

Cost Effective Secondary Road Reclamation

Utilizing

Steel Slag Aggregates

JOHN YZENAS JR. / KELLY COOK

EDWARD C. LEVY CO.

ZACK SMITH -

NOBLE COUNTY INDIANA – HIGHWAY ENGINEER

OCTOBER 11 > 13TH, 2017

9TH EUROPEAN SLAG CONFERENCE – METZ, FRANCE

County Roads

SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



Urban Sprawl

SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES

Reclamation Benefits

- Reduced Costs of Construction
- Conservation of Aggregates and Binders
- Preservation of Existing Pavement Geometrics
- Preservation of the Environment
- Conservation of Energy
- Less User Delay
- No need to remove materials

Kandhal and Mallick 1997

Pavements

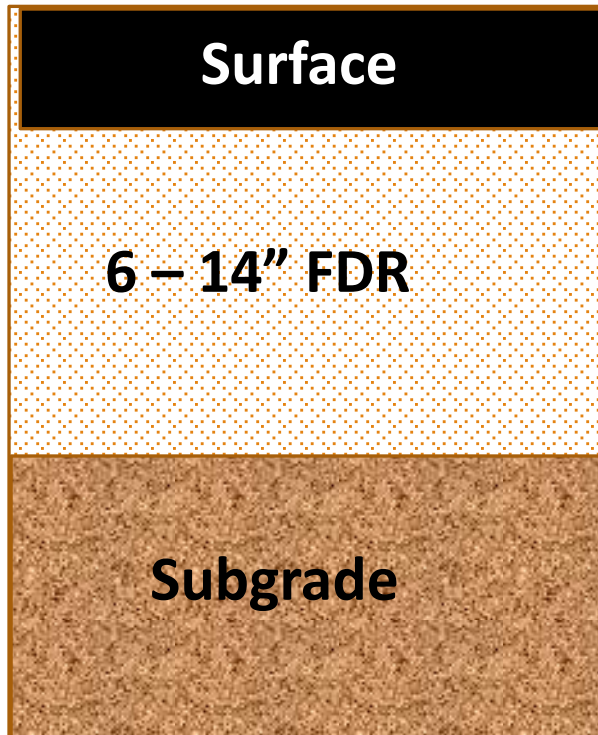
The most important part of a roadway is the subgrade / sub-base condition. If this layer is good a smaller asphalt cross-section is required to provide a stable pavement section. If this supporting layer is poor a thicker asphalt section is required.



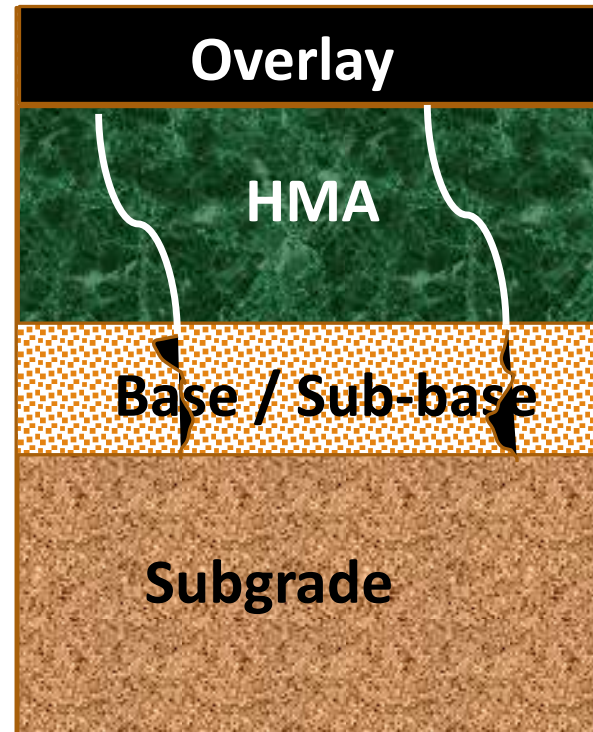
MINIMUM PAVEMENT THICKNESS – ASPHALT/AGGREGATE			
SURFACE SM-9.5	1.5"	1.5"	1.5"
BASE IM-19.0	2.0"	2.5"	3.0"
AGGREGATE BASE 21B	6"	6"	6"
SUBGRADE CONDITION	Good (DCBR >10)	Fair (DCBR 6-10)	Poor (DCBR 3 - 6)

Improved Foundation = Added Strength / Life

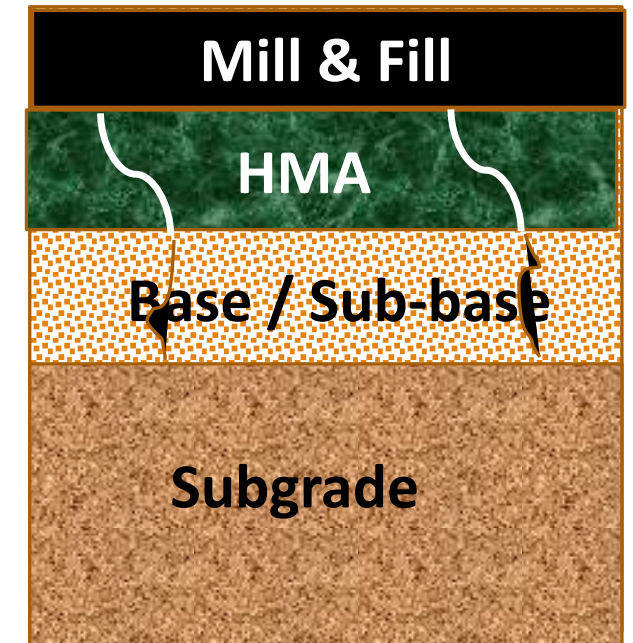
Reclamation



Overlay



Mill & Fill



State Road (SR) 46

County	McKean Co.
Project Length	4.65 Miles (7.75 km)
Estimated Project Cost/ Cost per mile	
Average Daily Truck Traffic	1,035
Average Daily Truck Traffic	376
Scope of repairs proposed:	12" (300 cm) Full-depth reclamation (FDR) to widen the base from 20' to 24' (6.1 to 7.3 m). Approximately 100,000 Cubic feet (2832 m ³) / 6,500 ton (5900 metric ton) of slag is to be used as the aggregate to obtain the necessary structure for widening. Overlay with 3" (75 cm) Binder & 1.5" (37.5 mm) Wearing course at 22' (. Guiderail safety upgrade, tree trimming and some drainage will be addressed.

Design Criteria / Job Mix Formula

PROPERTIES	CRITERIA
Indirect Tensile Strength of Control Specimens, min.	45-50 psi at 50 gyrations
Indirect Tensile Strength Ratio, min.	0.7

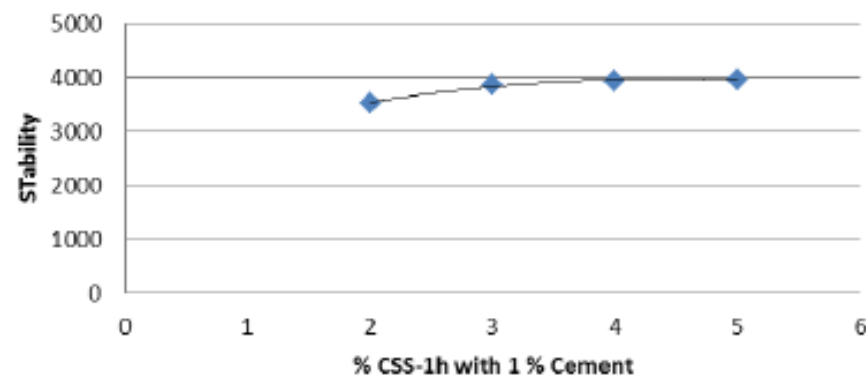
- 3% CSS-1h Emulsion (175 l/m²)
- Cement @1% (6.5 kg/m²)
- Slag (110 kg/m²)
- Moisture 3% by weight



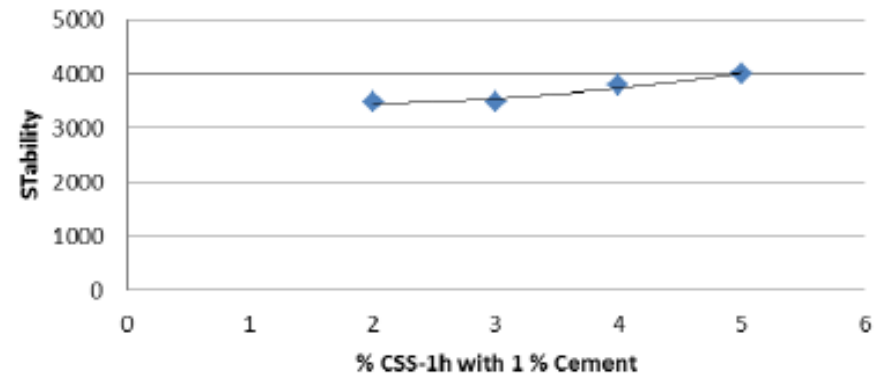
STRUCTURAL COEFFICIENTS

Full Depth Reclamation	
Pulverization	0.11
Calcium Chloride and similar additives	0.14
Asphalt Stabilization	0.25 - 0.30
Chemical Stabilization	0.32 - 0.35

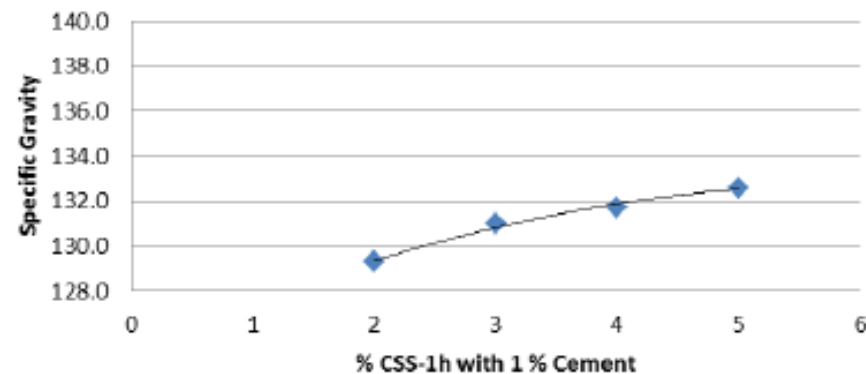
**Stability VS % CSS-1h
(Slag 2A Type Aggregate)**



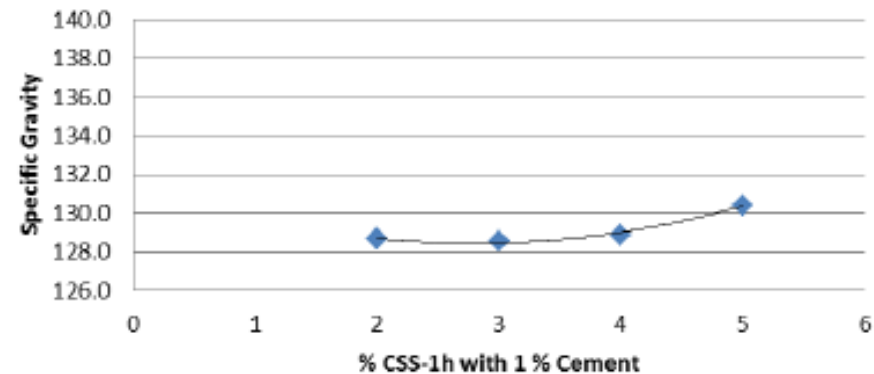
**Stability VS % CSS-1h
(2A Type Aggregate)**



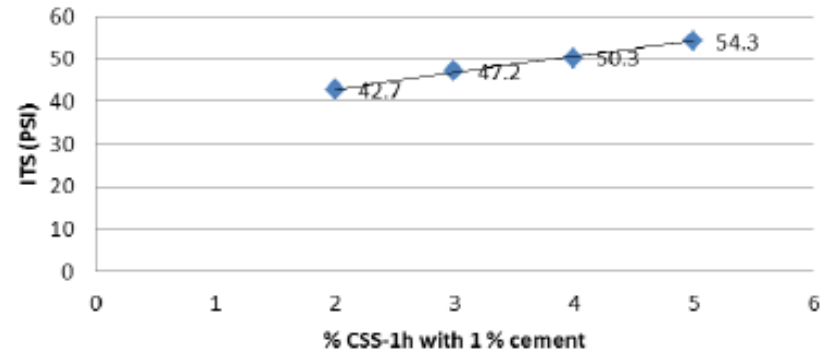
**Specific Gravity VS % CSS-1h
(Slag 2A Type Aggregate)**



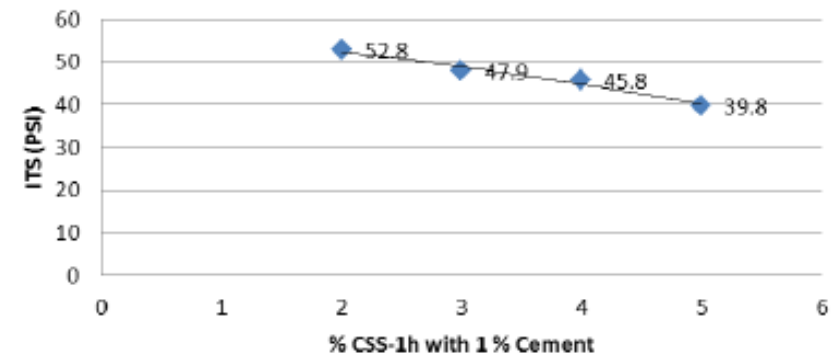
**Specific Gravity VS % CSS-1h
(2A Type Aggregate)**



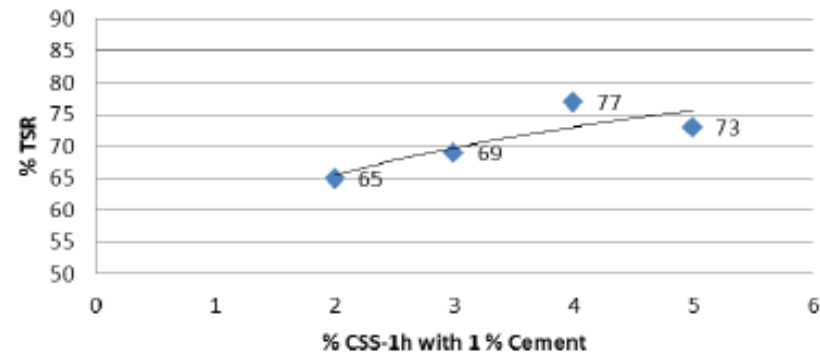
**Pub 242 RT 46 Slag Section Design
DRY ITS VS % Emulsion**



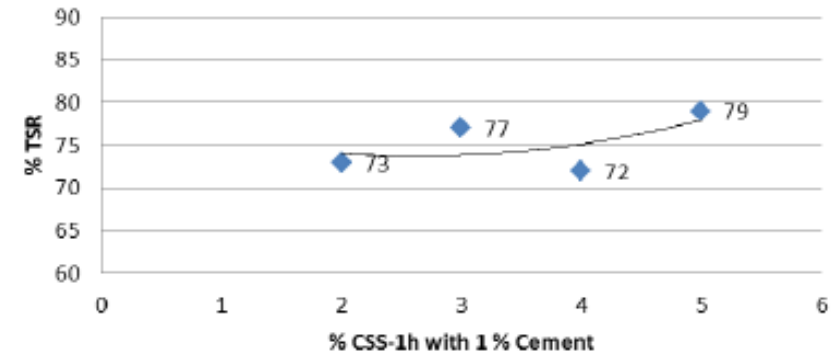
**Pub 242 RT 46 2A Design Section
DRY ITS VS % Emulsion**



**Pub 242 RT 46 Slag Design
% TSR VS % Emulsion**



**Pub 242 RT 46 2A Design
% TSR VS % Emulsion**





SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES

Noble County Indiana

22 km / year (3 years)

8" (200 mm) depth

- Avoid penetrating sub-base

3" (75 mm) steel slag (Duraberm) addition

- EAF / LMF Blend
- 0 X 37.5 mm
- Autoclave expansion 5 to 10%

Calcium Chloride binder versus emulsion

Various final surface(s)



Slag Addition - Triaxial Data

	Unconfined Compression	
	No Aging	28 Day
Existing Roadway	23.0 psi	46.5 psi
W/ 30% Blend	26.4 psi	80.9 psi
W/ 40% Blend	39.5 psi	85.3 psi
W/ 50% Blend	57.5 psi	90.3 psi
W/ 60% Blend	61.8 psi	96.0 psi

Testing

	CBR			
	Penetration		Swell	IDT
	0.1	0.2		
Roadway	10.1	13.5		
Blend (Roadway w/slag)	44.3	60.5		
Blend w/ 3% CaCl	68.5	73.8	0.153	2.049
Blend w/ 3% Emulsion	83.2	96.9	0.262	2.115



Tailgating



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES

Blending / Liquid Binder



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES

Cost: \$94,000 - \$188,000 USD / km



SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES

Cost Breakdown

➤ 8" (200 mm) Depth with 2 liter CaCl / m²

➤ Base

➤ \$18,400 USD / km (6.7 m wide)

➤ With Triple Chip and Seal / Fog Seal

➤ \$42,077 USD / km

➤ With 1.5" Overlay

➤ \$56,744 USD / km

➤ 8" (200 mm) Depth with 4 liter emulsion / m²

➤ Base 4" (100 mm add)

➤ \$31,250 USD / km (6.1 m wide)

➤ With Double Chip and Seal

➤ \$46,875 USD / km

Traditional FDR

\$94,000 - \$188,000 USD / km

Traditional Reconstruction

\$188,000 - \$312,000 USD / km

Questions?

SECONDARY ROAD RECLAMATION UTILIZING STEEL SLAG AGGREGATES



Thank You

