PavementDesigner.org

Thickness Design and Cross Sections

MI – Concrete Pavement for Local Agencies Seminar

Southfield, MI

April 25, 2025

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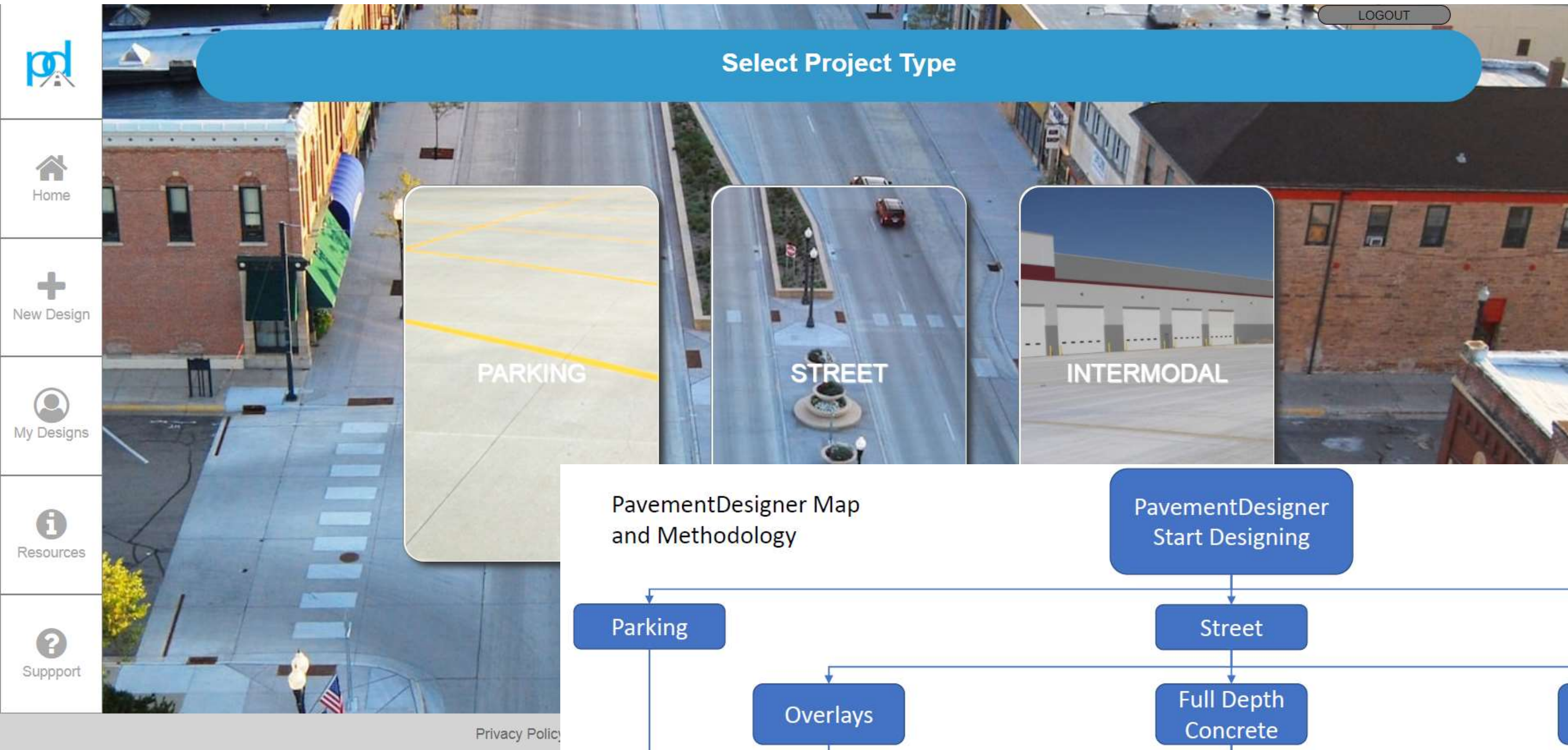
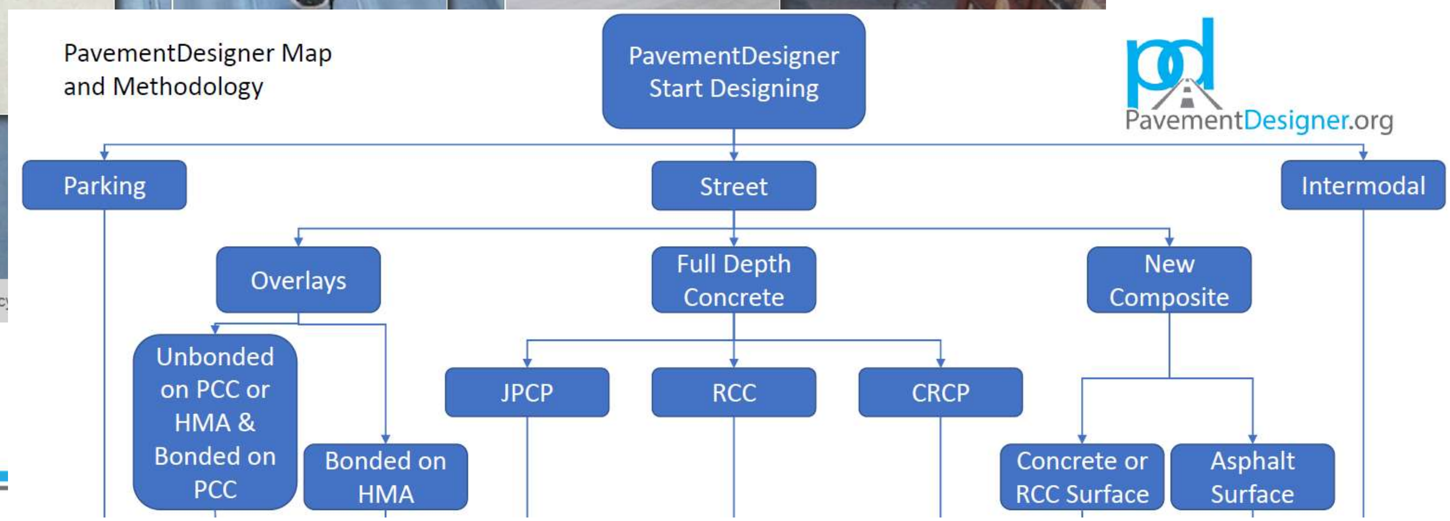
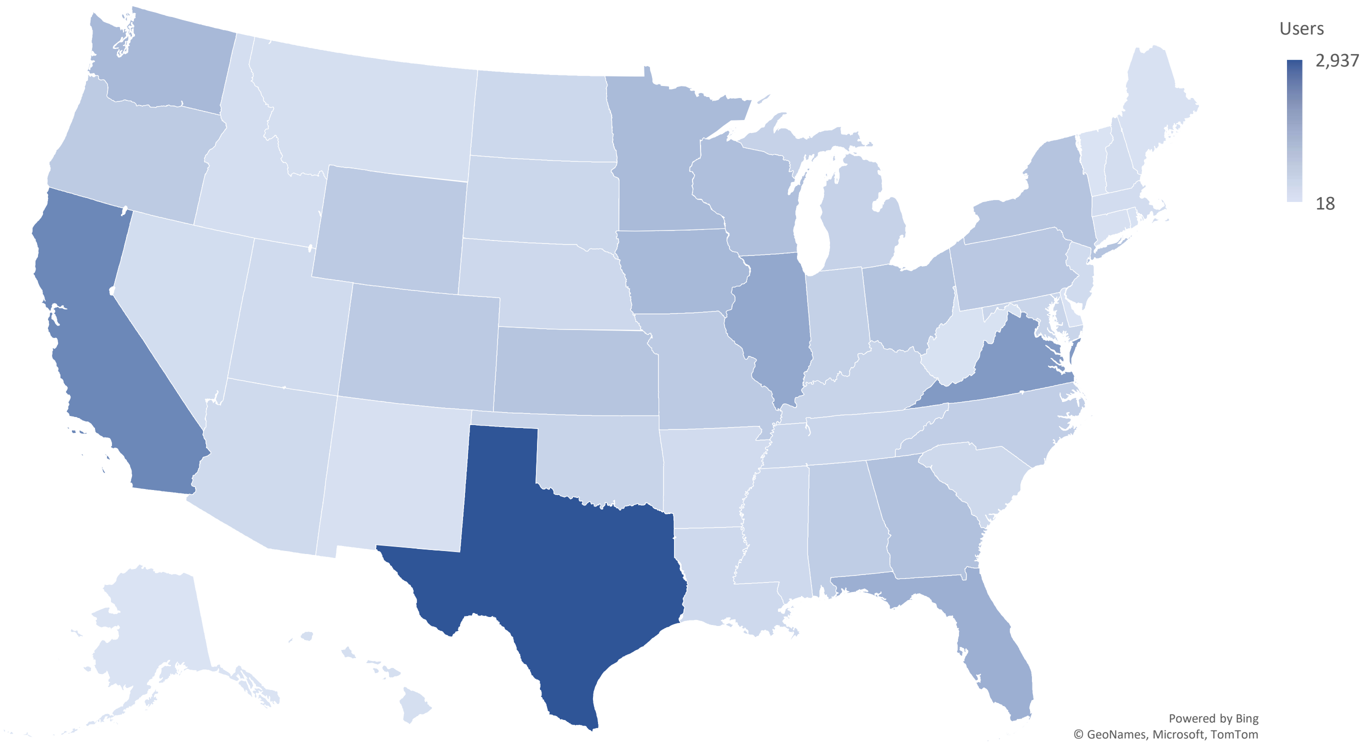
PavementDesigner





PavementDesigner User Metrics

PavementDesigner Users by State



Overview and Background

- ACPA, NRMCA, and PCA partnership, with a contribution from the RCC Council to develop a website application to design cement-based solutions for:
  - Streets and Local Roads
  - Parking Lots
  - Intermodal/Industrial Facilities
- Design guidance and tools for:
  - Jointed-Plain Concrete Pavements
  - Continuously Reinforce Concrete Pavement
  - Concrete Overlays
  - Composite Pavements
  - Roller Compacted Concrete
  - Cement Modified Soils
  - Cement-Treated Base
  - Full-Depth Reclamation

ACPA

NRMCA

PCA America's Cement Manufacturers™

RCC Pavement Council

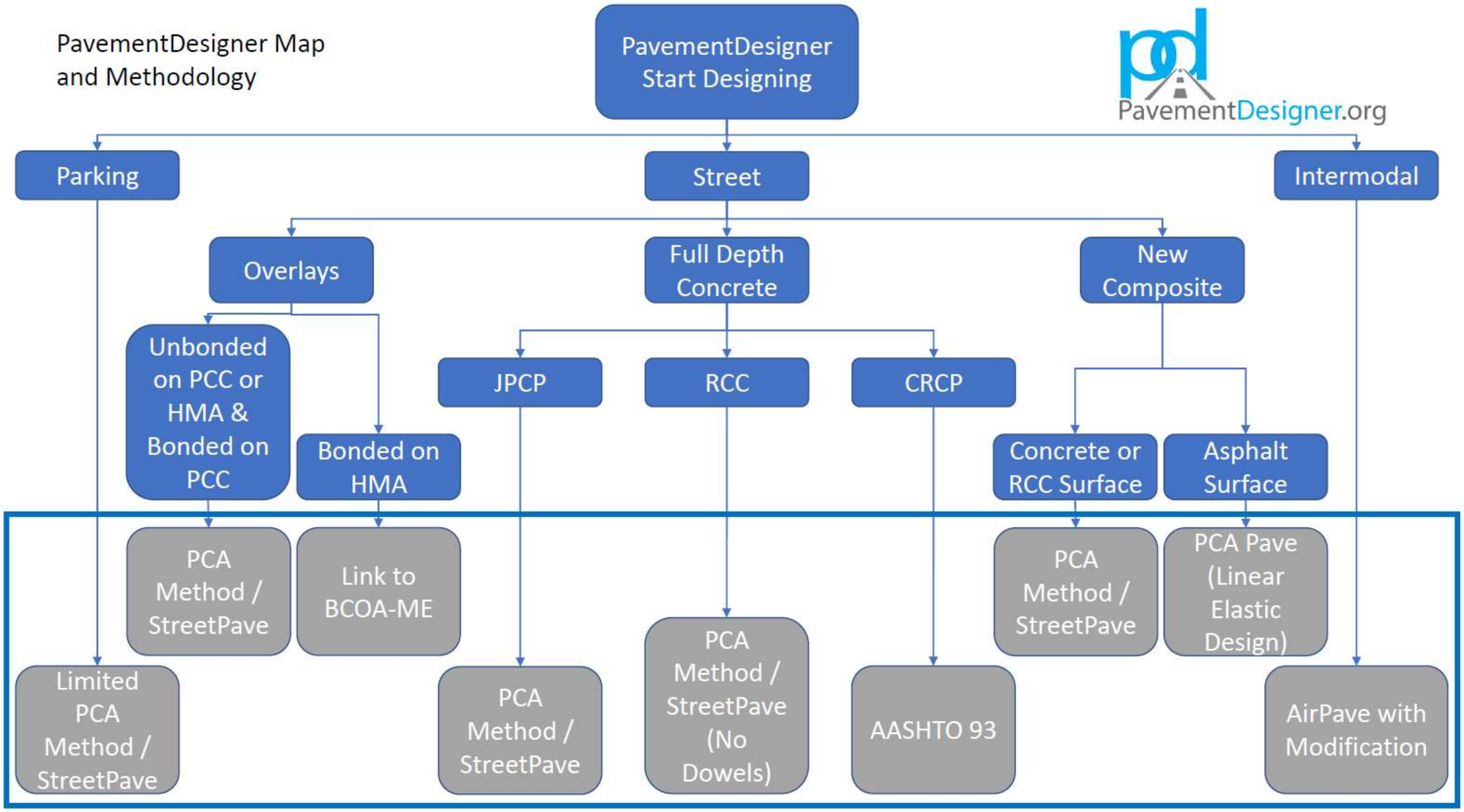
PavementDesigner.org

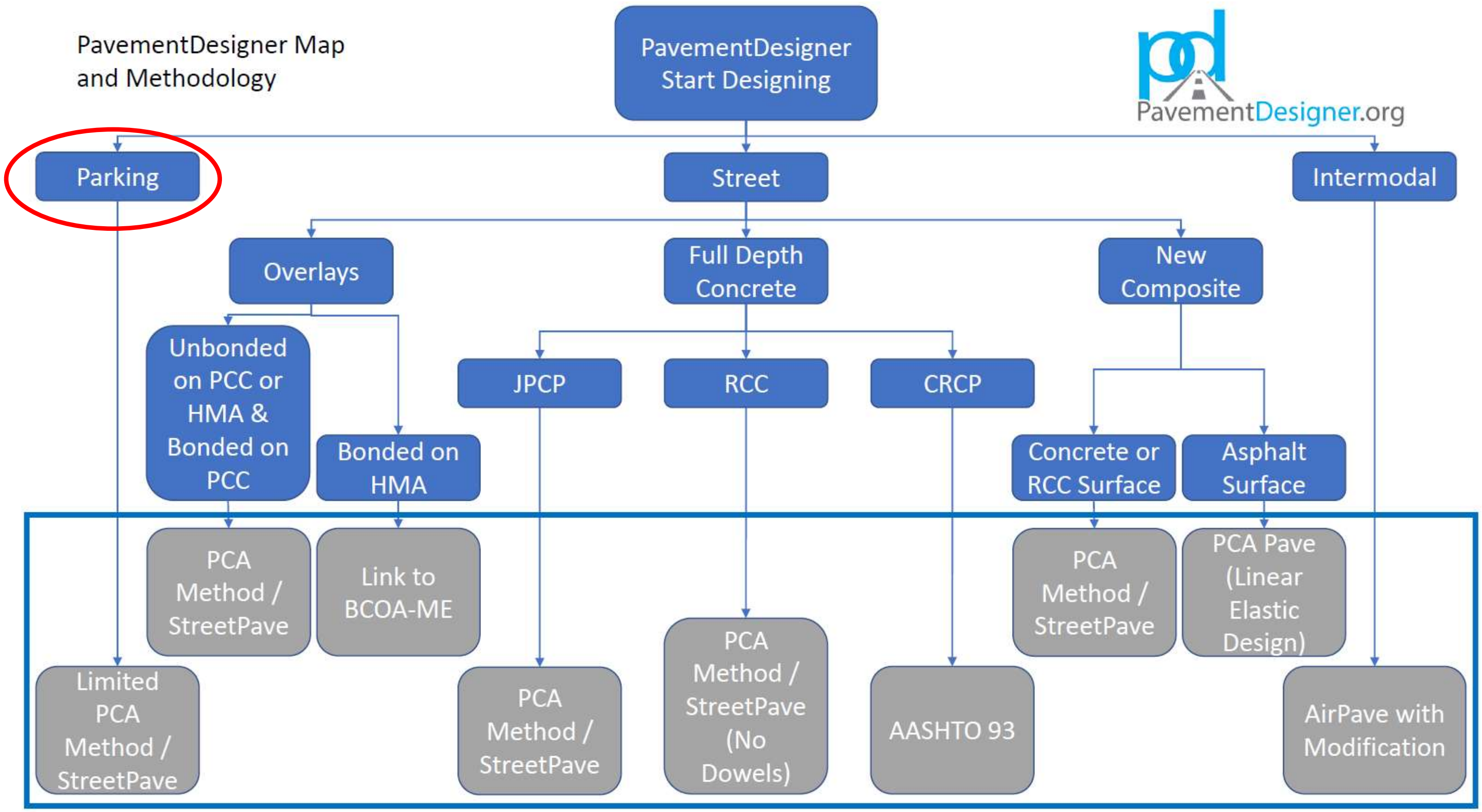
Summary –

- Primary audience is city, county, and consultant engineers who design pavements
- Secondary audience is professors and students
- Unifies design methods, providing promoters with a single source to direct target audience to for consistent answers
- Fills a design void for some products
- Web-based platform, appealing to existing and future generations of design engineers…
- …with broad industry partner support!
- **FREE** and easily accessible!

PavementDesigner.org

Bringing Online the Best
of the Best Available Design Tools

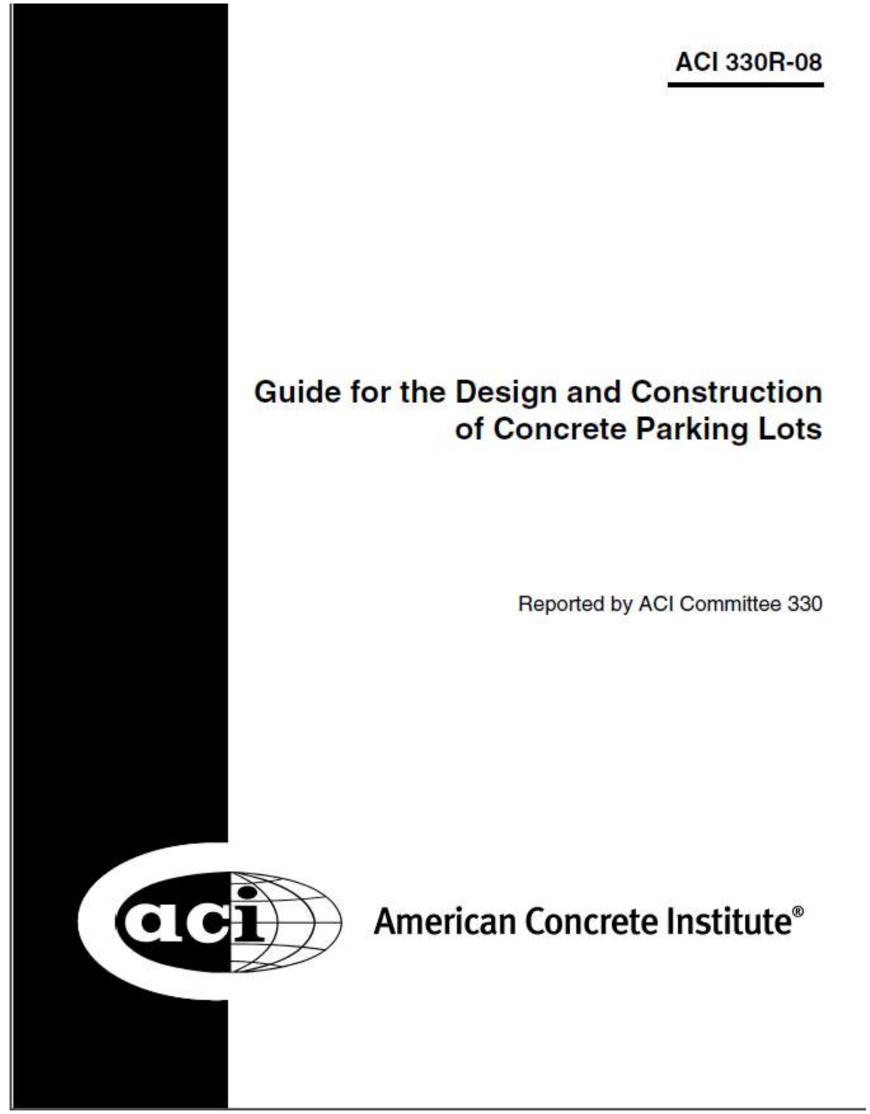




PARKING LOTS

Old Ways of Designing Parking Lots

- AASHTO 93/86/72
- ACI 330R-08 & 330R-18
  - Guide for Concrete Parking Lots


ACI 330R-08

Guide for the Design and Construction of Concrete Parking Lots

Reported by ACI Committee 330

American Concrete Institute®

ACI 330

Table 3.1—Subgrade soil types and approximate support values (Portland Cement Association 1984a,b; American Concrete Pavement Association 1982)

Type of soil	Support	k, psi/in.	CBR	R	SSV
Fine-grained soils in which silt and clay-size particles predominate	Low	75 to 120	2.5 to 3.5	10 to 22	2.3 to 3.1
Sands and sand-gravel mixtures with moderate amounts of silt and clay	Medium	130 to 170	4.5 to 7.5	29 to 41	3.5 to 4.9
Sand and sand-gravel mixtures relatively free of plastic fines	High	180 to 220	8.5 to 12	45 to 52	5.3 to 6.1

BR = California bearing ratio; R = resistance value; and SSV = soil support value. 1 psi = 0.0069 MPa, and 1 psi/in. = 0.27 MPa/m.

Table 3.2—Modulus of subgrade reaction k^*

Subgrade k value, psi/in.	Sub-base thickness: 4 in.	6 in.	9 in.	12 in.
	Granular aggregate subbase			
50	65	75	85	110
100	130	140	160	190
200	220	230	270	320
300	320	330	370	430
	Cement-treated subbase			
50	170	230	310	390
100	280	400	520	640
200	470	640	830	—
	Other treated subbase			
50	85	115	170	215
100	175	210	270	325
200	280	315	360	400
300	350	385	420	490

*For subbase applied over different subgrades, psi/in. (Portland Cement Association 1984a,b; Federal Aviation Administration 1978).
Note: 1 in. = 25.4 mm, and 1 psi/in. = 0.27 MPa/m.

e 3.4—Twenty-year design thickness recommendations, in. (no dowels)

		k = 500 psi/in. (CBR = 50; R = 86)				k = 400 psi/in. (CBR = 38; R = 80)				k = 300 psi/in. (CBR =26; R = 67)			
	MOR, psi:	650	600	550	500	650	600	550	500	650	600	550	500
ffic ory*	A (ADTT =1)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5
	A (ADTT = 10)	4.0	4.0	4.0	4.5	4.0	4.0	4.5	4.5	4.0	4.5	4.5	4.5
	B (ADTT = 25)	4.0	4.5	4.5	5.0	4.5	4.5	5.0	5.5	4.5	4.5	5.0	5.5
	B (ADTT = 300)	5.0	5.0	5.5	5.5	5.0	5.0	5.5	5.5	5.0	5.5	5.5	6.0
	C (ADTT = 100)	5.0	5.0	5.5	5.5	5.0	5.5	5.5	6.0	5.5	5.5	6.0	6.0
	C (ADTT = 300)	5.0	5.5	5.5	6.0	5.5	5.5	6.0	6.0	5.5	6.0	6.0	6.5
	C (ADTT = 700)	5.5	5.5	6.0	6.0	5.5	5.5	6.0	6.5	5.5	6.0	6.5	6.5
	D (ADTT = 700)†	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
		k = 200 psi/in. (CBR = 10; R = 48)				k = 100 psi/in. (CBR = 3; R = 18)				k = 50 psi/in. (CBR = 2; R = 5)			
	MOR, psi:	650	600	550	500	650	600	550	500	650	600	550	500
Traffic category*	A (ADTT =1)	4.0	4.0	4.0	4.5	4.0	4.5	4.5	5.0	4.5	5.0	5.0	5.5
	A (ADTT = 10)	4.5	4.5	5.0	5.0	4.5	5.0	5.0	5.5	5.0	5.5	5.5	6.0
	B (ADTT = 25)	5.0	5.0	5.5	6.0	5.5	5.5	6.0	6.0	6.0	6.0	6.5	7.0
	B (ADTT = 300)	5.5	5.5	6.0	6.5	6.0	6.0	6.5	7.0	6.5	7.0	7.0	7.5
	C (ADTT = 100)	5.5	6.0	6.0	6.5	6.0	6.5	6.5	7.0	6.5	7.0	7.5	7.5
	C (ADTT = 300)	6.0	6.0	6.5	6.5	6.5	6.5	7.0	7.5	7.0	7.5	7.5	8.0
	C (ADTT = 700)	6.0	6.5	6.5	7.0	6.5	7.0	7.0	7.5	7.0	7.5	8.0	8.5
	D (ADTT = 700)†	7.0	7.0	7.0	7.0	8.0	8.0	8.0	8.0	9.0	9.0	9.0	9.0

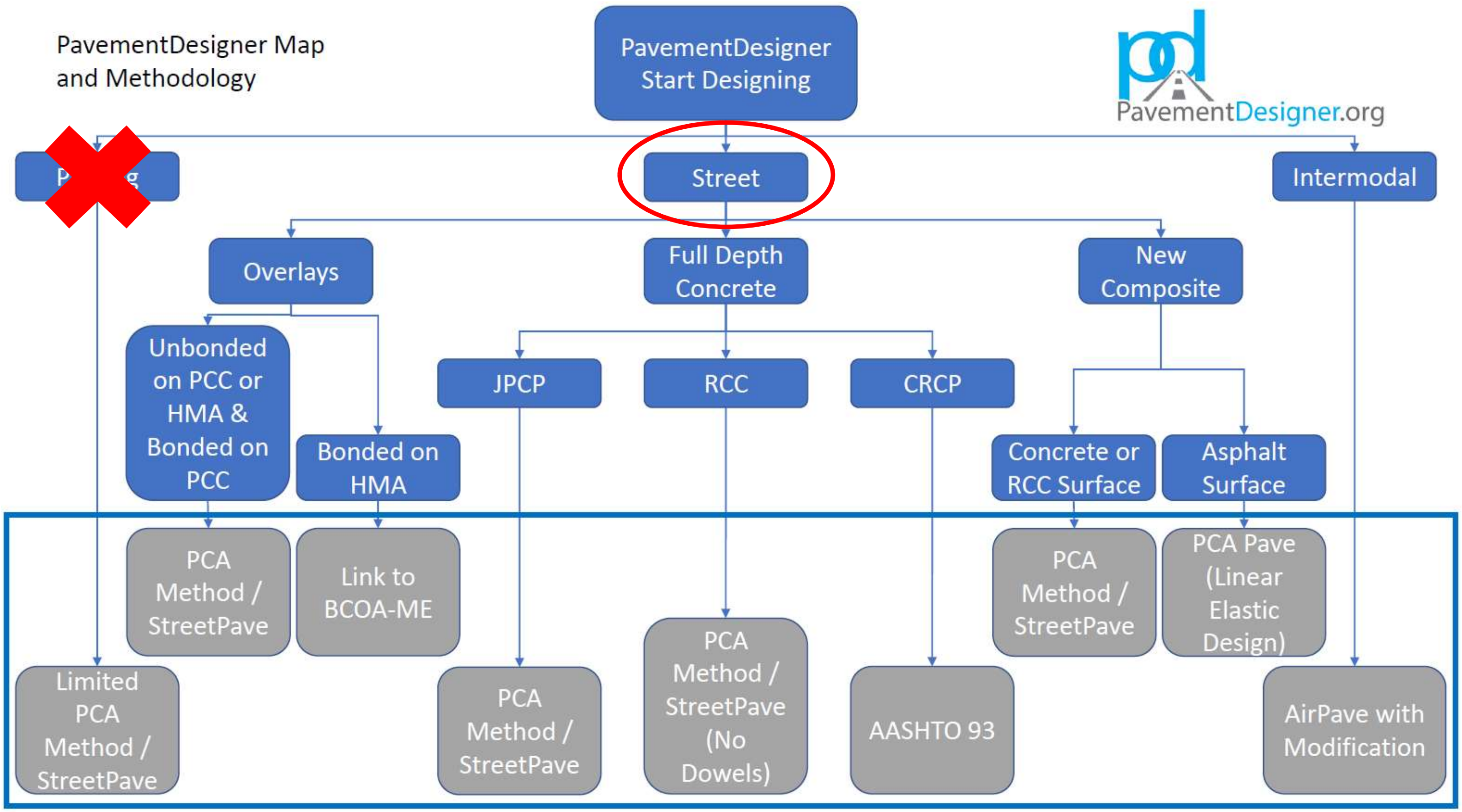
*ADTT = average daily truck traffic. Trucks are defined as vehicles with at least six wheels; excludes panel trucks, pickup trucks, and other four-wheel vehicles. Refer to Appendix A.
k = modulus of subgrade reaction; CBR = California bearing ratio; R = resistance value; and MOR = modulus of rupture.

Parking Lot Design with PavementDesigner

- PavementDesigner's Parking design uses a slightly modified version of the Street's Module for the sake of simplicity
  - Allows for various design lives, reliabilities, and percent slabs cracked at the end of the design life

Parking Lot Design with PavementDesigner

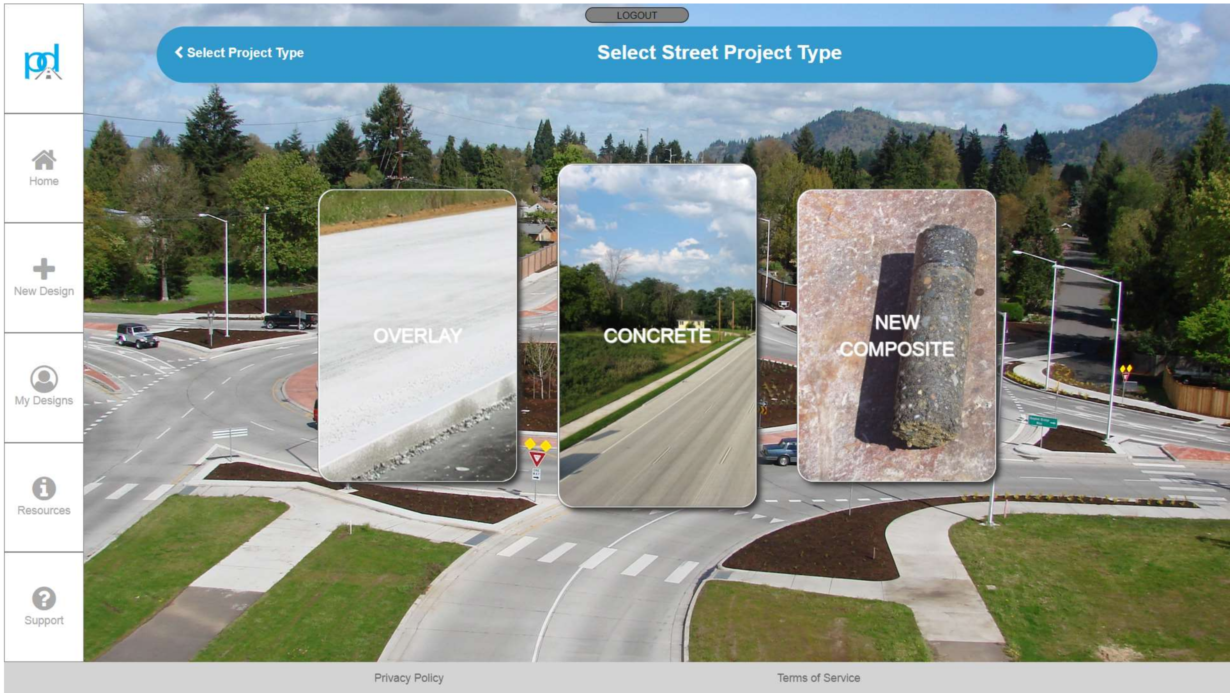
- Design a bus terminal that serves ~50 buses a day
- Existing subgrade is clay



STREETS & LOCAL ROADS

Municipal Street Design with PavementDesigner

- Overlays
  - On Asphalt and Concrete
  - Bonded and Unbonded
- Full-Depth Concrete
  - JPCP
  - RCC
  - CRCP
- Composite Pavements

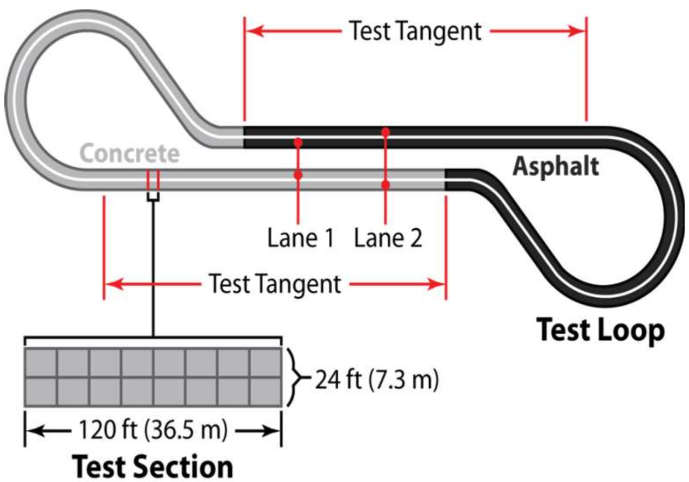


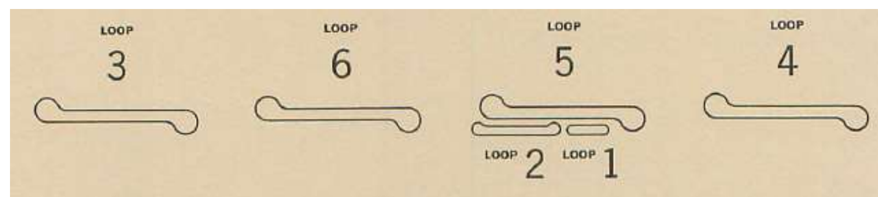
Other Ways of Designing Municipal Streets

- AASHTO 93/86/72
- Pavement ME
- ACI 325.12R-02
  - Guide for Design of Jointed Concrete Pavements for Streets and Local Roads
- StreetPave

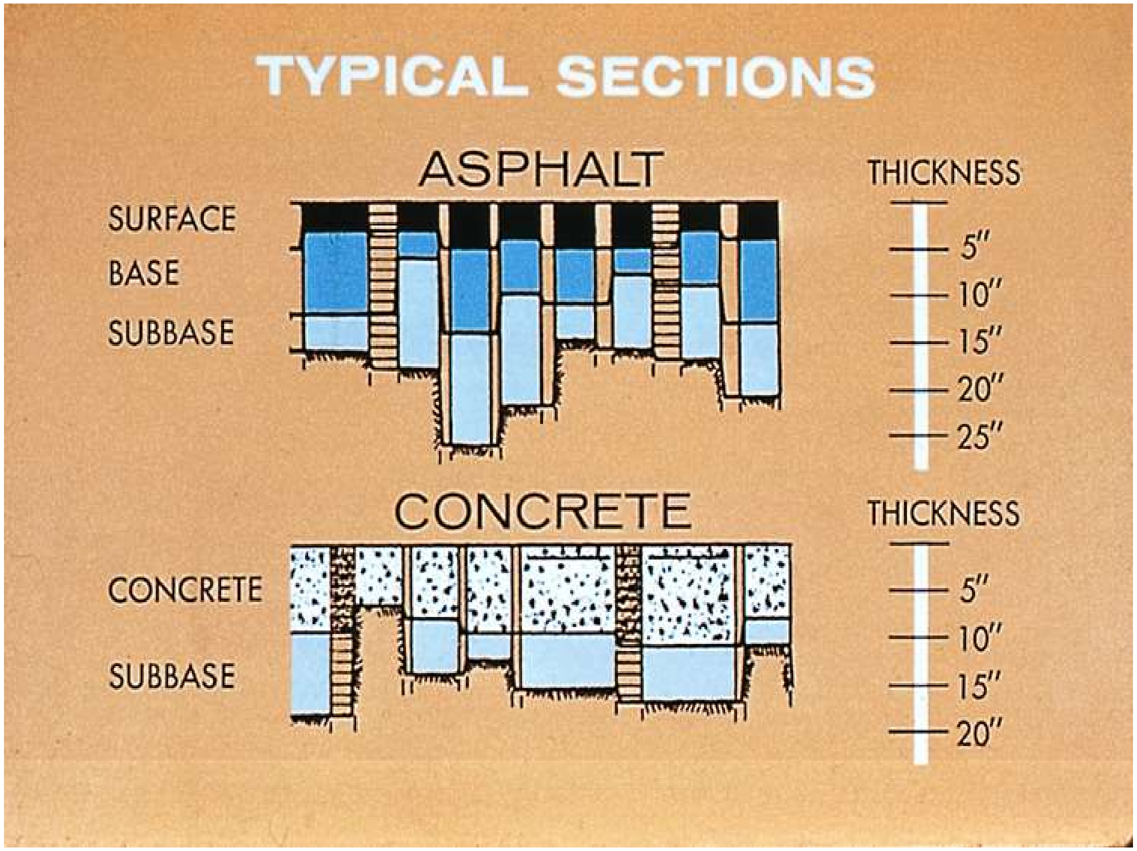
AASHTO 93

- Wholly empirical – AASHO Road Test
- Limited inference space:
  - Materials
  - Structural sections
  - Soils
  - Traffic





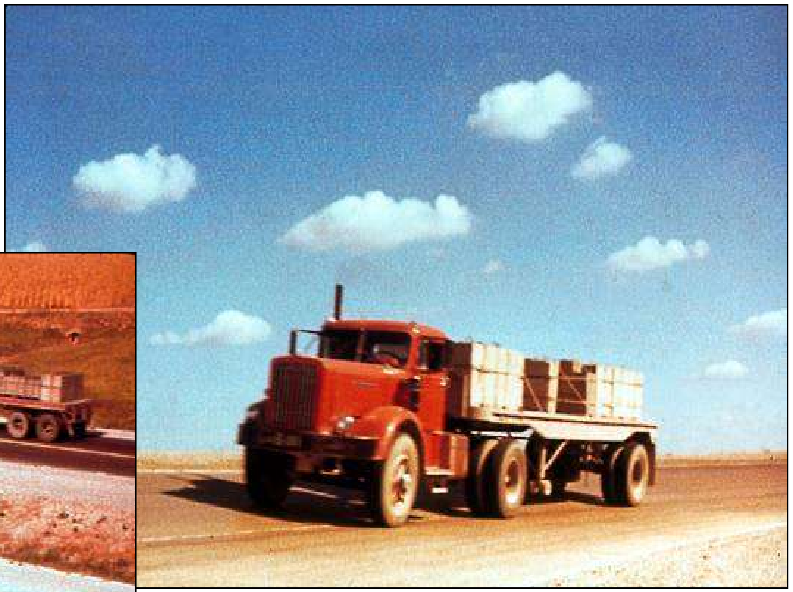
Necessary Thickness was Guessed!



Subgrade = Clay Soil

Sections Loaded for 2 Yrs | 1.1 Mil Reps

Max Single Axle



Max Tandem Axle

1986-93 JPCP AASHTO 93 Equation

$$Log(ESAL) = Z_R * s_o + 7.35 * Log(D+1) - 0.06 + \frac{Log\left[\frac{\Delta PSI}{4.5-1.5}\right]}{1 + \frac{1.624*10^7}{(D+1)^{8.46}}}$$

$$+ (4.22 - 0.32 * p_t) * Log\left[\frac{S_c' * C_d * (D^{0.75} - 1.132)}{215.63 * J * \left[D^{0.75} - \frac{18.42}{(E_c/k)^{0.25}}\right]}\right]$$

Traffic

Standard Normal Deviate

Overall Standard Deviation

Thickness

Change in Serviceability

Terminal Serviceability

Modulus of Rupture

Drainage Coefficient

Load Transfer

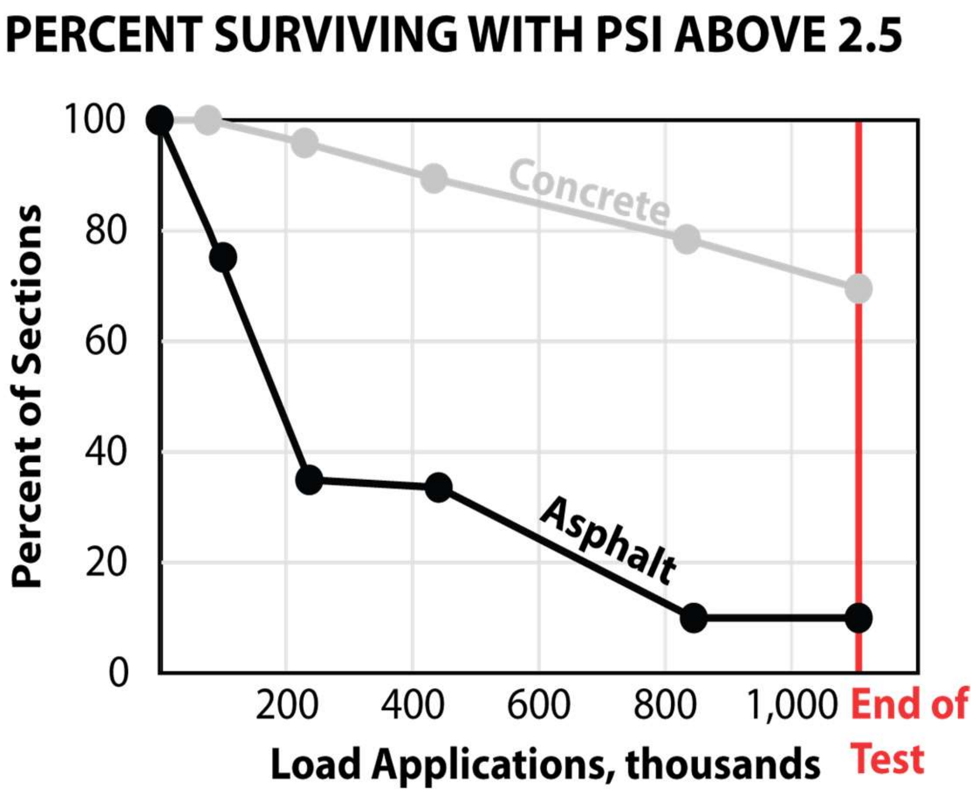
Modulus of Elasticity

Modulus of Subgrade Reaction

WHAT DO DESIGNERS FOCUS ON?

Performance Estimated Subjectively

- **Present Serviceability Index (PSI)**
  - 4.0 – 5.0 = Very Good
  - 3.0 – 4.0 = Good
  - 2.0 – 3.0 = Fair
  - 1.0 – 2.0 = Poor
  - 0.0 – 1.0 = Very Poor
- "Failure" at the Road Test considered @ 1.5
- Typical U.S. state agency terminal serviceability in practice = 2.5



Note on Inference Space of '93

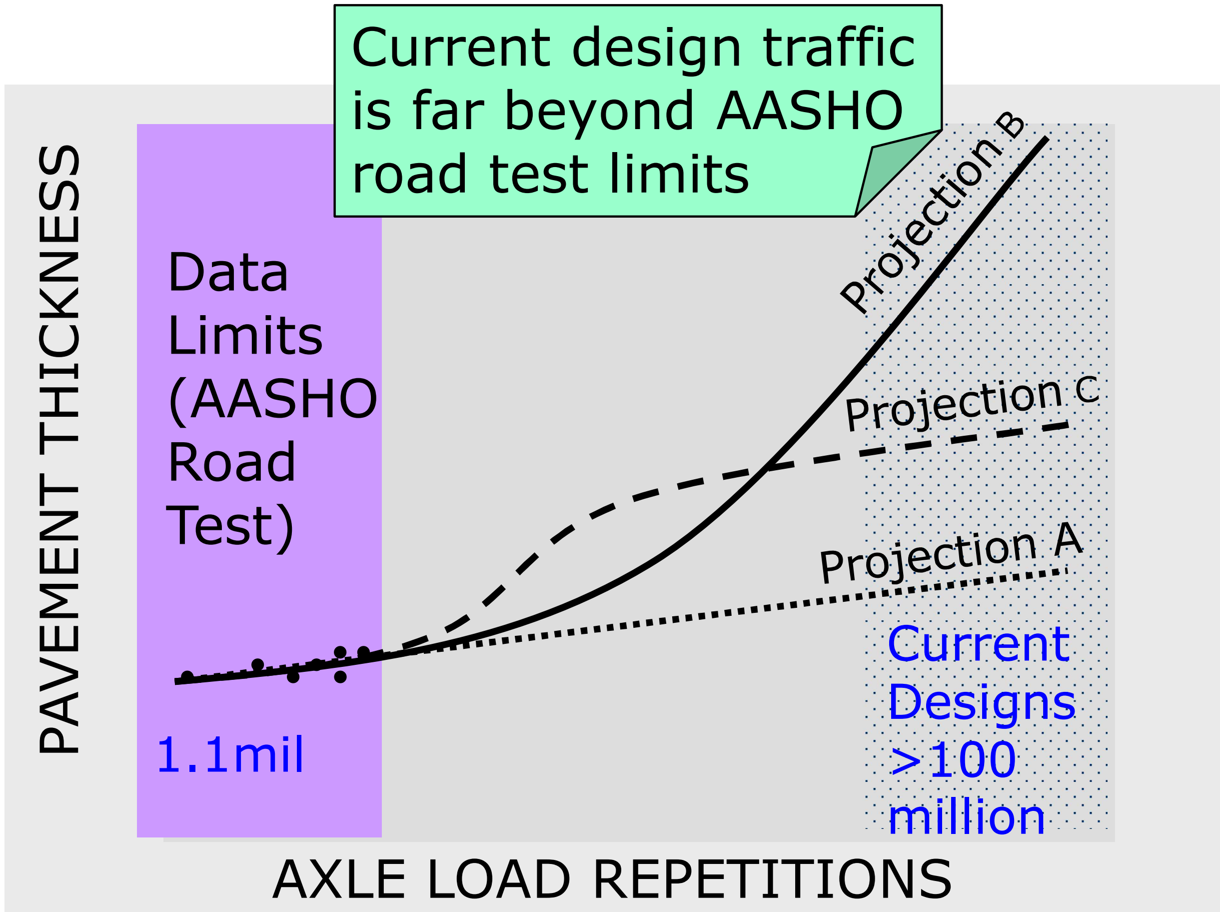
The experimental design at the AASHO Road Test included a wide range of loads as previously discussed (Section 1.4.1); however, the applied loads were limited to a maximum of 1,114,000 axle applications for those sections which survived the full trafficking period. Thus, the maximum number of 18-kip equivalent single axle loads (ESAL's) applied to any test section was approximately one million. However, by applying the concept of equivalent loads to test sections subjected to only 30-kip single axle loads, for example, it

is possible to extend the findings to 8×10^6 ESAL's. Use of any design ESAL's above 8×10^6 requires extrapolation beyond the equations developed from the Road Test results. Such extrapolations have, how-

AASHTO® Guide for
Design of Pavement Structures
1993

Published by the
American Association of State Highway
and Transportation Officials

444 N. Capitol Street, N.W., Suite 249
Washington, D.C. 20001


Current design traffic is far beyond AASHO road test limits
Data Limits (AASHO Road Test)
1.1mil
Projection B
Projection C
Projection A
Current Designs >100 million
PAVEMENT THICKNESS
AXLE LOAD REPETITIONS

Don’t Just Take My Word…

United States General Accounting Office

GAO

Report to the Secretary of Transportation

November 1997

TRANSPORTATION INFRASTRUCTURE

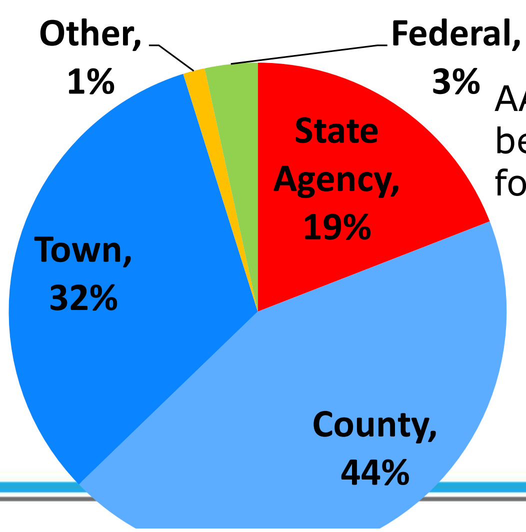
Highway Pavement Design Guide Is Outdated

GAO/RCED-98-9

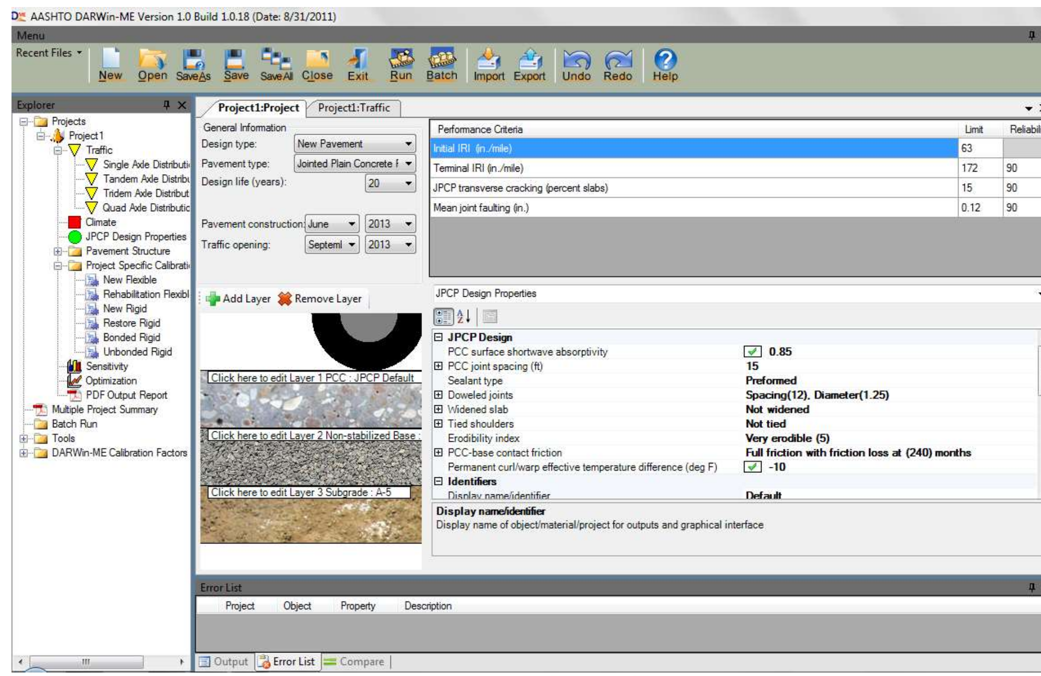
“The current design guide and its predecessors were largely based on design equations empirically derived from the observations AASHTO’s predecessor made during road performance tests completed in 1959-60. Several transportation experts have criticized the empirical data thus derived as outdated and inadequate for today’s highway system. In addition, a March 1994 DOT Office of Inspector General report concluded that the design guide was outdated and that pavement design information it relied on could not be supported and validated with systematic comparisons to actual experience or research.” **…this is why Pavement ME exists!**

AASHTOWare Pavement ME Design

- Developed for Highways
  - NOT street, road, parking lot, etc.
- Complex
- Expensive

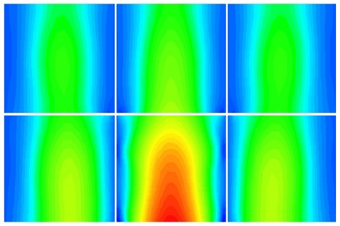


AASHTO tools are being developed for these owners…



Pavement ME Design

- Not "perfect" & not intended to be a "final" product
- Complex and relatively costly
- Primarily for high volume roadways

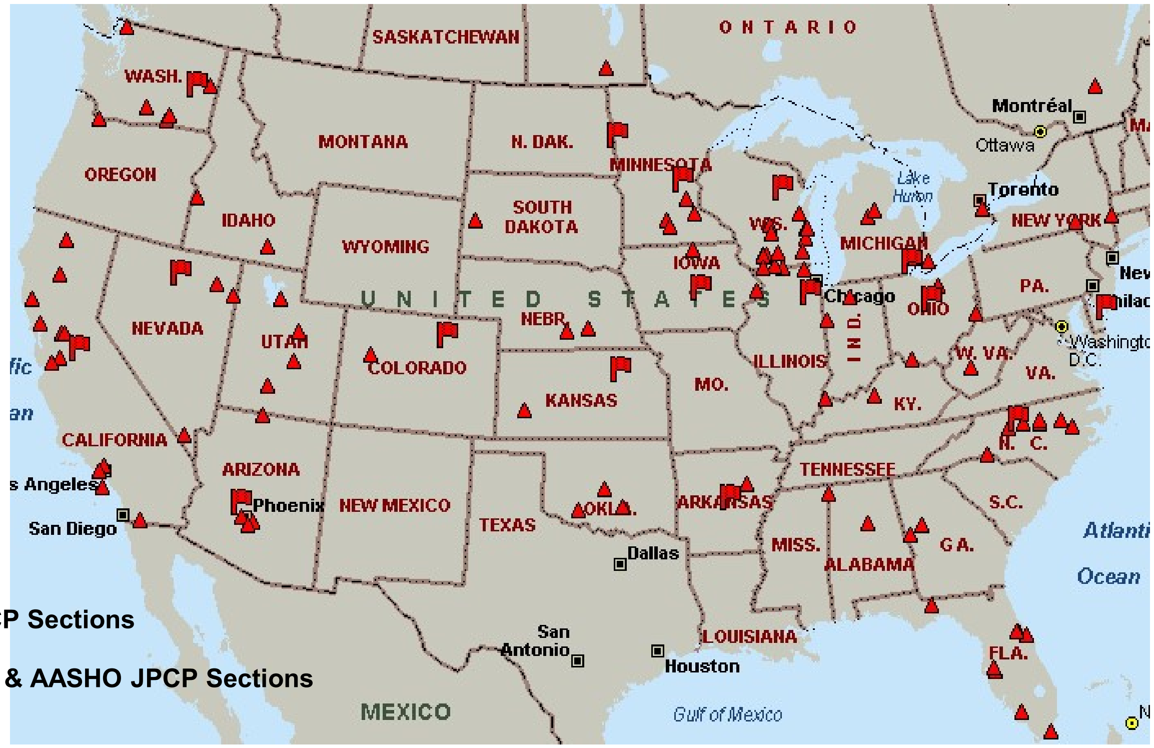


Mechanistic Calculation of Responses

Empirical Tie to Ground

Pavement Performance Prediction

JPCP Calibration – **BIG INF. SPACE!**



▲ LTPP GPS-3 & RPPR JPCP Sections

LTPP SPS-2, MnROAD, & AASHO JPCP Sections

Sounds Easy Enough, Right?

$$Fault_m = \sum_{i=1}^{m} \Delta Fault_i$$

$$\Delta Fault_i = C_{34} * (FAULTMAX_{i-1} - Fault_{i-1})^2 * DE_i$$

$$FAULTMAX_i = FAULTMAX_0 + C_7 * \sum_{j=1}^{m} DE_j * Log(1 + C_5 * 5.0^{EROD})^{C_6}$$

$$FAULTMAX_0 = C_{12} * \delta_{curling} * \left[Log(1 + C_5 * 5.0^{EROD}) * Log\left(\frac{P_{200} * WetDays}{p_s}\right) \right]^{C_6}$$

$$\sigma_0 = \frac{E_{PCC} \Delta \varepsilon_{tot}}{2(1 - \mu_{PCC})}$$

n = traffic path.

The damage increments were discussed previously in this section.

The applied number of load applications ($n_{i,j,k,l,m,n}$) is the actual number of axle type k of load level l that passed through traffic path n under each condition (age, season, and temperature difference). The allowable number of load applications is the number of load cycles at which fatigue failure is expected (corresponding to 50 percent slab cracking) and is a function of the applied stress and PCC strength. The allowable number of load applications is determined using the following fatigue model:

$$\log(N_{i,j,k,l,m,n}) = C_1 \cdot \left(\frac{MR_i}{\sigma_{i,j,k,l,m,n}} \right)^{C_2} + 0.4371 \qquad (3.4.10)$$

where,

$N_{i,j,k,...}$ = allowable number of load applications at condition i, j, k, l, m, n
MR_i = PCC modulus of rupture at age i, psi
$\sigma_{i,j,k,...}$ = applied stress at condition i, j, k, l, m, n
C_1 = calibration constant = 2.0
C_2 = calibration constant = 1.22

The fatigue damage calculation is a simple process of summing damage from each damage increment, except that a numerical integration scheme is used to accurately determine the effects of traffic wander. The fatigue damage at the critical damage location caused by an axle load placed at any random distance away from the pavement edge (point j) is given by the following:

$$FD^*_{ij} = P(COV_j) \cdot FD_{ij} \qquad (3.4.11)$$

where,

FD^*_{ij} = fatigue damage at location i (critical damage location) due to the fraction of

$$IRI = IRI_I + C1*CRK + C2*SPALL + C3*TFAULT + C4*SF$$

cation) due to the traffic load

The probability of coverage is determined assuming normal distribution.

$$NORMDIST = \frac{1}{SD_{traf}\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \qquad (3.4.12)$$

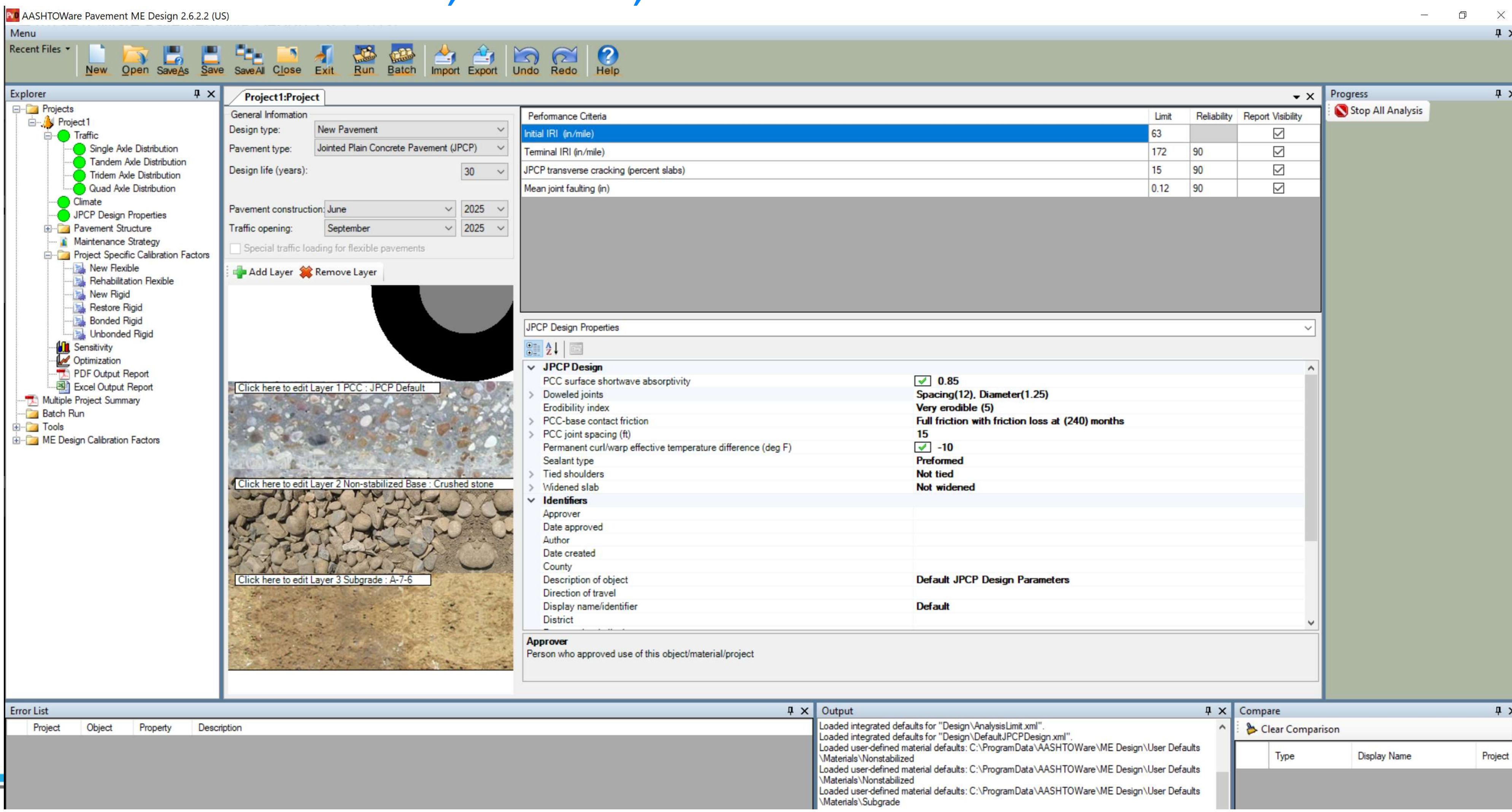
where,

$NORMDIST$ = normal distribution density function.
x = wheel location – distance from pavement edge (or outside of the paint stripe for widened slab) to the outer edge of outermost wheel, in.

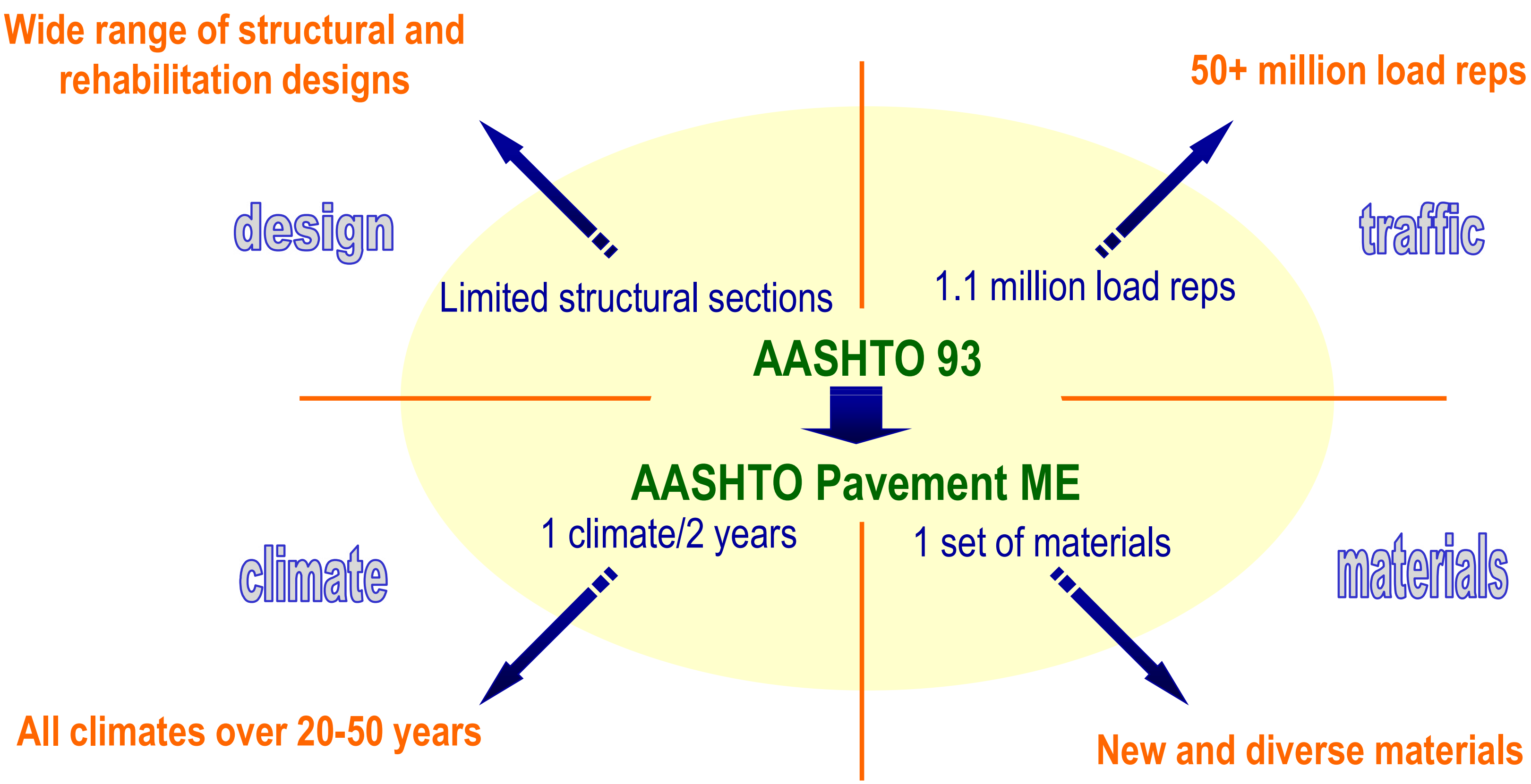
$$SCF = -1400 + 350 \cdot AIR\% \cdot (0.5 + PREFORM) + 3.4 f'c \cdot 0.4 - 0.2 (FTCYC \cdot AGE) + 43\, h_{PCC} - 536\, WC\_Ratio$$

$$cw = Max\left(L \cdot \left(\varepsilon_{shr} + \alpha_{PCC} \Delta T_{\varsigma} - \frac{c_2 f_\sigma}{E_{PCC}} \right) \cdot 1000 \cdot CC, 0.001 \right) \qquad 3.4.64$$

INPUTS, INPUTS, INPUTS!!!!



AASHTO 93 vs. ME



ACI 325

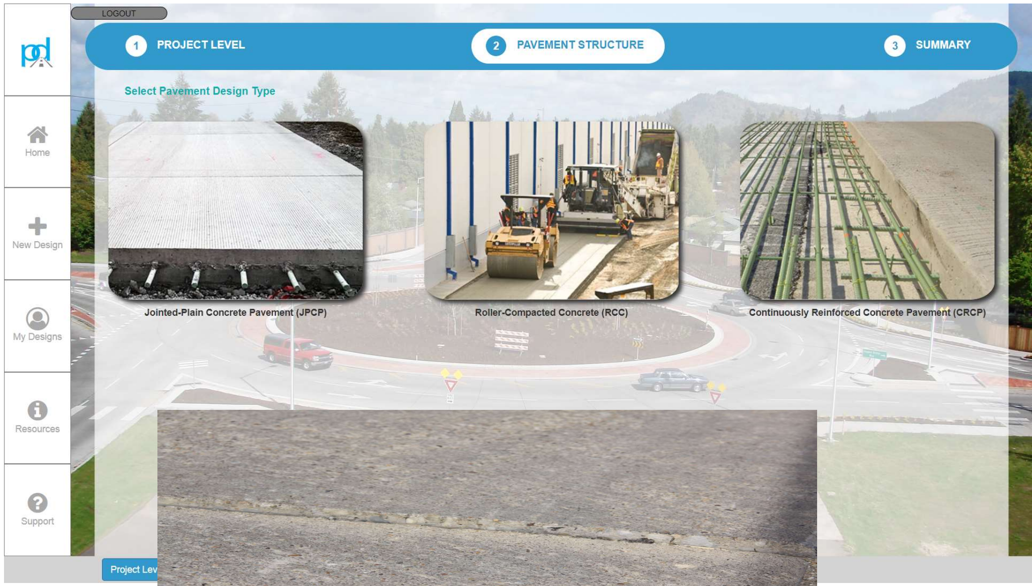
- Limited design charts
- Previously based on StreetPave runs
- Updated version based on PavementDesigner runs

Table 3.4—Twenty-year design thickness recommendations, in. (no dowels)

		k = 500 psi/in. (CBR = 50; R = 86)				k = 400 psi/in. (CBR = 38; R = 80)				k = 300 psi/in. (CBR =26; R = 67)			
	MOR, psi:	650	600	550	500	650	600	550	500	650	600	550	500
Traffic category*	A (ADTT =1)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5
	A (ADTT = 10)	4.0	4.0	4.0	4.5	4.0	4.0	4.5	4.5	4.0	4.5	4.5	4.5
	B (ADTT = 25)	4.0	4.5	4.5	5.0	4.5	4.5	5.0	5.5	4.5	4.5	5.0	5.5
	B (ADTT = 300)	5.0	5.0	5.5	5.5	5.0	5.0	5.5	5.5	5.0	5.5	5.5	6.0
	C (ADTT = 100)	5.0	5.0	5.5	5.5	5.0	5.5	5.5	6.0	5.5	5.5	6.0	6.0
	C (ADTT = 300)	5.0	5.5	5.5	6.0	5.5	5.5	6.0	6.0	5.5	6.0	6.0	6.5
	C (ADTT = 700)	5.5	5.5	6.0	6.0	5.5	5.5	6.0	6.5	5.5	6.0	6.5	6.5
	D (ADTT = 700)†	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
		k = 200 psi/in. (CBR = 10; R = 48)				k = 100 psi/in. (CBR = 3; R = 18)				k = 50 psi/in. (CBR = 2; R = 5)			
	MOR, psi:	650	600	550	500	650	600	550	500	650	600	550	500
Traffic category*	A (ADTT =1)	4.0	4.0	4.0	4.5	4.0	4.5	4.5	5.0	4.5	5.0	5.0	5.5
	A (ADTT = 10)	4.5	4.5	5.0	5.0	4.5	5.0	5.0	5.5	5.0	5.5	5.5	6.0
	B (ADTT = 25)	5.0	5.0	5.5	6.0	5.5	5.5	6.0	6.0	6.0	6.0	6.5	7.0
	B (ADTT = 300)	5.5	5.5	6.0	6.5	6.0	6.0	6.5	7.0	6.5	7.0	7.0	7.5
	C (ADTT = 100)	5.5	6.0	6.0	6.5	6.0	6.5	6.5	7.0	6.5	7.0	7.5	7.5
	C (ADTT = 300)	6.0	6.0	6.5	6.5	6.5	6.5	7.0	7.5	7.0	7.5	7.5	8.0
	C (ADTT = 700)	6.0	6.5	6.5	7.0	6.5	7.0	7.0	7.5	7.0	7.5	8.0	8.5
	D (ADTT = 700)†	7.0	7.0	7.0	7.0	8.0	8.0	8.0	8.0	9.0	9.0	9.0	9.0

PavementDesigner for Roadways

- Roots date back to the 1960s PCA Method
- Tailored for streets and roads
- Failure modes are cracking and erosion



PavementDesigner.org Evaluation and Comparison to MnPAVE-Rigid

Final Report

Prepared By:

Kenneth A. Tutu
Neil G. Lund

Braun Intertec Corporation

October 2019

Minnesota Department of Transportation
State Aid for Local Transportation, MS 500
395 John Ireland Boulevard
St. Paul, MN 55155

http://www.dot.state.mn.us/stateaid/projectdelivery/pdp/pavement/pavment-design-software-comp-review.pdf

MINNESOTA DEPARTMENT OF TRANSPORTATION
State Aid Division
Technical Memorandum No. 20-SA-01
November 5, 2020

To: County Engineers
City Engineers
MnDOT District State Aid Engineers
MnDOT District Materials Engineers
FHWA

From: Kristine Elwood, P.E.
State Aid Engineer

Subject: **State Aid for Local Transportation (SALT)**
Use of PavementDesigner.org Software for Design of Concrete Pavements for Cities and Counties

Expiration

This Technical Memorandum will remain in effect until November 5, 2025 unless superseded prior to this date, or the information provided in this Technical Memorandum is incorporated into the State Aid Manual.

Implementation

This Technical Memorandum, which allows the use of the PavementDesigner.org (PavementDesigner) software for jointed concrete pavement design as an alternative to the MnPAVE-Rigid software, is effective immediately. In deciding which software program to use, several factors, including those mentioned in this Technical Memorandum, shall be considered by the Engineer. City, county and consultant engineers working on State Aid and Federal-aid concrete pavement projects are allowed to use the PavementDesigner software program as an alternative to the MnPAVE-Rigid software program. However, concrete pavement projects within Trunk Highway right-of-way must continue to implement the MnPAVE-Rigid design software.

Introduction

To stay current with new technology and design methods, in October 2019 State Aid for Local Transportation (SALT) initiated a study by Braun Intertec to compare PavementDesigner to MnPAVE-Rigid.

Based on the recommendations found the in the report titled "PavementDesigner.org Evaluation and Comparison to MnPAVE-Rigid", SALT will allow the PavementDesigner software to be used as an alternative design mechanism for concrete pavement.

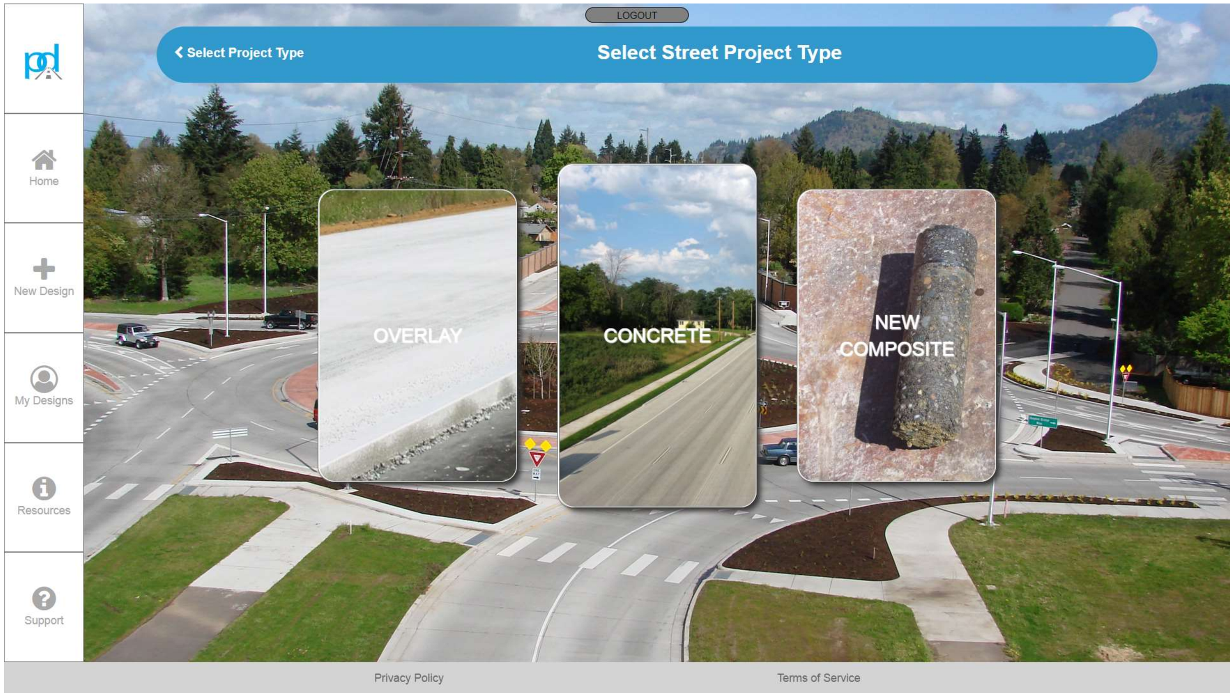
Purpose

There are three main purposes of this Technical Memorandum. First, to describe which

http://www.dot.minnesota.gov/stateaid/admin/memos/20-sa-01.pdf

Municipal Street Design with PavementDesigner

- Design for Overland Parkway with ~100 trucks/day
- Existing Subgrade is poorly graded silt (A-5)



DESIGN SUMMARY REPORT FOR

JOINTED-PLAIN CONCRETE PAVEMENT (JPCP)

DATE CREATED:

Thu Oct 04 2018 15:10:11 GMT-0500 (Central Daylight Time)

Project Description

Project Name:	ARDOT - I-30 Calculated	Owner:	undefined	Zip Code:	undefined
Designer's Name:	undefined	Route:	undefined		
Project Description:	undefined				

Design Summary

	Doweled	Undoweled		Doweled	Undoweled
Recommended Design Thickness:	8.50 in.	8.50 in.	Maximum Joint Spacing:	15 ft.	15 ft.
Calculated Minimum Thickness:	8.43 in.	8.43 in.			

Pavement Structure

SUBBASE

User-Defined Composite K-Value of Substructure: 160 psi/in

Layer Type	Resilient Modulus	Layer Thickness
JOINTED PLAIN CONCRETE SURFACE		
Hot-Mix or Warm-Mix Asphalt Base	450,000 psi	1 in
Cement Stabilized Subgrade	100,000 psi	6 in
SUBGRADE		

CONCRETE

28-Day Flex Strength:	630 psi	Edge Support:	Yes
Modulus of Elasticity:	3500000 psi	Macrofibers in Concrete:	No

SUBGRADE

R-Value:	20
Calculated MRSG Value	4,305 psi

Project Level

TRAFFIC

Spectrum Type:	Major Arterial
Design Life:	20 years

USER DEFINED TRAFFIC

Trucks Per Day:	7,860
Traffic Growth Rate %:	1 % per year
Directional Distribution:	50 %
Design Lane Distribution:	60 %

GLOBAL

Reliability:	90 %
% Slabs Cracked at End of Design Life:	5 %
Avg Trucks/Day in Design Lane Over the Design Life:	2,596
Total Trucks in Design Lane Over the Design Life:	18,964,076

ARDOT - I-30 and Ramps Concrete Pavement Design Analysis - Optimi

File Name: C:\Users\eferrebee.acpa\Documents\My ME Design\ARDOT - I-30 and Ramps Concrete Pavement Design Analysis - Optimized.dgpx

Design Inputs

Design Life:	20 years	Existing construction:	-	Climate Data Sources (Lat/Lon)	34.747, -92.233
Design Type:	JPCP	Pavement construction:	June, 2020		
		Traffic opening:	September, 2020		

Design Structure

Layer type	Material Type	Thickness (in)
PCC	JPCP Default	9.0
Flexible	Default asphalt concrete	1.0
Cement_Base	Cement stabilized	6.0
Subgrade	A-7-6	10.0
Subgrade	A-7-6	Semi-infinite

Joint Design:	
Joint spacing (ft)	15.0
Dowel diameter (in)	1.25
Slab width (ft)	12.0

Traffic

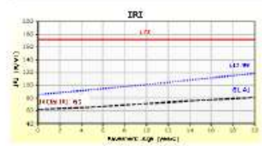
Age (year)	Heavy Trucks (cumulative)
2020 (initial)	7,860
2030 (10 years)	9,775,300
2040 (20 years)	22,134,400

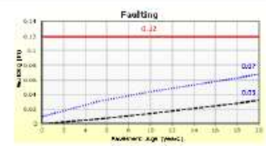
Design Outputs

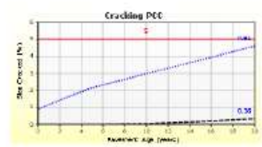
Distress Prediction Summary

Distress Type	Distress @ Specified Reliability		Reliability (%)		Criterion Satisfied?
	Target	Predicted	Target	Achieved	
Terminal IRI (in/mile)	172.00	117.99	90.00	99.92	Pass
Mean joint faulting (in)	0.12	0.07	90.00	99.90	Pass
JPCP transverse cracking (percent slabs)	5.00	4.61	90.00	91.91	Pass

Distress Charts





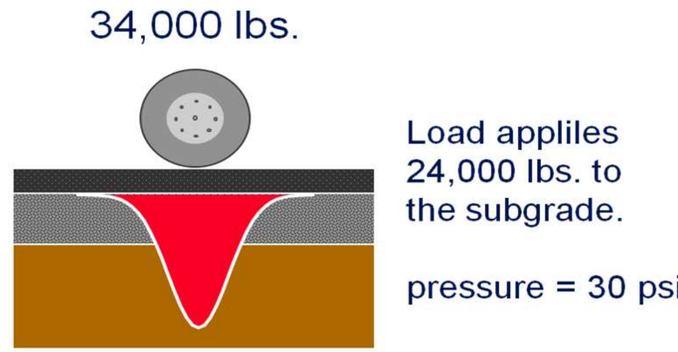


Threshold Value ····· @ Specified Reliability - - - @ 50% Reliability

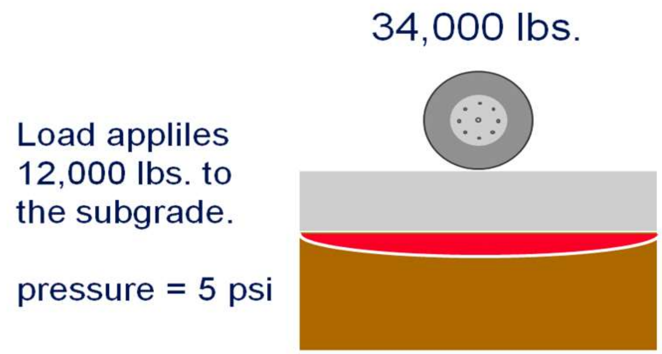
Typical Sections – Foundation Design

- Commonly Used Concrete Section… Why?

- Asphalt designs heavily utilize supporting layers >

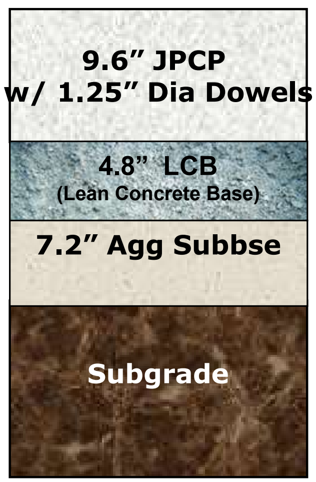


- Concrete spreads the load over larger areas, reducing reliance on bases >

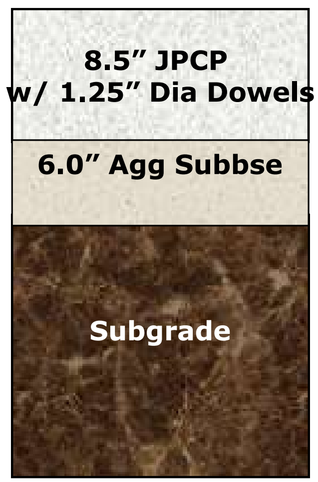


PROJECT SPECIFIC PAVEMENT DESIGN LOWERS COST AND ENVIRONMENTAL IMPACT

Caltrans Concrete Design



Optimized Concrete Design



	Original CALTRANS Schedule		Optimized Pavement-ME Design	
	LCA (tons CO2e)	**LCCA (NPV $)**	**LCA (tons CO2e)**	**LCCA (NPV $)**
Initial Const.	**3,954**	**$3,147,585**	**3,063**	**$2,256,638**
Pavement	*2,860*	*$2,229,803*	*2,803*	*$2,021,307*
LCB	*781*	*$644,902*	*--*	*--*
Agg Subbase	*313*	*$272,880*	*260*	*$235,331*
Rehabilitation	**479**	**$911,663**	**54**	**$315,798**
Carbonation	**(123)**		**(87)**	
PVI-Deflection	**604**		**704**	
PVI-Roughness	**1,912**		**2,110**	
Total	**6,826**	**$4,059,248**	**5,844**	**$2,572,437**

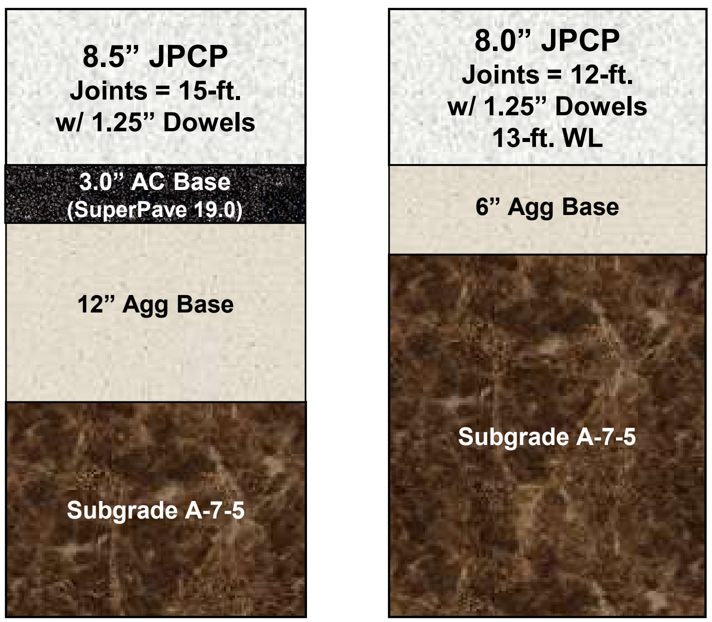
Optimization reduced the initial construction GWP by 890 tons (22.5%) and the life cycle GWP by 980 tons (14.3%)

Optimization reduced the initial construction costs by $890k (28.3%) and the life cycle cost $1.48M (36.6%)

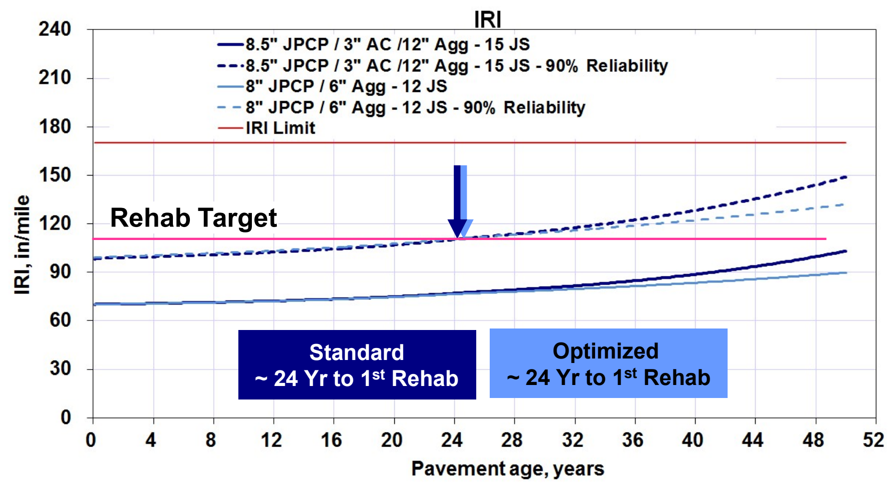
Caltrans Concrete Design: From Table 623.1E (South Coast/Central Coast, Type II SG
Initial AADTT = 1,357 / day, 4% Compound Growth (Initial ESAL = 335,000 / yr)
20 Yr ESALs = 10,650,000; 50 Yr ESALS = 51,151,000

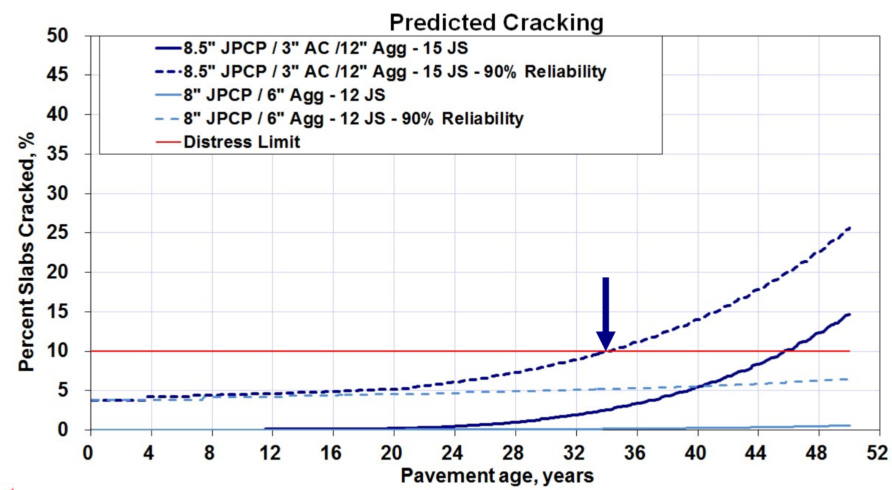
PAVEMENT ME PROVIDES A PROCESS TO COMPARE DIFFERENT DESIGNS / DIFFERENT FEATURES

Original Concrete Design | **Optimized Concrete Design**



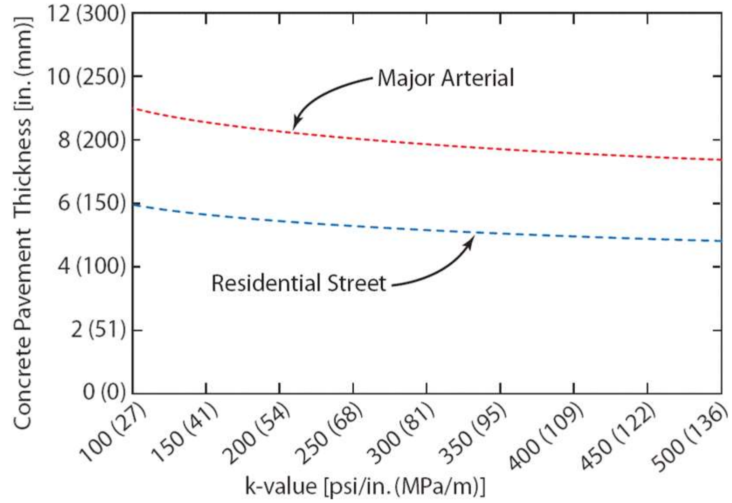
Pavement ME gives a repeatable, non-biased, scientific process to determine how a specific pavement design will perform

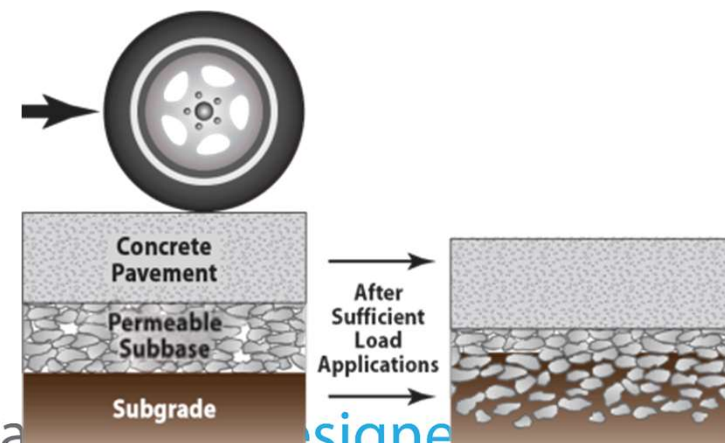




Typical Sections – Foundation Design

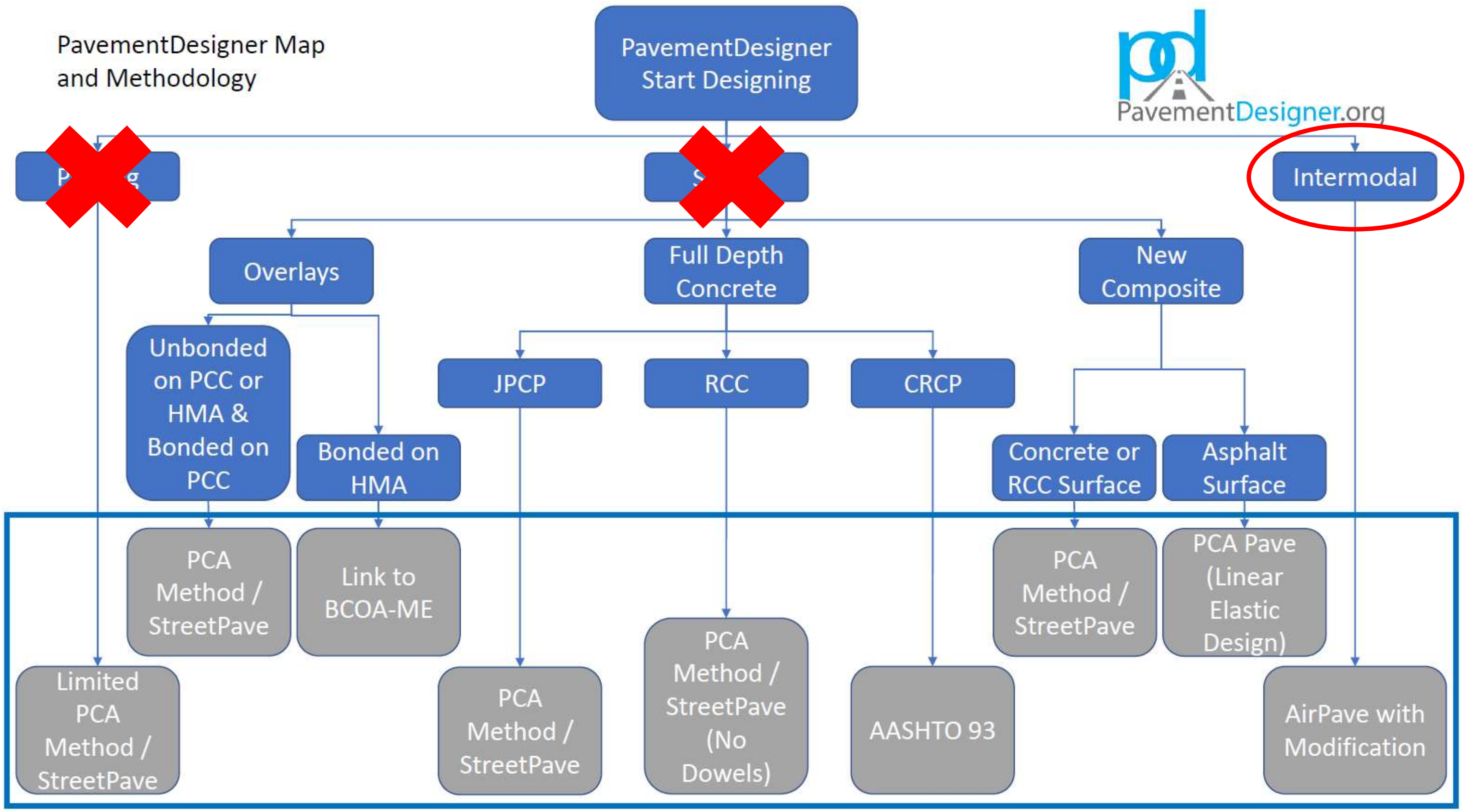
- Concrete needs:
  - Stability
  - Uniformity
  - Some drainability (50 – 150 ft/day)
    - Achieved with either:
      - Daylighted subbases
      - Edge drains
- Concrete does not need:
  - Excessive strength ->
  - Extra layers
  - Permeable bases ->





Differences Between Parking and Street Design

- Simplicity in Parking:
  - Limited Spectrums (for now)
  - Growth Rate = 0%
  - Directional Dist = 100%
  - Design Lane Dist = 100%
  - Fibers not allowed
  - Edge support assumed to be yes
  - Only allows 1 subbase layer

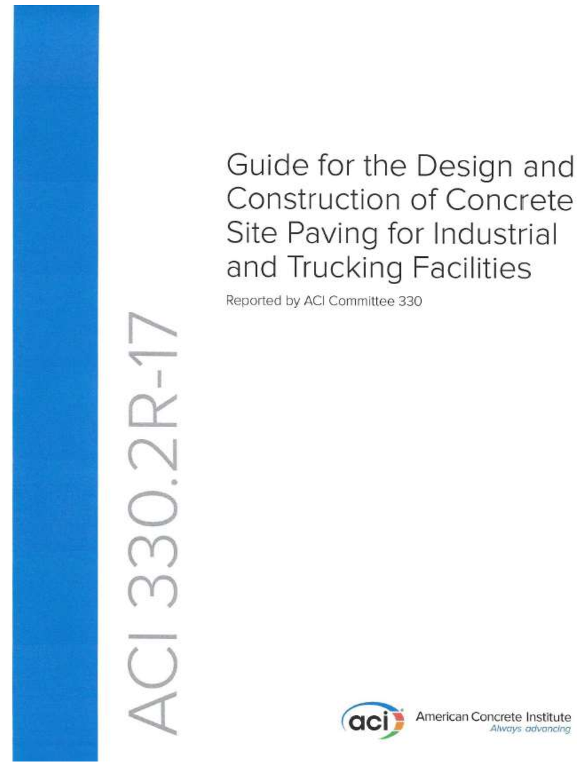


INTERMODAL DESIGN

Intermodal Design?

What Designs are Available for Heavy Intermodal/Industrial Vehicles

- ACI 330.2R-17 – Guide for the Design and Construction of Concrete Site Paving for Industrial and Trucking Facilities
  - Uses design tables (Mainly for Trucks)
  - Lists additional design software:
    - ACPA StreetPave
    - Pavement ME
    - TCPavements / Optipave
    - ACPA AirPave


ACI 330.2R-17

Guide for the Design and Construction of Concrete Site Paving for Industrial and Trucking Facilities

Reported by ACI Committee 330

American Concrete Institute
Always advancing

Intermodal Design with PavementDesigner

- Design for a CAT 986 Loader
  - 130,000 lb
  - Wheel base = 12.5 ft
  - Axle width = 10 ft
  - Tire Pressure = 90 psi

Engine		
Engine Model	Cat® C15 ACERT™	
Gross Power – ISO 14396	329 kW	441 hp
Net Power – SAE J1349	305 kW	409 hp
Buckets		
Bucket Capacities	5-10.3 m^3	6.5-13.5 yd^3

Operating Specifications		
Rated Payload – Quarry Face	10 tonnes	11 tons
Rated Payload – Loose Material (Standard)	12.7 tonnes	14 tons
Rated Payload – Loose Material (High Lift)	11 tonnes	12.1 tons
Operating Weight	43 717 kg	96,379 lb

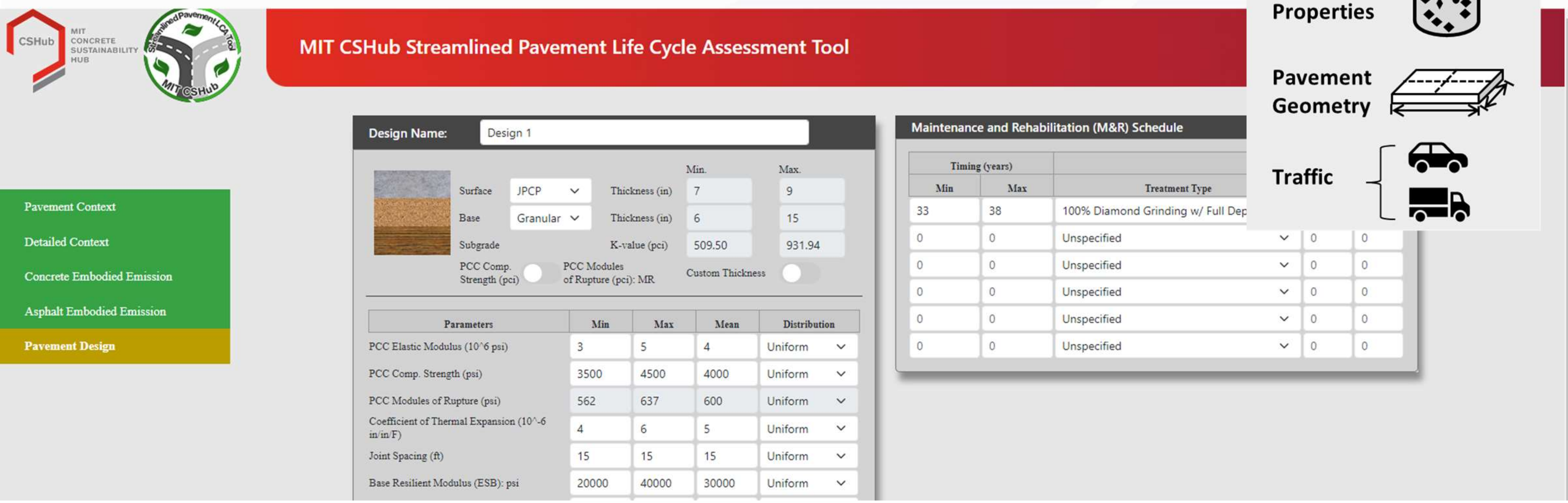
Optimization in the Future…Today!
Pavement Design and LCA
LCCA In a Future Update

http://pavementlca.mit.edu/

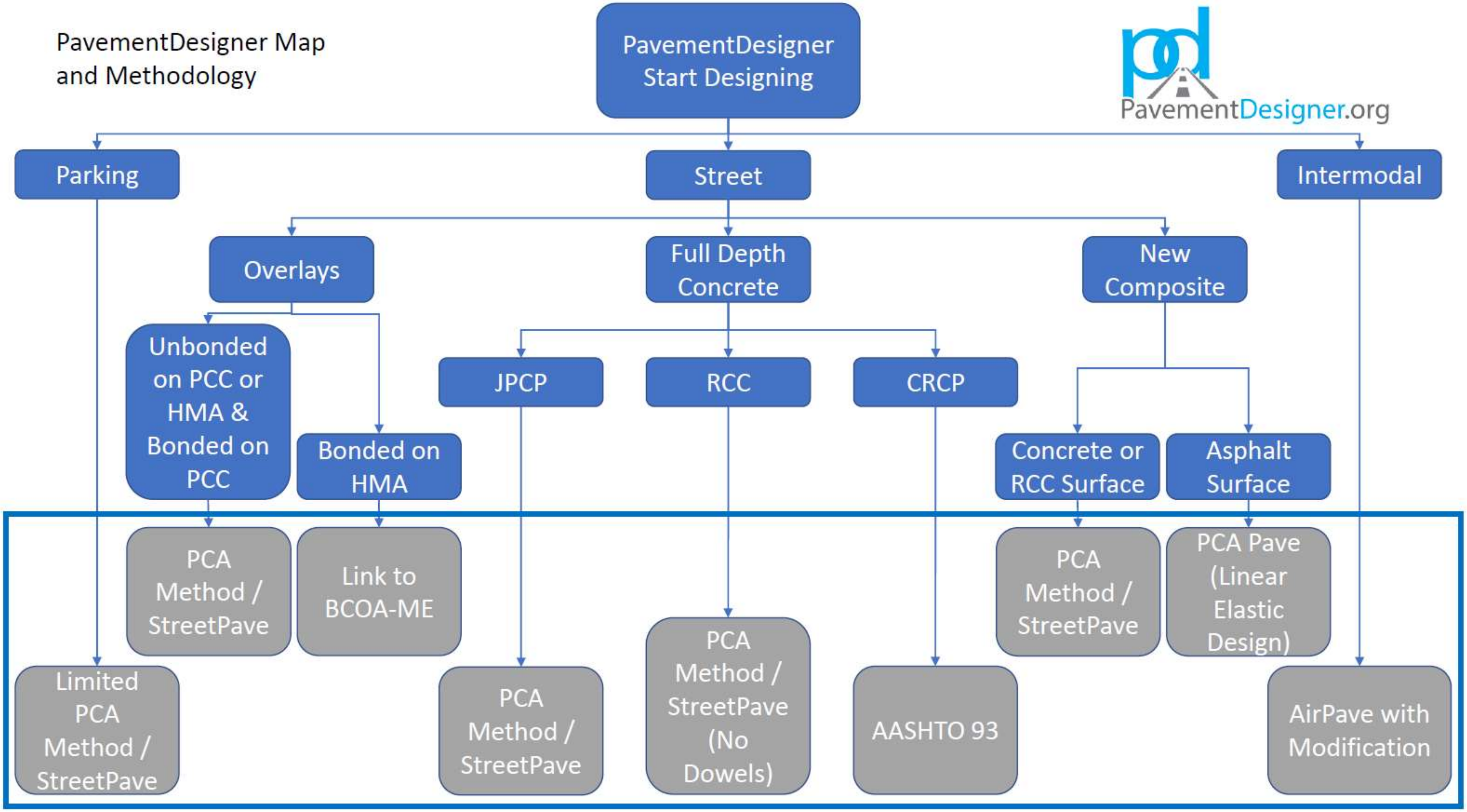
Input Data

Pavement Contexts

- Geographical Location
- Climatic Conditions
- Material Properties
- Pavement Geometry
- Traffic



PavementDesigner Map and Methodology



Thank You!

Any Questions?

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