Municipal Pavement Design with StreetPave Software

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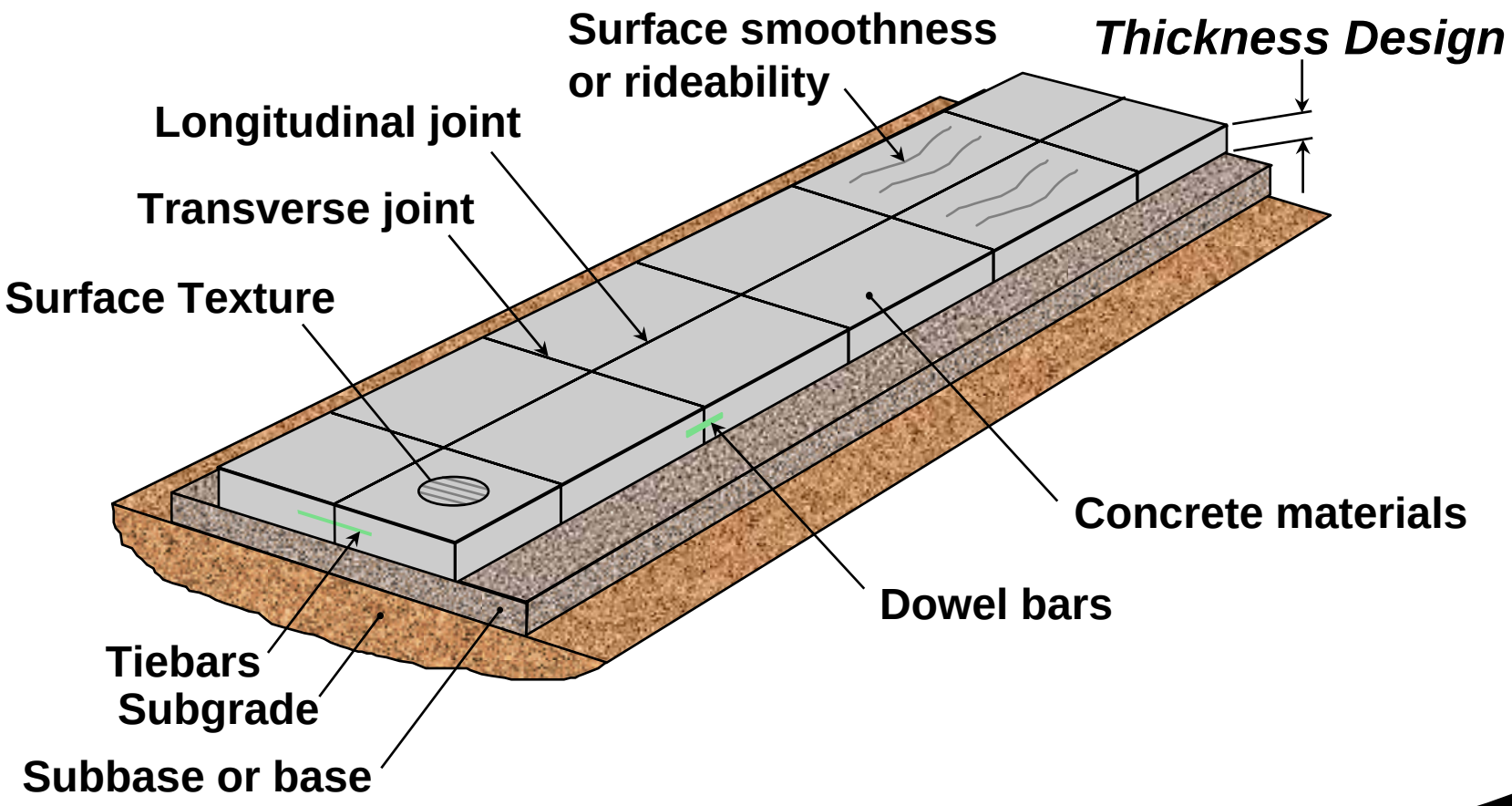
Presentation Overview

- Background / history of the design procedure
- Concrete pavement design principles
- Discussion of the primary factors (inputs) affecting concrete pavement design
- Example using StreetPave design software

Municipal Pavement Design

Thickness Design Basics

Streets and Local Roads Thickness Design Procedure



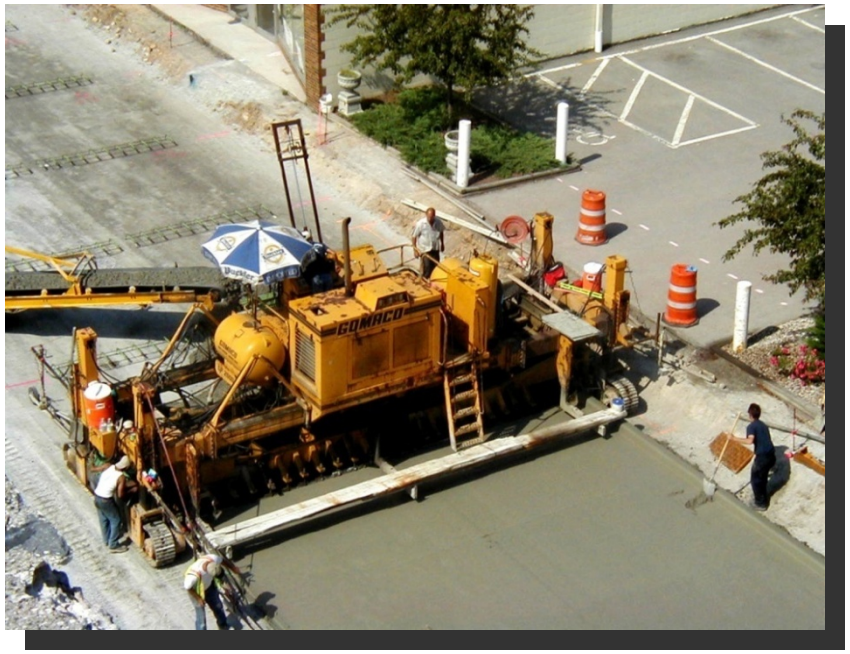
Thickness Design Procedures

- Empirical Design
  - Based on observed performance
    - AASHO Road Test
- Mechanistic Design
  - Based calculated pavement responses
    - PCA Design Procedure (PCAPAV)
    - StreetPave (ACPA Design Method)

AASHO Test Road:
Ottawa, Illinois (approximately 80 miles southwest of Chicago) between 1956 and 1960

StreetPave Design Software

- Pavement design tool geared primarily for roads & streets
- Based on the PCA's pavement thickness design methodology
- Checks adequacy of concrete thickness using both fatigue and erosion criteria

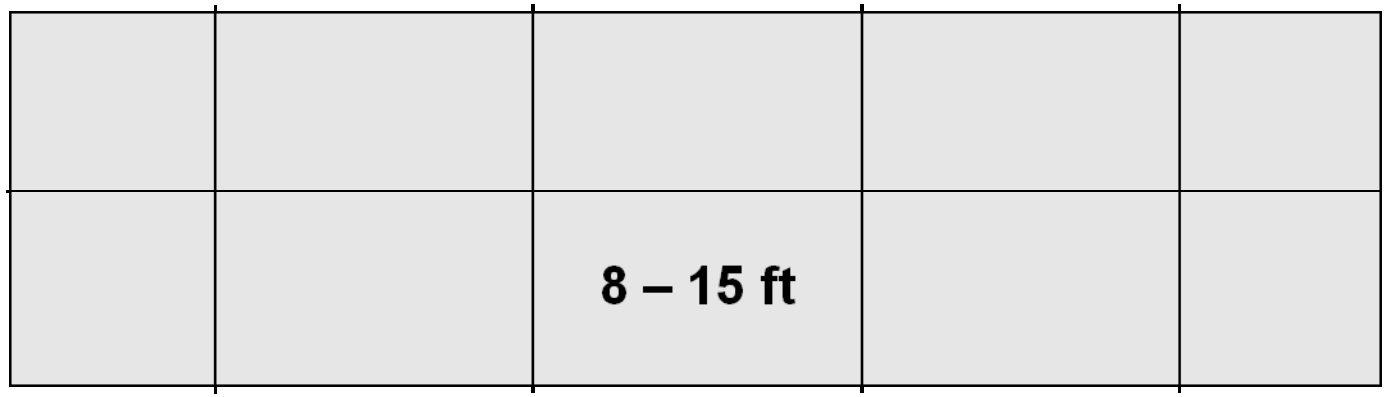


Concrete Pavement Types

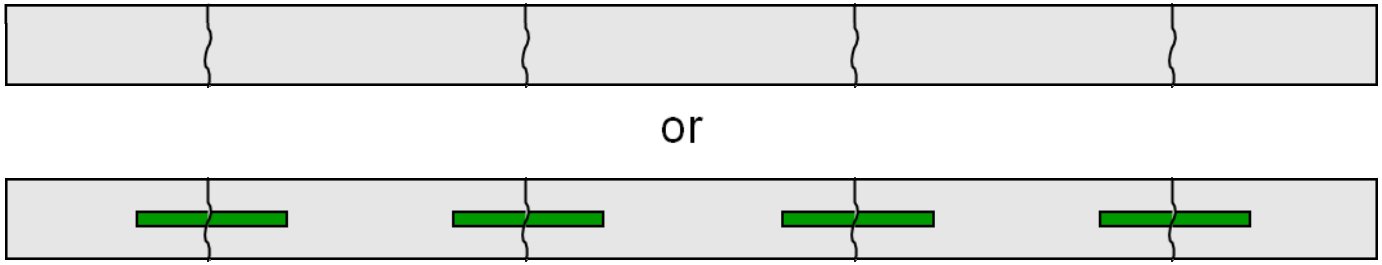
- Jointed Plain
  - Undoweled
  - Doweled
- Jointed Reinforced
- Continuously Reinforced
- Prestressed

Jointed Plain

Plan



Profile



SLR Pavement Design

- Street classification
- Traffic
- Geometric design
- Subgrade and subbase
- Concrete quality
- ***Thickness design***
- Jointing
- Dowel Bar Recommendations

Street Classifications

Street Class	Description	Two-way Average Daily Traffic (ADT)	Two-way Average Daily Truck Traffic (ADTT)	Typical Range of Slab Thickness
Light Residential	Short streets in subdivisions and similar residential areas – often not through-streets.	Less than 200	2-4	4.0 - 5.0 in. (100-125 mm)
Residential	Through-streets in subdivisions and similar residential areas that occasionally carry a heavy vehicle (truck or bus).	200-1,000	10-50	5.0 - 7.0 in. (125-175 mm)
Collector	**Streets that collect traffic from several residential subdivisions, and that may serve buses and trucks.**	**1,000-8,000**	**50-500**	**5.5 - 9.0 in. (135-225 mm)**
Business	Streets that provide access to shopping and urban central business districts.	11,000-17,000	400-700	6.0 - 9.0 in. (150-225 mm)
Industrial	Streets that provide access to industrial areas or parks, and typically carry heavier trucks than the business class.	2,000-4,000	300-800	7.0 - 10.5 in. (175-260 mm)
Arterial	Streets that serve traffic from major expressways and carry traffic through metropolitan areas. Truck and bus routes are primarily on these roads.	4,000-15,000 (minor) 4,000-30,000 (major)	300-600 700-1,500	6.0 - 9.0 in. (150-225 mm) 7.0 - 11.0 in. (175-275 mm)

Municipal Pavement Design

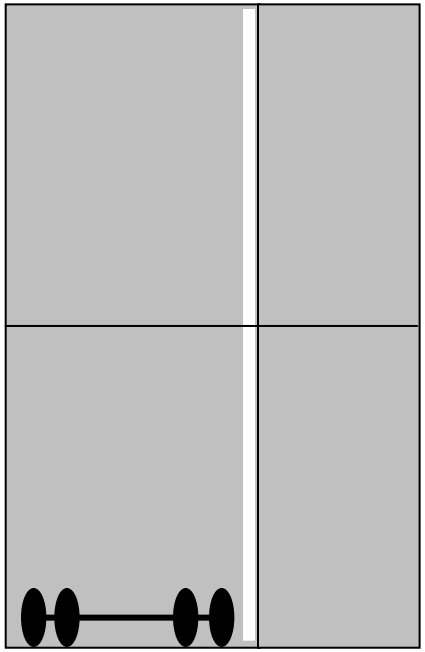
Geometric Design

Geometric Design

- Increase Edge Support
  - Integral Curb
  - Tied Curb & Gutter
  - Widened Lanes (2 feet no parking)
  - Parking Lanes
  - Rural Areas – Tied Concrete Shoulders

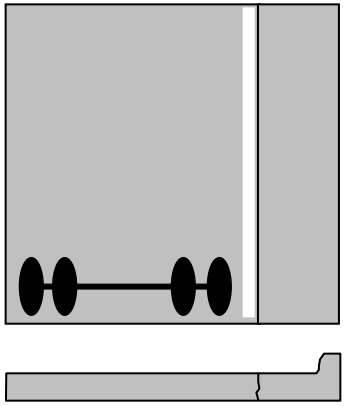
Edge Support

Concrete Shoulder



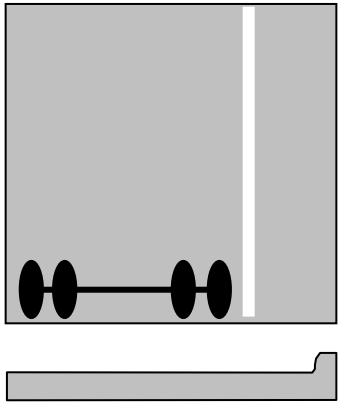
Curb & Gutter

separate

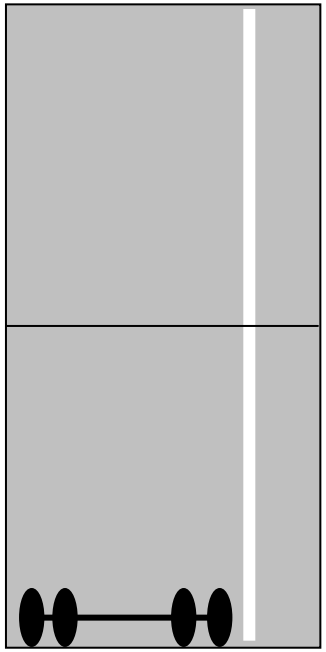


or

integral



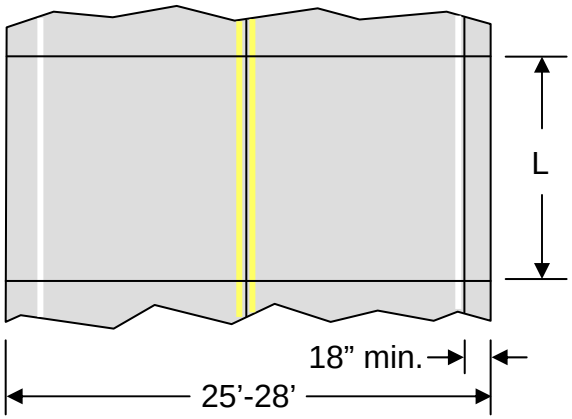
Widened Lane



Basic Two-Lane Sections

25’ to 28’ wide

PLAN



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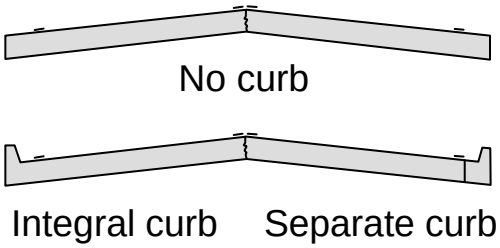
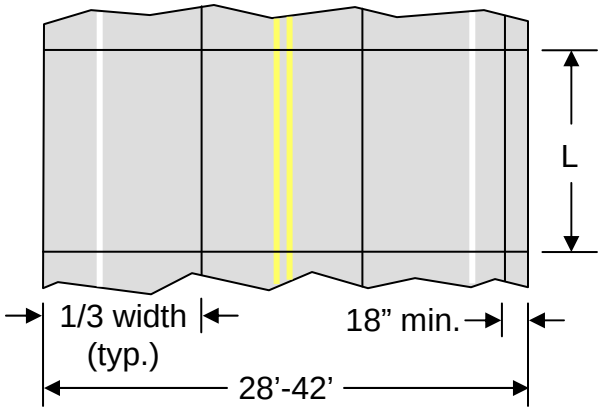


28’ to 42’ wide

PLAN



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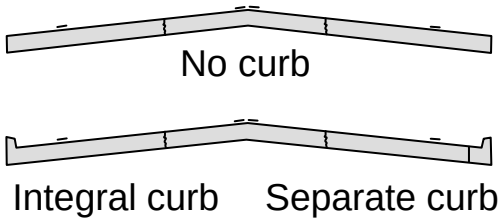
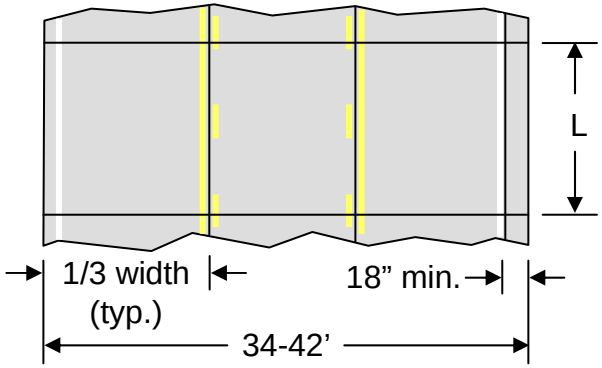


NOT TO SCALE

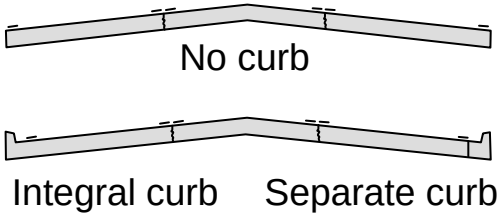
Three-Lane Section

34’ to 42’ wide

PLAN



PROFILE



NOT TO SCALE

Subgrades and Subbases

- Subgrade
  - Natural ground, graded, and compacted on which the pavement is built.
- Subbase
  - Layer of material directly below the concrete pavement.

Design for Uniform Support

<u>Three Major Causes for Non-Uniform Support</u>

- Expansive Soils
- Differential Frost Heave
- Pumping (loss of support)

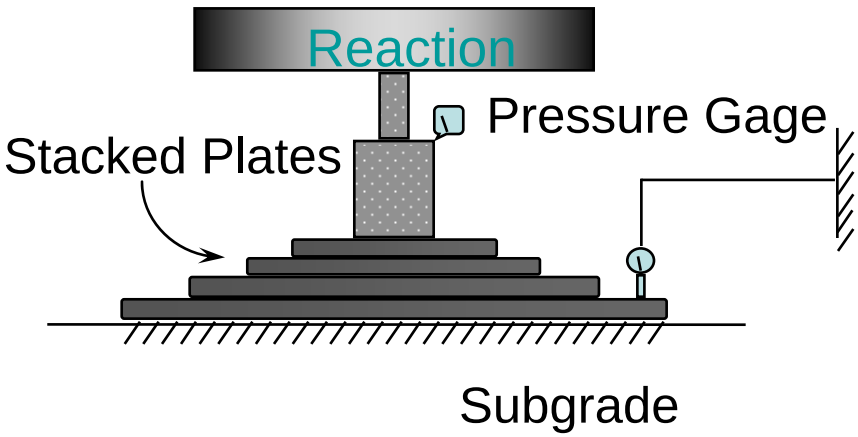
Subgrade Properties

Modulus of Subgrade Reaction, k-value

$$k = \frac{\text{Plate load on subgrade}}{\text{Plate deflection on subgrade}}$$

$$k = \frac{5.0 \text{ psi}}{0.5 \text{ in}} = 100 \text{ psi / in.}$$

Plate-Load Test



Subgrade Properties

Subgrade Soil Types and Approximate k Values

Type of Soil	Support	k value range)
Fine-grained soils in which silt and clay-size particles predominate	Low	75 - 120 pci (20 - 34 MPa/m)
Sands and sand-gravel mixtures with moderate amounts of silt and clay	Medium	130 - 170 pci (35 - 49 MPa/m)
Sands and sand-gravel mixtures relatively free of plastic fines	High	180 - 220 pci (50 - 60 MPa/m)

Subgrade Properties

Resilient Modulus of the Subgrade

Soil Type	Support	Resilient Modulus (MR), psi
Fine-grained with high amounts of silt/clay	Low	1455-2325
Sand and sand-gravel with moderate silt/clay	Medium	2500-3300
Sand and sand-gravel with little or no silt/clay	High	3500-4275

Subgrade Properties

Typical composite k-values for unbound granular, aggregate, or crushed stone subbase

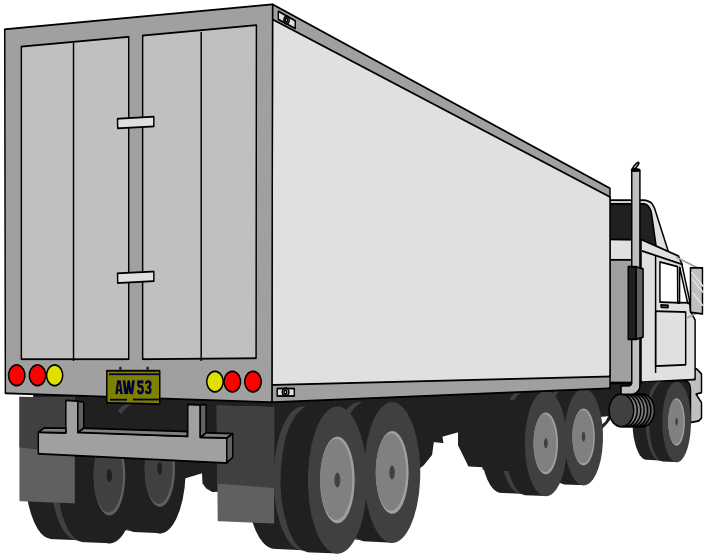
Subgrade k-value (pci)	Thickness of Unbound Granular or Crushed Stone Subbase			
	4”	6”	9”	12”
50	65	75	85	110
100	130	140	160	190
150	176	185	215	255
200	220	230	270	320

Subgrade and Subbases Design Summary

- Subgrade strength is not a critical element in the **<u>thickness design</u>**.
  - Has little impact on thickness.
- Need to know if pavement is on:
  - Subgrade ($k \approx 100$ psi/in. (25 MPa/m)),
  - Granular subbase ($k \approx 150$ psi/in. (40 MPa/m)),
  - Asphalt treated subbase ($k \approx 300$ psi/in. (80 MPa/m))
  - Cement treated/lean concrete subbase ($k \approx 500$ psi/in. (125 MPa/m)).

Subbase Effects

At the AASHO Road Test, concrete pavements with granular bases could carry about 30% more traffic.

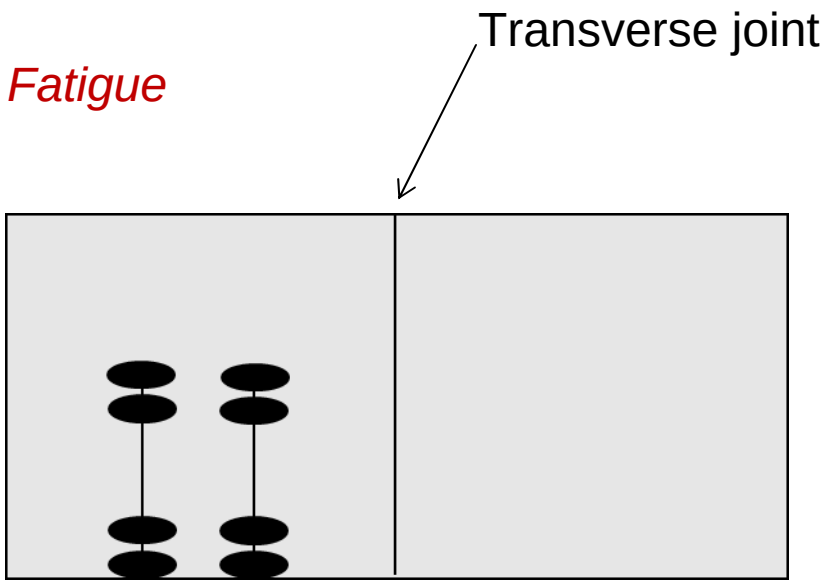


The current design procedures allows concrete pavements built with granular bases to carry about 5 - 8% more traffic.

Fatigue Analysis

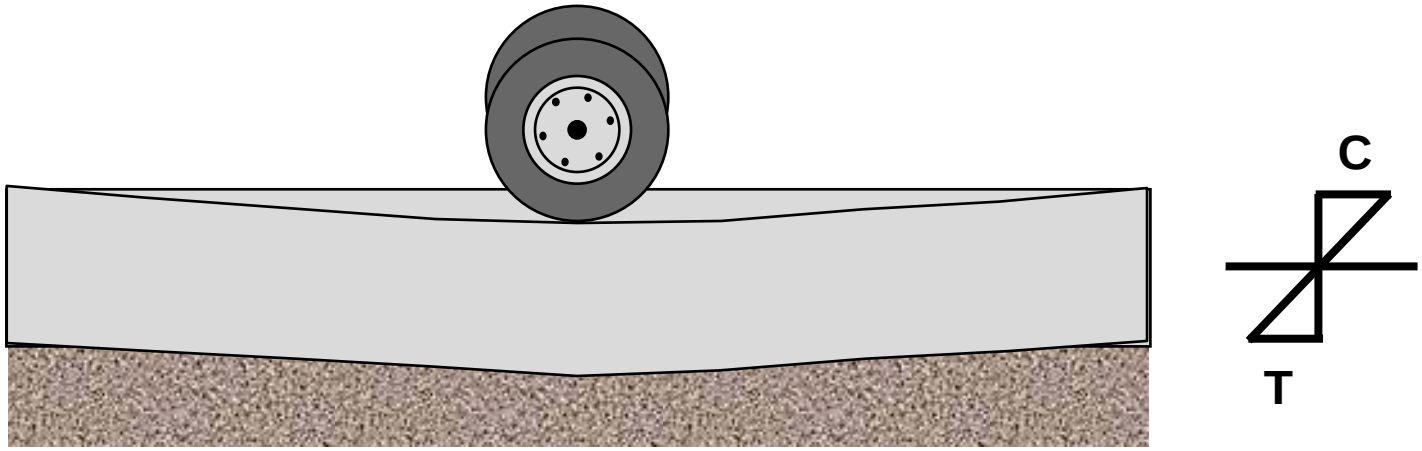
- Allowable number of load repetitions for each axle group is determined
- % Fatigue is calculated for each axle group
- Total fatigue consumed should not exceed 100%.

Critical Loading Position



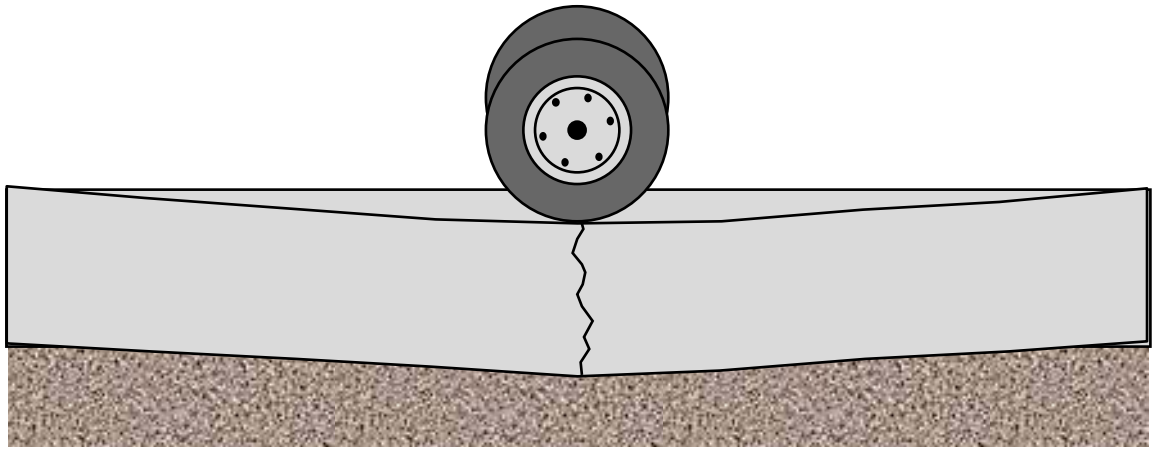
Midslab loading away from transverse joint produces critical edge stresses

Pavement Design Principle #1
Stress / Fatigue



- Compressive strength: ~4000 psi
- Flexural strength: ~600 psi

Pavement Design Principle #1
Stress / Fatigue

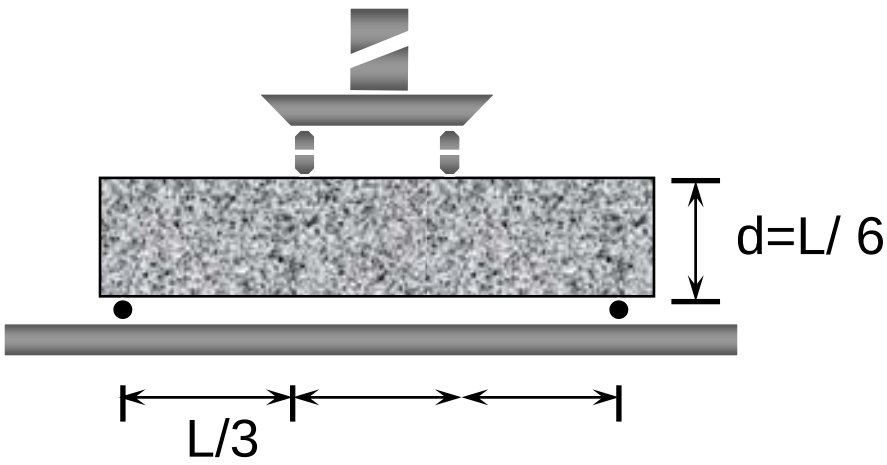


Thickness Design Procedure

Concrete Properties

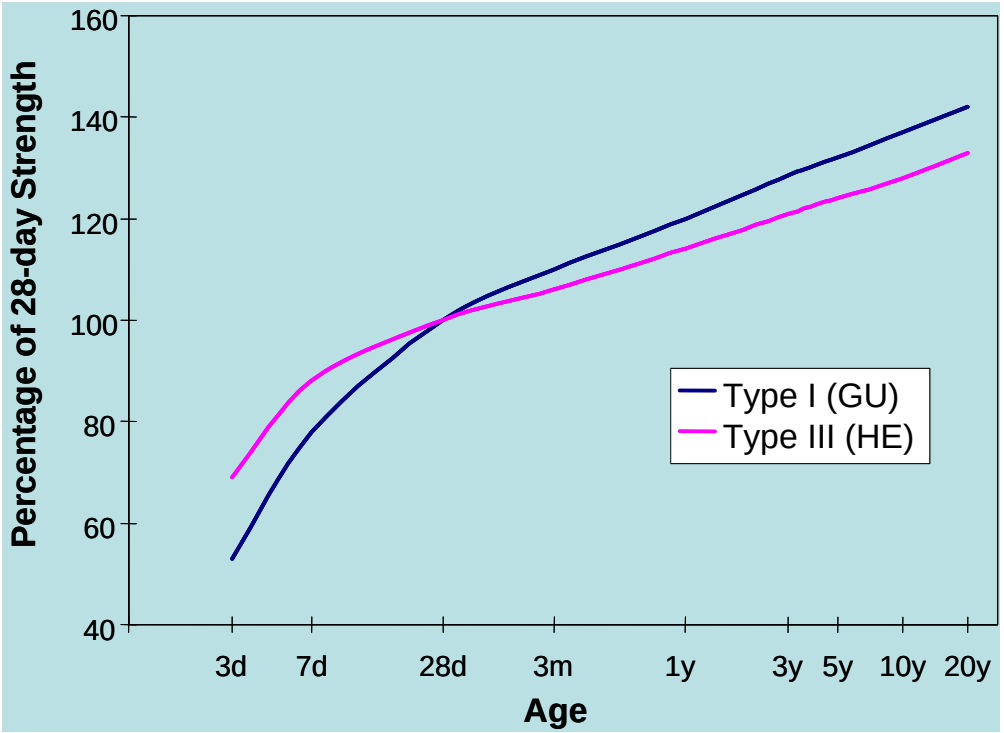
- Flexural Strength
  (Modulus of Rupture, ASTM C 78)
  - Avg. 28-day strength in 3rd-point loading
- Other Factors:
  - Concrete Strength Gain w/ Age
  - Fatigue Properties

Third-point Loading



Span Length = L

Concrete Strength Properties



If specify minimum flexural strength at 28-day of 550 psi & allow 10% of beams to fall below minimum:

<u>STEP 1</u>

Estimate SDEV:

9% for typical ready mix.

SDEV = 550 * 0.09 = 50 psi

<u>STEP 2</u>

S'c *design* = S'c *minimum* + z * SDEV

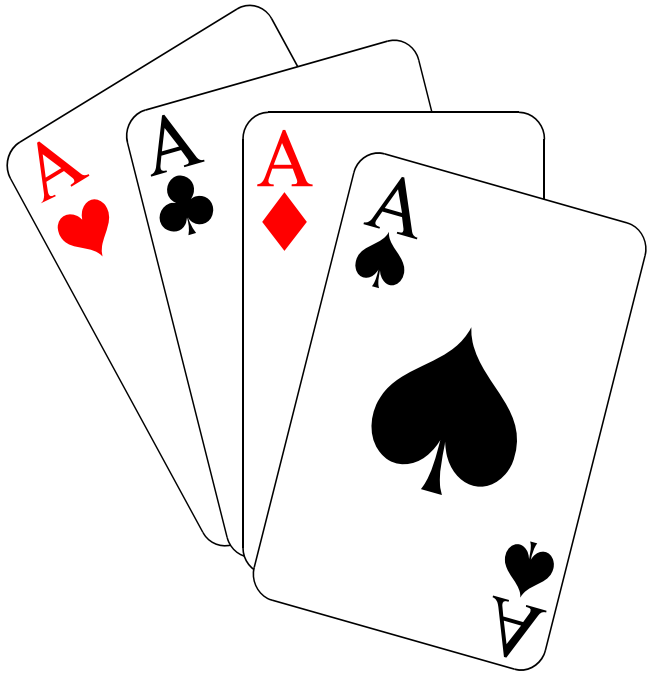
S'c *design* = 550 + 1.282 * 50

S'c *design* = 614 psi

Design Period/Life

- 20 to 35 years is commonly used
- Shorter or longer design period may be economically justified in some cases
- High performance concrete pavements
  - Long-life pavements
  - A special haul road to be used for only a few years
  - Cross-overs
  - Temporary lanes

Reliability



Probability of “Winning”

- Is simply the factor of safety
- Usually expressed as %
- Is a measure of how likely the design will fail due to fatigue or erosion
- Or can be used to estimate the amount of pavement repair required at the end of design period/life

Reliability

Levels of Reliability for Pavement Design

Functional Classification of Roadway	Recommended Reliability	
	Urban	Rural
Interstates, Freeways, and Tollways	85 - 99	80 – 99
Principal Arterials	80 - 99	75 – 95
Collectors	80 - 95	75 – 95
Residential & Local Roads	50 - 80	50 – 80

Thickness Design

Recommended Levels of Slab Cracking by Roadway Type

Roadway Type	**Recommended Percent of Slabs Cracked at End of Design Life**
(Default)	15%
Interstate Highways, Expressways, Tollways, Turnpikes	5%
State Roads, Arterials	10%
Collectors, County Roads	15%
Residential Streets	25%

Effects of Combined Reliability & Slab Cracking

Table 5. Typical Values of Reliability and Percent Cracking

Street classification	Specified reliability	Percent cracking	Average percent cracking
Light residential	75%	15%	7.5%
Residential	80%	15%	6%
Collector	85%	10%	3%
Minor arterial	90%	10%	2%
Major arterial	95%	5%	0.5%

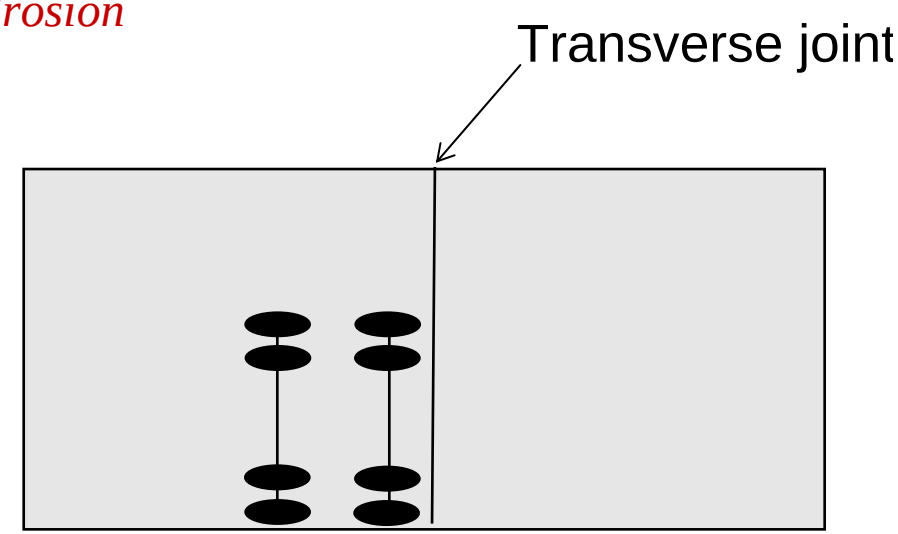
*Average percent cracking = (100 – User-specified reliability) * Percent cracking / 50.*

Erosion Analysis

- Repetitions of heavy axle loads cause:
  - pumping; erosion of subgrade, subbase and shoulder materials; voids under and adjacent to the slab; and faulting of pavement joints.
- A thin pavement with its shorter deflection basin receives a faster load punch than a thicker slab.

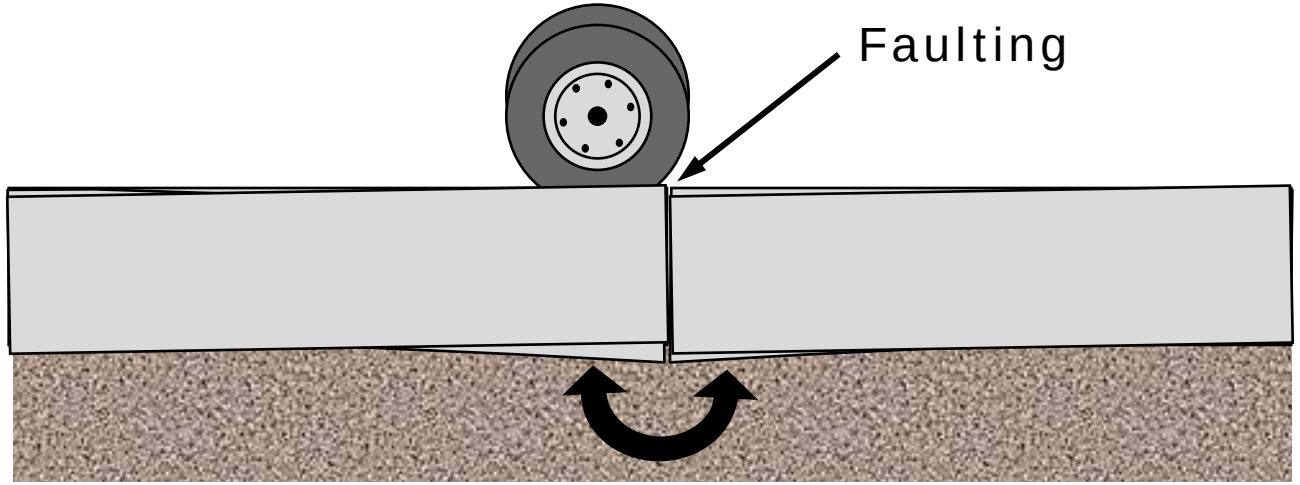
Critical Loading Position

Erosion



Corner loading produces
Critical pavement deflections

Pavement Design Principle #2
Deflection / Erosion / Pumping



Design - Erosion

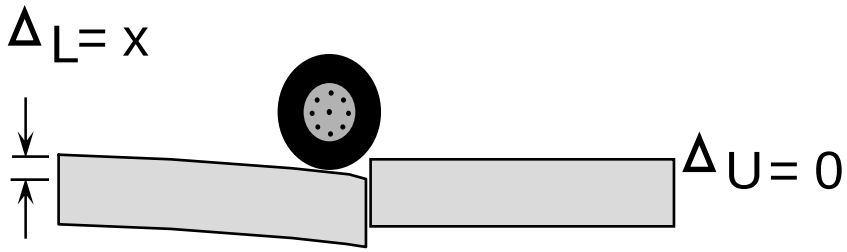
Conditions for Pumping:

- Subgrade soil that will go into Suspension
- Free water between slab and subgrade
- Frequent heavy wheel loads / large deflections

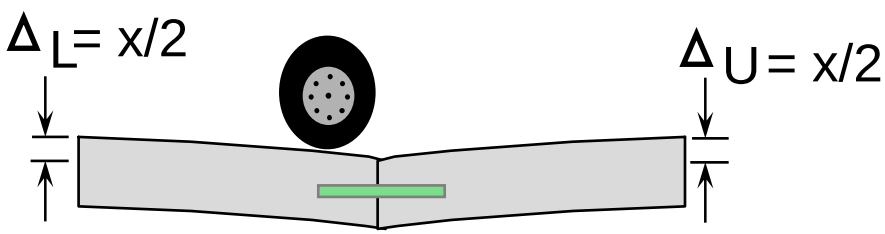
Concrete Pavement Design for Municipal Streets

Load Transfer = slabs ability to share its load with neighboring slabs

- Aggregate Interlock
- Dowels
- Edge Support
  - Tied curb & gutter
  - Integral curb & gutter
  - Parking lane
  - Tied concrete

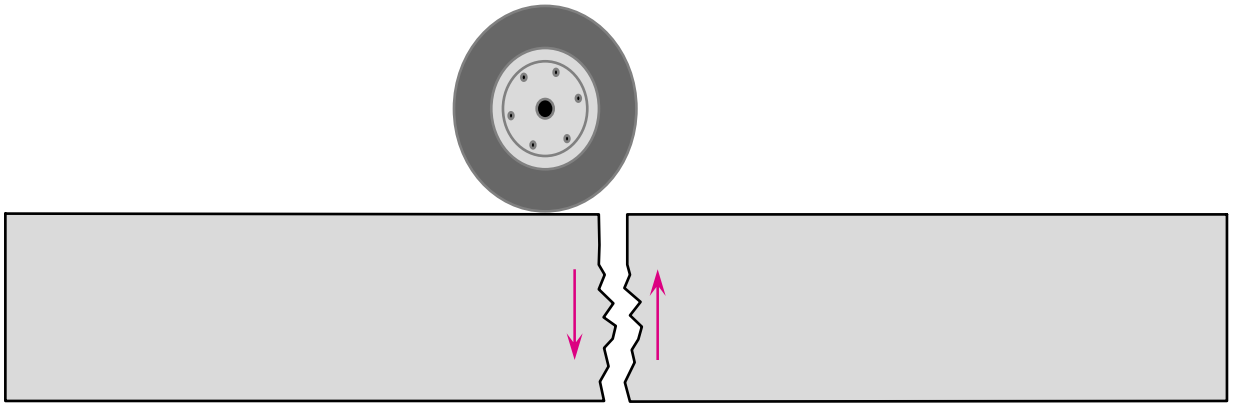


Poor Load Transfer



Good Load Transfer

Aggregate Interlock



Shear between aggregate particles
below the initial saw cut

Aggregate Interlock

Dowel Recommendations

- Dowels recommendations:
  - If pavement thickness is 7” or less dowels not recommended
  - If pavement thickness is 7.0” & 7.5” use 1” dowels, stabilized subgrade, or 4-6” subbase. Note: If erosion is the failure mechanism.
  - If pavement thickness is 8” or greater use 1¼“ dowels

Dowel bars

- Length 14” min.
- 6.0 in. minimum embedment length
- Diameter:
  - 1.0 in streets and roads
  - 1.25 - 1.50 in. for arterials roads
- Epoxy or other corrosion protection for harsh climates

Table 13(a). Concrete Thickness (inches), 30-Year Design WITH Concrete Curb and Gutter or Concrete Shoulders

Traffic classification		k = 100 pci			k = 150 pci			k = 200 pci			k = 300 pci		
		Modulus of rupture (psi)			Modulus of rupture (psi)			Modulus of rupture (psi)			Modulus of rupture (psi)		
		550	600	650	550	600	650	550	600	650	550	600	650
Light residential													
2-lane	ADTT = 3	5.0	5.0	4.5	5.0	4.5	4.5	4.5	4.5	4.0	4.5	4.0	4.0
Residential													
2-lane	ADTT = 10	5.5	5.5	5.0	5.5	5.0	5.0	5.0	5.0	4.5	5.0	4.5	4.5
	ADTT = 20	6.0	5.5	5.5	5.5	5.5	5.0	5.5	5.0	5.0	5.0	5.0	4.5
	ADTT = 50	6.0	6.0	5.5	5.5	5.5	5.0	5.5	5.0	5.0	5.0	5.0	4.5
Collector													
2-lane	ADTT = 50	6.5	6.0	6.0	6.0	6.0	5.5	6.0	5.5	5.5	5.5	5.5	5.0
	ADTT = 100*	6.5	6.5	6.0	6.5	6.0	6.0	6.0	6.0	(5.5)	6.0	(5.5)	(5.5)
	ADTT = 500*	7.0	6.5	6.5	6.5	6.5	6.0	6.5	6.0	6.0	6.0	6.0	(5.5)
Business													
2- or	ADTT = 400*	7.0	6.5	6.5	6.5	6.5	6.0	6.5	6.0	6.0	6.0	6.0	(5.5)
4-lane	ADTT = 700*	7.0	7.0	6.5	7.0	6.5	6.0	6.5	6.0	6.0	6.0	6.0	(5.5)
Minor arterial													
4-lane	ADTT = 300*	7.5	7.5	7.0	7.5	7.0	6.5	7.0	6.5	6.5	6.5	6.5	6.0
	ADTT = 600*	8.0	7.5	7.0	7.5	7.0	7.0	7.5	7.0	6.5	7.0	6.5	6.5
Industrial													
4-lane	ADTT = 300*	8.0	8.0	7.5	8.0	7.5	7.0	7.5	7.0	7.0	7.0	7.0	6.5
	ADTT = 800*	8.5	8.0	8.0	8.0	7.5	7.5	8.0	7.5	7.0	7.5	7.0	7.0
Major arterial													
4-lane	ADTT = 700*	8.5	8.0	7.5	8.0	7.5	7.5	8.0	7.5	7.0	7.5	7.0	6.5
	ADTT = 1100*	8.5	8.0	8.0	8.0	8.0	7.5	8.0	7.5	7.0	7.5	7.0	7.0
	ADTT = 1500*	8.5	8.5	8.0	8.5	8.0	7.5	8.0	7.5	7.5	7.5	7.5	7.0

* Dowels recommended when ADTT is greater than or equal to 80:

1. If pavement thickness is 6" or less dowels not recommended
2. If pavement thickness is 6.5" to 7.5" use 1" dowels
3. If pavement thickness is 8" or greater use 1¼" dowels

CONVERSIONS

1 in. = 25.4 mm

100 psi = 0.689 MPa

100 pci = 27.15 MPa/m

NOTES FOR BOTH TABLES 13(a) and 13(b):

Table 13(b). Concrete Thickness (inches), 30-Year Design WITHOUT Concrete Curb and Gutter or Concrete Shoulders

		k = 100 pci			k = 150 pci			k = 200 pci			k = 300 pci		
		Modulus of rupture (psi)			Modulus of rupture (psi)			Modulus of rupture (psi)			Modulus of rupture (psi)		
Traffic classification		550	600	650	550	600	650	550	600	650	550	600	650
Light Residential	ADTT = 3	6.0	5.5	5.5	5.5	5.5	5.0	5.5	5.0	5.0	5.0	5.0	4.5
Residential 2-lane	ADTT = 10	6.5	6.5	6.0	6.5	6.0	6.0	6.0	6.0	5.5	6.0	5.5	5.5
	ADTT = 20	7.0	6.5	6.0	6.5	6.0	6.0	6.5	6.0	5.5	6.0	5.5	5.5
	ADTT = 50	7.0	7.0	6.5	7.0	6.5	6.0	6.5	6.0	6.0	6.0	6.0	5.5
Collector 2-lane	ADTT = 50	7.5	7.0	7.0	7.0	7.0	6.5	7.0	6.5	6.5	6.5	6.5	6.0
	ADTT = 100*	8.0	7.5	7.0	7.5	7.0	6.5	7.0	7.0	6.5	7.0	6.5	6.0
	ADTT = 500*	8.0	8.0	7.5	8.0	7.5	7.0	7.5	7.0	7.0	7.0	7.0	6.5
Business 2- or 4-lane	ADTT = 400*	8.0	8.0	7.5	7.5	7.5	7.0	7.5	7.0	7.0	7.0	7.0	6.5
	ADTT = 700*	8.5	8.0	7.5	8.0	7.5	7.0	7.5	7.5	7.0	7.5	7.0	6.5
Minor Arterial 4-lane	ADTT = 300*	9.0	8.5	8.0	8.5	8.0	7.5	8.0	8.0	7.5	8.0	7.5	7.0
	ADTT = 800*	9.5	9.0	8.5	9.0	8.5	8.0	8.5	8.0	7.5	8.0	7.5	7.5
Industrial 4-lane	ADTT = 300*	9.5	9.0	8.5	9.0	8.5	8.0	8.5	8.5	8.0	8.5	8.0	7.5
	ADTT = 800*	10.0	9.5	9.0	9.5	9.0	8.5	9.0	9.0	8.0	8.5	8.0	8.0
Major Arterial 4-lane	ADTT = 700*	10.0	9.5	9.0	9.5	9.0	8.5	9.0	8.5	8.0	8.5	8.0	8.0
	ADTT = 1100*	10.0	9.5	9.0	9.5	9.0	8.5	9.0	8.5	8.5	8.5	8.5	8.0
	ADTT = 1500*	10.0	9.5	9.0	9.5	9.0	8.5	9.0	9.0	8.5	9.0	8.5	8.0

* Dowels recommended when ADTT is greater than or equal to 80:

1. If pavement thickness is 6" or less dowels not recommended
2. If pavement thickness is 6.5" to 7.5" use 1" dowels
3. If pavement thickness is 8" or greater use 1¼" dowels

CONVERSIONS

1 in. = 25.4 mm

100 pci = 0.689 MPa

100 pci = 27.15 MPa/m

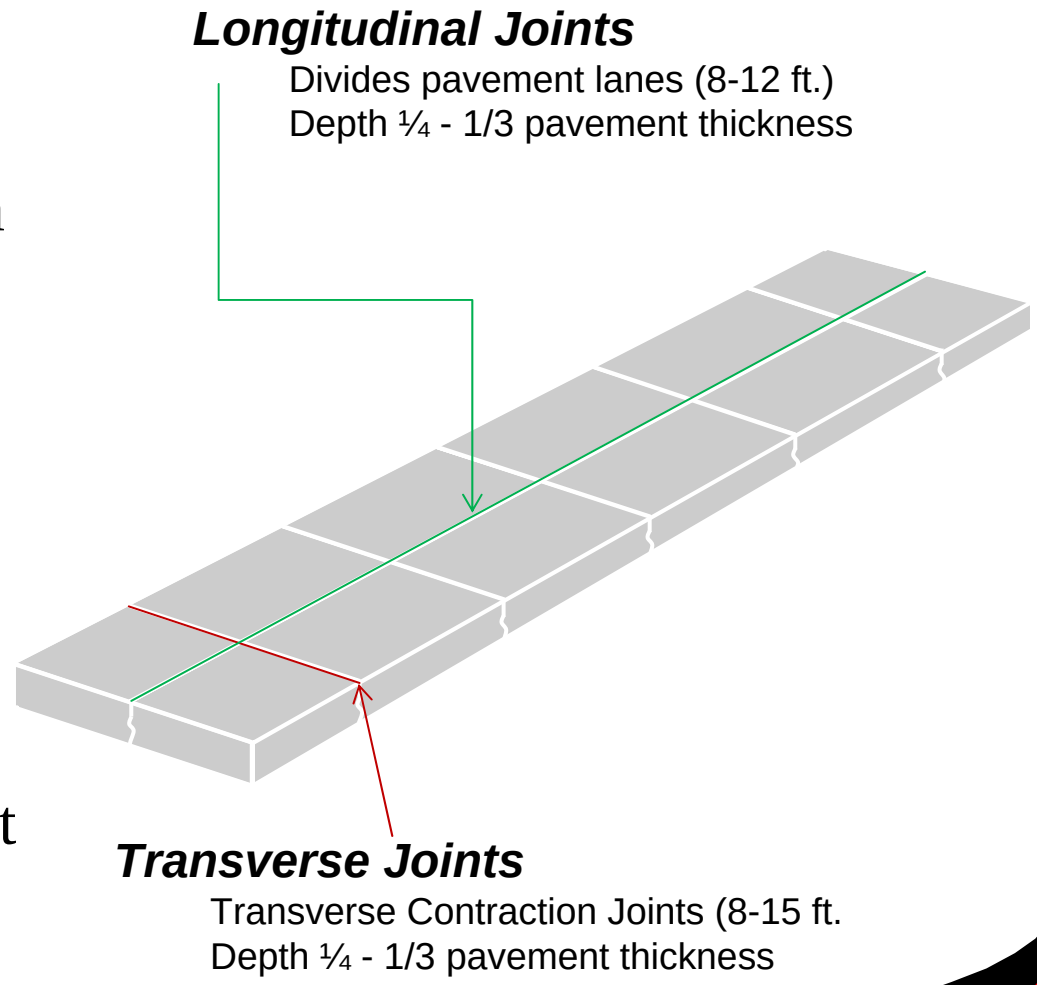
Thickness Design Procedure

Design controlled by:

- Fatigue usually controls design of light-traffic pavements, light residential, collector, minor arterial
  - Single-axles usually cause more fatigue damage
- Erosion usually controls design of undoweled medium- and heavy-traffic pavements, minor and major arterials
  - Tandem-axles usually cause more erosion damage
  - Tridem-axles usually cause more erosion damage

Jointing

- Control natural transverse and longitudinal crack from internal slab stresses
- Divide pavement into construction lanes or increments
- Accommodate slab movements
- Provide load transfer
- Provide uniform sealant reservoir



Municipal Pavement Design

StreetPave Example

StreetPave User Inputs & Outputs

- Global Settings
  - Region
  - Units (English or Metric)
  - Terminal Serviceability
  - Percent Slabs Cracked at end of design Life
- Design Life
- Reliability
- Traffic
- Pavement Properties
- Thickness/Dowel/Jointing Recommendations

Design Example – Inputs

- Design life = 30 years
- k-value = 100 pci
- Concrete flexural strength = 600 psi
- Load transfer (dowels) = No/yes
- Edge support = yes
- Traffic category = Collector
- 2-way ADTT = 100
- Reliability = 80%
- Percent Slabs Cracked = 15%

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Enable Walkthrough Wizard

Project Information:

Project Name

Project Description

Route

Owner / Agency

Location

Design Engineer

Design/Analysis Type:

- (•) Determine Concrete Thickness and
  - [ ] Determine Equivalent Asphalt Thickness
  - [ ] Determine Life-Cycle Costs
- ( ) Analyze Existing Concrete Pavement

Project-Level Inputs:

Design Life 20 years Help

Reliability 85 % Help

StreetPave Global Settings

Edit your global settings below.

1. Region (refer to map)

- MAAT = 45°F
- MAAT = 60°F
- MAAT = 75°F

2. Units

- English
- Metric

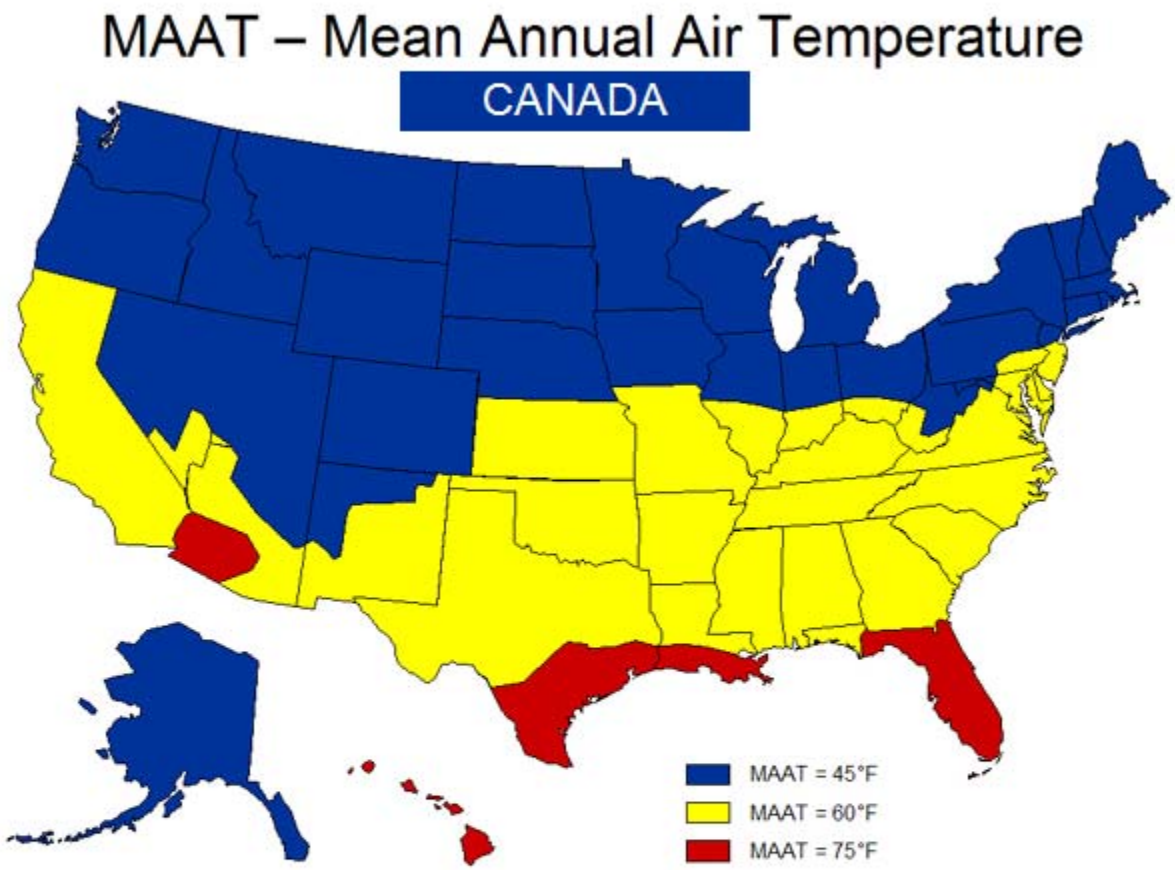
3. Terminal Serviceability

2 Help

4. Percent of Concrete Slabs Cracked at End of Design Life

15 % Help

Save and Close



StreetPave Global Settings

Edit your global settings below.

1. Region (refer to map)

- MAAT = 45°F
- MAAT = 60°F
- MAAT = 75°F

2. Units

- English
- Metric

3. Terminal Serviceability

2 Help

4. Percent of Concrete Slabs Cracked at End of Design Life

15 % Help

Save and Close

Help (Terminal Serviceability)

Serviceability is a measure of pavement condition. It was devised for the AASHO Road Test, which occurred from 1958 to 1960 in Ottawa, Illinois. The serviceability of a pavement is rated on a scale from 0 (completely impassable) to 5 (perfect pavement condition). Terminal serviceability is the point at which the pavement needs rehabilitation of some sort, such as restoration, resurfacing, or reconstruction.

StreetPave uses terminal serviceability to calculate the equivalent single axle loads (ESALs) carried by the pavement structure over the design life. The calculation of ESALs is not very sensitive to terminal serviceability, so an estimate of the desired terminal serviceability is adequate.

Typical terminal serviceability values include:

Terminal Serviceability	Road or Street Classification
2.50	Interstates, Tollways, Major Highways, Major Arterials
2.25	Primary Roads, Minor Arterials, Industrial and Commercial Streets
2.00	Secondary Roads, Collector Residential Streets
1.50	Complete Pavement Failure

StreetPave Global Settings

Edit your global settings below.

1. Region (refer to map)

- MAAT = 45°F
- MAAT = 60°F
- MAAT = 75°F

2. Units

- English
- Metric

3. Terminal Serviceability

2 Help

4. Percent of Concrete Slabs Cracked at End of Design Life

15 % Help

Save and Close

Help (Percent Cracking)

This input should reflect the allowable percent of concrete slabs that are cracked at the end of the design life of the pavement. This number could correspond to the percent of slabs that are intended to be replaced in determining future rehabilitation of the pavement for life cycle cost analysis. Recommended percentages are as follows:

Type	Recommended Percent of Concrete Slabs Cracked at End of Design Life
Default	15%
Interstate Highways, Expressways,Tollways, Turnpikes	5%
State Roads, Arterials, Collectors, County Roads	15%
Residential Streets	25%

The asphalt fatigue equation (or relationship) on which the asphalt design procedures are based was obtained from laboratory fatigue data which had been adjusted to provide an indication of approximately 20 percent or greater fatigue cracking (based on total pavement area) in selected sections of the AASHO Road Test. Therefore, asphalt designs are essentially locked at 20 percent cracking or greater (45 percent in the wheel path [1]) while cor ete pavements are typically designed for less than that amount. [2]

1. Asphalt Institute, "Research and Development of the Asphalt Institute's Thickness Design Manual (MS-1) Ninth Edition," RR-82-2, August 1982, p. 9.

2. National Cooperative Highway Research Program, Recommended Performance-Related Specification for Hot-Mix Asphalt Construction: Results of the WesTrack Project, NCHRP Report 455, 2002, p. 31.

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Step 1. Choose the Design/Analysis Type(s) you would like to perform and then click the Confirm button. Confirm

Project Information:

Project Name

Project Description

Route

Owner / Agency

Location

Design Engineer

Design/Analysis Type:

- (•) Determine Concrete Thickness and
  - [x] Determine Equivalent Asphalt Thickness
  - [x] Determine Life-Cycle Costs
- ( ) Analyze Existing Concrete Pavement

Project-Level Inputs:

Design Life 20 years Help

Reliability 85 % Help

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 2. Enter Project Information and Project-Level Inputs then click the Next button. | Next

Project Information:

Project Name: Virginia Concrete Pavement Confere

Project Description: 2-Lane Collector

Route: Route 1

Owner / Agency: City of Richmond

Location: Richmond, VA

Design Engineer: Scott Haislip

Design/Analysis Type:

- (•) Determine Concrete Thickness and
  - [x] Determine Equivalent Asphalt Thickness
  - [x] Determine Life-Cycle Costs
- ( ) Analyze Existing Concrete Pavement

Project-Level Inputs:

Design Life: 30 years [Help]

Reliability: 80 % [Help]

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 3. Define Traffic by filling in and making choices for all inputs. | Next

Traffic category

- ○ Residential
- ◉ Collector
- ○ Minor Arterial
- ○ Major Arterial

User Defined

Help

Total Number of Lanes: Choose Number

2
4
6
8
10

Directional Distribution — Help

Design Lane Distribution — Help

- ◉ ADTT (average daily truck traffic, two-way): 100
- ○ ADT (average daily traffic, two-way): 2000
- % trucks: 1

Help

Truck traffic growth: 2 % per year

Traffic Category:	Collector
kips	Axles / 1000 trucks
Single Axles	
26	0.07
24	1.6
22	2.6
20	6.63
18	16.61
16	23.88
14	47.76
12	116.76
10	142.7
8	233.6
Tandem Axles	
44	1.16
40	7.76
36	38.79
32	54.76
28	44.43
24	30.74
20	45
16	59.25
12	91.15
8	47.01
Tridem Axles (User Defined Only)	
62	0
56	0
50	0
44	0
38	0
32	0
26	0
20	0
14	0
8	0

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 3. Define Traffic by filling in and making choices for all inputs. | Next

Traffic category

- ○ Residential
- ◉ Collector
- ○ Minor Arterial
- ○ Major Arterial

User Defined

Help

Total Number of Lanes: 2

Directional Distribution: 50 % Help

Design Lane Distribution: 100 % Help

- ◉ ADTT (average daily truck traffic, two-way): 100
- ○ ADT (average daily traffic, two-way): 2000

% trucks: 1

Help

Truck traffic growth: 2 % per year

Traffic Category:	Collector
kips	Axles / 1000 trucks
Single Axles	
26	0.07
24	1.6
22	2.6
20	6.63
18	16.61
16	23.88
14	47.76
12	116.76
10	142.7
8	233.6
Tandem Axles	
44	1.16
40	7.76
36	38.79
32	54.76
28	44.43
24	30.74
20	45
16	59.25
12	91.15
8	47.01
Tridem Axles (User Defined Only)	
62	0
56	0
50	0
44	0
38	0
32	0
26	0
20	0
14	0
8	0

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 4. Define Pavement Properties by filling in and making choices for all inputs. | Next

CONCRETE PAVEMENT | ASPHALT PAVEMENT

Resilient Modulus of the Subgrade (M_{RSG})
(used for both concrete and asphalt designs)
Calculate | 1940 psi | Help

Composite Modulus of Subgrade Reaction (k)

- (•) **Design subbase layer system and use calculated k value**
  Add Layers | 100 pci | Help
- ( ) **User-defined k value for existing subbase layer system**
  161 pci

Select Concrete Properties

28-Day Flexural Strength (MR) 600 psi Help

Modulus of Elasticity (E) 4050000 psi Help

Select Load Transfer Dowels

( ) yes (•) no Help

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

(•) yes ( ) no Help

Adjust Support for Asphalt Design Reliability

Coefficient of Variation (COV) 38 % Help

Design (M_{RSG}) 1319.56 psi Info*

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.

Select Asphalt Pavement Type

Design Type: Choose Type

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 4. Define Pavement Properties by filling in and making choices for all inputs. | Next

CONCRETE PAVEMENT | ASPHALT PAVEMENT

Resilient Modulus of the Subgrade (M_{RSG}) (used for both concrete and asphalt designs) — Calculate — 1940 psi — Help

Composite Modulus of Subgrade Reaction (k)

- (●) **Design subbase layer system and use calculated k value** — Add Layers — 100 pci — Help
- ( ) **User-defined k value for existing subbase layer system** — 161 pci

Select Concrete Properties

28-Day Flexural Strength (MR) — 600 psi — Help

Modulus of Elasticity (E) — 4050000 psi — Help

Select Load Transfer Dowels

( ) yes (●) no — Help

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

(●) yes ( ) no — Help

Adjust Support for Asphalt Design Reliability

Coefficient of Variation (COV) — 38 % — Help

Design (M_{RSG}) — 1319.56 psi — Info*

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.

Select Asphalt Pavement Type

Design Type: Choose Type

- Asphalt with 6" Granular Base
- Asphalt with 12" Granular Base

StreetPave

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Help (Subgrade Modulus Coefficient of Variation)

The asphalt design procedure used in this program incorporates reliability of the asphalt design section as a function of the subgrade resilient modulus. To accomplish this adjustment, a coefficient of variation of the supporting soils is needed. Also, seasonal variation is not considered as part of this procedure. Average conditions should be used.

The equation used is as follows:

MRSG [design] = MRSG [user-entered] × (1 - ZR × COV)

Where:

MRSG [design] = the value of subgrade resilient modulus to use in the asphalt design equation

MRSG [user-entered] = the subgrade resilient modulus value that is entered (or calculated) by the user

ZR = standard normal variate, calculated from user-entered reliability (R)

COV = coefficient of variation typical of the project type and soils for the project

Typical values to use for coefficient of variation, if the value is unknown for a particular project:

Range	Note
0.28-0.38	Projects with extremely high levels of quality control and very homogenous soils throughout the project. Projects characteristic of research sections and special projects.
0.38-0.45	Projects with typical levels of quality control and typical variation of soils within the project. Typical mainline highway construction.
0.46-0.58	Projects with typical levels of quality control in variable soils. Typical mainline roadway construction or high-quality municipal construction.
0.59-0.70	Projects with little quality control of soils. Sections typical of municipal paving or industrial sections built with little or no inspection.
0.38	Note: The coefficient of variation for soils on the flexible sections at the AASHO Road Test, 1958-1960, Ottawa, Illinois, USA.

Note: This guidance is based largely on experience in looking at field data as well as reports and data from state highway agencies.

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 4. Define Pavement Properties by filling in and making choices for all inputs. | Next

CONCRETE PAVEMENT ASPHALT PAVEMENT

Resilient
(used for bo

Composite Modu
Design subba
Add Layers
User-defined

Select Concre
28-Day Flex
Strength (
Modulu
Elasticity

Select Load Tr
yes

Select Edge S
and gutter, or
yes

Help (Asphalt Subgrade Resilient Modulus)

Consistent with asphalt industry procedures, the asphalt design equations used in StreetPave are not calibrated to subgrade resilient moduli lower than 3000 psi. However, values less than 3000 psi can be used in StreetPave, if a base course is specified under the asphalt. On softer soils, a base (or subbase) course of crushed stone or other quarried material becomes a construction platform to aid asphalt compaction. In order to obtain the required density in the asphalt during construction, the asphalt lifts need to be placed against a material that can provide adequate support. If a specific soil has a resilient modulus lower than 3000 psi, it can also be improved through the use of chemical stabilization or modification agents such as cement, cement kiln dust, fly ash, lime, or lime kiln dust.

StreetPave uses the MRSG [design] value as opposed to the MRSG [user-entered] value for calculations and analysis. This is consistent with asphalt industry practice, which incorporates reliability into pavement design by directly adjusting the resilient modulus of the subgrade (MRSG Design). The MRSG [design] equation is provided below.

Your current values:

MRSG [user-entered]: 1940 psi **MRSG [design]: 1319.6 psi**

The equation used is as follows:

MRSG [design] = MRSG [user-entered] x (1 - ZR x COV)

Where:

MRSG [design] = the value of subgrade resilient modulus to use in the asphalt design equation

MRSG [user-entered] = the subgrade resilient modulus value that is entered (or calculated) by the user

ZR = standard normal variate, calculated from user-entered reliability (R)

COV = coefficient of variation typical of the project type and soils for the project

***Design Limitation**

The full depth asphalt design type is not available because your current MRSG [design] value is less than 3000 psi. If full-depth asphalt designs are desired, the user-entered subgrade resilient modulus, reliability, and/or coefficient of variation must be modified in order to obtain a design subgrade resilient modulus greater than 3,000 psi.

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 4. Define Pavement Properties by filling in and making choices for all inputs. | Next

CONCRETE PAVEMENT | ASPHALT PAVEMENT

Resilient Modulus of the Subgrade (M_{RSG}) (used for both concrete and asphalt designs) — Calculate — 1940 psi — Help

Composite Modulus of Subgrade Reaction (k)

- (●) **Design subbase layer system and use calculated k value** — Add Layers — 100 pci — Help
- ( ) **User-defined k value for existing subbase layer system** — 161 pci

Select Concrete Properties

28-Day Flexural Strength (MR) — 600 psi — Help

Modulus of Elasticity (E) — 4050000 psi — Help

Select Load Transfer Dowels

( ) yes (●) no — Help

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

(●) yes ( ) no — Help

Adjust Support for Asphalt Design Reliability

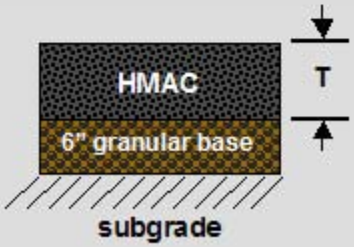
Coefficient of Variation (COV) — 38 % — Help

Design (M_{RSG}) — 1319.56 psi — Info*

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.

Select Asphalt Pavement Type

Design Type: Asphalt with 6" Granular Base



StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Ar

Previous | Step 4. Define Pavement Properties by filling in and ma

CONCRETE PAVEMENT

Resilient Modulus of the Subgrade (M_{RSG})
(used for both concrete and asphalt designs)

Composite Modulus of Subgrade Reaction (k)

- (•) **Design subbase layer system and use calculated k value**
  - Add Layers — 100 pci — Help
- ( ) **User-defined k value for existing subbase layer system**
  - 161 pci

Select Concrete Properties

28-Day Flexural Strength (MR): 600 psi — Help

Modulus of Elasticity (E): 4050000 psi — Help

Select Load Transfer Dowels

(•) yes ( ) no — Help

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

(•) yes ( ) no — Help

Calculate k-value

Your current Resilient Modulus of Subgrade value (M_{RSG}) is: 1940 psi

The corresponding k-value before adding subbase layer(s) is: 100 pci

To determine the k-value for a subbase layer system, use the calculator tool below. First input the subbase(s) resilient modulus and thickness. Next, click the calculate k-value button.

Step 1 - From the Top Down, Input Subbase(s) Resilient Modulus and Thickness

Number of subbase layers between subgrade and concrete pavement: 1 Layer

Top Layer: Unbound Compacted Granular Materials (sand/gravel, crushed stone)

Resilient Modulus of Subbase M_{RSB}: 25000 psi
Alllowable Range: 15,000 - 45,000
Thickness of Subbase: 6 in.

Layer 2: Choose Layer

Resilient Modulus of Subbase M_{RSB}: 0 psi
Alllowable Range: Choose Layer Type
Thickness of Subbase: 0 in.

Layer 3: Choose Layer

Resilient Modulus of Subbase M_{RSB}: 0 psi
Alllowable Range: Choose Layer Type
Thickness of Subbase: 0 in.

Step 2 - Calculate K — **K Value**: Run Calculation pci

Close Window and Save K

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous | Step 4. Define Pavement Properties by filling in and making choices for all inputs. | Next

CONCRETE PAVEMENT

ASPHALT PAVEMENT

Resilient Modulus of the Subgrade (M_{RSG}) (used for both concrete and asphalt designs) — Calculate — 1940 psi — Help

Composite Modulus of Subgrade Reaction (k)

- (●) **Design subbase layer system and use calculated k value**
  - Add Layers — 131 pci — Help
- ( ) **User-defined k value for existing subbase layer system**
  - 161 pci

Select Concrete Properties

28-Day Flexural Strength (MR) — 600 psi — Help

Modulus of Elasticity (E) — 4050000 psi — Help

Select Load Transfer Dowels

( ) yes (●) no — Help

Select Edge Support (tied concrete shoulder, curb and gutter, or widened lane)

(●) yes ( ) no — Help

Adjust Support for Asphalt Design Reliability

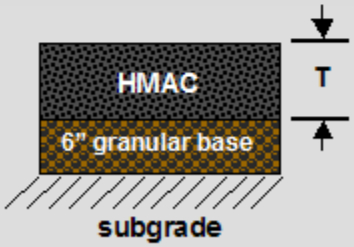
Coefficient of Variation (COV) — 38 % — Help

Design (M_{RSG}) — 1319.56 psi — Info*

*Full-depth design type not available due to MRSG [design] value. Click MRSG help for details.

Select Asphalt Pavement Type

Design Type: Asphalt with 6" Granular Base



StreetPave

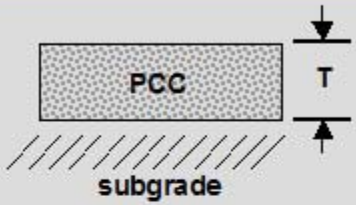
File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Previous

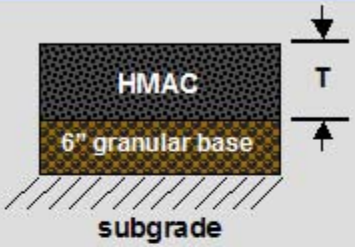
Step 5. Click the Run Analysis button.

CONCRETE PAVEMENT



Run Analysis

ASPHALT PAVEMENT



Composite Modulus of Subgrade Reaction (k) = pci

Resilient Modulus of the Subgrade:

MRSG [user-entered] = psi

MRSG [design] = psi

Base =

Flexible ESALs =

Design Concrete Thickness = in.

Design Asphalt Thickness = in.

Concrete Recommendations:

Concrete Thickness = in.

Maximum Transverse Joint Spacing = ft.

Dowel Bars:

Fatigue/Erosion Table | Rounding Considerations

View and Print Reports

Design and Analysis Summary

Sensitivity Analysis of:

- k-value
- Reliability
- Concrete Strength
- % Slabs Cracked
- Design Life

View

Progress Bar

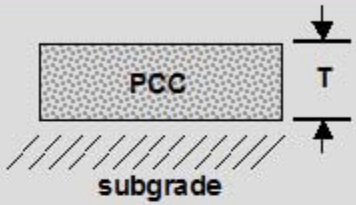
StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

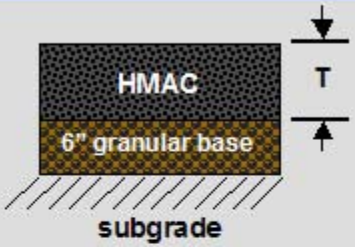
Previous | Step 6. Analysis results and additional reports are now available. | Next

CONCRETE PAVEMENT



Run Analysis

ASPHALT PAVEMENT



Composite Modulus of Subgrade Reaction (k) = 100 pci

Resilient Modulus of the Subgrade:

MRSG [user-entered] = 1940 psi

MRSG [design] = 1319.6 psi

Base = 6 inch Granular Base

Flexible ESALs = 405,148

Design Concrete Thickness = 6.17 in.

Design Asphalt Thickness = 11.03 in.

Concrete Recommendations:

Concrete Thickness = 6.50 in.

Maximum Transverse Joint Spacing = 13 ft.

Dowel Bars: Dowel bars not chosen and not recommended.

Fatigue/Erosion Table | Rounding Considerations

View and Print Reports

Design and Analysis Summary

Sensitivity Analysis of:

- (•) k-value
- ( ) Reliability
- ( ) Concrete Strength
- ( ) % Slabs Cracked
- ( ) Design Life

View

Progress Bar

Fatigue and Erosion Analysis

Traffic Category:	Collector		Fatigue Analysis			Erosion Analysis		
Axle Load, kips	Axles per 1000 Trucks	Expected Repetitions	Stress Ratio	Allowable Repetitions	Fatigue Consumed	Power	Allowable Repetitions	Erosion Consumed
Single Axles								
26	0.07	52	0.745	613	8.45	41.27	72376	0.07
24	1.6	1185	0.691	1973	60.04	35.165	116612	1.02
22	2.6	1925	0.637	8950	21.51	29.549	199505	0.96
20	6.63	4909	0.582	66415	7.39	24.421	371220	1.32
18	16.61	12298	0.527	1021592	1.2	19.781	785109	1.57
16	23.88	17680	0.472	48451152	0.04	15.63	2080692	0.85
14	47.76	35360	0.416	unlimited	0	11.967	9417566	0.38
12	116.76	86445	0.36	unlimited	0	8.792	unlimited	0
10	142.7	105650	0.303	unlimited	0	6.106	unlimited	0
8	233.6	172950	0.246	unlimited	0	3.908	unlimited	0
Tandem Axles								
44	1.16	859	0.541	481498	0.18	36.082	107901	0.8
40	7.76	5745	0.494	8597075	0.07	29.82	193842	2.96
36	38.79	28719	0.448	437882443	0.01	24.154	385261	7.45
32	54.76	40543	0.401	unlimited	0	19.085	900109	4.5
28	44.43	32895	0.354	unlimited	0	14.612	2874421	1.14
24	30.74	22759	0.306	unlimited	0	10.735	24143258	0.09
20	45	33317	0.258	unlimited	0	7.455	unlimited	0
16	59.25	43867	0.209	unlimited	0	4.771	unlimited	0
12	91.15	67484	0.159	unlimited	0	2.684	unlimited	0
8	47.01	34805	0.109	unlimited	0	1.193	unlimited	0
Tridem Axles								
62	0	0	0.455	210578356	0	243.013	463	0
56	0	0	0.414	unlimited	0	198.254	837	0
50	0	0	0.372	unlimited	0	158.047	1604	0
44	0	0	0.33	unlimited	0	122.392	3313	0
38	0	0	0.287	unlimited	0	91.288	7560	0
32	0	0	0.245	unlimited	0	64.736	19877	0
26	0	0	0.201	unlimited	0	42.736	65335	0
20	0	0	0.157	unlimited	0	25.288	330276	0
14	0	0	0.112	unlimited	0	12.391	7389444	0
8	0	0	0.066	unlimited	0	4.046	unlimited	0
				Total Fatigue Used:	**98.88**		Total Erosion Used:	**23.13**

Rounding Considerations

StreetPave recommends rounding the exact design thickness up to the nearest 0.5 inch (12.7 mm). Rounding up will increase both the reliability and theoretical life of the pavement. The effects of rounding up or down on both the reliability and theoretical life of the pavement are shown below.

Specified Design Life	30	Recommended Thickness	**6.50**
Specified Reliability	**80**	Rounded-Down Thickness	**6.00**
Design Thickness	**6.17**		

Theoretical Life of Recommended Concrete Design

59 years @ **80** % reliability

Theoretical Life of Rounded-Down Concrete Design

17 years @ **80** % reliability

Reliability of Recommended Concrete Design

90.1 % reliability for **30** -year design

Reliability of Rounded-Down Concrete Design

71.2 % reliability for **30** -year design

Design and Analysis Summary Replace with PDF Desktop

StreetPave

Pavement Design & Analysis Software

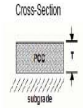
American Concrete Pavement Association

Report for Concrete Pavement Design

Project Name: Municipal Concrete Pavement
Route: Route 401
Location: Toronto, Ontario
Project Description: 2-Lane Collector
Owner/Agency: Cement Association of Canada
Design Engineer: Scott Haislip

Recommended Concrete Pavement Design

Cross-Section



Thickness 6.50 in

Joint Spacing 13 ft

Dowel Bars Dowel bars not chosen and not recommended.

Effect of Rounding on Thickness

Exact design thickness = 6.17 in

Theoretical Life of Rounded-Up Concrete Thickness — Rounded-Up Thickness
59 years @ 80% reliability

Reliability of Rounded-Up Concrete Thickness — 6.50 in
90.1% reliability for 30-year design

Expected Life of Rounded-Down Concrete Thickness — Rounded-Down Thickness
17 years @ 80% reliability

Reliability of Rounded-Down Concrete Thickness — 6.00 in
71.2% reliability for 30-year design

Inputs

Design Life 30 years

Reliability

Specified Reliability = 80%

Allowable Percent Cracked Slabs at End of Design Life = 15%

Traffic

Traffic Category: Collector

Total Number of Lanes 2

Direction Distribution 50

Design Lane Distribution 100

ADTT 100 per day
(average daily truck traffic, two-way, all lanes)

Truck Traffic Growth 2% per year

5/14/2007 8:31:43AM Engineer: Scott Haislip Page 1 of 6

StreetPave

Pavement Design & Analysis Software

American Concrete Pavement Association

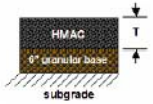
Report for Asphalt Pavement Design

Project Name: Municipal Concrete Pavement
Route: Route 401
Location: Toronto, Ontario
Project Description: 2-Lane Collector
Owner/Agency: Cement Association of Canada
Design Engineer: Scott Haislip

Recommended Asphalt Pavement Design

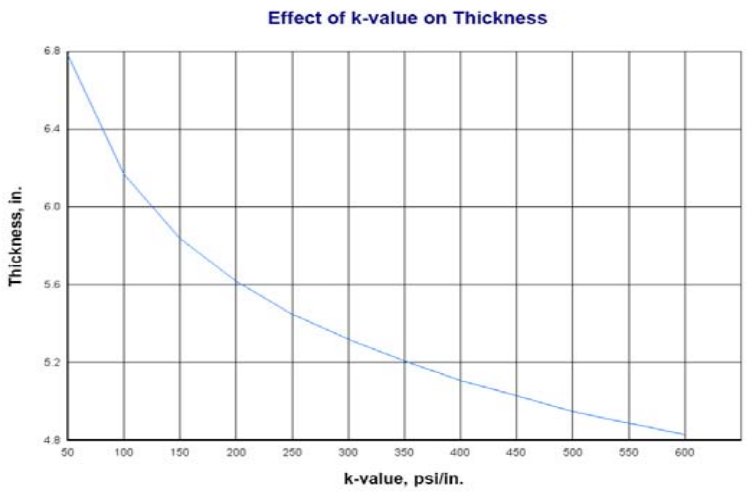
Asphalt Thickness 10.13 in

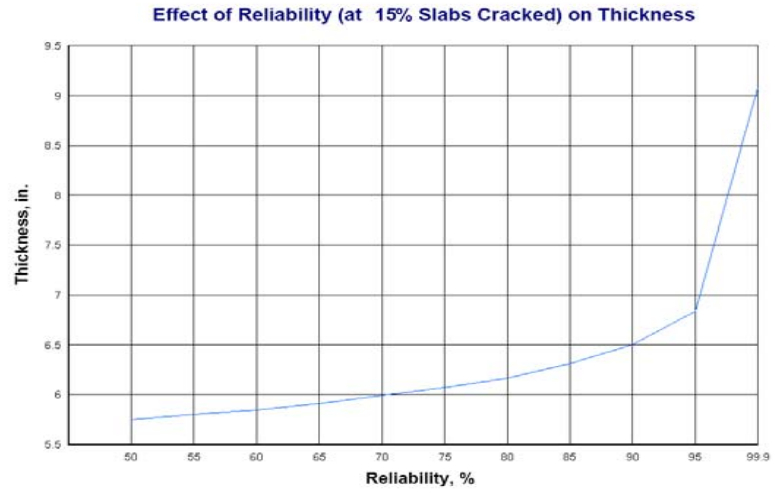
Cross-Section

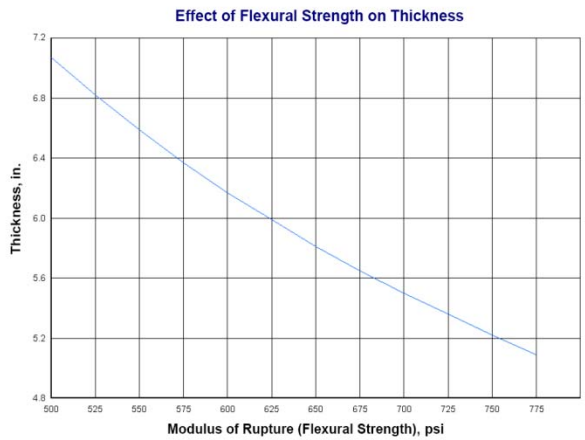


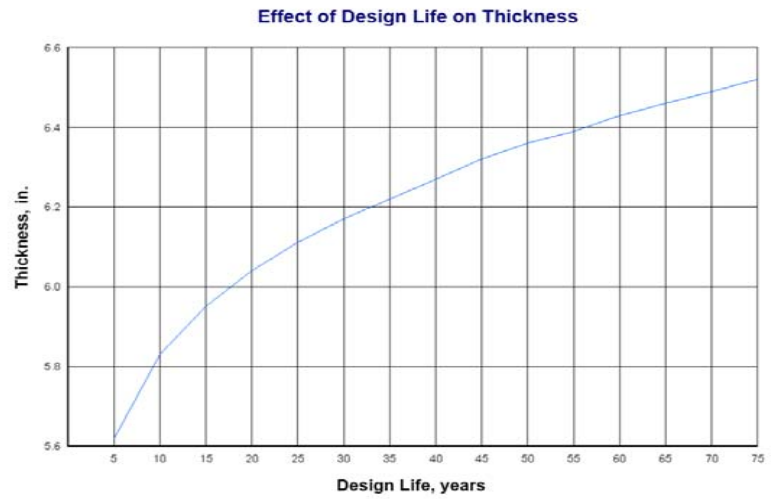
5/14/2007 8:31:44AM Engineer: Scott Haislip Page 4 of 6

Sensitivity Charts

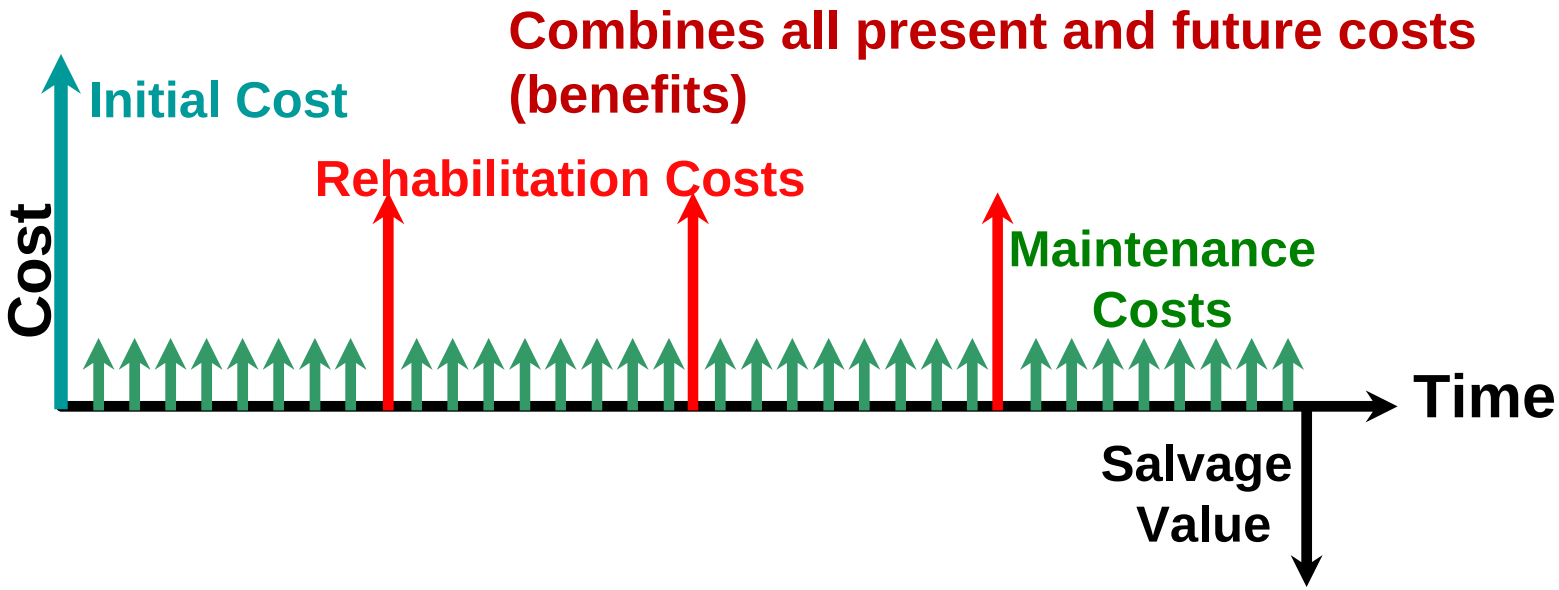








Life-Cycle Cost Analysis



StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

Project Level Inputs

Concrete and Asphalt

Project length	1	miles
Lane width	12	ft
Analysis Period	30	year

Discount Rate Applied to Future Maintenance Items

(•) Interest Rate	5.00	%
Inflation Rate	3.00	%
( ) Discount Rate	1.94	%

Asphalt Only

Design thickness	10.13	in
Amount of design thickness which is surface course	0	in
Remaining base amount	10.13	in
Surface course density	145	lb/ft³
Base density	140	lb/ft³
Aggregate base density	120	lb/ft³

Concrete Only

Composite aggregate base density 120 lb/ft³

Concrete Pavement Initial Costs

(•) Use concrete pavement (material) AND 75.00 $/yd³
concrete placement (cure, saw, seal) 5.00 $/yd²

( ) Use single 16.25 $/yd²
concrete cost

Aggregate base 12.00 $/ton

Concrete Pavement Maintenance Costs

Joint sealant:

(•) No seal		
( ) Hot-pour filler in single sawcut	1.75	$/lf
( ) Hot-pour sealant (w/backer rod)	2.00	$/lf
( ) Silicone sealant (w/backer rod)	3.00	$/lf
( ) Preformed neoprene compression seal	5.00	$/lf

Concrete annual maintenance	0.00	$/yd²
Full-depth repairs	90.00	$/yd²
Partial-depth repairs	150.00	$/yd²
Diamond grinding	5.50	$/yd²

Asphalt Pavement Initial Costs

Surface course 42.00 $/ton Base 40.50 $/ton Aggregate base 12.00 $/ton

Asphalt Pavement Maintenance Costs

Asphalt annual maintenance	0.15	$/yd²	Milling	1.00	$/yd²*in	Seal coat	1.50 $/yd²
Crack sealing	0.75	$/lf	Chip seal	3.00	$/yd²		

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

Previous | Step 7. Fill in Project Inputs and all known Costs. | Next

Project Level Inputs

Concrete and Asphalt

Project length	1	miles
Lane width	12.0	feet
Analysis Period	30	years

Discount Rate Applied to Future Maintenance Items

(•) Interest Rate	5.00	%
Inflation Rate	3.00	%
( ) Discount Rate	1.94	%

Asphalt Only

Design thickness	11.03	in
Amount of design thickness which is surface course	1.5	in
Remaining base amount	9.53	in
Surface course density	145	lb/ft²
Base density	140	lb/ft²
Aggregate base density	120	lb / ft³

Concrete Only

Composite aggregate base density 120 lb / ft³

Concrete Pavement Initial Costs

(•) Use concrete pavement (material) AND 94.00 $ / yd³
concrete placement (cure, saw, seal) 5.00 $ / yd²

( ) Use single 16.25 $ / yd²
concrete cost

Aggregate base 12.00 $/ton

Concrete Pavement Maintenance Costs

Joint sealant:

( ) No seal		
(•) Hot-pour filler in single sawcut	1.75	$ / lf
( ) Hot-pour sealant (w/backer rod)	2.00	$ / lf
( ) Silicone sealant (w/backer rod)	3.00	$ / lf
( ) Preformed neoprene compression seal	5.00	$ / lf

Concrete annual maintenance	0.00	$ / yd²
Full-depth repairs	100.00	$ / yd²
Partial-depth repairs	150.00	$ / yd²
Diamond grinding	5.50	$ / yd²

Asphalt Pavement Initial Costs

Surface course 65.00 $ / ton Base 55.00 $ / ton Aggregate base 12.00 $/ton

Asphalt Pavement Maintenance Costs

Asphalt annual maintenance	0.15	$ / yd²	Milling	1.00	$ / yd² • in	Seal coat	1.50 $ / yd²
Crack sealing	0.75	$ / lf	Chip seal	3.00	$ / yd²		

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

CONCRETE PAVEMENT

Maintenance, Preservation, and Rehab Items: 2

Year	Item	Available Quantity		Amount	Units
10	Reseal joints	100	%	13728	lf
20	Reseal joints	100	%	13728	lf
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		
0	Select Item	0	%		

ASPHALT PAVEMENT

Maintenance, Preservation, and Rehab Items: 4

Year	Item	Amount	Units
8	Rout & seal cracks	500	lf
12	Asphalt Overlay	1.5	in
20	Rout & seal cracks	1000	lf
24	Asphalt Overlay	1.5	in
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

Note: Life cycle cost reports and graphs are only available after running a new pavement analysis and proceeding directly to the life cycle cost section.

Run a life cycle cost report to view initial pavement costs, present value maintenance costs, and cumulative costs over the analysis period.

Life Cycle Cost Report

The life cycle cost graph depicts cumulative costs over the analysis period.

Life Cycle Cost Graph

LCCA Report

StreetPave

Pavement Design & Analysis Software

American Concrete Pavement Association

Life Cycle Cost Analysis

Project Name: Municipal Pavement Design Webinar
Route: Route 1
Location: Skokie, IL
Project Description: 2-Lane Collector
Owner/Agency: American Concrete Pavement Association
Design Engineer: Scott Haislip

Initial Cost

Concrete Pavement Details

Project Length:	1.0	miles	
Number of Lanes:	2		
Lane Width:	12.0	feet	
Design Thickness:	6.50	in.	*StreetPave Recommended Value

Aggregate Base Thickness: Top Layer = Not Selected
Thickness = 0in.
Layer 2 = Not Selected
Thickness = 0in.
Layer 3 = Not Selected
Thickness = 0in.

Composite Aggregate Base Density: 120 lb/ft³

Cost Inputs

Concrete Pavement (material):	$94.00	/ yd³
Concrete Placement (cure, saw, seal):	$5.00	/ yd²
Aggregate Base:	$12.00	/ ton

Calculated Initial Cost for Concrete =	$309,369
Calculated Initial Cost for Aggregate Base =	$0
Total Initial Cost for Concrete Pavement Design =	**$309,369**

StreetPave

Pavement Design & Analysis Software

American Concrete Pavement Association

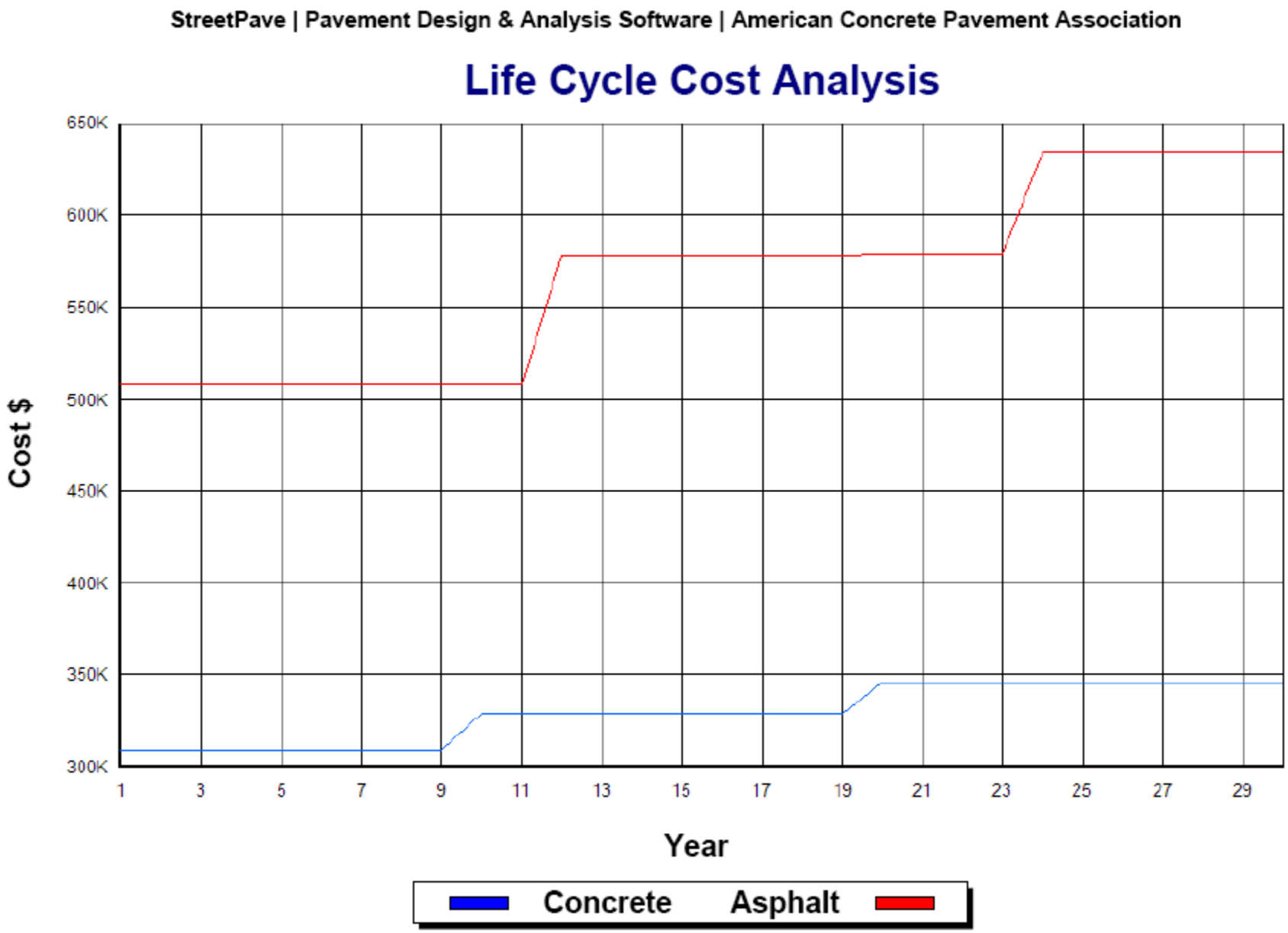
Asphalt Pavement Details

Project Length:	1	miles	
Number of Lanes:	2		
Lane Width:	12.0	feet	
Design Thickness	11.03	in.	*StreetPave Recommended Value
Surface Coarse Thickness:	1.5	in.	
Remaining Base Thickness:	9.53	in.	
Aggregate Base Thickness:	6 inch Granular Base		
Surface Course Density:	145	lb/ft³	
Base Density:	140	lb/ft³	
Aggregate Base Density:	120	lb/ft³	

Cost Inputs

Asphalt Surface Course:	$65.00	/ ton
Asphalt Base:	$55.00	/ ton
Aggregate Base:	$12.00	/ ton

Calculated Initial Cost for Asphalt Surface Course =	$74,646
Calculated Initial Cost for Asphalt Base =	$387,452
Calculated Initial Cost for Aggregate Base =	$45,619
Total Initial Cost for Asphalt Pavement =	**$507,717**


StreetPave | Pavement Design & Analysis Software | American Concrete Pavement Association
Life Cycle Cost Analysis
650K
600K
550K
500K
450K
400K
350K
300K
Cost $
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
Year
Concrete
Asphalt

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

Project Level Inputs

Concrete and Asphalt

Project length	1	miles
Lane width	12.0	feet
Analysis Period	40	years

Discount Rate Applied to Future Maintenance Items

(•) Interest Rate	5.00	%
Inflation Rate	3.00	%
( ) Discount Rate	1.94	%

Concrete Only

Composite aggregate base density 120 lb / ft³

Asphalt Only

Design thickness	11.03	in
Amount of design thickness which is surface course	1.5	in
Remaining base amount	9.53	in
Surface course density	145	lb/ft³
Base density	140	lb/ft³
Aggregate base density	120	lb / ft³

Concrete Pavement Initial Costs

(•) Use concrete pavement (material) AND 94.00 $ / yd³
concrete placement (cure, saw, seal) 5.00 $ / yd²

( ) Use single 16.25 $ / yd²
concrete cost

Aggregate base 12.00 $/ton

Concrete Pavement Maintenance Costs

Joint sealant:

( ) No seal		
(•) Hot-pour filler in single sawcut	1.75	$ / lf
( ) Hot-pour sealant (w/backer rod)	2.00	$ / lf
( ) Silicone sealant (w/backer rod)	3.00	$ / lf
( ) Preformed neoprene compression seal	5.00	$ / lf

Concrete annual maintenance	0.00	$ / yd²
Full-depth repairs	100.00	$ / yd²
Partial-depth repairs	150.00	$ / yd²
Diamond grinding	5.50	$ / yd²

Asphalt Pavement Initial Costs

Surface course 65.00 $ / ton Base 55.00 $ / ton Aggregate base 12.00 $/ton

Asphalt Pavement Maintenance Costs

Asphalt annual maintenance	0.15	$ / yd²	Milling	1.00	$ / yd² • in	Seal coat	1.50 $ / yd²
Crack sealing	0.75	$ / lf	Chip seal	3.00	$ / yd²		

StreetPave

File Global Settings About

Project | Traffic | Pavement Properties | Existing Pavement Analysis | New Pavement Analysis | Life Cycle Cost

Project Inputs/Costs | Maint/Rehab Schedule | Report/Graph

CONCRETE PAVEMENT

Maintenance, Preservation, and Rehab Items: 6

Year	Item	Available Quantity	Amount Units
10	Reseal joints	100	%
20	Reseal joints	100	%
28	Full-depth repairs	6	%
28	Partial-depth repairs	2	%
28	Diamond grinding	95	%
28	Reseal joints	100	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%
0	Select Item	0	%

ASPHALT PAVEMENT

Maintenance, Preservation, and Rehab Items: 6

Year	Item	Amount	Units
8	Rout & seal cracks	500	lf
12	Mill & Asphalt Overlay	1.5	in
20	Rout & seal cracks	1000	lf
24	Mill & Asphalt Overlay	1.5	in
30	Rout & seal cracks	1500	lf
34	Asphalt Overlay	1.5	in
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
0	Select Item	0	
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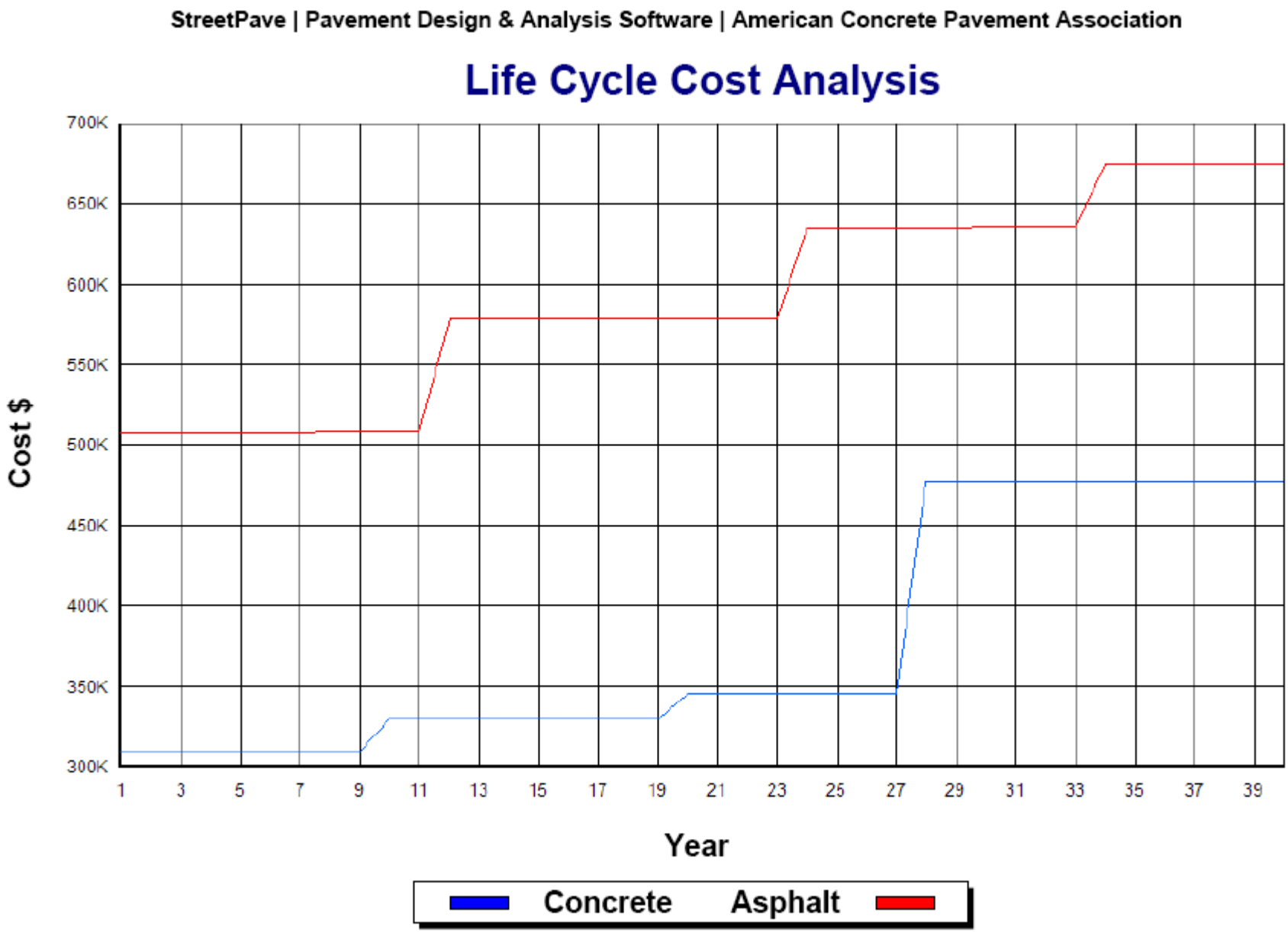

StreetPave | Pavement Design & Analysis Software | American Concrete Pavement Association
Life Cycle Cost Analysis
Cost $
700K
650K
600K
550K
500K
450K
400K
350K
300K
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
Year
Concrete
Asphalt

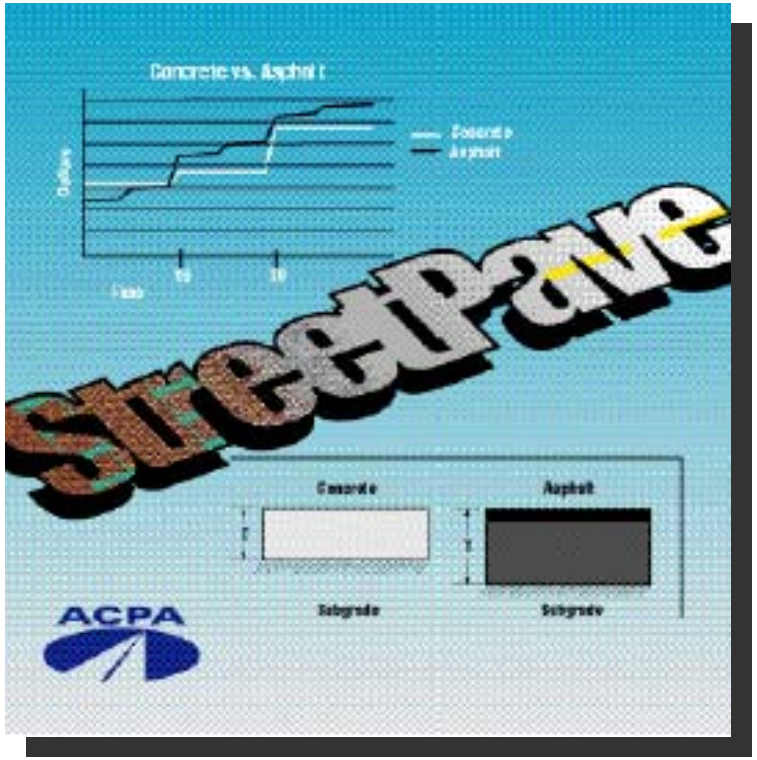
Summary

- StreetPave program incorporates reliability and slab cracking into fatigue for concrete pavement design
- Can be used to compare the outcome of altering design inputs to obtain cost-effective pavement sections
- Principles can also be applied to concrete overlays

StreetPave Software Availability

Available from:

Bob Long
Executive Director
Mid-Atlantic Chapter ACPA



Patch v1.3: www.pavement.com

Questions?

Thank You!!!

Please contact PRESENTER

with questions or comments:

Shaislip@ConcreteLot.com