ASPHALT

THE SMOOTH QUIET RIDE

ASPHALT 100% RECYCLABLE

2017 Local Roads Workshop

PaveXpress Update

March 2017

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

MICHIGAN RIDES ON US Asphalt.

PaveXpress

What's New With PaveXpress?

NATIONAL ASPHALT PAVEMENT ASSOCIATION

SAPA
State Asphalt Pavement Associations

ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

MICHIGAN RIDES ON US Asphalt.

What Is PaveXpress?

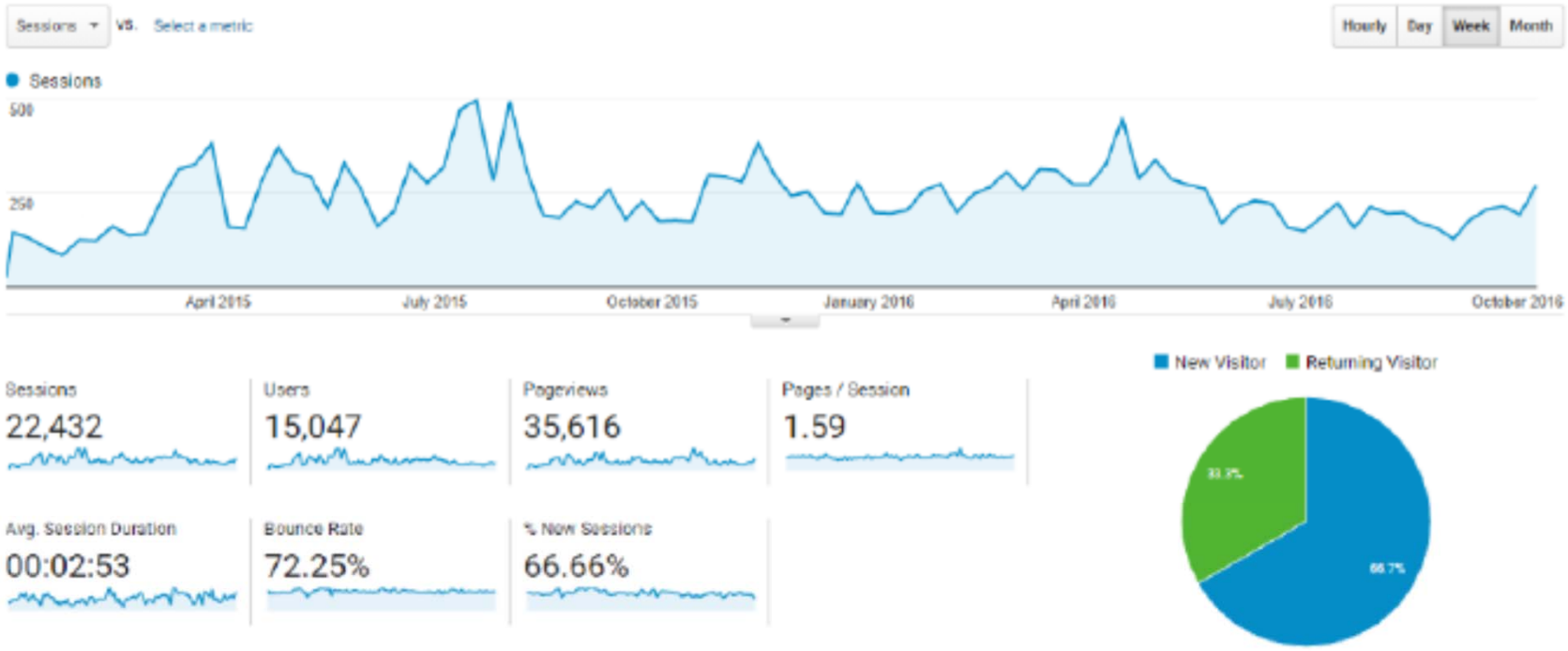
A free, online tool to help you create and evaluate pavement designs and overlays using key engineering inputs, based on the AASHTO 1993 and 1998 supplement pavement design process.

- ✓ **Free** — no cost to use
- ✓ **Accessible** – via the web and mobile
- ✓ **Standards Based** - AASHTO and/or industry standard practices
- ✓ **User-friendly** – streamlined UI/UX
- ✓ **Collaborative** - share, save, and print
- ✓ **Interactive** – help and resources

Who is it for?

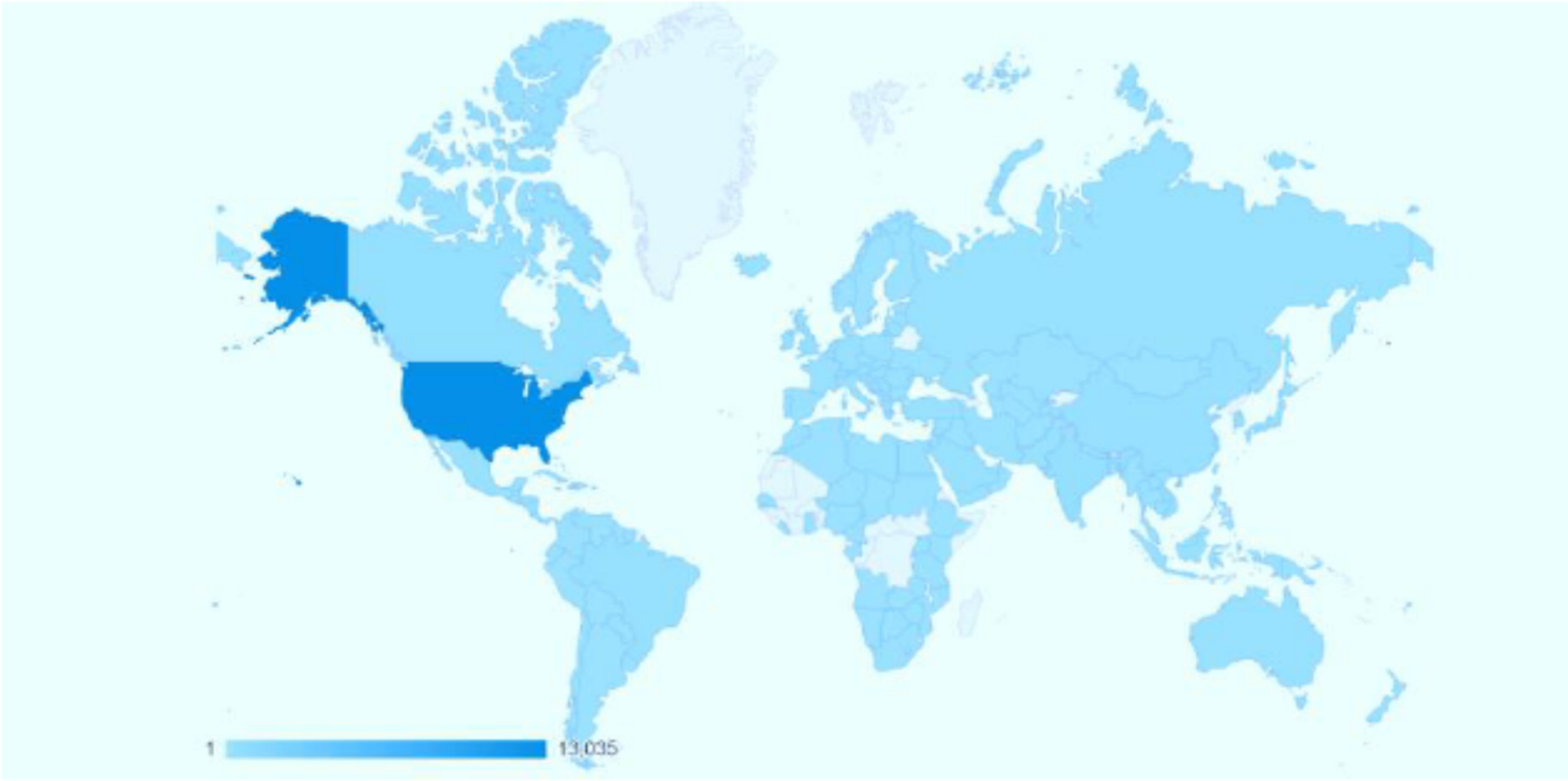
- Local Government Agencies
- A/E/C Firms
- Engineering Students
- State Transportation Agencies
- FHWA
- Foreign Companies and Governments

Over 15,000 users with 1/3 returning

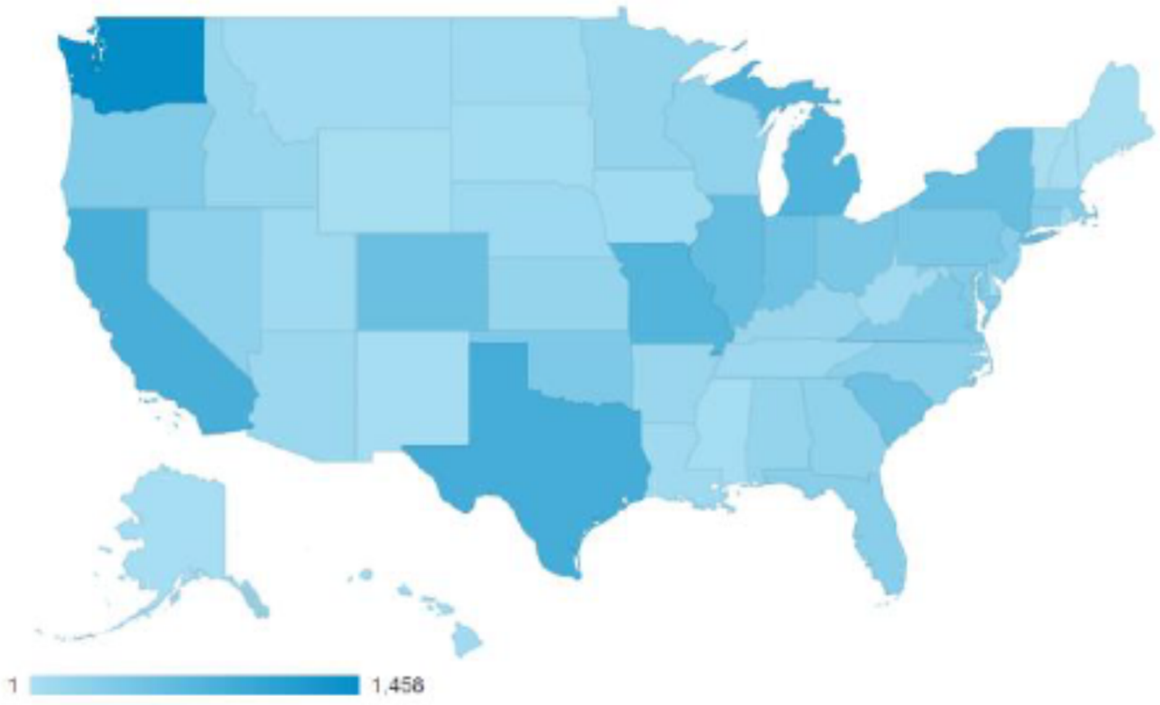


Since Jan 1 2015

Users from 157 countries -> 66% from U.S.



Users from every state in the U.S.



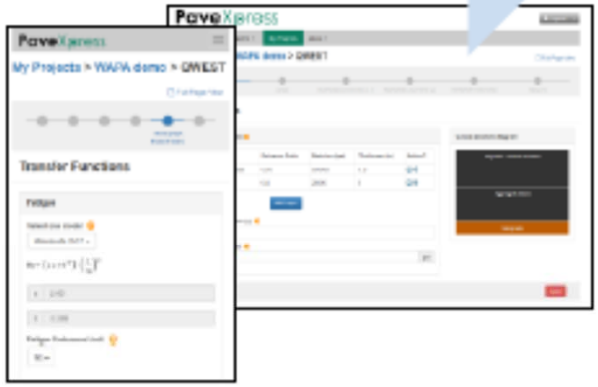
What does it all mean?

The evolution of PaveXpress....

- New Flexible
- New Rigid
- Parking Lots

- Cost Module
- LEA Module
- UI/UX Update

- Overlay design
- Condition Survey
- NDT



Approach: Technical

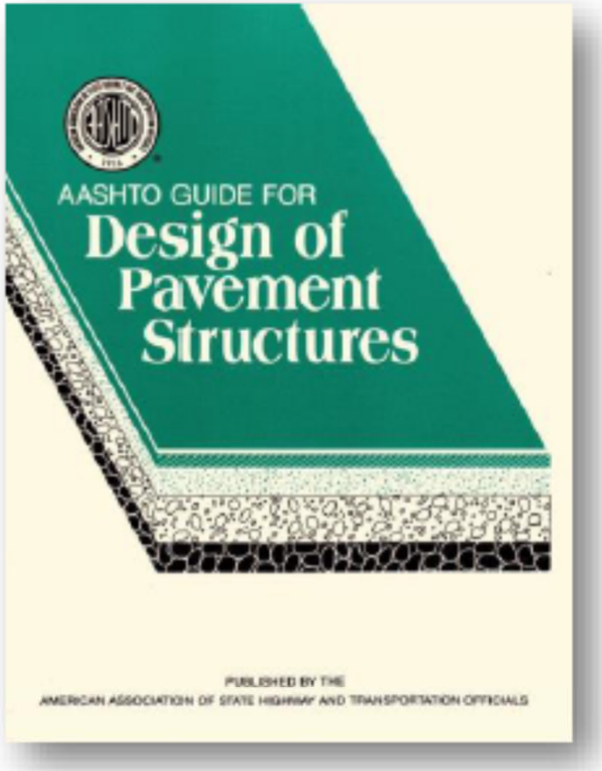
Provide technically sound designs using:

- Flexible: AASHTO '93
- Rigid: AASHTO '93 w/ '98 Supplement
- Parking lot guidance (Flexible only)

Use industry accepted standards and guidance

Linkages to State and Local guidance

Linkages to Pavement Interactive



What came with Version 2.0

AC Overlay Design for Flexible Pavement Rehabilitation Only

Evaluation Methods for Existing AC Pavement

- Condition Survey
- Non-Destructive Deflection Testing

Includes Questions on Coring and Milling

- Delamination/Stripping
- Top-Down or Bottom-Up Cracking

Adjustment to Existing Pavement Layer Coefficients

User Stories for Version 3.0

Cost Module

As a _____ **I want to** be able to apply material unit costs and quantities for a new or rehabilitation pavement design **so that I can** estimate how much the design will cost.

Layered Elastic Analysis (ME)

As a _____ **I want to** model the deflection, stress and strain of a pavement structure **so that I can** determine how many load cycles my pavement can sustain

As a _____ **I want to** model how various loading configurations impact the deflection, stress and strain of my pavement structure **so that I can** determine how these loads impact my pavement

Empirical and Mechanistic

Empirical

Based on observation and experience to derive equations to describe the behavior of the pavement.

(AASHO Road Test)

Mechanistic

Uses stresses, strains and deflections within a pavement structure to mathematically model behavior.

(Layered analysis)

Benefits to a mechanistic-empirical pavement analysis and design

- ✓ A design check against methodologies such as AASHTO 93.
- ✓ The assessment of different load magnitudes and configurations.
- ✓ The ability to examine how new materials behave in a pavement structure.
- ✓ Achieve a better understanding of construction-related factors.
- ✓ The accommodation of environmental and aging effects on materials.

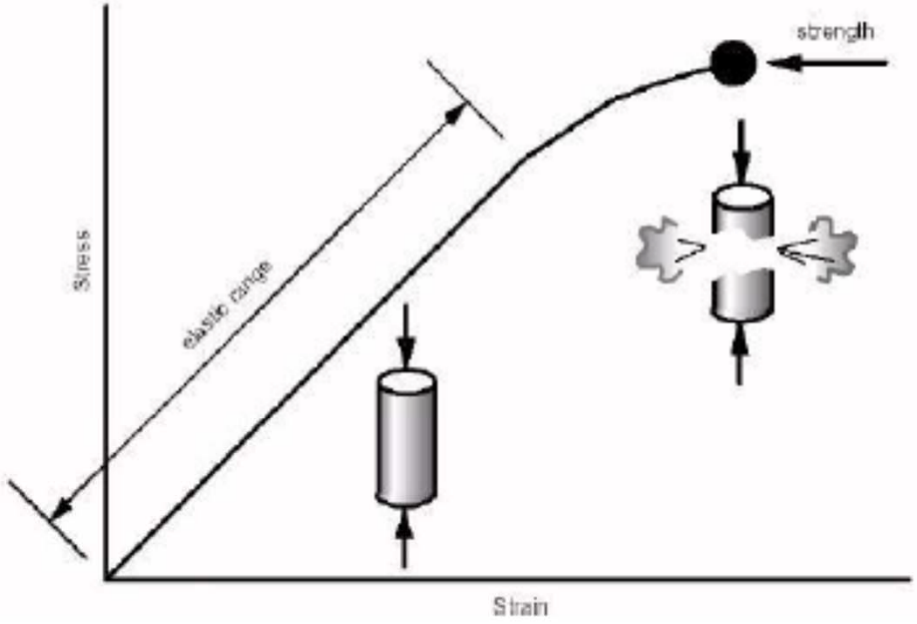
Layered Elastic Analysis

- The algorithms which are now contained within PaveXpress originated from a program called Everstress.
- Everstress was originally developed from the WESLEA layered elastic analysis program (provided by the Waterways Experiment Station, U.S. Army Corps of Engineers).
- The pavement system is multi-layered elastic using multiple wheel loads (up to 20). The program can analyze a pavement structure containing up to five layers.

Key inputs to make it happen

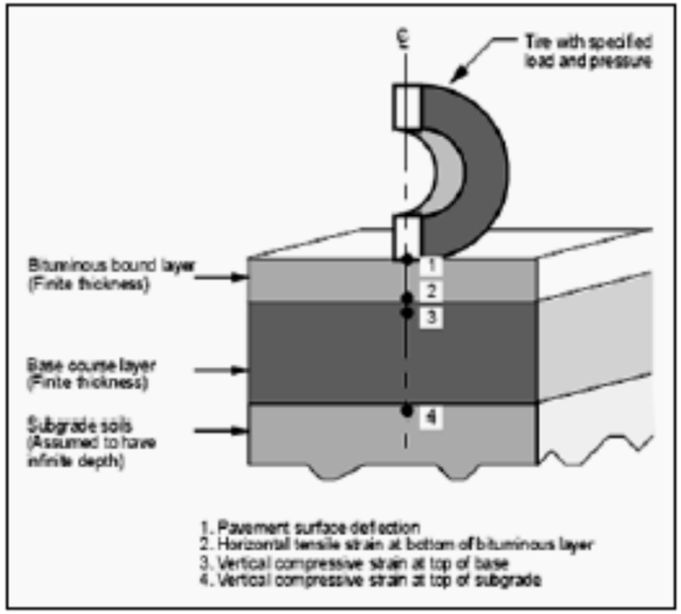
The modulus of elasticity (E) and Poisson's ratio (μ) are used to define each layer in the pavement along with the layer thickness. The calculations estimate the pavement responses of stresses, strains, and deflections. The major assumptions include:

- Materials remain in their elastic range; hence, the use of modulus of elasticity.
- Layers extend infinitely in the horizontal direction and semi-infinitely for the subgrade depth.
- Tire contact areas are circular.



Measure critical responses of the pavement

Location	Response
Pavement surface (1)	Vertical deflection (good estimate of overall pavement strength)
Bottom of HMA layer (2)	Horizontal tensile strain (prediction of fatigue life)
Top of intermediate layer (3) (base or subbase)	Vertical compressive strain (prediction of rutting)
Top of subgrade (4)	Vertical compressive strain (prediction of rutting)

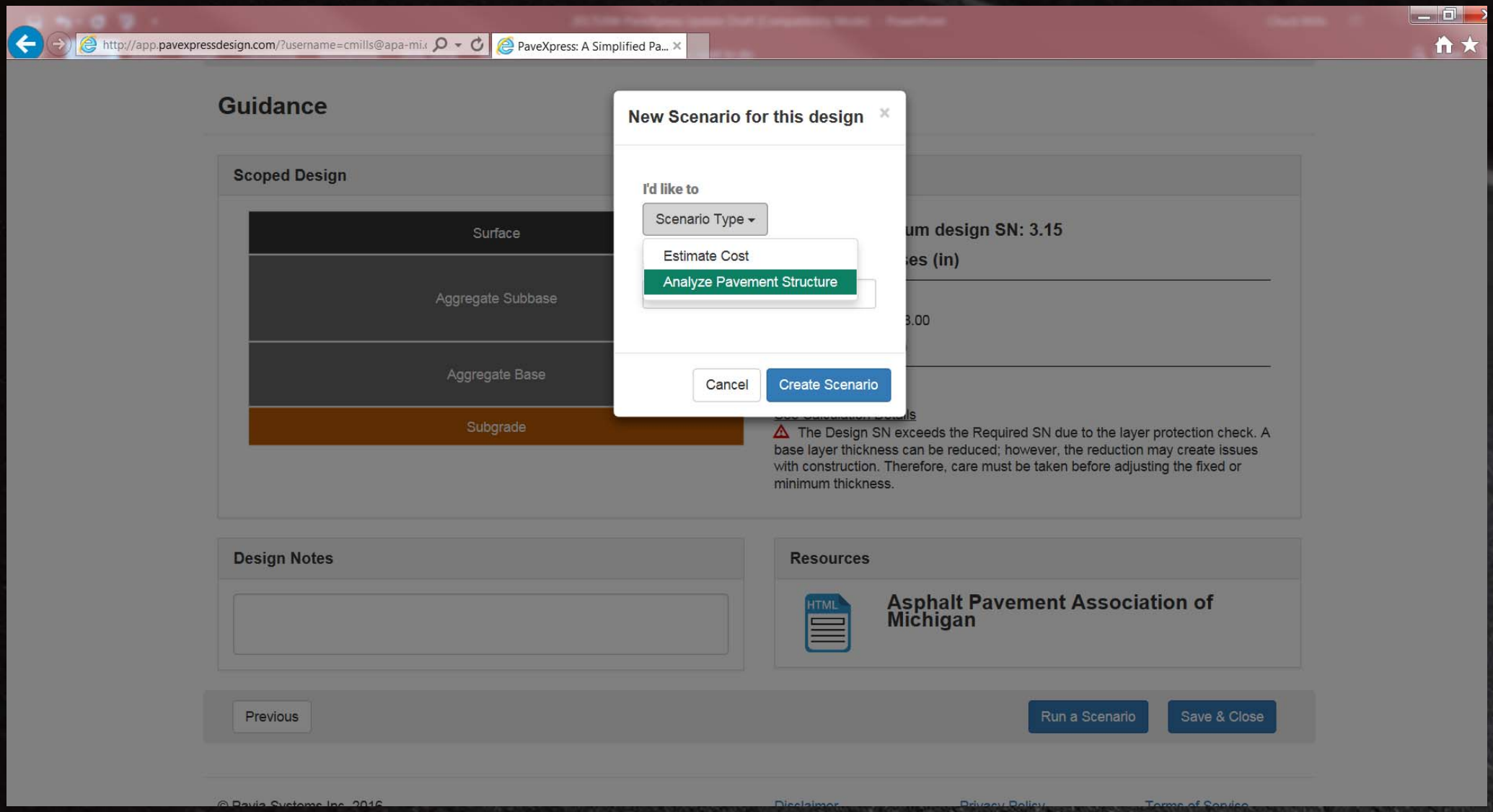


Failure Criteria – Transfer Functions

Fatigue Cracking

Rutting

For estimating the loads to failure for a specific type of strain, there are two general models typically used for both estimating fatigue cracking and rutting (image is for illustration of rutting only).



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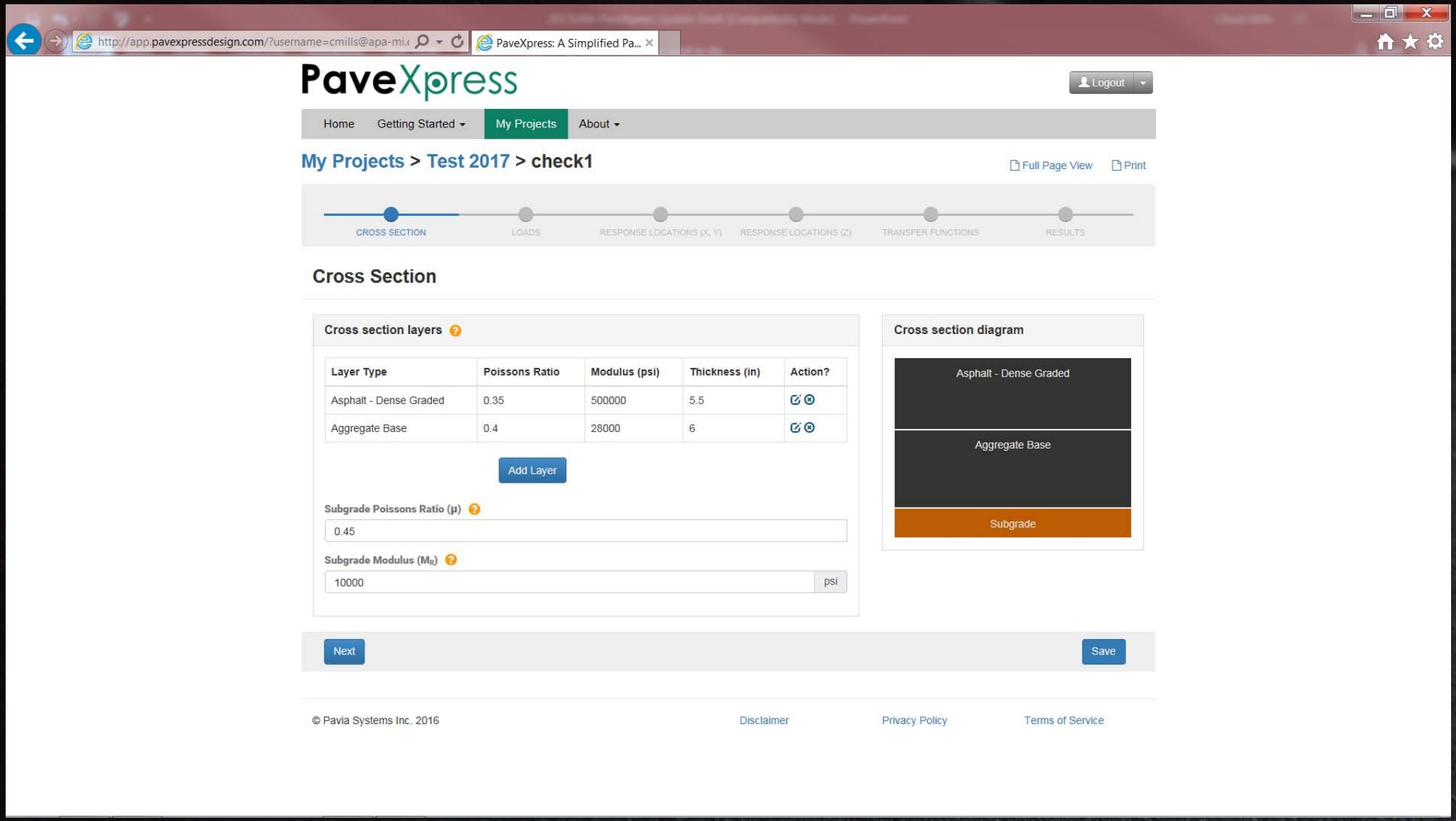

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PaveXpress: A Simplified Pa...

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CROSS SECTION — LOADS — RESPONSE LOCATIONS (X, Y) — RESPONSE LOCATIONS (Z) — TRANSFER FUNCTIONS — RESULTS

Loads

Load data

Load Configuration

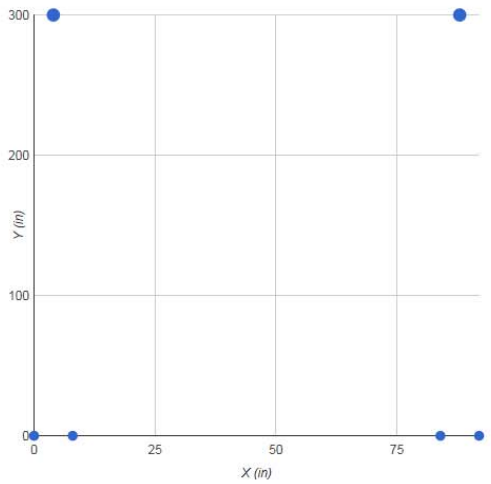
Preset Load Configuration(s)

3S2

Load #	Location (x, y)	Load (lbs)	Tire pressure (psi)	Action?
1	0", 0"	5000	140	
2	8", 0"	5000	140	
3	84", 0"	5000	140	
4	92", 0"	5000	140	
5	4", 300"	8000	140	
6	88", 300"	8000	140	

Add Load

Load plot



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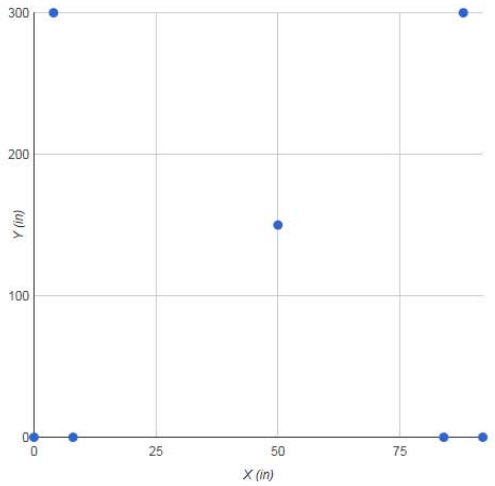
Response Locations (X, Y)

Response (X, Y) data

Location (X, Y)	Action?
50", 150"	
0", 0"	N/A
8", 0"	N/A
84", 0"	N/A
92", 0"	N/A
4", 300"	N/A
88", 300"	N/A

Add Load Response

Response (X, Y) plot



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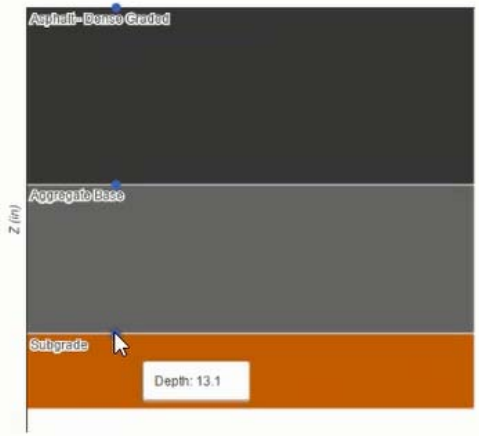
Response Locations (Z)

Response (Z) data

Layer	Depth (in)	Strain	Action?
Asphalt - Dense Graded	0		N/A
Asphalt - Dense Graded	7.1		N/A
Subgrade	13.1		N/A

Add Response

Response (Z) plot



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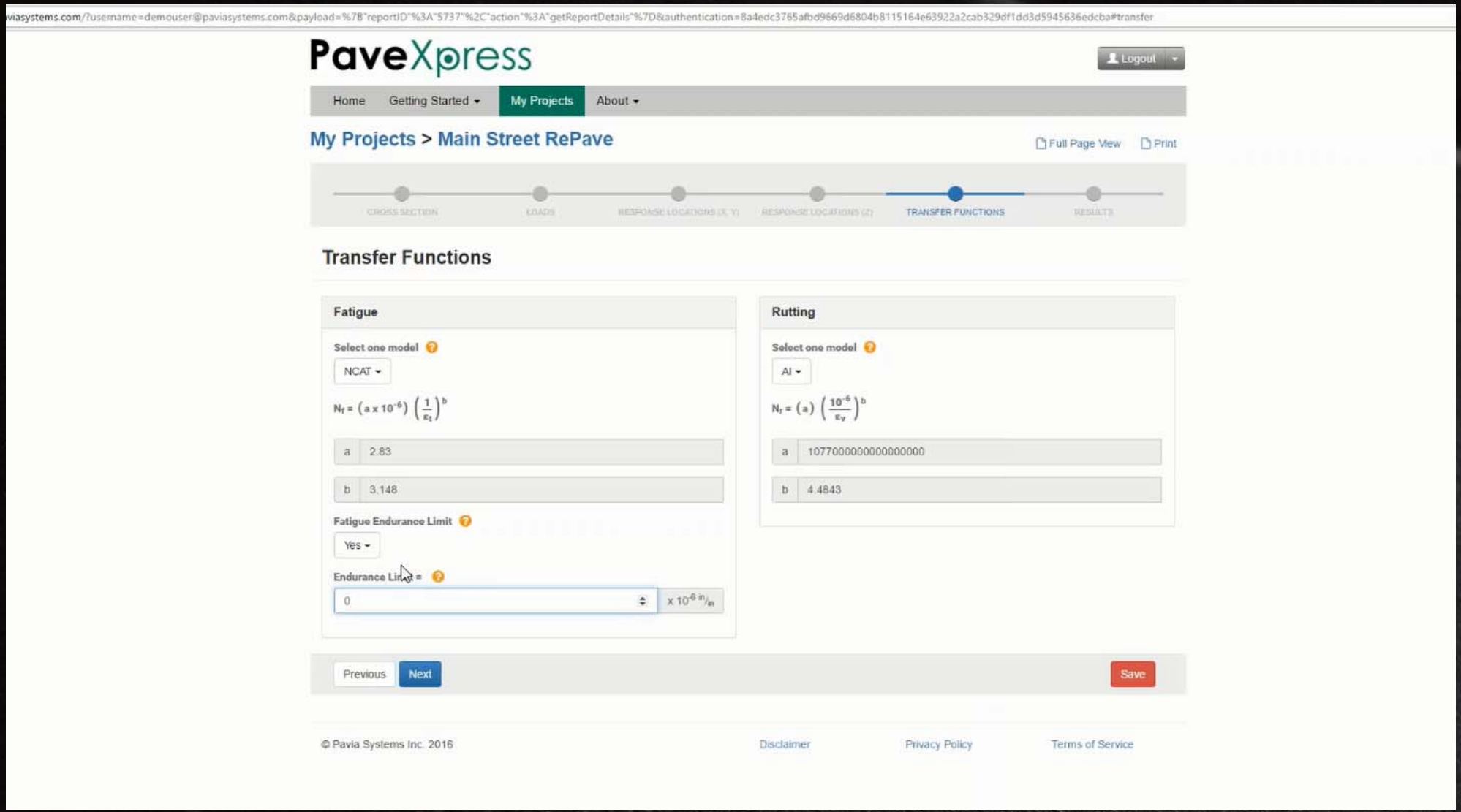
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Home
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My Projects
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My Projects > Main Street RePave
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Print
CROSS SECTION
LOADS
RESPONSE LOCATIONS (X, Y)
RESPONSE LOCATIONS (Z)
TRANSFER FUNCTIONS
RESULTS
Transfer Functions
Fatigue
Select one model
NCAT
$N_f = (a \times 10^{-6}) \left(\frac{1}{\varepsilon_t}\right)^b$
a 2.83
b 3.148
Fatigue Endurance Limit
Yes
Endurance Limit =
0
x 10^{-6} in/in
Rutting
Select one model
AI
$N_f = (a) \left(\frac{10^{-6}}{\varepsilon_v}\right)^b$
a 1077000000000000000
b 4.4843
Previous
Next
Save
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CROSS SECTION — LOADS — RESPONSE LOCATIONS (X, Y) — RESPONSE LOCATIONS (Z) — TRANSFER FUNCTIONS — RESULTS

Results

Summary

Pavement Life

N_f = 826052 cycles (occurs at 84, 0, 0)

N_r = 1121314 cycles (occurs at 92, 0, 13.1)

Critical Strains

Direction	Location	Layer	Depth	Normal Strain (10^{-6})
X	(4, 300)	Asphalt - Dense Graded	0 "	-197
Y	(84, 0)	Asphalt - Dense Graded	0 "	228
Z	(92, 0)	Subgrade	13.1 "	470

Download all results as .csv

Plot

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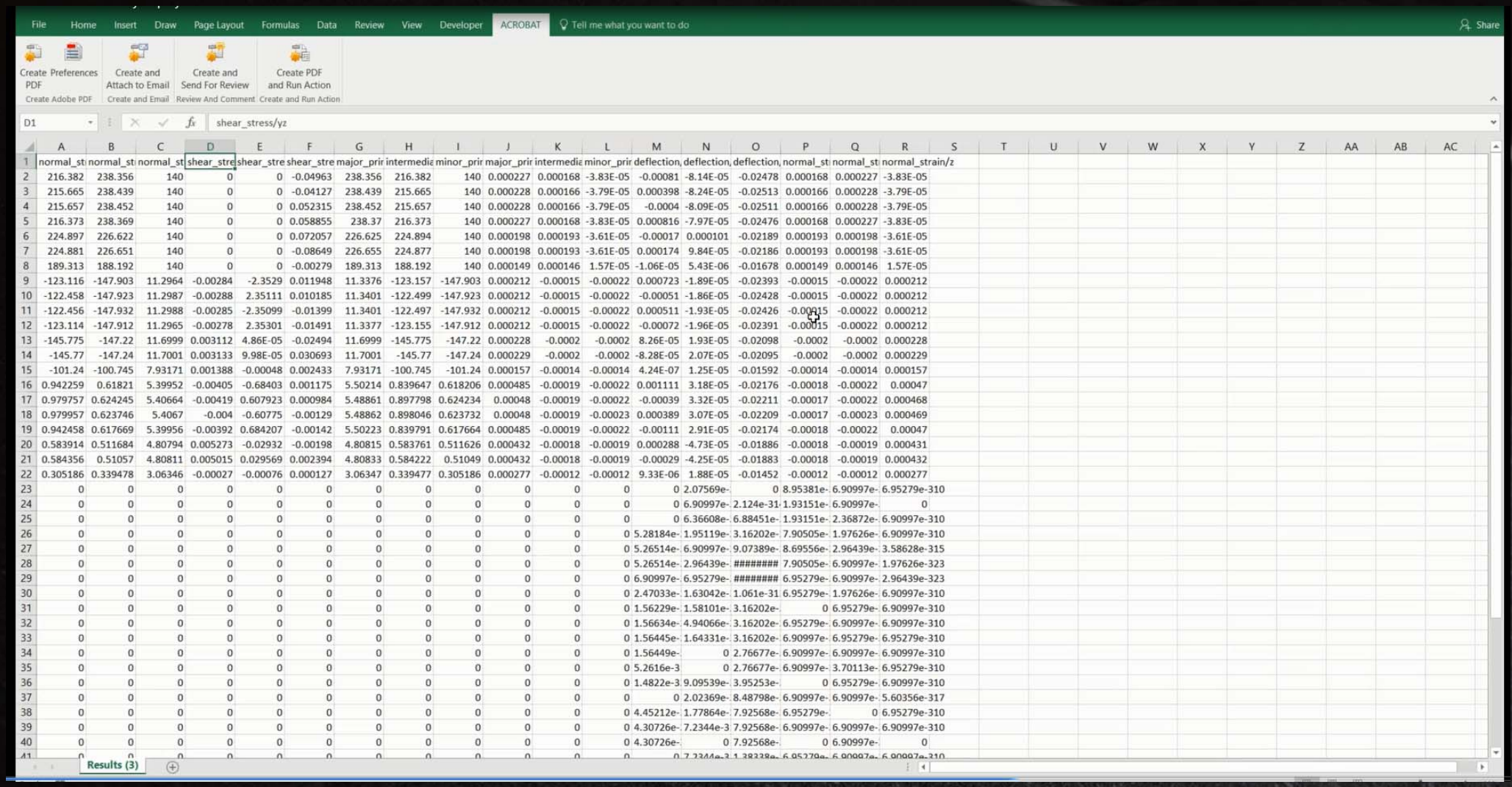

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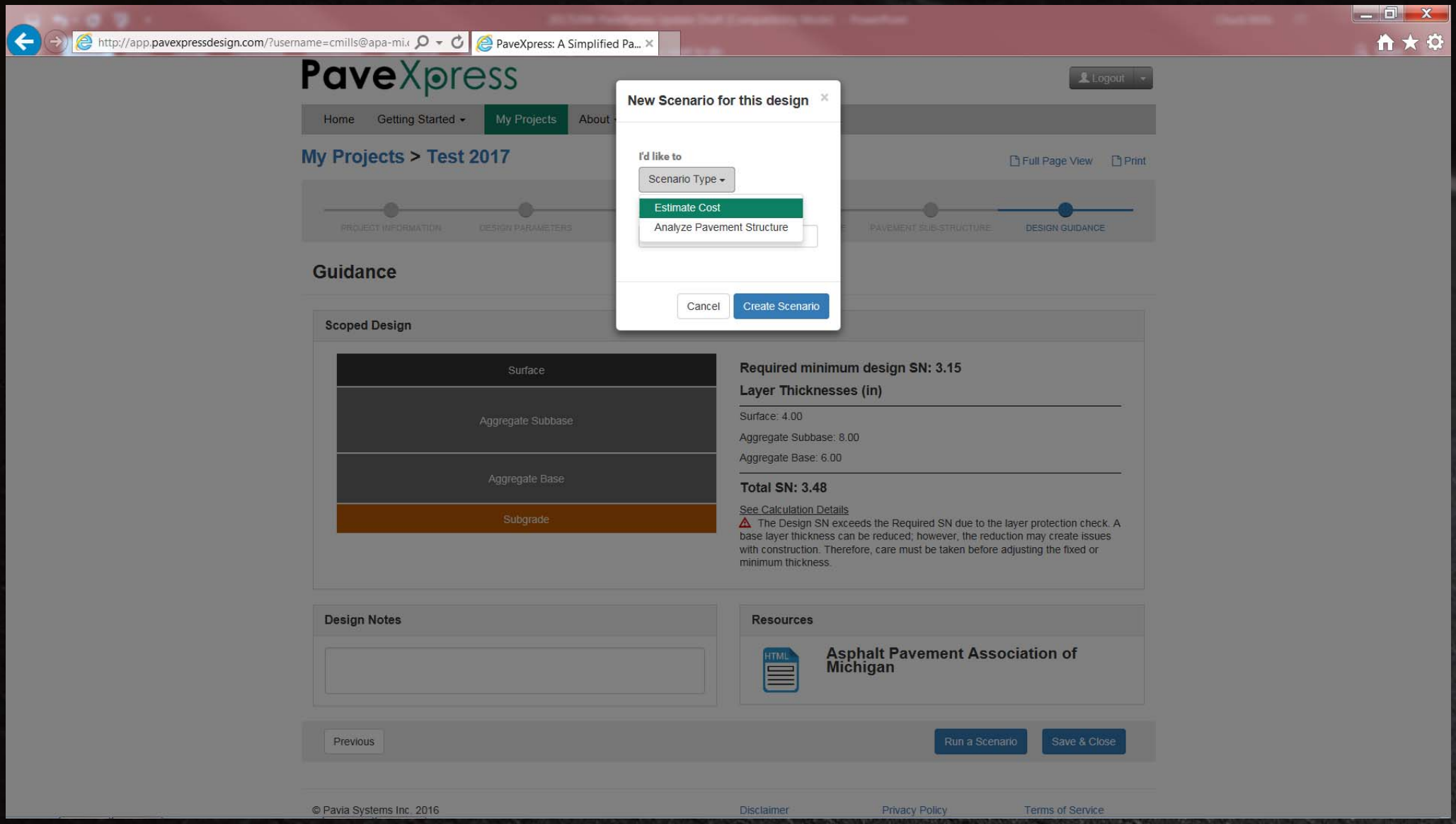
D1 shear_stress/yz

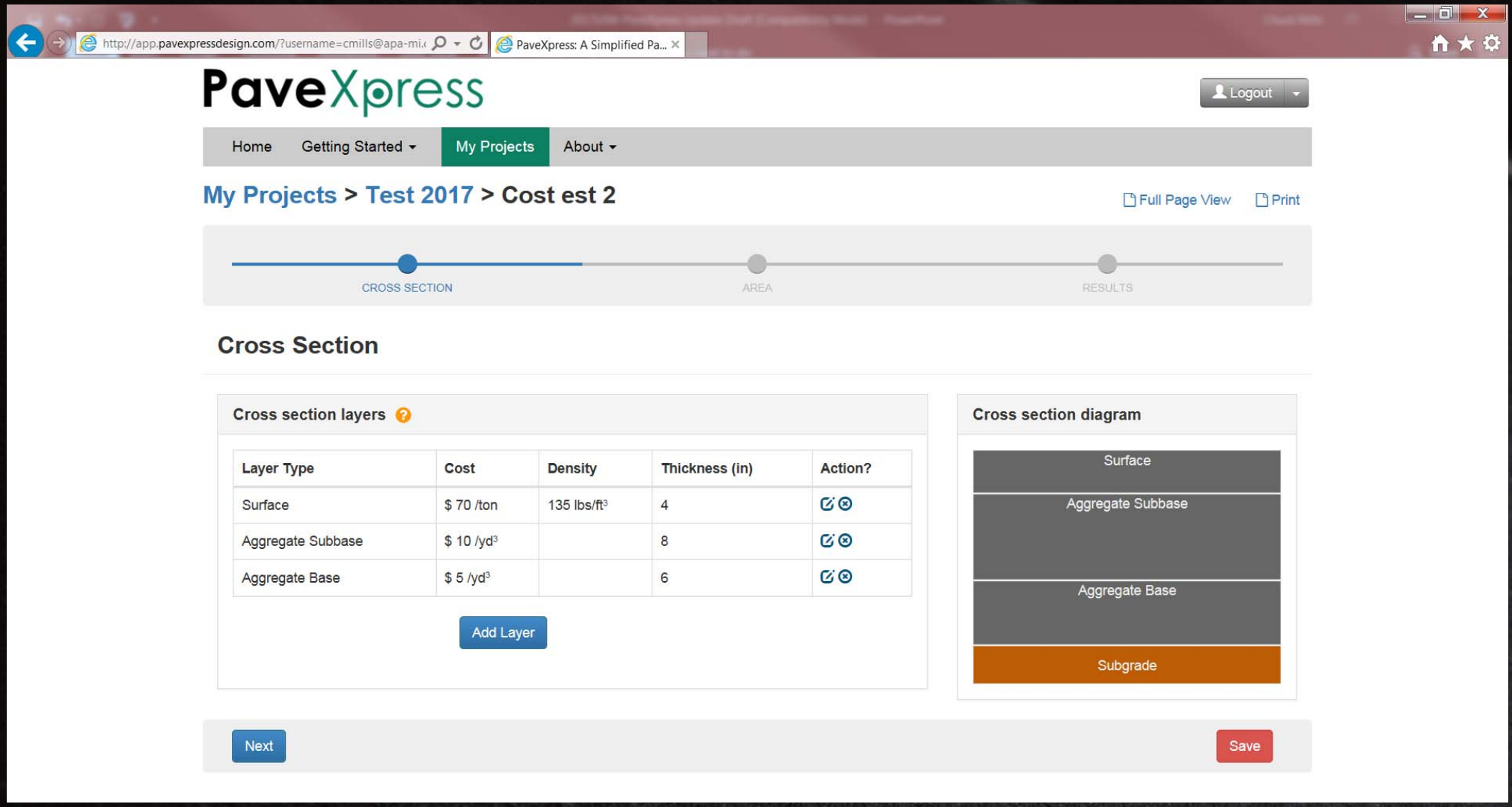
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1	normal_st	normal_st	normal_st	shear_stre	shear_stre	shear_stre	major_prir	intermedia	minor_prir	major_prir	intermedia	minor_prir	deflection	deflection	deflection	normal_st	normal_st	normal_strain/z											
2	216.382	238.356	140	0	0	-0.04963	238.356	216.382	140	0.000227	0.000168	-3.83E-05	-0.00081	-8.14E-05	-0.02478	0.000168	0.000227	-3.83E-05											
3	215.665	238.439	140	0	0	-0.04127	238.439	215.665	140	0.000228	0.000166	-3.79E-05	0.000398	-8.24E-05	-0.02513	0.000166	0.000228	-3.79E-05											
4	215.657	238.452	140	0	0	0.052315	238.452	215.657	140	0.000228	0.000166	-3.79E-05	-0.0004	-8.09E-05	-0.02511	0.000166	0.000228	-3.79E-05											
5	216.373	238.369	140	0	0	0.058855	238.37	216.373	140	0.000227	0.000168	-3.83E-05	0.000816	-7.97E-05	-0.02476	0.000168	0.000227	-3.83E-05											
6	224.897	226.622	140	0	0	0.072057	226.625	224.894	140	0.000198	0.000193	-3.61E-05	-0.00017	0.000101	-0.02189	0.000193	0.000198	-3.61E-05											
7	224.881	226.651	140	0	0	-0.08649	226.655	224.877	140	0.000198	0.000193	-3.61E-05	0.000174	9.84E-05	-0.02186	0.000193	0.000198	-3.61E-05											
8	189.313	188.192	140	0	0	-0.00279	189.313	188.192	140	0.000149	0.000146	1.57E-05	-1.06E-05	5.43E-06	-0.01678	0.000149	0.000146	1.57E-05											
9	-123.116	-147.903	11.2964	-0.00284	-2.3529	0.011948	11.3376	-123.157	-147.903	0.000212	-0.00015	-0.00022	0.000723	-1.89E-05	-0.02393	-0.00015	-0.00022	0.000212											
10	-122.458	-147.923	11.2987	-0.00288	2.35111	0.010185	11.3401	-122.499	-147.923	0.000212	-0.00015	-0.00022	-0.00051	-1.86E-05	-0.02428	-0.00015	-0.00022	0.000212											
11	-122.456	-147.932	11.2988	-0.00285	-2.35099	-0.01399	11.3401	-122.497	-147.932	0.000212	-0.00015	-0.00022	0.000511	-1.93E-05	-0.02426	-0.00015	-0.00022	0.000212											
12	-123.114	-147.912	11.2965	-0.00278	2.35301	-0.01491	11.3377	-123.155	-147.912	0.000212	-0.00015	-0.00022	-0.00072	-1.96E-05	-0.02391	-0.00015	-0.00022	0.000212											
13	-145.775	-147.22	11.6999	0.003112	4.86E-05	-0.02494	11.6999	-145.775	-147.22	0.000228	-0.0002	-0.0002	8.26E-05	1.93E-05	-0.02098	-0.0002	-0.0002	0.000228											
14	-145.77	-147.24	11.7001	0.003133	9.98E-05	0.030693	11.7001	-145.77	-147.24	0.000229	-0.0002	-0.0002	-8.28E-05	2.07E-05	-0.02095	-0.0002	-0.0002	0.000229											
15	-101.24	-100.745	7.93171	0.001388	-0.00048	0.002433	7.93171	-100.745	-101.24	0.000157	-0.00014	-0.00014	4.24E-07	1.25E-05	-0.01592	-0.00014	-0.00014	0.000157											
16	0.942259	0.61821	5.39952	-0.00405	-0.68403	0.001175	5.50214	0.839647	0.618206	0.000485	-0.00019	-0.00022	0.001111	3.18E-05	-0.02176	-0.00018	-0.00022	0.00047											
17	0.979757	0.624245	5.40664	-0.00419	0.607923	0.000984	5.48861	0.897798	0.624234	0.00048	-0.00019	-0.00022	-0.00039	3.32E-05	-0.02211	-0.00017	-0.00022	0.000468											
18	0.979957	0.623746	5.4067	-0.004	-0.60775	-0.00129	5.48862	0.898046	0.623732	0.00048	-0.00019	-0.00023	0.000389	3.07E-05	-0.02209	-0.00017	-0.00023	0.000469											
19	0.942458	0.617669	5.39956	-0.00392	0.684207	-0.00142	5.50223	0.839791	0.617664	0.000485	-0.00019	-0.00022	-0.00111	2.91E-05	-0.02174	-0.00018	-0.00022	0.00047											
20	0.583914	0.511684	4.80794	0.005273	-0.02932	-0.00198	4.80815	0.583761	0.511626	0.000432	-0.00018	-0.00019	0.000288	-4.73E-05	-0.01886	-0.00018	-0.00019	0.000431											
21	0.584356	0.51057	4.80811	0.005015	0.029569	0.002394	4.80833	0.584222	0.51049	0.000432	-0.00018	-0.00019	-0.00029	-4.25E-05	-0.01883	-0.00018	-0.00019	0.000432											
22	0.305186	0.339478	3.06346	-0.00027	-0.00076	0.000127	3.06347	0.339477	0.305186	0.000277	-0.00012	-0.00012	9.33E-06	1.88E-05	-0.01452	-0.00012	-0.00012	0.000277											
23	0	0	0	0	0	0	0	0	0	0	0	0	0	2.07569e-	0	8.95381e-	6.90997e-	6.95279e-310											
24	0	0	0	0	0	0	0	0	0	0	0	0	0	6.90997e-	2.124e-31	1.93151e-	6.90997e-	0											
25	0	0	0	0	0	0	0	0	0	0	0	0	0	6.36608e-	6.88451e-	1.93151e-	2.36872e-	6.90997e-310											
26	0	0	0	0	0	0	0	0	0	0	0	0	0	5.28184e-	1.95119e-	3.16202e-	7.90505e-	1.97626e-	6.90997e-310										
27	0	0	0	0	0	0	0	0	0	0	0	0	0	5.26514e-	6.90997e-	9.07389e-	8.69556e-	2.96439e-	3.58628e-315										
28	0	0	0	0	0	0	0	0	0	0	0	0	0	5.26514e-	2.96439e-	########	7.90505e-	6.90997e-	1.97626e-323										
29	0	0	0	0	0	0	0	0	0	0	0	0	0	6.90997e-	6.95279e-	########	6.95279e-	6.90997e-	2.96439e-323										
30	0	0	0	0	0	0	0	0	0	0	0	0	0	2.47033e-	1.63042e-	1.061e-31	6.95279e-	1.97626e-	6.90997e-310										
31	0	0	0	0	0	0	0	0	0	0	0	0	0	1.56229e-	1.58101e-	3.16202e-	0	6.95279e-	6.90997e-310										
32	0	0	0	0	0	0	0	0	0	0	0	0	0	1.56634e-	4.94066e-	3.16202e-	6.95279e-	6.90997e-	6.90997e-310										
33	0	0	0	0	0	0	0	0	0	0	0	0	0	1.56445e-	1.64331e-	3.16202e-	6.90997e-	6.95279e-	6.95279e-310										
34	0	0	0	0	0	0	0	0	0	0	0	0	0	1.56449e-	0	2.76677e-	6.90997e-	6.90997e-	6.90997e-310										
35	0	0	0	0	0	0	0	0	0	0	0	0	0	5.2616e-3	0	2.76677e-	6.90997e-	3.70113e-	6.95279e-310										
36	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4822e-3	9.09539e-	3.95253e-	0	6.95279e-	6.90997e-310										
37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.02369e-	8.48798e-	6.90997e-	6.90997e-	5.60356e-317										
38	0	0	0	0	0	0	0	0	0	0	0	0	0	4.45212e-	1.77864e-	7.92568e-	6.95279e-	0	6.95279e-310										
39	0	0	0	0	0	0	0	0	0	0	0	0	0	4.30726e-	7.2344e-3	7.92568e-	6.90997e-	6.90997e-	6.90997e-310										
40	0	0	0	0	0	0	0	0	0	0	0	0	0	4.30726e-	0	7.92568e-	0	6.90997e-	0										
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2344e-3	1.38338e-	6.95279e-	6.90997e-	6.90997e-310										

Results (3)



ASPHALT PAVEMENT ASSOCIATION OF MICHIGAN

MICHIGAN RIDES ON US Asphalt.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Cross Section
Cross section layers
Layer Type
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Density
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$ 70 /ton
135 lbs/ft3
4
Aggregate Subbase
$ 10 /yd3
8
Aggregate Base
$ 5 /yd3
6
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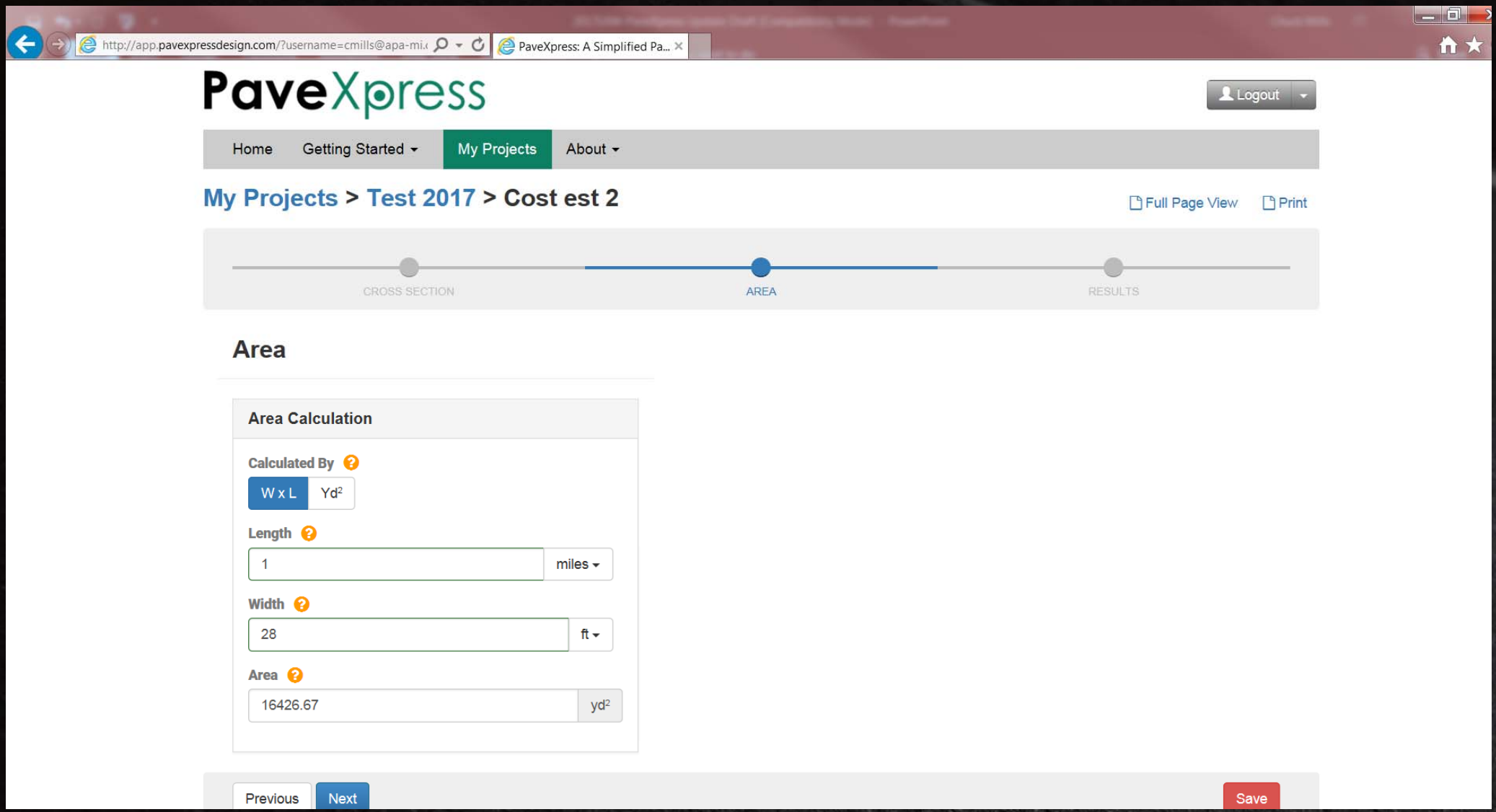
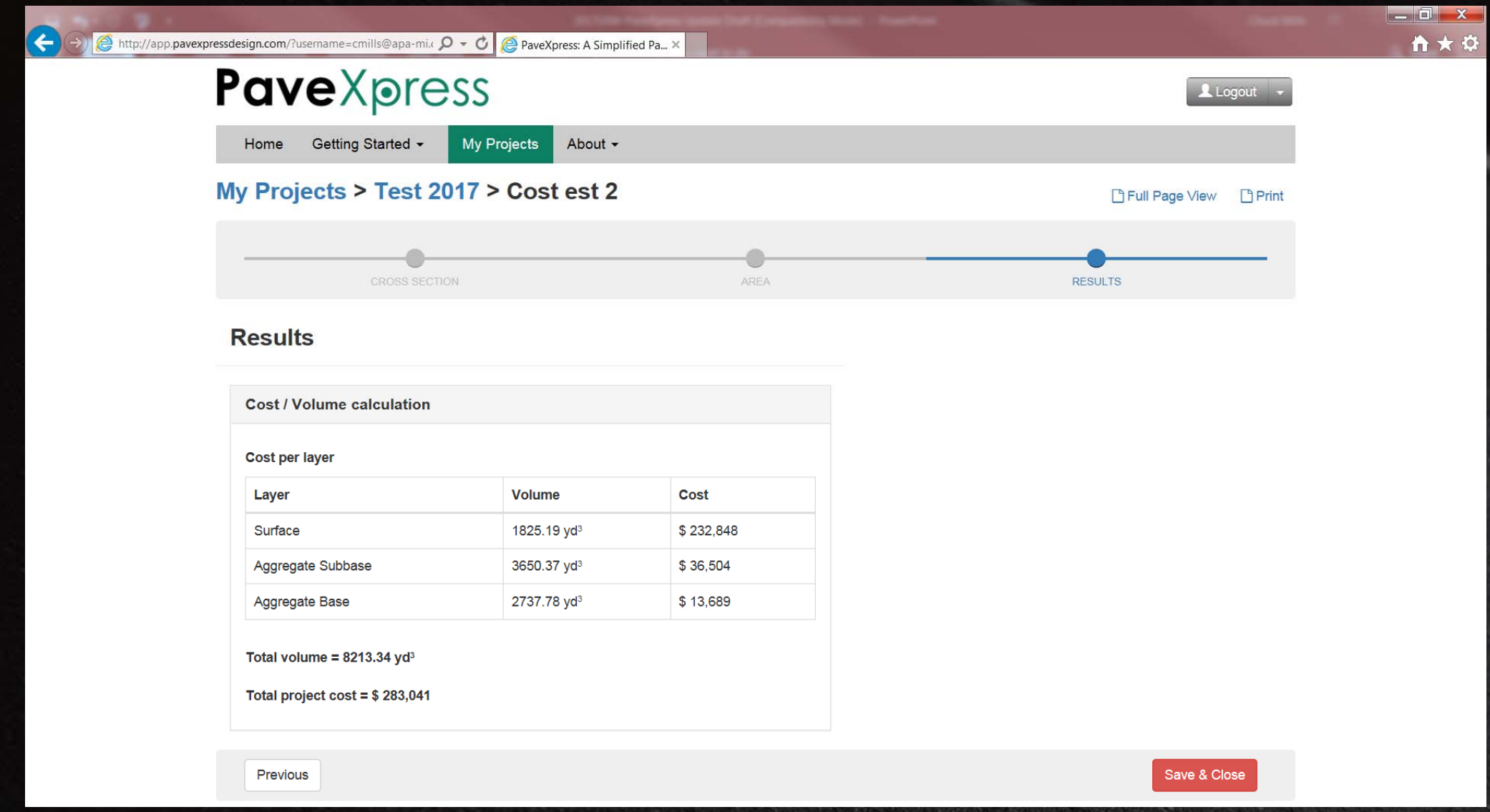
Cross section diagram
Surface
Aggregate Subbase
Aggregate Base
Subgrade
Next
Save





What's Next?

Pending upcoming modules:

- Integration with PerRoad
- LCCA framework (ie: RealCost)
- Porous Asphalt Pavement Design

Questions ??

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