2007 APPLICATION FORM

(required for each entry)

Job No. J8I0796 & J8I0797 **Route** I-44 **County** Greene,Webster,Laclede

STIP Description (Scoping or **Construction**, state which STIP) 05-09☐ 06-10☒ 07-11☐

Guard cable and guardrail end section upgrades from Route 360 to Route 5 in Lebanon

Project Manager (could have both)

MoDOT Don Saiko **Consultant** _____

Active core team members as approved by the MoDOT PM (may include consultants)

Larry Colson - D8 Design	_____	_____
Mark Adams – D8 Design	_____	_____
Jason Shafer – D8 Design	_____	_____
John Sanders – D8 Construction	_____	_____

Project Contacts (will have both for consultant entry)

District 8 **Consultant** $_____

STIP budget $7,194,000 (contract estimate) or **Award cost** $5,925,059.20

Value Engineering study during design? yes☐ no☒ (if yes) **Project Stage** _____

VE Contact person _____

Construction-stage VE (VECP)? yes☒ no☐ (if yes) **Explain**

Another guard cable supplier received approval to allow their system to be installed on slopes steeper than 6:1 and offered a lower price. This happened just after the project was awarded.

Total VECP savings $608,500 ($304,250 MoDOT) **VECP Contact Person** John Sanders/Don Saiko

Why is this entry the "poster" image for MoDOT's practical design philosophy?

(In layman's terms – 100 words or fewer – attach additional sheet if necessary) _____

The I-44 median guard cable installation project encompasses everything MoDOT seeks in practical design – quality, safety, and cost savings while providing an effective solution to a specific need. The design involves installing high-tension cable using existing 4:1 median slopes, eliminating additional fill in the median to flatten out slopes. This system provides greater "stopping" power than a generic low-tension system while reducing rutting repairs. The high-tension, socketed system allows MoDOT maintenance crews to repair damage quicker and cheaper than on-call contractors. Other state DOT's have taken notice and are reconfiguring guard cable projects to include the high-tension, steeper slope system.

Send entries to: MoDOT Design Division, ATTN: Jay Bestgen
1320 Creek Trail Dr.
Jefferson City, Missouri 65109

All entries must be received no later than close of business on February 1, 2007

High-Tension Guard Cable Using Practical Design

The guard cable installed in 2006 along I-44 in Greene, Webster and Laclede counties in District 8 uses a high-tension system designed for steeper slopes unlike the low-tension system typically used. While this system may be more expensive initially, in the long run, it is expected to reduce repair costs and repair turn-a-round time by having maintenance complete the necessary repairs. This project is the result of a practical design approach and is being submitted for consideration for the 2007 Awards for Excellence.

In mid-2004, I was assigned to the I-44 median guard cable project (which also included upgrading guardrail to meet length of need). Early on, I noticed that the traditional design called for guard cable to be installed on a 6:1 or flatter slope. However, I wanted to know why guard cable couldn't be installed on steeper slopes that are considered "recoverable". I was told guard cable had been crash-tested only on flat slopes and that 6:1 was considered a flat slope.

Re-thinking the standards. Many areas of I-44 had been overlaid through the years and the original median slopes were reconstructed to 4:1 slopes to match the existing ditch elevations due to the increased pavement thickness. Reconstructing the 4:1 slopes to 6:1 slopes to add guard cable did not make sense for many reasons.

1. The *AASHTO Roadside Design Guide* states 4:1 slopes are considered "recoverable." This means once a vehicle leaves the pavement, the driver should be able to recover and regain control of the vehicle. Given that, it seemed a vehicle would be able to hit guard cable on this slope and still be re-directed to a safe stop.

2. Increasing the ditch elevation by adding fill material in the median would keep the existing pavement base from draining water because the ditch would be constructed higher than the bottom of the pavement base. This would cause future pavement failures because water would be trapped in the pavement base and any existing pavement edge drains would become non-functional. It is difficult to determine when the pavement might start failing but eventually this would happen and would be expensive to repair.

3. Adding fill to the median would cover the hard existing ground and leave the top material soft, leading to increased erosion. Vehicles driving off into the median would more easily tear up the new, hard-to-compact fill. (See Photos 1 and 2.) This in turn would cause additional work -- and expense -- for maintenance forces to repair the rutting slopes.

4. Adding extra fill in the median would cover existing drop inlets. To avoid this, the drop inlets would have to be reconstructed to meet the new ditch elevations, adding additional expense to the project. Filling in the median would also create some new low points, causing water to pond in the median.

5. Steeper slopes with a deeper ditch would give vehicles a better opportunity to slow down before entering the opposing lanes, reducing accident severity. Vehicles on flatter slopes that penetrate the guard cable would be entering the opposing lanes at a higher speed with the potential for more serious or fatal accidents.

I introduced the concept of using 4:1 slopes -- and the reasons behind it -- during an October 2005 core team meeting. The team agreed I should pursue it. I submitted a design exception letter in February 2006, but Central Office was unable to approve it since the design had not been formally crash-tested and approved by FHWA.

Crash testing and FHWA Approval. In March 2006, at the annual TEAM Conference, I asked guard cable supplier Gibraltar to consider testing its product on 4:1 slopes. Company representatives said they had not been asked about this before and that it would be expensive to test. Yet the idea would be presented to the company president.

In April 2006, Central Office called to say that Brifen USA, another supplier of guard cable, had tested its guard cable system on 4:1 slopes and received FHWA approval to use its system on steeper slopes. I immediately asked to change our plans to use 4:1 slopes because I felt filling in the median to flatten the slopes carried too many negatives. With the bid letting less than a month away, I had the design team change the design plans to include using the existing 4:1 slopes.

After the project was awarded using the Brifen system, Gibraltar crash-tested its system on 4:1 slopes. The FHWA approved their system for use and the contractor submitted a construction-stage value engineering study to use the newly approved system because it was easier to install and less expensive. MoDOT agreed to use the Gibraltar system because it would save the department $304,250.

New approach benefits drivers, saves money. The design has benefited the traveling public from the beginning. Construction time was shortened dramatically by not having to adjust drop inlets and by not adding fill material to the median. Using the socketed system has allowed District 8 to use its own maintenance forces to make repairs. These repairs require less equipment and are completed quicker, thus returning the protective cable to service with much less delay than using an on-call contractor.

This project provided a design that had never been used. Traditionally, we would have filled in the median with earthwork and reconstructed the drop inlets to meet the new elevation of the ditch. Then we would have installed the low-tension guard cable system in the center of the median ditch.

The high-tension system that we used allowed us to keep from filling in the median. It was installed away from the center of the median ditch in drier, more stable soil. Having the guard cable installed on the slope meant fiber optic cable did not have to be relocated, which in turn saved additional money.

The cost of installing high-tension guard cable may be more expensive initially, but it will break even in less than four years due to lower maintenance costs and with increased competition, prices should become more competitive. (See handouts for initial construction cost and comparison between District 8 maintenance and on-call repair contractors.)

Safety wins out in Missouri. Other states show interest. MoDOT recently completed an in-house study by Organizational Results entitled *Median Guard Cable Performance in Relation to Median Slope*. This study of I-44 found that guard cable has been more effective in preventing crossovers in areas where guard cable was installed on steeper slopes than in areas with flatter slopes. (See additional handout.) This supports my argument that when guard cable is placed on flatter slopes, vehicles tend to hit the cable at greater speeds, increasing the chance of passing through the cable. When steeper slopes are used with a deeper median ditch, some of the vehicle's energy is dissipated before hitting the cable.

Using guard cable on existing median slopes of up to 4:1 has had an impact not only in Missouri but also in other states. State DOTs elsewhere have called me to inquire about using 4:1 slopes on their guard cable projects. Some have pulled existing guard cable contracts from their lettings to pursue using existing steeper slopes.

It is difficult to put a dollar figure on future cost savings but allowing guard cable to be placed on 4:1 slopes will save money not only on MoDOT projects but on projects nationwide. More state DOTs are now looking into this design. With more companies getting approval for this design and competition increasing, projects will be cheaper. The installation work will be completed faster and repair to damaged sections will be done quicker. This means fewer disruptions to the traveling public and greater safety.

Don Saiko
Project Manager
District 8 - Springfield

Photo 1. Low-tension guard cable with median filled in with earthwork to obtain flatter slopes. This shows how easily the soft median is disturbed after an accident and how water ponds. Low-tension cables also begin to sag after being hit.

Photo 2. Limited damage was done to the well established, undisturbed median slopes using the Gibraltar high-tension guard cable system even after a tractor-trailer entered the median.

Photo 3. Using high-tension guard cable approved for steeper slopes up to 4:1 allows the existing median to be used without adding additional earthwork to flatten slopes.

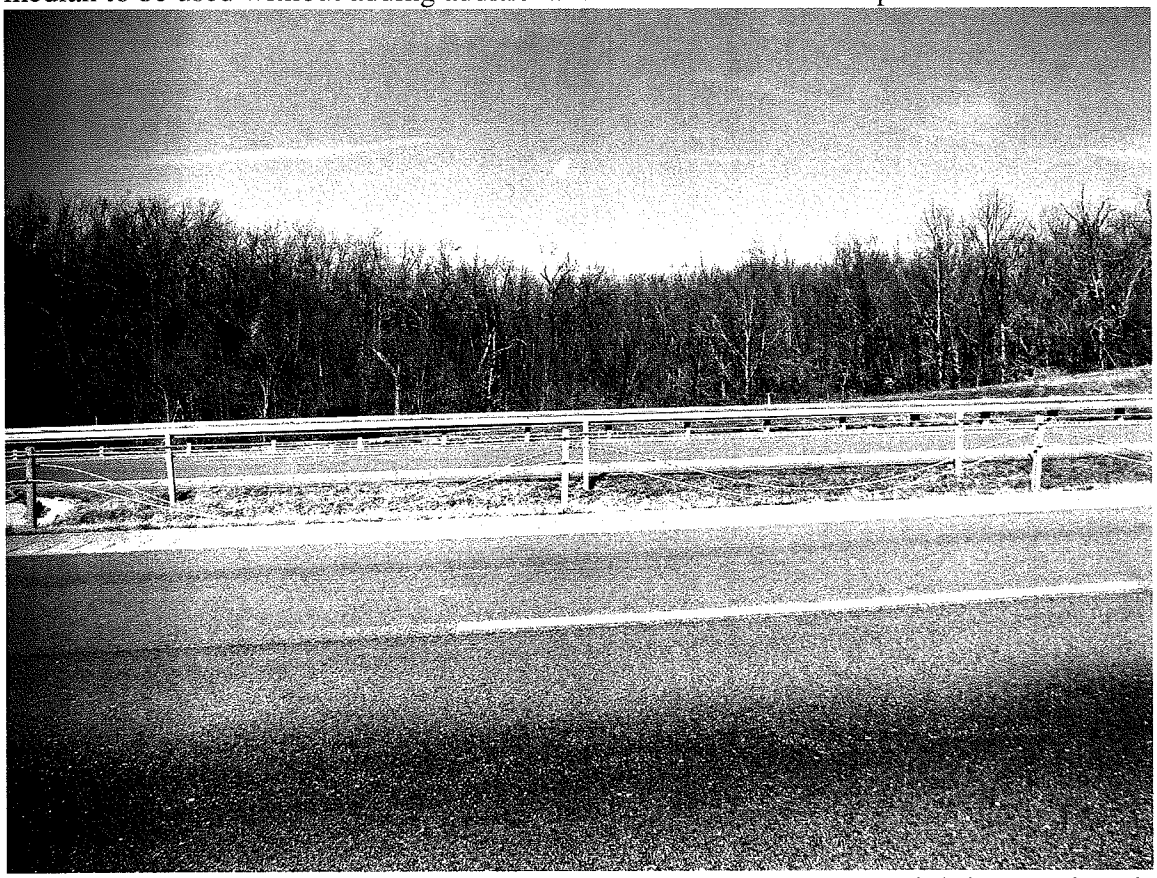

Photo 4. Low-tension cable becomes loose and sags after being hit until it is retensioned. High-tension cable in most cases remains taut after being hit, making it more effective.

On-Call Repair Cost vs. District 8 Maintenance Repair of Guard Cable

Note: The typical accident damages approximately 5 posts. These calculations were done based on a 5-post accident.

Low-tension cost to repair guard cable done by on-call contractor (based on current prices):

Pay Item Description	Quantity used	Unit Price	Total
Remove/replace line post	5	$ 75	$ 375
Reattach cable to post	5	$ 23	$ 115
Retension guard cable	1	$ 175	$ 175
Traffic Control	1	$ 350	$ 350
		Total:	$ 1,015

High-tension cost to repair guard cable by district 8 maintenance:

Pay Item Description	Quantity used	Unit Price	Total
Remove/replace line post	5	$ 55	$ 275
Labor including benefits	2 workers for 1.5 hrs.	$ 35	$ 105
Mileage for 50 miles	50 mile trip	$ 0.50/mile	$ 25
Traffic Control	0	Part of MoDOT stock	$ 0
Misc. Cost (20% of cost)	0.20	$ 405	$ 81
		Total:	$ 486

District 8 has had approximately 30 hits to the guard cable per month or 360 hits per year. Based on this, District 8 is saving $190,440 each year repairing the guard cable internally. Over a 10-year period, District 8 will save $1,904,400 that can be used on other projects.

Initial Cost Comparison Between Low-Tension and High-Tension Guard Cable

The following estimate numbers are based on how the project was bid and not on the final totals.

District 7 (Job No. J7I0791) – 65 miles

Item Description	Total Price
Median cable	$ 2,336,045
Anchors	$ 33,860
Embankment in Place	$ 651,943
Adjusting Drop Inlets	$ 207,215
Erosion Control for Median Work	$ 435,523
Geotextile and Aggregate for mowing strip	$ 1,435,813 *
Total:	$ 3,664,586 or $56,378 per mile
Total with mowing strip:	$ 5,100,399 or $78,468 per mile

District 8 (Job Nos. J8I0796 and J8I0797) – 55 miles

Item Description	Total Price
Median cable	$ 4,735,335
Anchors	$ 233,700
Embankment in Place	$ 0
Adjusting Drop Inlets	$ 0
Erosion Control for Median Work	$ 0
Value Engineering Savings (Brifen 4-cable to Gibraltar 3-cable)	$ 608,500 **
Total:	$ 4,360,535 or $79,282 per mile

** This is the total value engineering savings (MoDOT plus Contractor)

District 9 (Job No. J8I0560) – 50 miles

Item Description	Total Price
Median cable	$ 1,610,400
Anchors	$ 45,100
Total:	$ 1,655,500 or $33,110 per mile ***

*** District 9 did not check for steep slopes prior to the bid letting and had major overruns because they had to run guard cable on either both sides or fill in the median to flatten slopes. Because of this, I doubled the price per mile ($66,220), which is probably a conservative estimate.

Information From MoDOT In-House Study on Guard Cable

The following information was taken from an in-house study conducted by Organizational Results entitled *Median Guard Cable Performance in Relation to Median Slope.* Based on the findings of this study, it was recommended that design standards could be revised allow installation on steeper slopes without re-grading the slopes to a 6:1 slope.

2-2. Guard Cable Performance in Relationship to Median Slopes

Among the 225 guard cable crashes, 103 of them happened on median slopes steeper than 6:1 (H:V < 6:1), and 7 of them were failures. This results in success rate of 93.2% for the median guard cable on slopes steeper than 6:1. The other 122 crashes happened on median slope equal to or flatter than 6:1 (H:V >= 6:1), and 10 were failures. This results in a success rate of 91.8% for the median guard cable on slopes equal or flatter than 6:1. See Table 3 below.

Table 3. Median Slope vs. Performance

Slope	Total Count of Crashes	Count of Fail	Fail rate	Count of Success	Success Rate
< 6 (Steeper)	103	7	6.8 %	96	93.2 %
>= 6 (Flatter)	122	10	8.2 %	112	91.8 %
Total	225	17	n/a	208	N/a

The median slopes are further categorized into smaller groups, instead of 6:1 being the only dividing line. The guard cable performance is summarized in the table below.

Table 4. Slope vs. Performance or Success

Slope	Total Count of Crashes	Count of Failure	Fail rate (%)	Count of Success	Success Rate (%)
S < 3 (Steeper)	1	0	0	1	100
4 > S >= 3	15	0	0	15	100
5 > S >= 4	30	3	10	27	90
6 > S >= 5	57	4	7	53	93
7 > S >= 6	57	5	8.8	52	91.2
8 > S >= 7	29	0	0	29	100
9 > S >= 8	22	1	5	21	95
10 > S >= 9	6	3	50	3	50
10 > s (Flatter)	8	1	12.5	7	87.5
Total	225	17	7.6	208	92.4