	0	1	5	0	0	0	0	1	2.5
Maintenance-reported	0	0	1	5	0	0	0	0	1	2.5
Unreported	0	0	17	90	12	100	9	100	38	95
Total	8	100	19	100	12	100	9	100	40	100

Where both inventory and collision information are available, it is possible to calculate expected average collision rates based on the number of vehicles passing guardrail installations. The Iowa control section was inventoried and the locations of bullnose systems were recorded. There were twelve bullnose installations on this segment of interstate highway, and the ADT was approximately 32,000 vehicle/day. Nearly three million vehicles pass bullnose installations each year in this 35.8-km section of interstate highway as shown in Table 8.

As shown in Table 6, during the two years of data collection there was evidence of 40 collision events, one of which was reported to the police. Using these data, the collision rates shown in Table 8 can be calculated. One collision event (e.g., reported and unreported) occurred for every 130,000 vehicle-

kilometers that were traveled past a bullnose. As shown earlier in Table 6, 95 percent of these can be expected to be minor collisions that result in little property damage and no occupant injury. Collisions serious enough to be reported to the police will occur on average once for every 5.18 million vehicle-kilometers past a bullnose. This analysis, of course, is based on the average occurrence of guardrail collisions. Some sites will experience higher or lower rates because of traffic conditions or site characteristics at that specific location. In any case, Tables 6, 7 and 8 demonstrate that collisions with guardrails are rare events, and those serious enough to report to the police are exceptionally rare.

Table 8. Collision rates for bullnose median barriers in a four-county area in Iowa.

Characteristics	Iowa control section [¶]
No. of installations	12
Length of installations (m)	457
Million vehicle-km per year	2.59
Collision events in one year	
All collisions	20
All reported collisions [§]	1
Police-reported	0.5
Millions of vehicle-km passing for one collision	
All collisions	0.13
All reported collisions	2.59
Police-reported	5.18

§ Reported collisions are those that are reported to either a police agency or a maintenance agency.

¶ The Iowa control section is a 35.8-km long segment of the east-bound alignment of an Interstate in Johnson County, Iowa with a one-way ADT of approximately 15,500 vehicles/day.

OCCUPANT INJURY

The most important measure of roadside hardware performance is the amount of human trauma resulting from roadside hardware impacts. The reason for installing the hardware in the first place is to minimize the risk to vehicle occupants by shielding them from even more serious collisions with more hazardous roadside objects like poles, trees and steep side slopes. The severity of injuries to the vehicle occupants were assessed using the occupant injury codes listed on the police report (e.g., the KABCO scale). Each case was assigned the code for its most severe injury.

Table 9 summarizes the occupant injuries in the police-reported collisions, and Table 10 includes the unreported collisions, which are presumed to have resulted in only property damage.

Table 9. Occupant injury severity in 28 police-reported bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Severe or Fatal (A+K)	2	33	0	0	3	27	0	0	5	18
Moderate Injury (B+C)	0	0	3	37	5	46	2	67	10	36
Property damage only	4	67	5	63	3	27	1	33	13	46
Total	6	100	8	100	11	100	3	100	28	100

Table 10. Occupant injury severity in 66 bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Severe or Fatal (A+K)	2	33	0	0	3	13	0	0	5	8
Moderate Injury (B+C)	0	0	3	12	5	22	2	17	10	15
Property damage only	4	67	22	88	15	65	10	83	51	77
Total	6	100	25	100	23	100	12	100	66	100

Of the six police-reported nose collisions, four resulted in only property damage and two involved severe injuries. Of the eight police-reported near-nose collisions, five resulted in only property damage and three involved moderate injuries. Of the eleven police-reported bullnose transition collisions, three resulted in only property damage and eight involved injuries or fatalities. Of the three police-reported mid-length collisions, one involved only property damage and two involved moderate injuries. A slight majority of the police-reported collisions involved some level of occupant injury. The nose impacts and near-nose impacts had a similar frequency of injury cases, but the injuries

in the nose collisions were severe (A+K), while the injuries in the near-nose collisions were moderate (B+C). The proportion of injury accidents in the bullnose transition cases was higher than in any other category, followed closely by the nose impact cases.

SEVERE INJURY CASES

Five A+K cases were collected during the 24-month-long study. Since these are the most serious collisions in terms of occupant injury, it may be helpful to examine the characteristics of these special collisions. Two of the cases were nose impacts and three were bullnose transition impacts. All were single-vehicle collisions, all but one of the drivers were wearing seatbelts and four cases took place in good weather (e.g., clear and dry).

The first nose impact (case I97090401) involved a Freightliner dump truck that lost control due to a blown tire, penetrated the nose of the system, and continued through the guardrail from behind, across the opposing lanes, and into a ditch, where it rolled over. The driver, who was the only occupant, suffered major head injuries. Repairs to the guardrail cost \$2205. Figure 5 shows the repaired bullnose and the tracks of the dump truck heading toward the nose.



Figure 5. Vehicle approach path in an end-on collision (Case I97090401).

The other nose collision (case I98060502), which occurred in the rain, involved a passenger car that was stopped in contact with the bullnose. The driver, who was the only occupant, suffered multiple major injuries. Repairs to the guardrail cost \$1390. Figure 6 shows the repaired bullnose in this case.



Figure 6. Repaired bullnose after an end-on collision (Case I98060502).

The first bullnose transition collision (case I98042701) involved a Ford F350 pickup that hit the bullnose and was redirected across both lanes of traffic into a bridge railing on the other side of the roadway. The driver and right rear passenger suffered major injuries to the upper torso, and the other two passengers suffered minor injuries to the upper torso. The cost to repair the guardrail was \$746. Figures 7 and 8 show the bullnose after this collision.



Figure 7. Vehicle approach path (Case I98042701).



Figure 8. Bullnose damage (Case I98042701).

The next bullnose transition collision (I98092303) was an unusual collision in which the driver of a car lost control and spun around in the roadway. The vehicle slid backwards and hit the guardrail on the passenger side going backwards. The vehicle vaulted over the rail and flipped over, finally coming to rest on a railroad track below the twin bridges. The four occupants were injured severely, and the right rear passenger later died from his injuries.

He had not been wearing his seatbelt. Repair

costs from this collision are not known. Figure

9 shows the damaged guardrail and Figure 10

shows the damaged car.



Figure 9. Case I98092303



Figure 10. Vehicle after collision (Case I98092303).

The last bullnose transition collision (case I98112601) involved a pickup that penetrated the guardrail and hit a bridge pier. Two passengers suffered multiple major injuries, the driver and three other passengers suffered minor injuries, and the vehicle was destroyed. The total cost to repair the guardrail was \$644. Figure 11 shows the repaired guardrail.



Figure 11. Case 98112601

No one characteristic or group of similar characteristics seems to account for the severity of these collisions. Although one case involved a large dump truck and another involved unusual impact characteristics (i.e., a vehicle sliding backwards into a guardrail), the other three collisions were cases in which the guardrail could reasonably have been expected to perform much better than it actually did. This may indicate one or more design flaws with the bullnose system.

INSTALLATION CHARACTERISTICS

As discussed in the introduction, bullnose median barriers have only performed successfully in crash tests when installed on flat terrain. The data collected for this project usually included approach slopes for a typical cross-section. Table 11 summarizes the slopes for 35 of the bullnose installations.

Table 11. Approach slopes in 35 bullnose collisions.

	Nose	Near-nose	Transition	Mid-length	Total
No. of cases	7	10	14	4	35
Mean	1:12	1:16	1:23	1:27	1:18
Minimum	1:0	1:0	1:-6	1:0	1:-6
Maximum	1:6	1:6	1:12	1:12	1:6

GUARDRAIL DAMAGE

The amount and type of damage that a guardrail experiences can provide information about typical performance problems and the amount of resources required to repair the barrier. This information was available for 34 of the 42 bullnose collisions. The damage characteristics of the collisions are shown in Tables 12 and 13.

The number of posts broken or bent over, shown in Table 12, is an indication of the length of barrier damage. For both the G4(1W) and the bullnose in Iowa, which use timber posts, posts may be either broken off or displaced in the soil.

Table 12. Posts broken or bent in 34 bullnose collisions.

	Nose	Near-nose	Transition	Mid-length	Total
Cases with broken posts	4	7	8	0	19
Total cases	7	11	14	2	34
Mean	1.7	1.3	1.2	0	0.8
Minimum	0	0	0	0	0
Maximum	4	4	3	0	4

It was not uncommon to observe minor collisions that did not break any posts, although the majority of nose or

near-nose impacts did break one to four posts. In general, collisions near the ends resulted in more broken posts than did mid-length collisions.

The guardrail bolt should pull through the guardrail slot if the post is broken away or experiences large rotations. The purpose of this feature is to prevent the guardrail from being pulled to the ground when a post rotates in the soil. As shown in Table 13, the majority of cases did not result in the guardrail bolt pulling through the slot or failing. This may be because the collisions were relatively minor and did not involve large displacements of the post. One or more guardrail bolts did fail or pull through in four cases, however.

Table 13. Component failures in 34 bullnose collisions.

	Nose	Near-nose	Transition	Mid-length	All bullnose
Guardrail bolt performance					
Pulled through or failed	1	1	2	0	4
No failure	6	10	12	2	30
Total	7	11	14	2	34
Guardrail performance					
Tearing observed	2	1	2	0	5
No tearing	5	10	12	2	29
Total	7	11	14	2	34

Splice failures and tearing of the guardrail were not common occurrences in the real-world collisions. Guardrail tearing was noted whenever any evidence of tearing was observed, such as when a tear initiated in a splice bolt hole. There was no evidence of a splice failure or guardrail tearing in the mid-length cases, although there was one splice failure in a bullnose transition case and some evidence of tearing in two nose impacts, one near-nose impact, and two bullnose transition cases, as shown in Table 13. The vehicles in the collisions where tearing was observed included a dump truck, a passenger car, a pickup, a van, and one unknown vehicle type.

Repair cost data were available for 26 of the bullnose collision cases, including 17 police-reported cases. Table 14 summarizes the costs associated with repairing the damaged bullnose median barriers.

Table 14. Repair costs associated with 26 bullnose collisions.

	Nose	Near-nose	Transition	Mid-length	Total
All cases					
No.	8	8	7	3	26
Mean (\$)	1282	1154	810	6610	1730
Minimum (\$)	361	741	119	852	119
Maximum (\$)	2205	1681	1862	16,627	16,627
Police-reported cases					
No.	5	7	3	2	17
Mean (\$)	1584	1079	442	9489	2105
Minimum (\$)	1006	741	119	2350	119
Maximum (\$)	2205	1441	642	16,627	16,627
Maintenance-only cases					
No.	3	1	4	1	9
Mean (\$)	778	1681	1087	852	1024
Minimum (\$)	361	1681	536	852	361
Maximum (\$)	1389	1681	1862	852	1862

In summary, the ends of the bullnoses generally experienced more damage than the mid-length sections, including broken posts and torn guardrails. The overall performance of the bullnose systems in terms of guardrail damage was adequate.

CONCLUSIONS

The previous sections have described a preliminary analysis of the data collected in an in-service performance evaluation of the bullnose median barrier in the State of Iowa. Passenger cars and pickups dominated the in-service collision data, although there were a number of larger vehicles involved in collisions. One tractor-trailer collision was included in the data.

The majority of the collisions resulted in only property damage, but five of the 28 police-reported collisions involved severe occupant injuries or fatalities. Occupant injuries were most common in bullnose transition collisions and most severe in end-on nose collisions. Damage to the guardrail was generally less severe in mid-length collisions than in collisions near the end of a bullnose.

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