

## Winneshiek County Frac Sand Haul Route Pavement Analysis

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## **Design Objective**

- Evaluate the current pavement condition on potential haul routes for hydraulic fracturing sand mining in Winneshiek County, Iowa
- Determine the extent of pavement deterioration due to the estimated additional mining truck traffic
- Estimate the future pavement rehabilitation costs due to the added mining truck traffic

#### Background

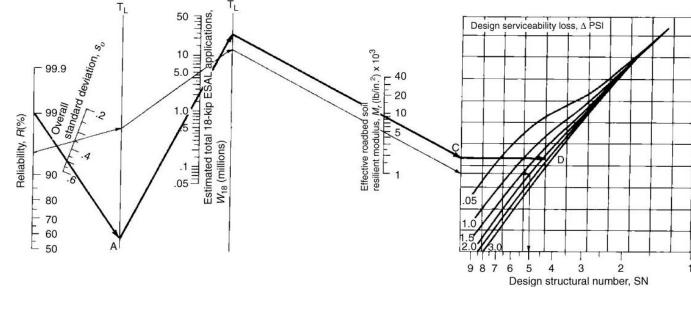
- As the frac sand mining industry is growing fast in Midwest, Winneshiek County considers potential frac sand mining development in their community. Prior to a development plan, Winneshiek County has requested an impact study from the lowa Initiative for Sustainable Communities and students and faculty from University of Iowa College of Engineering
- In CEE 4560: Pavement Engineering course at the University of Iowa, students were divided into three groups to investigate different types of existing pavements with Portland Cement Concrete (PCC), PPC with asphalt overlay and asphalt on potential truck routes, U.S. Route 52 and Big Canoe Road in the north of Decorah, in Winneshiek County
- First, each group conducted literature reviews on similar case studies in other States to better understand the potential impact of increased truck traffic on the roads.
- Second, they evaluated the properties of the subgrade materials that support pavements from underneath by performing laboratory testing such as the California Bearing Ratio (CBR) test. Based on the laboratory results, they used AASHTO soil classification system to determine its suitability for a pavement subgrade.
- Lastly, AASHTO 93 design guide and M-E software were utilized to analyze the traffic impact by increased truck traffic from sand mines. Based on these results, recommended options for future pavement construction due to sand mine development were generated based on the expected Equivalent Standard Axle Loads (ESALs).

#### **Big Canoe** Road

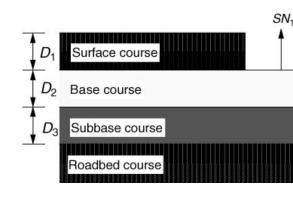
#### **Pavement Information Pavement Information**

- Reconstructed in 2008 Constructed in 1964
- 5 inches Hot Mix • 10 inch concrete slab Asphalt (HMA) on 5 on 6 inch rolled stone inches cold-in-place base recycled asphalt on 6 Pavement Condition inches rolled stone Index measured to be • base 20 (100 is best, 0 is worst, <55 is sealed every year considered "poor")
- Cracks have been since 2008, pavement is in relatively good condition





 $\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN + 1) - 0.20 + \dots$ 



**Pavement Engineering Class, Spring 2015** 

College of Engineering - Department of Civil and Environmental Engineering

#### **US – 52** (Concrete)



(1961)

**Pavement Information** 

• Constructed in 1961,

rehabilitated in 2012

• 10 in. concrete slab on

6 in. rolled stone base

7.5 inch HMA overlay

of concrete (2012)

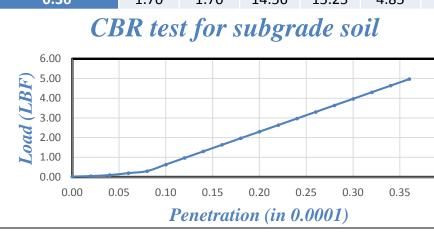
after crack and seating

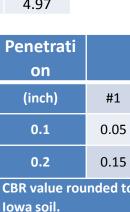
- Pavement is in urgent need of rehabilitation
- 5" HMA on 5" CIF Recycled HMA 7.5" HMA Overlay

### California Bearing Ratio (CBR) Test

This test evaluated the properties of the subgrade soils which lie underneath the existing pavement. CBR test results were used to check its suitability for potential pavement construction.

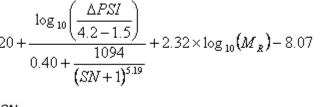
CBR Test Data (in 0.0001")								
				Boring #5	5			
Penetration	Lo	ad	Load	(LBF)	Stress (psi)			
(inch)	Trial #1	Trial #2	Trial #1	Trial #2	Trial #1	Trial #2	Avg.	
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	
0.02	0.30	0.30	0.00	0.00	0.00	0.00	0.05	
0.04	0.40	0.55	0.00	0.00	0.00	0.00	0.10	
0.06	0.65	0.70	0.00	0.00	0.00	0.00	0.20	
0.08	0.70	0.80	0.56	1.25	0.19	0.42	0.30	
0.10	0.85	0.90	1.56	2.25	0.52	0.75	0.63	
0.12	0.90	1.00	2.56	3.25	0.85	1.08	0.97	
0.14	1.00	1.10	3.56	4.25	1.19	1.42	1.30	
0.16	1.05	1.15	4.56	5.25	1.52	1.75	1.63	
0.18	1.15	1.20	5.56	6.25	1.85	2.08	1.97	
0.20	1.20	1.30	6.56	7.25	2.19	2.42	2.30	
0.22	1.25	1.30	7.56	8.25	2.52	2.75	2.63	
0.24	1.30	1.45	8.56	9.25	2.85	3.08	2.97	
0.26	1.35	1.50	9.56	10.25	3.19	3.42	3.30	
0.28	1.40	1.50	10.56	11.25	3.52	3.75	3.63	
0.30	1.50	1.60	11.56	12.25	3.85	4.08	3.97	
0.32	1.60	1.60	12.56	13.25	4.19	4.42	4.30	
0.34	1.70	1.70	13.56	14.25	4.52	4.75	4.63	
0.36	1.70	1.70	14.56	15.25	4.85	5.08	4.97	

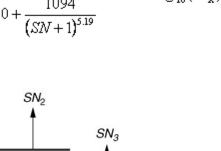




## **AASHTO 93 Structural Design Guide**

#### **AASHTO Highway Flexible Pavement Design Chart**

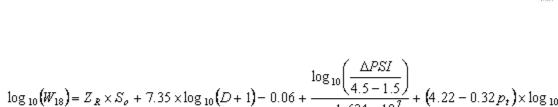




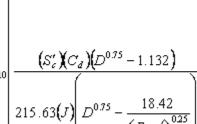
# oncrete Elastic Modulus, E<sub>c</sub> (10<sup>6</sup>psi

**AASHTO Highway Rigid Pavement Design Chart** 

Effective Modulus of Subgrade

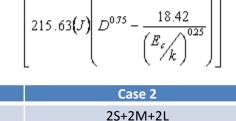


 $1 + \frac{1.624 \times 10^7}{(D+1)^{8.46}}$ 



 $\begin{array}{l} R = 95\% \left( Z_{R} = -1.645 \right) E^{\star} \mbox{ Application of reliability} \\ \begin{tabular}{l} & & \\ \end{tabular} \\ PSI = 4.2 & -2.5 & = 1 \\ W_{10} = 5.1 \pm 10^6 \mbox{ (18 kip E} \end{tabular} \end{tabular}$ 

olution: D=10.0 inche



	Case 1	Case 2	ļ
	S+M+L	2S+2M+2L	
ESALs (current)	658440	658440	
ESALs (increased due to mine)	820460	982480	
Traffic due to mine	162020	324040	
Slab Thickness (current)	6.745 (7.0) in	6.745 (7.0) in	
Slab Thickness (increased due to mine)	7.045 (7.5) in	7.245 (7.5) in	

k = 72 pci

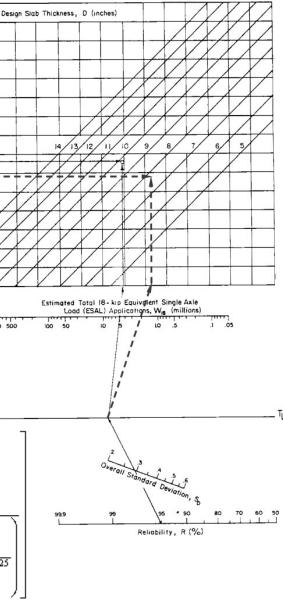
Ec = 5 x 10<sup>6</sup> psi

S' = 650 psi J = 3.2





CBR					
	#2	Avg.	Max		
5	0.07	0.06	0.15		
5	0.16	0.15	0.15		
to 3 for typical number for					



Case 3 3S+3M+3L 658440 1144500 486060 6.745 (7.0) in

7.495 (7.5) in

### **Mechanistic-Empirical Pavement Design Guide**

v D				ement D:\Pavement.dg	рх			AASHTO
Design Iı	nputs							
Design Life:	-	Existin	g construction:	May, 2016	Cli	imate Data	a 42.554, -92	.401
-	e: AC over JPC		ent construction:	June, 2017	•	ources (La	· · · · ·	
		Traffic	opening:	September	r, 2017			
Design Str	ructure						Traffic	
	Layer type	Material Type	Thickness (in	.): Volumet	ric at Constru	ction:		Heavy Tru
Layer 1 Flexible : D	Flexible	Default asphalt concrete	7.0	Effective content (	11	1.6	Age (year)	(cumulati
Layer 3 Non-stabil	PCC	JPCP Default	6.0	Air voids		.0	2017 (initial) 2027 (10 years)	4,000 6,939,75
Layer 5 Subgrade	NonStabilized	A-1-a	10.0				2037 (20 years)	13,879,5
	NonStabilized Subgrade	Crushed gravel A-7-6	6.0 Semi-infinite	_				
		<u> </u>	Serii-Inninte					
Design O	utputs							
Distress	Prediction Su	immary						
					) Specified	Rel	iability (%)	Criterion
	Dist	ress Type			bility			Satisfied
Torminal	IPI (in /mile)			Target 172.00	Predicted 130.35	<b>Targe</b> 90.00		Pass
	IRI (in./mile) nt deformation - t	otal pavement (in.)		0.75	0.44	90.00		Pass Pass
		+ Alligator) (percer		15	6.67	-	-	Pass
	al cracking (ft/mil			1000.00	258.89	90.00	100.00	Pass
	nsverse cracking			15.00	3.83	90.00		Pass
	n-up fatigue crac	• /		25.00	1.45	90.00		Pass
	own fatigue crack	• • •		2000.00 0.50	1939.93 0.44	90.00 90.00		Pass Pass
	nt deformation - A			0.50	U.44 HMA Layer 1: Layer 1 Flexi			rass
Distress Charts	Predicted IRI	Predic	ted Total Rutting (Perman	ent Deformation)	10000000		r Curve HMA Layer 1	
180	172	0.9 <b>E</b> 0.7	0.75		100000			
E 140 - Threshol		130.40	Threshold Value     @ Specified Reliability	0.44	100000- 2 10000-			×14 °F
100 @ 50%R 80 Initial IRI: 63-		95.50 95.4 	- @ 50% Reliability	0.32	<u>ت</u> دوور			● 70 年 ● 100 年
60 40				14 15 18	10			▶130 %
Total Crac	6 8 10 12 14 Pavement Age (years) cking (Reflective + Alliga		2 4 6 8 10 12 Pavement Age (ye nermal Cracking: Total Lei	ars)	-7 -6	-5 -4 -3	-2 -1 0 1 2 (Reduced Time(sec))	3 4
£ 16	15	1200 aliono	1000		7,		Curve HMA Layer 1	
2 12 2 12 2 10 — Threshol 2 8 @ 50%R	ld Value		- Threshold Value		6			
0 8 @50%R	eliability	6.67 ti 600	•• @ Specified Reliability • @ 50% Reliability	258.8				+ 14 % ★40 %
2-		200			-			×70 ↔ ×100 ↔
0 2 4	6 8 10 12 14 Pavement Age (years)	16 18 20 0	2 4 6 8 10 12 Pavement Age (ye		-2		*	130 %
Traffic Inputs	sentation of Traffic Input	5			-5-10 20 30		0 70 80 90 100 110 Temperature (°F)	) 120 130
Initial two-way AA		4,000 Percent of	f trucks in design direction (%): f trucks in design lane (%):	50.0 95.0	LOC	Viscosi	y Curve HMA Layer 1	
	-	Operation	nal speed (mph)	60.0		log(log(viscosity)) = Ar	o + UTSo; Ao = 11.01, VTSo = -3.701	
	Distribution by Vehicle C		Truck Distribution by H	our	sity (cP))			
(%) (%) (%)	52.3%	tion (%)	8 AM 5.0%	PM	10 points	+	+	+
So Contraction of the second s			1 AM	8 PM 3 1 %				
20 15.1%	9%		2.3%		1 2.69 2.7	2.71 2.72 Lo	2,73 2,74 2,75 2,76 a(Temperature(@R])	2.71 2.78
0 0.2%	1.0% 4.6% 0	2.2% 0.0% 0	M 6 AM 9 AM 12 PM 3 PM	6.PM 9.PM 24	2 18 2 16-		ng (Reflective + Alligator) old Value @ 50% Reliability	
4 S	Vehicle Class		AxlesperTruck by Vehicl		0 14- 0 12- 10-			
	wth Factor by Venicle Clas	4.5 4 Singl	e					
(%) (%)		3.5 STride	m		0 2 <sup>1200</sup>		king: Total Length vs. Time ••• @ Specified Reliability @ 50%	Reliability
Growth and a state of the of t	LE LEW				E 1000-			
-30		1.5						
-50 4 5	6 7 8 9 10	11 12 13 0.5			200 0.1 2.0 9/2017 8/2019 8	4.0 6.0 /2021 8/2023 8	8.0 10.0 12.0 14.0 2025 8/2027 8/2029 8/2031	16.0 19.0 20.4 8/2033 8/2035 8/20
	Vehicle Class		Vehicle Class			P	avement Age (years/date)	
	Rec	omr	men	de	<b>d O</b>	)ni	inn	2
				<b>u</b> C		Υ		
Assu	med 12' l	ane 🔽						
with 4	4' wide sh	noulder	Option 1	64.3	Option		the state of the second state of the Second	otion 3
	wide lane)		Asphalt Overlay of 4 in	ches.	Asphalt Overlay	of 4 inches.		<pre>kisting PCC with Asph of 5 inches.</pre>
,	,		<b>\$224</b> C		¢004	007		
• 16'* <del>(</del>	5280' (1mil	e) =	\$234,6	0/	<b>\$234</b> ,	667	\$29	6,333
84480	0 sf = 9387	yards^2		SECOND A	850 ( <b>1</b> 446)	MANDON	Wei Carrow Mining	OVERLAY
			HMA 4" OVERLAY.	ARCAN STOCKEL	HMA 4" OVE	HLAY.	HMA 5	UVERLAY
	l" overlay	cost:	EXISTING 8" PC	C	EXISTING	B" PCC	EXISTING	8" PCC C&S
\$25 /	/yards^2		STONE BASE 6	п.	STONE BA	SE 6"	STON	BASE 6"
		100	STONE DASE U		STUNE DA	OL U	SION	DAOL U
-	- 11 1			and the second	Star Para Star And	ALCONTRACT.		TO LE STAR & S
For 5	5" overlay ⁄yards^2	cost:	UNSTABILIZED S	)IL	UNSTABILIZ	ED SOIL	UNSTAB	ILIZED SOIL