

The Concrete Advantage in Parking Lots

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National Ready Mixed Concrete Association

PAVE  AHEAD
DURABLE. SUSTAINABLE. **CONCRETE.**

Benefits of a Concrete Parking Lot

Environmentally Friendly

Does not pollute waterways

Uses less raw materials

No hazardous materials
used

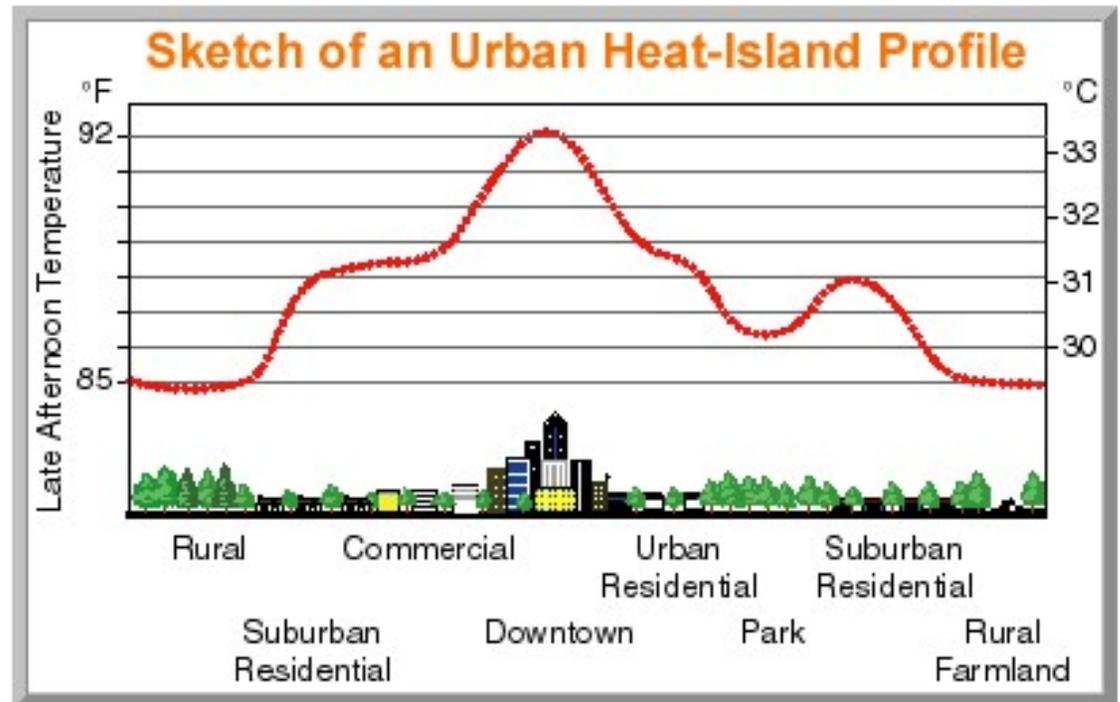
Recycled materials can be
used

Conserves petroleum
resources

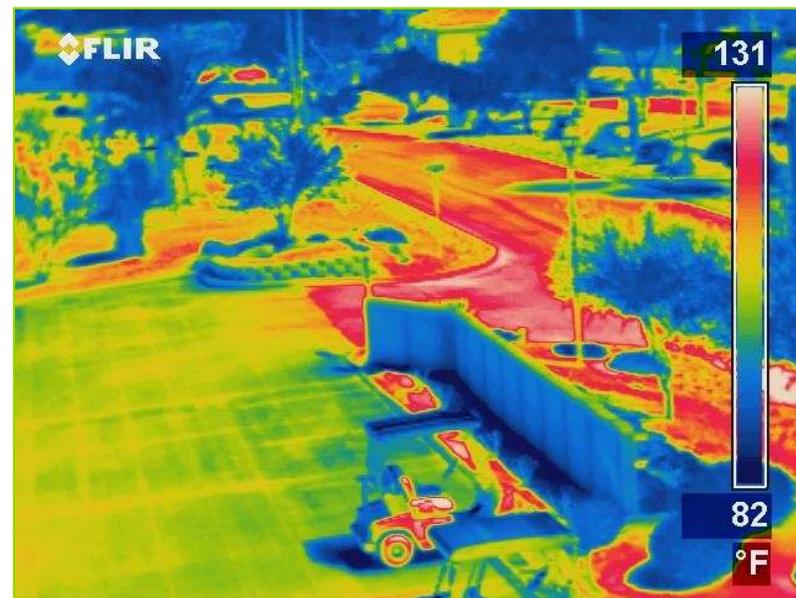


Heat Island Mitigation

- Concrete's lighter color means less heat absorption
- Lowers ambient air temperature by 7 to 10 degrees
- 1 degree equals 1.5% change in energy consumption



Concrete Pavements can Reduce Global Warming Potential by 50%



Photos courtesy of the American Concrete Pavement Association

Benefits of a Concrete Parking Lot

Performance

Proven long life

No potholes, bumps,
or wrinkles

Evenly carries heavy
loads

Resistance to
freeze/thaw

Positive first
impression



Bellefontaine, OH

- Placed 1891
- Guaranteed for 5 years
- 131 years old and still in service!



Energy Savings and Illumination

Based on $.315 \text{ cd/ft}^2$

36% fewer luminaires
needed for equivalent
luminance

OR

Reduce light wattage
from 400 to 250 per lamp
Approximately 37%
reduction in energy
consumption



LED Lighting – A new opportunity!



Concrete's reflectivity optimizes performance of LED lighting
Reduce wattage from 400W to 125W

“The higher reflectance values from concrete play as much of a role in the visibility and apparent brightness of the site as the lighting.”



www1.eere.energy.gov/femp/technologies/solid_state_lighting.html

Concrete is too expensive!



Benefits of a Concrete Parking Lot

First Cost

Affordable and
competitively priced

Minimum subbase
preparation

One pass completion

**COMPETITIVE
PRICING**

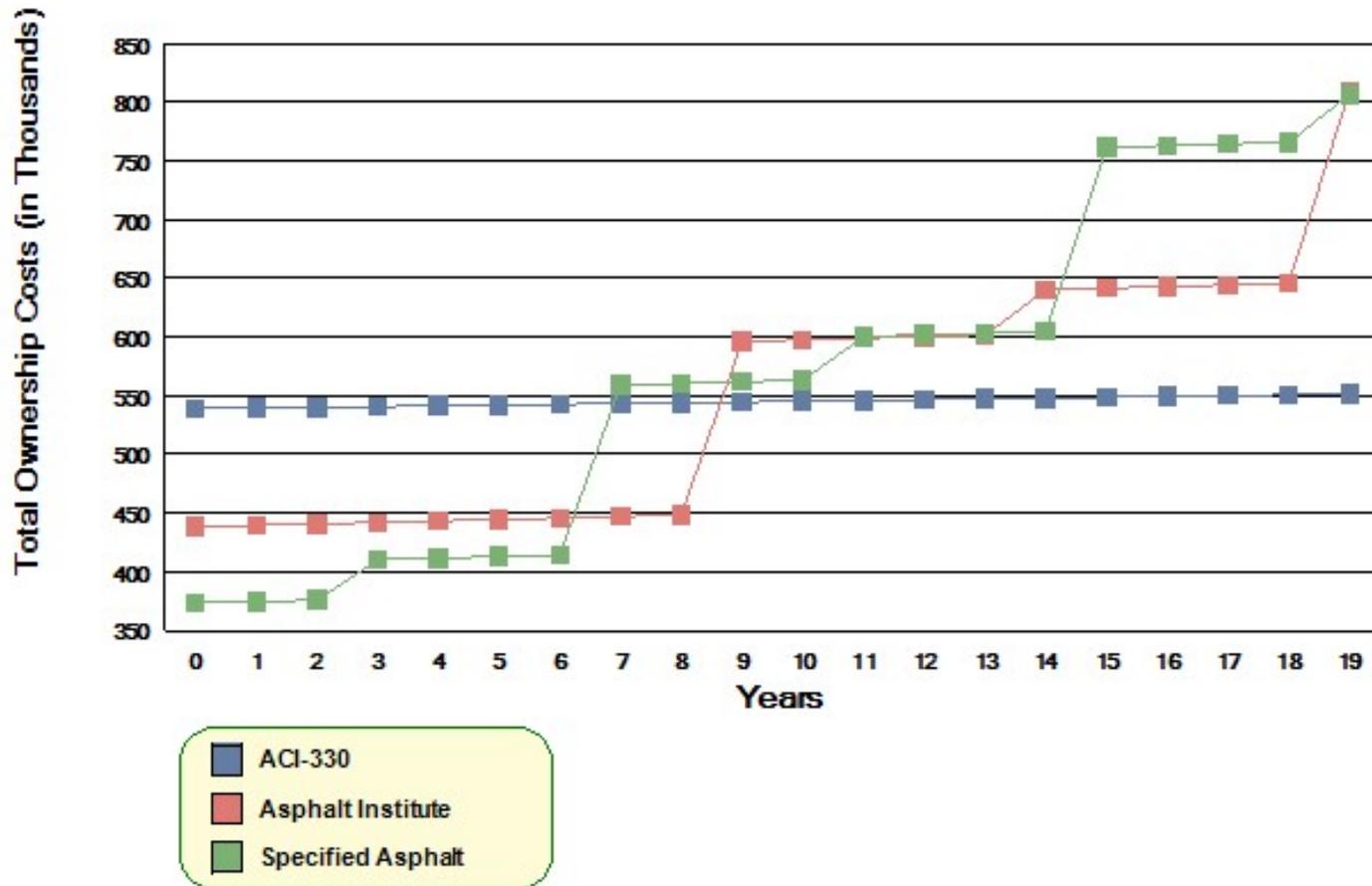
Benefits of a Concrete Parking Lot

Long-Term Cost

- Lower annual maintenance
- No scheduled re-paving
- No business interruption
- Lower life-cycle cost



Life-Cycle Cost Analysis





Rational Standard Design

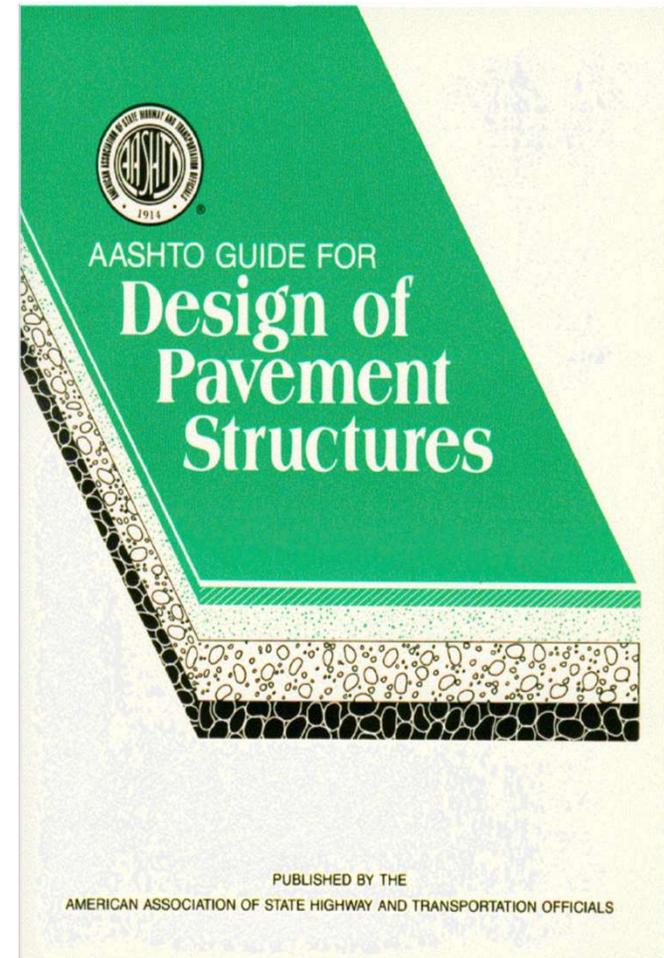
Source of Much of What We Know About Pavement Design

AASHO Road Test
Late 50's and early 60's
Ottawa, Illinois



American Association of State
Highway and Transportation
Officials (AASHTO)

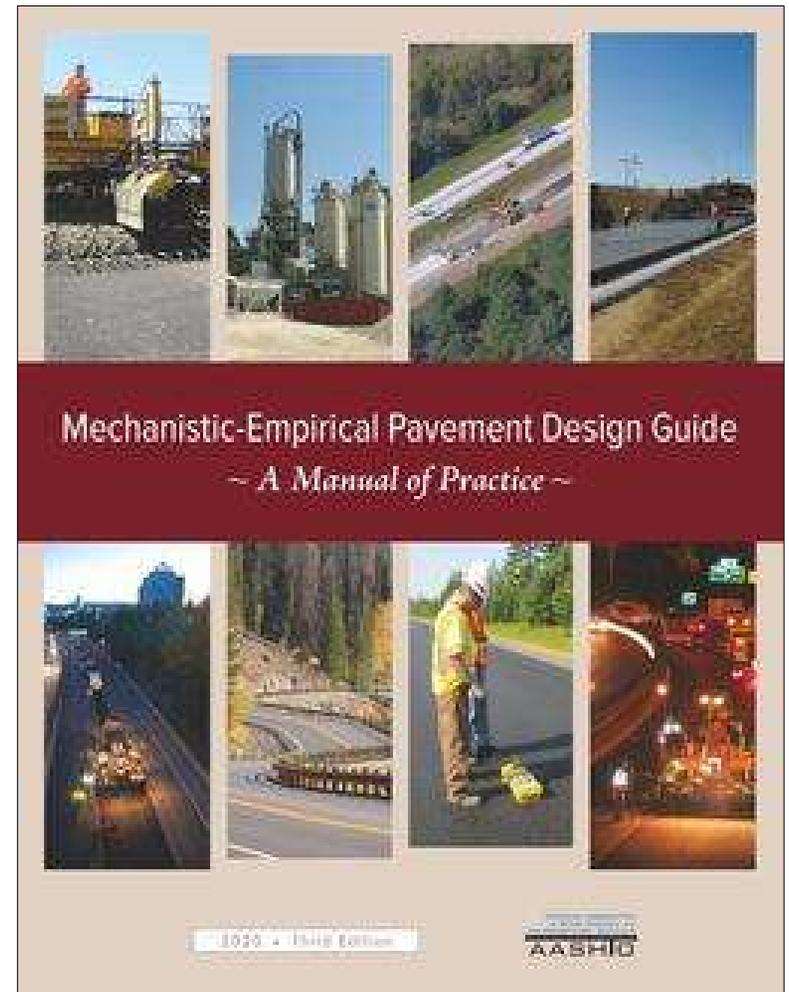
Guide for Design of Pavement
Structures (1993)



American Association of State
Highway and Transportation
Officials (AASHTO)

Guide for Design of Pavement
Structures (1993)

Mechanistic-Empirical Pavement
Design Guide (3rd edition – 2020)





What do designers currently use for concrete parking lots?

Nothing – Only design in asphalt
DOT specifications

(Do DOT's design parking lots?)

AASHTO Design Guide

AASHTO is meant for Highway Design

- Highways:
 - High speed traffic
 - One directional
 - Loading near pavement edge
 - Drain water rapidly

Parking Lots are not Highways

- Highways:
 - High speed traffic
 - One directional
 - Loading near pavement edge
 - Drain water rapidly
- Parking Lots:
 - Low speed traffic
 - Multi-directional
 - Interior loading
 - May be designed to collect water

ACI 330

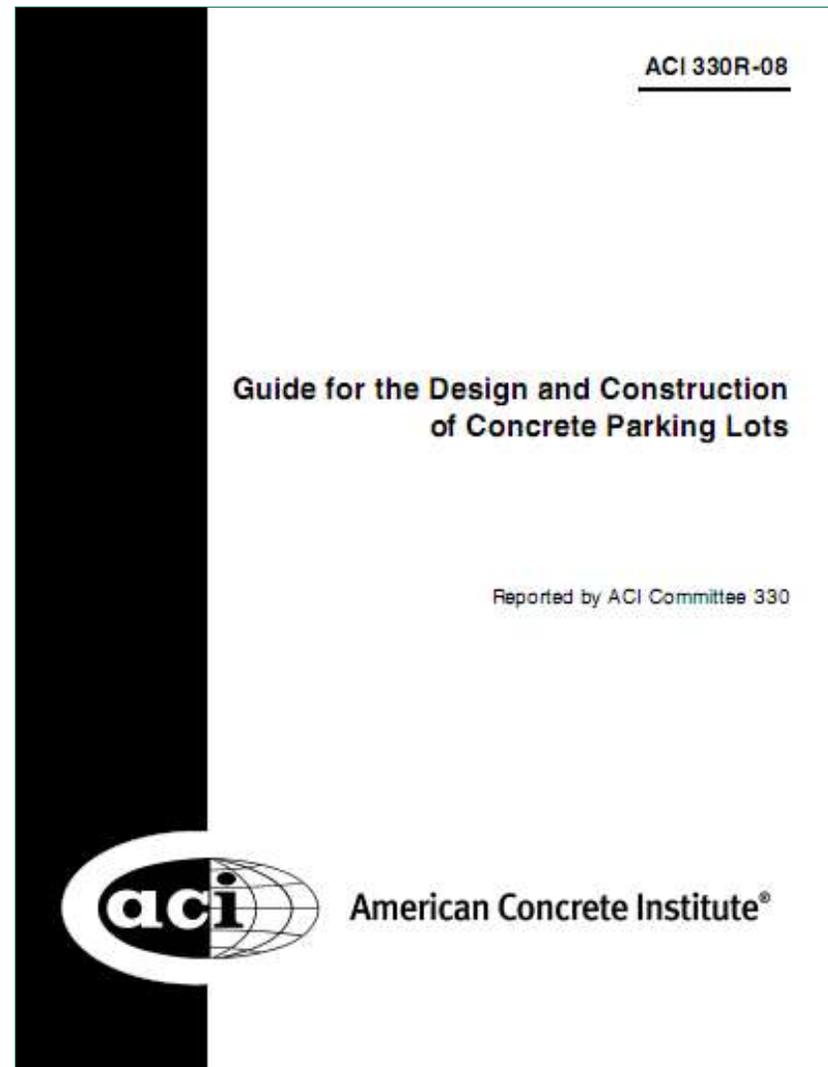
- Rational Standard
for Design

- Complete and
Concise

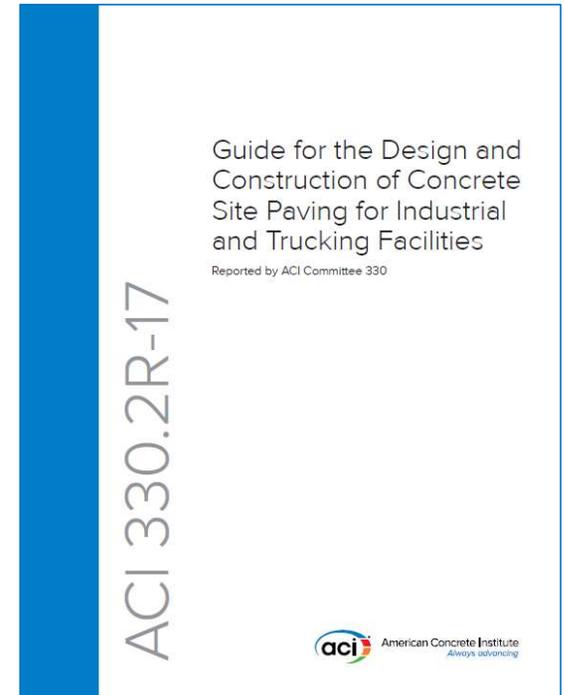
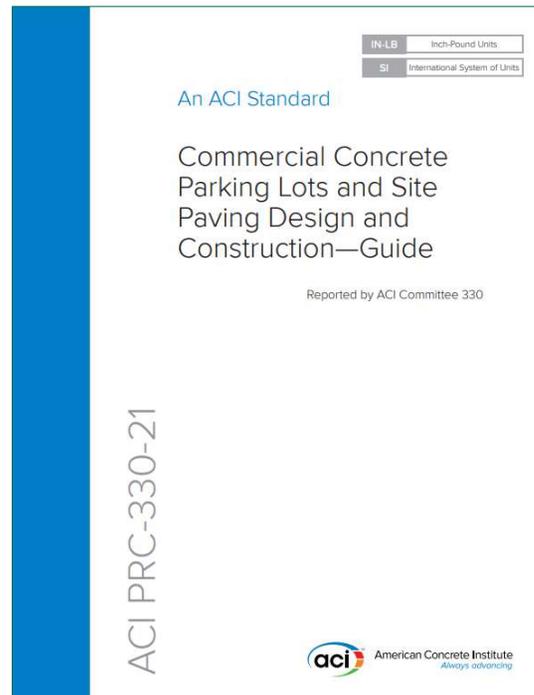
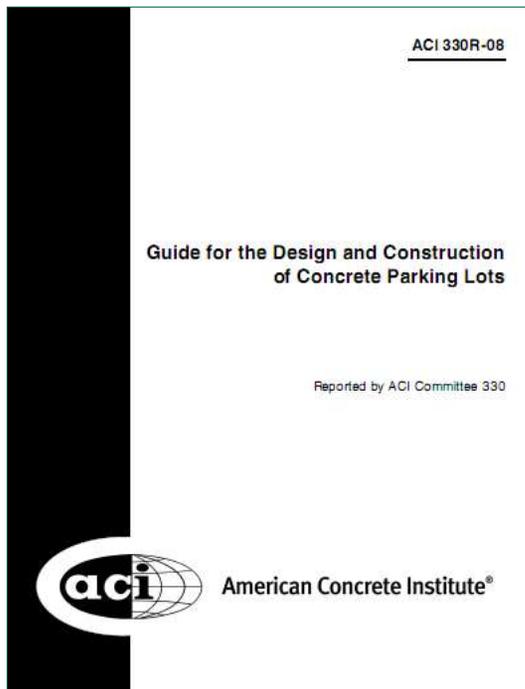
- Design

- Construction

- Maintenance



Changes to Design Guides



Why Use It?

Economical 20 Year Design

Addresses All Aspects of Concrete Parking
Lots

Based on Sound *Conservative* Engineering

Only Document Created Specifically for
Concrete Parking Lots

ACI 330 is *The Industry Standard!*

Why Use It?

- Design for purpose (adjust thickness)
 - Passenger vehicle parking
 - Truck lanes
 - Loading areas
 - Truck parking (sand shoes/dollies)
 - Increase thickness
 - Thickened beam

Established rational design – ACI 330

- 4000 psi
- Unreinforced
- Placed on compacted subgrade

No stone base required

An ACI Standard

Commercial Concrete
Parking Lots and Site
Paving Design and
Construction – Guide

Reported by ACI Committee 330

ACI PRC-330-21



American Concrete Institute
Always advancing

ACI PRC 330-21

Low to Medium Duty Parking Lots

IN-LB Inch-Pound Units
 SI International System of Units

An ACI Standard

Commercial Concrete
Parking Lots and Site
Paving Design and
Construction—Guide

Reported by ACI Committee 330

ACI PRC-330-21

 American Concrete Institute
Always advancing



EASY AS 1,2,3!



1 – Subgrade Support

k – modulus of subgrade or

CBR – California Bearing Ratio

R - Resistance Value

SSV – Soil Support Value

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

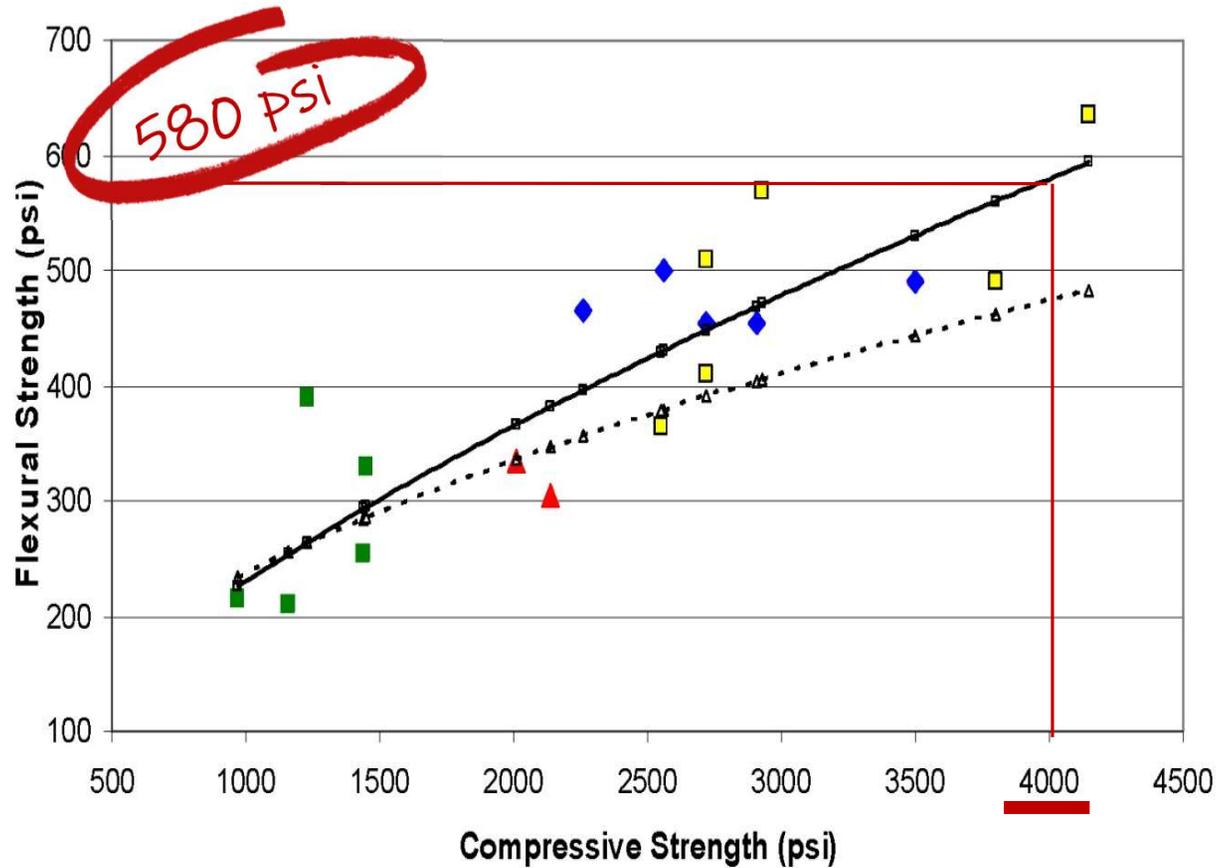
Notes: CBR = California bearing ratio; R = resistance value; and SSV = soil support value. 1 psi = 0.0069 MPa, and 1 psi/in. = 0.27 MPa/m.

2 – Concrete Strength

MOR – modulus of rupture/flexural strength

*Concrete Industry uses compressive strength (f'_c)

Flexural Strength vs. Compressive Strength



3 – Intended Traffic

ADTT – Average Daily Truck Traffic

Table 3.6a—Traffic categories*

Category	Description
A [†]	Car parking areas and access lanes
B	Entrance and truck service lanes
C [‡]	Buses
D	Heavy-duty trucks
E	Garbage or fire truck lane

ACI PRC-330-21 Guidelines – Table 3.6b

Table 3.6b—Twenty-year design thickness: no dowels; edge support provided*

Category ¹	Trucks ²	$k = 100 \text{ pci (27 MPa/m)}$			
		MOR, psi (MPa)	450 (3.1)	550 (3.8)	650 (4.5)
		E , psi (MPa)	3,037,500 (20,960)	3,712,500 (25,620)	4,387,500 (30,275)
		D , in. (mm)	D , in. (mm)	D , in. (mm)	
A	1	5.00 (125)	4.25 (105)	4.00 (100)	
A	10	5.50 (140)	4.75 (120)	4.50 (115)	
B	10	6.00 (150)	5.25 (135)	4.75 (120)	
B	25	6.25 (160)	5.50 (140)	5.00 (125)	
B	50	6.50 (165)	5.75 (145)	5.25 (135)	
C	5	8.75 (220)	8.00 (200)	7.25 (185)	
D	1	5.25 (135)	5.25 (135)	4.75 (120)	
D	10	6.25 (160)	5.50 (140)	5.00 (125)	
D	25	6.75 (170)	5.75 (145)	5.75 (145)	
E	1	7.75 (195)	6.75 (170)	6.25 (160)	

For Example...

Table 3.6b—Twenty-year design thickness: no dowels; edge support provided*

Category ¹	Trucks ²	<i>k</i> = 100 pci (27 MPa/m)			
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		<i>E</i> , psi (MPa)	3,037,500 (20,960)	3,712,500 (25,620)	4,387,500 (30,275)
		<i>D</i> , in. (mm)	<i>D</i> , in. (mm)	<i>D</i> , in. (mm)	
A	1	5.00 (125)	4.25 (105)	4.00 (100)	
A	10	5.50 (140)	4.75 (120)	4.50 (115)	
B	10	6.00 (150)	5.25 (135)	4.75 (120)	
B	25	6.25 (160)	5.50 (140)	5.00 (125)	
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C	5	8.75 (220)	8.00 (200)	7.25 (185)	
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D	10	6.25 (160)	5.50 (140)	5.00 (125)	
D	25	6.75 (170)	5.75 (145)	5.75 (145)	
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Recommended Thickness is 5.25 inches

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		<i>D</i> , in. (mm)	<i>D</i> , in. (mm)	<i>D</i> , in. (mm)	
A	1	5.00 (125)	4.25 (105)	4.00 (100)	
A	10	5.50 (140)	4.75 (120)	4.50 (115)	
B	10	6.00 (150)	5.25 (135)	4.75 (120)	
B	25	6.25 (160)	5.50 (140)	5.00 (125)	
B	50	6.50 (165)	5.75 (145)	5.25 (135)	
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D	1	5.25 (135)	5.25 (135)	4.75 (120)	
D	10	6.25 (160)	5.50 (140)	5.00 (125)	
D	25	6.75 (170)	5.75 (145)	5.75 (145)	
E	1	7.75 (195)	6.75 (170)	6.25 (160)	

5.25

Industrial Concrete Pavements

- Standard trucks
- Industrial lift trucks
- Front end loaders
- Tracked equipment
- Straddle carriers
- Cranes
- Military equipment
- Buses & coaches



Industrial Concrete Pavements – Where do they fit?

Highway Pavements

Pneumatic tires

Channelized traffic

Design for fatigue

Failure modes:

Cracking

Edge of road

Faulting

Permanent deflection

Roughness

IRI

Because of speed

Interior Floor Slabs

Small, hard wheels

Variable traffic

Design for capacity

Failure modes:

Cracking

Curl, joint spacing, etc.

Support or edge?

Joint Spalling

Differential deflection

Flatness & levelness

Lift truck requirements

ACI 330.2R-17

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

ACI 330.2R-17

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

Reported by ACI Committee 330



STILL

EASY AS 1,2,3!



1 – Subgrade Support

k – modulus of subgrade or

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SSV – Soil Support Value

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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

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

2 – Concrete Strength

MOR – Modulus of Rupture/flexural strength

- Concrete Industry uses compressive strength (f'_c)

E_c – Modulus of Elasticity

- Ratio of stress to strain
 - Based on correlations with compressive strength provided in ACI 318: Building Code Requirements for Structural Concrete
- 

3 – Intended Traffic

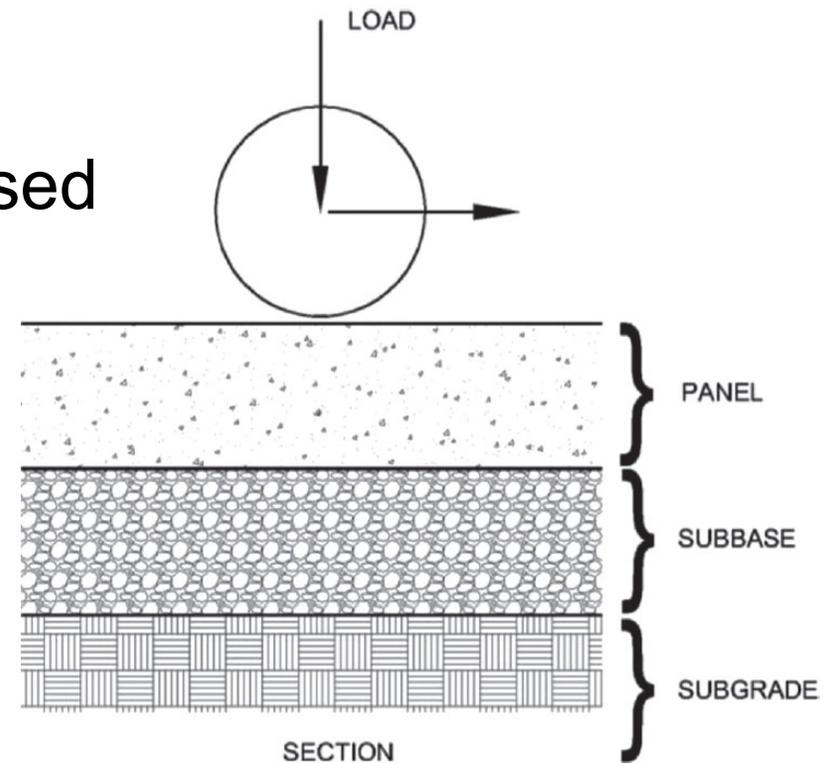
No More ESALs!

Trucks per day + load spectrum now used

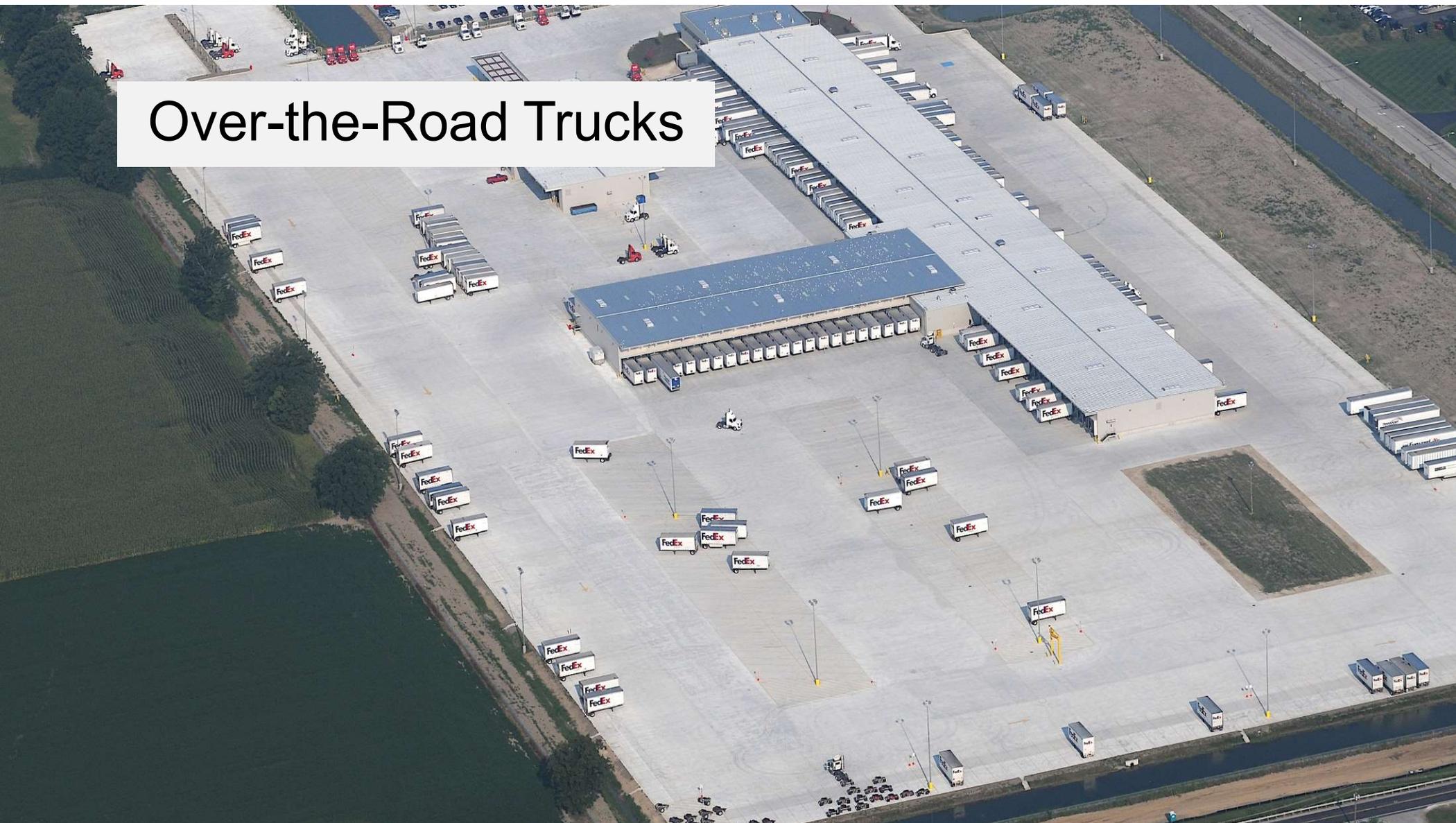
ESAL was never a pure metric of traffic or loads

ESAL = metric of damage caused by traffic

ESALs don't work with multiple failure modes



Over-the-Road Trucks



Over-the-Road Truck Design Tables

Table 4.7.3b—Thickness (d) and joint spacing (JS) for over-the-road truck category D: no dowels in contraction joints; $k = 150 \text{ pci}$ (41 MN/m^3)*

No. of trucks per day design lane	Modulus of rupture, psi (MPa)					
	550 (3.8)		650 (4.5)		750 (5.2)	
	d , in. (mm)	Max. JS, ft (m)	d , in. (mm)	Max. JS, ft (m)	d , in. (mm)	Max. JS, ft (m)
10	5.5 (140)	11 (3.4)	5.0 (130)	10 (3.1)	5.0 (130)	10 (3.1)
50	6.5 (165)	13 (4.0)	6.0 (150)	12 (3.7)	6.0 (150)	12 (3.7)
100	7.0 (180)	14 (4.3)	6.5 (165)	13 (4.0)	6.5 (165)	13 (4.0)
200	7.0 (180)	14 (4.3)	7.0 (180)	14 (4.3)	7.0 (180)	14 (4.3)
500	7.5 (190)	15 (4.6)	7.5 (190)	15 (4.6)	7.5 (190)	15 (4.6)
1000	8.0 (200)	15 (4.6)	8.0 (200)	15 (4.6)	7.5 (190)	15 (4.6)

Over-the-Road Truck Design Tables

Table 4.7.3b—Thickness (d) and joint spacing (JS) for over-the-road truck category D: no dowels in contraction joints; $k = 150$ pci (41 MN/m³)

No. of trucks per day design lane	Modulus of rupture, psi (MPa)					
	550 (3.8)		650 (4.5)		750 (5.2)	
	d , in. (mm)	Max. JS, ft (m)	d , in. (mm)	Max. JS, ft (m)	d , in. (mm)	Max. JS, ft (m)
10	5.5 (140)	11 (3.4)	5.0 (130)	10 (3.1)	5.0 (130)	10 (3.1)
50	6.5 (165)	13 (4.0)	6.0 (150)	12 (3.7)	6.0 (150)	12 (3.7)
100	7.0 (180)	14 (4.3)	6.5 (165)	13 (4.0)	6.5 (165)	13 (4.0)
200	7.0 (180)	14 (4.3)	7.0 (180)	14 (4.3)	7.0 (180)	14 (4.3)
500	7.5 (190)	15 (4.6)	7.5 (190)	15 (4.6)	7.5 (190)	15 (4.6)
1000	8.0 (200)	15 (4.6)	8.0 (200)	15 (4.6)	7.5 (190)	15 (4.6)

Over-the-Road Truck Design Tables

Table 4.7.3e—Thickness (*d*) and joint spacing (JS) for over the road trucks category D: with dowels in contraction joints; *k* = 150 pci (41 MN/m²)

No. of trucks per day design lane	Modulus of rupture, psi (MPa)					
	550 (3.8)		650 (4.5)		750 (5.2)	
	<i>d</i> , in. (mm)	Max. JS, ft (m)	<i>d</i> , in. (mm)	Max. JS, ft (m)	<i>d</i> , in. (mm)	Max. JS, ft (m)
100	6.0 (150)	12 (3.7)	6.0* (150*)	12* (3.7*)	6.0* (150*)	12* (3.7*)
200	6.0 (150)	12 (3.7)	6.0* (150*)	12* (3.7*)	6.0* (150*)	12* (3.7*)
500	6.5 (165)	13 (4.0)	6.0 (150)	12 (3.7)	6.0 (150)	12 (3.7)
1000	6.5 (165)	13 (4.0)	6.0 (150)	12 (3.7)	6.0 (150)	12 (3.7)

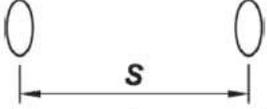
*Minimum recommended design thickness increased to facilitate dowel installation and joint spacing adjusted for thickness.

Industrial Vehicle



Industrial Design Table: Single Wheel

Table 4.7.4a—Thickness in. (mm) for industrial lift trucks with single wheeled drive axle



				Subgrade reaction $k = 150$ pci (41 MN/m ³)			Subgrade reaction $k = 200$ pci (54 MN/m ³)			Subgrade reaction $k = 300$ pci (81 MN/m ³)		
				Modulus of rupture, psi (MPa)			Modulus of rupture, psi (MPa)			Modulus of rupture, psi (MPa)		
Load on drive axle, lb (kN)	Spacing S , in. (mm)	Tire pressure contact, psi (MPa)	Contact area, in. ² (cm ²)	550 (3.8)	650 (4.5)	750 (5.2)	550 (3.8)	650 (4.5)	750 (5.2)	550 (3.8)	650 (4.5)	750 (5.2)
6400 (29)	26 (660)	100 (0.7)	32 (206)	4.5 (115)	4.0 (100)	4.0 (100)	4.5 (115)	4.0 (100)	3.5 (90)	4.0 (100)	4.0 (100)	3.5 (90)
		250 (1.7)	13 (84)	5.0 (130)	4.5 (115)	4.0 (100)	5.0 (130)	4.5 (115)	4.0 (100)	4.5 (115)	4.0 (100)	4.0 (100)
10,400 (46)	31 (785)	100 (0.7)	52 (336)	5.5 (140)	5.0 (130)	4.5 (115)	5.5 (140)	5.0 (130)	4.5 (115)	5.0 (130)	4.5 (115)	4.5 (115)
		250 (1.7)	21 (136)	6.0 (150)	5.5 (140)	5.0 (130)	6.0 (150)	5.5 (140)	5.0 (130)	5.5 (140)	5.5 (140)	5.0 (130)
14,600 (65)	32 (815)	100 (0.7)	73 (470)	6.5 (165)	6.0 (150)	5.5 (140)	6.5 (165)	6.0 (150)	5.5 (140)	6.0 (150)	5.5 (140)	5.0 (130)
		250 (1.7)	29 (187)	7.0 (180)	6.5 (165)	6.0 (150)	7.0 (180)	6.5 (165)	6.0 (150)	6.5 (165)	6.0 (150)	5.5 (140)
22,200 (99)	37 (940)	100 (0.7)	111 (716)	8.0 (200)	7.0 (180)	6.5 (165)	7.5 (190)	7.0 (180)	6.5 (165)	7.5 (190)	6.5 (165)	6.0 (150)
		250 (1.7)	44 (284)	8.5 (215)	8.0 (200)	7.5 (190)	8.0 (200)	8.0 (200)	7.0 (180)	8.0 (200)	7.5 (190)	7.0 (180)
32,500 (145)	37 (940)	100 (0.7)	162 (1045)	9.5 (240)	9.0 (225)	8.0 (200)	9.5 (240)	8.5 (215)	8.0 (200)	9.5 (240)	8.0 (200)	7.5 (190)
		250 (1.7)	65 (419)	10.5 (265)	9.5 (240)	9.0 (225)	10.5 (265)	9.5 (240)	9.0 (225)	10.0 (250)	9.0 (225)	8.5 (215)
42,000 (187)	40 (1015)	100 (0.7)	210 (1355)	11.0 (280)	10.0 (250)	9.0 (225)	10.5 (265)	9.5 (240)	9.0 (225)	10.0 (250)	9.0 (225)	8.5 (215)
		250 (1.7)	84 (542)	12.0 (300)	11.0 (280)	10.0 (250)	11.5 (290)	10.5 (265)	10.0 (250)	11.0 (280)	10.5 (265)	9.5 (240)

Industrial Design Table: Dual Wheel

Table 4.74b—Thickness in. (mm) for industrial lift trucks with dual-wheeled drive axle



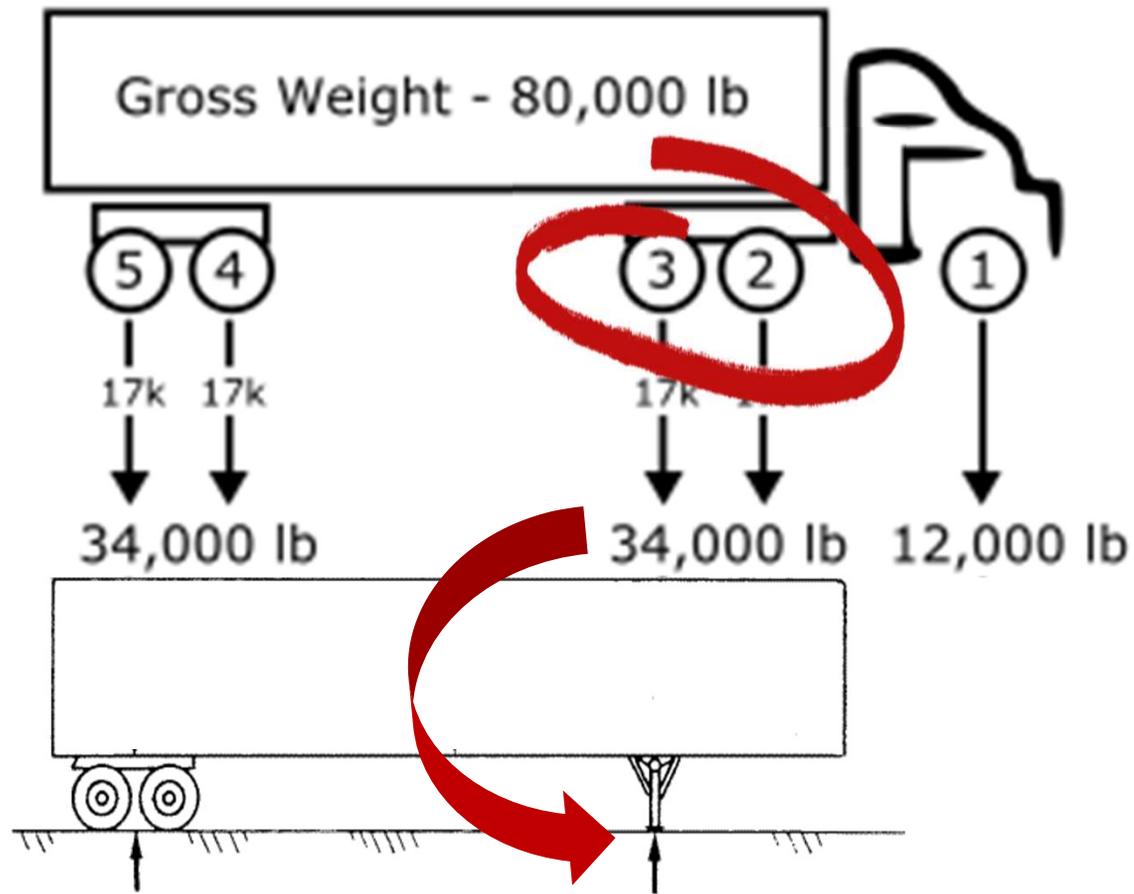
The diagram shows two pairs of wheels. The distance between the centers of the two wheels in a pair is labeled S_d . The distance between the centers of the two pairs is labeled S .

					Subgrade reaction $k = 150$ pci (41 MN/m ³)			Subgrade reaction $k = 200$ pci (54 MN/m ³)			Subgrade reaction $k = 300$ pci (81 MN/m ³)		
					Modulus of rupture, psi (MPa)			Modulus of rupture, psi (MPa)			Modulus of rupture, psi (MPa)		
Load on drive axle, lb (kN)	Spacing S , in. (mm)	Spacing S_d , in. (mm)	Tire pressure contact, psi (MPa)	Contact area, in. (cm ²)	550 (4.0)	650 (4.5)	750 (5.0)	550 (4.0)	650 (4.5)	750 (5.0)	550 (4.0)	650 (4.5)	750 (5.0)
22,200 (99)	41 (1040)	10 (255)	100 (0.7)	56 (361)	8.0 (200)	7.5 (190)	7.0 (180)	8.0 (200)	7.5 (190)	7.0 (180)	7.5 (190)	7.0 (180)	6.5 (165)
			250 (1.7)	22 (142)	7.5 (190)	7.0 (180)	8.0 (200)	7.5 (190)	7.0 (180)	7.5 (190)	7.0 (180)	6.5 (165)	
32,500 (145)	47 (1195)	10 (255)	100 (0.7)	81 (523)	9.0 (225)	8.5 (215)	7.5 (190)	9.0 (225)	8.0 (200)	7.5 (190)	8.5 (215)	7.5 (190)	7.0 (180)
			250 (1.7)	35 (213)	9.5 (240)	8.5 (215)	8.0 (200)	9.5 (240)	8.5 (215)	8.0 (200)	9.0 (225)	8.0 (200)	7.5 (190)
42,000 (187)	54 (1370)	12 (305)	100 (0.7)	105 (672)	10.0 (250)	9.0 (225)	9.0 (225)	9.5 (240)	9.0 (225)	8.0 (200)	9.5 (240)	8.5 (215)	8.0 (200)
			250 (1.7)	42 (271)	10.5 (265)	9.5 (240)	9.0 (225)	10.0 (250)	9.5 (240)	8.5 (215)	10.0 (250)	9.0 (225)	8.5 (215)
63,300 (282)	57 (1450)	14 (355)	100 (0.7)	159 (1026)	12.5 (320)	11.5 (290)	10.5 (265)	12.0 (300)	11.0 (280)	10.0 (250)	11.5 (290)	10.5 (265)	9.5 (240)
			250 (1.7)	64 (413)	13.0 (330)	12.0 (300)	11.0 (280)	12.5 (320)	11.5 (290)	10.5 (265)	12.0 (300)	11.0 (280)	10.0 (250)
100,600 (448)	73 (1855)	18 (460)	100 (0.7)	252 (1626)	15.0 (380)	14.0 (355)	12.5 (320)	14.5 (370)	13.5 (345)	12.5 (320)	14.0 (355)	12.5 (320)	11.5 (290)
			250 (1.7)	101 (652)	16.0 (405)	14.5 (370)	13.5 (345)	15.5 (395)	14.0 (355)	13.0 (330)	14.5 (370)	13.5 (345)	12.5 (320)
132,000 (587)	70 (1780)	21 (534)	100 (0.7)	330 (2129)	17.5 (445)	16.0 (405)	14.5 (370)	16.5 (420)	15.0 (380)	14.0 (355)	16.0 (405)	14.5 (370)	13.5 (345)
			250 (1.7)	132 (852)	18.0 (460)	16.5 (420)	15.5 (395)	17.5 (445)	16.0 (405)	15.0 (380)	16.5 (420)	15.0 (380)	14.0 (355)



Punching Shear Stress

Punching Shear Stress



Punching Shear Stress Check

Table 4.7.5a—Allowable static load on one 12 x 12 in. (300 x 300 mm) plate (corner loading), lb (kg)

Thickness, in. (mm)	Modulus of rupture, psi (MPa)		
	550 (3.8)	650 (4.5)	750 (5.2)
5.0 (130)	7294 (3309)	8644 (3921)	9995 (4534)
6.0 (150)	9329 (4232)	11,056 (5015)	12,784 (5799)
7.0 (180)	11,486 (5210)	13,612 (6175)	15,739 (7139)
8.0 (200)	13,764 (6243)	16,312 (7399)	18,861 (8555)
9.0 (225)	16,163 (7331)	19,156 (8689)	22,150 (10,047)
10.0 (250)	18,684 (8475)	22,144 (10,044)	25,605 (11,614)
11.0 (280)	21,327 (9674)	25,276 (11,465)	29,226 (13,257)
12.0 (300)	24,091 (10,928)	28,552 (12,951)	33,014 (14,975)

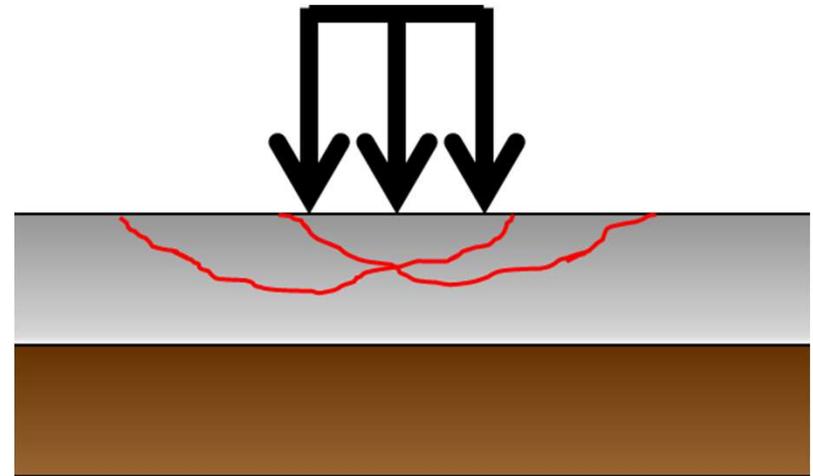
Assumptions in table (adapted from ACI 318):

- Unreinforced panels
- Live load factor of 1.6
- Nominal shear strength reduced by factor of 0.60
- Nominal base plate width and length of 12 in. (300 mm)
- $\frac{3}{4}$ in. (19 mm) thickness reduction for placement tolerance

Bearing Stress Check

Table 4.7.6—Minimum compressive strength for static load applied to selected plates, psi (MPa)

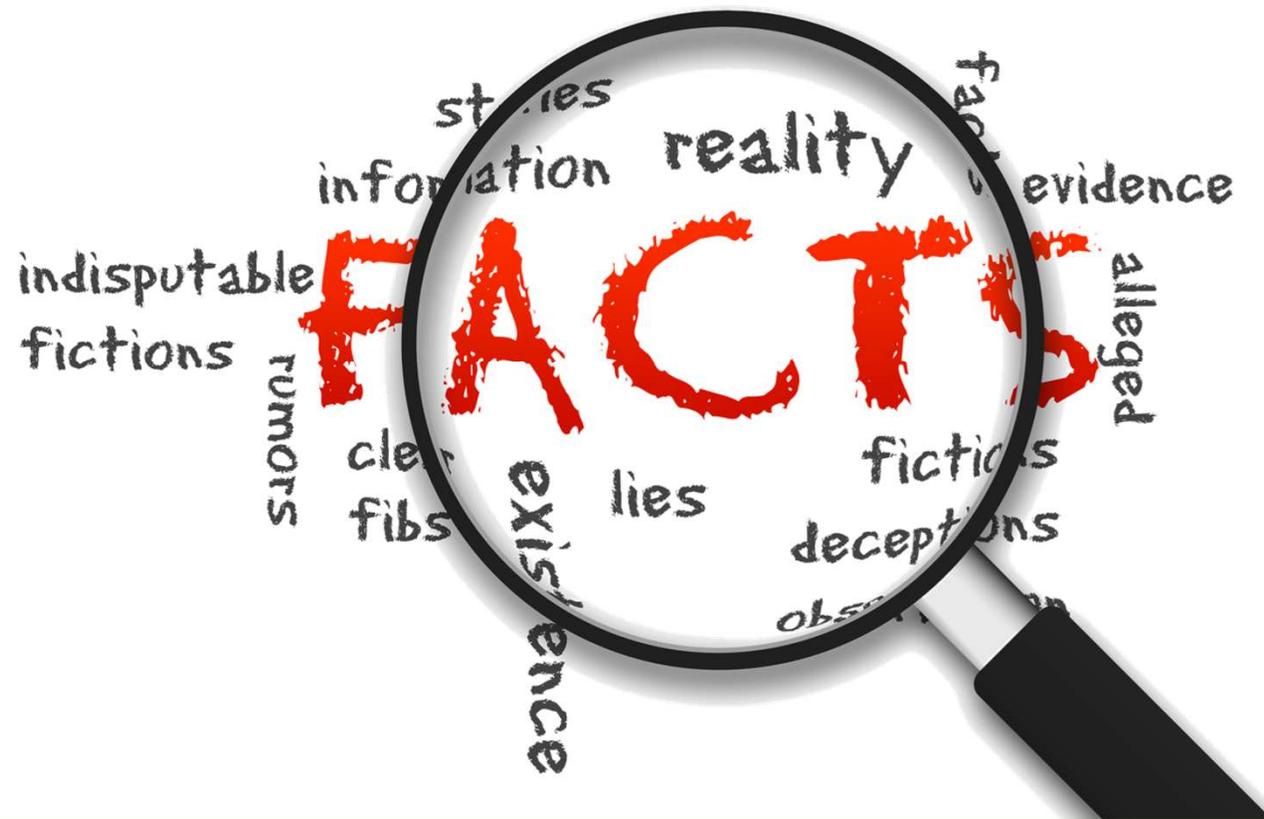
Static load, lb (kg)	1 x 3 in. (25 x 75 mm)	2 x 2 in. (50 x 50 mm)	3 x 3 in. (75 x 75 mm)	4 x 4 in. (100 x 100 mm)
4000 (1814)	4183 (28.8)	3137 (21.6)	1394 (9.6)	784 (5.4)
6000 (2722)	6275 (43.3)	4706 (32.4)	2092 (14.4)	1176 (8.1)
8000 (3629)	NA	6275 (43.3)	2789 (19.2)	1569 (10.8)
10,000 (4536)	NA	NA	3486 (24.0)	1961 (13.5)
12,000 (5443)	NA	NA	4183 (28.8)	2353 (16.2)
14,000 (6350)	NA	NA	4880 (33.6)	2745 (18.9)
16,000 (7257)	NA	NA	5577 (38.5)	3137 (21.6)
18,000 (8164)	NA	NA	6275 (43.3)	3529 (24.3)
20,000 (9072)	NA	NA	6972 (48.1)	3922 (27.0)



Assumptions in table (adapted from ACI 318):

- Unreinforced panels
- Live load factor of 1.6
- Nominal bearing strength reduced by a factor of 0.60

Common Design Misconceptions



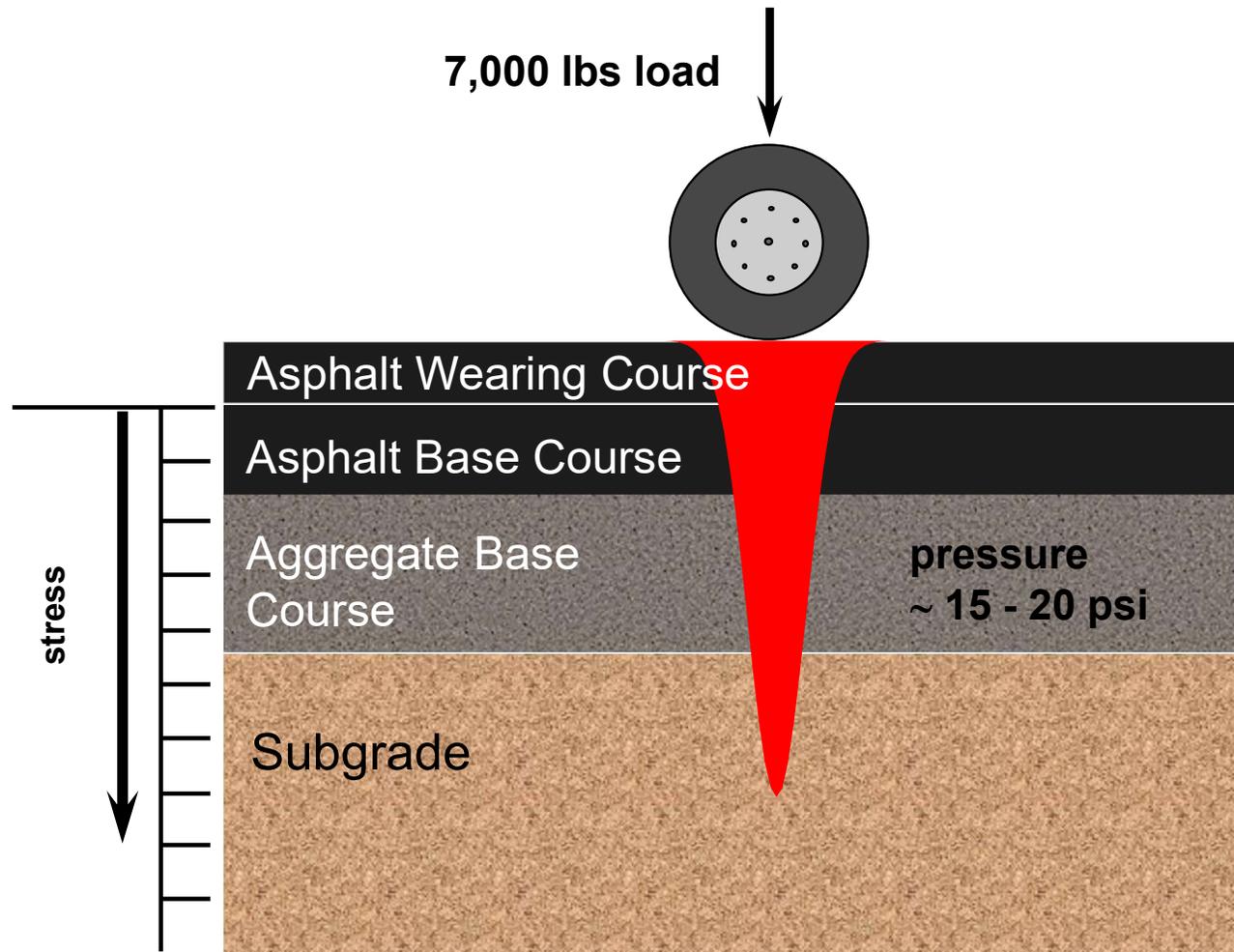
Common Design Misconception #1

“Concrete
pavement
requires a
subbase”*

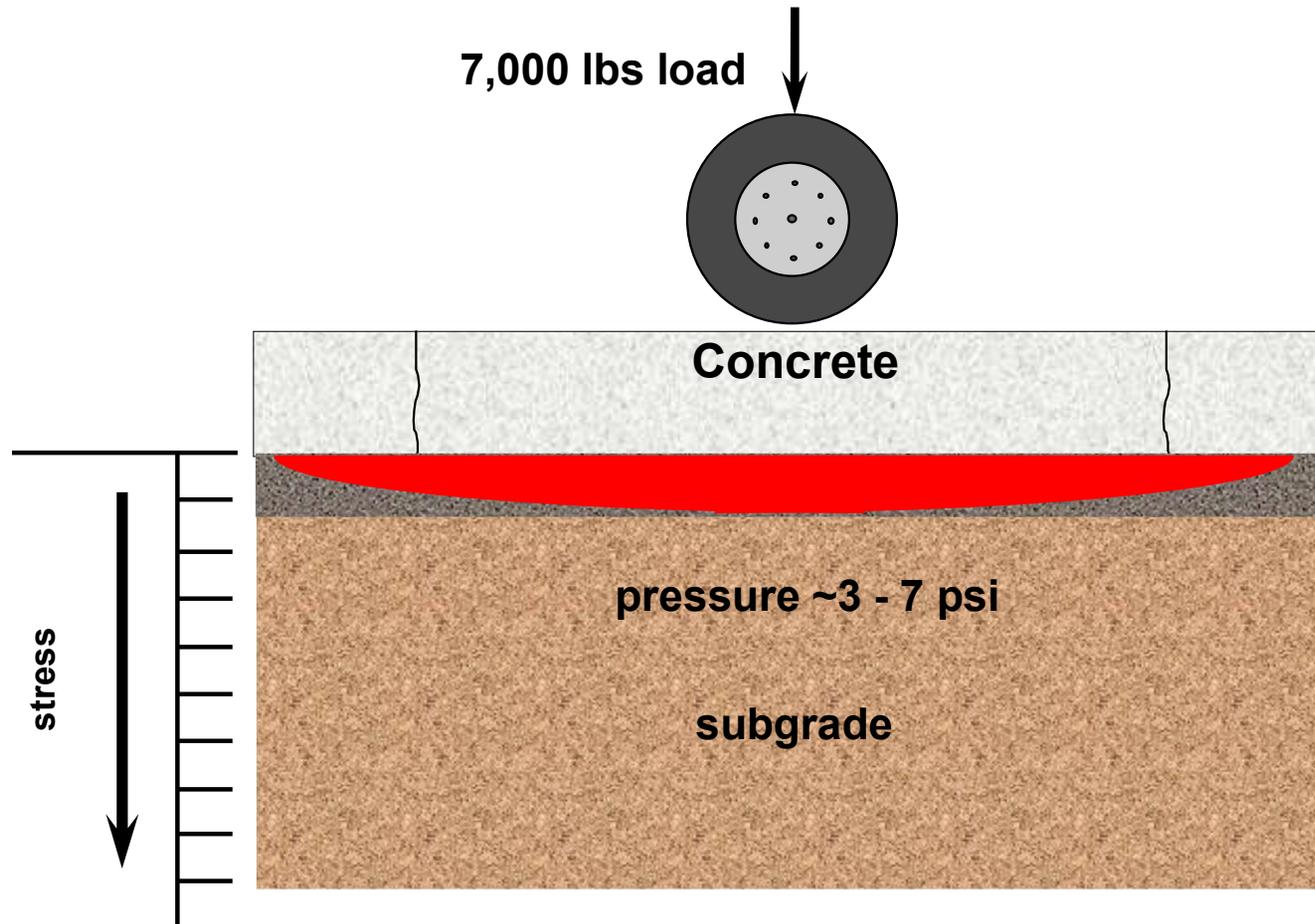


*Subbase: a layer of imported or improved material between the natural site material (subgrade) and the concrete.

Load-Carrying Structure for Flexible Pavement



The load-carrying structure for concrete pavement is primarily thickness.



ACI 330 position on subgrade/subbase

“A well-prepared, uniform subgrade at the correct elevation is essential to the construction of a quality pavement.”

“The subgrade should have a dense, firm, and uniformly smooth surface when concrete is placed on it.”

“Granular aggregate subbases are not normally used for concrete parking lots.”



Do you ever need a subbase layer?

May warrant consideration if:

- Construction platform is needed

- Subgrade is very poor quality

- Heavy truck traffic & load transfer concerns

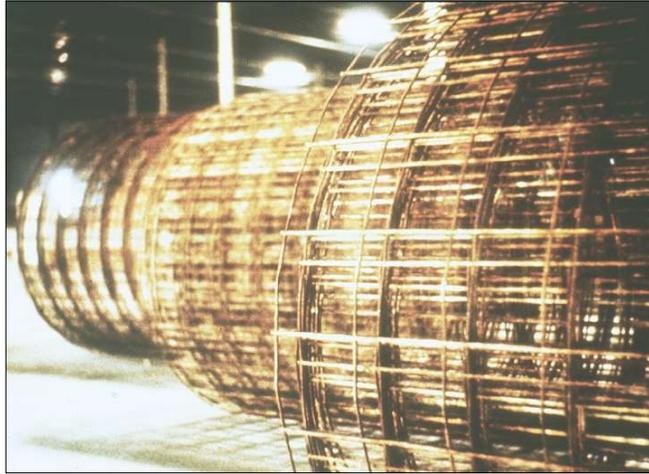
- Pumping of subgrade is likely

Can result in higher k value for design and slightly thinner concrete section

Common Design Misconception #2

Concrete pavements require steel reinforcement!





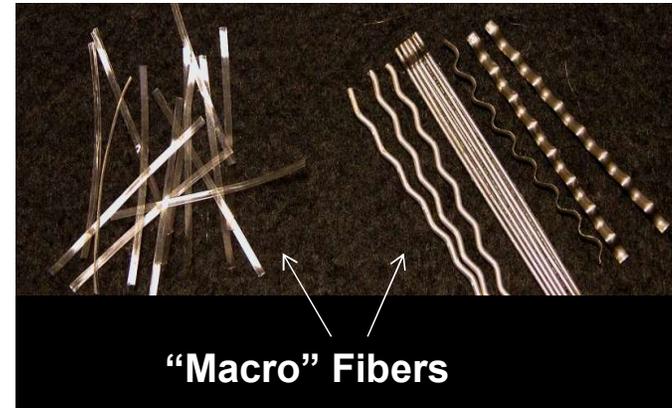
Secondary Steel Reinforcement

- Does not make concrete stronger!
- Does not stop concrete from cracking!
- Holds concrete together when it cracks

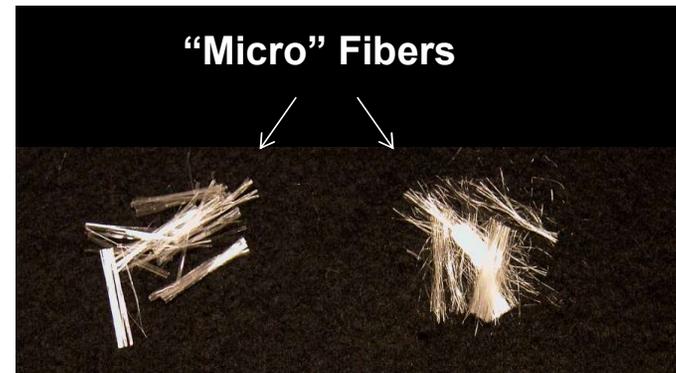


What about Fibers?

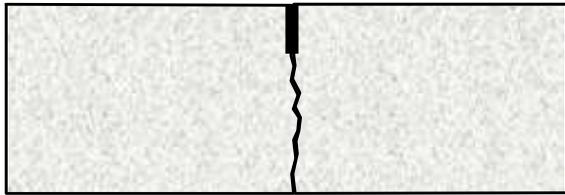
Steel & Macro Fibers
(0.008-0.03")
Secondary Reinforcement



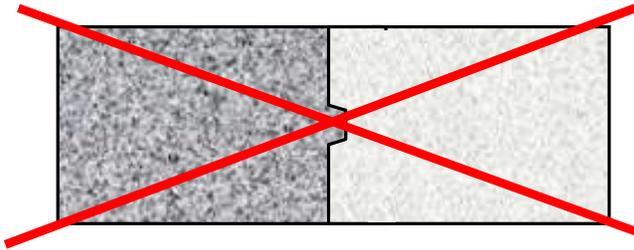
Micro Fibers (<0.004")
Plastic Shrinkage
Crack Control



Load transfer joint details: Pavements less than 7"



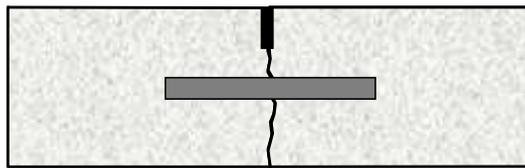
Aggregate Interlock



Keyways

Load transfer joint details:

Pavements greater than 7"



Round Dowels

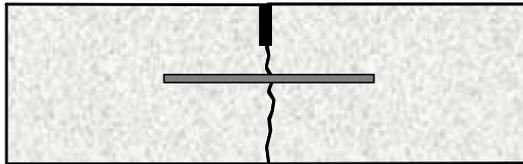
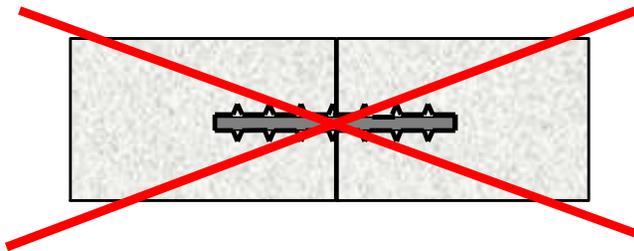
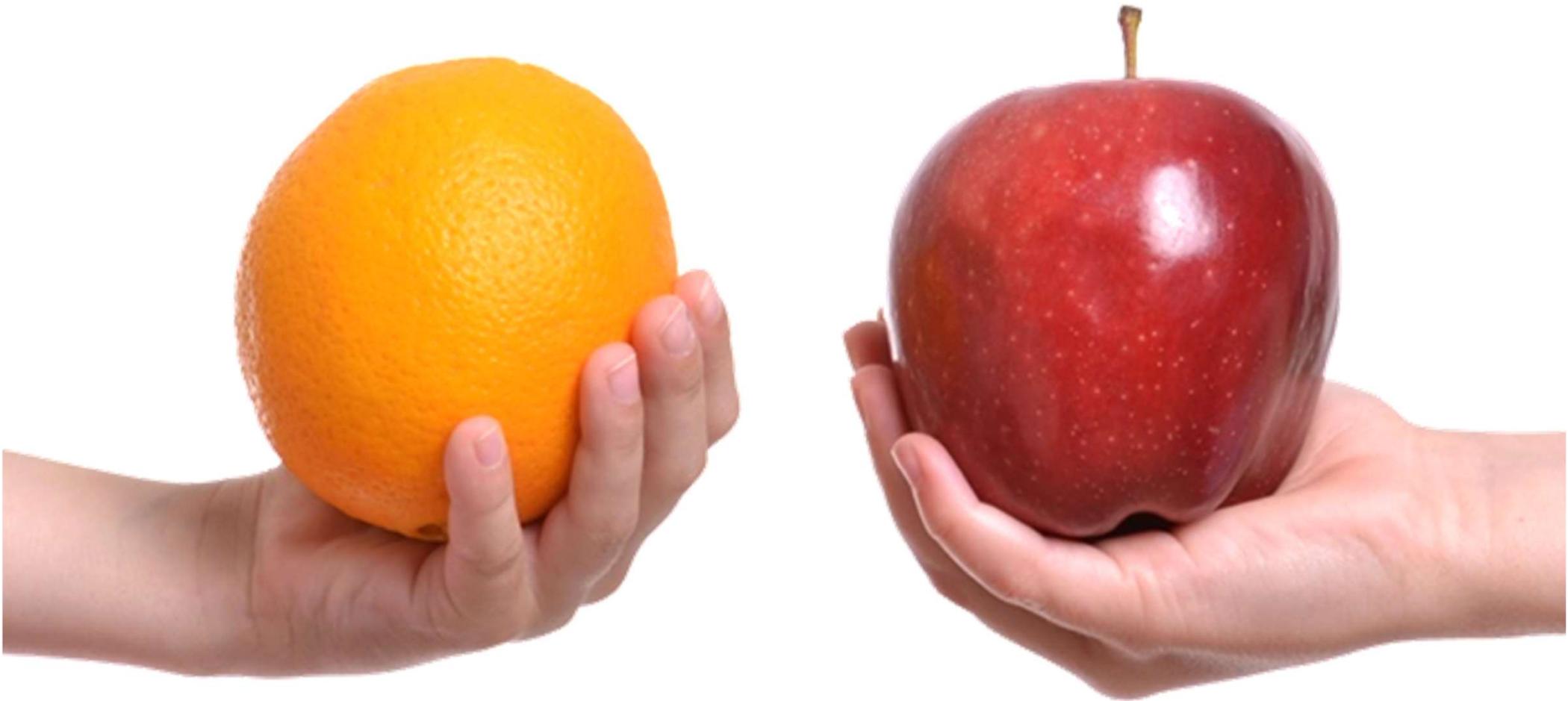


Plate Dowels



Tiebars \neq Dowels!
(not used for load transfer)

Evaluating Concrete and Asphalt Using Structural Numbers



Structural Layer Coefficient

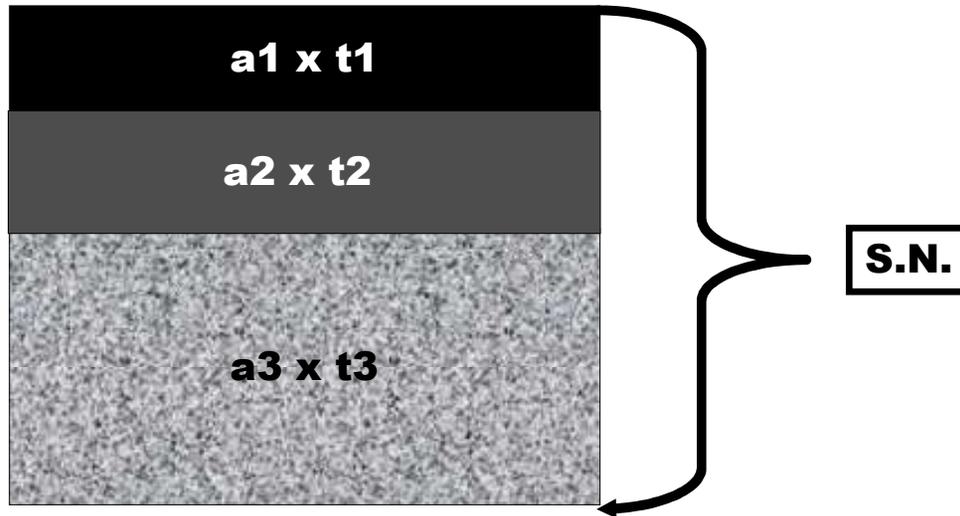
A relative number assigned for the value of 1" of material

Using proper values is critical in order to achieve accurate output

SLC's for pavement determined from AASHO Road Test - 1960

The Structural Number

$$\mathbf{S.N.} = (a_1 t_1) + (a_2 t_2) + (a_3 t_3) \dots$$



Structural Layer Coefficients per AASHO Road Test

Concrete = 0.50

Surface Asphalt = 0.20 to 0.42

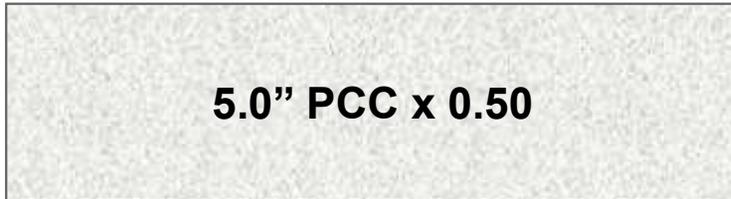
Bituminous Base = 0.10 to 0.34

Aggregate Base = 0.07 to 0.14

Let's Build an Asphalt Section

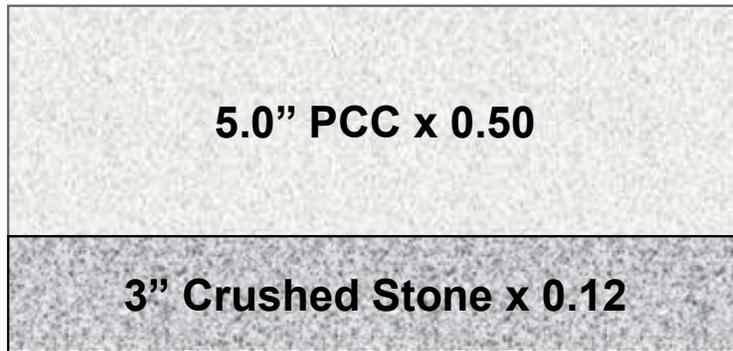
1.5" Bit. SC x 0.44	0.66
3.0" Binder x 0.38	+ 1.14
6" Crushed Stone x 0.12	<u>+ 0.72</u>
	S/N 2.52

Now Let's Build an Equivalent Concrete Section

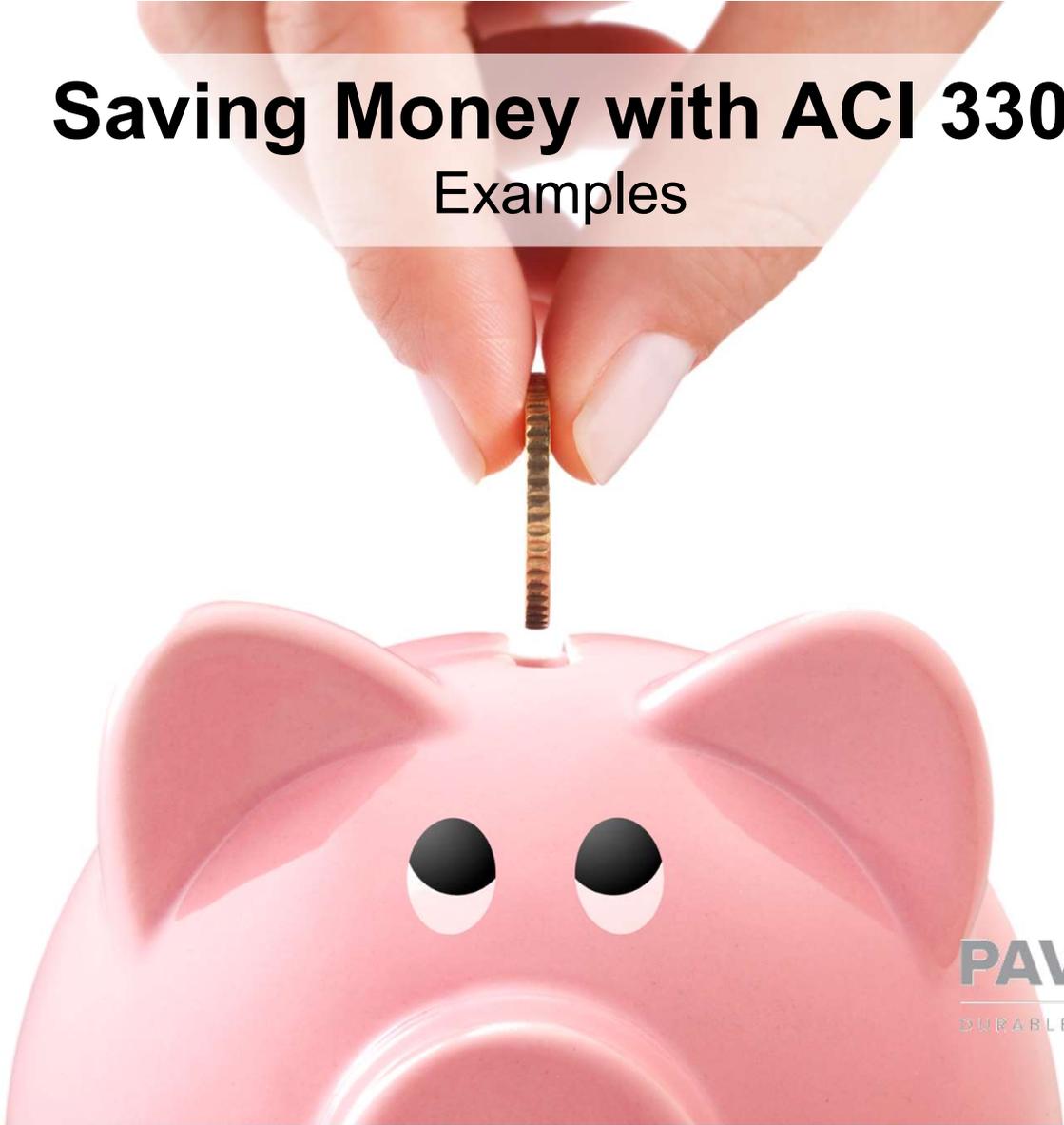


S/N 2.50

Now Let's Build an Equivalent Concrete Section



$$\begin{array}{r} 2.50 \\ + \quad 0.36 \\ \hline \text{S/N } 2.86 \end{array}$$

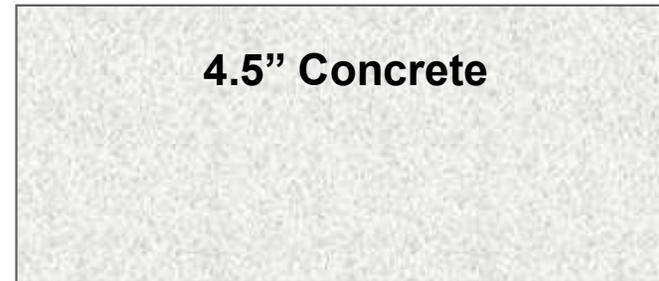
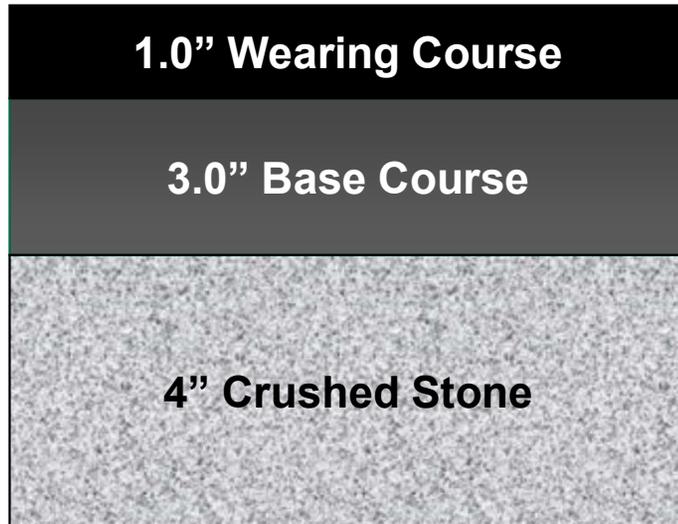
A hand is shown from the top, holding a coin and dropping it into the slot of a pink piggy bank. The piggy bank has two black circular eyes and a snout. The background is white.

Saving Money with ACI 330

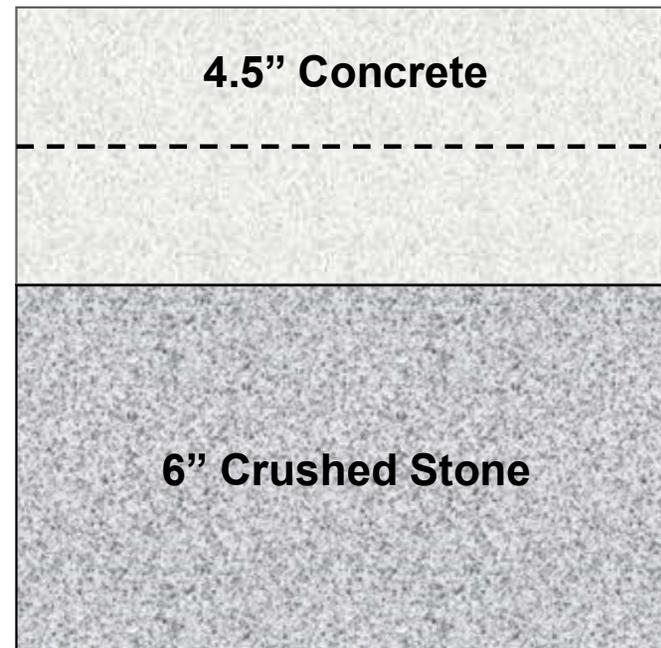
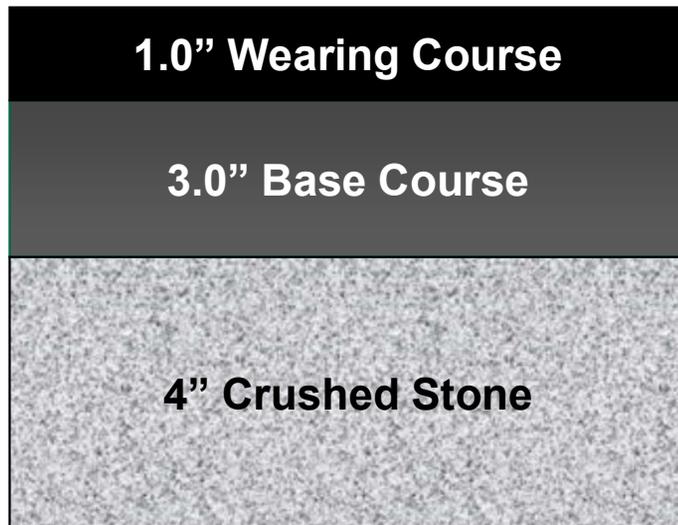
Examples

PAVE  AHEAD
DURABLE. SUSTAINABLE. CONCRETE.

ACI 330: National Account - Auto Dealer



ACI 330: National Account - Auto Dealer



"Nearly \$500,000 too high"

“Nearly \$500,000 too high”

6" stone subbase

\$25/ton in-place

\$1.27 per yd²/inch

\$265,846

6x6 wwf

\$0.67 per ft²

\$210,380

\$476,226

ACI 330.2-17: Pallet Plant Project



- Original Design
14" Asphalt
(wc/bc/subbase)
- New Design
7" Concrete
- 15% Cost Savings

ACI 330.2-17: Distribution Center Project



1.2 million ft² exterior pavement

Original Concrete Design:
(AASHTO 93)

9 ½" w/ 6" subbase
& 15' joint spacing

New Concrete Design:
(ACI 330 / 330.2)

Heavy Duty - 7"
(12' joint spacing)

Medium Duty - 5.5"
(6' joint spacing)

Light Duty - 4"
(6' joint spacing)

Resources





CONCRETE IN MARYLAND

Let the concrete industry drive success for your next project.

[ABOUT US >](#)

MARYLAND READY MIX CONCRETE ASSOCIATION, INC.

OUR STATEMENT

Maryland's ready mix concrete producers want owners, architects, contractors, designers, engineers, legislators, and customers to know that there's no greater material for structures or paving than concrete.

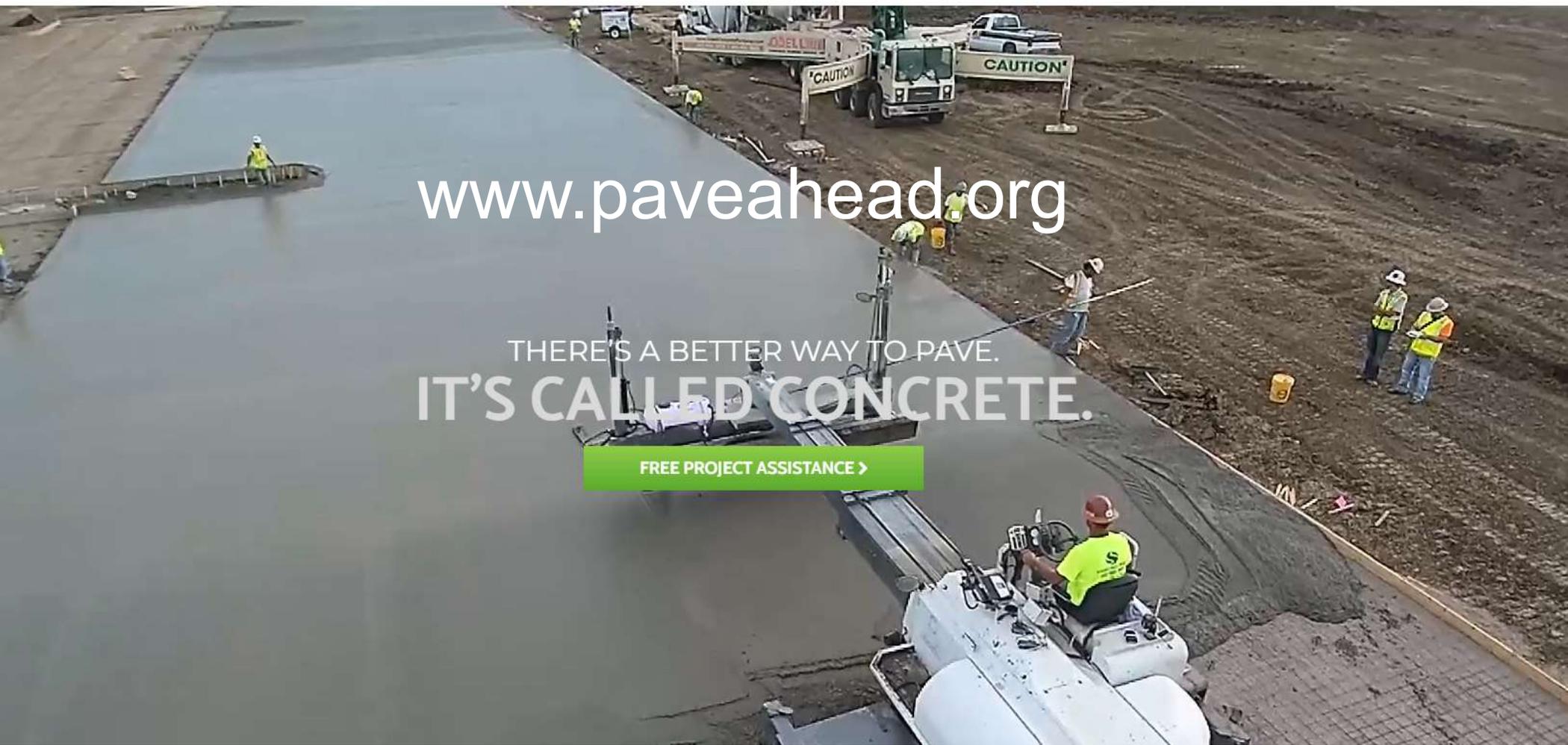
No product stands up to Mother Nature better. No product lasts longer. No product's life cycle is more environmentally friendly. No product is more locally sourced. And no product offers a better return on investment.

By investing in new technologies, ingredients and business practices, Maryland's ready mix concrete producers are proud to provide the most sustainable concrete ever without sacrificing strength or durability.

[ABOUT US >](#)

MAKE A CONCRETE DECISION.™

SUSTAINABLE | INNOVATIVE | VERSATILE
THAT'S CONCRETE MADE IN MARYLAND



www.paveahead.org

THERE'S A BETTER WAY TO PAVE.
IT'S CALLED CONCRETE.

[FREE PROJECT ASSISTANCE >](#)

www.pavementdesigner.org

The image is a screenshot of the website www.pavementdesigner.org. The main content area features a blue header with the text "Select Project Type" and three large, semi-transparent buttons labeled "PARKING", "STREET", and "INTERMODAL". The background of the website is an aerial view of a city street with a brick building on the left and a modern building on the right. A vertical sidebar on the left contains navigation icons: a logo, a home icon, a plus sign, a right-pointing arrow, an information icon, and a question mark icon. At the bottom of the page, there are links for "Privacy Policy" and "Terms of Service".

pd

Select Project Type

Home

New Design

Log In
Signup

Resources

Support

PARKING

STREET

INTERMODAL

Privacy Policy

Terms of Service



NRMCA Design Assistance Program





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215-779-7375

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