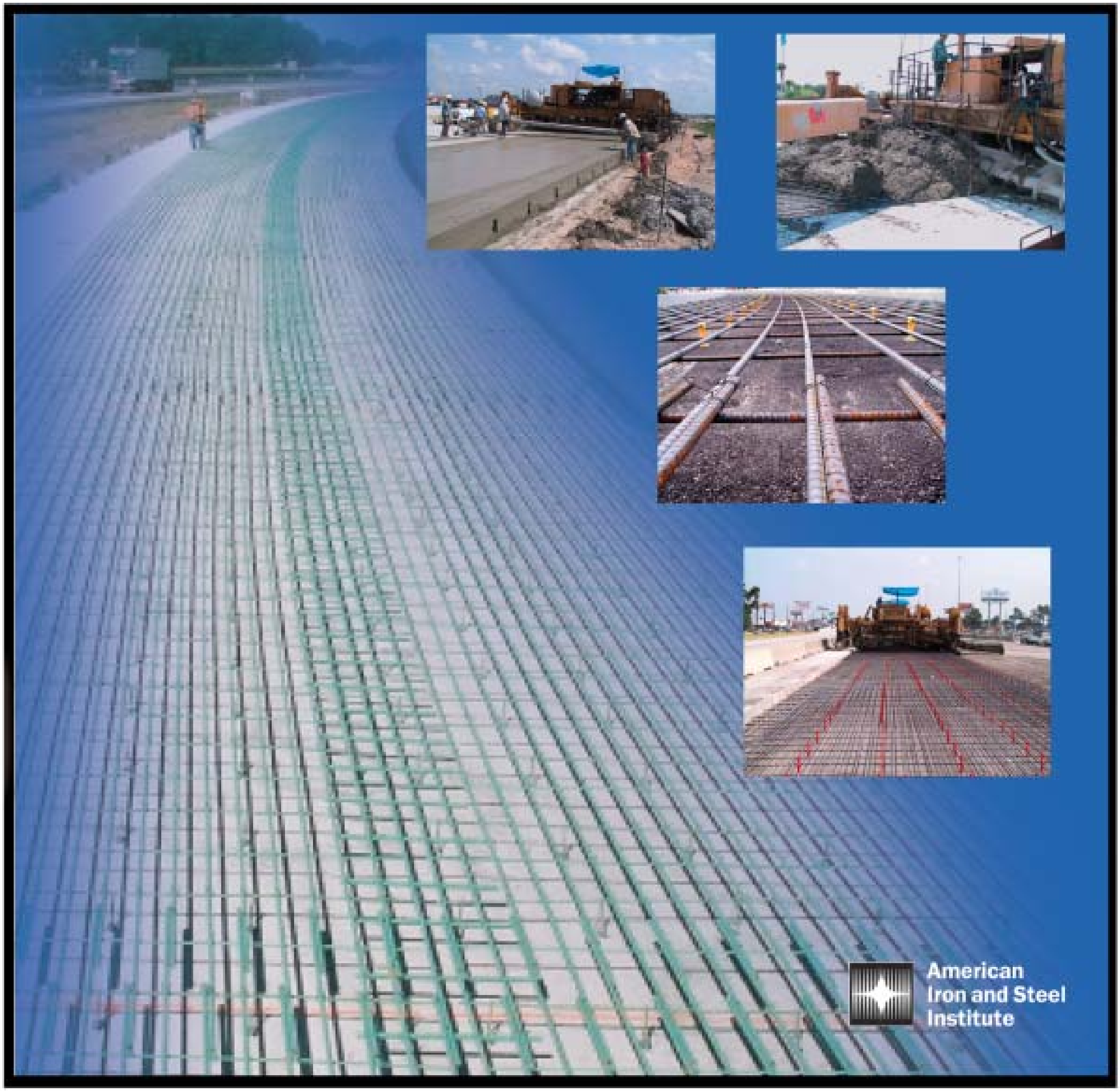


American Iron and Steel Institute

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

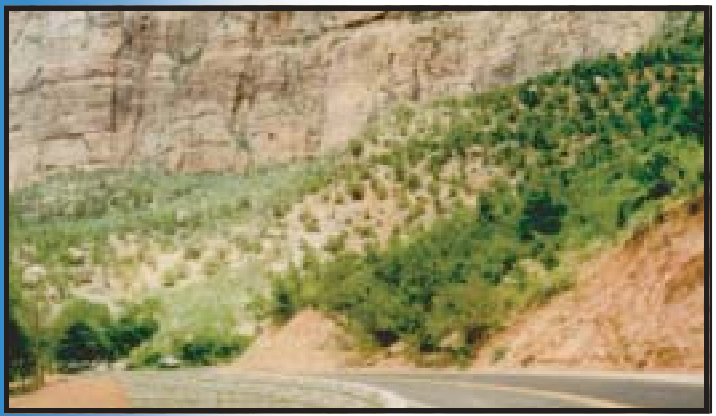
Investing for the future with continuously reinforced concrete pavement (CRCP) means longevity, which leads to reduced costs to road owners and reduced costs and impacts to road users. A wise investment!

INVEST WISELY IN YOUR STATE AND NATIONAL ROADWAYS

To make the correct decision on pavement design (type and structure) for use on any roadway project, engineers must consider many factors. In a 2000 CRSI survey of state highway agencies, pavement and material engineers ranked initial costs, life-cycle costs, and traffic volumes as the most important factors that influence the selection of pavement type.

Factoring intangibles, items that are not easily quantified, is also important. Intangibles include using sustainable construction materials, long-term environmental friendliness, and impacts to motorists (time factor) and their vehicles (repair cost).

To compare optimized pavement design alternatives correctly, owners agree that a thorough economic analysis (initial and long term) is required. Recent U.S. projects and studies that have demonstrated the economic benefits of CRCP, when compared to other pavement types over the long-term, include projects at the following locations:



- Interstate Toll Highway 294 in Illinois.
- Interstate 35 and State Route 130 in Texas.
- US Route 190 near Baton Rouge, Louisiana.
- Interstate highway system under the Oregon Department of Transportation.
- State Route 288 in Virginia, public-private partnership.

Several major toll road projects being built overseas are wisely investing in Continuously Reinforced Concrete Pavement (CRCP):

- The M6 Toll, a 27 mile, 3 lane motorway through the West Midlands of England is Britain's first toll road and uses CRCP on a critical central section.
- The 25 mile Westlink M7 near Sydney, Australia's biggest current urban road project being constructed under a design, build, operate and maintain contract uses over 90,000 cubic yards of CRCP.

INVEST WISELY IN CRCP FOR ALL OF YOUR ROADWAY PROJECTS

Several state highway agencies extensively use CRCP for its lower life-cycle cost, its competitive initial cost, its minimal maintenance requirement, its ability to handle the heaviest trucks, loads, and volume and comfortable drive.

LOWER LIFE-CYCLE COST

To aid pavement designers and owners in comparisons of key CRCP design features, CRSI in 2004 sponsored the report "Life Cycle Cost Analysis of Continuously Reinforced Concrete Pavements." For example, a recent corridor study on long term pavement performance demonstrated the superiority of CRCP.

COMPETITIVE INITIAL COST

To "invest wisely", highway engineers should consider all design options and compare CRCP against alternative pavement types. Optimizing initial cost requires an understanding of the interrelationship of pavement features.

LESS FREQUENT MAINTENANCE AND RESURFACING

During the first 20 years of its service life, a CRCP pavement requires virtually no maintenance. In addition to the reduced maintenance, there is a significant reduction in the need for periodic surface treatment, which also lessens the impact on motorists using the highway. Additionally, CRCP provides a long-lasting base for resurfacing overlays.

HANDLE THE HEAVIEST TRUCKS, LOADS, AND VOLUME

The U.S. Government Long-Term Pavement Performance (LTPP) program evaluates pavement attributes regionally and nationally. The study, "Performance of Continuously Reinforced Concrete Pavement in the LTPP Program" by Construction Technology Laboratories, 2000, highlights the reasons CRCP outperforms other pavement types.

INTANGIBLES

CRCP is sustainable pavement for which all constituent materials are produced from recycled product, and all CRCP can be recycled at the end of its life. CRCP means reduced cost to motorists, since its stays the smoothest the longest. Higher vehicle repair costs and lower fuel economy have been observed in studies of rough roads. Refer to the LTPP Tech Brief "What Makes Portland Cement Concrete Pavements Rough?" from the Federal Highway Administration, 1998. Also note that the traveling public ranked ride quality as most important in National Quality initiative surveys from in 1996 and 1999.

INVEST WISELY IN THE OPTIMUM CRCP

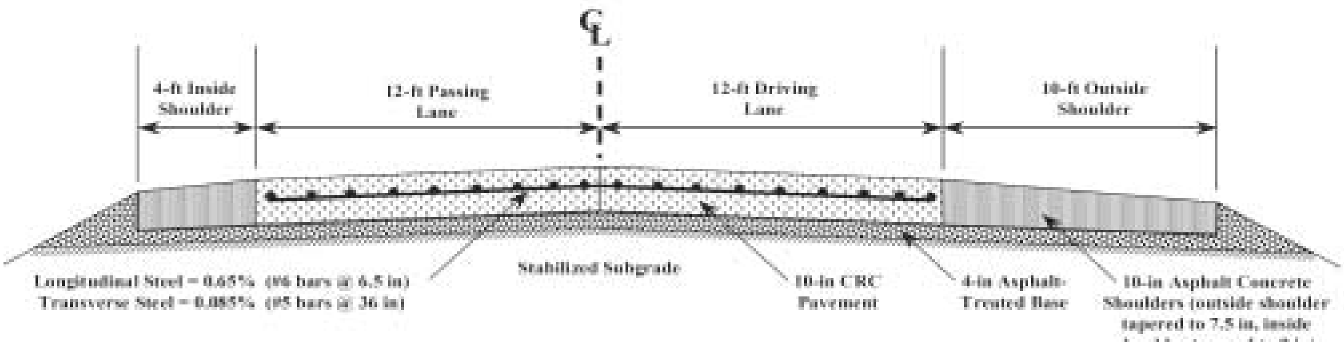
Report: Life Cycle Cost Analysis Of Continuously Reinforced Concrete Pavement

State highway agencies, including Texas and Illinois, rely on CRCP extensively due to its proven reliability and long-term durability. Many other highway agencies include CRCP in their inventory and consider its benefits when selecting pavement type for major highway projects.

A recent study using life-cycle cost analysis (LCCA) techniques confirmed the benefits of CRCP, without directly comparing it to alternate pavement types. State highway departments, contractors, and state-of-the-art performance/design models provided data for this report. The study examined the cost-effectiveness of five of the most influential CRCP design criteria: concrete slab thickness, longitudinal steel reinforcement amount, base type and thickness, shoulder type, and slab width. The study also analyzed life cycle cost of these design criteria in 13 common combinations, and estimated relative costs and performance of each design.

One pavement cross section was selected as a reference base to compare and contrast changes in design features and their subsequent impact on initial cost, life cycle costs, and performance. Additional inputs to the study were: traffic levels at 750,000 ESALs/year initially with a three percent annual growth, resulting in 84.6 million cumulative ESALs over 50 years; and four percent discount rate. For each design feature, the percent change in initial construction cost and estimated life, when compared to the reference design, were computed and plotted.

A benefit-cost analysis was also performed, using documented initial cost data and average service life estimates and prediction models.



Reference Design Cross-Section: 10-inch CRCP

To arrive at an optimum CRCP design solution (cost and life), the sensitivity analysis included the important design criteria, such as slab width, steel percentage and slab thickness, as shown here.

Representative Design	Design Feature Variation					Service Life Used in LCCA, yrs.
	Slab thickness	Long. Steel	Base Type	Shoulder	Widened Lane	
1	8 in.	0.6%	6 in. CTB	FDAC	14 ft	18
2	9 in.	0.6%	4 in. ATB	PCC		22
3	9 in.	0.65%	6 in. CTB	PCC		26
4	9 in.	0.7%	6 in. DAB	5 in. AC		17
5 (ref.)	10 in.	0.65%	4 in. ATB	FDAC		30
6	10 in.	0.65%	6 in. DAB	FDAC	14 ft	28
7	10 in.	0.7%	4 in. ATB	PCC		39
8	10 in.	0.7%	6 in. DAB	PCC		28
9	10 in.	0.7%	6 in. CTB	FDAC		33
10	11 in.	0.7%	4 in. ATB	PCC		47
11	11 in.	0.7%	6 in. CTB	FDAC	14 ft	42
12	12 in.	0.65%	6 in. CTB	PCC		40
13	12 in.	0.7%	4 in. ATB	FDAC		46

Note: CTB= cement treated base; ATB=asphalt treated base; DAB=dense aggregate base
FDAC=full-depth asphaltic concrete; PCC=portland cement concrete; AC=asphaltic concrete

BOTTOM LINE: A COST-EFFECTIVE DESIGN MUST BE SELECTED TO ACHIEVE A COMPETITIVE INITIAL COST.

A sensitivity plot shows how design changes affect longevity and cost. Ideally, a pavement designer should alter a particular design feature and experience as large a percent increase in life for the smallest increase in cost.

The LCCA study concluded that the most cost-effective CRCP design features are the following:

1. The amount of logitudinal reinforcing steel bars, and
2. The slab thickness.

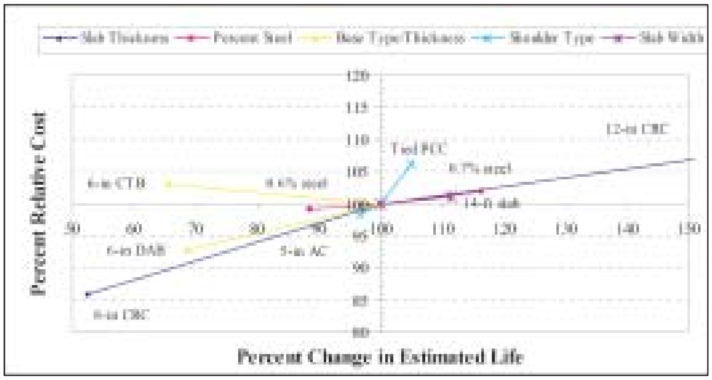
Base type selection also impacts the cost and performance of CRCP, but to a lesser degree than the above, while shoulder type impacts the initial cost, but has less impact on performance. Slab width can also be a cost-effective option for long-lasting performance.

Slab thickness - A 1-inch increase in slab thickness equates to a 5 to 8 percent increase in initial cost and a resulting 5 to 10 years increase in service life. The study showed that 9- and 10-inch-thick slabs can be most cost effective.

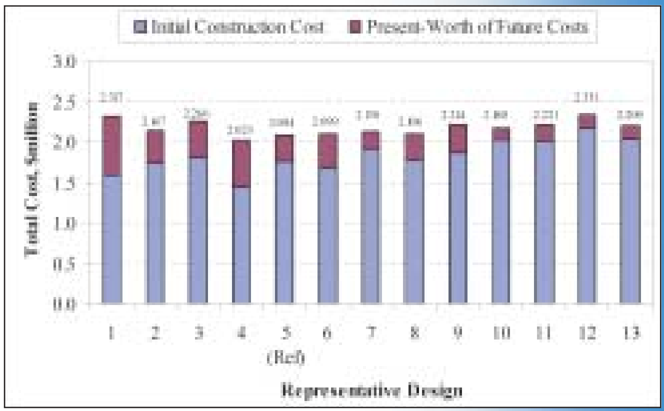
Steel Content - A 0.05 percent increase in steel amount equates to a 1 to 2 percent increase in initial cost and a resulting 3 to 5 year increase in service life. Values in the range of 0.65 and 0.70 percent total steel appear to be the most cost effective.

Slab Width - A 2-foot increase in slab width equates to increasing the initial cost by 2 to 3 percent and a resulting 2 to 3 year increase in service life. Thus, this can be considered a cost-effective option.

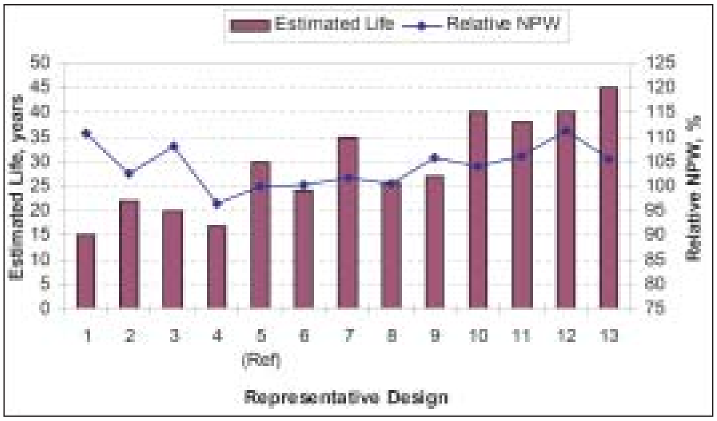
The figure at left shows that Net Present Worth ranges from 96.6 percent (more cost effective) to 111.3 percent (less cost effective). This indicates that for this road type the more economical designs may be those with moderately long service lives - 24 to 35 years (without considering user costs). Net Present Worth improved when CRCP uses higher percentages of longitudinal steel (Des. 7, 10, 11, 13).



Sensitivity Plots for Five Design Features Compared to Reference Design



Reference Design Cross-Section: 10-inch CRCP



Expected Life & Relative Net Present Worth (NPW)

INVEST WISELY IN THE LONG-TERM PERFORMANCE OF CRCP

Corridor Study: Long-Term Performance Of Pavement In Service For Up To 40 Years

In the late 1990s, studies were conducted to compare the performance and associated costs of multiple in-place pavement technologies along interstate highway corridors around the United States. These corridors were selected because of their alternative pavement structures; because they carried similar amounts of traffic, specifically, truck traffic; because they are subjected to similar climatic conditions; because they were constructed under similar situations; and because their construction and maintenance records were available.

One such study, an interstate highway corridor in South Dakota constructed between 1962 and 1974, used doweled jointed reinforced concrete pavement (JRCP), asphaltic concrete pavement (ACP), continuously reinforced concrete pavement (CRCP), and full-depth asphaltic concrete pavement (FDACP).

Original pavement data (design, cost and construction year) and historical rehabilitation data (design, cost and construction year) were obtained from the state highway agency's records. Additional historical and current pavement condition data were documented. All sections in the corridor were built with asphaltic concrete shoulders: 10-foot-wide outside, 4-foot-wide inside.

DESCRIPTIONS OF PAVEMENT TYPES IN CORRIDOR STUDY

Pavement Type & Year(s) Built	Length of Sections	Pavement Structure	Repairs/Rehabilitation
JRCP - jointed reinforced concrete pavement, built 1962 and 1963	46.45 directional miles	9-inch concrete slab, with joint spacings of 46 feet and 1-inch thick dowels, on an untreated aggregate base	Between 1985 and 1994, sections received restoration several times consisting of minor joint and spall repairs and joint resealing. In 1987, four under-bridge sections were reconstructed using jointed plain concrete pavement, with 20-foot joint spacings and no dowels.
ACP - asphaltic concrete pavement, built between 1964 and 1974	47.80 directional miles	4- to 8-inch AC layer, on a 10- or 12-inch untreated or lime-treated aggregate base	Sections originally built in 1964 or 1968 received AC overlays in the late 1970s, late 1980s, and late 1990s, and crack sealing in 1994. Sections originally built in 1974 received cold planing (i.e., milling only) in 1977 and one overlay in 1990
CRCP - continuously reinforced concrete pavement, built 1968 and 1974	53.46 directional miles	8-inch slabs with 0.59 percent longitudinal reinforcing steel, on a 3- to 4-inch lime-treated aggregate base	Sections built in 1968 received minor spall repairs in 1987, whereas sections that were built in 1974 have not received any maintenance or rehabilitation.
FDACP - full-depth asphaltic concrete pavement, built 1974	7.41 directional miles	10.8- or 13-inch AC layer, on a 12 inch untreated or lime-treated aggregate base	Sections received cold milling in 1977 and AC overlays in 1990.

The South Dakota study included a life-cycle cost analysis (LCCA) and a benefit-cost analysis (BCA), which were performed for each section of the corridor. Performance of the original pavements was evaluated using survival analysis. The LCCA included initial construction and various rehabilitation costs over 25 to 40 years, but did not include user cost estimates. LCCA assumptions included inflation rate of 3.77 percent, market interest rate of 7.32 percent, and discount rate of 3.55 percent.

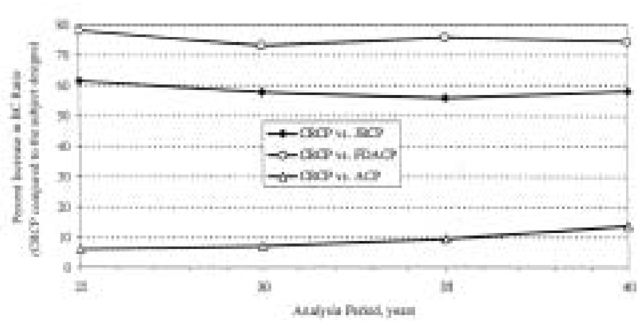
Summary: According to the report, the life-cycle cost study comparisons in the table show the "economic savings due to using CRCP instead of ACP, JRCP and FDACP."

		CRCP	ACP	JRCP	FDACP
No. of Sections		6	10	8	4
Age @ 75% Survival		>25	9	14	6
Age @ 50% Survival		>31	13.5	25	16
Avg. Mean Life		>31	12.1	16.5	16.0
40-yr EUAC, $/lane-mile-yr	Base yr=1968	6,181	6,273	8,537	9,626
	Base yr=1999	19,468	19,757	26,888	30,315
40-yr BC Ratio, compared to CRCP		-	1.14	1.58	1.74

Note: EUAC = equivalent uniform annual cost

COMPARISON OF SERVICE LIFE AND LIFE-CYCLE COSTS

The benefit-cost analysis was conducted using analysis periods of 25, 30, 25, and 40 years. The report says "...the benefit-cost analysis shows that CRCP is more cost effective than ACP, JRCP, and FDACP in the subject corridor." As the figure shows, if CRCP had been used, the BC ratios would have increased 6 to 14 percent compared to ACP, 56 to 61 percent compared to JRCP, and 73 to 78 percent compared to FDACP.



PAVE FOR THE FUTURE BY INVESTING WISELY IN CRCP TODAY!!

Continuously reinforced concrete pavement lasts longer and stays smoother than other pavement types, requires minimal maintenance, and supports overlays better.

Using CRCP means:

- Less cost to owners,
- Less work for maintenance crews,
- Decrease disruptions to traffic, and
- Improved ride comfort for drivers.

These attributes total up to the ultimate, as well as optimum, solution for pavement for this nation's important highway projects.

State and national studies have shown CRCP's superior long-term performance. The Long-Term Pavement Performance (LTPP) program results show that CRCP stays smoother longer. Local state highway districts with CRCP sections can attest to its minimal maintenance requirements. State studies have indicated that overlays perform better on top of CRCP.

Life-cycle cost studies and pavement type comparison studies done by states have resulted in the recent selection of CRCP by the Georgia Department of Transportation, the Illinois State Toll Highway Authority, the Virginia Department of Transportation, the Texas Department of Transportation, and others.

The 2004 report "Life Cycle Analysis of Continuously Reinforced Concrete Pavements" provides detailed information on CRCP performance and cost. The study is based on data collected from actual projects around the United States and uses the latest design procedures validated by actual performance.

CONCRETE REINFORCING STEEL INSTITUTE

Since 1924, the Concrete Reinforcing Steel Institute (CRSI) has fostered the continued growth of reinforced concrete construction through marketing and direct promotion, technical support, research, and code and specification development. CRSI industry members consist of reinforcing steel producers, fabricators, epoxy coaters, distributors, placers, and related industry suppliers. Professional members include designers, engineers and contractors.

CRSI®

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FOR MORE INFORMATION

To learn more about the initial and long-term costs of building continuously reinforced concrete pavements, ask for the "Life-Cycle Cost Analysis of Continuously Reinforced Concrete Pavements" study by contacting CRSI or by visiting www.crsi.org.

AMERICAN IRON AND STEEL INSTITUTE'S BAR AND ROD MARKET DEVELOPMENT GROUP

AISI is a non-profit association of North American companies engaged in the iron and steel industry. The Institute serves as the voice of the North American steel industry, speaking out on behalf of its members in the public policy arena and advancing the case for steel in the marketplace as the preferred material of choice. AISI also plays a lead role in the development and application of new steels and steelmaking technology. AISI comprises 31 member companies, including integrated and electric furnace steelmakers, and 118 associate and affiliate members who are suppliers to or customers of the steel industry.

Under the auspices of the American Iron and Steel Institute, the Bar and Rod Market Development Group strives to grow the market for value-added steel bar and rod products. The group pursues this goal through two task forces committed to developing innovative solutions to the challenges facing their customers and the steel industry.

These task forces include:

- Automotive/Heavy Equipment
- Construction/Infrastructure

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