ALTERNATE DESIGN – ALTERNATE BID

USING LIFE CYCLE COST ANALYSIS

Louisiana Department of Transportation and Development

March 2007

ADAB LCCA

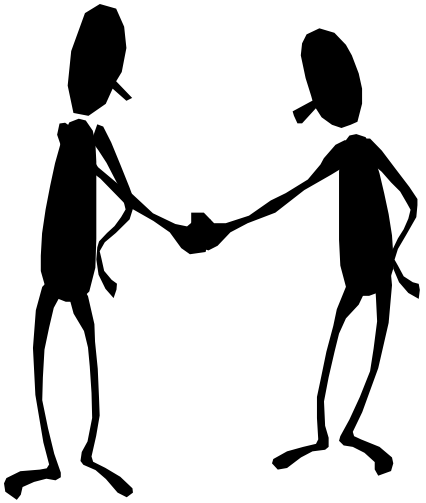
- Political Issues – competing industries, industry relationships
- Administrative Issues– design and selection policies
- Engineering/Technical Issues —structural design, life cycle cost analysis

Pavement Type Selection Policy

- Previous policy: Urban Concrete, Rural Asphalt
- Industry not satisfied
- Previous policy based on concept of “Get out and Stay out”
- User delay considerations for future rehabilitation

Industry Consensus

- Consensus with both paving industries on process
- ASSUMPTIONS: Time to next overlay, major maintenance, (C)
- Discount Rate
- Salvage Costs, etc.
- Alternate Design/Alternate Bid had not been successful in other states due to lack of consensus



LAPA

CAAL

LDOTD

TYPE OF PAVEMENT

(LANE MILES)

• TOTAL	37,148	
• CONCRETE	4,211	11%
• ASPHALT	22,634	61%
• COMPOSITE	10,302	28%

Where Do We Use The Alternate Design / Alternate Bid Model?

	Million Dollars	Alternate Design / Alternate Bid
PRESERVATION		
- Non-Interstate Pavement	$125	No
- Interstate Pavement (IM)	$65	No
- Bridge (On / Off System)	$101	No
OPERATIONS	$36	No
- ITS, Weigh Stations,		
- Rest Areas,		
- Contract Maintenance		
SAFETY	$38	No
- Highway		
- Railroad Crossing		

Where Do We Use The Alternate Design / Alternate Bid Model?

	Million Dollars	Alternate Design / Alternate Bid
CAPACITY	$132	Yes
MISCELLANEOUS		
- Enhancement Program	$9	No
- Urban Systems	$48	Yes
- Federal Earmark (DEMO)	$70	Yes
- TIMED (4 Laning)	$324	Yes
- Bonds (State Funds)	$168	Yes
Totals:	$1,116	$742
Alternate Design / Alternate Bid		66%

Pavement Types
Positive Attributes

Concrete Pavements

- Low initial maintenance
- Long lasting friction properties
- Resists surface deformations

Asphalt Pavements

- Lower initial cost
- Smoother ride
- Ease of resurfacing
- Lower traffic tire noise

ASPHALT CONCRETE IMPROVEMENTS TO EXTEND LIFE

- POLYMERS
- SUPERPAVE VOLUMETRIC DESIGN
- MATERIALS TRANSFER DEVICE
- ANTI STRIP ADDITIVES

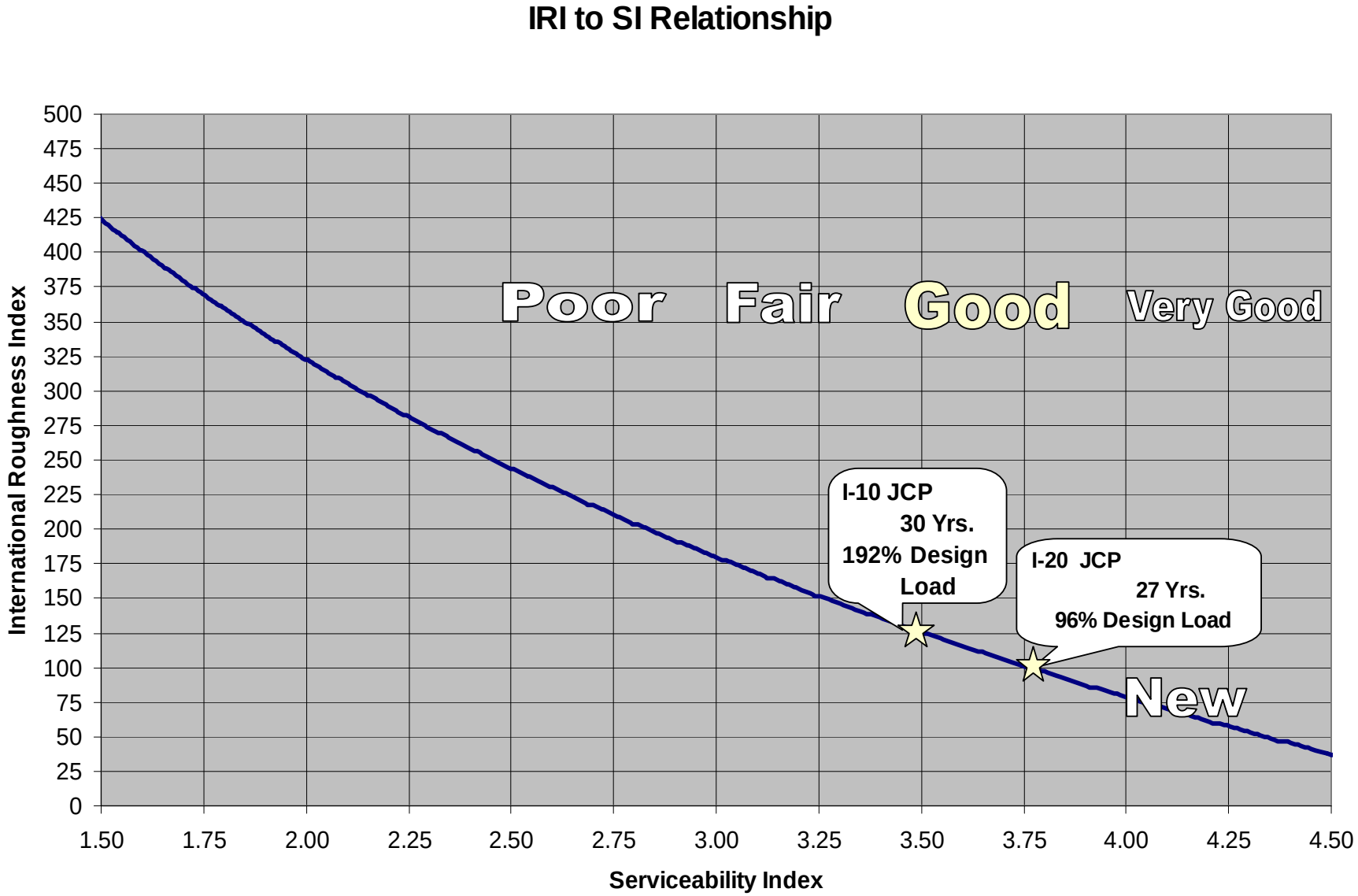
STUDY OF OLDEST 10 SUPERPAVE SECTIONS BUILT IN 1998

PCC IMPROVEMENTS EXPECTED TO EXTEND LIFE

- THICKER SLABS
- LARGER PLASTIC COATED DOWELS
- 20 FT JOINT SPACING
- INTERNAL DRAINAGE
- TIED PCC SHOULDER OR WIDENED LANE
- LONG LASTING JOINT SEALANTS

Interstate JCP

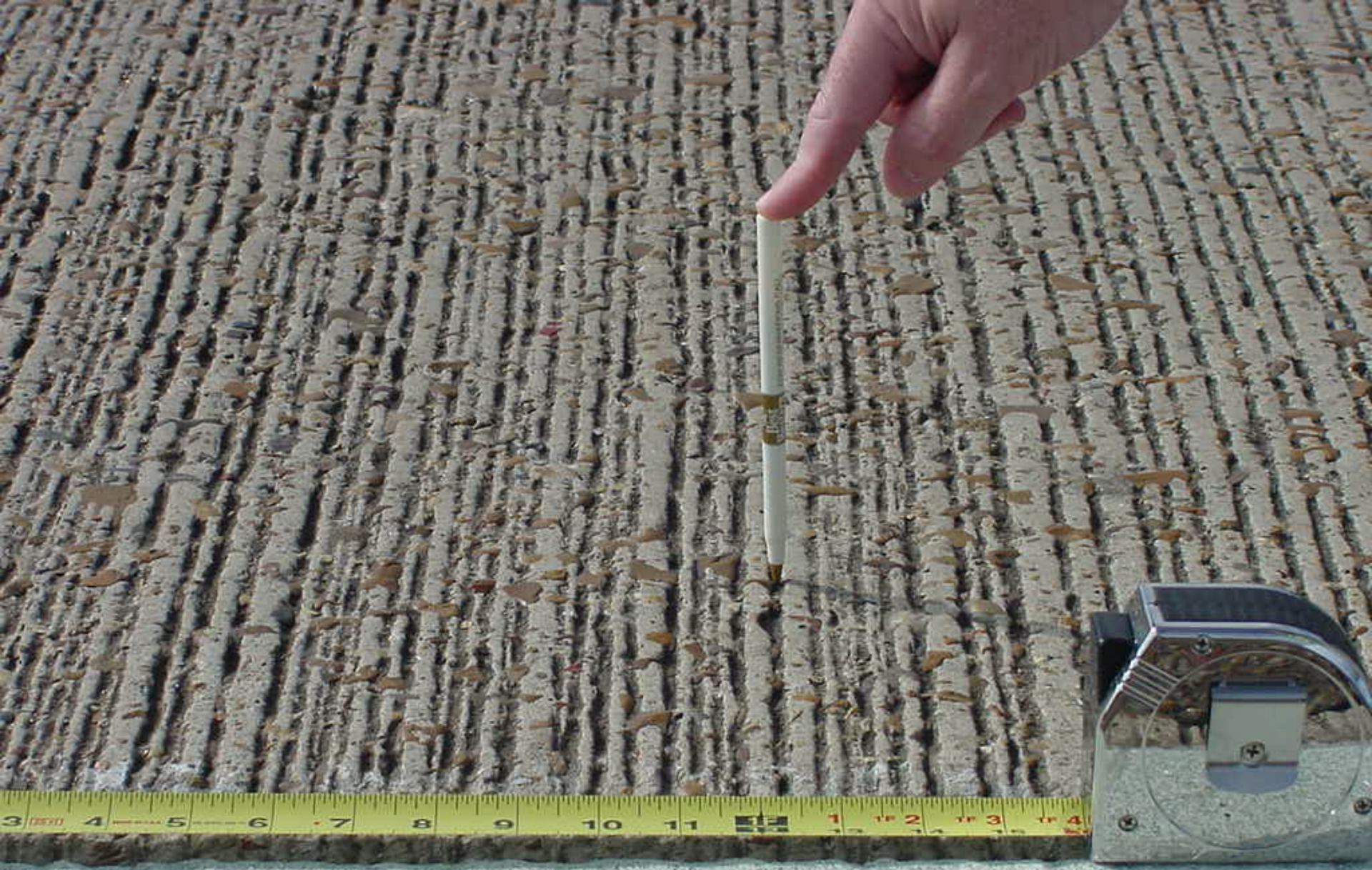
30 year performance of Two Interstate Projects



Interstate JCP

- **I-10 Baton Rouge**
- **Built 1974 (32 yrs.)**
- **Carried 192% Load**
- **Faulting 0.2 in.**
- **Joints Patched 2%**
- **IRI 130**
- **Serviceability Good**
- **Friction 44/27**

- **I-20 Monroe**
- **Built 1977 (29 yrs.)**
- **Carried 98% Load**
- **Faulting 0.1 in.**
- **Joints Patched 1%**
- **IRI 100**
- **Serviceability Good**
- **Friction 44/27**



30 year PCC on Interstate 10 in Baton Rouge

10 inch JCP

4 inch HMAC

Soil Subbase

I-10

Baton Rouge

TYPICAL DESIGN STRUCTURE

Class	PCC	HMAC
Interstate	13”	12” – 15”
Primary	8” – 10”	10”
Secondary	8”	6” – 8”

For ADAB, total pavement thickness is held constant

Pavement Design

- 1972 Interim Guide
- 1986 Revised Guide
- 1993 Revised Guide
- 2009 MEPDG implementation
- For JCP: Flexural Strength requirements 750 psi to reduce required slab thickness where greater than 12 in. is indicated

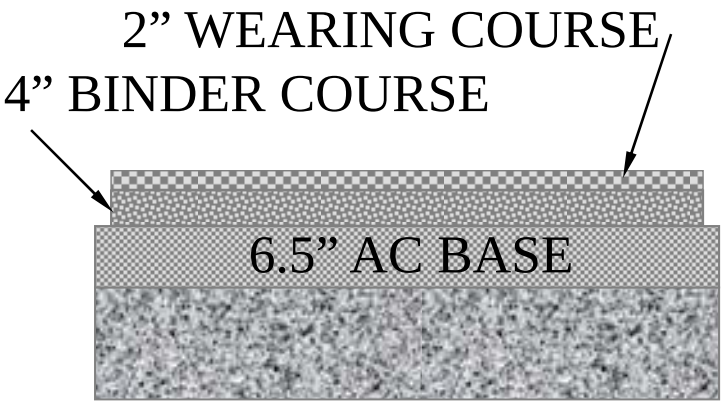
20 Year Design:

(Based upon 1993 AASHTO Pavement Design procedure)

Rigid

12” CRUSHED STONE

Flexible



12” CRUSHED STONE

(Designer to provide same initial elevation for earthwork and same final surface elevation for the two alternates)

Base Course Design

- Use of Soil Cement as a lower layer
- Use of Crushed Stone as an upper layer
- Typical is

4 in. stone / 8 in. soil cement

Pavement Drainage

- Through-the-shoulder drainage daylighted for both rigid and flexible pavements
- Typically #57 stone layer wrapped in fabric
- Eliminated use of trench drains with outlet pipes and headwalls

Analysis Time Periods

- **Pavement Design Period:**

  The time span a pavement is designed to function - Typically 20 years

- **Performance Period:**

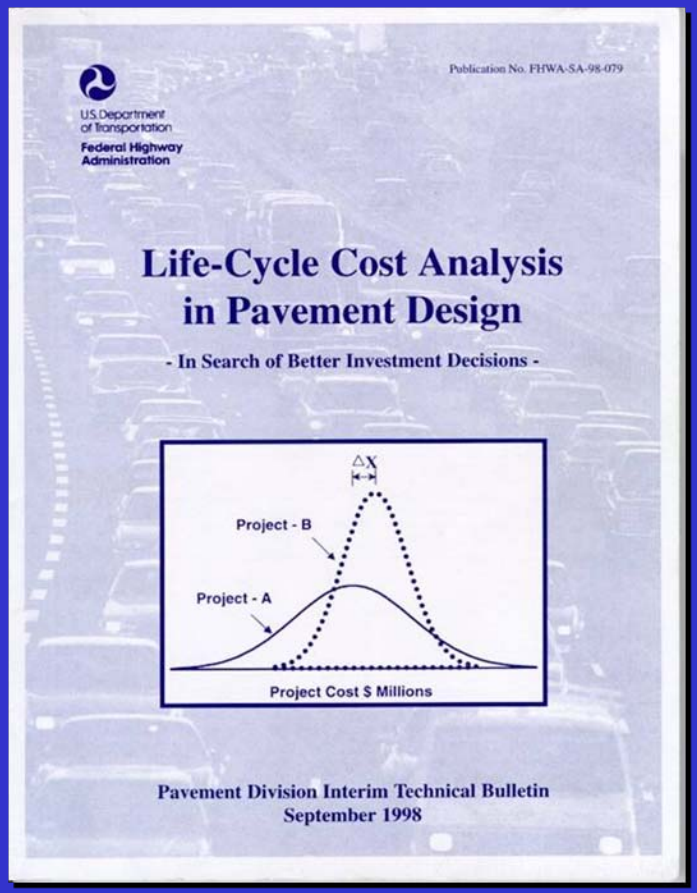
  The time between initial construction and major rehabilitation activity.

- **Analysis Period:**

  The time horizon over which future costs are calculated. Generally **30 years for Overlay**, and **40 years for New Construction.**

Life Cycle Cost Analysis (LCCA)

- LADOTD utilizes the Deterministic approach
- LADOTD includes agency costs and user costs in LCCA
- Publication No. FHWA-SA-98-079



INCENTIVE TO PAVE EXPEDITIOUSLY

- Minimize construction duration and impact
- A+B bid model
- B is the number of contract days translated into dollars
- ADT < 20k $5,000/day
- ADT 20-35k $10,000/day
- ADT > 35k $15,000/day

BID MODEL

- First design equal alternates
- Alternate bid model:
- “A” + “B” + “C” or “A” + “C”
- A = Construction Cost
- B = Time of construction expressed as $
- C = Cost of future overlay, rehabilitation, maintenance

ALTERNATE DESIGN ALTERNATE BID

- A+B+**C** Model
- **C** is a function of all future costs
- **C** is different for each alternate
- **C** is typically higher for Asphalt Concrete Alternate than Portland Cement Concrete Alternate

Life Cycle Cost Analysis
Present Value

- A1 **PCC**
- A = $ **7.2** M
- **C** = $ 4.8 M (0.46)
  = $ **2.2** M
- LCC = $ **9.4** M

- A2 **AC**
- A = $ **5.0** M
- **C** = $9.1 M (0.56)
  = $ **5.1** M
- LCC = $ **10.0** M

- LCC within 6%

FUTURE EXPENDITURES

- What future actions will be necessary for the two alternatives?
- When and at what cost?

Future Rehabilitation Activities

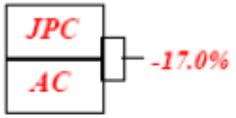
- Timing and scope of activities reflect anticipated improved performance for both flexible and rigid pavements
- Flexible: Superpave, better construction, improved quality control
- Rigid: thicker slabs and bases, larger dowels, drainage, tied shoulders, etc.

Assumptions & Activity Timing

(Arterial – New Construction)

- **Rigid**
  - Year 0
    - 20-year design
  - Year 20
    - Clean & re-seal joints
    - Patch 1% of joints
  - Year 30
    - Patch 2% joints
    - retexture
- **Flexible**
  - Year 0
    - 20-year design
  - Year 15
    - Cold plane & overlay
    - 15-year design
  - Year 30
    - Cold plane & overlay
    - 10 year design

LIFE CYCLE COST ANALYSIS



STATE PROJECT NO. 014-04-0028
Oberlin - Oakdale
Allen Parish
Route Us 165

ALTERNATE	YEAR 0 12400 ADT	PV FACTOR = 0.5553 YEAR 15 15700 ADT	PV FACTOR = 0.4564 YEAR 20 17000 ADT	PV FACTOR = 0.3083 YEAR 30 18800 ADT	YEAR 40 20800 ADT	PRESENT VALUE TOTALS
A1	NEW JPC PAVEMENT 230mm JPCP 250mm Crushed Stone/Recycled PCCP Base SHOULDERS 50mm AC Shoulder CONST. COST: $7,973,000 USER COST: $479,000 TOTAL COST: $8,452,000	NO ACTION TOTAL COST: $0	CLEAN/SEAL JOINTS Silicone PATCHING Patch 1% Of Joints SHOULDERS Cold Plane 50mm Of AC 50mm AC Wearing Course CONST. COST: $919,500 USER COST: $1,588,400 TOTAL COST: $2,507,900	RETEXTURE Travel Lanes Only PATCHING Patch 2% Of Joints CONST. COST: $543,600 USER COST: $470,200 TOTAL COST: $1,013,800	REMAINING INVESTMENT LIFE 0 YEARS TOTAL COST: $0	TOTAL INVESTMENT LIFE = 40 YEARS C = $1,457,200 CONST. COST: $8,560,300 USER COST: $1,348,900 TOTAL COST: $9,909,200
A2	NEW AC PAVEMENT 50mm AC Wearing Course 80mm AC Binder Course 100mm AC Base Course 250mm Crushed Stone/Recycled PCCP Base SHOULDERS 50mm AC Shoulder CONST. COST: $6,631,600 USER COST: $1,109,900 TOTAL COST: $7,741,500	STRUCTURE REHAB COLD PLANE 50mm WITH OVERLAY (Cold Planing Excludes Shoulders) 40mm AC Wearing Course 50mm AC Binder Course 180mm Existing AC Pavement 250mm Exist. Crushed Stone Base CONST. COST: $3,640,300 USER COST: $923,500 TOTAL COST: $4,563,800	NO ACTION TOTAL COST: $0	STRUCTURE REHAB COLD PLANE 50mm WITH OVERLAY (Cold Planing Excludes Shoulders) 40mm AC Wearing Course 50mm AC Binder Course 220mm Existing AC Pavement 250mm Exist. Crushed Stone Base CONST. COST: $3,640,300 USER COST: $1,105,700 TOTAL COST: $4,746,000	REMAINING INVESTMENT LIFE 0 YEARS TOTAL COST: $0	TOTAL INVESTMENT LIFE = 40 YEARS C = $3,997,500 CONST. COST: $9,775,400 USER COST: $1,963,600 TOTAL COST: $11,739,000

Life Cycle Cost Analysis

Year / Alt	Year 0 Costs	Year 15 Costs	Year 20 Costs	Year 30 Costs	Year 40 Costs	PV Totals
PCC	Construction: $7,973,000 User Cost: $479,000 **Total: $8,452,000**	No work in Year 15	Reseal Joints Patch 1% Joints $919,500 User Cost: $1,588,400 **Total: $2,507,900**	Retexture Patch 2% Joints $543,600 User Cost: $470,200 **Total: $1,013,800**		**C = $1,457,200** Const. = $8,560,300 User = $1,349,900 Total = **$9,909,200**
AC	Construction: $6,631,600 User Cost: $1,109,100 **Total: $7,741,500**	Mill & Overlay: $3,640,300 User Cost: $923,500 **Total: $4,563,800**	No work in Year 20	Mill & Overlay: $3,640,300 User Cost: $1,105,700 **Total: $4,764,000**		**C = $3,997,500** Const. = $9,775,400 User = $1,963,600 Total = **$11,739,000**

12,000 ADT Rural US Route Two Lane Addition
9” pavement over 10” stone base

Difference in Initial Construction Cost	= $1,341,400
Difference in Initial Total Cost	= $ 710,500
Difference in C (PV)	= $2,540,300
Difference in LCC (PV)	= $1,829,400
% Difference	= 18%

Competition Range

- TOTAL LCC WITHIN 25%, LET AS ALTERNATES
- DIFFERENCE IN LCC GREATER THAN 25%, MAKE A PAVEMENT TYPE SELECTION (Competition consideration)

Competition Break Point

(LADOTD BID SYSTEM)

ADT	% Difference in LCC
1000 - 2000	35
2000 - 3000	23
3000 – 4000	34
4000 - 5000	7
5000 - 6000	8
6000 - 7000	13
7000 - 8000	8
8000 - 9000	5
9000 - 10000	3

User Cost Components:

- Speed Change Delay - the additional time necessary to decelerate and accelerate
- Speed Change VOC – the additional vehicle operating cost associated with the deceleration and acceleration
- Reduced Speed Delay – the additional time necessary to traverse the work zone at the lower posted speed

USER DELAY EXAMPLE

- “June 2006 Interstate Crash Cost Motorists nearly $1Million” *The Advocate*
- Traffic down to one lane on I-10 for 4 hours
- Estimated $670,420 in wasted time
- Estimated $218,702 in wasted fuel

Production Rates for User Costs Due to Construction

- The rate to place asphaltic concrete is 2000 tons per day
- The rate to pace 8” crushed stone base is 4500 sq. yds. per day
- The rate to pace 12” PCCP is 10,000 sq. yds. per day
- The unit weight of asphaltic concrete is 110 lb. per sq. yd. per inch
- The rate of cleaning and sealing joints is 2500 lin. ft. per day
- The rate of cold plane maximum 2” is 10,000 sq. yds. per day
- The rate of retexture on PCCP is 3 lane-miles per day
- 1% of total joints need to be patched in Year 20
- 2% of total joints need to be patched in Year 30
- The rate of joint patching is 12 joints per day

Discount Future Costs to Present Value

- Use real dollars
- Discount rate: 4%

(Discount rate = interest rate – inflation rate)

$$\text{NPV} = \text{Initial Cost} + \sum_{k=1}^{N} \text{Rehab Cost}_k \bullet \left(\text{P/F}_k, \text{i\%}, \text{n}_k\right)$$

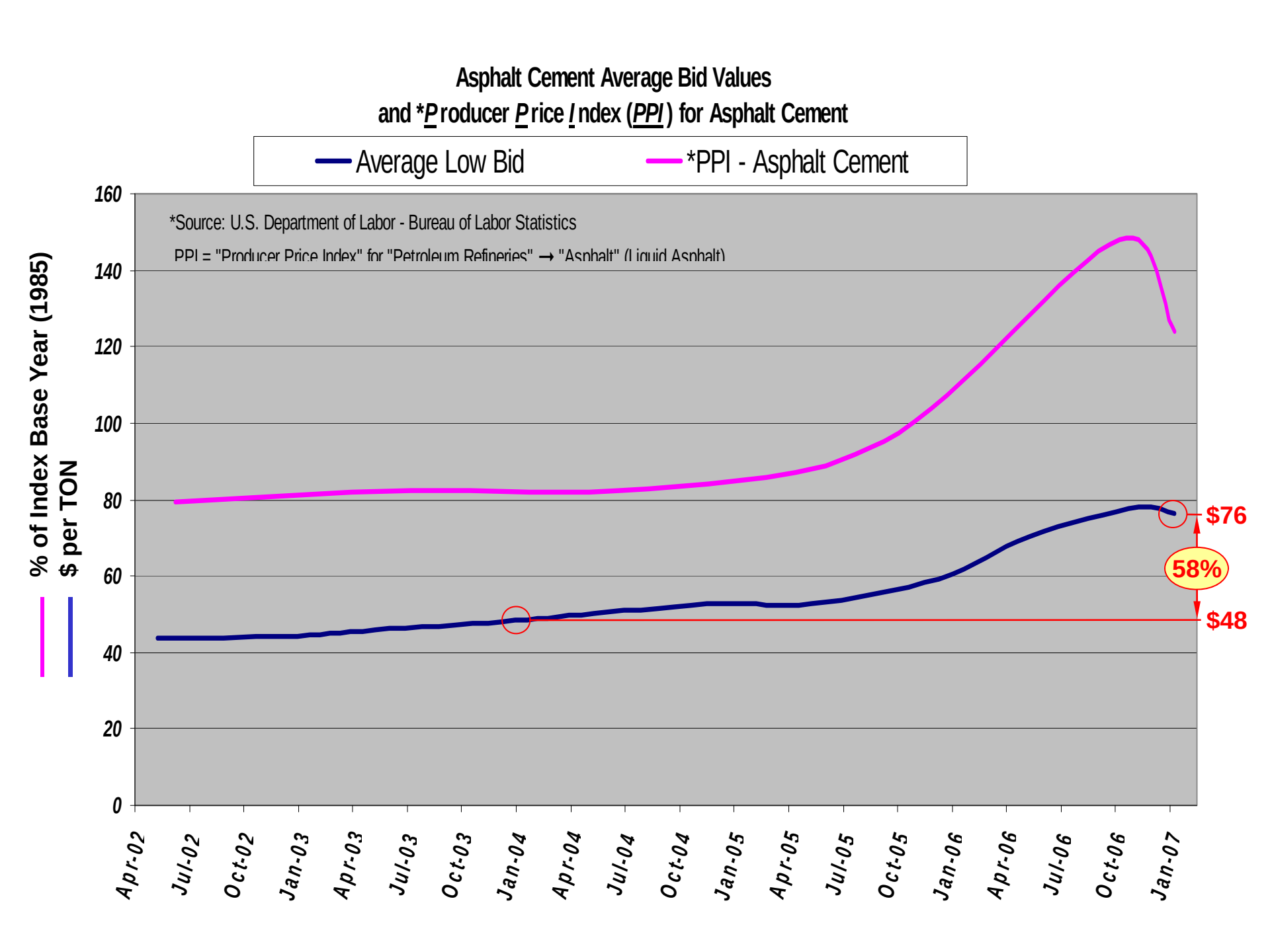
$$\textit{Where : discounting factor } (P/F_k, i\%, n_k) = \left[\frac{1}{(1+i)^{n_k}}\right]$$

$i = \textit{discount rate}$

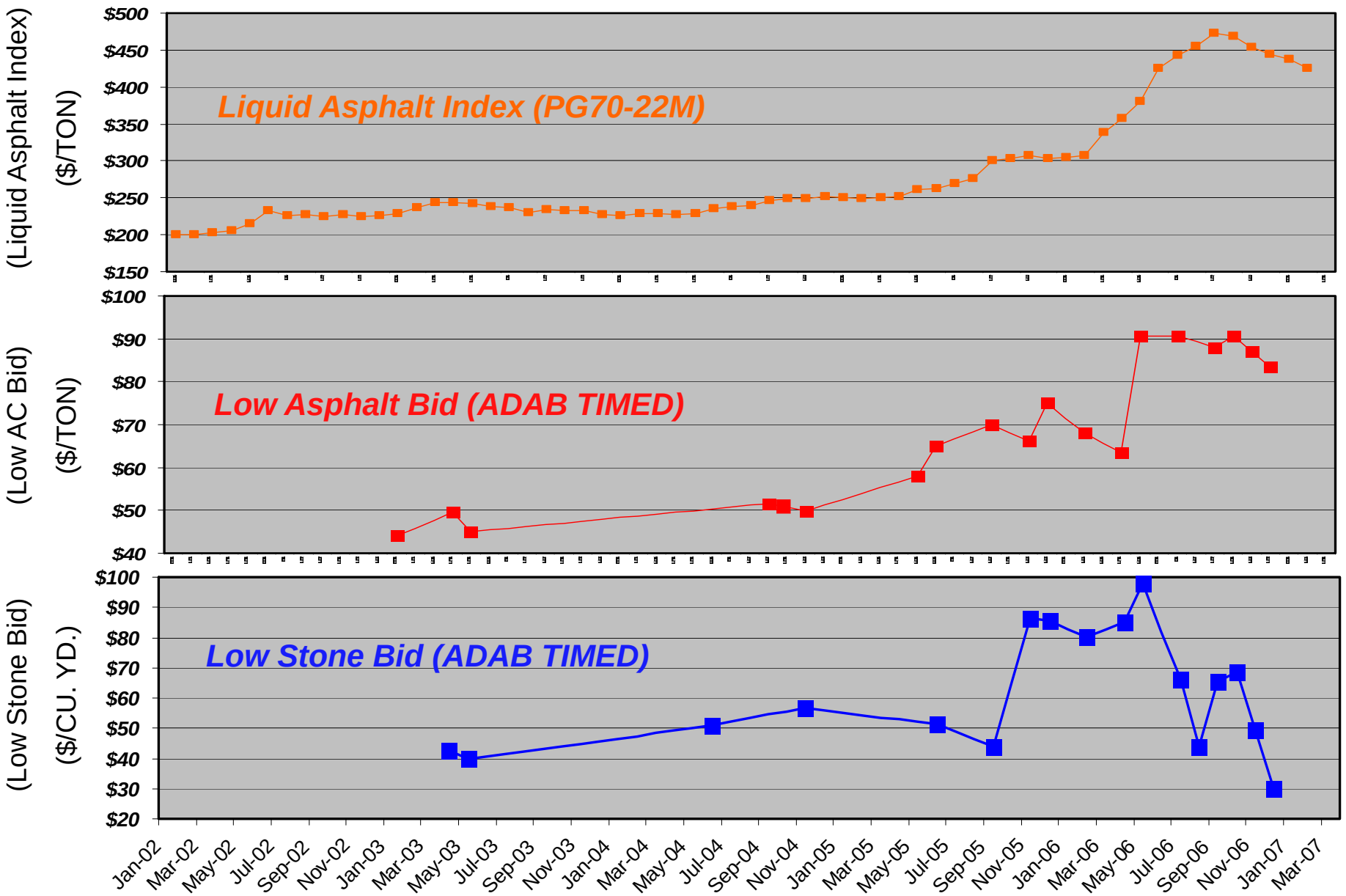
$n = \textit{year of expenditure}$

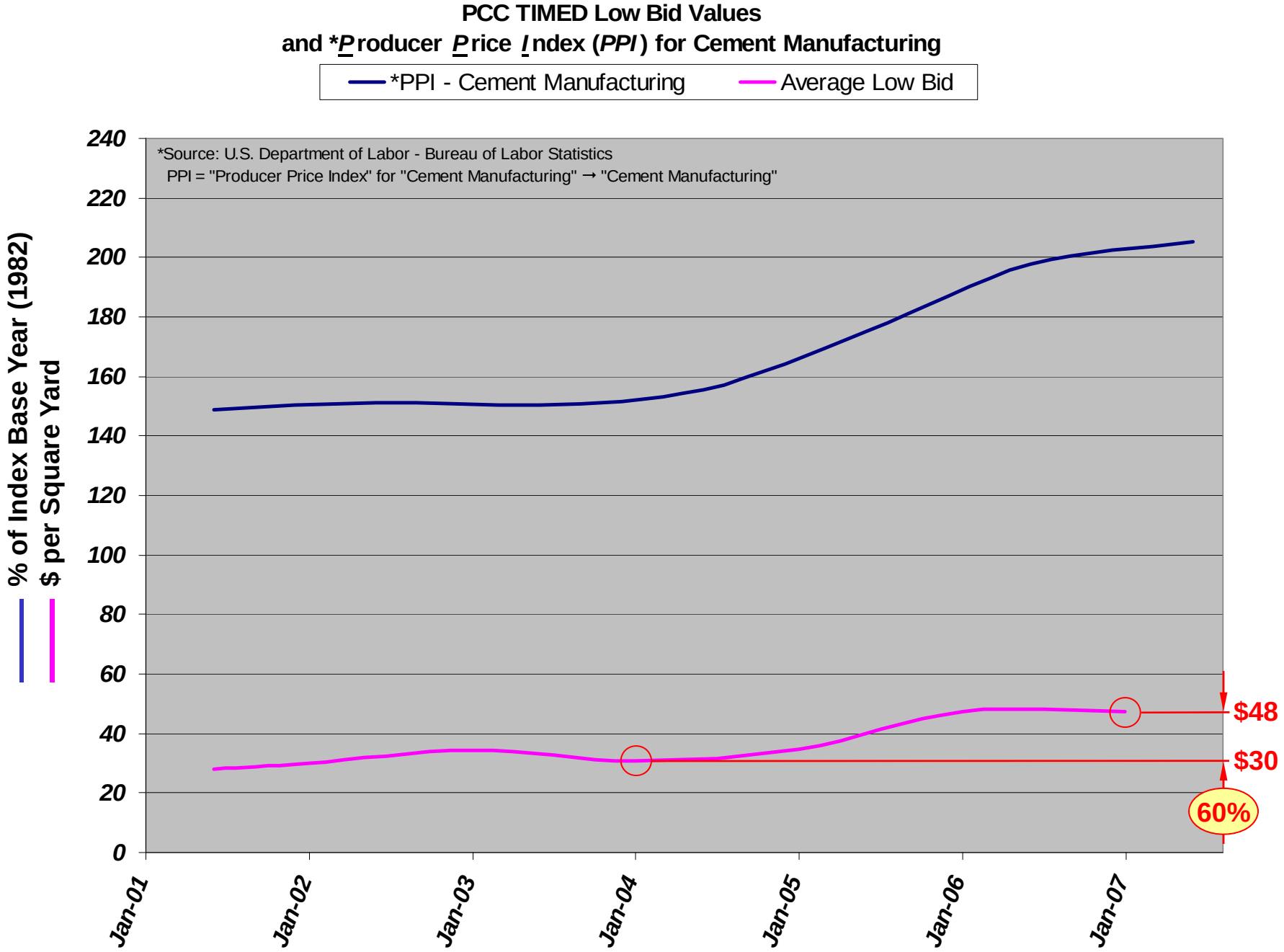
Unit Price of Materials (2001 vs 2006)

1. 12” JPC = $32.00 sq. yd.	$40 (2006)
2. Cold plane 2” = $1.00 sq. yd.	$2 (2006)
3. 12” stone base = $6.50 sq. yd. (2001)	$27 (2006)
4. Retexturing travel lanes = $1.50 sq. yd.	$2.50 (2006)
5. Concrete patching = $120.00 sq. yd.	$125 (2006)
6. Asphalt concrete = $35/ton	$80 (2006)


Asphalt Cement Average Bid Values
and *Producer Price Index (PPI) for Asphalt Cement
Average Low Bid
*PPI - Asphalt Cement
*Source: U.S. Department of Labor - Bureau of Labor Statistics
PPI = "Producer Price Index" for "Petroleum Refineries" → "Asphalt" (Liquid Asphalt)
% of Index Base Year (1985)
$ per TON
160
140
120
100
80
60
40
20
0
Apr-02
Jul-02
Oct-02
Jan-03
Apr-03
Jul-03
Oct-03
Jan-04
Apr-04
Jul-04
Oct-04
Jan-05
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan-07
$76
58%
$48

Comparison of DOTD Asphalt Index (PG70-22M), Low Asphalt Bid Price and Low Stone Bid Price of TIMED Alternate Design/Alternate Bid Projects)

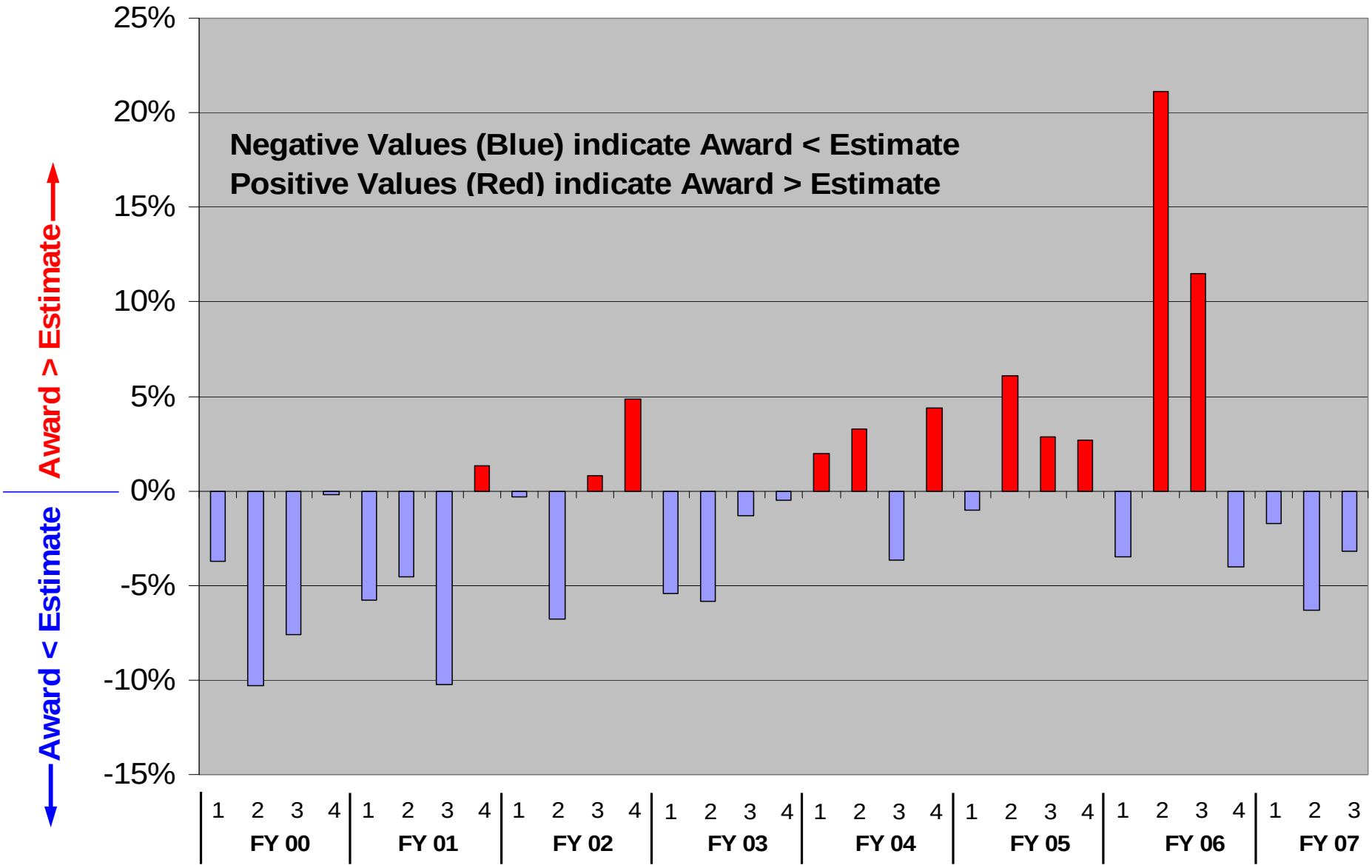



PCC TIMED Low Bid Values
and *Producer Price Index (PPI) for Cement Manufacturing
*PPI - Cement Manufacturing
Average Low Bid
*Source: U.S. Department of Labor - Bureau of Labor Statistics
PPI = "Producer Price Index" for "Cement Manufacturing" → "Cement Manufacturing"
% of Index Base Year (1982)
$ per Square Yard
240
220
200
180
160
140
120
100
80
60
40
20
0
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
$48
$30
60%

Overall Program
Pavement Types Selected

Date	AC	PCC	Total
(Pre Katrina)			
6/01-8/05	11	5	16
(Post Katrina)			
9/05- 12/06	8	8	16
Total	19 (59%)	13 (41%)	32

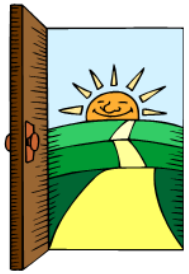
Fiscal Year Comparison of Engineer's Estimate and Award Cost

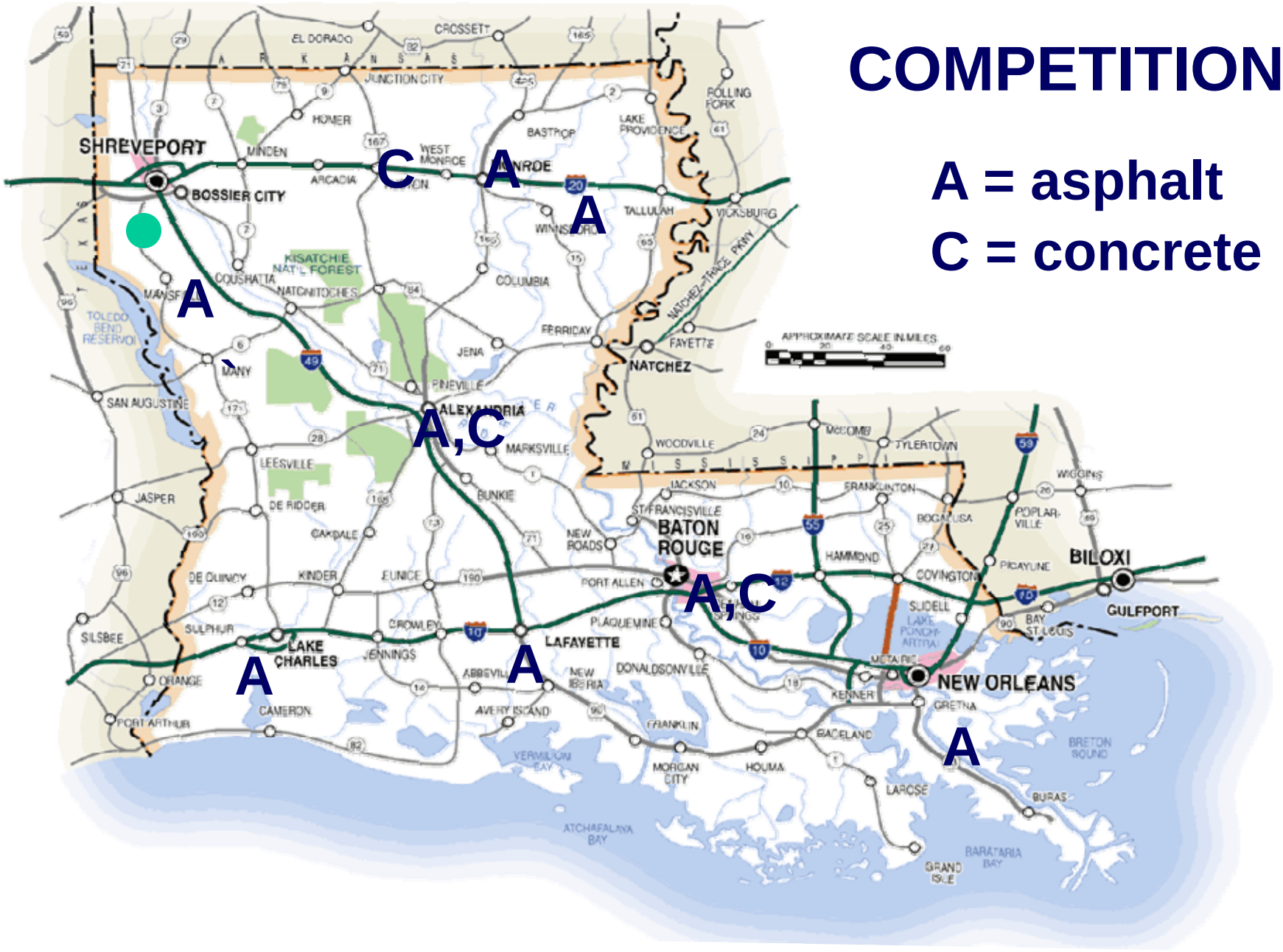


Opportunity for Industry

- Location, location, location
- Territory protection
- Keep work in state
- Influence of market conditions
- Position for next work
- AC/PCC Pavers: resource opportunity

- ADAB bid model opens the door




COMPETITION
A = asphalt
C = concrete
SHREVEPORT
BOSSIER CITY
MINDEN
HOMER
EL DORADO
CROSSETT
JUNCTION CITY
ARKANSAS
WEST MONROE
MONROE
BASTROP
LAKE PROVIDENCE
ROLLING FORK
TALLULAH
VICKSBURG
WINNSBORO
ARCADIA
KISATCHIE NAT'L FOREST
COUSHATTA
NATCHITOCHES
COLUMBIA
MANSFIELD
TOLEDO BEND RESERVOIR
FERRIDAY
FAYETTE
NATCHEZ
NATCHEZ-TRACE PKWY
JENA
PINEVILLE
ALEXANDRIA
SAN AUGUSTINE
LEESVILLE
MARKSVILLE
WOODVILLE
MCCOMB
TYLERTOWN
JACKSON
FRANKLINTON
WIGGINS
JASPER
DE RIDDER
BUNKIE
ST. FRANCISVILLE
BATON ROUGE
NEW ROADS
BOGALUSA
POPLARVILLE
OAKDALE
HAMMOND
PICAYUNE
BILOXI
DE QUINCY
KINDER
EUNICE
PORT ALLEN
COVINGTON
SLIDELL
GULFPORT
SULPHUR
CROWLEY
PLAQUEMINE
LAKE CHARLES
LAFAYETTE
JENNINGS
ABBEVILLE
NEW IBERIA
DONALDSONVILLE
METAIRIE
NEW ORLEANS
KENNER
GRETNA
ORANGE
CAMERON
PORT ARTHUR
AVERY ISLAND
FRANKLIN
RACELAND
HOUMA
MORGAN CITY
LAROSE
BURAS
BRETON SOUND
VERMILION BAY
ATCHAFALAYA BAY
BARATARIA BAY
GRAND ISLE
A
A
C
A
A
A,C
A,C
A
APPROXIMATE SCALE IN MILES

COMPETITION
Number of Bidders per Project

- 12 Monthly Lettings 2005-2006 (Since Katrina)
- ADAB Average 3.9 bidders
- All other projects Average 2.6 bidders

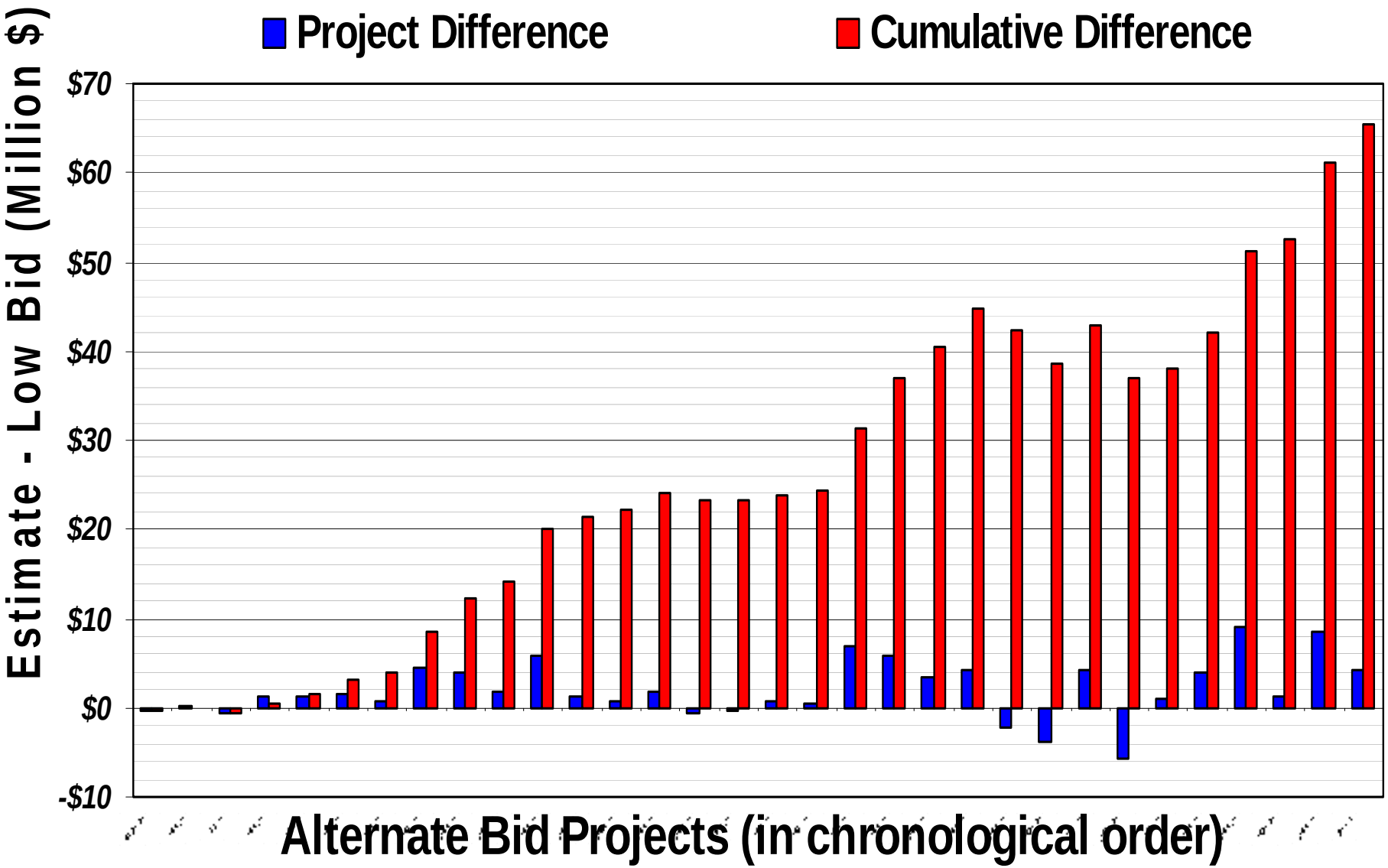
COMPETITION
Estimate vs. Low Bid

- 12 Monthly Lettings 2005-2006
  (Since Katrina)

- ADAB projects (-9%) 9% lower than estimate

- All other projects (+20%) 20% higher than estimate

Alternate Design/Alternate Bid
(Cumulative Savings)



Design Effort

- 32 Projects
- $62.5M under estimate
- Avg. 11% per project
- $2.0M per project

- Pavement Design
- EI 12 hours
- PE 4 hours
- $500

- With LCCA/ADAB
- EI 80 hours
- PE 16 hours
- $2000

- **Cost Benefit Ratio:**
- **1000 to 1**

Reasons to Use ADAB

- ✓ Allows both paving industries to participate; and considers future expenditures
- ✓ Encourages the agency to consider user cost effects and possibly alternate construction scenarios
- ✓ Increases the bid pool which has proven to result in lower bid prices to the contracting agency