

VERMONT AGENCY OF TRANSPORTATION

**Materials & Research Section
Research Report**



**AN EVALUATION OF BRIFEN WIRE ROPE
SAFETY FENCE**

Report 2013 – 06

May 2013

An Evaluation of Brifen Wire Rope Safety Fence

Final Report

Report 2013 – 06

May 2013

Follow Up to Initial Report U2006-4

Reporting on Work Plan 2005-R-11

STATE OF VERMONT
AGENCY OF TRANSPORTATION

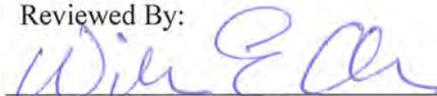
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16. Abstract <p>Three-strand cable barriers were first developed in the 1960's and found to have several desirable characteristics as compared to other roadside barriers such as guard rail. Brifen Wire Rope Safety Fence is a four strand woven wire rope intended to prevent vehicles from veering off a road. This experimental feature is manufactured by Brifen USA Inc. and adheres to NCHRP 350 test level three. This designation implies that the product can withstand the impact of a vehicle traveling at 60 mph. The purpose of this investigation was to evaluate the woven rope system in comparison to a more widely used three wire rope cable barrier. Comparatively, the four stand woven wire rope is marketed to provide enhanced levels of safety while providing substantial reductions in installation, maintenance and repair costs.</p> <p>The Brifen system required an increased level of effort during initial installation when compared with a standard three-cable wire rope fence. The resulting system appeared to be stronger, with less deflection in the cable along its entire length. The initial installation encountered no difficulties, as observed by Construction, Operations or Research staff.</p> <p>Through site observations conducted by Materials and Research personnel it appears that the safety fence is performing considerably well, however the posts under torque is causing concern of how well the fence will continue to work when vehicles make contact with it. The excluder caps, post caps, and locator pegs should be replaced with a more durable material due to excessive cracking and breaking. This fence might not be an ideal choice for Vermont due to the inclement weather and the involved tasks of repairing the fence after accidents. Operations have claimed that the repair process is quite extensive.</p>					
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ABSTRACT

Three-cable wire barriers were first developed in the 1960's and found to have several desirable characteristics as compared to other roadside barriers such as steel beam guard rail. Brifen Wire Rope Safety Fence is a four-cable woven wire rope intended to prevent vehicles from veering off a road. This experimental feature is manufactured by Brifen USA Inc. and complies with NCHRP 350 test level three. This designation implies that the product can withstand the impact of a vehicle traveling at 60 mph. The purpose of this investigation was to evaluate the woven rope system in comparison to a more widely used three wire rope cable barrier. Comparatively, the four-cable woven wire rope is marketed to provide enhanced levels of safety while providing substantial reductions in installation, maintenance and repair costs.

The Brifen system required an increased level of effort during initial installation when compared with a standard three-cable wire rope fence. The resulting system appeared to be stronger, with less deflection in the cable along its entire length. The initial installation encountered no difficulties, as reported by Construction, Operations, and Research staff who observed the operation.

Through site observations conducted by Materials and Research personnel it appears that the system is performing considerably well, however the posts under torque is causing concern of how well the fence will continue to work when vehicles make contact with it. The excluder caps, post caps, and locator pegs should be replaced with a more durable material due to excessive cracking and breaking. This fence might not be an ideal choice for Vermont due to the inclement weather and the involved tasks of repairing the fence after accidents. Operations staff have stated that the repair process is quite extensive. (4)

INTRODUCTION

This report summarizes the implementation and observations with regard to an experimental highway safety feature known as “Brifen Wire Rope Safety Fence,” a four strand woven wire rope intended to prevent vehicles from veering off a road. This experimental feature is manufactured by Brifen USA Inc. and adheres to NCHRP 350 test level three. This designation implies that the product can withstand the impact of a vehicle traveling at 60 mph. The purpose of this investigation was to evaluate the woven rope system in comparison to a more widely used three wire rope cable barrier.

Features of the Brifen System include slender posts and cables that can be powder coated to provide an unobstructed view from passenger cars. The posts are typically not driven; rather, they are set into concrete sockets. The wire ropes are anchored into concrete blocks at either end of their lengths, and then the wire ropes are tensioned between anchors. The cables are interwoven between the posts to prevent spreading. This highway restraint system can continuously span for miles. The system provides for simple and quick repair after a collision event. See appendix A for the Brifen Wire detail sheet.

Three-strand cable barriers were first developed in the 1960’s and found to have several desirable characteristics as compared to other roadside barriers such as guard rail. The cable barriers were less rigid than beam guardrails and concrete barriers, which resulted in a reduced force exerted on impacting vehicles. These low tensioned systems can be used in both roadside and median applications and are designed to provide a low cost alternative. Comparatively, the four stand woven wire rope is marketed to provide enhanced levels of safety while providing “substantial reductions in installation, maintenance and repair costs. (1)

PROJECT LOCATION AND SUMMARY

The Brifen Wire Rope Safety Fence was installed on the shoulder of the northbound passing lane of I-89 from mile marker 56.545 to mile marker 56.860. Construction activities took place from May 30, 2006 to June 19, 2006. Installation of the Brifen Wire Safety Fence is shown in Figure 1.

For further installation details please see Vermont Agency of transportation Initial Report No. U2006-4.



Figure 1: Fence installation

MATERIAL DESCRIPTION

The general description of the Brifen safety fence provided by the manufacturer is as follows, “The fence consists of four tensioned galvanized steel wire ropes having a top rope height of 23 inches and a lower rope height of 19.3 inches supported by galvanized steel posts at nominally 8’-2” to 10’-6” centers. The two (or one for three-cable fences) upper ropes are located in a slot in the top of the posts and the two lower ropes are interwoven along the fence between each pair of posts. The ropes are joined and tensioned by means of rigging screws provided at intervals not exceeding 505ft. The ends of the ropes are attached to anchors embedded in the ground, or to surface mounted anchors. Where the length of the fence is greater than 4,544 ft., intermediate anchors are used. To provide continuity two ropes (i.e. one upper and one lower) of the four ropes are anchored at each intermediate anchor. The connection between each rope and its anchor is designed to uncouple when a vehicle impact occurs in the vicinity of the anchor. The movement of the released rope is restrained by a safety check rope.” Posts were spaced at 10’-6” on center for this installation. Please see Appendix A for an overall view of the fence. (8) The two end anchor terminals were held in place by 6’ x 6’ x 10’ reinforced concrete blocks.

During fabrication, each rope was pretensioned to insure a tight connection and to limit deflection upon impact. According to the manufacturer, the safety fence provides for low decelerations thus resulting in a softer impact with little associated injury. It has been shown to display deflections of 5' or less during a collision while the standard three-cable barrier system typically deploys a deflection of 10' or less. This is most likely due to the fact the three-cable barrier system is not pretensioned allowing for additional deflection. Please note that both barriers systems are NCHRP 350 test level three approved. (1)

PERFORMANCE AND OBSERVATIONS

During the initial post installation site visit conducted on June 21st, 2006, the fence appeared to be very highly tensioned and visibly stronger than the standard three rope safety fence which seemed to sag in the middle between posts (See Figures 2 and 3). The referenced three-cable barrier is located on the shoulder of the break down lane of I-89 northbound diagonally across from the Brifen test site and end at MM 56.53. It was also observed that all four wire ropes were secured at the end terminals. While the three-cable wire fence is hung on the front face of the post, the Brifen system weaves two wires around both sides of the posts as shown in Figure 2 and Figure 3.



Figure 2: Traditional Three-Rope Fence



Figure 3: Brifen Wire Rope Fence Showing Interwoven Wire Ropes

During an inspection on August 25, 2008, it was noted that eight of the posts were leaning, twisted, or bent. It appeared that an impact or some kind of torque and tension caused the force/damage to the posts. Some of the wires appeared to be not as tight as other sections on the fence. This might have been caused from the previously mentioned posts that are under torque and are twisting and bending from the force. These defects are illustrated in Figure 4, Figure 5 and Figure 6, which are all examples of posts in tension.



Figure 4



Figure 5



Figure 6

During an inspection on September 30, 2009, it was noted that the post caps and excluders did not appear to be very durable. Many of the caps were cracked, broken, or missing (Figure 7). Many of the excluders were broken. The damage was assumed to be caused by snowplow damage. Almost all excluders were allowing debris and water to build up inside the base (Figure 8). This is a cause of concern due to freeze/thaw and repairing the posts in the winter months. (2)



Figure 7: Cracked post cap



Figure 8: Debris and water build-up in and around the posts

Upon inspection of the Brifen Wire Rope Safety Fence on Monday, August 25, 2008, a considerable amount of erosion was noted. Erosion was evident along the bank of the northbound passing lane, and around the concrete anchors for fence posts, shown in Figure 9 and Figure 10. (4)



Figure 9: Erosion of the bank - median side



Figure 10: Erosion around the post foundation

Crash Data and Repair

Crash Data

Table 1 represents traffic accidents on State Highway and Federal Highway Systems, specifically I89 Northbound approximately between MM 56.545 and MM 56.86 from January 1, 2006 to December 31, 2010. (5)

COST ANALYSIS

The total bid price for this project was \$76,500.00. An amount of \$26,550 was allocated to Traffic officers, traffic control, message signs, aggregate, testing equipment, flaggers and mobilization/demobilization. The remaining \$40,750 was dedicated to the wire safety fence and the two end terminals. The cost of the system was \$25 per linear foot for 1,630 LF equaling \$40,750, plus 2 end terminals at \$4,600 each. (1)

The total cost of repairs is summarized in Table 2. As of September 29th, 2011 there has been 13 repairs totaling \$9,391.51. It is important to note that the extensive labor involved in repairing the fence as Operations have noted is evident in the breakdown of the repair costs. The labor in many instances shown below is more expensive than equipment and material. It should be noted that repair costs in winter months (October to March) were equivalent to repairs during summer months (April-September). Winter repairs totaled \$4,388.14 where summer repairs totaled \$5,003.37.

Table 1 Traffic Accidents on State Highway and Federal Highway Systems

Date	Time	Mile Marker	Weather	Contributing Circumstances	Direction of Collision	Number of Injuries	Number of fatalities
1/18/2006	22:45	56.47	Snow	Driving too fast for conditions, failure to keep in proper lane	Single Vehicle Crash	4	0
6/24/2006	14:15	56.47	Clear	Failure to keep in proper lane	Single Vehicle Crash	0	0
3/8/2007	7:19	56.56	Cloudy	Driving too fast for conditions	Single Vehicle Crash	0	0
1/5/2008	21:49	56.61	Snow	Driving too fast for conditions	Head on	0	0
1/18/2008	10:11	56.65	Clear	Driving too fast for conditions	Single Vehicle Crash	0	0
8/6/2007	13:17	56.76	Cloudy	Driving too fast for conditions, failure to keep in proper lane	Single Vehicle Crash	0	0
1/23/2006	12:43	56.8	Snow	Driving too fast for conditions	Single Vehicle Crash	1	0
3/6/2008	19:35	56.8	Clear	Fatigue, asleep, failure to keep in proper lane	Single Vehicle Crash	0	0
10/30/2009	19:40	56.8	Rain	Driving too fast for conditions	Single Vehicle Crash	0	0
2/20/2009	23:50	56.85	Snow	Driving too fast for conditions, failure to keep in proper lane	Single Vehicle Crash	0	0

Table 2 Total Cost of Repairs

Season	Repair #	Repair Date	Cost				Location	Comments
			Labor	Equipment	Material	Total		
Winter	1	1/23/2007	\$317.04	\$187.70	\$64.80	\$569.54	56.55	3 posts and caps
	2	2/13/2007	\$437.54	\$116.23	\$145.20	\$698.97	56.7	6 posts
	5	12/26/2007	\$638.57	\$294.44	\$234.90	\$1,167.91	56.75	N/A
	6	3/17/2008	\$262.74	\$143.30	\$75.60	\$481.64	56.85	2 posts and 20 caps
	8	2/26/2009	\$465.79	\$319.20	\$99.00	\$883.99	56.85	5 posts
	9	11/5/2009	\$272.66	\$144.23	\$169.20	\$586.09	56.4	8 posts
	Total			\$2,394.34	\$1,205.10	\$788.70	\$4,388.14	
Summer	3	4/10/2007	\$306.55	\$369.72	\$175.05	\$851.32	56.7	7 posts
	4	8/7/2007	\$306.22	\$90.20	\$377.40	\$773.82	56.65	16 posts
	7	5/1/2008	\$297.72	\$73.85	\$157.09	\$528.66	56.5	1 post and 2 panels
	10	8/13/2010	\$149.94	\$82.68	\$217.80	\$450.42	56.7	11 posts
	11	8/13/2010	\$149.94	\$150.36	\$138.60	\$438.90	56.85	7 posts
	12	7/25/2011	\$523.78	\$343.08	\$126.00	\$992.86	56.6	N/A
	13	9/29/2011	\$365.39	\$308.00	\$294.00	\$967.39	56.75	7 posts
	Total			\$2,099.54	\$1,417.89	\$1,485.94	\$5,003.37	
Total			\$4,493.88	\$2,622.99	\$2,274.64	\$9,391.51		49 posts + caps

SUMMARY AND RECOMMENDATIONS

The Brifen system required an increased level of effort during initial installation when compared with a standard three-cable wire rope fence. The resulting system appeared to be stronger, with less deflection in the cable along its entire length. The initial installation encountered no difficulties, as observed by Construction, Operations or Research staff.

Through site observations it appears that the safety fence is faring considerably well, however the posts under torque is causing concern of how well the fence will continue to work when vehicles make contact with it. The excluder caps, post caps, and locator pegs should be replaced with a more durable material due to excessive cracking and breaking. This fence might not be an ideal choice for Vermont due to the inclement weather and the involved tasks of repairing the fence after accidents. Operations have stated that the repair process is quite extensive, especially in winter months. (4) Shown in Table 2 above, although half as many posts needed replacement over the course of the evaluation the labor costs in the winter months were far more expensive due to the increased effort of extracting the damaged post and replacing and setting the new posts, and tensioning the fence due to cold, inclement temperatures. Labor costs during the winter months, totaled \$2394.34 and during the summer months, totaled \$2099.54. It was reported that 24 posts were replaced during winter months at \$99.76 per post. The cost per post during the summer months was \$42.85. The post replacement costs in the summer months proved less than half of what post replacement costs were during wintertime.

IMPLEMENTATION STRATEGY

Due to the concerns of the Operation's staff, it is recommended that this fence be used only in certain circumstances including using within limited deflection zones or where conventional steel beam guardrail systems would be deemed inappropriate.

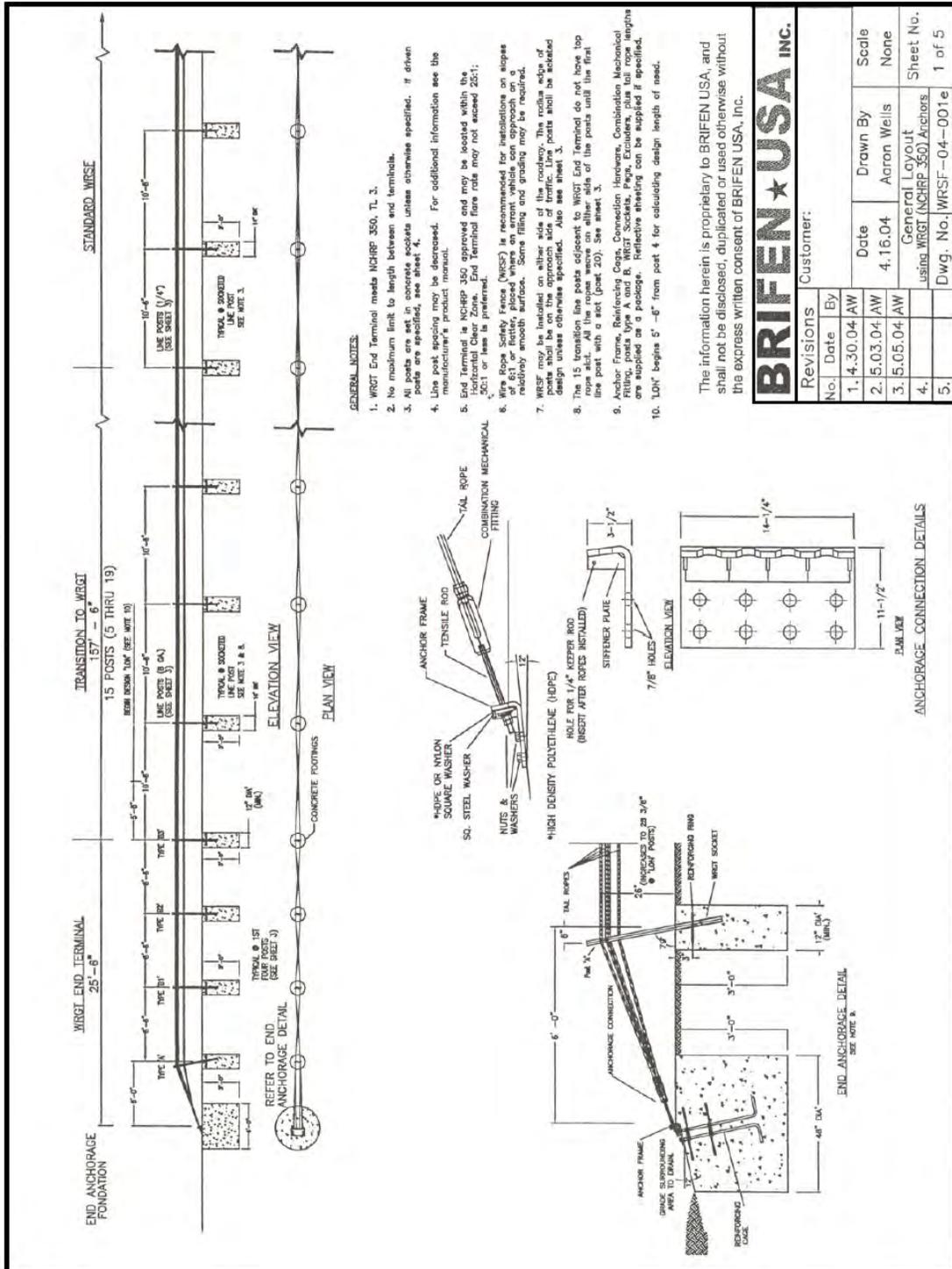
REFERENCES

1. Patterson, Kat. *Brifen Wire Rope Safety Fence, Initial Report U2006-4*. Vermont Agency of Transportation. 8-22-2006
2. Kipp, Wendy. *Site Visit Report*. Vermont Agency of Transportation Materials and Research Section. 9-30-2009
3. Patterson, Kat. *Brifen Wire rope Safety Fence, Work Plan No. WP 2005-R-11*. State of Vermont Agency of Transportation Materials and Research Section. 5-4-2005.
4. Kipp, Wendy. *Site Visit Report*. Vermont Agency of Transportation Materials and Research Section. 8-25-2008.
5. Vermont Agency of Transportation Traffic Safety.

<http://www.aot.state.vt.us/planning/Documents/HighResearch/Publications/pub.htm> 1/10/12
6. Fitch, Jennifer. *Site Visit Report*. Vermont Agency of Transportation Materials and Research Section. 1-23-2007
7. Brifen USA Inc. *Brifen USA Inc. Wire Rope Safety Fence*. Pg. 21.
<http://www.Brifenua.com/> 1-11-12
8. Brifen USA Inc. *Brifen Wire Rope Safety Fence TL-3 (4-Rope) WRSF (With WRGT End Anchor) Product Manual*. Attachment 5. Drawing No. WRSF-06-201a. 7-12-2007

APPENDIX A

Brifen Wire Rope Safety Fence Details.



The information herein is proprietary to BRIFEN USA, and shall not be disclosed, duplicated or used otherwise without the express written consent of BRIFEN USA, Inc.

BRIFEN USA INC.		Customer:	
		No.	By
1.	4.30.04 AW	Date	4.16.04
2.	5.03.04 AW	Drawn By	Aaron Wells
3.	5.05.04 AW	Scale	None
4.		General Layout	Sheet No.
5.		Using WRSF (NCHRP 350) Anchors	1 of 5
		Dwg. No.	WRSF-04-001e

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH SECTION

CATEGORY II WORK PLAN FOR
Brifen Wire Rope Safety Fence
Work Plan No. WP 2005-R-11

OBJECTIVE OF STUDY: This study will evaluate the effectiveness of a proprietary four steel-rope cable barrier system in preventing crossover crashes, impacts, decelerations and maintenance repair. This evaluation is being done at the request of the Traffic Operation Engineer.

LOCATION: The product will be installed as a cable guard rail along the median of Interstate 89 NB in Middlesex, VT. The length of the experimental feature will begin approximately at MM 56.55 and end at MM 56.86 for a total length of 0.31 miles.

MATERIAL: Brifen Wire Rope Safety Fence, which is a 4 rope cable barrier system. This barrier system was tested to standards developed through the NCHRP 350 testing program and meets the criteria of test level 3 (successful crash test at 62.5 MPH). The product also meets criteria set forth in AASHTO M 268-00 for Type Four adhesive reflective sheeting which is applied to the posts, as well as AASHTO M30-92 for galvanized wire rope.

COST: The cost of the Brifen Wire Safety Fence is \$13.50/lf to \$17.00/lf for the length of the needed barrier. For this project the cost of the fence itself may range from \$21,400 to \$27,000. In addition, each end anchor system will cost \$1,270. The cost for installation will be borne as a Statewide Guardrail Improvement project number STP GARD(1).

SURVEILLANCE AND TESTING: Research personnel will monitor the installation of the materials and visually inspect them each spring and fall for the duration of the study. Research personnel will also be present for maintenance activities involving the materials to evaluate the ease and cost of those activities. The surveillance shall include the following:

- 1) Effectiveness in preventing crossover crashes
- 2) Deflection characteristics and rollover incidence
- 3) Ease of installation
- 4) Ease of repair.
- 5) Frequency and character of needed repairs

6) Cost evaluation

The initial data will be collected at the end of the construction, through interviews and record reviews. Semi-annual data will be collected through Operations Division records (MATS) and interviews with district personnel. Crash reports will be reviewed for summary of activity. If possible, an incident description detailing damage, deflection and rebound will be prepared prior to repair.

DURATION OF THE STUDY: The duration of this study will be no more than three years or until final conclusions can be drawn from the observation.

REPORTS: An initial report will be prepared to include the installation of the materials, with subsequent reports on an annual basis. A final report will be published after the three year duration, and any additional interim reports will be published as warranted.

Agency of Transportation Reviewed By:
Materials and Research Section

Donald H. Lathrop, P.E.
Materials & Research Engineer
Date:

Approved by Material and Research (DHL)
Approved by Federal Highway Administration (CPJ)