Stabilized Roadways

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Rapid City, South Dakota

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Outline

- Richland Co Background Information
- Approach to Solution
- Alternatives Considered
- 2009 & 2010 ~ Trial Sections
- 2011 ~ 25 Mile Project
- Summary
- Richland Co Task Force

County 2008 Mission

- Ensure Public Safety on Road System
- Meet Public Expectations
- Address air quality and DEQ concerns
- Adhere to GRAVEL stewardship for the next generations
- Find surfacing alternatives with better **cost/benefit**

The Problem

- Heavy Truck Traffic on Weak Soil Roads
- Extensive Road Network
- Limited Budget
- Limited Rock Resources

Local Standard

- 5” Asphalt, 8” Base Gravel
- 4” Gravel (New construction)
- Spot Graveling

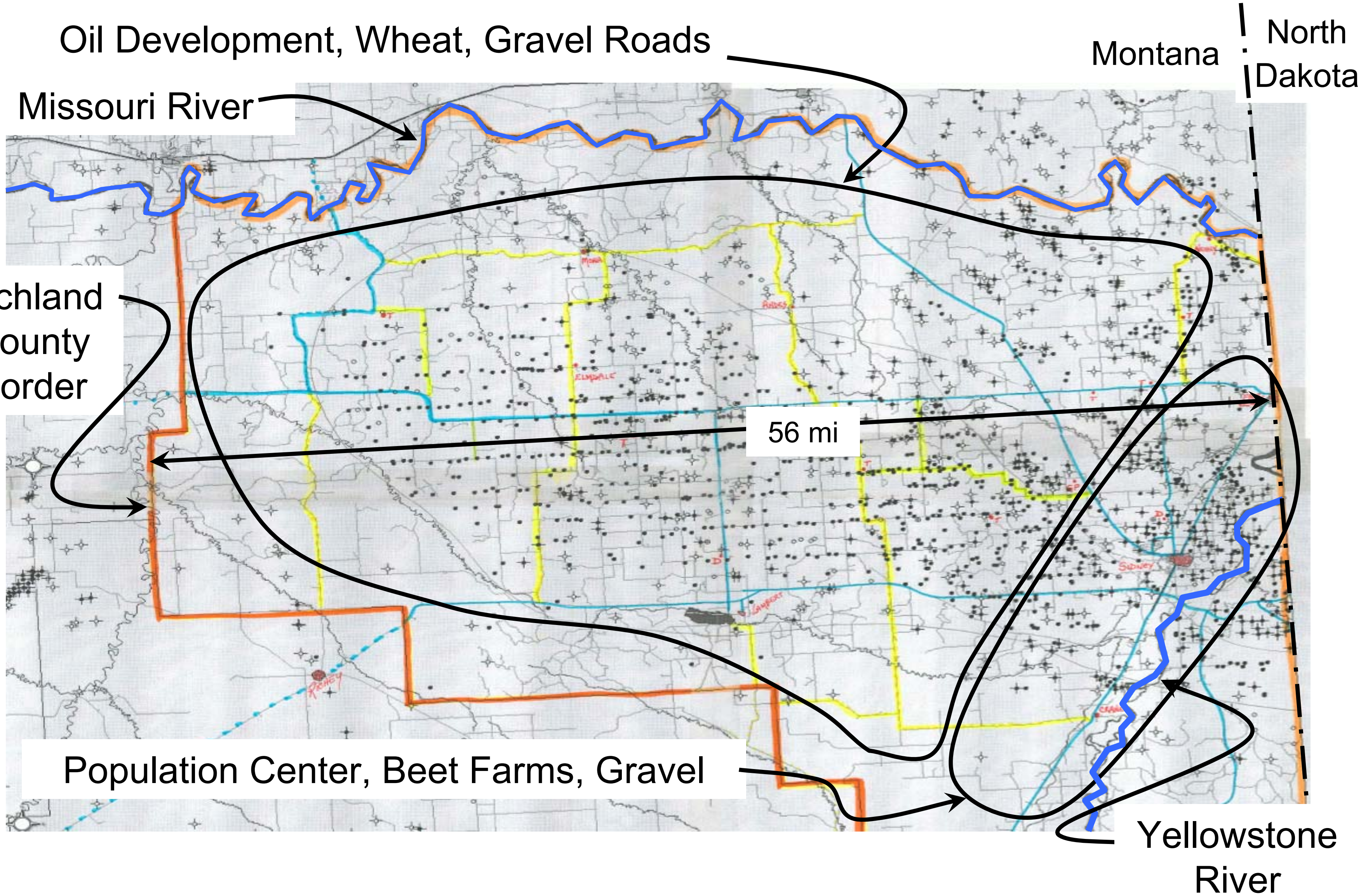
(Haul 90 to 110,000 cy / year)

Weak Soils (CBR= 3 or 4 typical)

5" Asphalt, + 6" Base (15 yrs old)

3" Scoria, old gravel base (after 3 months)

Richland Co Road Network & Resource Impacts



Road Network Miles & ADT

- Function Class Miles: 1132 (341 Bus Routes)

Arterials:	86
Major/Minor Coll:	232
Local:	701
Trails:	113

Hot Mix:	40
Surface Treat:	10
Gravel:	968
Dirt :	235

- CI Plan: Collectors (with) Bus Routes = 131.2 mi

  : Improve 20-25 mi. / year
- Truck Traffic
  - Ag Traffic: Beets (Sept & Oct), Cattle, & Grain hauling
  - Oil Field:
    - Well development: 1200 trucks over 3 months (each well)
    - Crude & Water Haul: 3 to 5 trucks/day for 25 years

Structural Thickness Design

		Inches of Gravel			
Soil Strength	Excellent	4	7	9	12
	Good	7	9	12	16
	Fair	9	12	16	20
	Poor	12	16	20	24
Trucks/Day→		**50**	**100**	**150**	**200**

Gravel Thicknesses are based on:

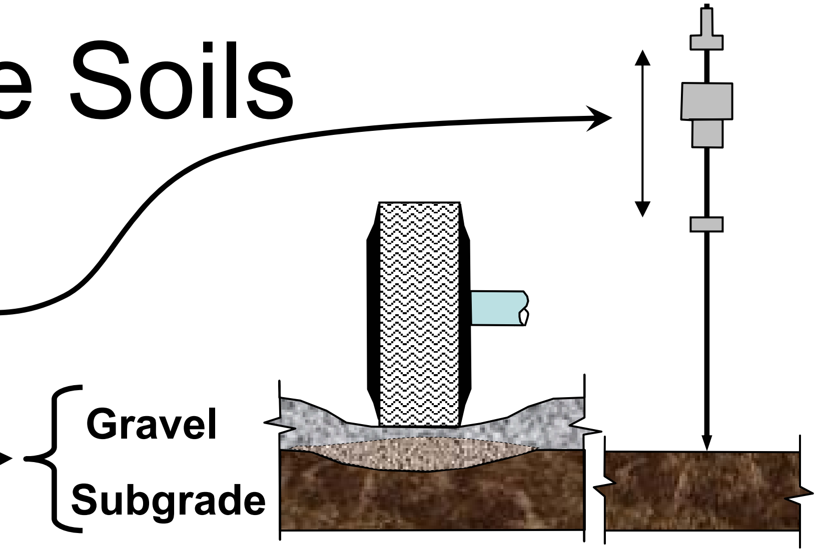
- **Soil Strengths**
- **Truck Traffic**
- **AASHTO 93 Guide**

For Example: Rd 127 had 71 Trucks per Day ~ Thickness required is 14

Risk	Factor, %	Route Type
Low	60%	Feeders, detour route available
Moderate	80%	Collectors, detour route available
High	100%	Arterials, no detour, school bus routes

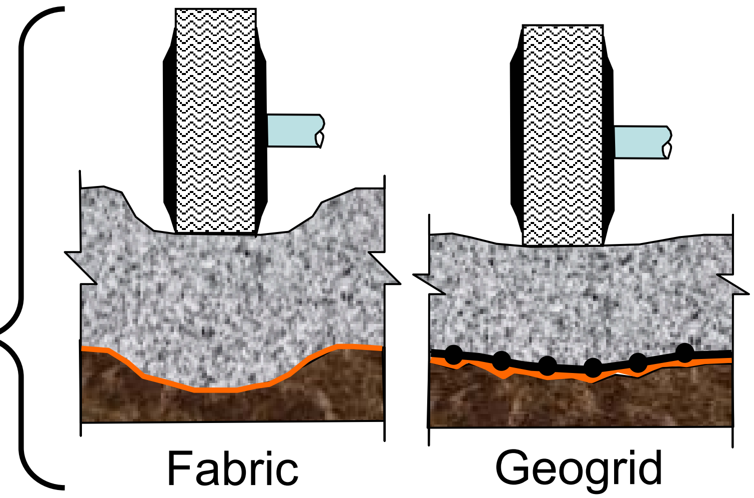
Weak Clay Subgrade Soils

Soil Strength by DCP:
CBR of 1 to 6



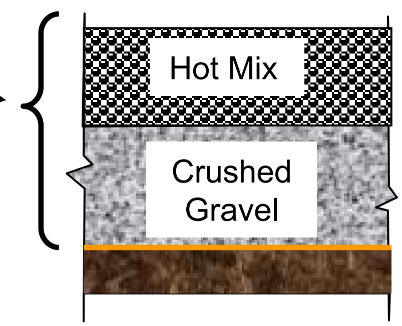
Thin gravel layers
mix with clay

Gravel with Fabric &
Geogrid too costly



Gravel $ Too High

Standard Paving
Design too costly



Approach to Solution

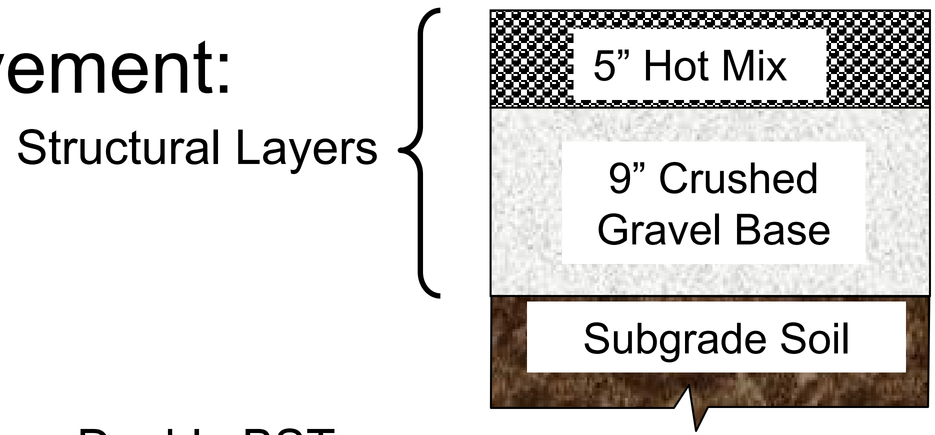
- Outside Assistance
  - Construction Management Contract (Century Companies)
  - Engineering Consultants (Boesh, Monlux, Holman)
- Look at all alternatives and materials available
- 2009 & 2011 ~ Build trial sections & evaluate
- 2011 ~ Project level construction with performance monitoring plan (FWD).

2010 Alternatives ~ Structural Support

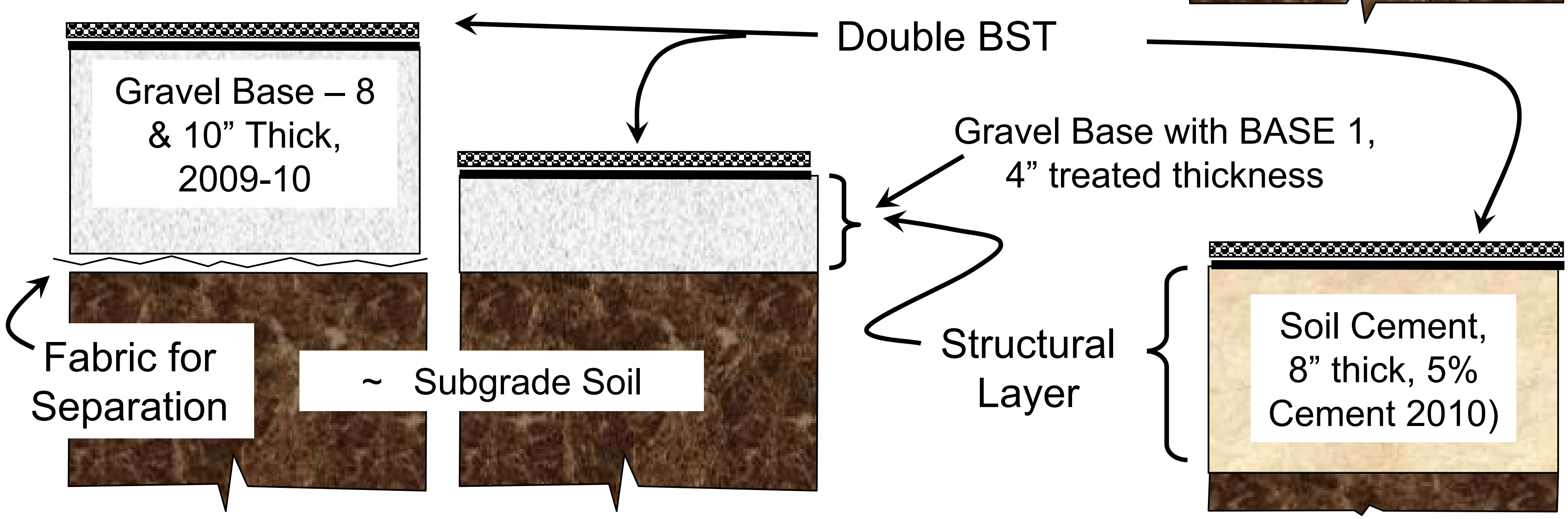
- Improve Subgrade
  - Increased Subgrade Compaction → minor benefit
  - Stabilization
    - **Portland Cement** → Lab mix designs promising
    - **Fly Ash** → Billings & Sidney fly ash had low strengths
    - Lime → Cement preferred for low Plasticity soils
    - Bottom Ash, Sugar Beet Lime, Enzymes, etc → unsure, inconsistent benefits
- Base Rock
  - **Fabric** → prevents clay contamination
  - Geogrid → unsure benefits with high truck traffic
  - BASE 1, Enzymes, etc → unsure, inconsistent benefits

Asphalt Alternatives

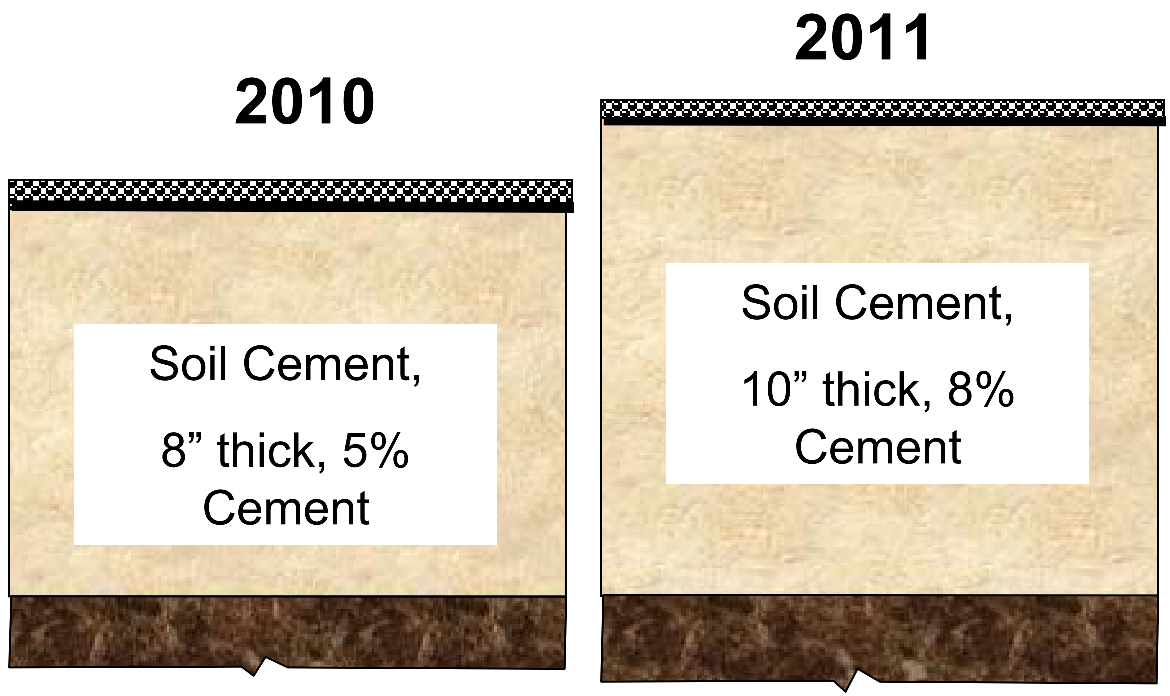
Traditional Flexible Pavement:
Rd 328 (2006)



Thin BST ‘Pavements’



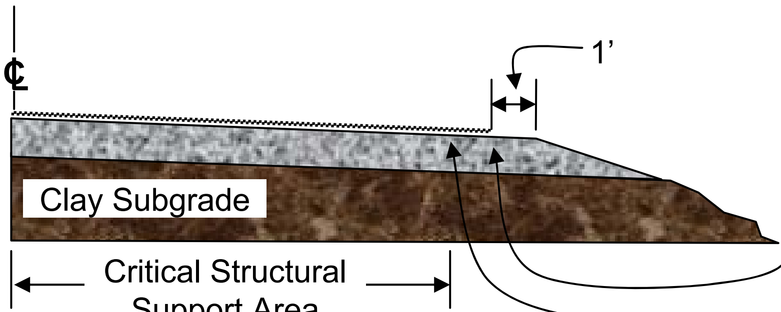
2010 & 2011 Soil Cement Designs



Compressive Strength	225 psi	300 psi
Freeze Thaw Durability	Marginal	Good
Flexural Strength		56% Increase

BST Surface on Gravel or Soil Cement?

BST over 10” Gravel Base

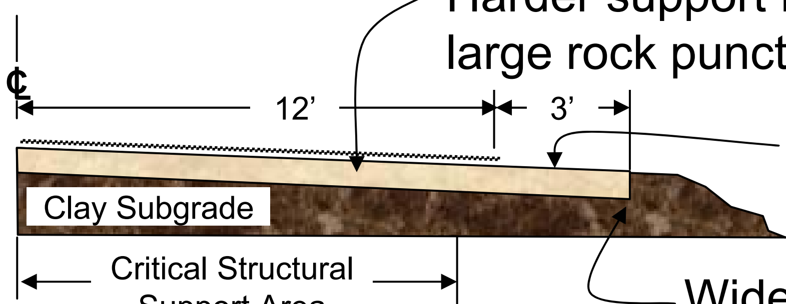


$ 400,000/mile, $2/Truck (*)

Water infiltration to Clay Subgrade is close to structural support area

Edge cracking & break off mtc. problems

BST over 8” Soil Cement



$250,000 /mile, $1/Truck(*)

Harder support from soil cement reduces damage from large rock punctures, turning movements, etc

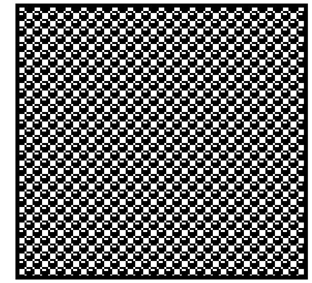
Flatter wider shoulder is less of a hazard

Wide impermeable shoulder keeps surface water further away from critical structure support area.

(*) Maintenance Cost ??

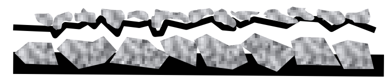
Thin vs. Thick Asphalt Layers

3” Hot Mix

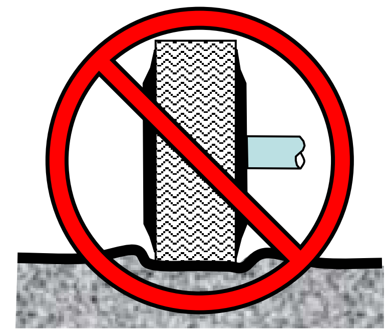


- Thin BST/Otta Seals (3/4” thick)

¾” BST



  - Lower costs for construction, maintenance, recycling & replacement
  - Suited for low traffic & cold climates ~ more flexible & less cracking
  - Good wear surface, no structural strength
  - Quick failure from overloads during thaw



Overloads cause Failures

- Thick Asphalt Pavements (>3” thick)
  - Stronger ~ supports greater loads
  - Cracks in cold climates
- Warning – Both thick & thin options must have good structural support and drainage

Rock Used for Double BST

5/8” & 3/8” Clean Chips

Cost/Mile ≈ $75,000 (Double Shot with Fabric)

AC (PG-58-28): 0.85 gal/SY

MC-3000: 0.40 gal/SY:

Total Chip #/SY: 45#/SY & 27 #/SY

5/8” Gravel – Otta Seal

Cost/Mile ≈ $60,000 (Double Shot)

Total HF 125S: 0.82 gal/SY

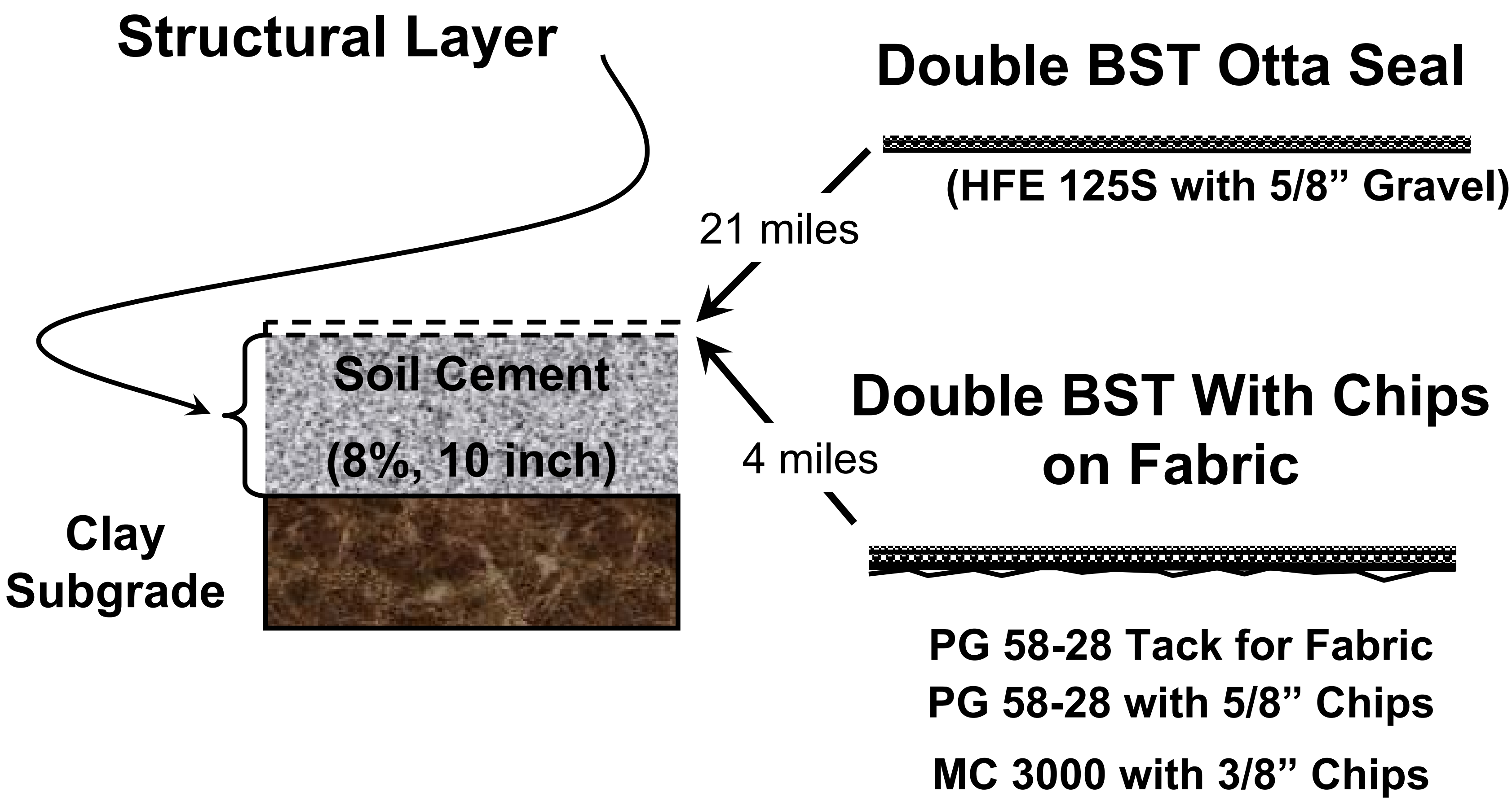
Total Gravel: 70 #/SY

Double BST Options

Otta Seal BST
with Gravel

Clean Chip
BST

2011 Project ~ BST on Soil Cement



Otta Seal Materials Specs

High Float Emulsion Spec (5-4-2011)

Requirement	HF125S (Note A)	
Tests on Emulsion	**Min**	**Max**
Viscosity, Saybolt Furol, Seconds at 50° C	35	150
Residue by Distillation, % by Mass	65	
Demulsibility, %, 50 ml 0.1 N $CaCl_2$	75	
Oil Portion of Distillate, volume/Mass, %	1.0	4.0
Sieve Test, % by Mass		0.1
Storage Stability Test, 24 hr, % by Mass		1
Coating Test	Note B	
Coating ability & water resistance ASTM D244:		
Coating, dry aggregate	good	
Coating, after spraying	fair	
Coating, wet aggregate	fair	
Coating, after spraying	fair	
Adhesion Agent, % by Weight of Residue	Note C	
Tests on Distillation Residue		
Penetration at 25°C, 5s, 100g	125	225
Solubility Trichloroethylene % by Mass	97.5	
Float Test at 60°C, s	1200	
Apparent Specific Gravity at 60°C, Pa.s		
Ductility, 25°C, 5cm/min, cm	40	

Note A: Certificate of Compliance and test reports are required.

Note B: Follow ASTM D244, except that the mixture of limestone and emulsified asphalt shall be capable of being mixed vigorously for 5 minutes, at the end of which period the stone shall be thoroughly and uniformly coated. The mixture shall then be completely immersed in tap water and the water poured off. The stone shall not be less than 90% coated.

Note C: The emulsion must include an adhesion agent and suppliers should cover costs for such in their bids. The actual amount of adhesion agent must be determined by ASTM D 244 with aggregate from the planned source after contract award."

Proposed Gradation Limits (5-4-2011)

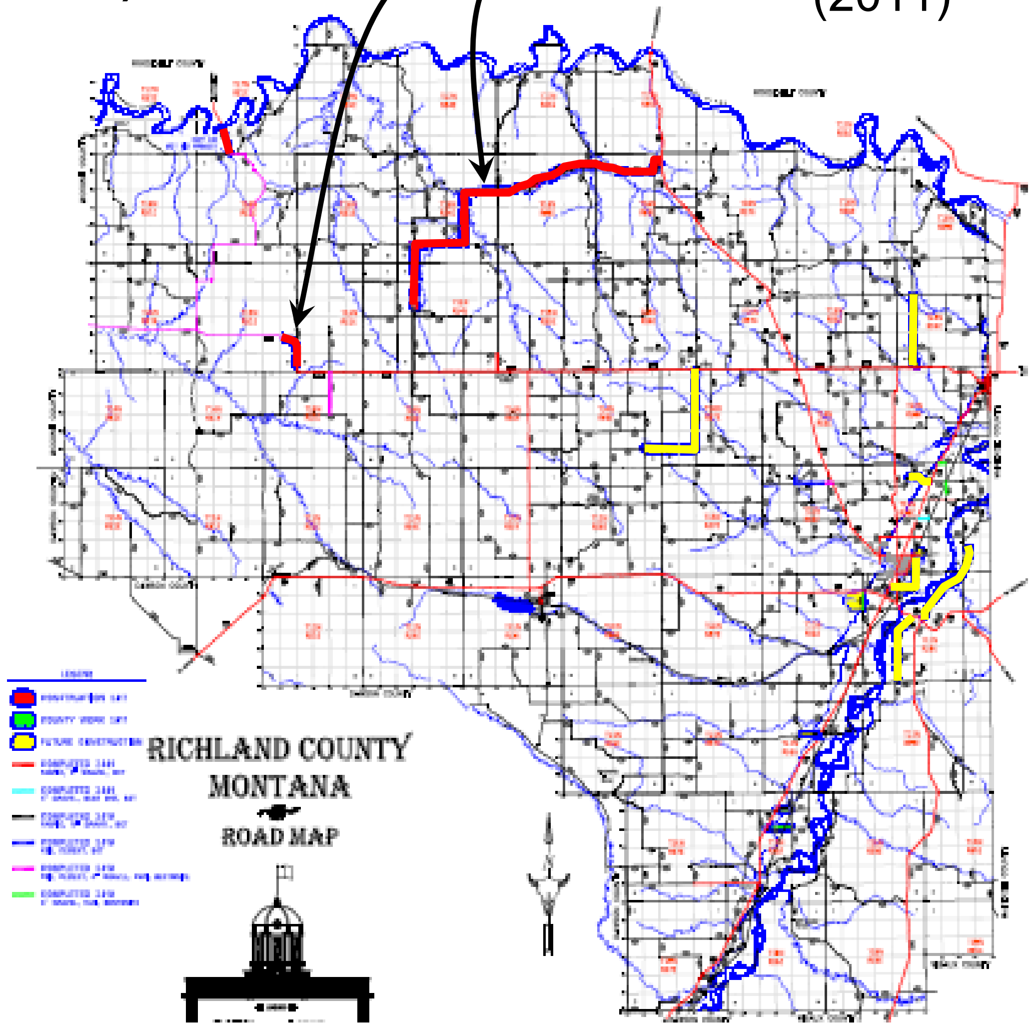
Sieve Size	Richland Co Spec		MN Otta Seal Spec	
	Min	Max	Min	Max
3/4"			100	
5/8"	100	100		
1/2"	82	94	84	100
3/8"	69	86	70	98
#4	48	67	44	70
#16	23	38	15	38
#40	14	26	7	25
#200	4	10	3	10

2011 & 2012 Projects (Tentative)

2011 Work

Future Construction

BST over Soil Cement 25 miles (2011)



Preliminary Cost Comparison

Option		Life by FWD (80,000 GVW trucks) (a)	Costs/Mile (b)		
Surface	Support Structure		Construction	Ann Mtc	Per Truck
5" Hot Mix	9" Base on Fabric	600,000	$900,000	?	$1.50

(a) Based on Spring 2011 FWD back-calculation, better info available in 2012 (Note that 75 Trucks/day ≈ 20,000/yr)

(b) Costs are very project specific

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Double Chip BST	10” Base on Fabric	100,000	$400,000	?	$4.00(c)

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(c) Base thickness inadequate – see next slide

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Double Chip BST	10" Base on Fabric	100,000	$400,000	?	$4.00(c)
Double Chip BST on Fabric	10" Soil Cement (8% Cement)	1,000,000	$300,000	?	$0.30
Double Otta Seal BST			$285,000	?	$0.29
Treated Gravel		2,000,000	$400,000	? (d)	$0.20

(a) Based on Spring 2011 FWD back-calculation, better info available in 2012 (Note that 75 Trucks/day ≈ 20,000/yr)

(b) Costs are very project specific

(c) Base thickness inadequate – see next slide

(d) Gravel replacement & treatment costs are likely high, replacement frequency variable

Base Thickness Requirements for BST Pavements (WSDOT - LE)

Max Traffic (80,000 GVW Trucks)	Subgrade Condition	Base Thickness, inches
50,000	Poor	18
	Average	13
	Good	12
125,000	Poor	21
	Average	16
	Good	12
250,000	Poor	24
	Average	18
	Good	13

WSDOT Flexible Pavement Layer Thicknesses Design Table for New or Reconstructed Pavements - LOW ESAL LEVELS

(English Version)

Design Period ESALs	Subgrade Condition	Layer Thickness[1] (feet)			
		HMA Surfaced		BST Surfaced	
		Reliability = 75%		Reliability = 75%	
		HMA Surface Course	Crushed Stone[2]	BST	Crushed Stone[2]
< 100,000	Poor	0.25	0.85	0.08	1.50
	Average	0.25	0.75	0.08	1.10
	Good	0.25	0.75	0.08	0.90[5]
100,000 to 250,000	Poor	0.30	0.95	0.08	1.75
	Average	0.30	0.70	0.08	1.30
	Good	0.30	0.70	0.08	1.00
250,000 to 500,000	Poor	0.35	1.00	0.08	2.00
	Average	0.35	0.65	0.08	1.50
	Good	0.35	0.65	0.08	1.10

1. Based on the 1993 AASHTO *Guide for Design of Pavement Structures* for flexible pavements with the following inputs:
   - $\Delta PSI = 1.7$
   - $S_D = 0.50$
   - $m = 1.0$
   - $a_{BST} = 0.20$
   - $a_{crushed\ stone} = 0.13$
   - Subgrade condition (effective modulus):
     - Poor: M_R = 35 MPa (5,000 psi)
     - Average: M_R = 70 MPa (10,000 psi)
     - Good: M_R = 140 MPa (20,000 psi)
2. Gravel borrow may be substituted for a portion of crushed stone when the required thickness of the crushed stone is at least 245 mm. The minimum thickness of crushed stone is 105 mm when such a substitution is made.
3. The assumed elastic modulus for BST (EBST) is 690 MPa (100,000 psi)
4. The assumed thickness for all BST layers is 25 mm (1 inch).
5. Crushed stone thickness increased to a total pavement structure of approximately 305 mm (1.00 ft) based on moisture and frost conditions.

Subgrade Condition	Modulus M_R, psi	CBR
Poor	5,000	3.5
Average	10,000	7
Good	20,000	13

BST over Base ~ Rehab Strategy (Government of Yukon)

- Rip and disc failed BST pavements
- If BST was rutting, add more base
- Rebuild BST

Summary/Conclusions

BST and Otta seal cost less to build and maintain than hot mix **if** structural support and drainage are adequate

Stabilize soil if rock costs are high

Fabric under chip seal reduces cracking & increases life

Gravel stabilized with clay & chloride can be cost effective

Estimate life cycle costs

Document performance and share information

Richland County Task Force

- **Russ Huotari - Richland Co**
- **Josh Johnson - Interstate Engineering**
- **John Twedt, Troy Kelsey - Century Companies**
- **Steve Monlux – LVR Consultants**

Last Slide of Presentation