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**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 bullnose barriers in the data collection area were usually installed consistent with Iowa DOT policy and represent good quality installations. Their collision performance was assessed in terms of collision characteristics, occupant injury and barrier damage. While the dataset for this study was small, examination of the collisions indicates that impacts at and near the nose often resulted in unacceptable vehicle behavior and severe occupant injuries. The data suggest that there is a need to develop median treatments that prevent vehicles from penetrating the system and contributing to injuries of vehicle occupants.

KEYWORDS

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

INTRODUCTION

Wide medians are an integral part of modern freeways. 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, such as high-mast lighting, bridge piers, openings between twin bridges and large sign bridge supports. These objects would be potentially hazardous if struck, so they must be shielded if they are within the clearzone.

Several states including Minnesota, Iowa, Michigan and Colorado use a guardrail envelope, often called a bullnose median treatment, to completely surround hazardous features of the median. While the middle portion of the bullnose is simply a W-beam 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. An example is shown in Figure 1.



Figure 1. Typical bullnose median treatment around bridge piers.

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⁾ 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 more realistic terrain and the latest crash test and evaluation procedures.⁽⁴⁾ This research determined that the performance of the standard 1.5-m radius bullnose 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 three-beam rails, modified three-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. The following sections describe the data collection and address the performance of the bullnose with respect to collision characteristics, occupant injury and barrier damage.

DATA COLLECTION

GENERAL

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 data collection team was notified about collisions from police and highway maintenance agencies, and information from 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 parallel to the roadway). One section of interstate highway within the data collection area, referred to as the “control section,” was also monitored for evidence of unreported bullnose collisions.

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 end, 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 bullnose system, shown in Figure 2, is usually installed in a ditch with typical slopes of 10:1.

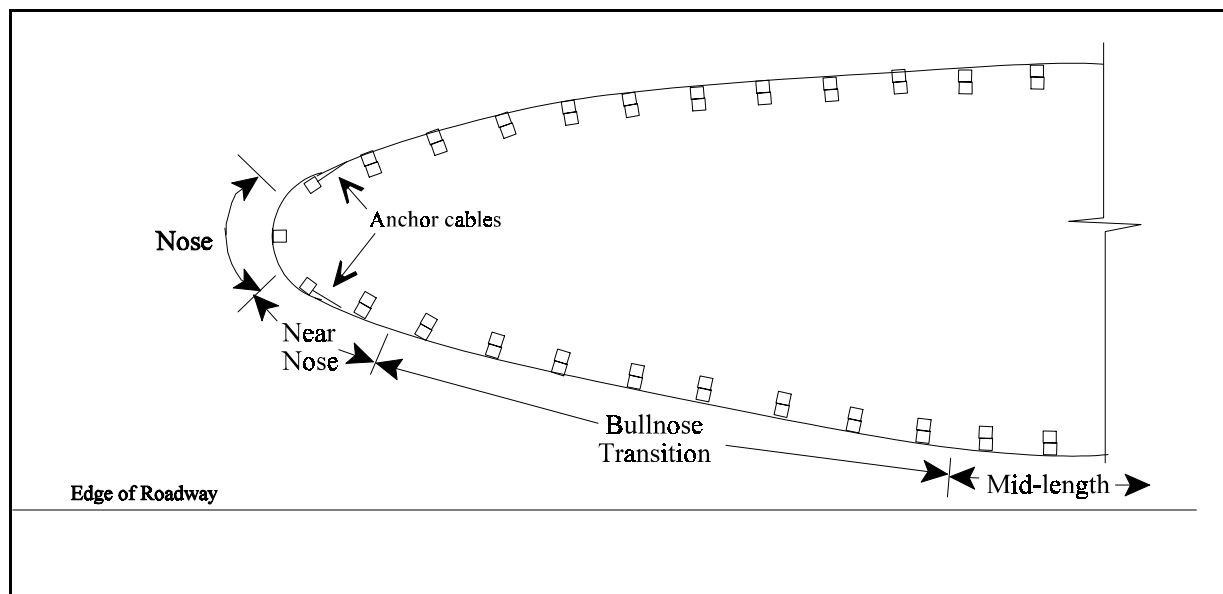


Figure 2. Typical Iowa bullnose installation.

DATA COLLECTION AREA

The data collection area was composed primarily of Cedar, Johnson, Linn and Scott Counties in southeastern Iowa. The area was selected based on Iowa DOT maintenance garage responsibility maps rather than political boundaries. In Iowa, bullnoses are only used on interstate highways since these are the only high-speed divided highways with medians. There were 290 km of interstate highways in the data collection area with an average traffic demand of 21,542 vehicles per day. There were approximately 368 bullnose installations in the data collection area based on the Iowa DOT area engineers' inventories.

POLICE REPORTS

Between 1989 and 1993, an average of nearly 100 guardrail-related collisions occurred each year in the four-county data collection area, almost 80 percent of them on the interstate system. Guardrail-related 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 identify bullnose collisions in the statewide collision data. As a result, an expected number of bullnose collisions in the data collection area and period could not be determined prior to the study.

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. All police agencies in Iowa use a uniform accident reporting form which simplified coordinating information on the accident reports between law enforcement agencies. Reports were available from the police as soon as the investigating officer completed the paperwork.

MAINTENANCE REPORTS

Since the Iowa DOT attempts to recover the cost of guardrail repairs from the people who damaged the roadside hardware in a collision, the DOT documents the materials, labor and equipment required to repair any State-owned property including bullnose median barriers. The police agencies normally notify the appropriate DOT maintenance supervisor whenever a collision occurs that involves damage to roadside hardware. 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 appropriate police report. 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 repair of the hardware. When the repair is complete, a "Memorandum of Cost Report" is 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, a 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. 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.

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. The approach slope was defined as the slope between the edge of the shoulder and the impact point on the barrier. The approach slope was flatter than 1:6 in all cases except one which was 1:4. Slopes flatter than 1:4 are generally considered traversable so the bullnoses were usually installed in a traversable ditch. Table 1 summarizes the slopes for 39 of the bullnose collision cases. This information was not available for the other three cases.

Table 1. Installation characteristics in bullnose collisions.

	Nose	Near-nose	Transition	Mid-length	Total
Steepest approach slope					
No. of cases	8	12	15	4	39
Mean	1:12	1:11	1:17	1:15	1:14
Minimum	1:0	1:0	1:0	1:0	1:0
Maximum	1:6	1:4	1:6	1:12	1:4
Rail height near impact point					
No. of cases	9	12	17	4	42
Design height (mm)	706	706	706	706	706
Mean (mm)	631	735	726	624	698
Minimum (mm)	515	620	630	500	500
Maximum (mm)	710	1010	860	672	1010
No. acceptable (± 75 mm)	5	8	15	3	31
No. too high	0	3	1	0	4
No. too low	4	1	1	1	7

Incorrect rail heights may contribute to poor barrier performance in collisions. The bottom portion of Table 1 describes the height of the top of the W-beam rail near the impact point in the bullnose collision cases. At the nose, the rail was unacceptably low in 44 percent of the cases, while the rail was installed at an acceptable height in 67 percent of the near-nose cases, 88 percent of the transition cases, and 75 percent of the mid-length cases. In general, bullnose installations in the data collection area had acceptable guardrail heights although the proportion of unacceptable heights increased nearer the nose. The height is difficult to maintain as the device is installed in a ditch and the results shown in Table 1 conform to this expectation.

COLLISION CHARACTERISTICS

Data from a total of 42 bullnose collisions were collected in the study area during the 24-month data collection period, including nine nose collisions, 12 near-nose collisions, 17 bullnose-transition collisions and four mid-length G4(1W) collisions. Of these, 28 (67 percent) were reported to the police and the rest were reported to maintenance personnel. 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, as well as the police officer's sketch of the impact when available.

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 as shown in Table 2. Altogether, 39 percent of the cases involved passenger cars and 39 percent involved pickups. Overall, pickups, SUVs, and vans made up 50 percent of the bullnose collisions.

Table 2. 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 3. The errant vehicle interacted with no other vehicles or objects prior to striking the guardrail in 74 percent of the cases. The errant vehicle 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.

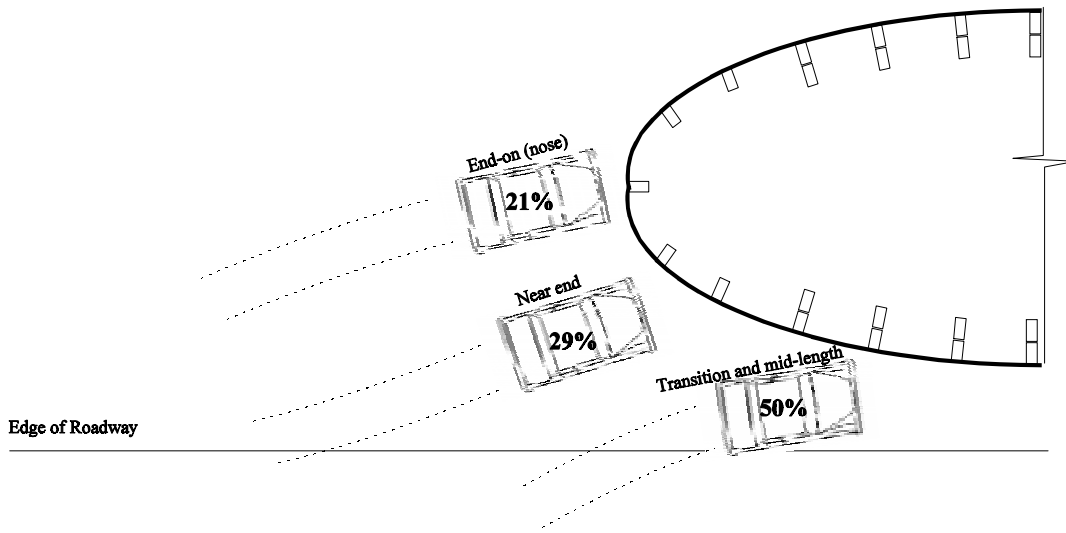
The result of the impact with the guardrail is shown in the middle portion of Table 3. The result of the collision was acceptable (e.g., the vehicle was redirected or stopped) in only twelve of the 28 bullnose collisions (43 percent). The bullnose was penetrated or overridden in 25 percent of the collisions and another 25 percent involved significant snagging or spin-outs.

The collision with the barrier was the last event in almost 50 percent of the cases as shown in the bottom portion of Table 3. There were four cases where the vehicle struck a tree or other roadside object after being redirected, one case where it struck another vehicle, and eight cases where it rolled over.

Table 3. Events in 28 police-reported bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Events prior to bullnose 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 bullnose 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 bullnose impact										
None	3	50	3	38	6	55	1	33	13	46
Rollover	2	33	2	25	3	27	1	33	8	29
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	0	0	2	7

Half of all the impacts occurred at or near the nose. Only two of the six nose collisions resulted in acceptable performance, (i.e., the vehicles were stopped by the bullnose end). It is unknown how far they traveled before stopping since both installations were repaired before the site visits. Two nose collisions resulted in override or penetration. All the penetration or override collisions occurred on curved portions of the bullnose (i.e., not the mid-length portion), and the proportion of overrides and penetrations increased closer to the nose. In general, bullnose collisions appear to result in a surprisingly high proportion of unacceptable collision results, especially when the collision is at or near the nose. Figure 4 summarizes the impact scenarios and their results.



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 police-reported bullnose collisions.

UNREPORTED COLLISIONS

A 35.8 km portion of an interstate in the Iowa data collection area, known as the “control section,” was closely monitored during the 24 months of data collection. This control section contained twelve bullnose installations and experienced average daily traffic (ADT) volumes of about 16,000 vehicles per day each direction. 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 control section approximately once every month and recorded any minor damage. Such damage generally consisted of paint scraps and black marks from tires, dents in the guardrail, collapsed end sections, or slightly bent posts.

There was evidence of at least 40 bullnose collision events on the twelve bullnoses in the control section as shown in Table 4. Of these 40 presumed collision events, one was reported to the police and one was reported to the DOT maintenance supervisor. 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. There was no evidence of an unreported collision event on the noses of any bullnose systems on the control section. This may indicate that when the nose is struck the collision will be reported to the police. Also, the nose is far from the traveled way so it is insulated from the many nuisance hits that occur closer to the road. The relatively poor end-on performance observed in the last section may suggest that nose collisions frequently result in serious collisions.

Table 4. 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	0	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. Nearly three million vehicles pass

bullnose installations each year in this 35.8-km section of interstate highway as shown in Table 5.

Table 5. Collision rates for bullnose median barriers in a four-county area in Iowa.

Characteristics	Nose & Near-nose	Transition & Mid-length	Entire Iowa control section¶
No. of installations	12	12	12
Length of installations (m)	91.2	365.8	457
Million vehicle-km per year	0.52	2.07	2.59
Collision events in one year			
All collisions	9.5	10.5	20
All reported collisions§	1	0	1
Police-reported	0.5	0	0.5
Millions of vehicle-km passing for one collision			
All collisions	0.05	0.20	0.13
All reported collisions	0.52	-	2.59
Police-reported	1.04	-	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.

As shown in Table 4, 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 5 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 4, 95 percent of these can be expected to be minor collisions, resulting in little property damage and no occupant injury, that are not reported to the police. 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 and may not result in accurate predictions of collision frequency at specific sites. Some sites will experience higher or lower rates because of traffic conditions or site characteristics. In any case, Tables 4 and 5 demonstrate that collisions with bullnose barriers are rare events, and those serious enough to report to the police are exceptionally rare.

OCCUPANT INJURY

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

The top portion of Table 6 summarizes the occupant injuries in the police-reported collisions, and the bottom portion summarizes occupant injuries in control section cases, including the unreported collisions which are presumed to have resulted in only property damage.

Table 6. Occupant injury severity in 28 police-reported bullnose collisions.

Scenario	Nose		Near-nose		Transition		Mid-length		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
<i>Police-reported cases (entire data collection area)</i>										
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
<i>All control section cases</i>										
Severe or Fatal (A+K)	0	0	0	0	0	0	0	0	0	0
Moderate Injury (B+C)	0	0	1	5	0	0	0	0	1	3
Property damage only	0	0	0	0	0	0	0	0	0	0
Not police-reported	0	0	18	95	12	100	9	100	39	97
Total	0	100	19	100	12	100	9	100	40	100

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 tended to be 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. None of the differences were statistically significant due to the small sample sizes.

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. The vehicle penetrated the nose of the system, 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 \$2,205. Figure 5 shows the repaired bullnose and the tracks of the dump truck heading toward the nose.

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 \$1,390.

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



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



Figure 6. Bullnose damage (Case I98042701).

upper torso. The cost to repair the guardrail was \$746. Figure 6 shows the bullnose after this collision.

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



Figure 7. Case I98092303

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 7 shows the damaged guardrail.

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.

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 better than it actually did. This may indicate one or more design flaws with the bullnose system. For example, impacts with the transition section would appear to redirect errant vehicles across the road into the opposite side bridge rail.

GUARDRAIL DAMAGE

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

The number of posts broken or bent over, shown in Table 7, is an indication of the length of barrier damage. The timber posts may be either broken off or displaced in the soil. 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. This is to be expected, since the posts near the end are designed to break away on impact.

Table 7. 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

The guardrail bolt should pull through the guardrail slot if the post is broken away or experiences large rotations, to prevent the guardrail from being pulled to the ground. One or more guardrail bolts failed or pulled through in only four cases. This may be because the rest of the collisions were relatively minor and did not involve large displacements of the posts.

Splice failures and tearing of the guardrail occurred in 14 percent of 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 but 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. 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. While guardrail rupture occurred in only one case, the presence of tearing indicates the potential for additional ruptures.

Repair cost data were available for 26 of the bullnose collision cases including 17 of the police-reported cases. Table 8 summarizes the costs associated with repairing the damaged bullnose median barriers.

Table 8. 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. Heavily damaged sections of bullnose barriers must be repaired immediately so that the barrier can function properly in subsequent collisions. The overall performance of the bullnose systems in terms of maintenance and repair was adequate.

CONCLUSIONS

An in-service performance evaluation of bullnose median treatments in a portion of Iowa was performed. This involved collecting information about bullnose collisions from field investigations, police reports and maintenance records. These sources of information indicated that the bullnose installations in the data collection area were usually installed consistent with Iowa DOT policy and represent good quality installations. While the dataset for this study was small (42 police and maintenance-reported cases and 38 unreported events) an examination of the characteristics of the collisions suggests that impacts at and near the nose often result in unacceptable penetrations or overrides. These collisions are not frequent, but when they occur they are often severe. Collisions at the nose resulted in serious or fatal injuries in one-third of the police-reported cases. While the bullnose does not appear to be particularly effective in nose and near-nose collisions it is unclear whether any other median treatment would result in better performance. These data suggest that there is a need to develop median treatments that prevent vehicles from penetrating the system and contributing to injuries of vehicle occupants.

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