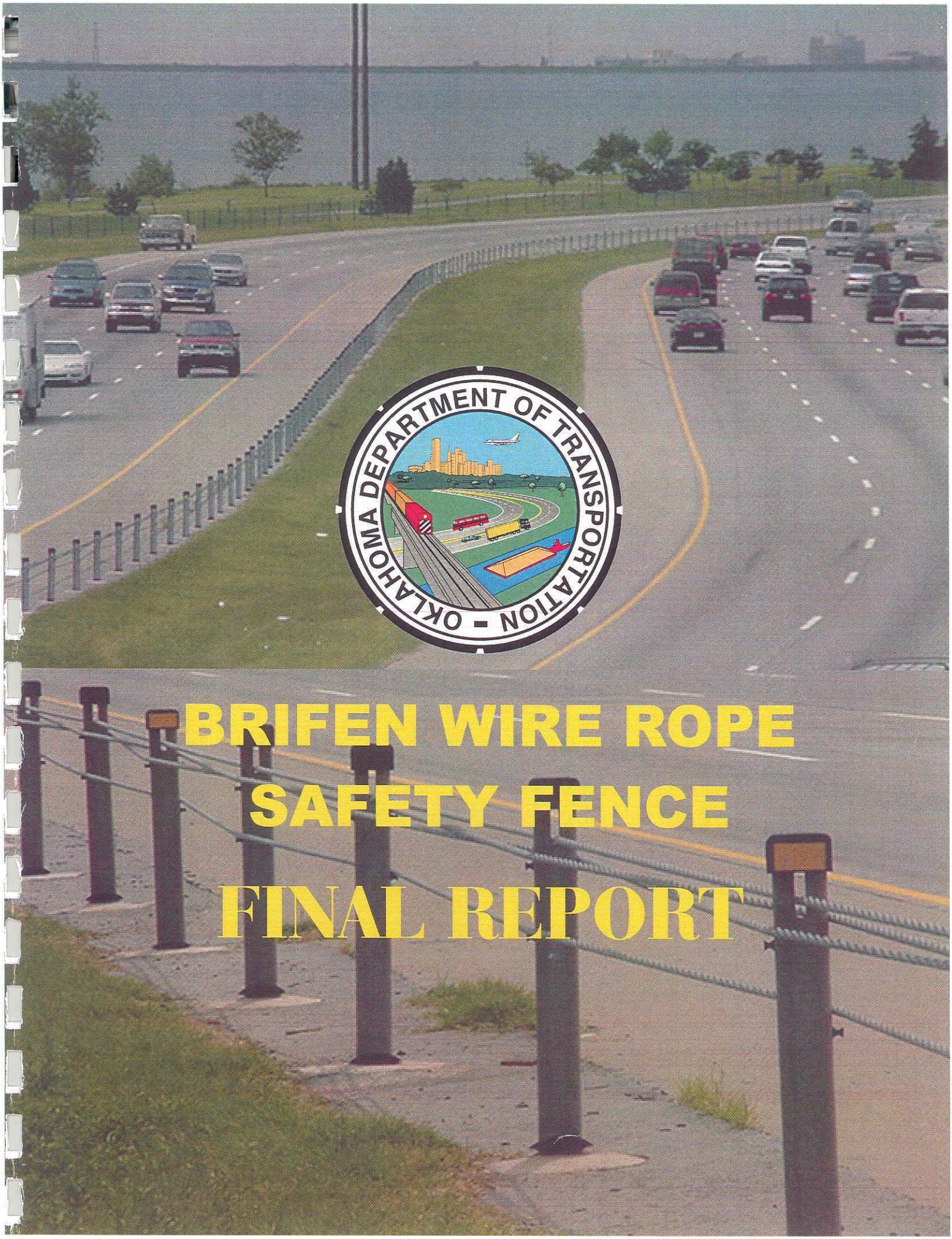
Appendix 7



OKLAHOMA DEPARTMENT OF TRANSPORTATION

BRIFEN WIRE ROPE SAFETY FENCE

FINAL REPORT

BRIFEN WIRE ROPE SAFETY FENCE FINAL REPORT

Oklahoma Department of Transportation
Traffic Engineering Division
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March 2003

Acknowledgments

Thanks and appreciations to the following individuals and groups for their assistance and guidance:

Harold Smart, P.E.	ODOT, Traffic Engineering Division
Red Miller, P.E.	ODOT, Traffic Engineering Division
Stanley Greene	ODOT, Traffic Engineering Division
FHWA	Oklahoma Division
Jerry Emerson	BRIFEN*USA
Steve Wells	Mid State Traffic Control Construction
Graham Sharp	BRIFEN

DISCLAIMER

This document is prepared under sponsorship of the Oklahoma Department of Transportation. The State of Oklahoma assumes no liability for its contents or use thereof.

The contents of this report reflect the results of experimental use of the BRIFEN Safety Wire Rope System in the State of Oklahoma. This report does not constitute a standard, specification, or regulation of usage of the BRIFEN Safety Rope System.

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1.0 INTRODUCTION

Lake Hefner Parkway (LHP), a section of State Highway 74 in northwest Oklahoma City, is a six-lane freeway connecting to I-44 at the south end and extending north to the Kilpatrick Turnpike for a distance of approximately seven miles. Traffic volume in 2000 was 108,000 vehicles per day and is increasing. The grassy center median varies in width from 36' to 42', with no initial installation of a cross-over barrier. There is no lighting or overhead signing along much of the LHP length since it traverses an environmentally sensitive area beside a large reservoir, Lake Hefner. Local residents did not want their view of the lake compromised, and Oklahoma Department of Transportation (ODOT) complied with these demands.

However, after opening to traffic in 1991, this highway began experiencing a high number of median cross-over collisions and fatalities. Between June 1, 1997, and May 31, 2000, 185 collisions were reported, including 11 cross-overs which resulted in four fatalities. This increasing number of cross-over collisions along with their high rate of severity prompted ODOT to research possible design alternatives to prevent or reduce the severity of these crashes.

The options considered included concrete median barriers, strong-post guardrail barriers and cable barriers. The design chosen was a British cable barrier system known as the BRIFEN Wire Rope Safety Fence (BRIFEN WRSF), which had never been used in the United States and, at the time, had not been approved as meeting the requirements of the National Cooperative Highway Research Program Report 350 (NCHRP-350). Roadside features used on the National Highway System (NHS) of which LHP is a part must meet NCHRP-350 requirements. Also, at the time, BRIFEN WRSF was fabricated using foreign steel which meant that it did not comply with the "Buy America" regulations. These and other issues were discussed with the local Federal Highway Administration (FHWA) Division office, which agreed with ODOT that, based upon its reported excellent performance worldwide, BRIFEN WRSF should be tried on an experimental basis by installing a section along the LHP.

A two-phase experimental project was initiated by ODOT and approved by the FHWA in August of 2000. The first phase, a 1000' section, was installed in August of 2000 for study and evaluation purposes.

During the winter of 2000 the experimental section was impacted several times, performed well, and was easily repaired. It was also considered aesthetically pleasing and did not cause snow drifts. The effectiveness of this section of BRIFEN WRSF warranted installation along all seven miles of LHP for further study and analysis. This document will present findings and evaluations from these experimental sections of BRIFEN WRSF regarding its effectiveness in preventing cross-over collisions, as well as its installation, maintenance and repair costs, and recommendations for future uses of the system.

2.0 DESIGN & CONSTRUCTION

2.1 MEDIAN BARRIER OPTIONS

ODOT has primarily used only two types of barriers for median applications to prevent cross-over crashes. Concrete "New Jersey" shape median barriers have been used predominately in the past, along with a few "single-slope" median barriers used more recently. The "F" shape median barrier will be ODOT's primary concrete barrier in the future. Steel "W-beam" barriers have had limited use for median applications, but are primarily used for bridge end, pier, and side slope shielding. These systems are designed to accommodate NCHRP-350 Test Level Three (TL-3) vehicles, such as small 820 kg (1800 lb) passenger cars up to 2000 kg (4500 lb) pick-up trucks which commonly travel through Oklahoma.

Another barrier, available to ODOT but never used, was the three-cable generic design used by states such as Arizona, New York, North and South Carolina, South Dakota and others. ODOT has never used a three-cable barrier due to the high level of maintenance required and the fact that this type of cable barrier typically falls to the ground after a hit, unable to sustain shielding until it is repaired. Several states (Arizona, New York, North Carolina, Oregon) have reported these types of problems. Another aspect of the three-cable barrier is that it deflects 3.4 - 3.7 m (11' to 12') when impacted, limiting its usage in areas where obstructions are close to the roadway. ODOT determined these characteristics were unacceptable for use on a high-volume traffic freeway such as the LHP.

The other option was the BRIFEN WRSF, which deflects much less (6' to 8'), remains upright after typical hits, and can handle additional hits before repair. It is also easy and quick to repair and is now a NCHRP-350 approved system at TL-3.

2.2 BRIFEN WIRE ROPE SAFETY FENCE

2.2.1 Introduction

The BRIFEN WRSF, originally developed by Briton, Ltd. of the United Kingdom (UK), is a four-rope system that, according to the manufacturer, has been in successful service since 1989 in over 30 countries around the world.

The BRIFEN WRSF used on the LHP consists of four pre-stretched wire ropes supported by weak steel posts and anchored at each end to concrete ground units. Since some posts can be damaged with every impact, using the socketed design allows posts to be replaced very quickly by one or two workers with only hand tools and no heavy equipment. Driving the posts would reduce initial costs slightly; however, maintenance costs would increase, requiring more time to drive each replacement post and possible lane closures during the repair.

2.2.2 Usage

BRIFEN WRSF consists of pre-stretched wire ropes that are highly tensioned after installation and are attached to weak steel posts that are designed to bend over and release the ropes on impact. As is typical for cable barrier systems, BRIFEN WRSF allows snow to pass through rather than drifting and building up against the barrier, as is common with a concrete or W-beam barrier. BRIFEN WRSF can be used in locations where obstructions are closer than could be tolerated by the three-cable design.

With its standard 3.2 m (10.5') post spacing, deflection during TL-3 tests with a 2000 kg (4500 lb) pickup was only 2.4 m (7.8'), as compared to typical three-cable barrier deflections of 11' to 12'. Computer simulations have shown that BRIFEN WRSF deflections could be reduced to approximately 1.2 m (3.9') if post spacings of 1.5 m (4.9') are used. All cable systems must be used where there is enough lateral clearance behind the system to allow for uninterrupted deflection during an impact.

With its standard post spacing, BRIFEN WRSF can be used in medians 4.9 m (16') or more in width without risk of vehicles crossing into opposing lanes, assuming the system was installed in the center of the median.

Many locations worldwide have used BRIFEN WRSF in medians with far less than minimum median width and reportedly have performed well. No cross-over collisions have ever been reported where BRIFEN WRSF was in place.

2.2.3 Initial System Installation Costs

Costs comparisons for BRIFEN WRSF and other commonly used median barrier systems are listed in **Table 2.1**. The BRIFEN WRSF initial cost is somewhat higher than the three-rope generic system, but less expensive than traditional W-beam systems. Concrete barriers are far more expensive.

Table 2.1: Initial Cost Comparisons of Median Barrier Types

Median Barrier Type	Cost per mile
BRIFEN WRSF, Driven Posts & Anchors	$68,000
BRIFEN WRSF, Socketed Posts & Anchors	$84,000
Three-Cable U.S. Generic Fence, & Anchors	$50,000
Double-Face W-beam Guardrail	$105,000
Concrete Median Barrier	$500,000

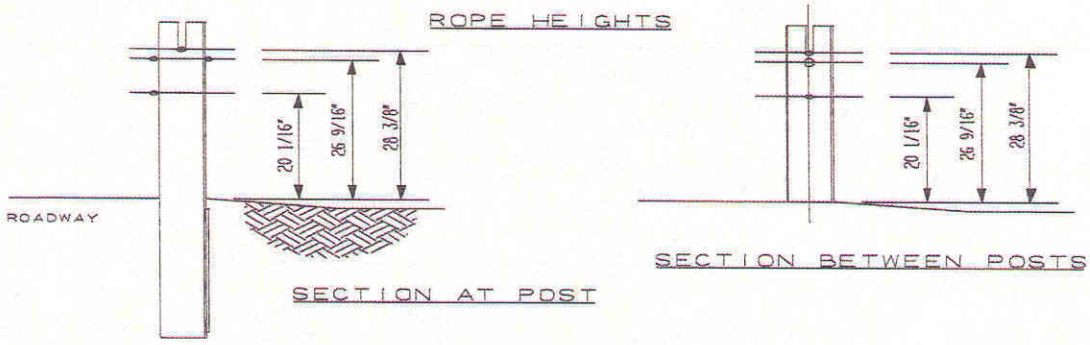
Cable barrier systems are typically less expensive due to their relatively light-weight design. Their metal posts are much smaller than W-beam posts, since they are intended to collapse upon impact, and little or no grading or earthwork is needed. Concrete barriers, by contrast, must usually be placed on a concrete or asphalt base with modified drainage features and extra paved shoulder widening or lane additions to fill the space between the barrier and the travel lanes. For these reasons the cost of concrete barriers tends to be significantly higher. This is especially true for wide medians.

Overall long-term costs for the above options are difficult to project; however, if vehicle damage and costs for severe injuries were included, W-beam and concrete barrier costs would be considerably higher when compared to cable systems. Maintenance costs for concrete barriers are low since they are rarely damaged enough to need repairs. This is not the case for W-beam barriers, which are maintenance intensive.

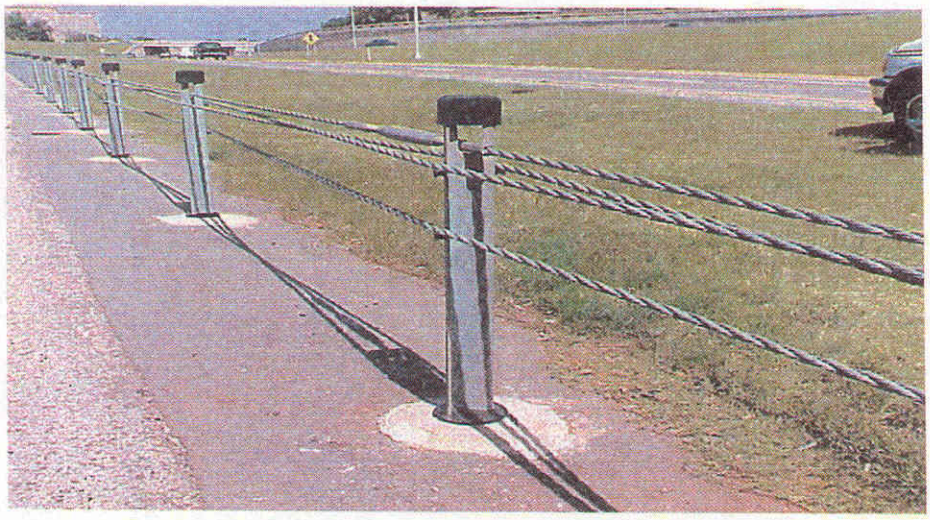
2.2.4 BRIFEN WRSF Design Details

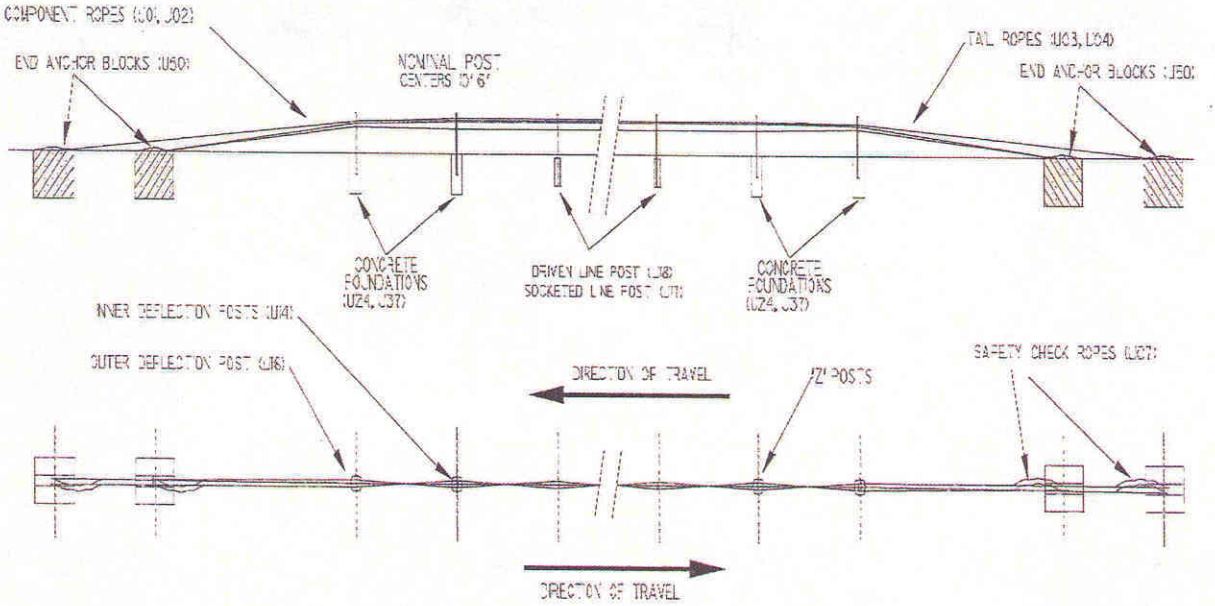
The BRIFEN WRSF consists of four 19 mm (3/4") pre-stretched galvanized wire ropes supported by "S" shape galvanized steel posts. The ropes along the necessary length are not directly attached to the posts. The top rope is 720 mm (28-3/8") above ground and is placed in a slot in the top end of the posts. The two intermediate ropes are 675 mm (26-9/16") above ground and are supported by hard plastic pegs on either side. These two ropes alternate sides from post to post. This patented "weaving" contributes to the small amount of deflection, when compared to the three-cable generic system, and helps to retain rope tension during an impact, acting as a "mini-anchor". The fourth rope, 510 mm (20-1/16") above the ground, rests on the same type of plastic peg and also weaves from side to side between posts.

There are two options for installing the BRIFEN WRSF support posts. They can either be driven in or placed into socketed concrete foundations. Because some posts will be damaged with every impact, using the socketed design allows the bent posts to be easily replaced. This can be done by one worker with only simple hand tools; no heavy equipment is needed. Driving the posts reduces the initial cost, but maintenance costs are increased, since driving each replacement post requires more time and possible traffic-lane closures during repair.

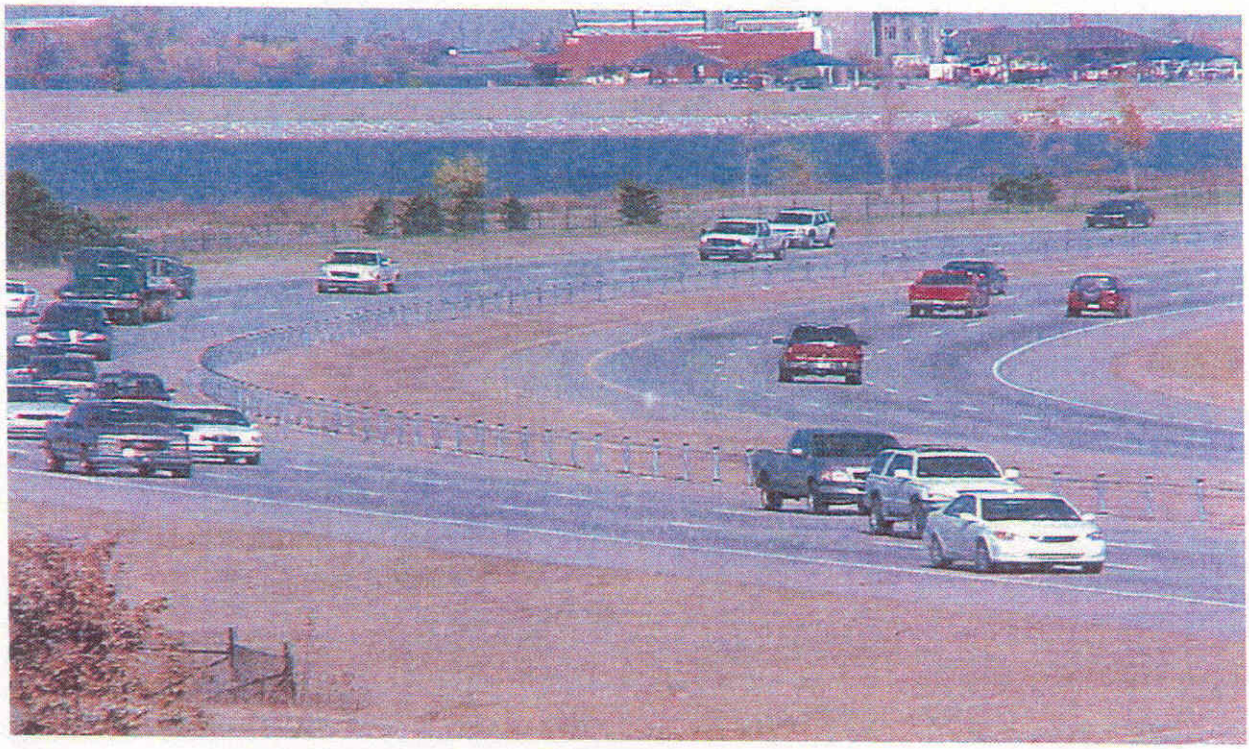


WSRF Post Details





Plan & Profile Views of BRIFEN WRSF



2.2.5 Advantages and Disadvantages

The BRIFEN WRSF has several advantages over the three-cable weak-post barrier currently used in the U.S. The initial construction cost of the BRIFEN WRSF is somewhat higher than the three-cable system, but maintenance and repair costs are less for the BRIFEN WRSF system when compared to the three-cable, weak-post barrier or W-beam guardrail. This is primarily due to the small amount of BRIFEN WRSF typically damaged during an impact.

The three-cable system is notorious for having re-tensioning problems due to "construction stretch" when impacted. Many times all of the cable between the anchors will fall to the ground and must then be re-tensioned after the posts are replaced, which means that the barrier is not capable of re-directing another vehicle. The ropes used in the BRIFEN WRSF are pre-stretched, then highly tensioned during installation, and, after most impacts, will continue to function and sustain additional hits prior to being repaired. Thus, BRIFEN WRSF has largely eliminated the "cable-on-the-ground" problem. The U.S. three-cable barrier uses either small steel I-beams or steel channel posts which are typically driven into the ground. These are time consuming to replace compared to the BRIFEN WRSF posts, especially if the posts are placed in socketed foundations. Replacing a few posts in the BRIFEN WRSF system takes one or two workers only a few minutes, requiring only minimal traffic delays. The ropes typically never need re-tensioning due to traffic impacts.

In the event that the ropes need to be loosened after a collision due to vehicle entanglement, it is easily done with the rigging screws (turnbuckles) which are spaced approximately every five hundred feet. Another advantage is the smaller deflections occurring with the BRIFEN WRSF system during an impact. Maximum deflection in TL-3 length of need tests was 2.4 m (7.8'), whereas the three-cable system deflects approximately around 3.4 to 3.7 m (11'-12'). An additional advantage of BRIFEN WRSF over the three-cable system is that it only needs an anchor at each end, regardless of the length of the section of BRIFEN WRSF. This is due primarily to the patented weaving of the ropes such that each post acts as a "mini-anchor" due to the friction generated as the ropes go around the sides of the posts.

102.3 LAKE HEFNER PARKWAY EXPERIENCE

Lake Hefner Parkway is a seven-mile section of SH-74, a six-lane divided freeway with a 36' to 42' median, located in northwest Oklahoma City. The LHP runs north from the 39th Expressway to the Kilpatrick Turnpike, and serves as a primary route for business commuters traveling from the surrounding housing communities and those further north into the metro area. In 2000, the average annual daily traffic was 108,000 vehicles per day. Approximately four percent of this traffic consisted of trucks.

2.3.1 Choosing BRIFEN WRSF

Another aspect discussed was safety to the driver and passengers within the vehicle colliding with the barrier. A concrete barrier is very rigid. Due to the number of cross-over collisions on the LHP, ODOT staff requested the approval of the Transportation Commission to research preliminary designs for a median barrier along the seven-mile extent north of 39th Street. Several alternatives were discussed along with the BRIFEN WRSF, which had never been used in the U.S. and had not been approved by the FHWA for use on the National Highway System. This product was brought to ODOT's attention by a safety engineer of the Federal Highway Administration (FHWA) Oklahoma Division Office, who had seen it while traveling in other countries.

The other alternative designs considered were an ultimate design consisting of added lanes and a concrete median barrier, an interim design of a concrete barrier on one shoulder, a strong-post guardrail, and the three-cable system currently being used in the U.S.

One consideration was cost, including initial and maintenance. The ultimate design, including added lanes and concrete barrier was the most maintenance-free, but the most expensive. The initial cost for this design was estimated at approximately $11.3 million, with low maintenance costs, since damage to concrete barriers is usually minimal. Concrete barriers located along one shoulder was also considered and was estimated at approximately $3.4 million with similar, low maintenance costs. Strong-post guardrail was estimated to cost approximately $1.5 million, with high maintenance costs, requiring replacement of both rail and posts after most high speed impacts, and requiring lane closures and other traffic control considerations.

The three-cable U.S. system was estimated to cost $409,142 but would likely have high repair costs due to replacing posts and re-tensioning the cables, and the need for frequent inspections to detect damaged sections which would be ineffective during subsequent hits until repairs could be made.

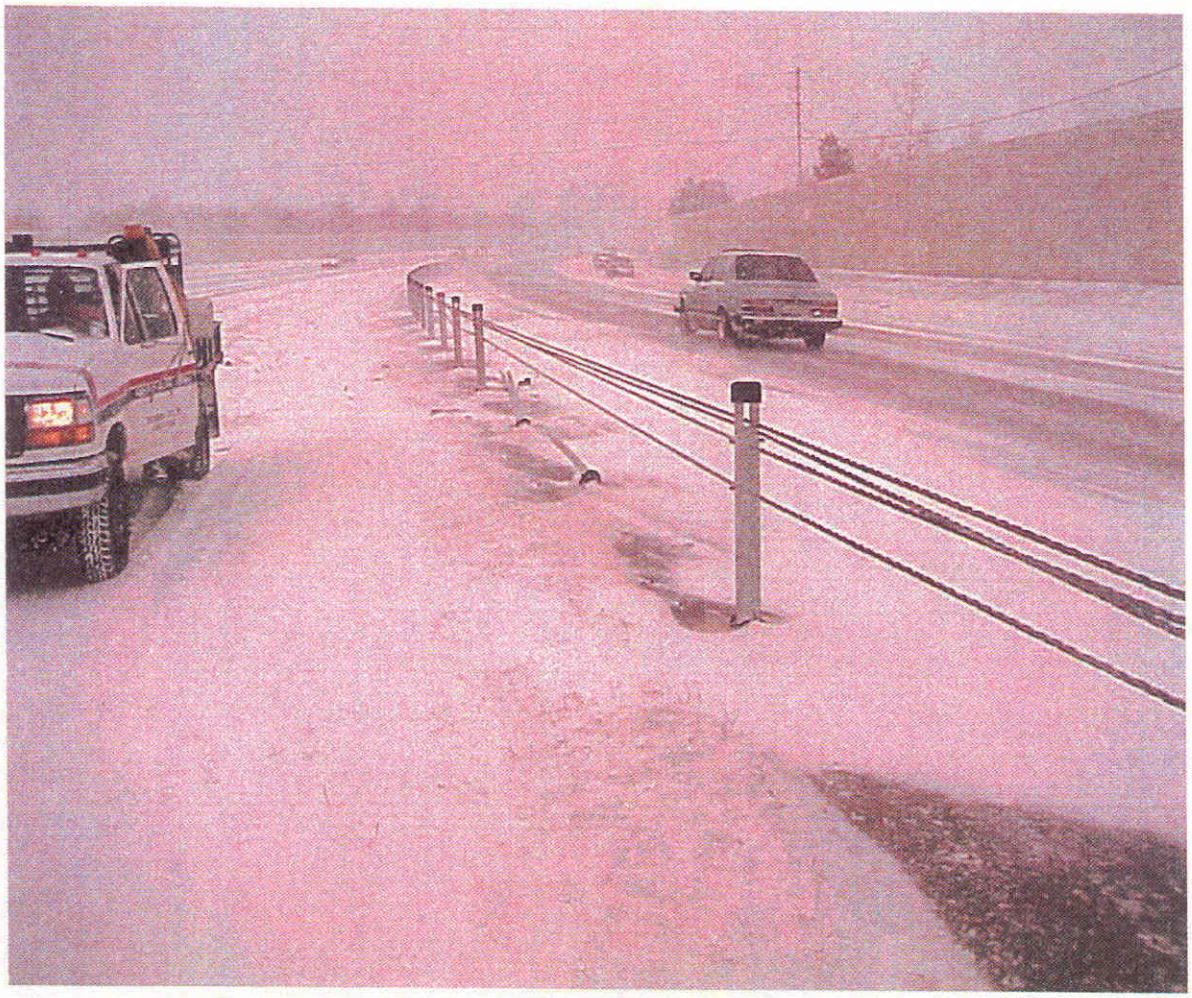
The BRIFEN WRSF system was estimated to cost $675,517, plus some additional costs for asphalt weed-control paving. This initial cost was higher than the three-cable U.S. system, but the maintenance cost was expected to be much lower; and the BRIFEN WRSF could be expected to remain at near-design height before being repaired. Considering both initial costs and long-term maintenance costs, the BRIFEN WRSF was considered to be the most efficient alternative.

Another consideration was effectiveness. Concrete barriers are almost 100% effective in that they usually will not allow a vehicle to cross the median. Guardrails are also generally effective; but, after an impact, will not work until repairs are made. Similarly, the U.S. three-cable system will stop most impacts, but, once hit, the low- tension cable falls to the ground making the whole stretch between anchors vulnerable to crossovers. Also, many more end anchors would be required since two anchors are required approximately every 1,000'. Frequent inspections are needed along with timely repairs to effectively maintain the system. The BRIFEN WRSF could be expected to eliminate most of these problems. ODOT was advised by the manufacturer and other agencies that impacts had occurred from many different angles, directions, and speeds and there had never been a cross-over incident reported with the system in place. In addition, after

being impacted, the high tension ropes usually stayed in place and continued to prevent secondary crossovers. In contrast, impacts with the concrete median barrier can do great damage to vehicles and cause serious injuries or death. The strong-post guardrail is semi-rigid but can still place large forces on vehicle occupants and cause major damage to vehicles. The three-cable system and the BRIFEN WRSF are the least likely to injure passengers because of the "soft," gradual deflection typical of the cables/ropes. With the use of the BRIFEN WRSF system, agencies reported that under many circumstances, when the fence is hit the vehicle is only slightly damaged. In these instances the driver vacates the collision site and leaves the repair cost to the public agencies. Both the three-cable and the BRIFEN WRSF systems do not deflect the vehicle back out into traffic. Finally, cable barrier systems do not block passage of wildlife.

The final consideration was aesthetic. The BRIFEN WRSF was considered by ODOT's design staff to be more visually pleasing and acceptable to the surrounding community than any of the other alternatives.

After comparing the advantages and disadvantages, the BRIFEN WRSF was determined to be the best alternative. Its initial cost was considered reasonable, with maintenance and repair simple and inexpensive. Evidence and testimony showed the system to be very effective at preventing vehicles from crossing over medians, reducing the degree of injuries, and continuing to provide post-hit protection.



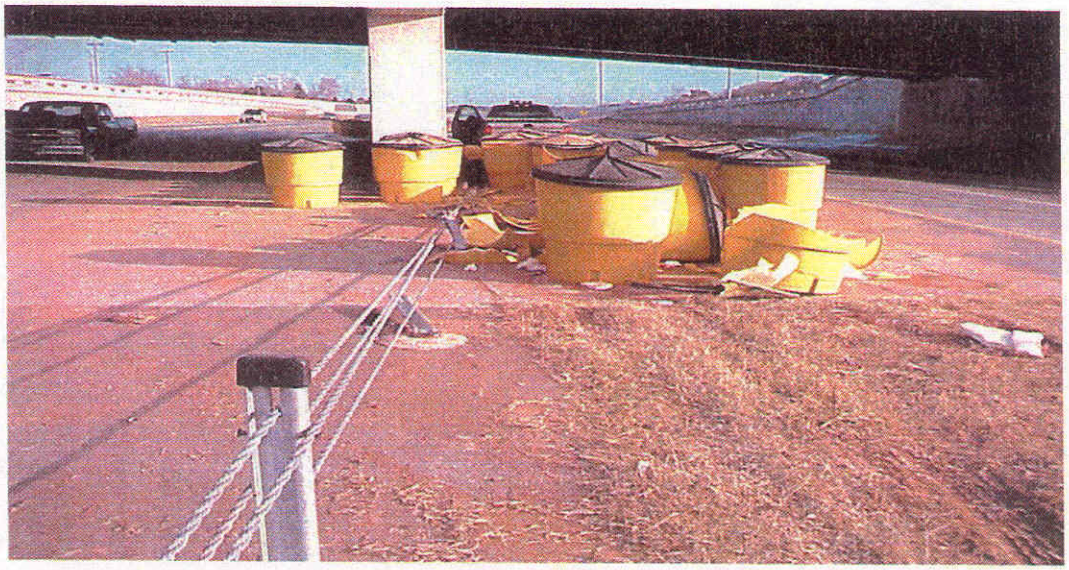
2.3.2 Experimental Project

Once ODOT chose to use the BRIFEN WRSF on the LHP, FHWA approval had to be requested because this system had not yet been approved for use on the National Highway System. During this time, BRIFEN WRSF had been attempting to get the system approved as meeting NCHRP-350, but in the interim the FHWA Oklahoma Division approved the installation of a 1000' section (donated by the BRIFEN Company) as Phase I of an experimental project. Shortly after the initial section was in place, BRIFEN WRSF was approved by FHWA as meeting NCHRP-350 Test Level 3 requirements and work continued on the development of TL-3 end anchors. The FHWA maintained that the experimental project could be installed as long as the end anchors were shielded from traffic or placed beyond the clear zone.

In September 2000, the manufacturer partnered with Midstate Traffic Control, Inc. of Oklahoma City and installed the test section where both end anchors could be located near existing overhead sign structures where protective sand barrel crash cushions were already in use.

During the next few months the section was hit four times and performed extremely well each time. Since the Phase I test was considered successful, Phase II was installed during summer 2001 for the remainder of the seven-mile length of the LHP. Since NCHRP-350 approval for the end anchor units had not been obtained, they were also shielded by existing sand barrel crash cushions The initial Phase I test section was constructed in the center of the median, but the remaining seven-mile Phase II section was placed just outside the southbound shoulder, with asphalt paving for weed control.

This placement was chosen for two reasons. First, due to existing drainage drop inlets, some sections of the slopes in the center median were considered too steep for the WRSF to work safely, and there was no reasonable way to flatten them without extensive and expensive drainage modifications. Second, placement of the weed control pavement section under the barrier was desired to reduce the difficulty in mowing and upkeep of the median, and this strip most logically should be placed adjacent to the shoulder. This close placement would mean more nuisance hits than if it were placed in the center of the median.



3.0 COLLISION REPORTS AND FINDINGS

3.1 HISTORICAL COLLISION SUMMARIES

The Oklahoma Department of Public Safety supplied police reports to ODOT for research purposes. These reports included data pertaining to road conditions, collision analysis, and damage estimates. ODOT compiled data for the period prior to installing BRIFEN WRSF and for the period after installation. Much of the data following installation was obtained from the contractor doing the maintenance, since most of the hits did not result in a collision report being filed because the vehicles did not stop. This study provides a clear definition of the existing problems on LHP and how BRIFEN WSRF affected the situation.

3.2 IMPACTS

3.2.1 Analysis of Impacts Before Installation

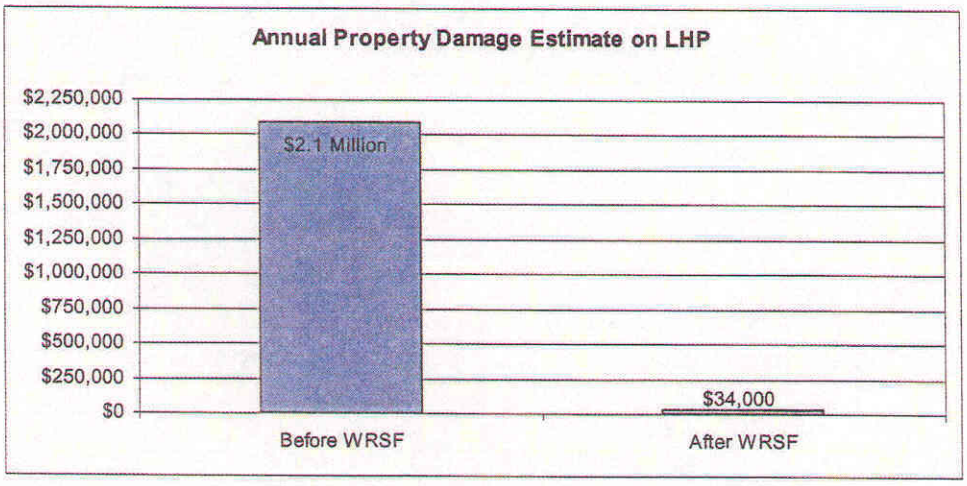
For the one year prior to installation of BRIFEN WRSF, the LHP experienced six recorded serious median traffic collisions. All of these collisions were cross-over events, one involving a fatality, and one involving a rear-end collision. Given the width of the LHP median, it is likely that other vehicle incursions into the median occurred, but drivers were able to regain control or stop before crossing over into oncoming traffic, thus generating no collision report.

3.2.2 Analysis of Impacts After Installation

During the analysis period from August of 2001 through July of 2002, LHP experienced 126 impacts into the BRIFEN WRSF (see Table 3.1, APPENDIX A: COLLISION RECORDS), 43 of these being potential cross-over collisions. Each time, the BRIFEN WRSF performed as described by the manufacturer and prevented vehicles from crossing over into oncoming traffic.

No vehicles passed through the BRIFEN WRSF under any weather conditions, including wet pavement, snow and ice. The barrier was hit by drivers who were intoxicated, asleep at the wheel, experienced a tire blowout, or were forced off the road by other vehicles.

In addition, there were several instances where a vehicle impacted the BRIFEN WRSF in the same or nearby location of a previous hit. During the initial impacts posts were knocked down, but the system was still functional and able to resist additional collisions before crews could repair the damaged sections. In several collisions, the vehicles did not hit the BRIFEN WRSF in a normal "tracking" situation. This means the wheels did not hit the barrier in a stable, 25 degree- (or less) angle and at a speed of 100 kph (62.5 mph) or less. There were two separate collisions where a vehicle actually hit the BRIFEN WRSF head-on (90 degrees) at a speed greater than 50 mph and did not pass through the system. Several hits were estimated to have occurred at a 45 degree angle, even in a backward orientation. By still containing the impacting vehicles and preventing them from crossing the median, the BRIFEN WRSF proved to be performing well above the minimum requirements of NCHRP-350.

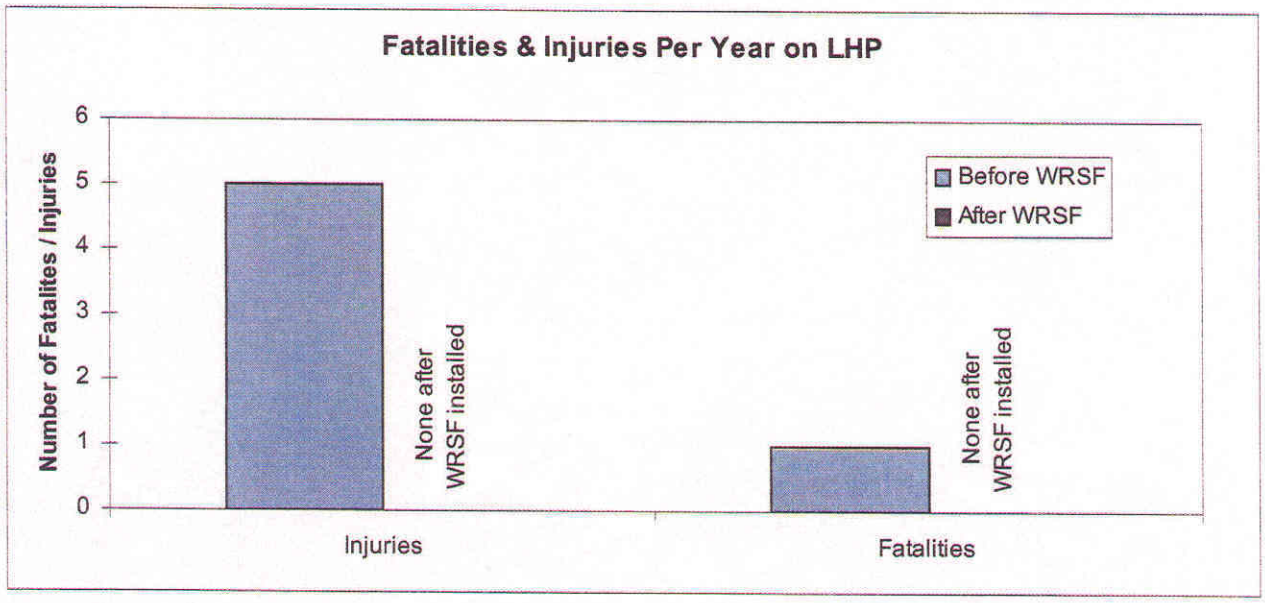


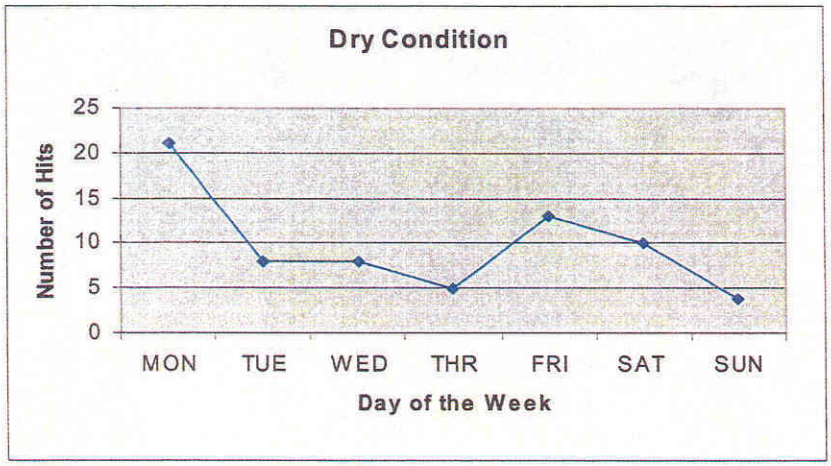
3.2.3 Fatalities and Injuries

Before the installation of BRIFEN WRSF, there had been 185 collisions on the LHP, resulting in six fatalities and 77 injuries between June 1, 1997, and May 31, 2000. Included in this number were four fatalities and six injuries resulting from cross-over collisions. ODOT considers a preventable fatality collision to be a $2,800,000 cost impact to the economy. The existing average of more than one fatality per year was considered unacceptable.

Since the BRIFEN WRSF installation there has not been a single fatality or serious injury, although there have been numerous collisions recorded which had a high potential for resulting in a fatality had the BRIFEN WRSF not been in place.

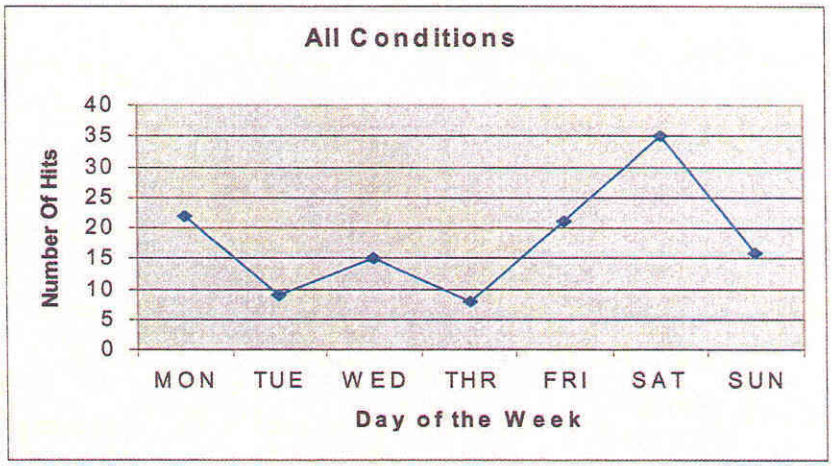
Prior to installation, the LHP experienced a recorded average of ten collisions per year with an average of $21,000 per collision in property damage. The completeness of the data is questionable because it is based only on crashes reported to the police. Some run-off-road events are assumed to have occurred, but are immeasurable. After installation, an average of 44 collisions per year was recorded with an average of $5,000 each in property damage incurred.

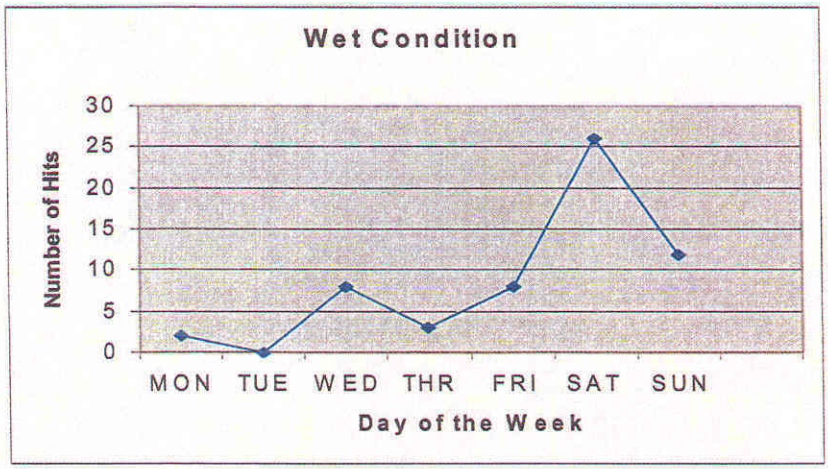




DRY CONDITION
Frequency of BRIFEN hits
Day of the week

ALL CONDITIONS
Frequency of BRIFEN hits
Day of the week





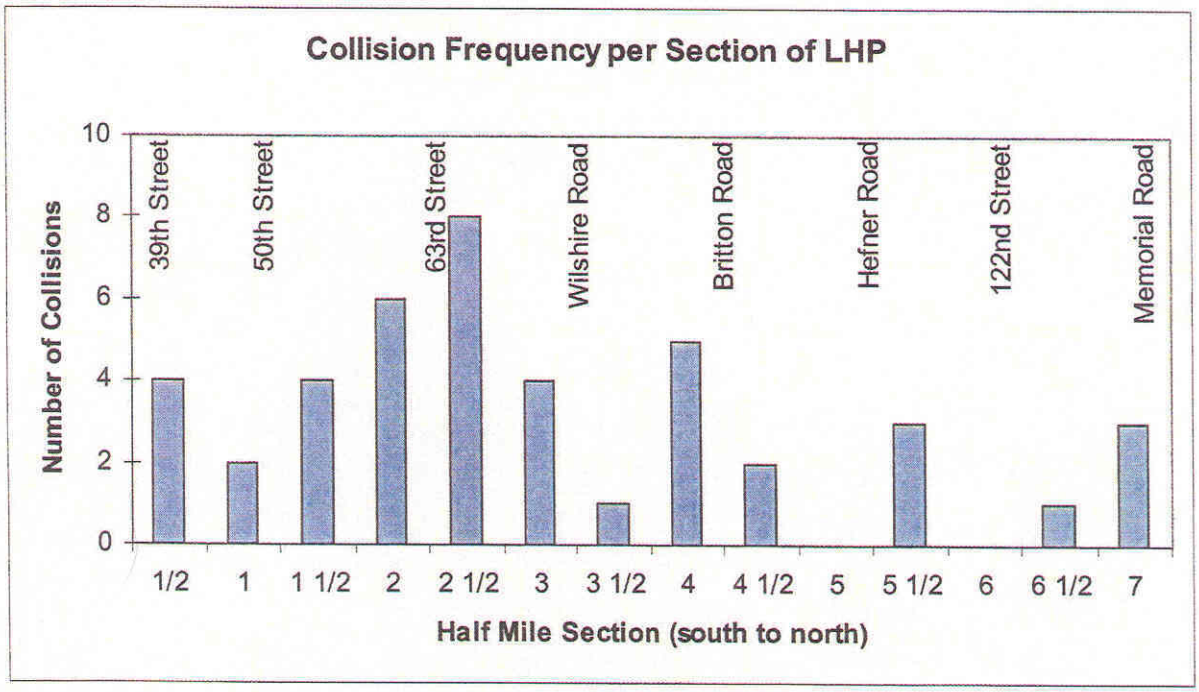
WET CONDITION
Frequency of BRIFEN hits
Day of the week

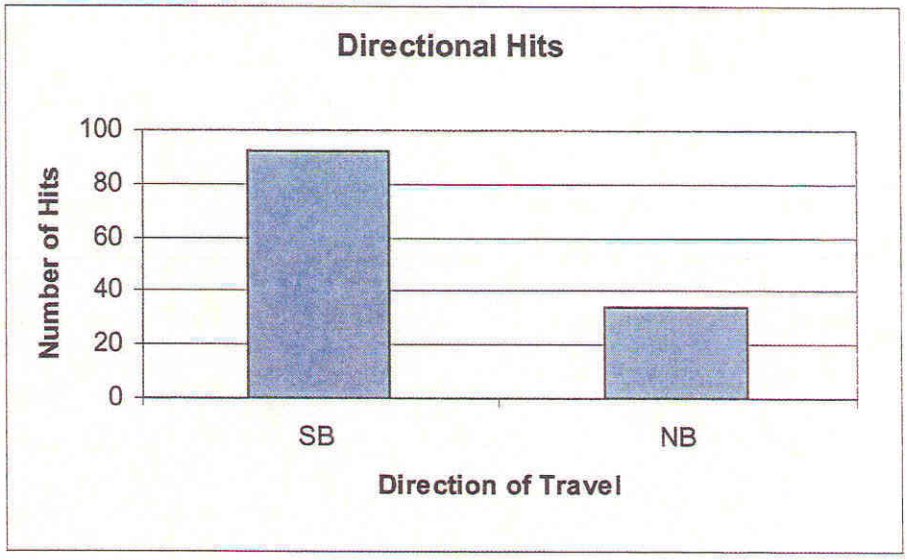
4.0 MAINTENANCE AND REPAIR

4.1 WRSF MAINTENANCE AND REPAIR COSTS

Midstate Traffic Control Inc. of Oklahoma City provided all installation and maintenance for BRIFEN WRSF during this study. On average, considering repair costs of about $63 per post replaced, a typical hit damaged an average of 4.71 posts, resulting in repair costs per incident of approximately $297, including required traffic control. There were some additional costs added for emergency repairs. After one year, there were 128 impacts to the BRIFEN WRSF, 37 were northbound and 91 southbound. The southbound hits were more than two times as frequent as northbound due to the close proximity of the BRIFEN WRSF to the southbound traffic. As of December 31, 2002, the total impacts increased to143. Southbound collisions were still double northbound.

ODOT and the Oklahoma City Police Department receive an average of about $75 per post for insurance collection purposes. Some of the crashes result in no collision report or insurance claim since some vehicles flee the scene if not damaged or before officials arrive.





4.2 COST ANALYSIS

ODOT previously installed three miles of concrete median barrier along I-44 south of the LHP. This section attaches to the BRIFEN WRSF and is part of this experimental project. Installation and maintenance costs for both median barrier systems are shown in **Table 4.1**.

Table 4.1: Initial Cost Comparisons of Median Barrier Types

Median Barrier Type	Installation Cost ($/mile)	Maintenance Costs ($/mile/year)
WRSF	$103,380	$4,558*
Concrete	$343,000	$1,500**

*Current maintenance cost is $52 per post, or $3,759/mile/year at the same collision rate.

** One collision along this section required two sections of concrete wall to be replaced. Concrete wall estimated at $250 per section, plus costs for traffic control.

4.3 CABLE BARRIER STUDIES FROM OTHER STATES

The repair costs from other states that have installed the three-wire rope system are shown in **Table 4.2**.

Table 4.2: Cost Comparisons with Other States Using Three-Wire Rope System

	Oklahoma BrifenWRSF	Oregon*	North Carolina
Study Year	2001	1998	1995
Miles of Barrier	7.0	14.5	13.7
Collisions/Year	42	20	N/A
Repairs/Year	24	40	71
Number of Injuries/Year	1	4	21
Number of Fatalities/Year	0	N/A	N/A
Prop. Damage/Year	$260,000	N/A	N/A
Repair Cost/Post	$63 **	$206	$65

* Data obtained from a 1998 study by the Oregon Department of Transportation on three-wire rope barrier systems.
** Current cost per post for repair is $52/post (includes costs for traffic control).

4.4 REPAIRS

From the initial complete installation of the BRIFEN WRSF on the LHP, there was a total of 143 impacts. The cost to repair damages has been $297 per collision, which includes traffic control and added costs for emergency repairs. Over the total length of seven miles the repair cost per year has been $4,558 per mile.

5.0 CONCLUSIONS AND RECOMMENDATIONS

* BRIFEN WRSF has shown excellent performance during the 16-month installation period. There have been no cross-over crashes or fatalities and only one reported minor, personal injury. The BRIFEN WRSF has performed extremely well in actual field usage crashes, which in many cases are more severe and unpredictable than passing TL-3 tests conducted under ideal conditions.

* Maintenance of the BRIFEN WRSF has proven to be quick, easy and inexpensive, averaging $297 per collision including traffic control. Typical five-post hits are repaired in less than 15 minutes by one person using only simple hand tools.

* Typical hits do not cause BRIFEN WRSF to fall to the ground, and it can generally sustain additional hits before being repaired. This is attributed to the patented weaving of the ropes between the posts and to the highly tensioned, pre-stretched ropes.

* Vehicle damage has typically been very light, and many vehicles continue on their way without stopping after a hit.

* Ease of post replacement makes the "socketed" post system the preferred alternative where high traffic volumes, curves, and other factors can be expected to cause numerous impacts. Driven posts would slightly reduce initial cost.

* Long distances of 3.2 km and 8.0 km (2.0 miles and 5.0 miles) between end anchors on the LHP system have proven to be satisfactory, and no loss of rope tension has been noted. Tension in the ropes has been checked frequently, and adjustment has not been necessary. Inspection of the wire ropes and rigging screws (turnbuckles) has shown no damage after sustaining 143 hits.

* BRIFEN WRSF has been well accepted by the local media, citizens of the area, and others for its visually pleasing appearance. It does not cause snow drifts or debris collection.

* Maximum deflection of BRIFEN WRSF on the LHP, noted from vehicle tracks, has been approximately 1.2 m (4'), while the NCHRP-350 TL-3 for WRSF is 2.4 m (7.8'). Both are less than the 3.4 to 3.7 m (11' to 12') typical of the standard three-cable system.

APPENDIX A: COLLISION RECORDS

Table 3.1

Incident #	Date	Day of the Week	# of Posts Damaged	Direction of Travel	Police Report	Road Condition	Repair Cost
1	08/11/01	SAT	11	SB	YES	Dry	$715.00
2	08/11/01	SAT	3	NB	YES	Dry	$195.00
3	08/12/01	SUN	3	NB	NO	Dry	$195.00
4	08/17/01	FRI	10	SB	YES	Dry	$650.00
5	08/17/01	FRI	3	SB	YES	Dry	$195.00
6	08/18/01	SAT	10	NB	YES	Dry	$650.00
7	08/30/01	THR	32	SB	YES	Dry	$2,080.00
8	08/31/01	FRI	16	SB	YES	Dry	$1,040.00
9	09/14/01	FRI	10	NB	YES	Dry	$650.00
10	09/15/01	SAT	2	NB	NO	Dry	$130.00
11	09/15/01	SAT	7	NB	YES	Dry	$455.00
12	09/22/01	SAT	4	NB	NO	Dry	$260.00
13	10/01/01	MON	2	NB	YES	Dry	$130.00
14	10/08/01	MON	7	SB	YES	Dry	$455.00
15	10/08/01	MON	4	SB	NO	Dry	$260.00
16	10/08/01	MON	7	NB	NO	Dry	$455.00
17	10/10/01	WED	5	SB	YES	Dry	$325.00
18	10/25/01	THR	4	SB	YES	Dry	$260.00
19	10/26/01	FRI	3	SB	YES	Dry	$195.00
20	10/27/01	SAT	10	SB	NO	Dry	$650.00
21	11/05/01	MON	6	NB	YES	Dry	$390.00
22	11/19/01	MON	5	SB	NO	Dry	$325.00
23	11/26/01	MON	3	NB	NO	Dry	$195.00
24	11/26/01	MON	5	SB	NO	Dry	$325.00
25	11/28/01	WED	19	SB	YES	Ice & Snow	$1,235.00
26	11/28/01	WED	1	SB	YES	Ice & Snow	$65.00
27	11/28/01	WED	2	SB	NO	Ice & Snow	$130.00
28	11/28/01	WED	2	SB	NO	Ice & Snow	$130.00
29	11/28/01	WED	1	NB	NO	Ice & Snow	$65.00
30	11/28/01	WED	2	SB	NO	Ice & Snow	$130.00
31	11/28/01	WED	1	SB	NO	Ice & Snow	$65.00
32	11/28/01	WED	1	SB	NO	Ice & Snow	$65.00
33	11/29/01	THR	3	SB	NO	Ice & Snow	$195.00
34	11/29/01	THR	1	SB	NO	Ice & Snow	$65.00
35	11/29/01	THR	1	SB	NO	Ice & Snow	$65.00
36	12/08/01	SAT	3	SB	NO	Dry	$195.00
37	12/10/01	MON	3	SB	NO	Dry	$195.00
38	12/25/01	TUE	5	SB	YES	Dry	$325.00
39	12/30/01	SUN	1	SB	NO	Ice & Snow	$65.00
40	12/30/01	SUN	1	SB	NO	Ice & Snow	$65.00
41	12/30/01	SUN	2	SB	NO	Ice & Snow	$130.00
42	12/30/01	SUN	1	SB	NO	Ice & Snow	$65.00
43	12/30/01	SUN	1	SB	NO	Ice & Snow	$65.00
44	12/30/01	SUN	1	NB	NO	Ice & Snow	$65.00
45	12/30/01	SUN	2	NB	NO	Ice & Snow	$130.00
46	12/30/01	SUN	4	NB	NO	Ice & Snow	$260.00
47	12/30/01	SUN	3	SB	NO	Ice & Snow	$195.00
48	12/30/01	SUN	1	NB	NO	Ice & Snow	$65.00
49	12/30/01	SUN	2	SB	NO	Ice & Snow	$130.00
50	12/30/01	SUN	2	SB	NO	Ice & Snow	$130.00
51	12/31/01	MON	2	SB	YES	Ice & Snow	$130.00
52	12/31/01	MON	4	NB	NO	Ice & Snow	$260.00
53	01/01/02	TUE	3	NB	NO	Dry	$195.00
54	01/22/02	TUE	4	SB	NO	Dry	$260.00
55	01/28/02	MON	4	SB	NO	Dry	$260.00
56	01/30/02	WED	2	SB	YES	Dry	$130.00
57	01/30/02	WED	6	NB	NO	Dry	$390.00
58	02/11/02	MON	4	SB	YES	Dry	$260.00

Incident #	Date	Day of the Week	# of Posts Damaged	Direction of Travel	Police Report	Road Condition	Repair Cost
59	02/11/02	MON	2	NB	YES	Dry	$130.00
60	02/11/02	MON	6	NB	YES	Dry	$390.00
61	02/25/02	MON	5	SB	YES	Dry	$325.00
62	03/01/02	FRI	4	NB	NO	Ice & Snow	$260.00
63	03/01/02	FRI	6	SB	NO	Ice & Snow	$390.00
64	03/01/02	FRI	3	SB	NO	Ice & Snow	$195.00
65	03/01/02	FRI	1	SB	NO	Ice & Snow	$65.00
66	03/01/02	FRI	1	SB	NO	Ice & Snow	$65.00
67	03/01/02	FRI	4	SB	NO	Ice & Snow	$260.00
68	03/01/02	FRI	2	SB	NO	Ice & Snow	$130.00
69	03/01/02	FRI	3	SB	NO	Ice & Snow	$195.00
70	03/02/02	SAT	3	SB	NO	Ice & Snow	$195.00
71	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
72	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
73	03/02/02	SAT	2	NB	NO	Ice & Snow	$130.00
74	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
75	03/02/02	SAT	4	SB	NO	Ice & Snow	$260.00
76	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
77	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
78	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
79	03/02/02	SAT	3	SB	NO	Ice & Snow	$195.00
80	03/02/02	SAT	4	SB	NO	Ice & Snow	$260.00
81	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
82	03/02/02	SAT	3	SB	NO	Ice & Snow	$195.00
83	03/02/02	SAT	1	NB	NO	Ice & Snow	$65.00
84	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
85	03/02/02	SAT	3	SB	NO	Ice & Snow	$195.00
86	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
87	03/02/02	SAT	4	SB	NO	Ice & Snow	$260.00
88	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
89	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
90	03/02/02	SAT	5	SB	NO	Ice & Snow	$325.00
91	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
92	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
93	03/02/02	SAT	2	SB	NO	Ice & Snow	$130.00
94	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
95	03/02/02	SAT	1	SB	NO	Ice & Snow	$65.00
96	03/15/02	FRI	5	SB	NO	Dry	$325.00
97	03/15/02	FRI	6	SB	NO	Dry	$390.00
98	03/25/02	MON	4	SB	NO	Dry	$260.00
99	04/02/02	TUE	9	SB	YES	Dry	$585.00
100	04/03/02	WED	2	NB	NO	Dry	$130.00
101	04/05/02	FRI	8	SB	YES	Dry	$520.00
102	04/08/02	MON	6	NB	NO	Dry	$390.00
103	04/08/02	MON	1	NB	NO	Dry	$65.00
104	04/17/02	WED	11	SB	NO	Dry	$715.00
105	04/22/02	MON	4	NB	NO	Dry	$260.00
106	04/22/02	MON	7	SB	NO	Dry	$455.00
107	05/09/02	THR	13	NB	NO	Dry	$845.00
108	05/10/02	FRI	1	NB	NO	Dry	$65.00
109	05/11/02	SAT	7	NB	NO	Dry	$455.00
110	05/12/02	SUN	3	SB	NO	Dry	$195.00
111	05/14/02	TUE	7	NB	NO	Dry	$455.00
112	05/17/02	FRI	4	SB	NO	Dry	$260.00
113	05/21/02	TUE	10	SB	YES	Dry	$650.00
114	050/24/02	FRI	4	SB	YES	Dry	$260.00
115	05/24/02	FRI	7	NB	NO	Dry	$455.00
116	06/04/02	TUE	6	SB	YES	Dry	$390.00
117	06/21/02	FRI	4	NB	NO	Dry	$260.00
118	06/22/02	SAT	4	SB	NO	Dry	$260.00
119	06/20/02	THR	4	NB	NO	Dry	$260.00

Incident #	Date	Day of the Week	# of Posts Damaged	Direction of Travel	Police Report	Road Condition	Repair Cost
120	07/02/02	TUE	11	NB	NO	Dry	$715.00
121	07/02/02	TUE	2	SB	NO	Dry	$130.00
122	07/15/02	MON	3	NB	NO	Dry	$195.00
123	07/17/02	WED	4	NB	NO	Dry	$260.00
124	07/17/02	WED	1	SB	NO	Dry	$65.00
125	07/25/02	THR	23	SB	NO	Dry	$1,495.00
126	07/31/02	WED	18	SB	NO	Dry	$1,170.00
TOTALS			557				$36,205.00

Totals thru 07/31/02

126 hits, 1 minor injury, no fatalities or cross-over crashes