Shoulder Rocking

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Objectives

Understand…

- Concept of Shoulder Rocking
- When to use Shoulder Rocking
- How to implement Shoulder Rocking

Background Issue

- Least Costly Way to Increase Capacity?
  - Widen roads within existing R/W
  - Do not re-build existing pavement
- Add Barrier Wall to …
  - Mitigate median CZ
  - Defend drop off on outside wall

Spread Issues

- Lanes Added Along Longitudinally Flat Roads
- Ditches Replaced with Shoulders and Barrier Walls
- Roadway Sections Sloped Towards Barrier Wall

Example of Spread Issue

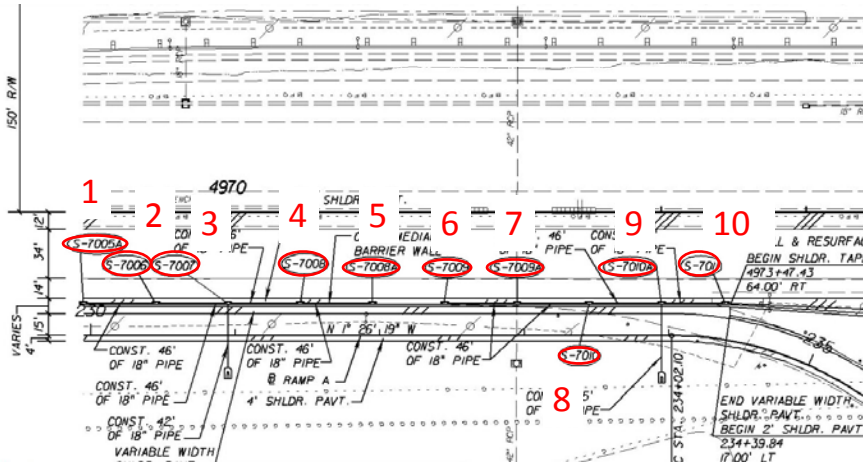
Possible Solutions

- Barrier Wall Inlets
- Trench Drain
- Rebuild Existing Roadway
- Saw-Tooth Shoulder
- Shoulder Rocking

Barrier Wall Inlets

- Expensive:
  - Many inlets needed
  - More pipe needed

Barrier Wall Inlets Example



10 Inlets within 450 feet!!!

Possible Solutions

- Barrier Wall Inlets
- Trench Drain
- Rebuild
- Saw-Tooth Shoulder
- Shoulder Rocking

Trench Drain

- Aesthetically Pleasing (at first)
- Expensive ($146/LF)
- Maintenance Intensive
  - Clogging Issues
  - Access Issues

Trench Drain

Possible Solutions

- Barrier Wall Inlets
- Trench Drain
- Rebuild
- Saw-Tooth Shoulder
- Shoulder Rocking

Rebuild Entire Roadway!

- Very Expensive
- Takes More Time
- Impact to Public
- Consider if….
  - Existing roadway flooding
  - Base clearance problems
  - Hydroplaning issues

Possible Solutions

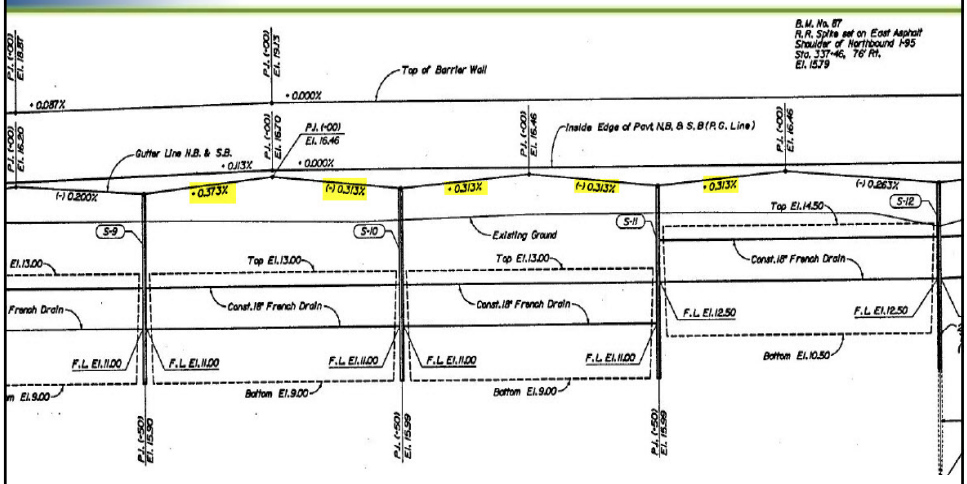
- Barrier Wall Inlets
- Trench Drain
- Rebuild
- Saw-Tooth Shoulder
- Shoulder Rocking

Saw-Tooth Shoulder

Vary Shoulder Cross Slope:

- Economical
- Not Aesthetically Pleasing
  - Looks like poor construction
  - Distracting to motorists
- Safety Concern When Using Shoulder

"Saw-Tooth" Technique

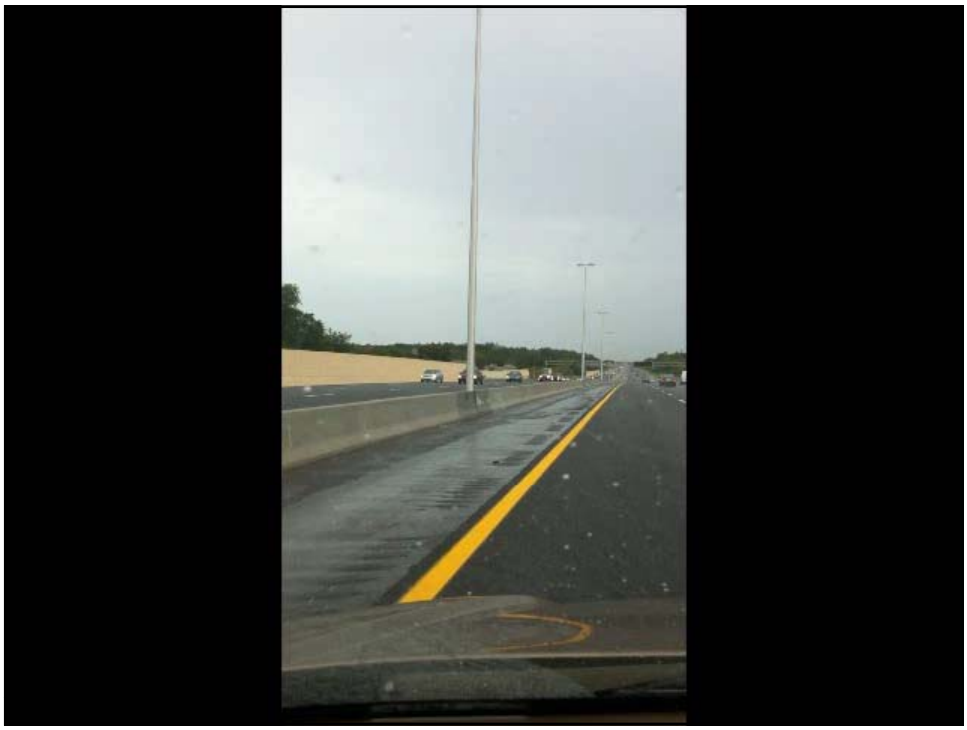


Possible Solutions

- Barrier Wall Inlets
- Trench Drain
- Rebuild
- Saw-Tooth Shoulder
- Shoulder Rocking

Shoulder Rocking

- *Gradually* rolling shoulder by transitioning shoulder cross-slope
- Most common along median
- Requires a variation
- Creator: Kevin Stewart, P.E. (FDOT's Turnpike Office)



Shoulder Rocking Benefits

- Economic
  - Less inlets and pipe
  - Not maintenance intensive
- Safety
  - Reduced spread
  - Less maintenance
  - Shoulder usage
- Aesthetically Pleasing

Shoulder Rocking Design Steps

- Determine need
- Determine geometric characteristics
- Calculate spread & place inlets
- Place special shoulder profile on profile sheet(s)
- Plan sheet(s) and typical section(s)

Need Determination

- Flat or near flat profile
  - Longitudinal slopes 0% - 0.24%
- Roadway sections sloped towards barrier
  - e.g. Shoulder sloped 6% towards median
- Potential spread issues

Spread Calculation without Shoulder Rocking

SPREAD CALCULATIONS

Chapter 12, FDOT General Reference Volume 2D, 1997.

Notes: Not for use with sag inlets.

	STATION TO (ft.)	SIDE	LONG. SLOPE Z	CROSS SLOPE Sx (ft/ft)	WIDTH (ft.)	AREA A (Ac.)	intensity i (in/hr)	Runoff Coef. C	FLOW Q (cfs)	BYPASS Qb (cfs)	TOTAL FLOW Qt (cfs)	SPREAD WIDTH (ft.)	Allowable Spread (ft)	REMARKS
inlet	581058.00	RT	1.26%	0.06	106.0	0.50	4.00	0.95	1.90	0.00	1.90	4.43	10.00	OK
inlet	581345.00	RT	0.08%	0.06	100.0	1.13	4.00	0.95	4.29	0.00	4.29	10.00	10.00	Need Additional Inlet
inlet/trench	581800.00	RT	0.08%	0.06	93.0	0.97	4.00	0.95	3.69	0.00	3.69	9.45	10.00	OK
trench	581850.00	RT	0.00%	0.06	88.0	0.10	4.00	0.95	0.38	0.00	0.38	14.30	10.00	Need Additional Inlet
inlet	581900.00	RT	0.00%	0.06	86.5	0.10	4.00	0.95	0.38	0.00	0.38	21.87	10.00	Need Additional Inlet
trench/inlet	582400.00	RT	0.00%	0.06	83.0	0.76	4.00	0.95	2.90	0.00	2.90	46.97	10.00	Need Additional Inlet
trench	582350.00	RT	0.00%	0.06	82.7	0.09	4.00	0.95	0.36	0.00	0.36	13.97	10.00	Need Additional Inlet
	582460.00	RT	0.00%	0.06	82.7	0.21	4.00	0.95	0.79	0.00	0.79	12.19	10.00	Need Additional Inlet
inlet/trench	582612.00	RT	0.04%	0.06	81.5	0.28	4.00	0.95	1.08	0.00	1.08	6.95	10.00	OK
inlet/trench	582730.00	RT	0.00%	0.06	81.5	0.51	4.00	0.95	1.92	0.00	1.92	16.98	10.00	Need Additional Inlet
inlet/trench	582930.00	RT	0.00%	0.06	81.5	0.37	4.00	0.95	1.42	0.00	1.42	15.17	10.00	Need Additional Inlet
	583153.00	RT	0.00%	0.06	82.3	0.42	4.00	0.95	1.60	0.00	1.60	15.86	10.00	Need Additional Inlet

Eight Inlets plus approximately 800 feet of Trench Drain Needed!

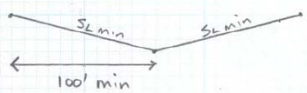
Shoulder Rocking Design Steps

- Determine need
- Determine geometric characteristics
- Calculate spread & place inlets
- Place special shoulder profile on profile sheet(s)
- Plan sheet(s) and typical section(s)

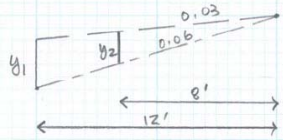
Geometric Determination

- Shoulder Cross-Slope Change:
  - Max. range from 3% to 6%
- Length of Transition:
  - Minimum 100 feet
- Shoulder Width:
  - Based off of 8 to 12 feet

PROFILE



Cross Section



$S_{L,min} = \frac{y_1}{L_{min}}$ $\quad L_{min} = 100'$ $\quad y_1 = 12'(0.06 - 0.03) = 0.36'$

$S_{L1\,min} = 0.36'/100' = \boxed{0.36\% \text{ For } 12' \text{ shoulder}}$ DESIGN

$S_{L2\,min} = 0.24'/100' = \boxed{0.24\% \text{ For } 8' \text{ shoulder}}$ DESIGN

* When construction tolerances are considered (FDOT STANDARD SPECS SECTION 327-3)
Cross slope of shoulder, tolerance ± 0.5%

$\boxed{S_{L1} = \frac{0.24}{100} = 0.24\%}$ $\quad y_1 = 12'(0.055 - 0.035) = 0.24$

$\boxed{S_{L2} = \frac{0.16}{100} = 0.16\%}$ $\quad y_2 = 8'(0.055 - 0.035) = 0.16$

Worse case as-built

Shoulder Rocking Design Steps

- Determine need
- Determine geometric characteristics
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Spread Criteria

3.9 Spread Standards

The spread resulting from a rainfall intensity of 4.0 inches per hour shall be limited as follows.

Typical Section Condition	Design Speed (mph)	Spread Criteria*
Parking Lane or Full Width Shoulders	All	No encroachment
All Other	Design speed ≤ 45	Keep ½ of lane clear
	45 < Design Speed ≤ 55	Keep 8' of lane clear
	Design Speed > 55	No encroachment

Drainage Manual

Spread Calculation

CURB AND BARRIE
SPREAD CALCULA
North Bound Turnp

Reference: Figure 12-1, Chapter 12, FDOT General Reference Volume 2B, 1987.

STRUCTURE NUMBER	STATION FROM (ft.)	STATION TO (ft.)	SIDE	LONG. SLOPE (ft/ft)	CROSS SLOPE Sx (ft/ft)	WIDTH (ft.)	AREA A (Ac.)	Intensity i (in/hr)	Re	inlets. REMARKS
S-01	5808+53.26	5810+58.00	RT	0.0126	0.06	106.0	0.498	4.00		OK
S-02	5810+58.00	5812+19.00	RT	0.0025	0.06	106.0	0.392	4.00		OK
S-02	5812+19.00	5813+41.00	RT	0.0025	0.06	99.0	0.277	4.00		OK
S-03	5813+41.00	5814+41.00	RT	0.0025	0.06	94.0	0.216	4.00		OK
S-03	5814+41.00	5815+66.00	RT	0.0025	0.06	89.5	0.257	4.00		OK
S-04	5815+66.00	5817+38.00	RT	0.0025	0.06	89.5	0.353	4.00		OK
S-04	5817+38.00	5818+38.00	RT	0.0025	0.06	89.5	0.205	4.00		OK
S-05	5818+38.00	5819+80.00	RT	0.0025	0.06	86.5	0.282	4.00		OK
S-05	5819+80.00	5821+70.00	RT	0.0025	0.06	85.0	0.371	4.00		OK
S-06	5821+70.00	5822+50.00	RT	0.0025	0.06	83.5	0.153	4.00		OK
S-06	5822+50.00	5824+30.00	RT	0.0025	0.06	82.7	0.342	4.00		OK
S-07	5824+30.00	5825+60.00	RT	0.0025	0.06	81.5	0.243	4.00		OK
S-07	5825+60.00	5826+65.00	RT	0.0025	0.06	81.5	0.196	4.00		OK
S-08	5826+65.00	5828+12.00	RT	0.0025	0.06	82.0	0.277	4.00		OK
S-08	5828+12.00	5829+16.00	RT	0.0025	0.06	83.0	0.198	4.00		OK
S-09	5829+16.00	5830+43.19	RT	0.0025	0.06	82.6	0.241	4.00		OK
S-09	5830+43.19	5831+53.55	RT	0.0025	0.06	82.3	0.209	4.00		OK

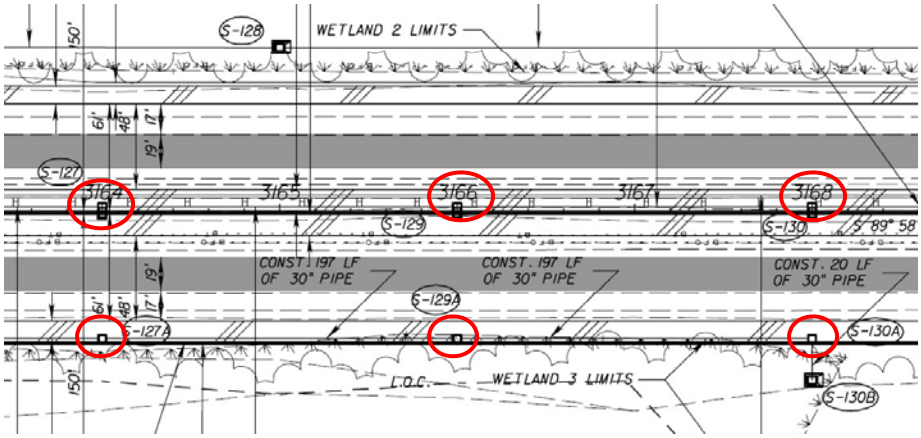
STRUCTURE NUMBER	STATION FROM (ft.)	STATION TO (ft.)
	580853.00	581058.00
inlet	580853.00	581345.00
inlet	581345.00	581800.00
inlet/trench	581800.00	581850.00
trench	581850.00	581900.00
inlet	582000.00	582400.00
trench/inlet	582300.00	582350.00
trench	582350.00	582460.00
	582460.00	582612.00
inlet/trench	582460.00	582730.00
inlet/trench	582730.00	582930.00
inlet/trench	582930.00	583153.00

Only 9 Inlets Needed

Compared to 8 Inlets and 800 feet of Trench Drain

Spread well within Allowable Criteria

Place Inlets as Required



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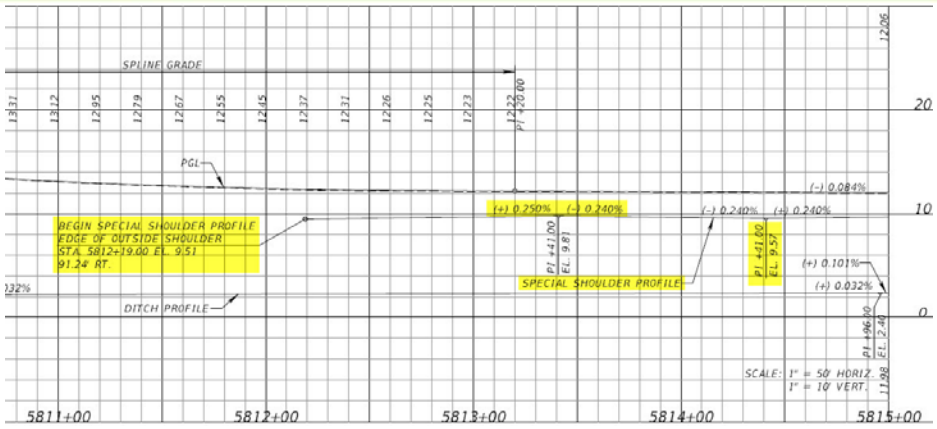
Profile Sheet Showing Special Shoulder Profile



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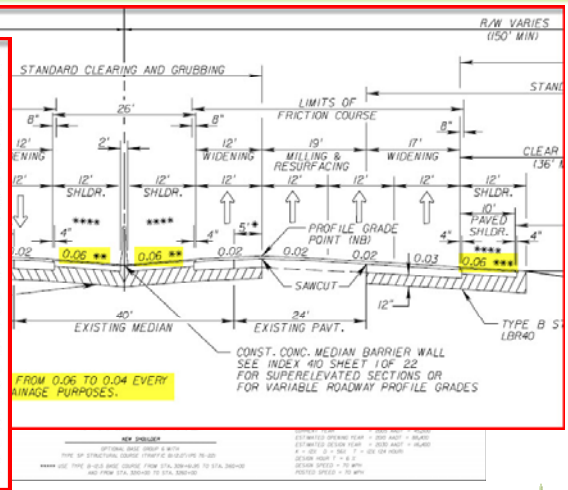
Typical Section Showing Shoulder Rocking Extents

** MEDIAN SHOULDER CROSS SLOPE VARIES FROM 0.06 TO 0.04 FOR DRAINAGE PURPOSES

MEDIAN SHOULDER ROCKING		
STA.	SIDE	CROSS SLOPE
3112+00.00	LT. & RT.	0.06
3113+12.00	LT. & RT.	0.04
3114+00.00	LT. & RT.	0.06
3114+90.00	RT.	0.04
3115+00.00	LT.	0.04
3116+00.00	LT. & RT.	0.06
3116+55.00	LT.	0.04
3116+70.00	RT.	0.04
3118+00.00	LT. & RT.	0.06
3148+00.00	LT. & RT.	0.06
3148+60.00	RT.	0.04
3148+65.00	LT.	0.04
3150+00.00	LT. & RT.	0.06
3150+60.00	LT.	0.04
3150+80.00	RT.	0.04
3152+00.00	LT. & RT.	0.06
3152+60.00	RT.	0.04
3152+70.00	LT.	0.04
3154+00.00	LT. & RT.	0.06
3154+40.00	LT.	0.04
3154+70.00	RT.	0.04
3156+00.00	LT. & RT.	0.06
3156+90.00	RT.	0.04
3157+00.00	LT.	0.04
3158+00.00	LT. & RT.	0.06



Shoulder Rocking Summary

- Use for widening projects with flat longitudinal slopes and spread problems
- Transition the shoulder cross-slope from 6% to 3% over a minimum 100 feet
- Place the shoulder rocking information in the plan, typical section, and profile views