Cable Barrier Implementation

2013 Design Training Expo

DRIVING DOWN FATALITIES

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

Cable Barrier Implementation

Course Outline:

Part 1 – Research Results

Part 2 - Current Guidance

Part 3 – Future Guidelines

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Part 1
Cable Barrier Research Results

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In-Service Performance Evaluation of Median Cable Barrier

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Florida International University

Presented by:
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Florida Department of Transportation

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Project Objectives

***Volume II*:**

- Perform an In-Service Performance Evaluation (ISPE) of Median Cable Barrier systems installed on limited access facilities in Florida.

VOLUME II: *Median Cable Barrier*

Data Collection

- 23 locations (***101 miles***) Limited Access Facilities with Cable Median Barriers
- From 2003-2010, ***8,818*** Crashes Occurred
- Barrier-related crash data evaluations include:
  - ✓***By Crash Severity*** and ***By Vehicle Type***
  - ✓Whether the vehicle crossed over the barrier or not (***barrier-crossover crash***)
  - ✓Whether the vehicle crossed over the median and went into the opposite travel lane or not (***median crossover crash***)
  - ✓Type of crossover: *under-ride, over-ride, or penetration*

Barrier Crossover Crashes by Individual Roadways

Roadway	Total Roadway Length (miles)	Barrier Crossover Crashes	Barrier Non-Crossover Crashes	Total Crashes	Percent of Barrier Non-Crossover Crashes
I-75	55.8	13	65	78	**83.3%**
I-4	27.0	62	274	336	**81.5%**
SR 528	11.0	8	45	53	**84.9%**
SR 821	6.1	6	73	79	92.4%
SR 417	0.5				
SR 429	0.7				
Total	**101.0**				

Study Data Trend Correlation:
Average in **%** of Barrier Non-Crossovers
By Individual Roadways =
Comparable to an Average of **83.6%**

Barrier Crossover Crash Statistics by Vehicle Type

Vehicle Type	Barrier Crossover Crashes	Barrier Non-Crossover Crashes	Total Crashes	Percent of Barrier Non-Crossover Crashes
Car	54	315	369	**85.4%**
Light Truck	31	123	154	**79.9%**
Medium Truck	1	1	2	50.0%
Heavy Truck	4	8	12	66.7%
Motorcycle	0	2	2	100.0%
Unknown				
Other				
Total				

Study Data Trend Correlation:

Difference in **%** of Barrier Non-Crossovers

By Vehicle Types

Cars Performed Better than Pickups by **5.6%**

Median Crossover Crash Statistics by Vehicle Type

Vehicle Type	Median Crossover Crashes	Median Non-Crossover Crashes	Total Crashes	Percent of Median Non-Crossover Crashes
Car	7	362	369	**98.1%**
Light Truck	7	147	154	**95.5%**
Medium Truck	0	2	2	100.0%
Heavy Truck	0	12	12	100.0%
Motorcycle	0	2	2	100.0%
Unknown				
Other				
Total				

Study Data Trend Correlation:

Difference in **%** of Median Non-Crossovers

By Vehicle Type For

Cars versus Pickups = 2**.6%**

Barrier Crossover Crash Statistics by Severity

Crash Severity	Barrier Crossover Crashes		Barrier Non-Crossover Crashes	
	Barrier Crossover Crashes (a)	Percent of Barrier Crossover Crashes (a)/90	Barrier Non-Crossover Crashes (b)	Percent of Barrier Non-Crossover Crashes (b)/459
Fatal (K)	3	**3.3%**	5	**1.1%**
Incapacitating (A)	9	**10.0%**	15	**3.3%**
Non-Incapacitating (B)	19	21.1%	36	7.8%
Possible (C)				
PDO (O)				
Unknown				
Total				

Study Data Trend Correlation:

Fatal (K) and Incapacitating (A) for Barrier Crossover to Non-Crossover = **1:3**

Median Crossover Crash Statistics by Severity

Crash Severity	Total Median Crossover Crashes (a)	Percent of Total Median Crossover Crashes (a)/14
Fatal (K)	1	**7.1%**
Incapacitating (A)	1	**7.1%**
Non-Incapacitating (B)	4	28.6%
Possible (C)	3	21.4%
PDO (O)		
Unknow		
Total		

Study Data Trend Correlation:

Fatal (K) and Incapacitating (A) for Total Median Crossovers = Comparable to other State DOT Studies @ 7%

Key Findings

- The ***23*** study locations experienced ***549*** cable barrier-related crashes.
- The overall effective rate of installing cable median barrier to prevent barrier crossover crashes was high at ***83.6%***.
- Only 14 crashes (i.e., ***2.6%***) resulted in vehicles traversing into the opposite travel lane.

Before-and-After Analysis

Data Preparation

- Only the locations with sufficient before and after analysis periods and those longer than ***3 miles*** were included in the analysis.
- Three relatively long segments (a total of about ***36 miles***) were analyzed.
- Analysis was based on ***median-related crashes***. A crash where an errant vehicle leaves the designated travel lane to the left (i.e., toward the median) at any point during the crash is classified as a median-related crash.

Changes in Crash Rates of Median Crossover Crashes

Road Name	Segment Length (mi)	Before Crash Rate	After Crash Rate	Percent Change in Crash Rate
SR 528	11.0	4.12	0.60	-85.0%
SR 821	6.1	2.23	0.25	-88.8%
I-4	18.9	1.28	0.39	-69.5%
Overall Median Crossover Crash Rate				

Study Data Trend Correlation:
Overall Average Reduction in Crash Rate
By Individual Roadways =
Comparable @ **78.8%**

Changes in Crash Rate by Vehicle Type

Vehicle Type	Before		After		Percent Change in (K+A) Crash Rate
	(K+A) Crash Number	(K+A) Crash Rate	(K+A) Crash Number	(K+A) Crash Rate	
Car	26	1.29	28	1.15	**-10.8%**
Light Truck	9	0.45	7	0.29	**-35.6%**
Medium Truck	1	0.05	0	0.00	-100.0%
Heavy Truck	1	[illegible]	1	[illegible]	[illegible]
Motorcycle	6				
Others	1				
Total	**44**				

Study Data Trend Correlation:

Reduction in Crash Rate (K+A) for

Cars versus Pickups = **1:3**

Changes in Crash Rate by Severity

Crash Severity	Before		After		Percent Change in Crash Rate
	Crash Number	Crash Rate	Crash Number	Crash Rate	
Fatal (K)	13	0.64	9	0.37	**-42.2%**
Incapacitating (A)	31	1.54	30	1.23	**-20.1%**
Non-Incapacitating (B)	59	2.93	63	2.59	-11.6%
Possible (C)	55	2.73	102	4.18	53.1%
PDO (O)	114	5.65	259	10.63	88.1%
Unknown					
Total					

Study Data Trend Correlation:

Reduction in Crash Rate By Severity for

Fatal (K) to Incapacitating (A) = **2:1**

Key Findings

- After the installations of Cable Median Barrier,
  - ✓ Overall Median-related Crash Rate increased (↑) by ***37.8***%
  - ✓ Overall Median Crossover Crash Rate decreased (↓) by ***78.8***%
- The installations of Median Cable Barrier resulted in ***88.1***% increase (↑) in ***PDO*** and ***53.1***% increase (↑) in ***Possible Injury*** crashes.
- ***This is expected as more vehicles hit median cable barrier due to reduction in the effective clear-recovery width in the median.***
- The overall Total Fatal and Severe injury (***K+A***) Crash Rate was Reduced by ***26.6***%**.**

Performance Comparisons of Cable Median Barrier vs. W-beam Guardrail

Barrier Crossover Crash Statistics by Vehicle Type

Study Data Trend Correlation:
In Preventing Barrier Non-Crossovers
The Differences for Guardrail and Cable =
Comparable @ **6.5% and 5.5%** Respectively

Study Data Trend Correlation:
In Preventing Non-Crossover Crashes the
Performance of Guardrail (Semi-Rigid) over
Cable (Flexible) = Anticipated @ **11.9%**

				le Median Barrier Crashes		
				l e an er over hes	Total Cable Median Barrier Crashes	Percent of Cable Median Barrier Non-Crossover Crashes
Car	92	4				
Light Truck	118	1				
Medium Truck	15					
Heavy Truck	30					
Motorcycle	2					
Other	5					
Unknown	1	38	97.4%	0	5	100.0%
Total	**263**	**5808**	**95.5%**	**90**	**549**	**83.6%**

Median Crossover Crash Statistics by Vehicle Type

Study Data Trend Correlation:
In Preventing Median Non-Crossover Crashes
The Differences for Guardrail and Cable =
Comparable @ **2.0% and 2.6%** Respectively

Study Data Trend Correlation:
In Preventing Median Non-Crossover Crashes
Performance of Guardrail (Semi-Rigid) over
Cable (Flexible) = Comparable @ **Δ = 1.2%**

				ble Median Barrier Crashes		
				tal lian sover shes	Total Median Crashes	Percent of Median Non-Crossover Crashes
Car	23					
Light Truck	35					
Medium Truck	4					
Heavy Truck	16					
Motorcycle	1					
Other	3					
Unknown	1	38	97.4%	0	5	100.0%
Total	**83**	**5808**	**98.6%**	**14**	**549**	**97.4%**

Barrier Crossover Crash Statistics by Severity

Study Data Trend Correlation:
In Preventing Barrier Crossover Crashes
The Ratios for Guardrail and Cable =
Comparable @ **1:3**

			ble Median Barrier Crashes	
	Crashes (a)	(a)/263	al Cable edian arrier ossover Crashes (b)	Percent of Cable Median Barrier Crossover Crashes (b)/90
Fatal (K)	20	**7.6%**	3	**3.3%**
Incapacitating (A)	55	**20.9%**	9	**10.0%**
Non-Incapacitating (B)	87	33.1%	19	21.1%
Possible (C)				
PDO (O)				
Unknown				
Total				

Study Data Trend Correlation:
The Ratio of Guardrail to Cable Barrier
For Fatal (K) and Incapacitating (A) = **2:1**
Comparable @ more than Double the
Installations of Guardrail to Cable Barrier

Median Crossover Crash Statistics by Severity

Study Data Trend Correlation:
In Preventing Median Crossover Crashes
The Ratio of **K** to **A** for Guardrail = **1:3**
and the Ratio of **K** to **A** for Cable = **1:1**
In this Case, Cable Outperforms Guardrail

			ble Median Barrier Crashes	
	(a)	(a)/83	l Median ossover ashes (b)	Percent of Median Crossover Crashes (b)/14
Fatal (K)	7	**8.4%**	1	**7.1%**
Incapacitating (A)	19	**22.9%**	1	**7.1%**
Non-Incapacitating (B)	30	36.1%	4	28.6%
Possible (C)	13	15.7%	3	21.4%
PDO (O)	14	16.9%	4	28.6%
Unknown	0	0.0%	1	7.1%
Total	**83**	**100.0%**	**14**	**100.0%**

Key Findings

Performance of Cable Median Barrier versus Guardrail:

- Due to its Elastomeric Properties, Cable Barrier May Allow Fewer Barrier Non-Crossover Crashes by Vehicle Type versus Guardrail
- As Installation Criteria Evolves, Cable Barrier is Anticipated to Equal Guardrail in Preventing Median Non-Crossover Crashes by Vehicle Type

Key Findings

Performance of Cable Median Barrier versus Guardrail:

- As Cable Median Barrier Installations Approach those of Existing Guardrail Installations;
  - ✓ Percentages of Barrier Crossover Crashes by Severity Type are Anticipated to Approach Existing Guardrail Installations
  - ✓ Percentages of Median Crossover Crashes by Severity Type May;
    - Approach Existing Guardrail for Fatal (K) Crashes
    - Remain Below Existing Guardrail for Incapacitating (A) Crashes

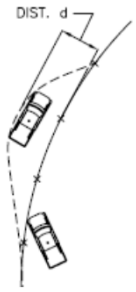
Part 2
Cable Barrier
Current Guidance

Cable Barrier – FDOT

Florida Department of Transportation

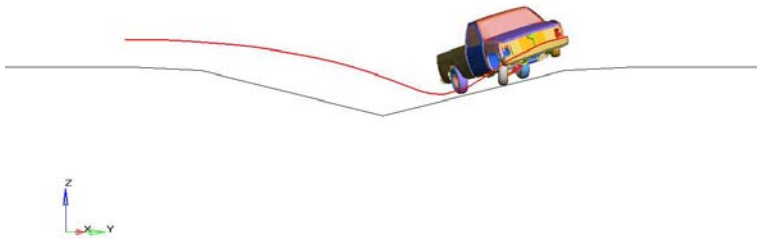
Uses

High Tension "Weak-Post" Pre-Stretched Cable Barrier Systems



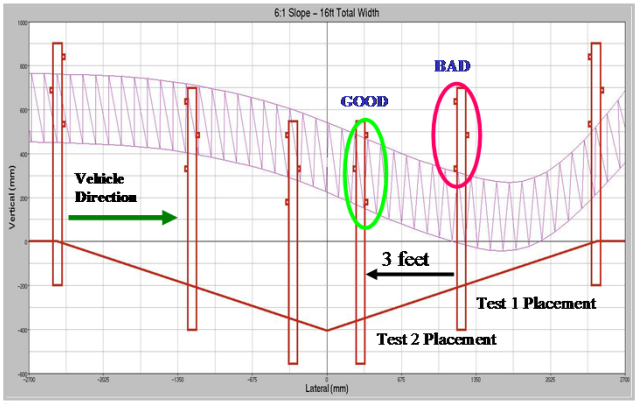
Cable Barrier – Exclusion Zones

Determining Exclusion Zones
For
Lateral Cable Barrier Placement



Cable Barrier – Exclusion Zones

Exclusion Zone for 16' Medians on 6:1 Cross Slopes



Vehicle Dynamics Analysis

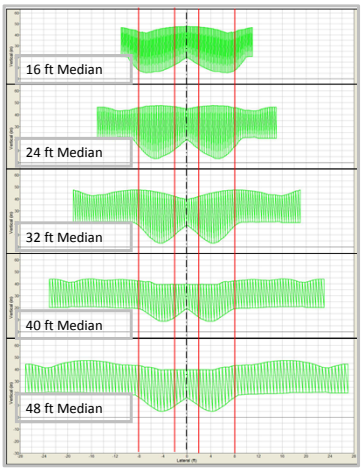
V-Shaped

6:1 Medians →

Exclude Barrier

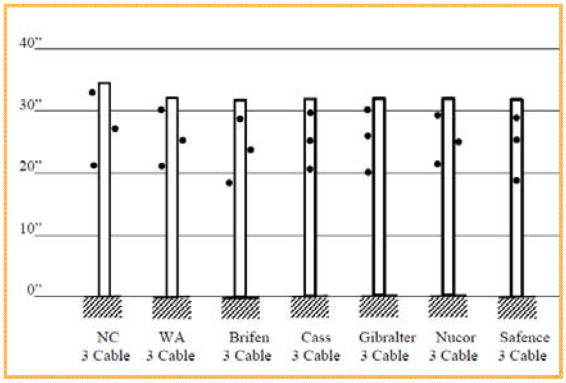
Placement 8'

On Either Side



Cable Barrier – Heights

Average Height of "3 Rope" TL-3 Cable Barrier Systems:
Top = 30" Plus 1" Tolerance & Bottom = 20" Minus 1" Tolerance



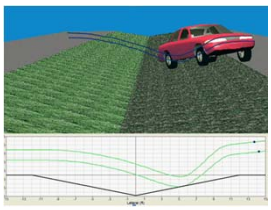
Lateral Dynamic Deflection

Lateral Dynamic Deflection Depends on:

- End Anchor Spacing (Length of Run),
- Post to Post Spacing,
- Cable Tensioning.

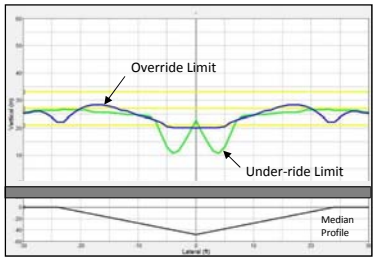
Cable Barrier – Lateral Placement

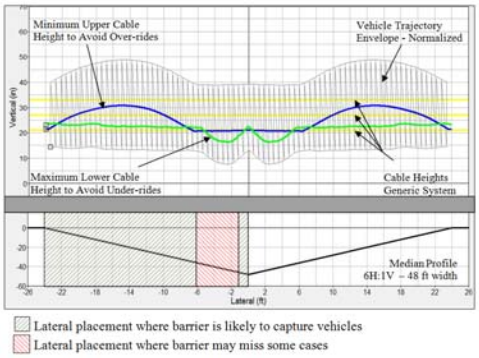
Computer Crash Simulations Calibrated with Crash Test Results:



Cable Barrier – Placement Interface

Over-Ride Equals the Under-Ride of Vehicles from Opposing Direction @ 8' from Bottom of V-Ditch





Yellow = 3 Wire Rope
Red = Bad Placement
(Exclusion Zone)

Cable Barrier – Sequential Plots

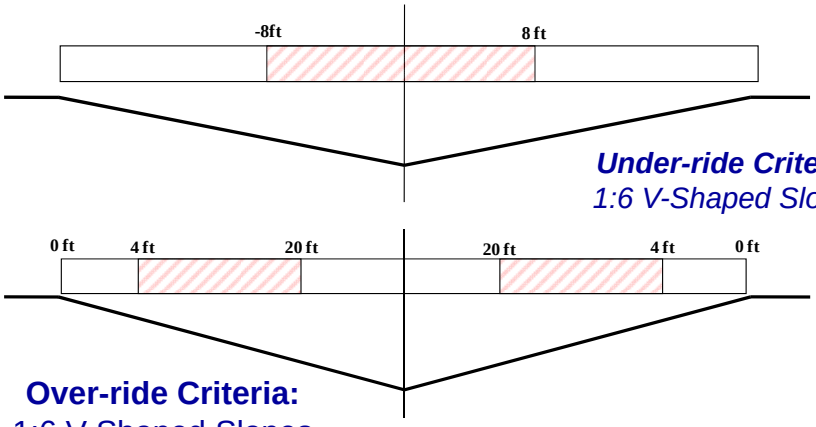
Compare Crash Simulation Sequential Plots to Crash Test Video

Cable Barrier – Sequential Plots

Compare Crash Simulation Sequential Plots to Crash Test Video

Cable Barrier – Research Findings

Based on Vehicle Dynamics Analysis (VDA)



Under-ride Criteria:
1:6 V-Shaped Slopes

Over-ride Criteria:
1:6 V-Shaped Slopes

Cable Barrier – Layout & Design

Layout and Design:

1. High Tension Cable Barrier Systems
2. Implementation Guidance
3. Anticipated Design Standards

Cable Barrier – Layout & Design

1. High Tension Cable Barrier Systems
   - Design Coordination Process
   - Guideline Issues
   - Plans Production

Design Coordination Process

Coordination Steps to Process Cable Barrier Designs:

1. Cable Barrier Maintenance Program Must be in Place
2. Contact District Specifications Office and Obtain
   - Developmental Specification, ***SECTION 540, HIGH TENSION CABLE BARRIER SYSTEM***
3. Contact the State Design Standards Manager, to Evaluate Your Conceptual Design and to Obtain Project Approvals
   - ***John Mauthner, P.E.***
   - ***(850) 414-4334***

Design Coordination Process

Design Standard Drawings are **Not** Available; but

Developmental Specification (**Dev 540**) and

Coordination with **Central Office** are

Accessible Options During the Design Process.

GUIDELINE ISSUES

- **FHWA Approved Proprietary High Tension Cable Barriers**
- **Cable Barrier Systems, include:**
  - 3 cable systems = TL-3
  - 4 cable systems = TL-3 or TL-4

- **Deflection Distances Depend on Post Spacing and Product**
  - Tables can be obtained from product specific manufacturers
- **Federal Oversight Projects Require FHWA Approval**

FHWA - Approved Proprietary High Tension Cable Barriers

Trinity CASS

Gibralter

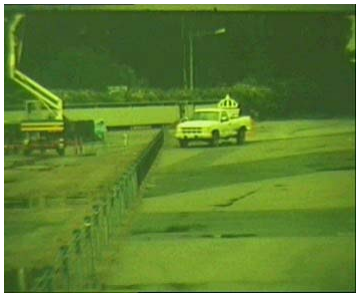
Marion

FHWA - Approved Proprietary High Tension Cable Barriers

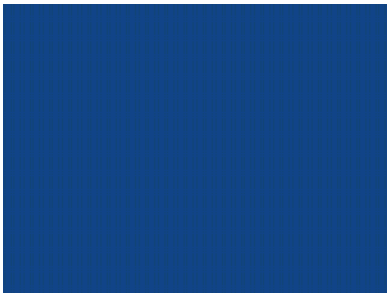
Safence

Brifen

Cable Barrier Systems



- **Test Level 3 (TL-3)**

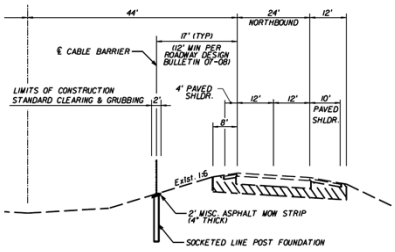


- **Test Level 4 (TL-4)**

Plans Production

Plans Production:

- **Plans Preparation Criteria**
- **Plan Set Components**
- **Design Documentation**



Plans Preparation Criteria

Placement:

- At Minimum of 12' Offset from Edge of Travel Way
- On 10:1 Slopes are Standard (Preferred Option)
- Can be on Shoulders or on Slopes of "up to" 1V:6H
- On Slopes Steeper Than 1:6 Require Approval from the State Roadway Design Engineer

Plans Preparation Criteria

- Median Placement, cable barrier *Shall NOT* be within the region 8' either side of the center 'V'
- Place at 8' Offset from the Centerline of a V-bottom Ditch
- Minimum System Length is 1000'
- Approach and Trailing End Terminals should be designed in the same manner as guardrail
  - ✓ See Index 400

Plan Set Components

- **Provide Typical Sections for Cable Installations**
- **Locate Cable Barrier Systems on Plan Sheets**
  - Label Begin and End Stations with Offset
  - Include any Necessary Alignment Data for Construction (such as Offsets, PC's, PT's, PI's, Alignment Transitions, Radii, etc.)
- **Generate Special Details Sheets**
- **Tabulate Quantities**

Plan Set Components

- **Summarize Cable Barrier Quantities on the Summary of Quantities Sheet by Location (*Station and Side*)**
- **Tabulate all Segment Lengths and Show the Total Plan Quantity of Cable Barrier Required for Project, include:**
  - ✓ **End Terminals**
  - ✓ **Concrete Aprons**

Summary of Quantities

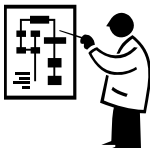
SUMMARY OF HIGH TENSION CABLE BARRIER SYSTEM

LOCATION		CABLE BARRIER (LF)					REMARKS	FIELD BOOK REFERENCE
STATION	SIDE	ROADWAY		END TERMINAL (EA)		CONCRETE APRON (SY)		
		P	F	P	F			
FROM								
TO								
FROM								
TO								
FROM								
TO								
FROM								
TO								
FROM								
TO								
FROM								
TO								
FROM								
TO								
TOTAL								

Design Documentation

Document Critical Design Issues:

- Typical Section Packages
- Summary of Quantities
- Engineers Construction Cost Estimate
- Drainage Concerns (*Median Linear Ponds*)



Cable Barrier – Layout & Design

Implementation Guidance:

- Developmental Specification, Section 540
- Valid Pay Item Use
- Deliverable Requirements

Current Implementation Guidance

Developmental Specification, Section 540

- Description
- Materials
- Train Installation Work Crew and On-Site Supervisor
- Construction Requirements
- Method of Measurement
- Basis of Payment

Current Implementation Guidance

Valid Pay Item Use:

904-540-2	**Socketed Post System, LF**
904-540-4	**End Terminal, EA**
904-540-5	**Reset Existing System, LF**
904-540-6	**Reset Existing End Terminal, EA**
904-540-10	**Relocate, LF**

Current Implementation Guidance

Deliverable Requirements:

- Follow Developmental Specification 540
- Ensure Proper Pay Item Use
- Require a Soils Specific Design for End Terminals
- Request Shop Drawings for Product Specific Installations
- Request Approvals for Federal Oversight Projects from FHWA and Add Project to Statewide Work Plan
- Provide Final Plans to Central Office, Roadway Design

Part 3
Cable Barrier
Future Guidelines

Cable Barrier – Future Guidelines

Implementation of Findings:

- Fulfill Intermediate Need Requirements
- Initiate "Development of Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems"
- Follow-through with Dependent Actions

Cable Barrier – Future Guidelines

Fulfill Intermediate Need Requirements:

- ✓ Develop Cable Barrier Special Provisions
- ✓ Establish District & FTE Cable Barrier Experts and Project Monitors
- ✓ Train District & FTE Cable Barrier Experts
- ✓ Evaluate and Monitor Performance

Cable Barrier – Future Guidelines

Initiate *"Development of Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems:"*

- ✓ Develop Geometrics & Criteria (PPM, Exhibits, Typical Sections, etc.)
- ✓ Design Standard Construction Details (Index 400)
- ✓ Generate Specifications According to the newest MASH Crash Test Matrix

Cable Barrier – Future Guidelines

Initiate *"Development of Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems:"*

- ✓ Establish Permanent Pay Item Structure
- ✓ Evaluate Products for Qualified Products List (QPL)
- ✓ Conduct Cable Barrier Training

Cable Barrier – Future Guidelines

Follow-through with Dependent Actions :

- ✓ Florida Greenbook Committee Actions
- ✓ Safety Assurance Reviews
- ✓ Safety Office - Fund Programming
- ✓ Revise Maintenance Office Operations

Anticipated Design Standards

Cable Barrier Critical Issues:

- Cable Barrier Lateral Placement
- Cable Barrier Deflection Criteria
- End Terminal and Post Anchoring Systems
- Interconnection with Other Barrier Systems

Anticipated Design Standards

Cable Barrier Critical Issues:

- Construction Tolerances;
  - Top Height Requirements (+ 1”)
  - Bottom Height Requirements (- 1”)
- Horizontal Curve Placement Guidance
- Installation vs. Maintenance Costs

In-service Performance Evaluations

- Evaluate and Monitor Performance
  - ✓ Safety Assurance Reviews
- Based on Installation Costs (Cost/Mile)
- Based on Maintenance Costs (Average Cost/Repair)

Proposed Design Criteria

- Derive Permanent Specifications
- Compile Foundation Design Parameters (Soils)
- Establish Permanent Pay Items
- Plans Preparation Manual Update
  - Update Chapter 4, PPM Vol. I
- Establish Guidelines for Cable Barrier Design
- Update Exhibits with Cable Barrier Examples

Proposed Design Standards

- Develop Proposed Standard Indexes
- Draft Generic High Tension Cable System Drawings
- Organize Drawings within the Index 400 Series
- Reference Specifications, Estimates, and Design Guidelines (AASHTO, MASH, RDG, HSM, etc.)
- Update Roadside Barrier Training - Based on New Criteria and Standards

Design Standards Team

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Thank You ...

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