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Designing Cost-Competitive Concrete Pavements

November 2023

Jim Mack, P.E.
CEMEX

IN ANY PAVEMENT TYPE SELECTION, INITIAL COSTS DRIVE THE RESULTS

Even in Life Cycle Cost Analysis, Initial costs drive the results

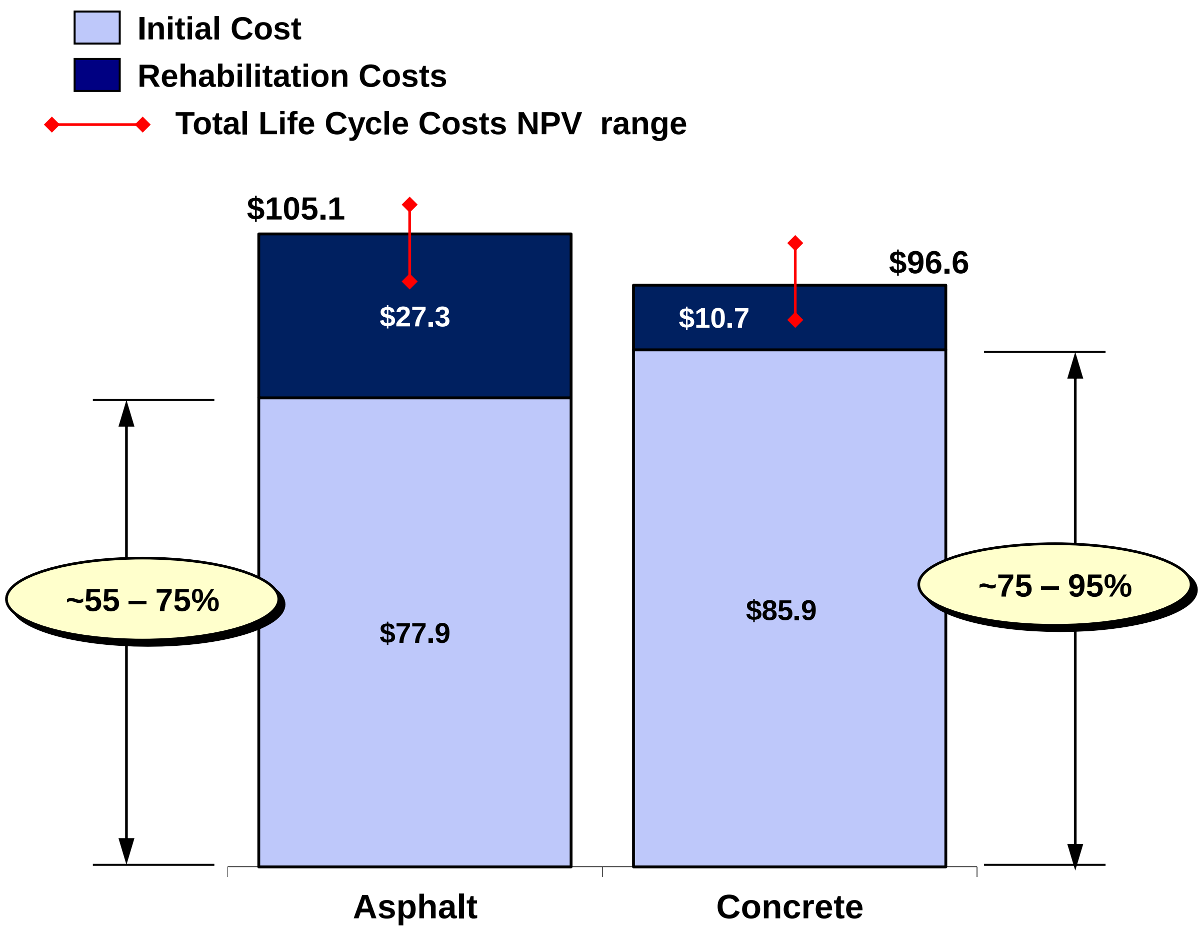
Initial costs account for

- **55-75% for Life Cycle Cost for Asphalt**
- **75-95% of Life Cycle Cost for Concrete**
  - ***Depends on designs, rehabilitation activities, rehabilitation timing, discount rates, etc.***

"Factors" that impact the initial cost

- **Thickness**
- **Design Features**
- **Competetion**
- **Bid Quantities – Economies of Scale**
- **Price Adjustment Clauses – Indexing**
- **Material Quantity Specifications – Impact on how contractors bid**
- **Etc.**

Initial Cost as % of Total Life Cycle Costs



Agencies / Designers must purposely work to instill practices and policies that impact Initial Costs while still maintaining low Life Cycle Costs

AGENDA

How Competition can Impact Pavement Costs

Optimize & Develop Project Specific Designs

Level Material Specifications

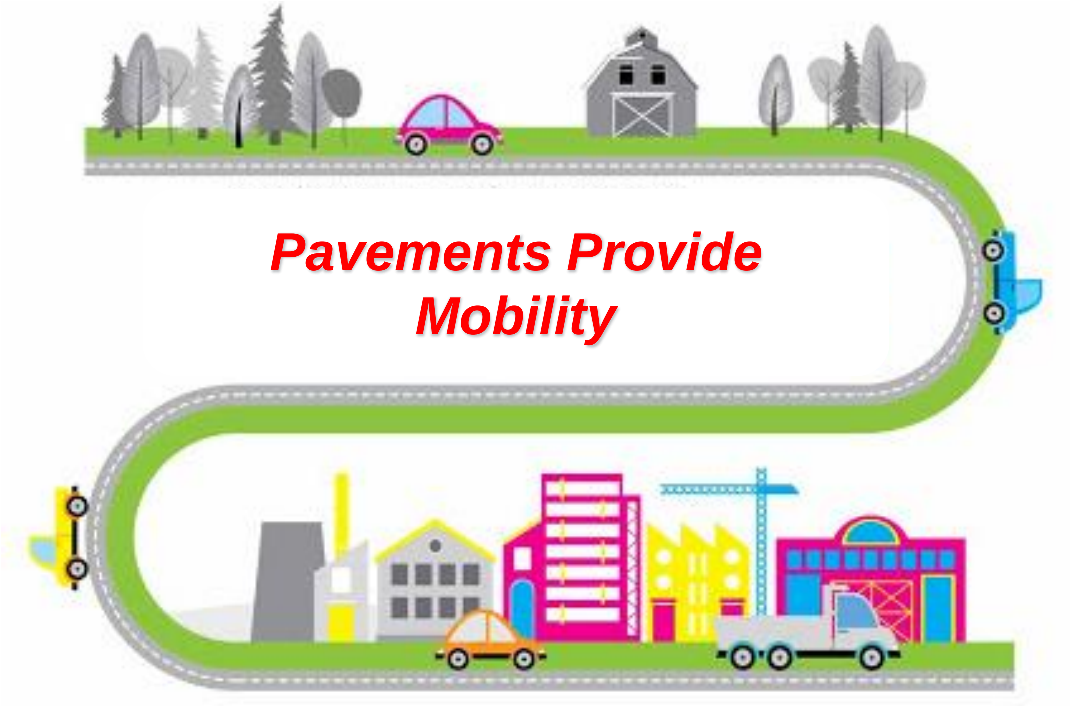
ECONOMIC THEORY STATES COMPETITION BETWEEN SUBSTITUTES REDUCES COSTS

Substitute: A product or service that satisfies the need that another product or service also fulfills

Bottles & Aluminum Cans are Substitutes that deliver Coca-Cola & Coke Purposely uses Both

ECONOMIC THEORY STATES COMPETITION BETWEEN SUBSTITUTES REDUCES COSTS

Substitute: A product or service that satisfies the need that another product or service also fulfills



Concrete & Asphalt Pavements are Substitutes that Can (and Should) have the Opportunity to Compete

THERE ARE TWO FORMS OF COMPETITION

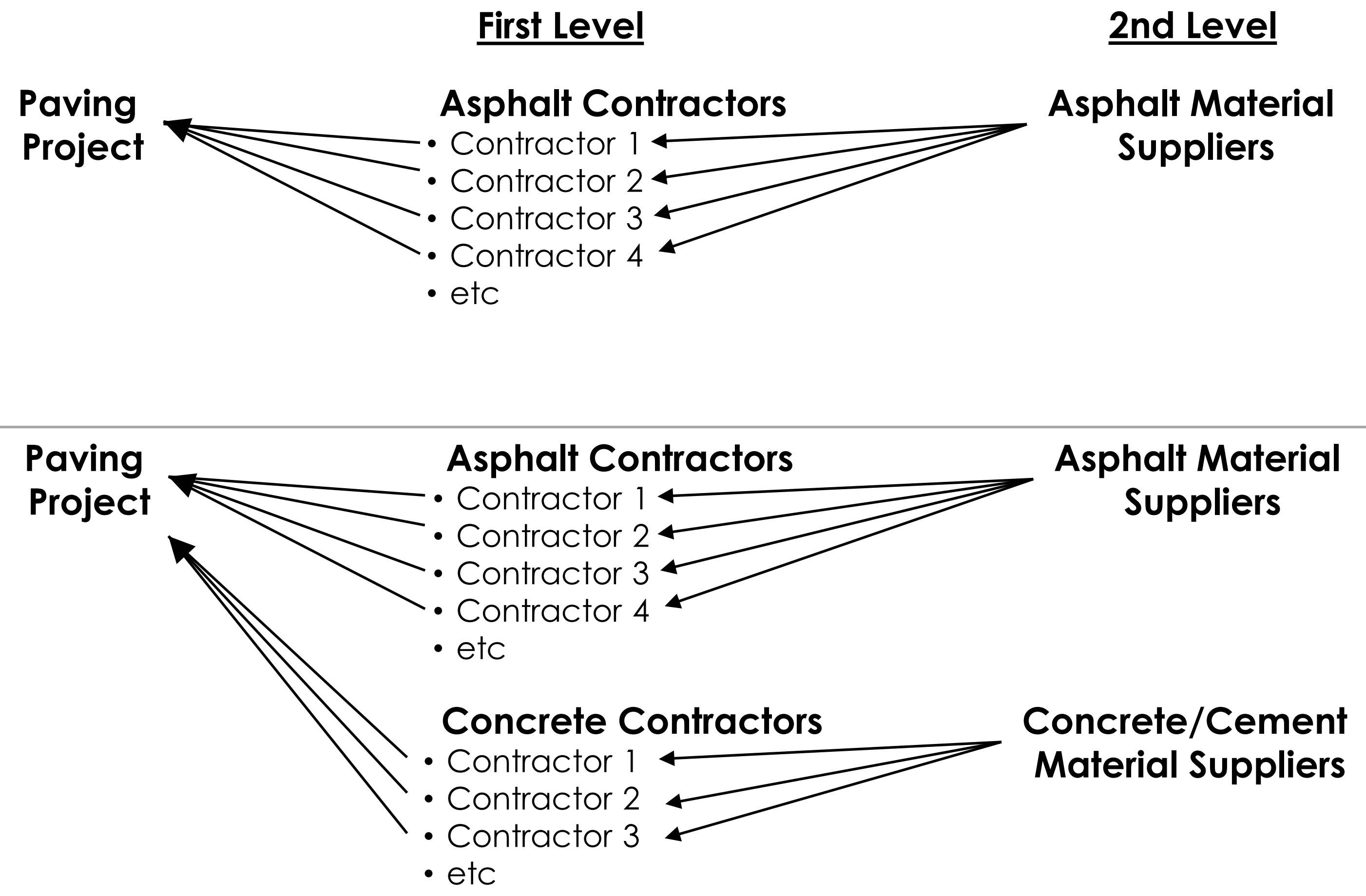
Inter-industry Competition Brings Another Level of Competition to the Supply Chain

Intra-Industry (Contractor) Competition

Competition Between firms that pave with the same material

Inter-Industry (Industry) Competition

Competition between firms that pave with different material substitutes



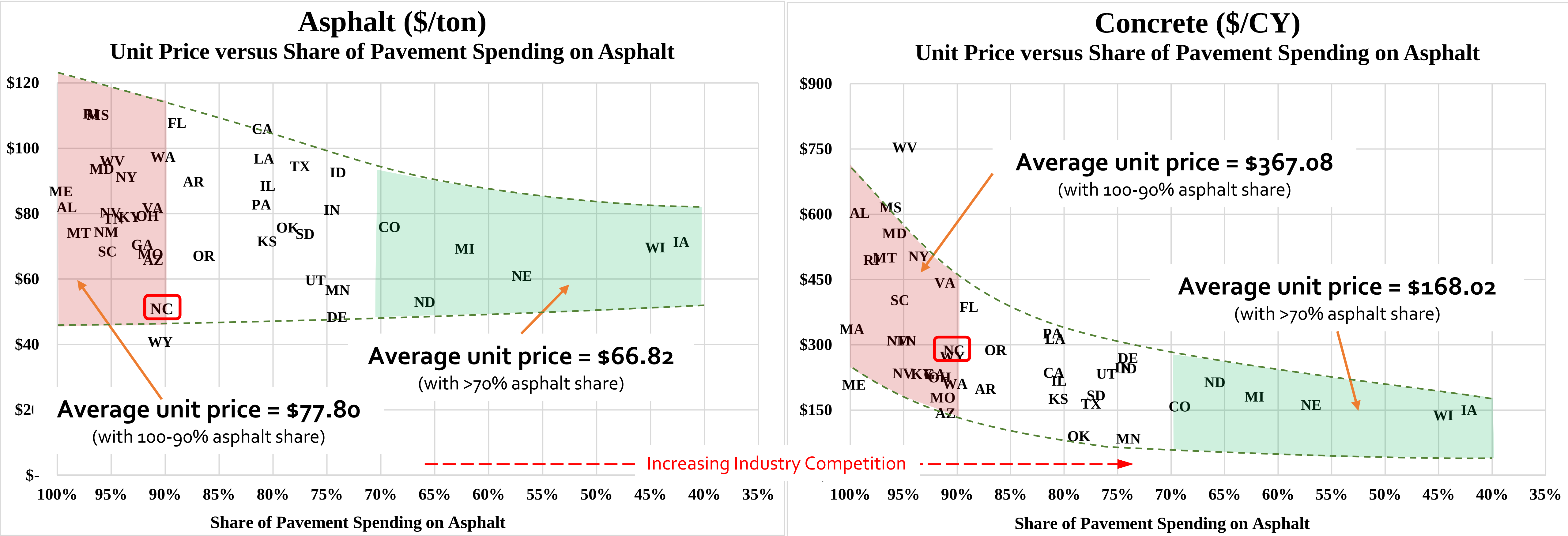
Contractor competition does not assure competition takes place at all levels of the supply chain

THERE IS LIMITED INTER-INDUSTRY COMPETITION IN MANY STATES

Most State DOTs spend most of their paving expenditures on Asphalt

(Note NC Asphalt price does not include binder costs)

2014-2018



While the trend shows competition between Paving Industries Brings Value, it does not consider other explanatory items or provide an indication to how competition could lower paving material unit costs

Sources:

1. Mack, J., Wathne, L., & Mu, F. (2016). Improving Network Investment Results by Implementing Competition and Asset Management in the Pavement Type Selection Process. *Proceedings of the 11th International Conference on Concrete Pavements, Aug 28-Sept 1, 2016.* San Antonio, TX.
2. Oman Systems, Inc Bid Tabulation Data. Retrieved from http://www.omansystems.com

QUESTION: DOES MORE OPPORTUNITIES FOR INDUSTRIES TO COMPETE CREATE SAVINGS IN PAVING?

MIT Analyzed 10 Years (2005-2014) of Pavement & Materials Pricing Data

- **Represented ~ 30,000 jobs.**
  - **Filtered to include only asphalt or concrete material pay items**
  - **Excluded activities that were not asphalt or concrete paving items (e.g., curbs, drainage, etc.)**
    - **73% of the asphalt pay items (94% of the asphalt pavement spending)**
    - **57% of the concrete pay items (88% of the concrete pavement spending)**

- **Developed statistical models to determine what factors had significant influence on paving costs:**
  - **Quantity / Project Size**
  - **Annual spending**
  - **Number of bidders**
  - **Share/number of AC and PCC bids**
  - **Price Adjustment Clauses**
  - **Share of spending on AC vs. PCC** **Proxy for inter-industry competition**

Slide Courtesy of MIT,
Source: Oman Systems, Inc Bid Tabulation Data. Retrieved from http://www.omansystems.com

INTER-INDUSTRY COMPETITION IMPACT IS LARGE

1st and 2nd Most Important Factor on Unit Costs for Concrete and Asphalt Paving

Significant factors

The wider the bar, the greater the impact

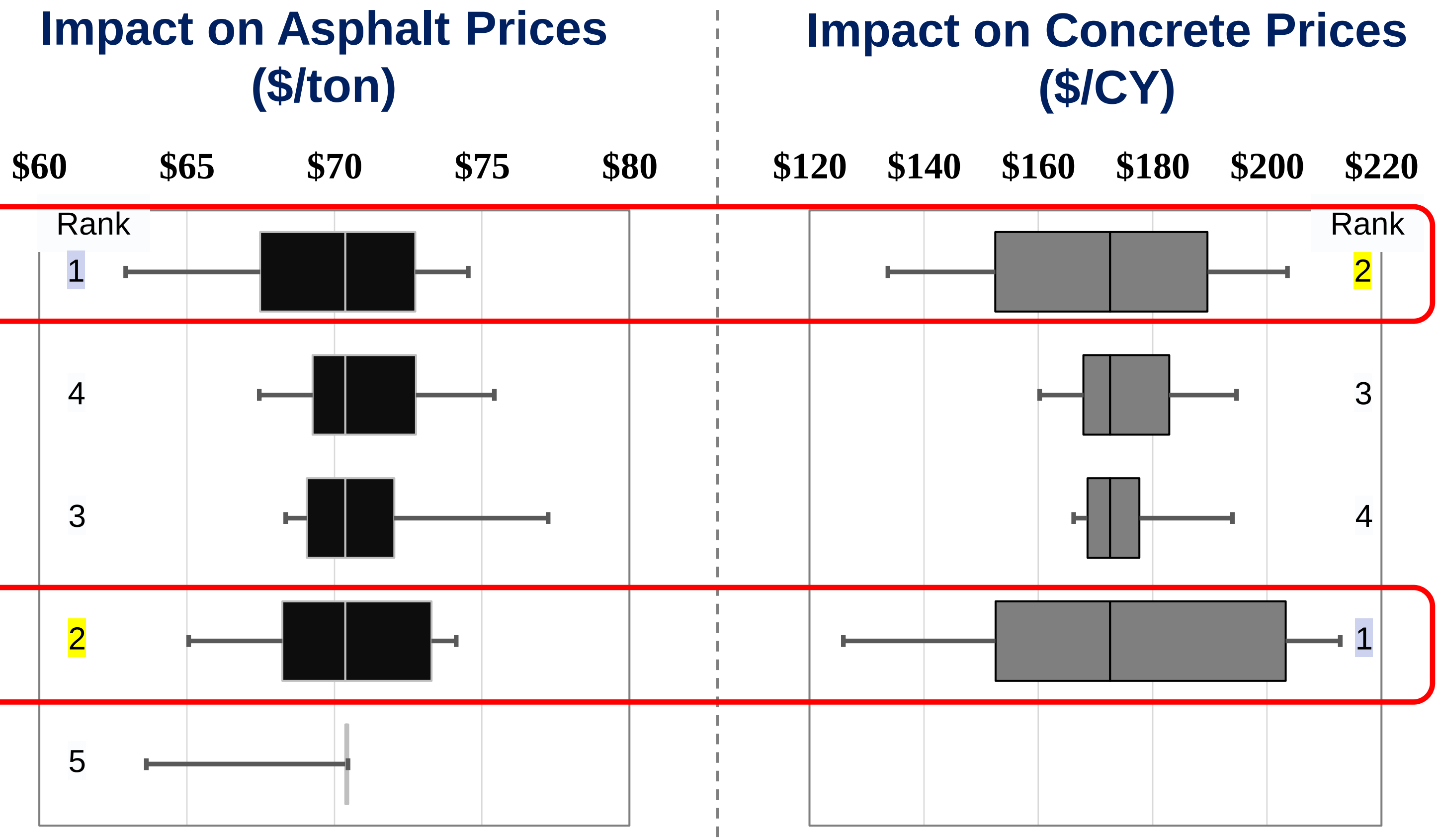
Project size: volume of paving material used in job

State market size: annual spending on paving

No. of bidders on a job: Intra-Industry Competition (Same industry)

Dominant market share: Inter-industry competition

Price adjustment clauses: Asphalt PAC used in a state to allow contractors to adjust prices after the initial bid



Competition between material industries has a larger impact than competition between multiple contractors

Slide Courtesy of MIT,

1 Indicates highest impact factor in paving costs

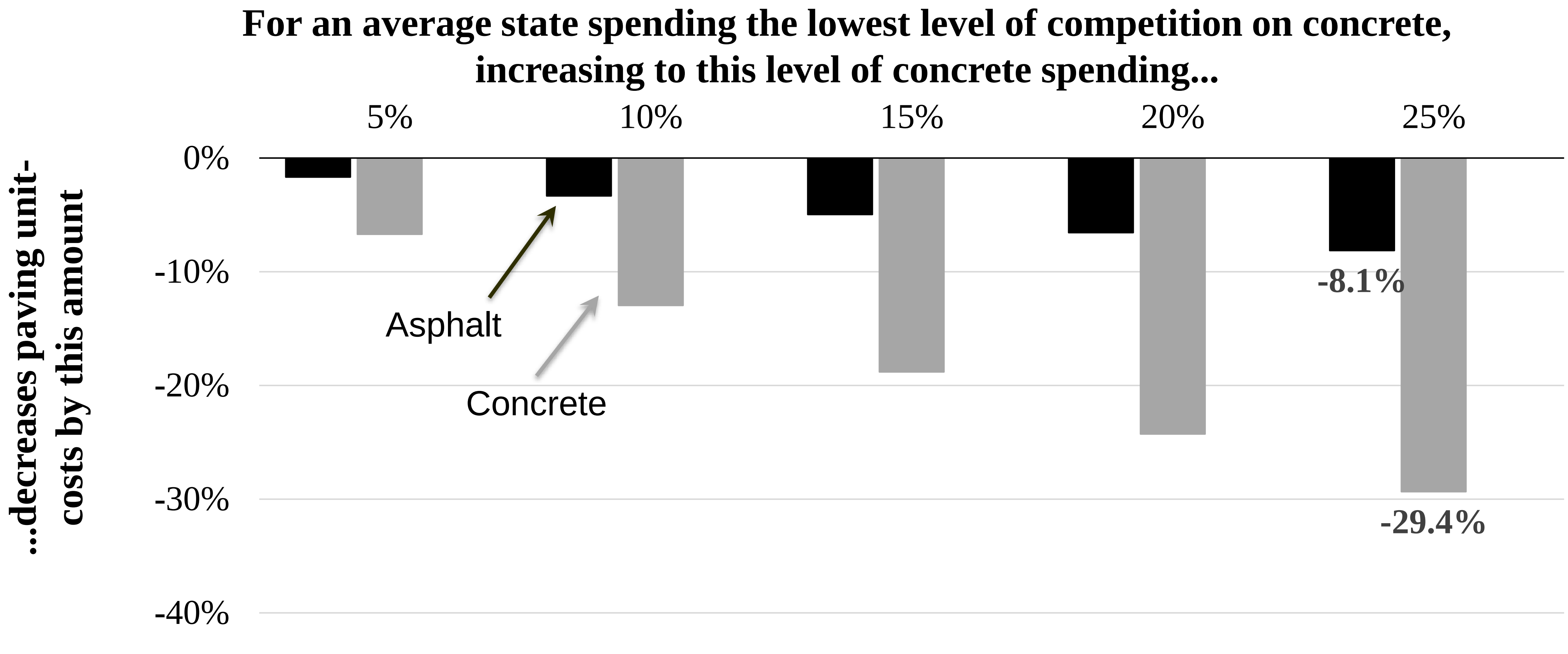
2 Indicates 2nd highest impact factor on paving costs

https://cshub.mit.edu/sites/default/files/images/0315%20New%20Competition%20Summary.pdf

CEMEX

INTER-INDUSTRY COMPETITION LOWERS UNIT COSTS

Allows Highway Agencies to do More with their Budgets

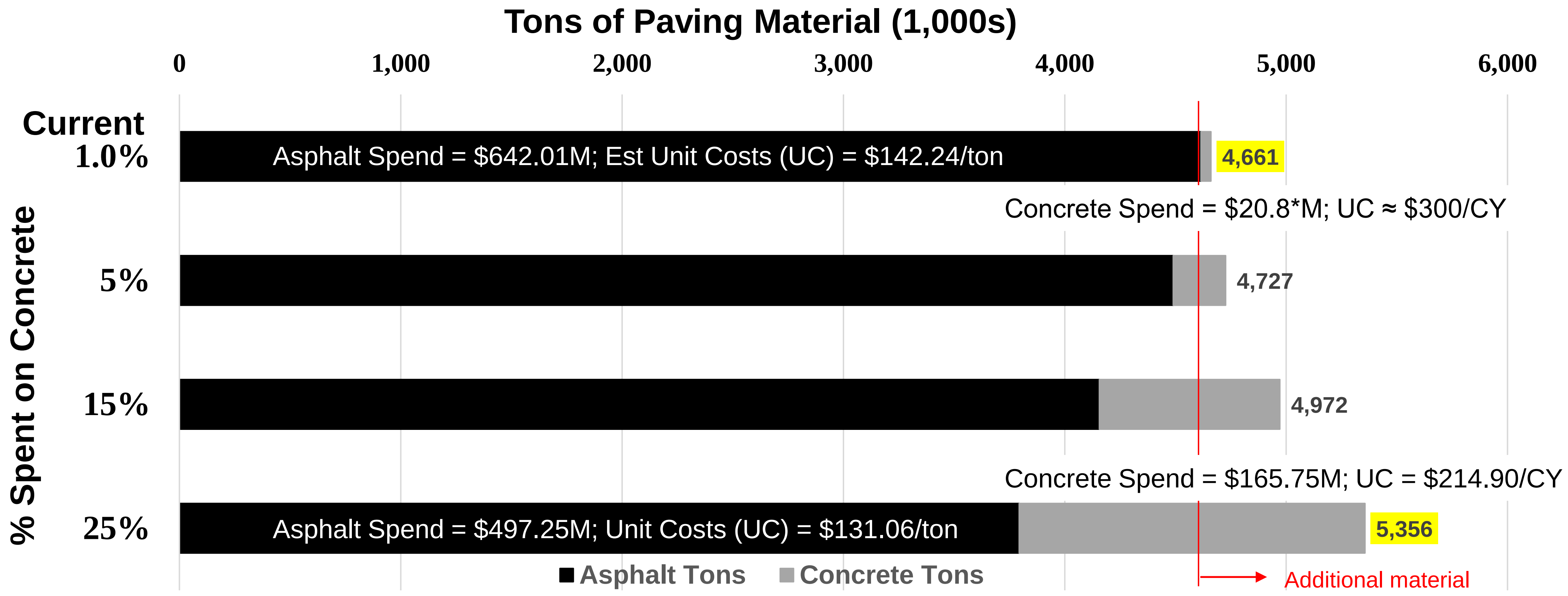


States with high industry competition pay ~ 8% and 29% less for asphalt and concrete pavements respectively vs. states with the low competition
(increasing competition between contractors only lowers cost ~ 5%)

Slide Courtesy of MIT,
https://cshub.mit.edu/sites/default/files/documents/CSHub%20Pavement%20Competition%20Topic%20Summary_Dec2017_FINAL.pdf

AGENCIES WITH A HEALTHY TWO-PAVEMENT SYSTEM CAN GET MORE PAVEMENT MATERIAL FOR THE SAME BUDGET

Example: NCDOT Pavement Budget ≈ $663M (2022 data)



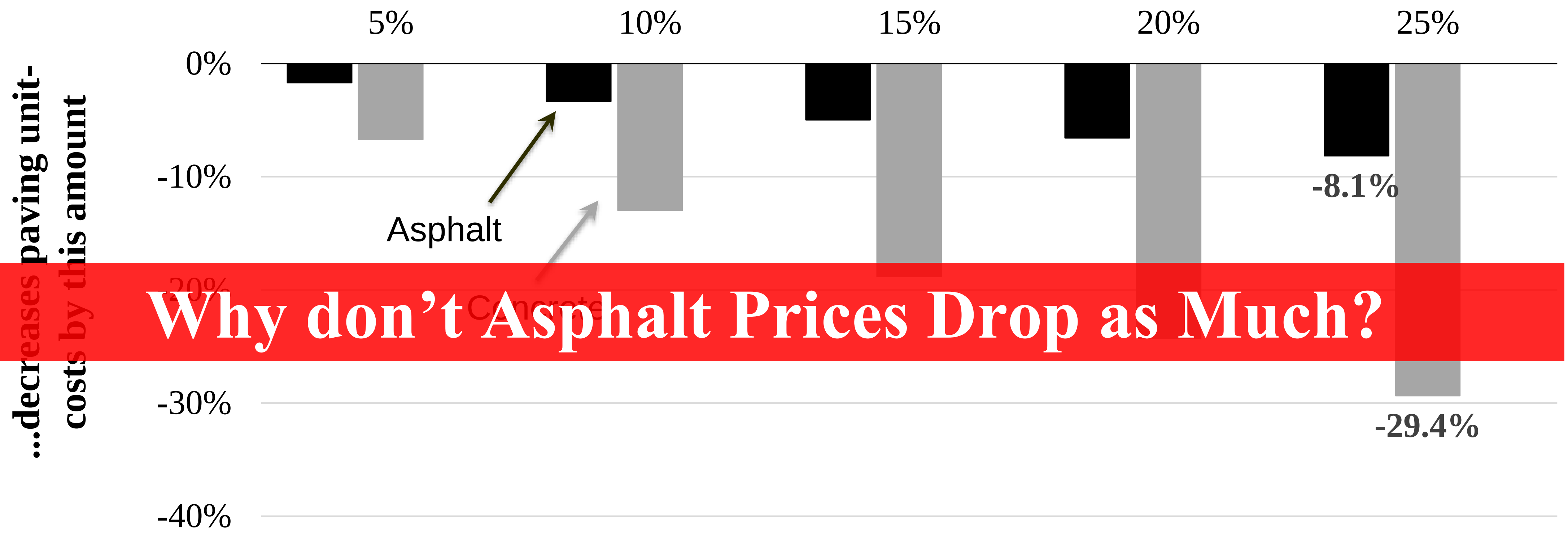
By marginally decreasing the purchases of asphalt tons, NCDOT has the opportunity to purchase 695,412 more tons of paving materials (~193 miles of 10-inch pavement) with the same $663 million

Prices based on 2022 NCDOT Oman Data: Asphalt & Concrete Items, Estimated AC UC based on ASP Concrete and ASP for Plant mix. (Conc includes patching, Latex concrete mixes, and paving)
Assumed unit weight of concrete = 150 lbs/ft^3

INTER-INDUSTRY COMPETITION LOWERS UNIT COSTS

Allows Highway Agencies to do More with their Budgets

For an average state spending the lowest level of competition on concrete, increasing to this level of concrete spending...



Why don’t Asphalt Prices Drop as Much?

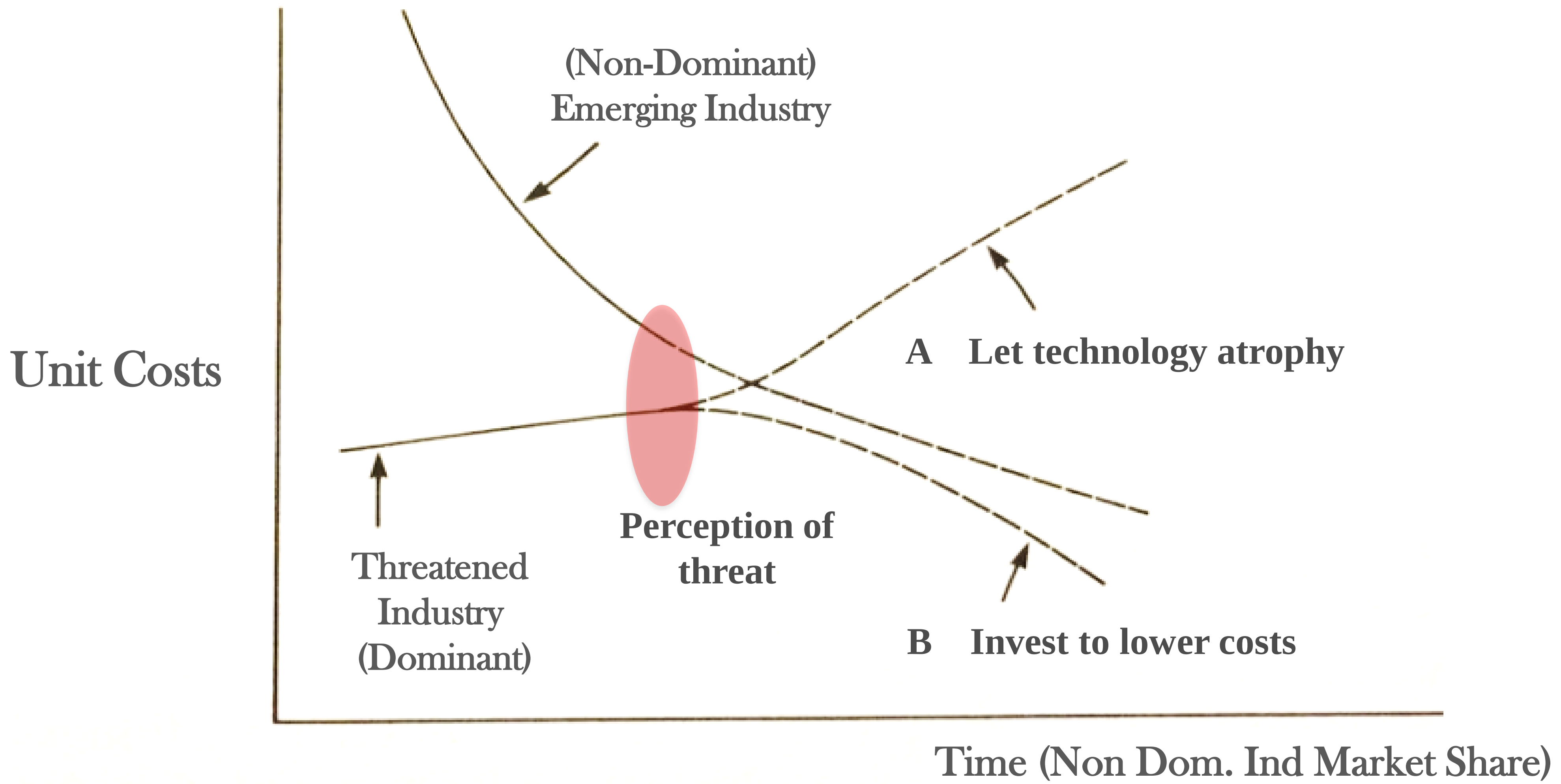
States with high industry competition pay ~ 8% and 29% less for asphalt and concrete pavements respectively vs. states with the low competition
(increasing competition between contractors only lowers cost ~ 5%)

Slide Courtesy of MIT,
https://cshub.mit.edu/sites/default/files/documents/CSHub%20Pavement%20Competition%20Topic%20Summary_Dec2017_FINAL.pdf

INTER-INDUSTRY COMPETITION REQUIRES A CRITICAL THREAT LEVEL

Competition Theory Threshold & Price Impact

Competitive Strategy in Emerging Industries

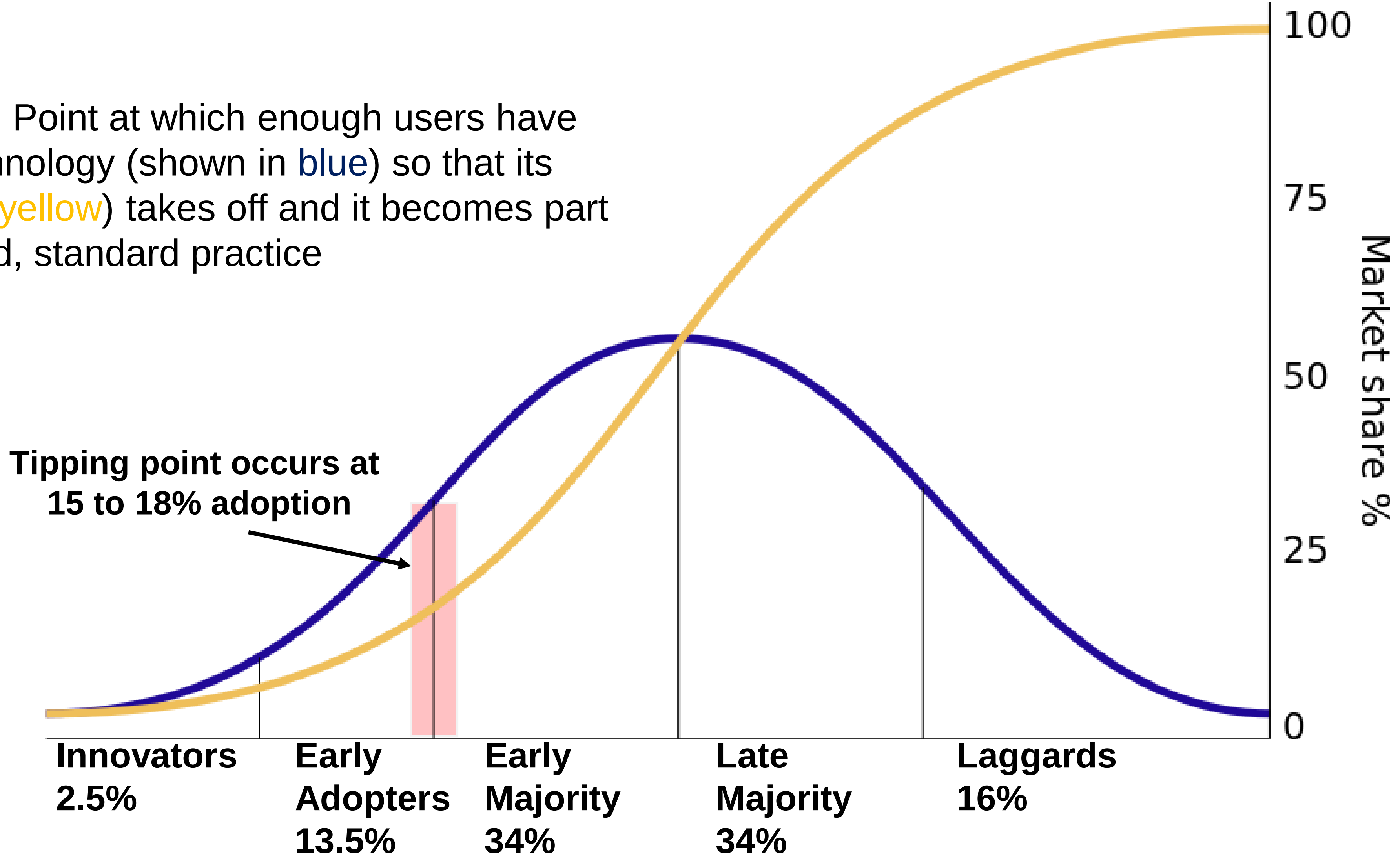


Source: Porter, M. E. (1980). Competitive Strategy: Techniques for Analyzing Industries and Competitors. New York: Free Press.

INTER-INDUSTRY COMPETITION REQUIRES A CRITICAL THREAT LEVEL

"Adoption Curve for Innovations" shows when reach a tipping point, the innovation is self-sustaining

Tipping point = Point at which enough users have adopted a technology (shown in blue) so that its use (shown in yellow) takes off and it becomes part of the accepted, standard practice



Source: Everett Rogers' *Diffusion of Innovations* (Rogers, 2003)
https://en.wikipedia.org/wiki/Diffusion_of_innovations

CEMEX

STEPS TO CREATE A PAVING PROGRAM WITH OPPORTUNITIES FOR INDUSTRIES TO COMPETE

Signals that the agency is serious about creating competition between industries

1. Transportation Agency announces their intention to have a concrete paving program
2. Agency adopts and uses all cement based / concrete solutions in multiple market applications
   - New Concrete, concrete overlays, RCC, reconstruction, interstates, state highways, rural roads, intersections, ramps
3. Agency purposely lets a given number of concrete projects each year and develops a Project Pipeline that covers several years
   - Programmatically designate approximately 15% of projects each year
4. Agency develops Technical Task Forces to address issues with specifications, design procedures, and other policy / design / construction issues
5. Use Life Cycle Cost Analysis and Alternate Pavement Bidding on Specific Pavement Projects

Only after agencies set the groundwork for an Inter-Industry Competitive Pavement Environment can LCCA and APB be used to lower costs even further on specific projects

AGENDA

How Competition can Impact Pavement Costs

Optimize & Develop Project Specific Designs

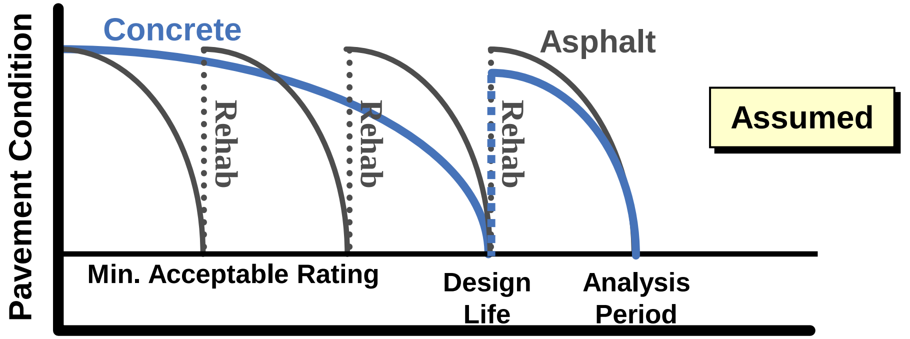
Level Material Specifications

CONCRETE PAVEMENTS HAVE HISTORICALLY BEEN “OVER-DESIGNED”

Which means their costs have been high

Pavements thicknesses & features are based on old design models (i.e. ASSHTO 93)

- **Concrete is assumed to last the design life, without rehabilitation**
- **Asphalt is designed with rehabilitation activities**
  - **Lower initial costs, but higher rehab. costs**



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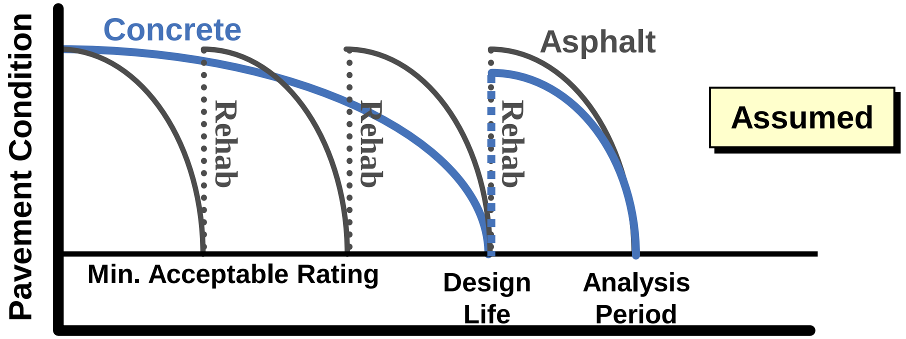
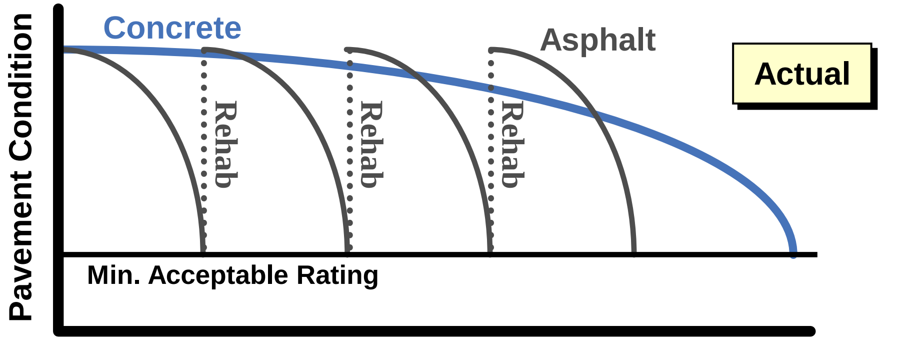


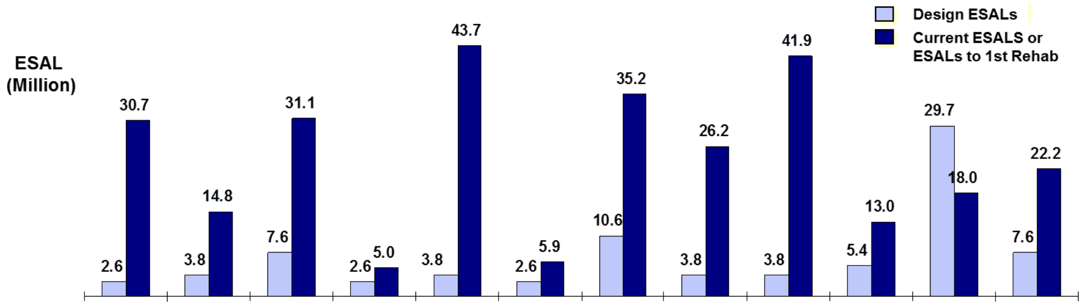
LTPP & other data shows that most concrete pavements have carried many more loads than for which they were designed

- **While increased performance is good, it comes at a cost that may be beyond the DOT's budget**



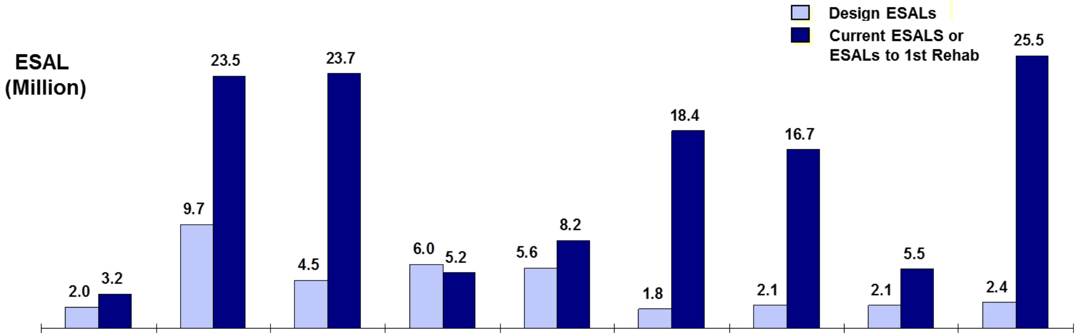
LTPP CONCRETE PAVEMENT TEST SECTIONS HAVE CARRIED MANY MORE TRUCKS THAN FOR WHAT THEY WERE DESIGNED

CALIFORNIA TEST SECTIONS (Avg ~ 5 times design traffic)



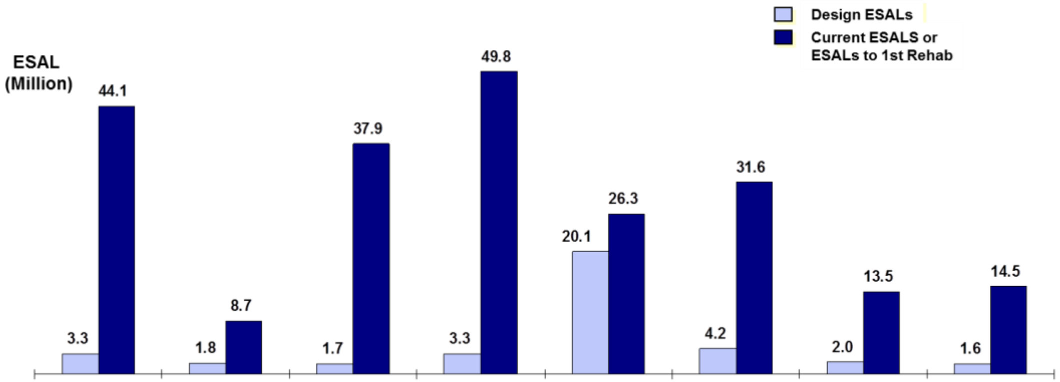
	I-5, Siskiyou County	I-15, San Diego County	I-15, Riverside County	Rte 2, Los Angeles County	I-15, Riverside County	I-8, San Diego County	I-15, Riverside County	I-5, Shasta County	I-5, San Joaquin County	I-5, San Joaquin County	I-5, San Joaquin County	I-15, San Diego County
Still Concrete	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Age at 1st Rehab	22	22						29		29	29	
Current Age	31	29	26	29	28	33	27	33	29			24

NORTH CAROLINA TEST SECTIONS (Avg ~ 10 times design traffic)



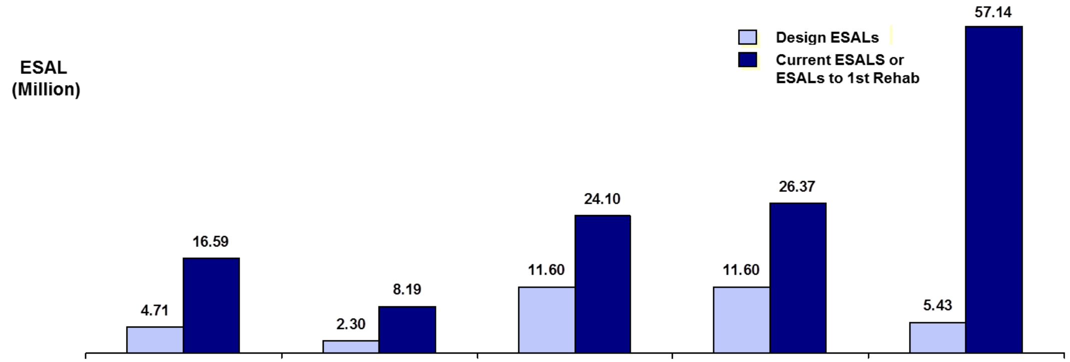
	US-74	I-95	I-85	US 52	SH-147	I-40	I-77	US 29	I-95 *
Still Concrete	No	Yes	No	Yes	Yes	Yes	No	No	No
Age at 1st Rehab	18		~29				27	30	33
Current Age	24	31	NA	27	34	35	31	35	NA

FLORIDA TEST SECTIONS (Avg ~ 9 times design traffic)



	I-95	SR 408	I-4	I-275	I-75	I-10	US 92	US 92 (2) *
Age at 1st Rehab	19	19	39		19	29		
Current Age	33	26	41	30	21	29	31	32

ALABAMA TEST SECTIONS (Avg ~ 2 to 10 times design traffic)



	I-59, Jefferson Cty (10" JPCP / 7" Agg)	I-20, Sumter Cty (8" CRCP / 5" Treat. Base)	I-59, Jefferson Cty (10.5" JRCP / 6" Agg)	I-59, Jefferson Cty (10.5" JRCP / 5.5" Agg)	I-20, Cleburne Cty (9"CRCP / 6" Treat. Base_
Concrete	No	No	Yes	No	Yes
Age at 1st Rehab	28 (CPR)	19 (AC)		25 (CPR)	
Age/Age at overlay	36	19	39	~30	33

CONCRETE PAVEMENTS HAVE HISTORICALLY BEEN "OVER-DESIGNED"

Which means their costs have been high

Pavements thicknesses & features are based on old design models (i.e. ASSHTO 93)

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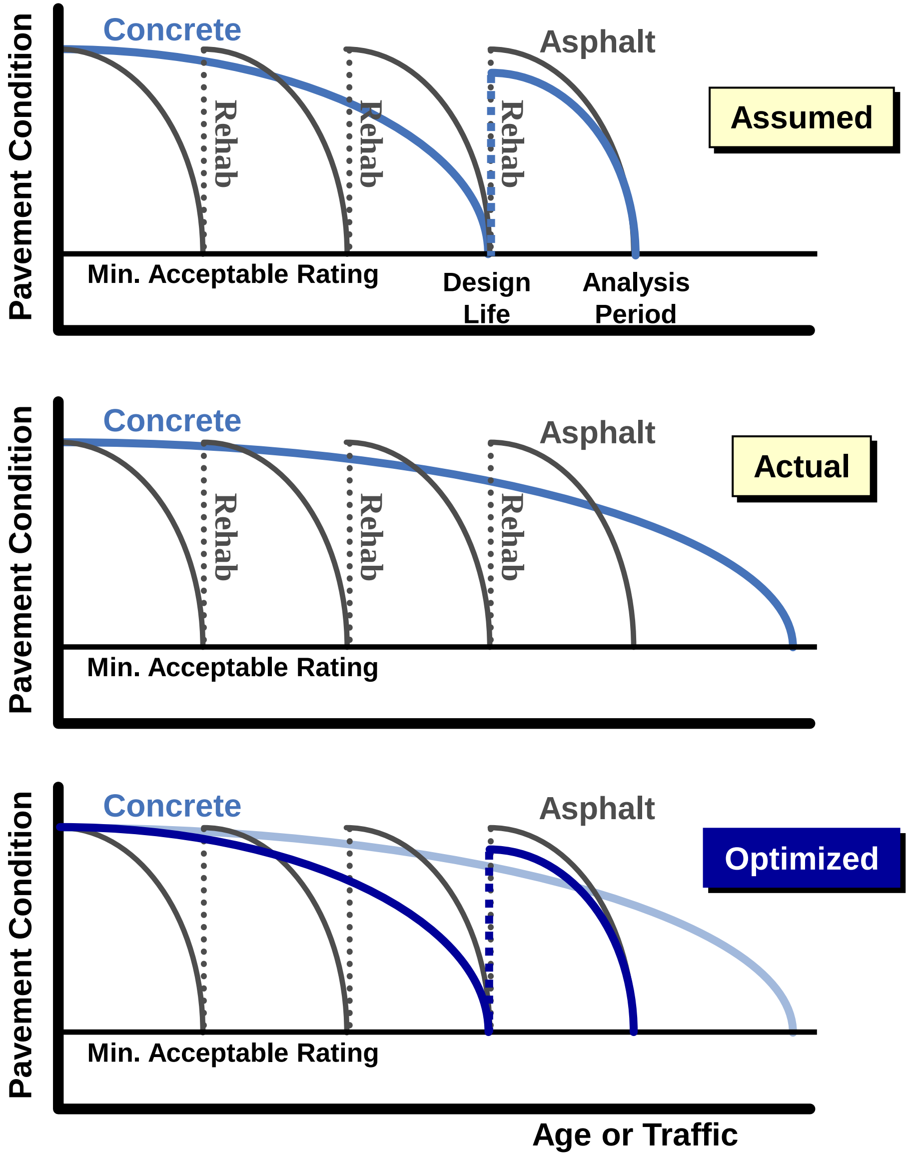
  - **Lower initial costs, but higher rehab. costs**

LTPP & other data shows that most concrete pavements have carried many more loads than for which they were designed

- **While increased performance is good, it comes at a cost that may be beyond the DOT's budget**

Optimizing designs uses newer models to match the pavement design life to the required performance life

- **Reduces the initial costs**
- **without sacrificing life cycle costs**



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TOOLS FOR OPTIMIZING DESIGNS FOR THE PAVEMENT SYSTEM

Optimizing designs balances the initial costs/impacts, life cycle costs/impacts & performance

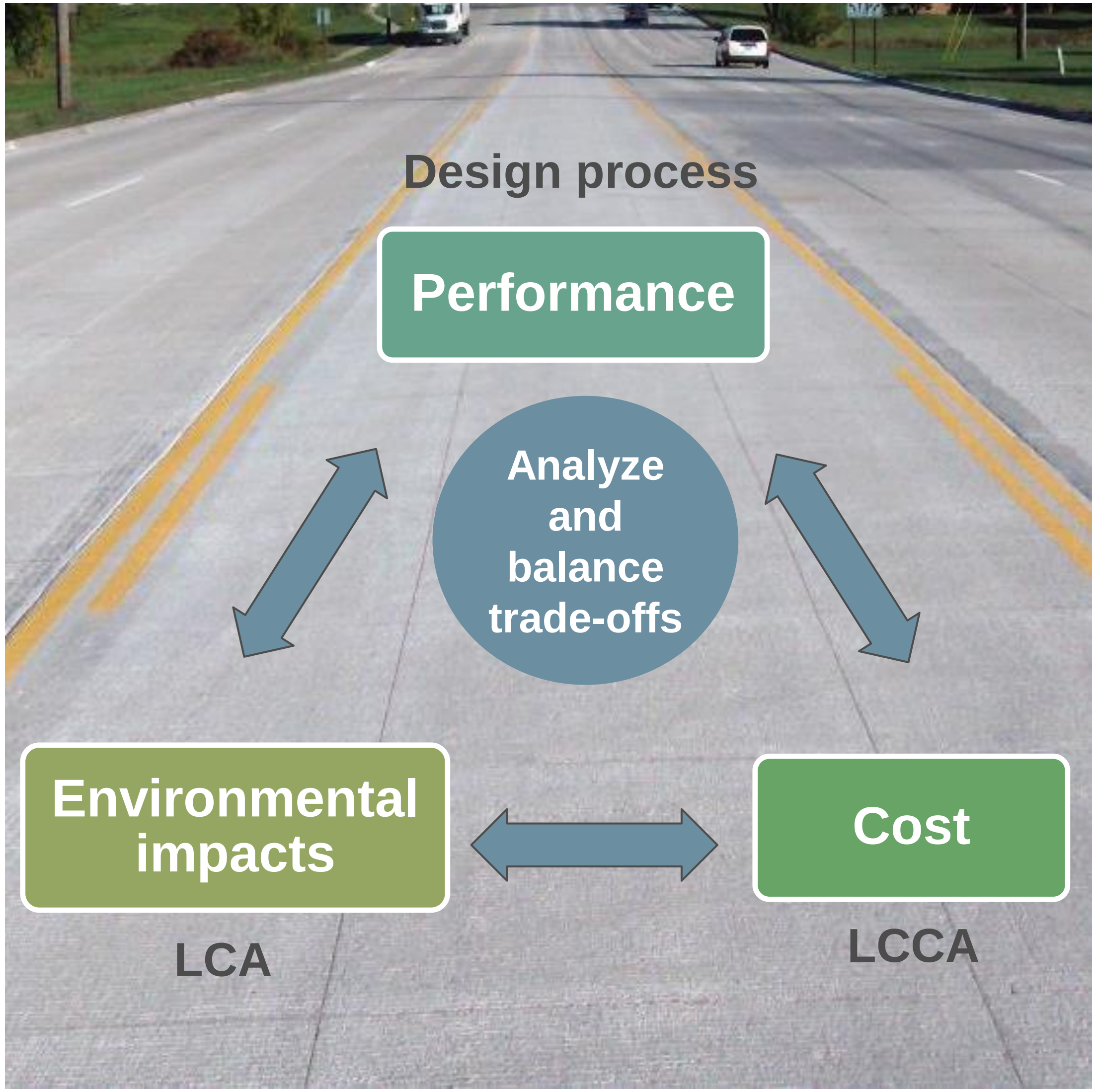
TOOLS

1. **AASHTO Pavement ME Design Procedure**
   Predicts pavement performance over the analysis period

2. **Life Cycle Cost Analysis (LCCA)**
   Determines which pavement design is most cost effective over the analysis period

3. **Life Cycle Assessment (LCA)**
   Determines which pavement design is most “sustainable” over the analysis period

Pavement ME tells how different pavements will perform & the LCCA / LCA helps designers make trade-offs to find cost-effective & environmentally responsible designs



PAVEMENT ME IS THE MOST ADVANCED DESIGN PROCEDURE

Covers a wide range of applications, including nearly all new & rehabilitation options

Can account for new and diverse materials and various failure mechanisms

State-of-the practice design procedure based on advanced models & actual field data collected across the US and Canada

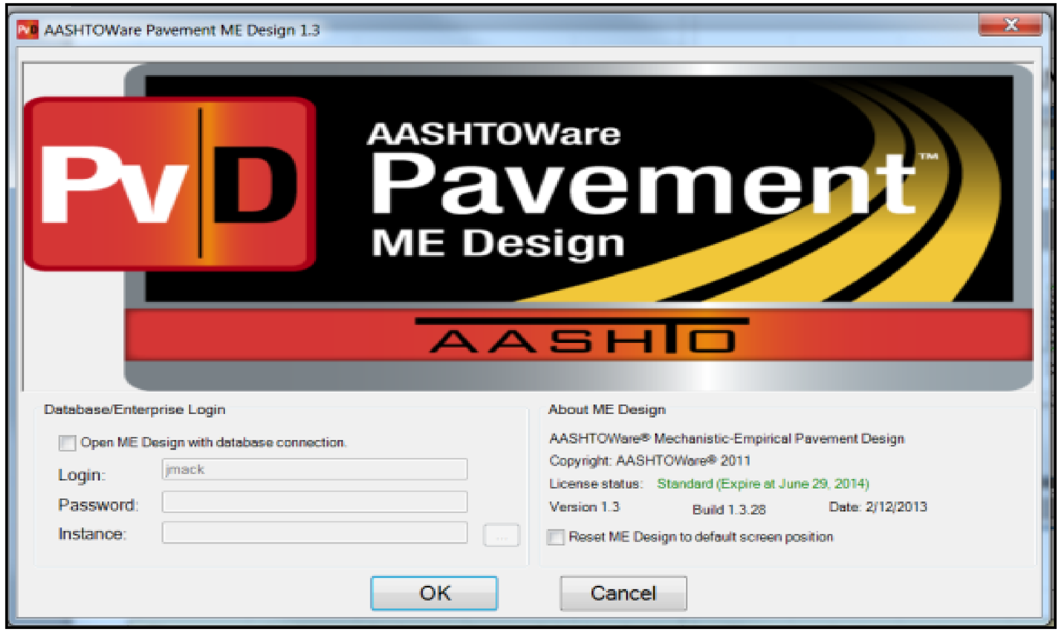
- **Adopted by AASHTO in 2011**
- **Calibrated to more than 2,400 asphalt & concrete pavement test sections, ranging in ages up to ~40+ years**

Based on mechanistic-empirical principles that account for site specific:

- **Traffic**
- **Climate**
- **Materials**
- **Proposed structure (layer thicknesses and features)**

Provides estimates of performance during the analysis period

- **Can match rehabilitation activities to performance**



New Pavement

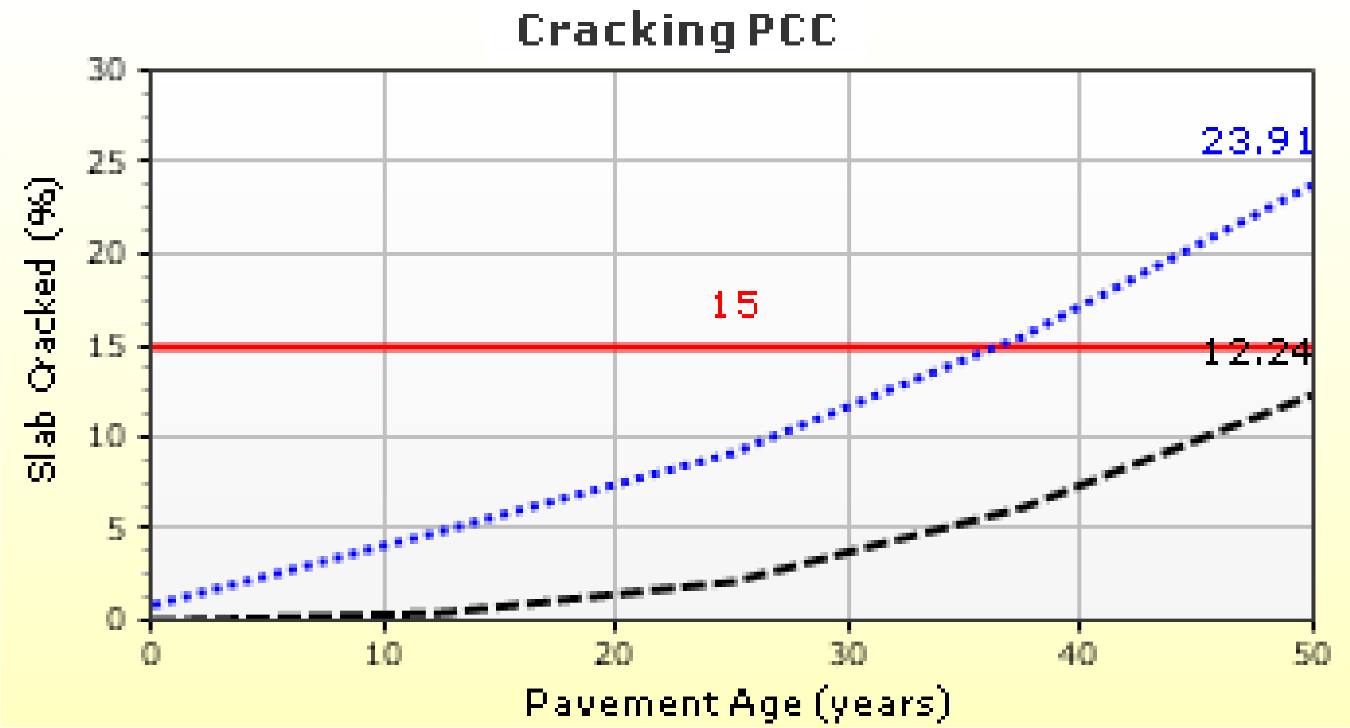
- **Asphalt Concrete (AC)**
- **Jointed Plain Concrete Pavement (JPCP)**
- **Continuously Reinforced Concrete Pavement (CRCP)**

Overlays & Restoration

- **AC over AC**
- **AC over JPCP / CRCP (w/ & w/o fracture)**
- **Bonded PCC over JPCP / CRCP**
- **Unbound PCC over JPCP / CRCP**
- **JPCP /CRCP over AC**
- **JPCP Restoration**

PAVEMENT ME DEFINES A SPECIFIC PAVEMENT'S PERFORMANCE

Predicting performance for key distresses allows for trade-off comparisons using Life Cycle Analysis



Red Line – **Predefined Distress Threshold Value. When major rehabilitation is needed (i.e. patching & DG or overlay).**

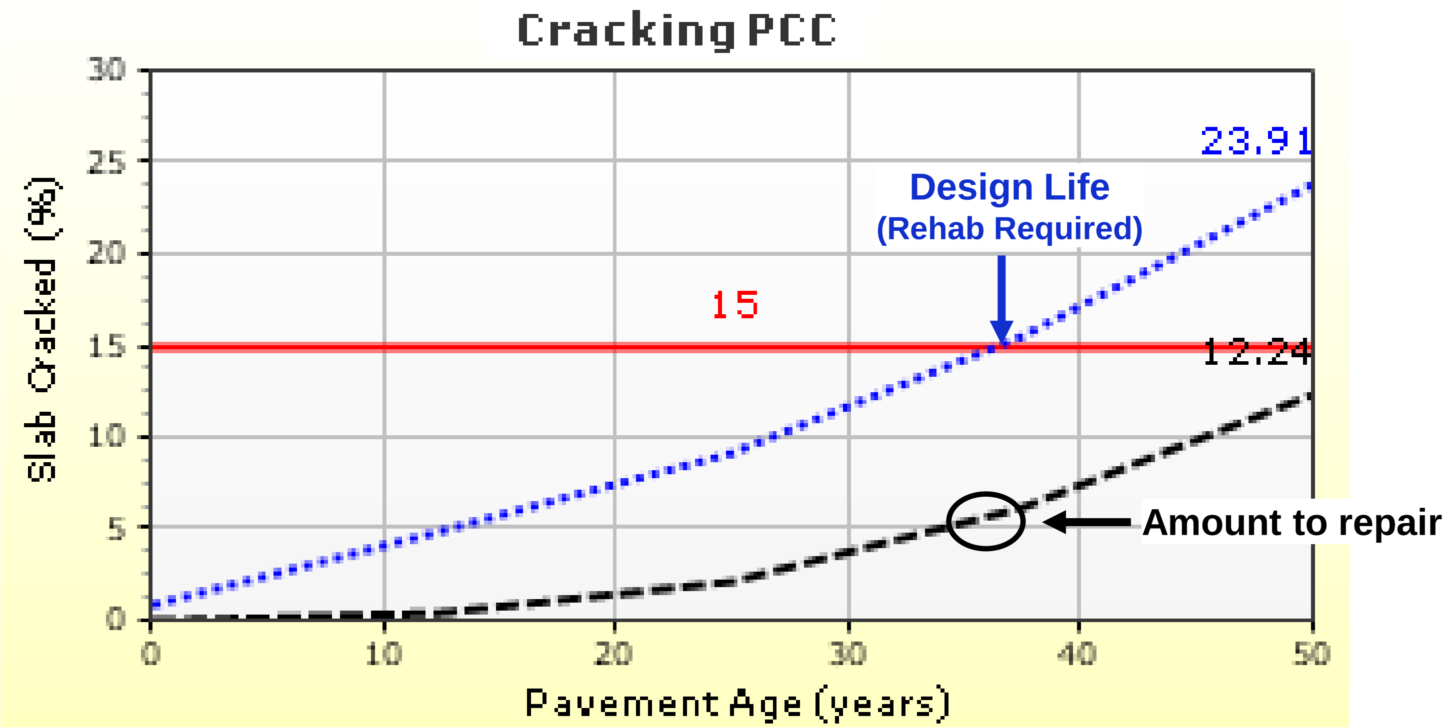
Black Dashed Line - The 50% Reliability (most likely) level of distresses predicted

Blue Dotted Line - The predicted distresses at the Specified Reliability Level (i.e. 90%). Designs are based on when this line hits the defined distress limit

Design life is when the Blue Reliability curve hits red Predefined Threshold Value (~33 years in this case)

PAVEMENT ME DEFINES A SPECIFIC PAVEMENT'S PERFORMANCE

Predicting performance for key distresses allows for trade-off comparisons using Life Cycle Analysis



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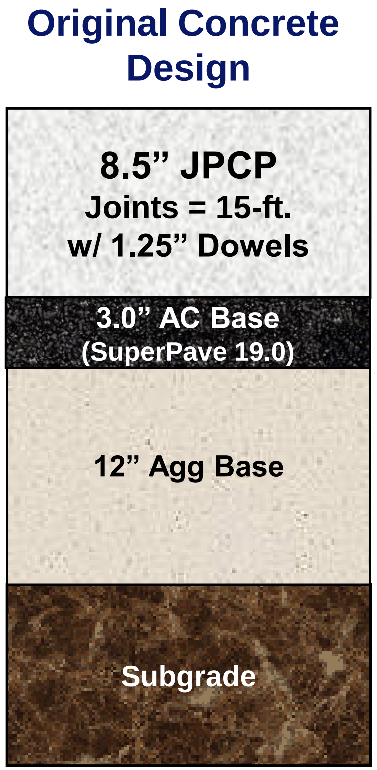
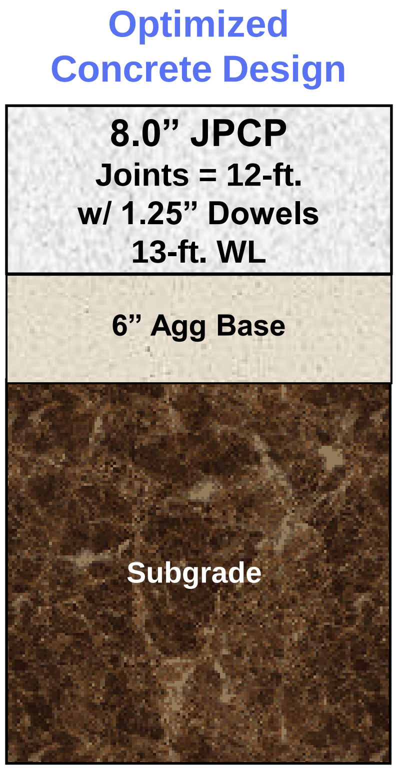
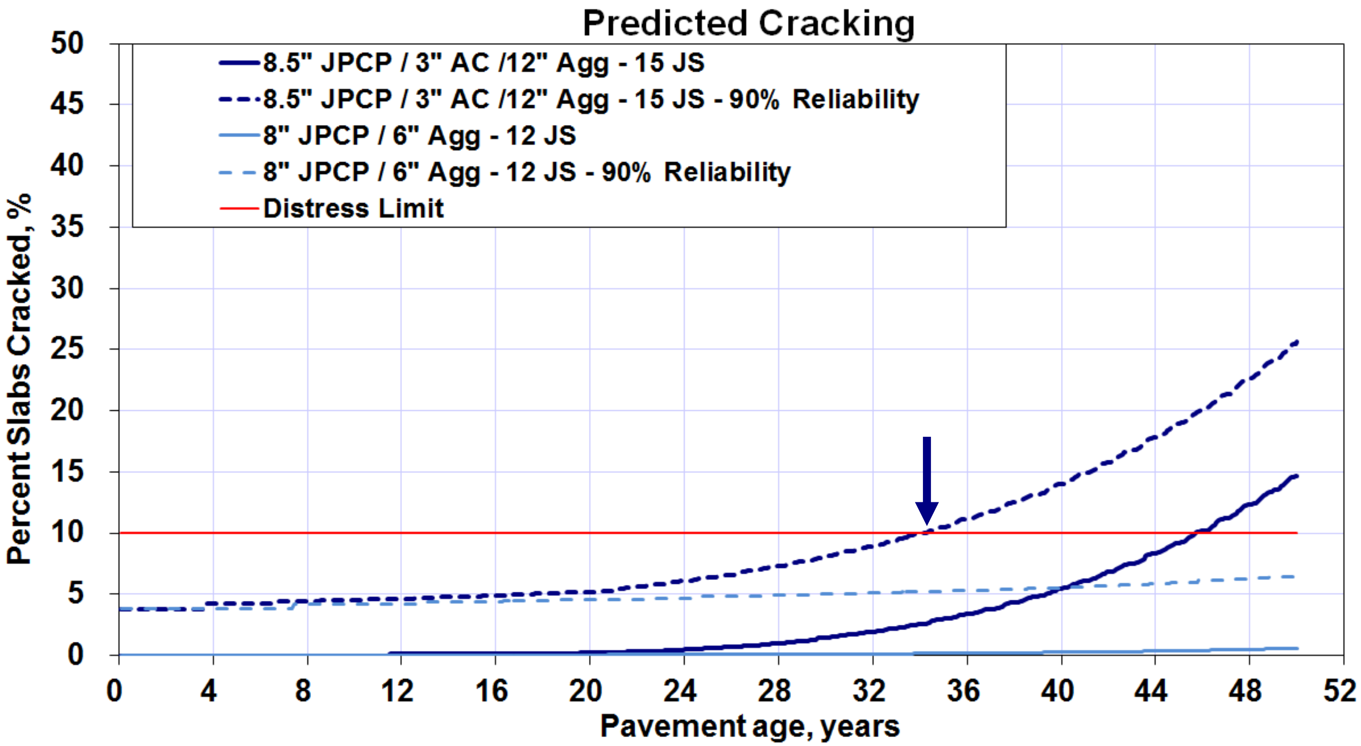
CEMEX

PAVEMENT ME ALLOWS FOR COMPARISONS OF DIFFERENT DESIGNS



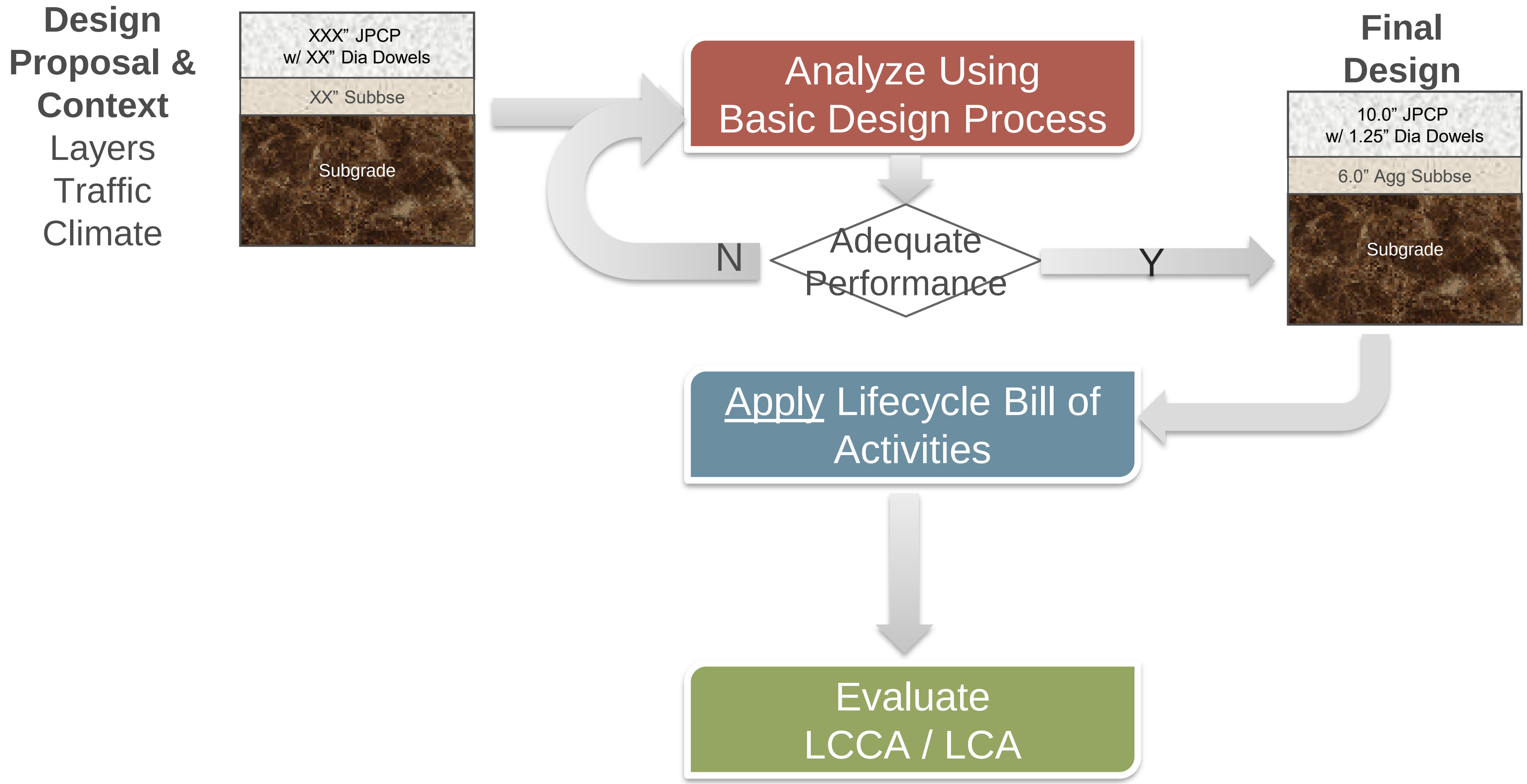




While both pavements perform well, optimizing improved performance by addressing the cause of cracking
Pavement ME gives a repeatable, un-biased process that shows how a specific pavement design will perform

CURRENTLY DESIGN IS DONE IN A “STATIC” MODE

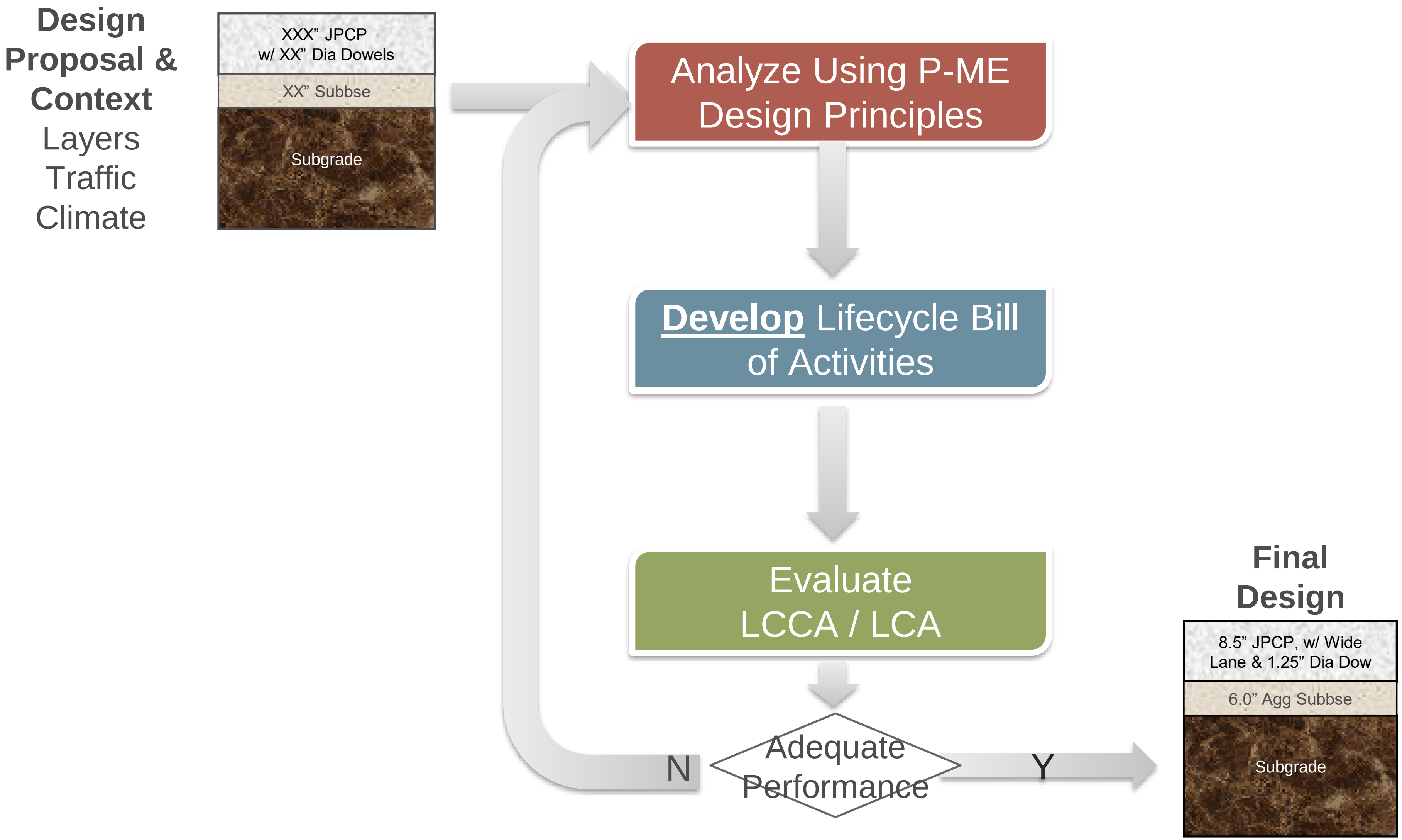
Designs are developed and then compared to select the final pavement design



Doing a LCCA/LCA at the end misses opportunities to make design changes

TO IMPROVE THE PAVEMENT DESIGNS

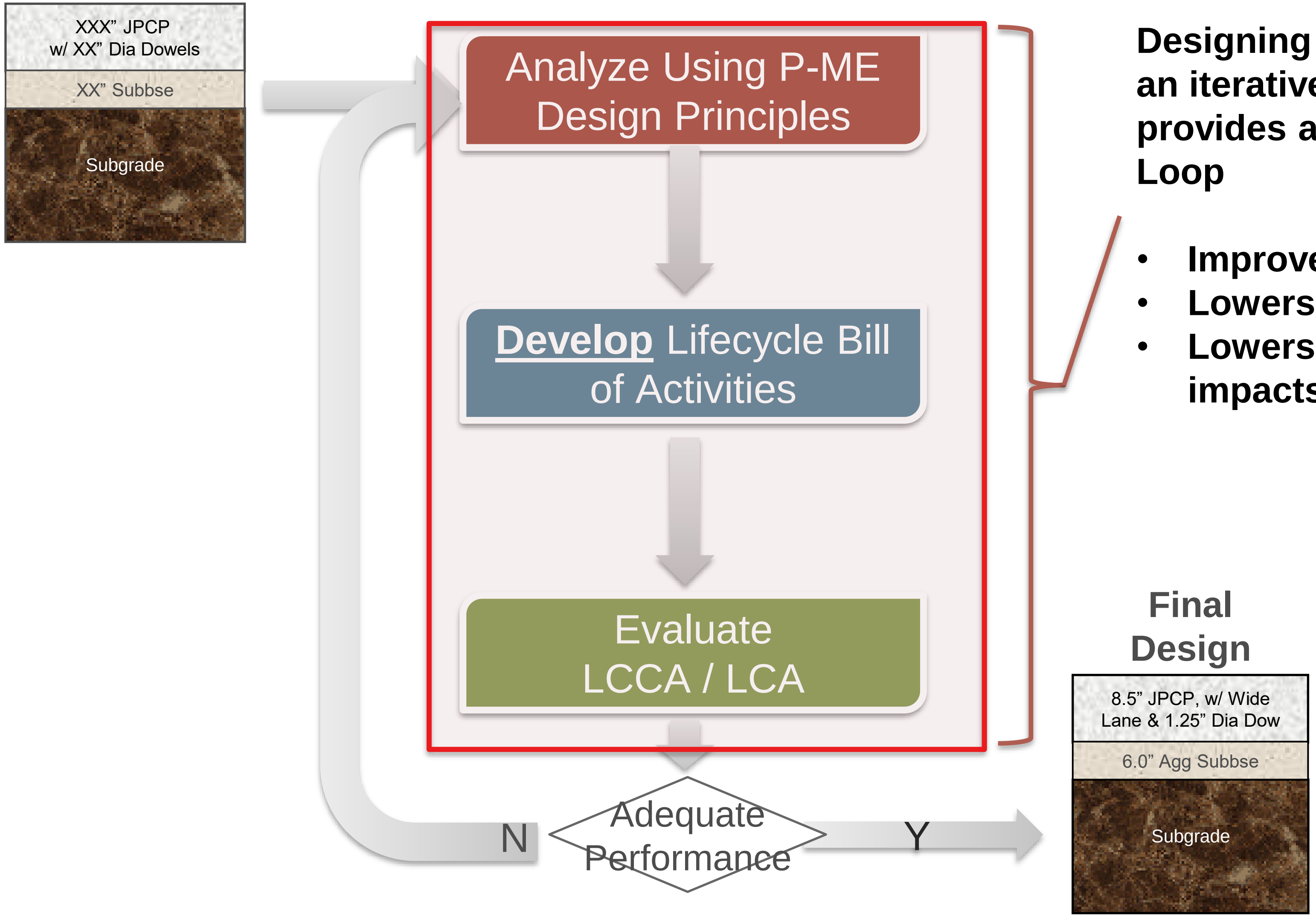
Need to create a link between Design and Evaluation in an iterative design process



TO IMPROVE THE PAVEMENT DESIGNS

Need to create a link between Design and Evaluation in an iterative design process

Design Proposal & Context
Layers
Traffic
Climate



Designing pavements in an iterative procedure provides a Feedback Loop

- **Improves performance**
- **Lowers cost**
- **Lowers environmental impacts**

Slide: Courtesy of MIT Concrete Sustainability Hub

CEMEX

DESIGN IMPROVEMENTS FOR CONCRETE PAVEMENTS

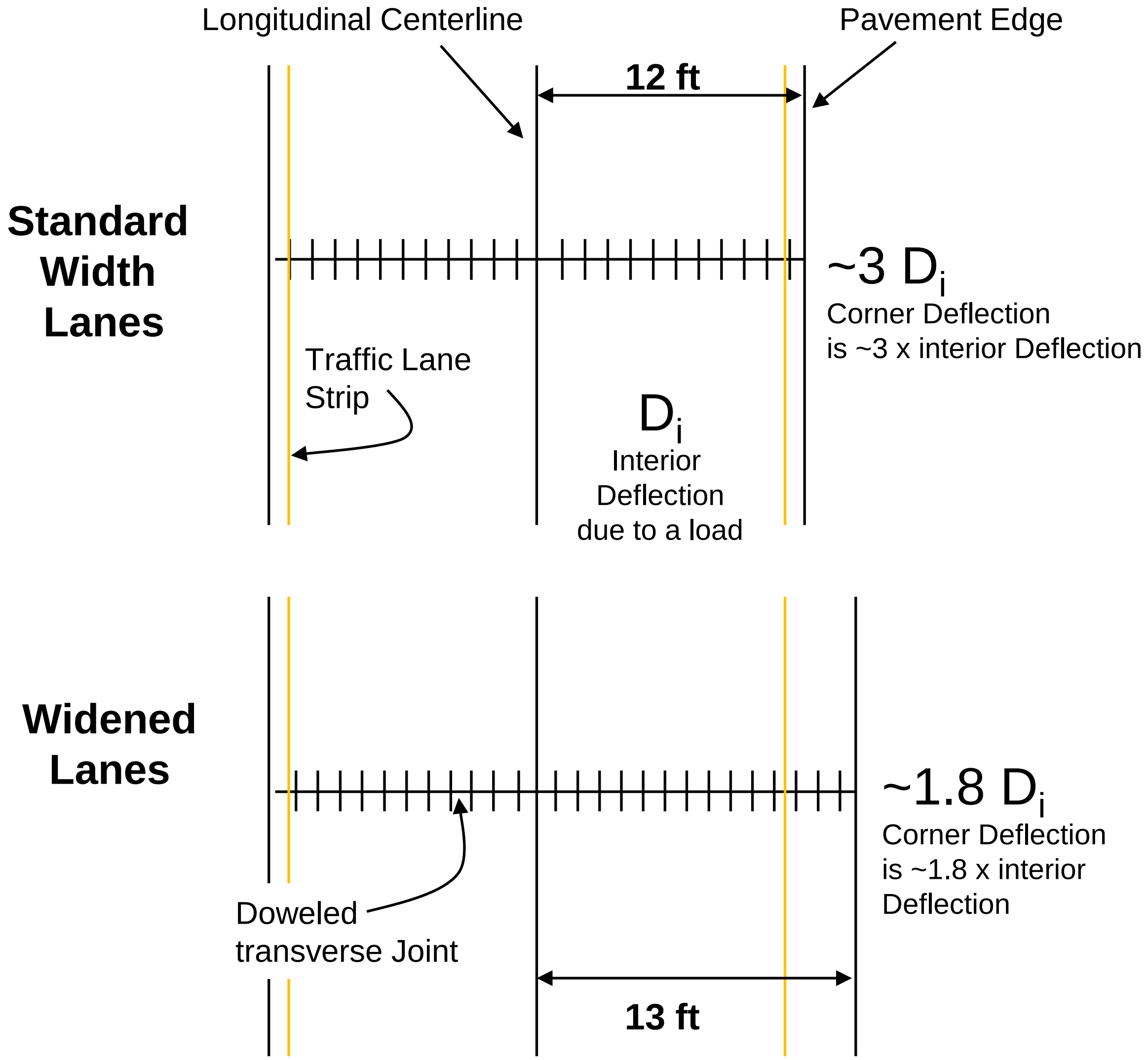
Each Design Feature must balance Performance and Cost (both initial & long term)

Feature	Benefit or Options
Optimize Thickness	Reduces overdesign, lowers costs and environmental impact
Shorten Joint Spacing	Reduces curling & warping stresses (reduces thickness but does increase joint sawing and dowel costs)
Use 13-ft Widened Outside Lanes	Shifts loading to "interior loading" (reduces thickness)
Use Dowels / Increase Dowel Size	Increases load transfer, reduces bearing stress reduces faulting
Change Shoulder Design	Tied Concrete vs AC vs RCC; reduced /tapered thickness; no dowels; different mix, etc. (improves edge support)
Optimized aggregate gradation	Reduces cement content, creates denser mix, less shrinkage
Use different concrete mixes	Mainline vs shoulder mixes, 2-layer construction
Change base type	Granular vs asphalt treated vs cement treated, reduce thickness, dense graded vs permeable; subgrade / chemical stabilization
Use single 1/8"-wide single saw cut and filled (not sealed)	Removes second sawing operation and reduces noise
Use Longitudinal tining or Next Generation Concrete Surface (NGCS)	Reduces noise, NGCS improves initial smoothness

"Features" an have a significant impact on performance & cost

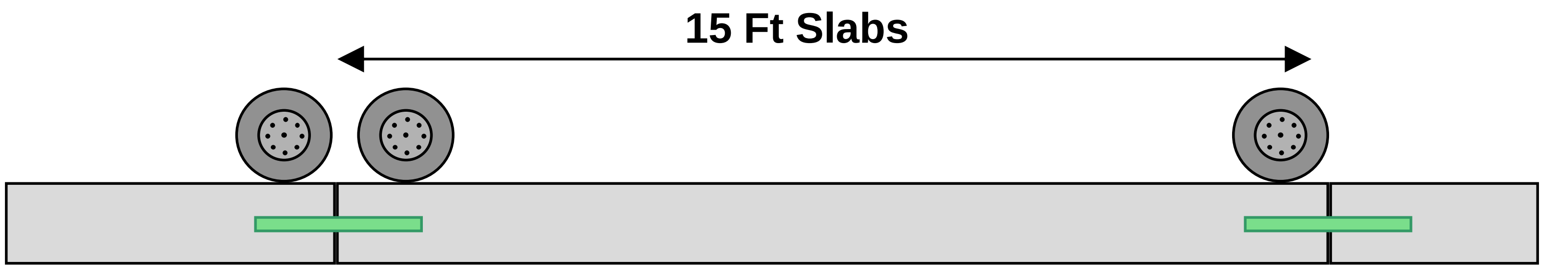
WIDENED LANES SHIFTS TRAFFIC AWAY FROM EDGE

Lowers Deflections And Stresses at the Edge

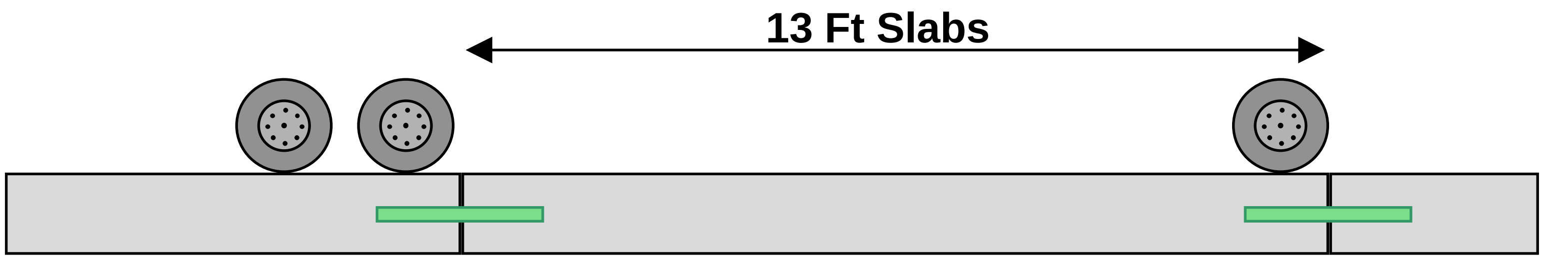


A 13-foot WL adds no costs if using a Concrete Shoulder
If using a Full Depth Asp Shoulder, costs ~ 0.60% more
(Pavement + Shoulder Costs)

SHORTER JOINT SPACING REDUCES WHEEL LOAD STRESSES



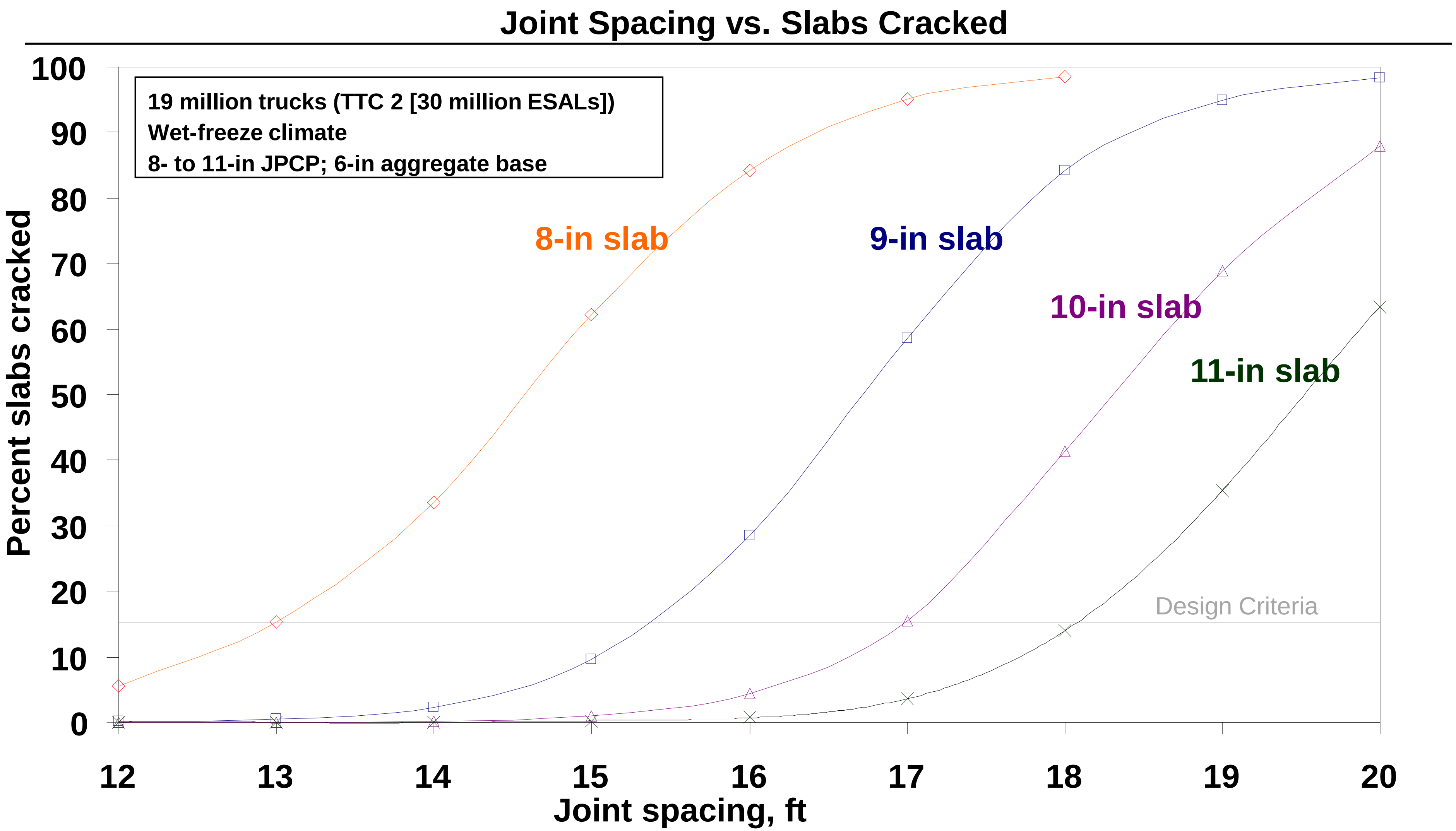
Loading the slab at each end creates additional top down stresses and causes earlier top down cracking



Reducing slab length means only one end is loaded by an axle, which reduces top down stresses and extends life

Each foot of reduced Joint spacing adds ~ 0.40% to Mainline Pavement/Shoulder Costs
Approximately equal to 1/8 to 1/4-inch of Concrete

SHORT JOINT SPACING (& WIDENED LANES) ALLOWS FOR THINNER SLABS TO BE USED MAKING CONCRETE MORE COST EFFECTIVE



1-inch of Concrete is ~4.5% Reduction of Mainline Pavement / Shoulder Costs

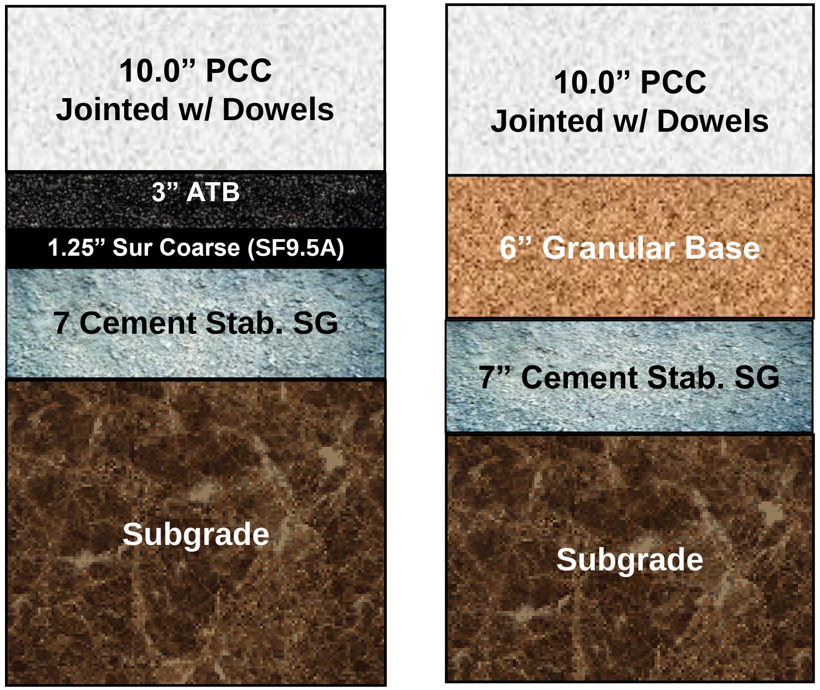
Graph Developed by Tommy E. Nantung
INDOT Office of Research and Development

WHETHER TO ADD FEATURES SHOULD BE BASED ON ITS COST / BENEFIT

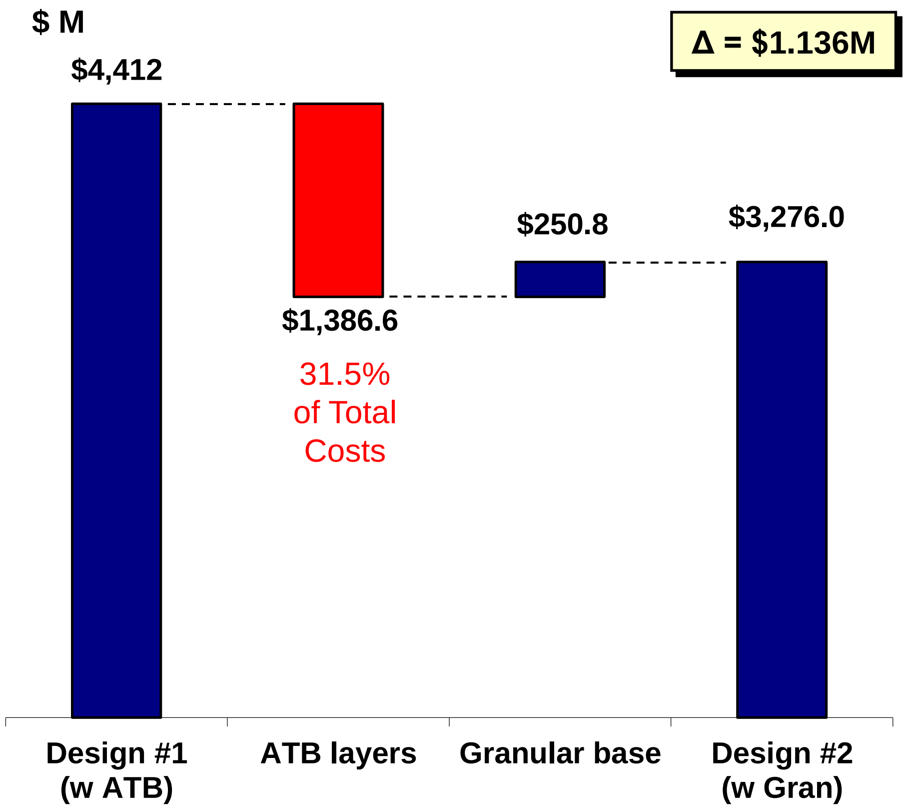
If they extend life long enough to cover its NPV, it should be used

Design #1
(with ATB Base)

Design #2
(6" Granular Base)



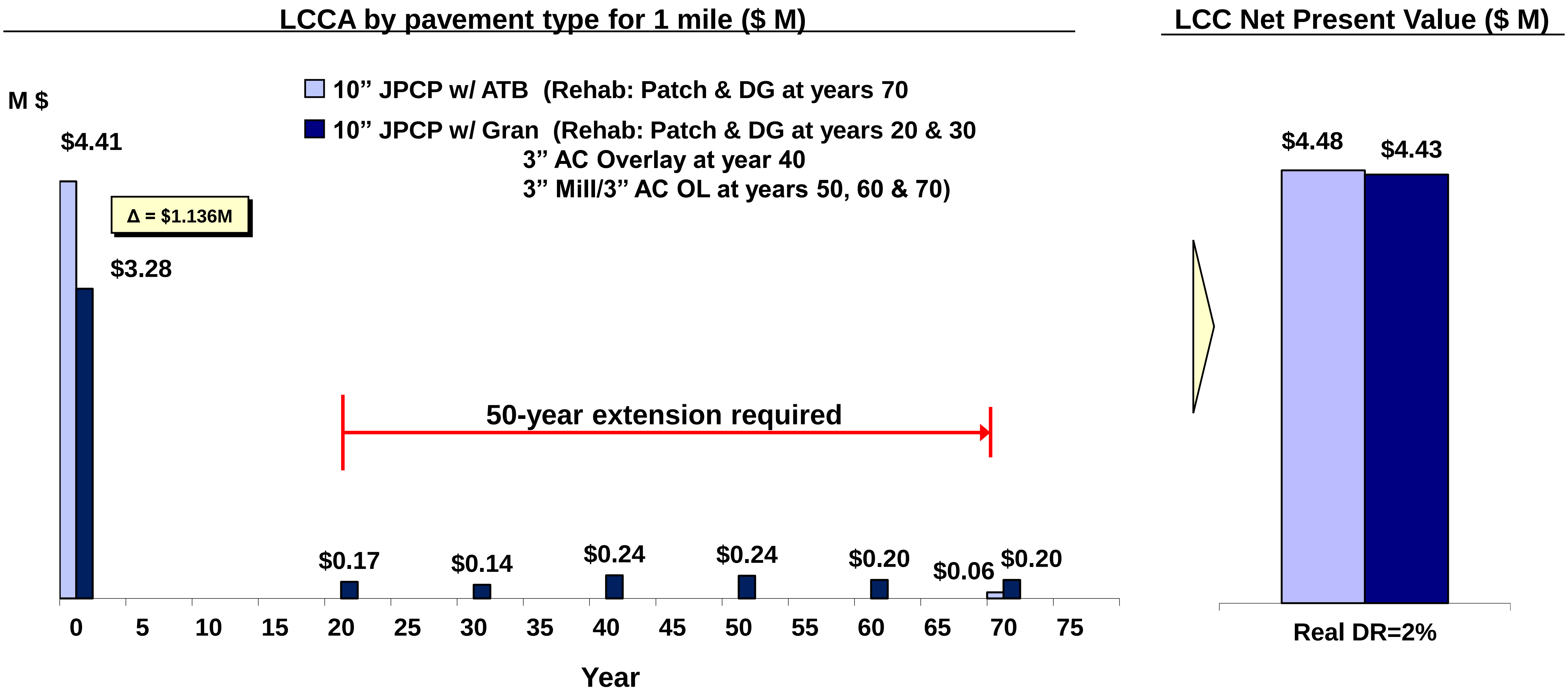
Component Cost for 1 mile of 4 lane pavement + Shoulder



For the ATB layer to be effective it must extend the pavements life to overcome <u>$1.136M</u> initial cost differential

THE PAVEMENT W/ ATB MUST LAST 70 YEARS BEFORE FIRST REHAB.

Based on an equivalent Life Cycle Costs comparison



Initial costs - Pavement, base, and subgrade stabilization materials and labor

Rehab costs also include other Incidental Costs (striping, mob, etc) - Assumed to be 1%, Traffic Control – 3%, & Engineering & Inspection - 2% of material cost each

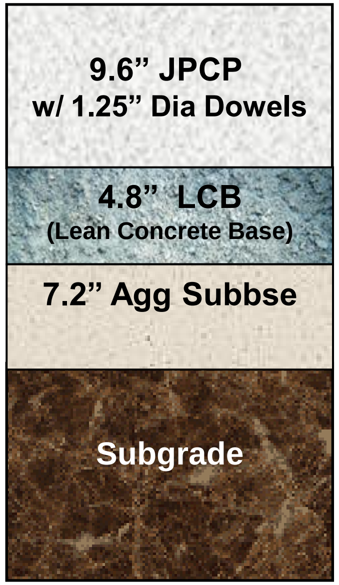
ROUTE 67 IN RAMONA, CA

Falls within the *South Coast* CALTRANS climatic region

Route 67 in Ramona, CA (at Route 78 junction)

- Moderate volume road:
- 35-mph urban road
- 2 lanes in each direction (+ middle turn lane)
- 2 inner/2 outer shoulders
- Daily traffic: 23,400 (ADTT = 1,357)
- Initial ESAL = 335,000 / year
- 20-year Design Life / 55-year Analysis Period

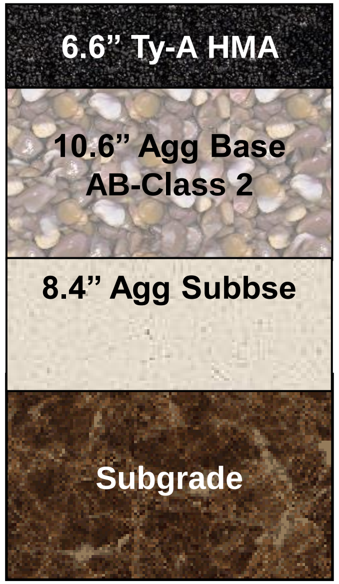
CALTRANS Concrete Design



JPCP new construction:
Design life = 20-years,
Maintenance Level = 1,2,3

- 2% Patch & DG at year 25,
- 4% Patch & DG at year 30
- 6% Patch & DG at year 40
- 3" Asphalt overlay in year 45 (10-year life)

CALTRANS Asphalt Design



HMA new construction:
Design life = 20-years,
Maintenance Level = 1,2

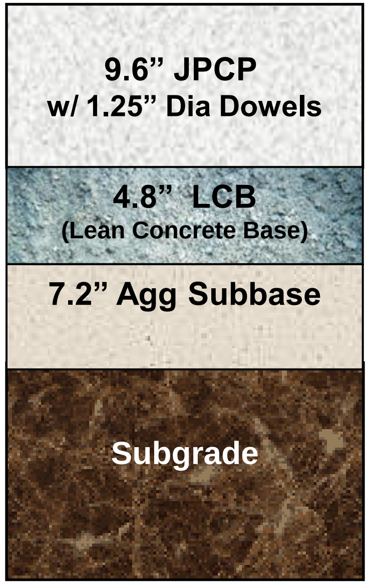
- 3” AC Overlay in years 20,
- Mill / 4" ACOL in year 25
- Mill / 3" ACOL in year 35
- Mill / 4" ACOL in year 45
- Mill / 3" ACOL in year 50 (5-year life)

Highway Design Manual 6th Ed. Sacramento: California Department of Transportation, CALTRANS, 2010.
Life-Cycle Cost Analysis Procedures Manual. Sacramento, CA: California Department of Transportation, CALTRANS, 2010.

ESTIMATED COST / GWP FOR STANDARD CALTRANS PAVEMENT DESIGNS

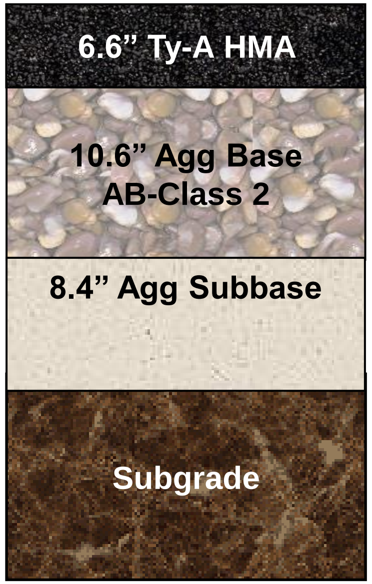
Route 67 - Ramona, CA

CALTRANS Concrete Design



	LCCA (NPV $/mile)	LCA (tons CO_2e/mile)
Initial Const.	**$3,147,585**	**3,954**
Pavement	*$2,229,803*	*2,860*
LCB	*$644,902*	*781*
Agg Subbase	*$272,880*	*313*
Rehabilitation	**$911,663**	**479**
Carbonation		**(123)**
PVI-Deflection		**604**
PVI-Roughness		**1,912**
Total	**$4,059,248**	**6,826**

CALTRANS Asphalt Design



	LCCA (NPV $/mile)
Initial Const.	**$2,278,102**
Pavement	*$1,437,480*
AB-Class 2	*$522,262*
Agg Subbase	*$318,360*
Rehabilitation	**$1,104,504**
Total	**$3,382,606**

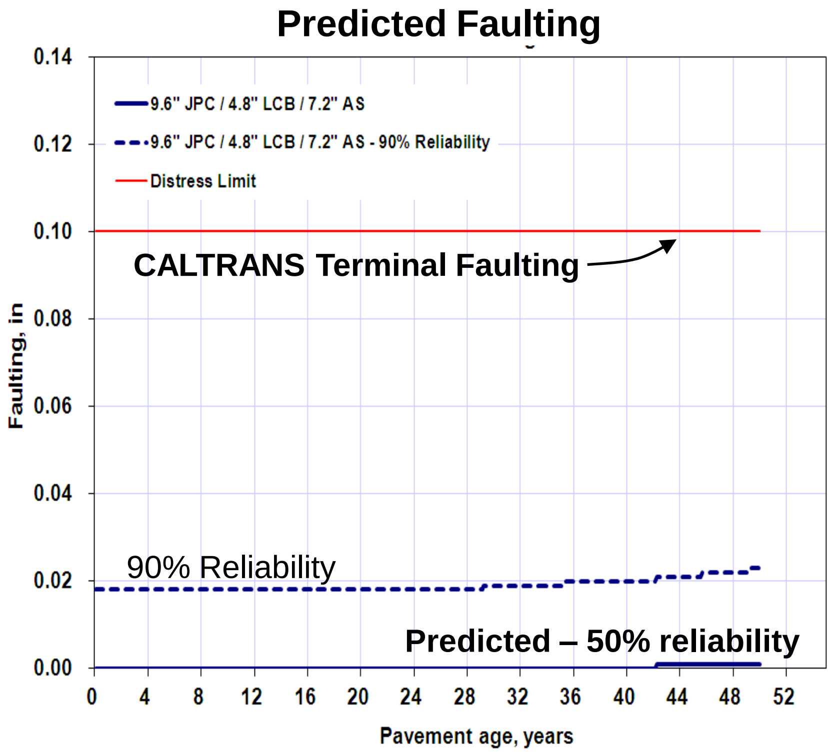
Asphalt is 38% lower in Initial Costs and 20% lower in Life Cycle Costs

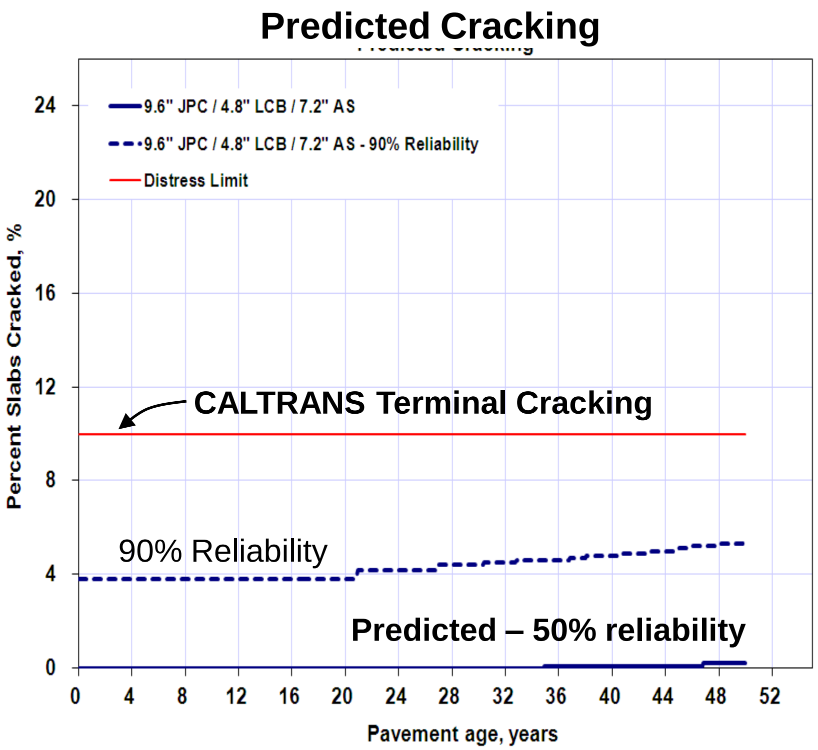
Caltrans Concrete Design: From Table 623.1E (South Coast/Central Coast, Type II SG
Initial AADTT = 1,357 / day, 4% Compound Growth (Initial ESAL = 335,000 / yr)
20 Yr ESALs = 10,650,000; 50 Yr ESALS = 51,151,000

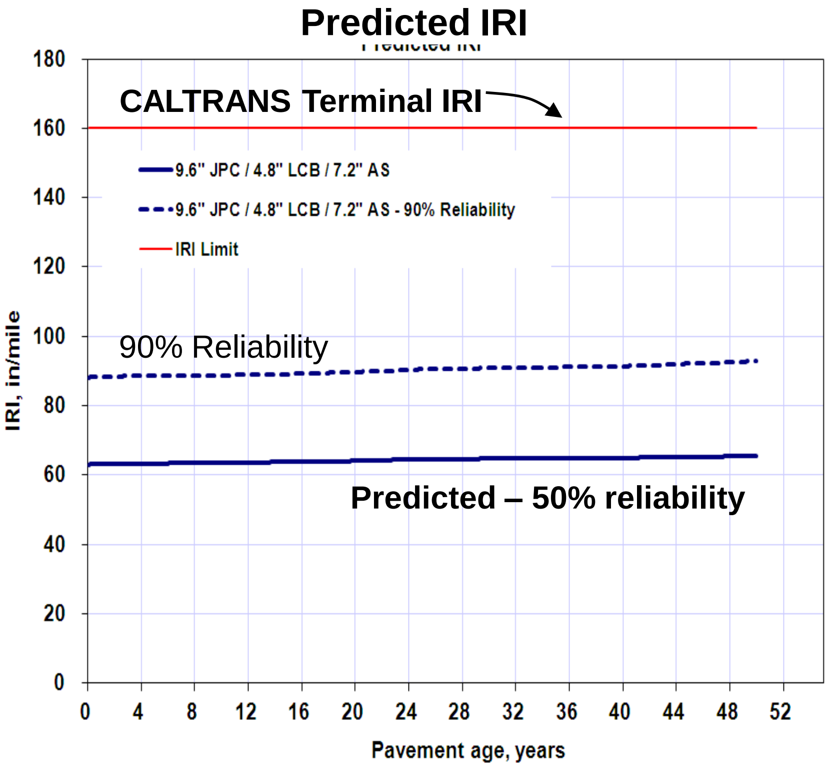
CEMEX

ROUTE 67 PAVEMENT-ME PREDICTED PERFORMANCE IS HIGH

Faulting, Cracking, & IRI are well below terminal levels for the entire analysis period







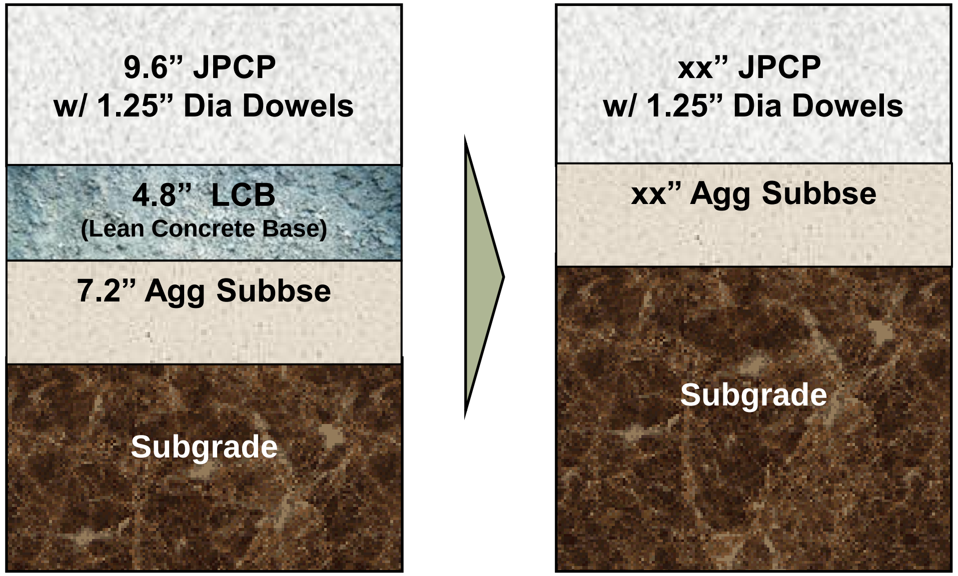
Pavement is over-designed because it does not need rehabilitation for the entire 50-year analysis period

Creates the opportunity for project specific optimization

OVER-DESIGN CREATES THE OPPORTUNITY FOR OPTIMIZATION

Each design feature needs need to balance performance, cost & environmental impact

CALTRANS Concrete Design | **Optimized Concrete Design**



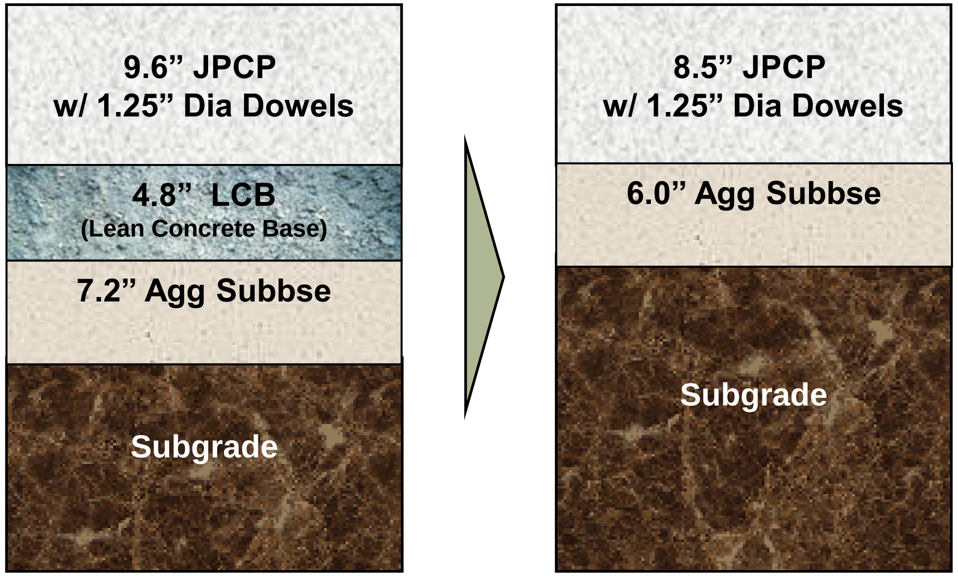
Features Evaluated

- Iterated Concrete Thickness
  - 9.0”
  - 8.5”
  - 8.0
- Removed 4.8” Lean Concrete Base
  - Accounts for 20% of the initial construction costs & GWP
  - Performance history shows that aggregate bases have worked in similar applications
- Iterated Aggregate base thickness
- Develop rehabilitation activities based on Pavement-ME distresses

OVER-DESIGN CREATES THE OPPORTUNITY FOR OPTIMIZATION

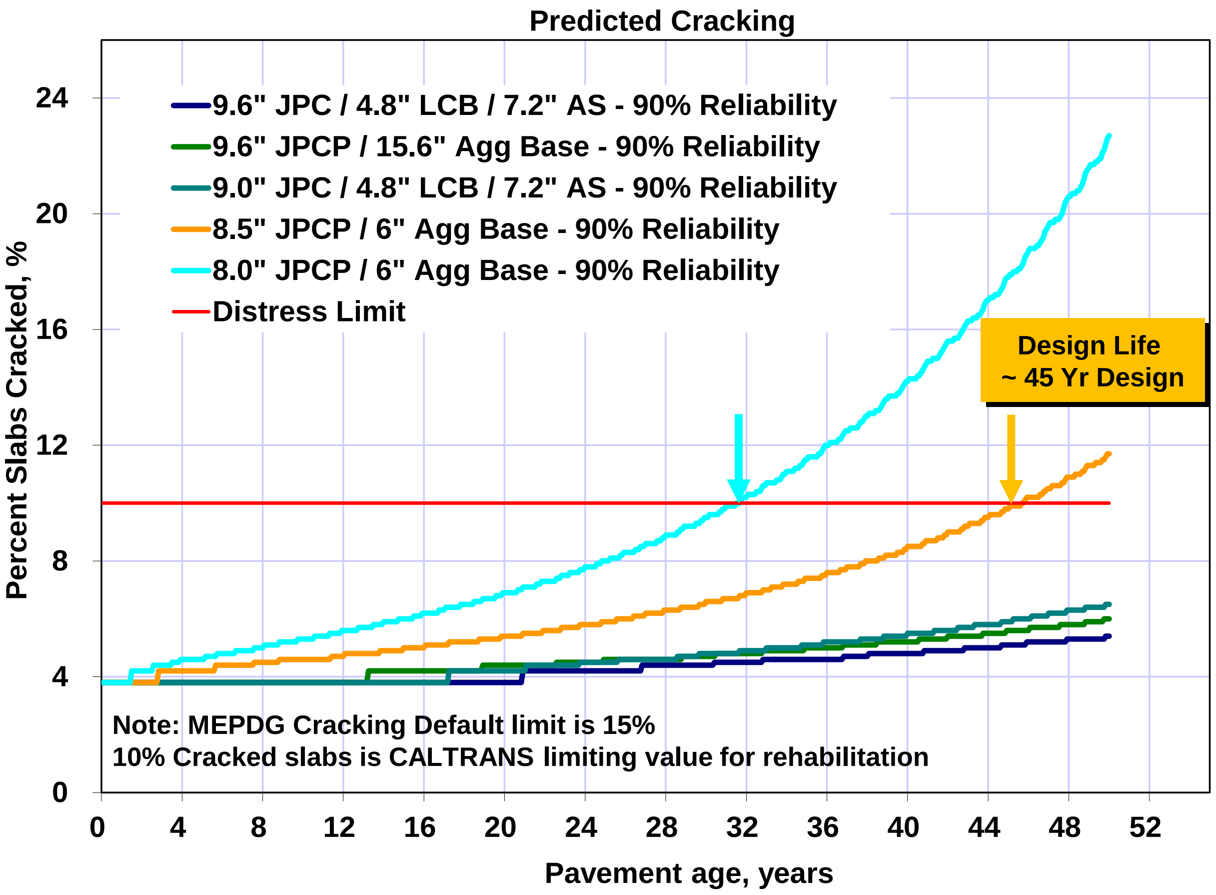
Each design feature needs need to balance performance, cost & environmental impact

CALTRANS Concrete Design | **Optimized Concrete Design**



Optimization does not mean choosing the Thinnest (cheapest) Pavement
Its about selecting the most Effective

Pavement-ME Predicted Performance

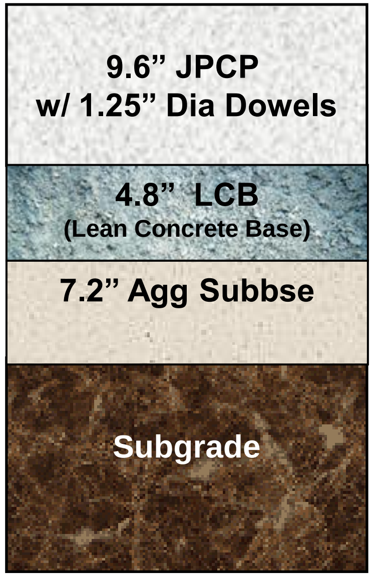


Arrows indicate year of predicted 1st rehabilitation for that given pavement

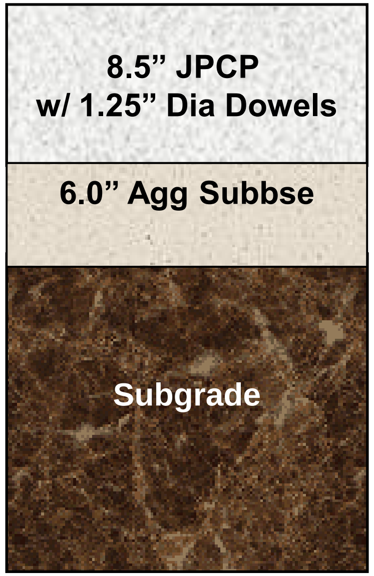
CEMEX

PROJECT SPECIFIC PAVEMENT OPTIMIZATION LOWERS COST & GWP

CALTRANS Concrete Design



Optimized Concrete Design



	Original CALTRANS Schedule		Optimized Pavement-ME Design	
	LCCA (NPV $)	LCA (tons CO_2e)	LCCA (NPV $)	LCA (tons CO_2e)
Initial Const.	**$3,147,585**	**3,954**	**$2,256,638**	**3,063**
Pavement	*$2,229,803*	*2,860*	*$2,021,307*	*2,803*
LCB	*$644,902*	*781*	*--*	*--*
Agg Subbase	*$272,880*	*313*	*$235,331*	*260*
Rehabilitation	**$911,663**	**479**	**$315,798**	**54**
Carbonation		**(123)**		**(87)**
PVI-Deflection		**604**		**704**
PVI-Roughness		**1,912**		**2,110**
Total	**$4,059,248**	**6,826**	**$2,572,437**	**5,844**

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

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

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

CEMEX

AGENDA

How Competition can Impact Pavement Costs

Optimize & Develop Project Specific Designs

Level Material Specifications

DIFFERENCES IN MATERIAL QUANTITY SPECIFICATIONS IMPACT COSTS

	Concrete	Asphalt

Bid and Payment Basis	• Concrete is bid and paid for by the Square Yard (SY)
	  • SY based on construction plans
		• Asphalt is bid and paid for by the Ton
		  • Tons based "Batch Tickets"
		  • for the "actual number of tons … incorporated into the … accepted work"

Thickness Requirements	• Thickness and depth check for every payment lot
	  • Penalty if concrete pavement thickness is low [1]
	  • Contractors place ~½-in thicker to avoid penalty
		• Batch ticket tonnage is compared to required tonnage
		  • If match, it is assumed asphalt is placed at the correct thickness
		• No depth checks or penalties

Placement Requirements	• Subgrade & base must be prepared using automatically controlled grading and paving equipment <u>meeting</u> the lines, grades and cross sections <u>required</u> by the plans • Tolerance = ± 1/4 inch	• Place material "in <u>reasonably close conformity</u> with the lines, grades, thickness … shown on the plans"[2]

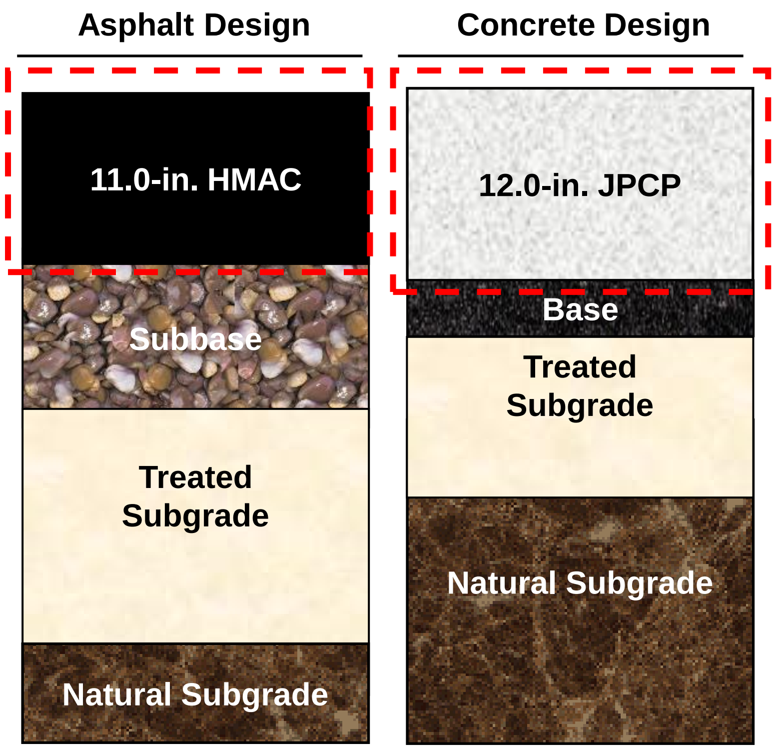
Miscellaneous Paving Quantities	• No pay adjustments for excess concrete needed for variation in pavement widths at ramp transitions, intersections, wedges, crossovers, base unevenness, etc.
	  • Contractors add 2 to 4% to concrete volumes to cover these items in their bid
		• Pays for excess asphalt needed for variation in pavement widths at ramp transitions, intersections, wedges, crossovers, base unevenness, etc.
		  • Contractors do not add additional asphalt tonnage to their bid

These additional requirements mean concrete pavers must add a bid premium (up to 8%)

1. NCDOT Construction Manual, Division 700
2. NCDOT Construction Manual, Division 610

EXAMPLE OF HOW MATERIAL QUANTITY SPECIFICATIONS REQUIREMENTS IMPACT BID PRICES AND PAYMENTS

Thickness Penalty and Misc Paving Impacts



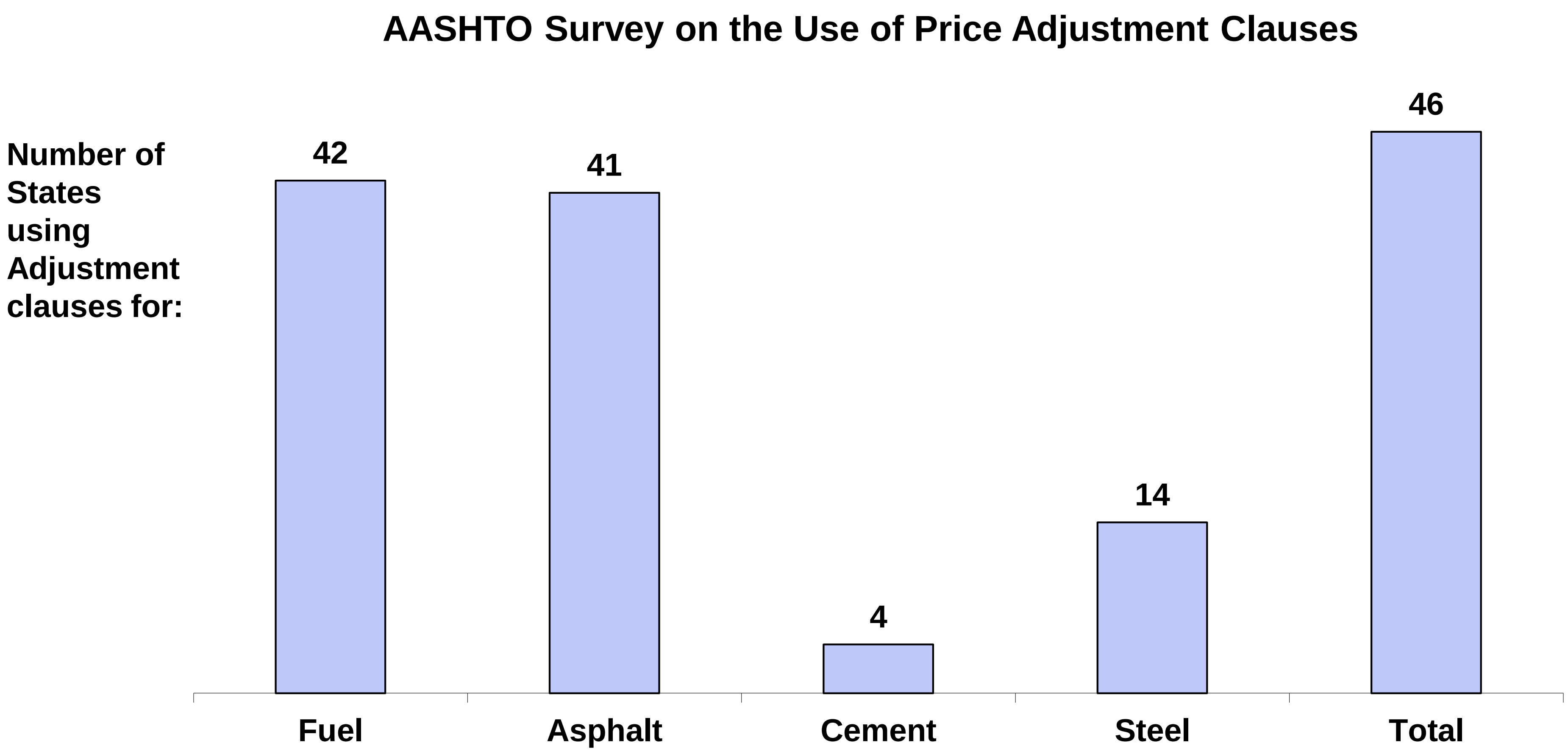
Contractor Calculation of Material Costs	Concrete		Asphalt
Pavement Area (SY)	44,587		44,587
Construction Plans Material Volume (CY)	14,862		13,624
Add. ½" concrete to avoid thickness penalty (CY)	619		-
Add. material for misc. paving - 3% of Vol (CY)	464		-
Total Material Volume (CY)	15,946		13,624
% increase over Construction Plans Material Volume	7.29%		
Paving Asphalt Material Weight (ton)			23,409
Liquid Asphalt (ton) – Assumed to be 5%			1,170
Material Unit Price	$200 / CY		$75 / ton
			$650 / ton
Total Concrete or Asphalt Material Costs	$3,189,185	21.10%	$2,516,415
Cost before additional material	$2,972,444	15.34%	

Payment by for Material Overages	Concrete		Asphalt
1% Overage	$3,189,185	20.31%	$2,541,579
5% Overage		17.15%	$2,642,235
8% Overage		14.78%	$2,717,728

Current Material Quantity Specifications covers Risks for Asphalt (but not for concrete),
while bidding process is set up to favor asphalt

Concrete and Asphalt Material Costs only, Pavement Specifics – 1 mile Interstate, 2 lanes / 2 directions plus shoulders (10' outside and 4' inside shoulder)
Asphalt Tonnage = Asp Unit Weight * Volume (Asp Unit Weight =140 lbs/CF)
Paving Asphalt & Concrete Prices based on ~ 2021 Avg AC bid price, 2022 Liquid binder Index and estimated Concrete placement Costs

PRICE ADJUSTMENT CLAUSES (AKA "INDEXING") ARE USED TO LIMIT A CONTRACTOR'S EXPOSURE TO PRICE FLUCTUATIONS

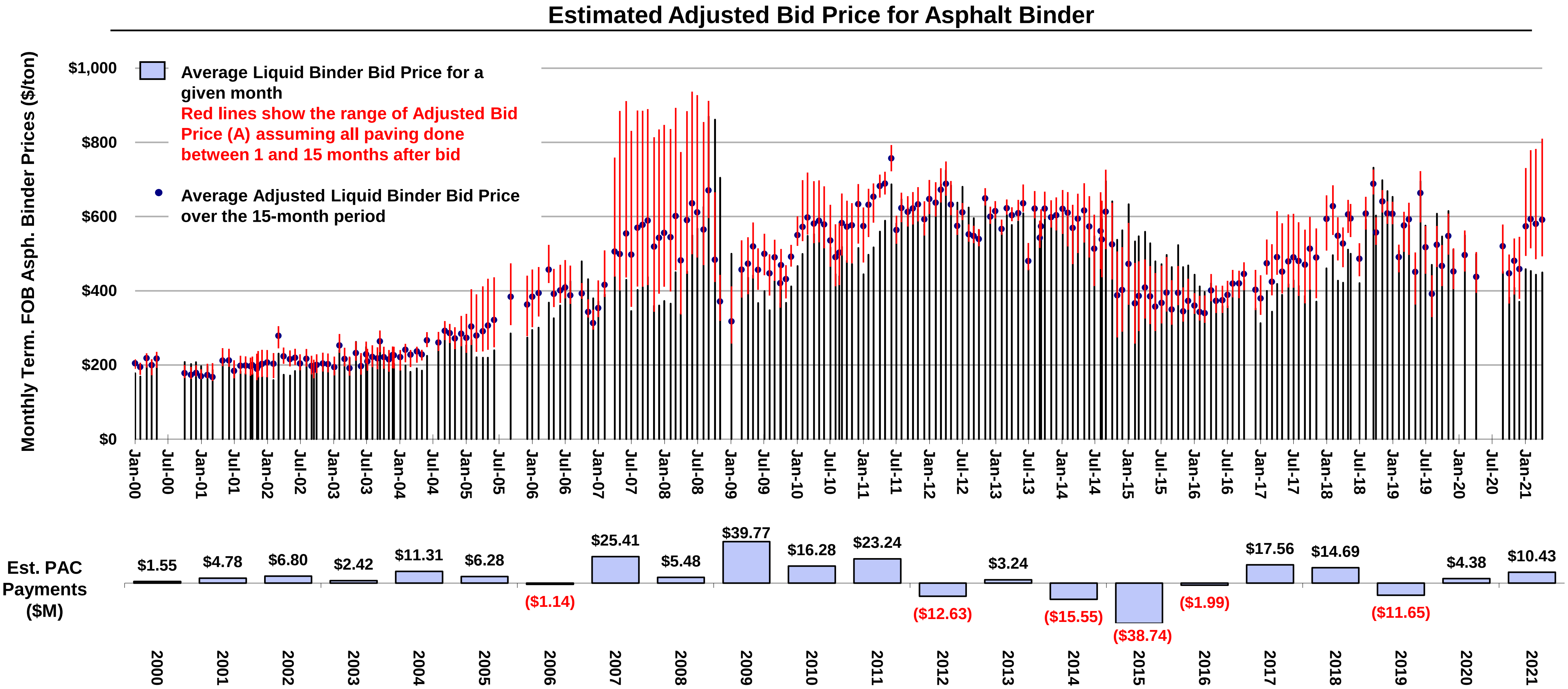


The use of PACs to address Asphalt price changes, but not accounting for the price changes in the bidding / cost analysis, bias the results

www.fhwa.dot.gov/programadmin/contracts/aashto.cfm

WHILE INDEXING DOES LIMIT A CONTRACTOR'S RISKS, IT COME AT A COST

Since 2000, it is estimated that NCDOT has paid ~$100M in PAC payments



1. NC Bid data from Oman Systems. January 18, 2000 to April 20, 2021 for projects w/ AC Tons >1000
2. NCDOT Monthly Terminal Asphalt Binder FOB Prices , http://www.ncdot.org/doh/operations/dp_chief_eng/constructionunit/paveconst/Asphalt_Mgmt/acprices/

SUMMARY

Agencies have the power to instill practices & policies that will lower Initial Costs for All Pavements

1. **Viable competition between two healthy paving industries can lower costs**
   - Sustained long term competition between material industries adds more contractors & another level of competition to the bidding process
   - Agencies must make a conscience choice to bid concrete to increase Inter-Industry Competition (firms that pave with different materials) and lower system-wide costs

2. **Optimizing Pavement Designs can make concrete pavements affordable**
   - Design features have a significant impact on performance & cost
   - Pavement ME, Life Cycle Cost Analysis and Life Cycle Assessment give a repeatable, un-biased process that allows for trade off analysis of different features on a specific pavement design

3. **Differences in Material Specifications affect how contractors bid and impacts costs**
   - Updating specifications to have similar Thickness Requirements, Base / subgrade grade requirements, and Material Quantity Risks will balance bidding practices and equivalize costs

Thank You

& Any Questions?

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