PLAIN PAVEMENT; AN ECONOMIC ALTERNATIVE

Ralph C. Blum
District Chief Design Engineer and
Clinton E. Solberg
Design Project Engineer
Wisconsin Department of Transportation
Madison, Wisconsin

INTRODUCTION

A current problem facing many State Transportation Departments is the lack of sufficient state dollars for the construction of needed highway improvements. This lack of dollars has, in some states, led to significantly curtailed programs with resultant staff layoffs. The shortage of dollars is further compounded by rampaging inflation in some of the major highway material component costs. The purchasing power of the 1976 dollar is about half of what it was in 1967. Optimization of the few remaining dollars has taken on a new importance. Wherever possible, economies must be realized.

This paper will relate how the Wisconsin Department of Transportation (WDOT), in this period of shrinking dollars and spiraling construction costs, met the challenge of providing a quality concrete pavement at less cost. It will examine in detail the factors that contributed to the decision to change from the usual steel reinforced pavement to a non-reinforced concrete pavement (without mesh or dowels) on a recent freeway project. It will demonstrate that, on a 20-mile (32 km) segment of Interstate Highway 43 (I-43), the WDOT realized a cost reduction of $1.6 million by specifying an 11-inch (275 mm) plain pavement with preformed compression seals in closely spaced skewed transverse joints. It will conclude that WDOT is stretching dollars further as more and more plain pavement is being constructed.

WISCONSIN'S DOLLAR DILEMMA

Historically, gasoline consumption in Wisconsin maintained an annual growth rate of 6 to 8 percent (1). Therefore, sufficient revenues from motor fuel taxes had been available to assure a continuing highway program after other deductions had been made. Both long range planning, and ongoing construction programs were predicated on the continuation of these trends. The energy crisis in 1974, with the attendant levelling of gasoline usage and the associated inflation, put well defined plans and programs into disarray.

Wisconsin Highway Revenues

The sources for Wisconsin's highway revenues are motor vehicle fuel taxes, motor vehicle registration fees, operators and chauffeurs license fees, and motor carrier fees. The greatest portion of these revenues comes from motor fuel taxes (about 63%). The proportionate sources of these funds are listed on Table 1.

TABLE 1 - WISCONSIN HIGHWAY REVENUES (74-75 F.Y.) (1)

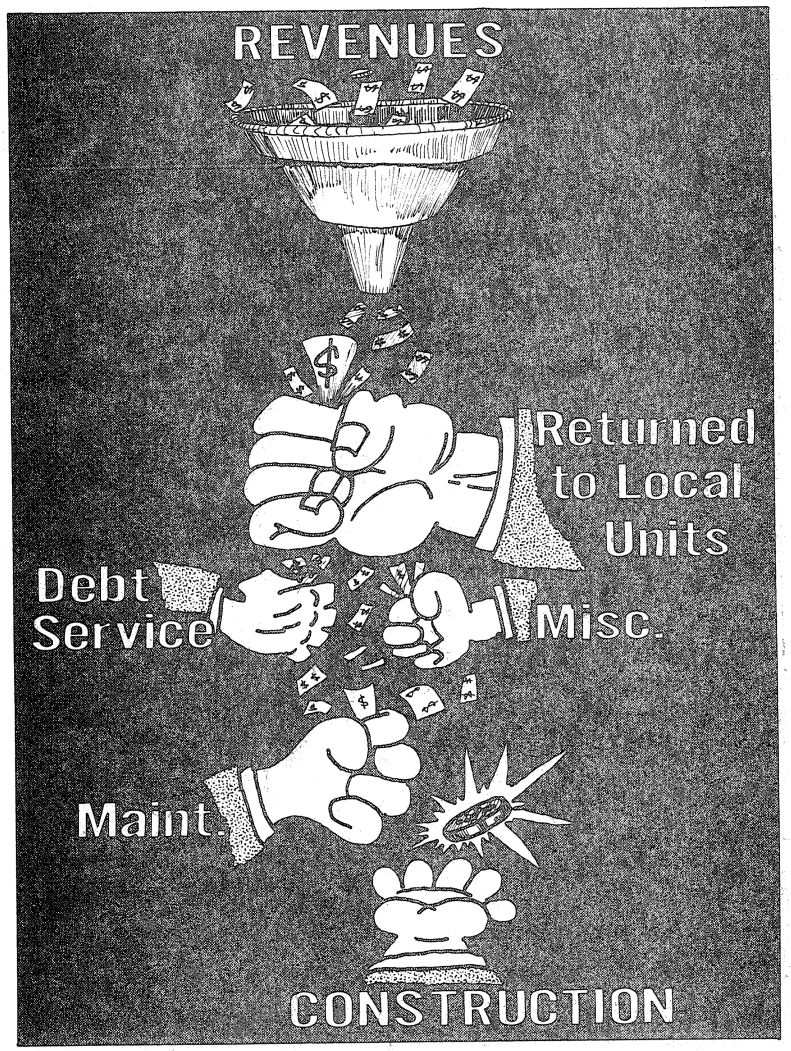
	Dollars ($)	Percent
Motor Vehicle Fuel Taxes	156,115,677	63.0
Motor Vehicle Registration Fees	82,918,676	33.5
Operator's & Chauffeur's Lic. Fees	7,856,993	3.2
Motor Carrier Fees	897,996	0.3
GROSS REVENUES	247,789,342	100.0

The gross revenues maintained an annual average growth rate of 5.8 percent from 1966-1973, however, in 1974 the revenue growth rate slowed to 3.0 percent and in 1975 decreased to 1.2 percent. The reduction in motor fuel tax revenues from $18.6 million in 1971-73 to $0.4 million in 1973-75 was the major cause of this slowdown.

Although the growth rate in revenues has slowed, demands have increased, especially in non-construction related areas.

Highway Fund Disbursements

A number of statutory obligations (1), in addition to the statewide highway construction program, are funded by gross revenues (Figure 1).



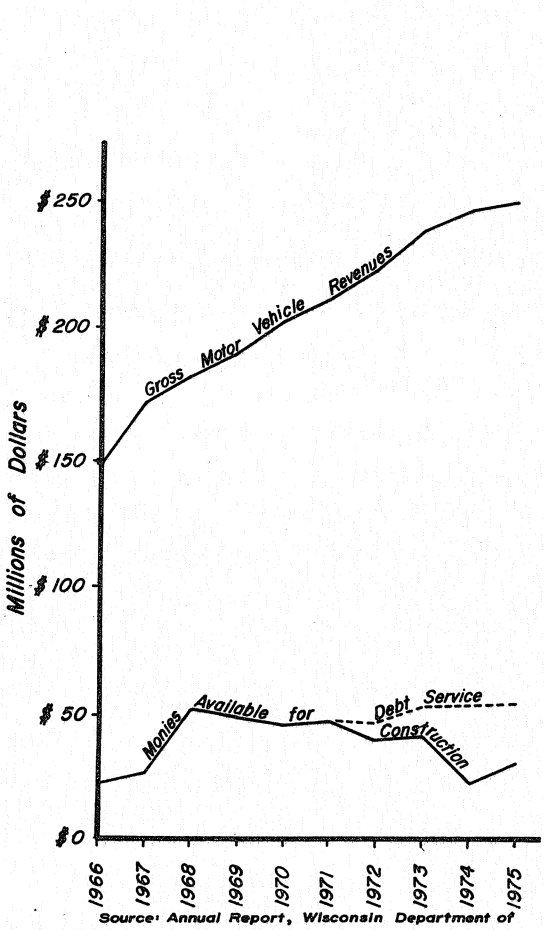
Source: Wis. D.O.T. Bureau of Budget, Finance and Accounting

FIG. 1 Distribution of Wisconsin Highway Fund Revenue.

The major statutory obligation is the revenues returned to local units of government - townships, counties, cities, and villages - in the form of state aids. For the fiscal year ending June 30, 1975, these aids amounted to 43.3 percent of the gross revenues. Debt service, maintenance, and miscellaneous items amount to another 46.3 percent of the revenues. Revenues available for the statewide highway construction program are the balance after funding all other obligations. Therefore, these construction programs must absorb the total slowdown in revenues.

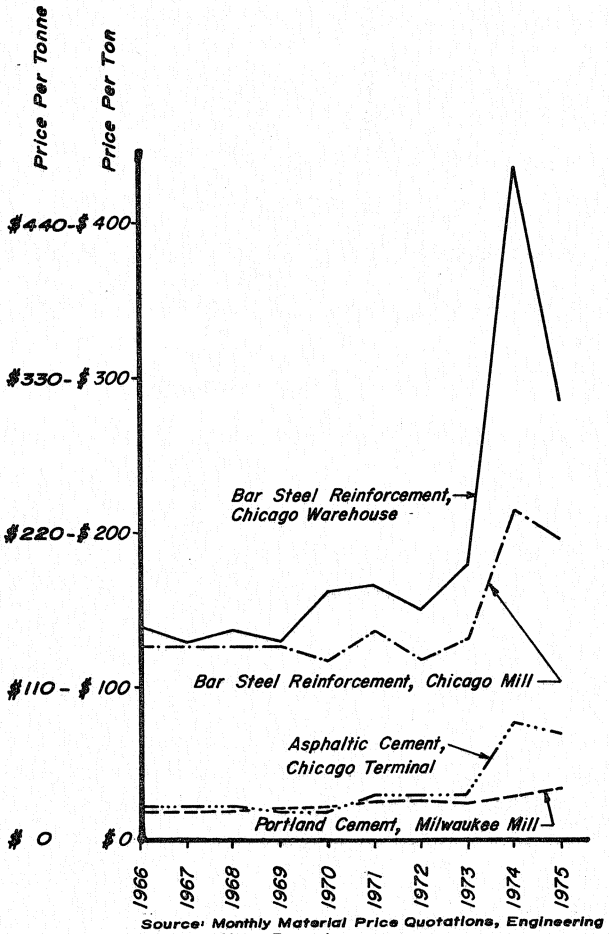
The net effect of the slowdown on construction dollars was a drop from over $40 million in 1973 to $22.4 million in 1974, or nearly a 50 percent reduction. This was the smallest amount of available construction dollars since 1966. Prior to the dramatic drop in 1974, continuing growth in other revenue obligations had caused a moderate decline of construction dollars from the maximum reached in 1968. While gross revenues (Figure 2) have climbed by $100 million since 1966, construction dollars have increased only $1.3 million from 1966 to 1974.

The minimal increase in available construction dollars during the past nine years, in combination with a 100 percent rise in the Cost Index (2) for basic highway construction materials during the same period, necessitated that an in-depth economic analysis be made. The analysis was used to determine if the increases occurred in all highway construction materials or was limited to selective items. It was found that some basic highway construction materials had undergone unprecedented price changes, in particular, reinforcing steel and asphaltic concrete increased by over 100 percent in 1974 (Figure 3). Other basic highway construction materials also experienced an increase, but of a significantly smaller rate.



Source: Annual Report, Wisconsin Department of Transportation.

FIG. 2 Construction Funds Versus Gross Revenue.



Source: Monthly Material Price Quotations, Engineering News Record.

FIG. 3 Prices of Paving Materials.

Construction Program Impacts

As a result of the circumstances prevailing in 1974 - increased inflation and reduction of state construction dollars - the WDOT was forced to cancel or delay numerous highway improvement projects. Schedules were being revised almost weekly and efforts to affect cost savings while maintaining quality were underway in various areas.

One of the principal projects affected was the scheduled paving, in 1975, of a 20-mile (32 km) segment of I-43 between Milwaukee and Green Bay. It appeared that the state dollars needed to pave the 20-mile (32 km) segment would not be available as planned. It was evident that significant cost reductions were necessary if delay in the completion of this important project was to be avoided.

PROJECT BACKGROUND

General

I-43 (Figure 4) will be a key commercial route providing for increased movement of goods between Milwaukee and Green Bay, and also several intermediate cities. It will also serve as an important recreational route, providing improved access to the highly popular Door County area and Wisconsin's northeast vacation land.

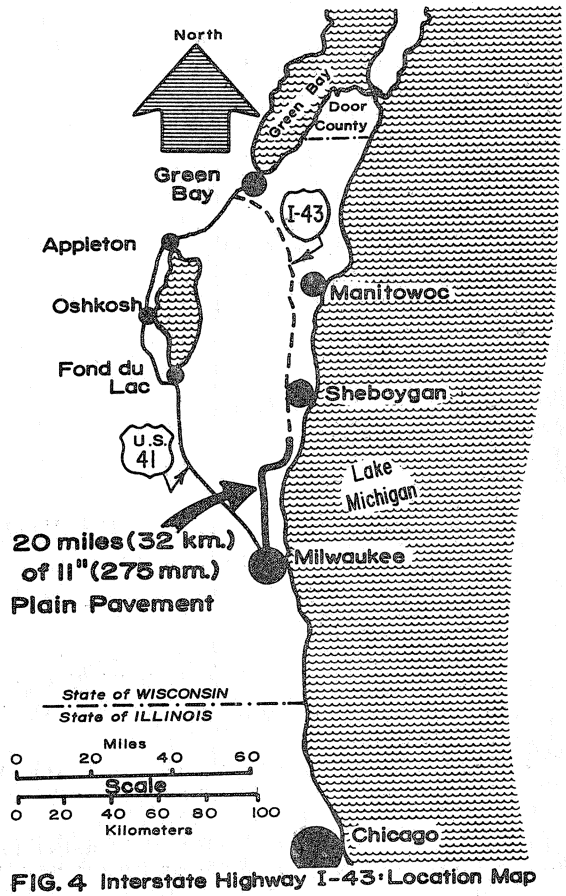


FIG. 4 Interstate Highway I-43 Location Map

I-43 is a rural freeway with two traffic lanes (24 feet) (7.2 m) in each direction. The specific 20-mile (32 km) segment of I-43 extends from Grafton to Cedar Grove. Construction of this segment commenced in 1971 and was essentially completed, except for the paving, in Fall 1974. The paving of the 20-mile (32 km) segment was scheduled for completion in Fall, 1975. The remaining portion of I-43 from Cedar Grove to Green Bay is scheduled for completion in 1981.

Climate

Generally, the climate in this part of Wisconsin is typical of interior North America with a large annual temperature range and frequent short period temperature changes (3). During a year the expected extreme temperatures are 104°F (40°C) and -25°F (-32°C). Mean monthly temperatures range from 72°F (22°C) to 18°F (-9°C). Maximum temperatures reach 90°F (32°C) or above 8 days a year on average. Minimum temperatures of 32°F (0°C) or less, occur 150 days per year.

Mean annual precipitation is 28 inches (710 mm) (4). Frost is present in the soil from December through most of March with average depths of around 18 inches (450 mm) during February (5). It is therefore considered reasonable to apply an AASHO regional factor (R) value of 3 to the I-43 segment (6).

Subgrade Soils

In common with the majority of southeastern Wisconsin, the subgrade soil is glacial in origin (7). It is described as a reddish-brown silty clay with an AASHO classification of A-7-6 and a general rating of fair to poor. The soil support (S) index ranges from 3.8 to 4.5. The modulus of subgrade reaction (R) varies from 125 to 200 psi/in (34 to 45 MPa/m).

Traffic

Traffic forecasts for 1995 on the 20-mile (32 km) segment of I-43 range from an ADT of 35,000 at the southerly end to 15,000 at the northerly terminus. The traffic forecast near the southerly terminus is significantly influenced by Milwaukee area commuter traffic. Forecasted average daily truck traffic (ADTT) by type, for this segment of I-43, over the 20-year period 1975-1995 is listed in Table 2.

TABLE 2 - TRUCK TRAFFIC FORECASTED

Truck Type	Description	1-Way ADTT	18 Kip Equivalents (Driving Lane)
2D	Heavy Truck - 2 axle	192	27
3A	Heavy Truck - 3 axle	54	16
2-S1	Tractor Semi-Trailer - 3 axle	42	18
2-S2	Tractor Semi-Trailer - 4 axle	132	97
3-S2 and over	Tractor Semi-Trailer - 5 axles or more	696	534
	TOTAL	1116	692

From application of loading factors to each truck classification, it is forecasted that the total pavement lane loading will average 692 equivalent 18-kip (8165 kg) axle loads per day, over the 20-year period 1975-1995. The number of 18-kip (8165 kg) axle loads is the primary factor WDOT uses in pavement design procedure.

Pavement Selection

In accordance with contemporary practice, the original pavement analysis report submitted in 1969 recommended a 9-inch (225 mm) mesh and dowel reinforced concrete pavement (RCP). Subsequently, an 8-inch (200 mm) continuously reinforced concrete pavement (CRCP) was given preference. Plans continued to be developed based on an 8-inch (200 mm) CRCP until 1974, when it became apparent that increasing costs would prohibit the construction of the first 20-mile (32 km) section as originally planned.

In response to the critical economic situation which prevailed in late 1974, a re-evaluation of the pavement design was conducted. This re-evaluation resulted in the decision to consider the elimination of all the reinforcing steel from the pavement design

PAVEMENT SELECTION ANALYSIS

Although an 8-inch CRCP had been recommended, the economic dilemma demanded consideration and evaluation of other pavement types that would allow project completion while meeting established performance requirements.

Two possible designs, 9-inch (225 mm) RCP (mesh and dowel), and 11-inch (275 mm) plain concrete pavement (PCP) were used for comparison with the 8-inch (200 mm) CRCP (Figure 5). The 11-inch (275 mm) PCP design was developed using the Brokaw method (8), which employs initial and terminal Pavement Serviceability Index (PSI) values and percentage increases for truck loadings, yielding a thickness required to reach a specified design life.

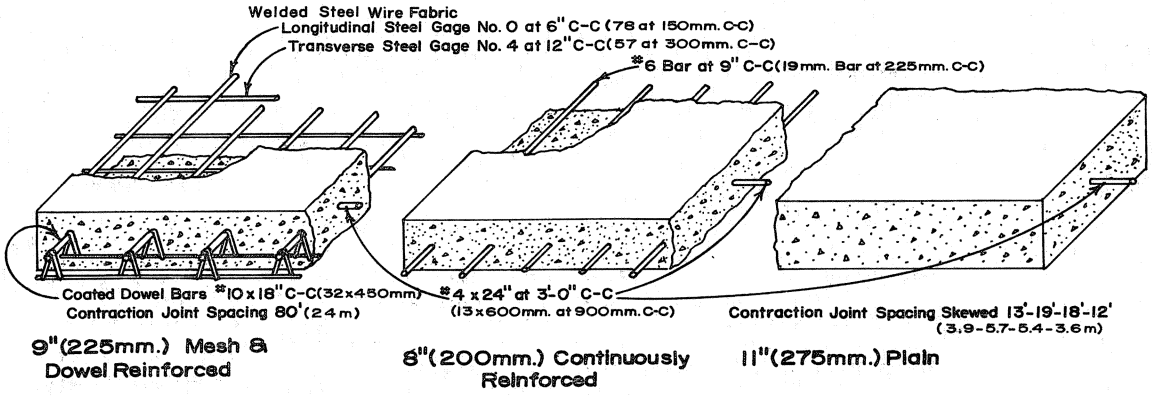


FIG. 5 Pavement Alternatives For I-43.

Once it was determined that the three designs possessed reasonably comparable structural characteristics required by subgrade soil values and traffic loading, the empirical phase of the evaluation could begin. Primary considerations were total pavement cost and potential performance. While establishing a method for comparing pavement costs was fairly straightforward, estimating potential performance would require detailed comparisons of existing pavements from serviceability and maintenance aspects. Based on the results of this analysis the pavement design was selected.

Cost Analysis

Normally, estimated prices for bid lettings are derived by utilizing previous contract costs, and applying adjustments to update to current price levels. However, a more analytical estimate was needed for this project, since no recent prices for PCP were available.

In order to estimate the unit prices, the pavement component parts (cement, steel, joint material, etc.) were costed separately, based on current trade magazine data, vendor estimates, and prevailing wage rates. The component costs were summed providing an estimate of the in-place unit cost. The estimated unit costs for each pavement design are listed in Table 3.

TABLE 3 - ESTIMATED COSTS OF CONCRETE PAVEMENT DESIGNS

Pavement Design	Estimated Unit Cost (Yd^2)	(m^2)	Total Cost*
8-inch (200 mm) CRCP	$9.85	$11.78	$6,530,550
9-inch (225 mm) RCP (mesh and dowel)	8.99	10.75	5,960,370
11-inch (275 mm) PCP	7.45	8.91	4,939,350

*Project quantity 663,000 Yd^2 (554,300 m^2)

When compared to a CRCP, the PCP would reduce the cost nearly 25 percent or $1.6 million.

While the PCP was the least costly, the ultimate test would be the quality of the pavement in place and its long-term performance under traffic. Accordingly, before a final decision could be made, a thorough survey of existing plain and reinforced concrete pavements in Wisconsin was essential.

The History of Plain Pavement in Wisconsin

The use of plain pavement in Wisconsin is more than a half century old. It began in 1913 (9) and by 1917 a total of 267 miles (430 km) of PCP had been constructed. The policy of building PCP remained in effect until 1956, by which time about 4000 miles (6400 km) had been constructed. The pavements did not contain any steel, had various contraction joint spacings [15 feet (4.5 m) to infinity], with thicknesses ranging from 7 to 9 inches (175 to 225 mm), had widths ranging from 14 feet (4.2 m) to 24 feet (7.2 m), and employed a number of methods including ribbon joints and sawing to induce contraction cracking. In 1946, Wisconsin adopted as its standard pavement design a modern PCP design utilizing 15-foot (4.5 m) contraction joints. About 430 miles (692 km) of this short jointed PCP was constructed on many of Wisconsin's major highways. From 1952 to 1956 PCP's were still constructed, however, contraction joint spacings were increased to 40 feet (12.2 m) and 80 feet (24.4 m).

In 1956 RCP (mesh and dowel) gained statewide acceptance. The first CRCP was constructed in 1961. Use of reinforced pavements, either RCP (mesh and dowel) or CRCP, was the practice on all subsequent major paving projects, including the interstate system. PCP was limited in use to urban streets and low volume rural highways.

Comparison of Existing Plain and Reinforced Pavement

To forecast the potential performance of PCP on I-43 an existing segment of USH 41 featuring similar roadways of both PCP and RCP (mesh and dowel) was examined in detail. USH 41 is a 4-lane divided expressway, carrying truck traffic similar to that forecasted for I-43. The segment examined, about 70 miles (112 km) in length, is

between Menomonee Falls and Oshkosh. The northbound lanes are PCP while the southbound lanes are RCP (mesh and dowel), thus providing an excellent opportunity for a comparison of pavement performance.

The northbound plain pavement was constructed between 1952 and 1954. It is 24 feet (7.2 m) wide and 9 inches (225 mm) thick with contraction joint spacings from 20 to 80 feet (6 to 24 m). The southbound RCP (mesh and dowel) was constructed between 1958 and 1962. It is 9 inches (225 mm) thick, 24 feet (7.2 m) wide and has contraction joint spacings ranging from 80 to 100 feet (24 to 30 m). In 1963, truck traffic on the two pavements was approximately 450 equivalent 18 k (8165 kg) axles per day. By 1974, this value had increased to approximately 751 equivalents. The 1974 truck classification data is listed in Table 4.

TABLE 4 - USH 41: 1974 TRUCK TRAFFIC
(South Fond du Lac County Line)

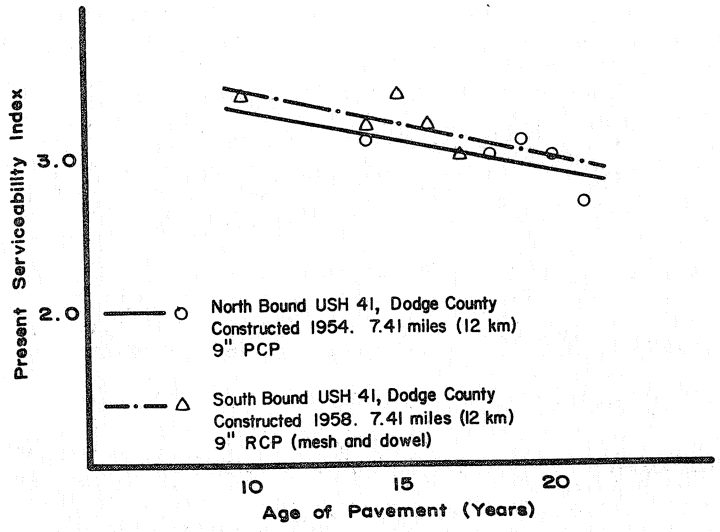
Truck Type	Description	1-Way ADTT	18 Kip Equivalents (Driving Lane)
2D	Heavy Truck - 2 axle	355	53
3-SU	Heavy Truck - 3 axle	40	13
2-S1	Tractor Semi-Trailer - 3 axle	37	17
2-S2	Tractor Semi-Trailer - 4 axle	112	85
3-S2 and over	Tractor Semi-Trailer - 5 axles or more	736	583
	TOTAL	1280	751

PSI values on USH 41 were obtained in 1968 and annually from 1972 through 1975. These PSI values represent a measure of the comparative performance of RCP (mesh and dowel) and PCP. A representative 7-mile (11.3 km) segment of USH 41 was selected to compare pavement performance. The relationship between pavement age and PSI was plotted (Figure 6) for each roadway.

This graphical data yielded the following interpretations:

1. Throughout the period of record the difference in PSI between PCP and RCP (mesh and dowel) is insignificant.

2. The rate of decline in PSI is relatively constant for both pavement designs.



Source: Wisconsin Roadmeter Inventory.

FIG. 6 PSI Comparison on USH 41

Maintenance and Rehabilitation of Concrete Pavements

Concrete pavement failures are hazardous to repair and further result in increased maintenance costs, thereby decreasing dollars available for construction. Experience in Wisconsin indicates that the majority of pavement failures occurred on RCP (mesh and dowel). The CRCP and PCP have required only minimal maintenance.

The majority of RCP (mesh and dowel) was constructed with 80-foot (24 m) contraction joint spacings. These joints were sealed with a rubberized asphaltic filler. The filler formed an adequate seal during the summer but became brittle and failed in winter. The failure of the filler, combined with the longitudinal movement that occurs with 80-foot (24 m) joints, allowed incompressibles to enter. As thermal stresses develop, the joints (containing incompressible materials) fail to function causing the pavement slabs to move longitudinally (Figure 7). As a result, the stress relief appears as pavement blowups or bridge abutment displacements. When closely spaced contraction joints are provided, only minimal evidence of pavement failures (from thermal stress relief) is present. This can be observed on a 12.5 mile (20 km) segment of USH 41 in Winnebago County. The southbound RCP (mesh and dowel) has experienced in excess of 90 blowups while the northbound PCP had only two or three. Similar experiences have been reported by others (11) (12).



FIG. 7 Longitudinal Displacement of Transverse Joint in Reinforced Pavement.

When PCP approaches terminal serviceability, joint faulting normally becomes more evident than on reinforced pavement. It has been suggested that this faulting be corrected before an Asphaltic Concrete (AC) overlay can be applied. Wisconsin experience, however, has proved otherwise and it was found that faulted PCP can be directly overlaid with a minimum of 3 inches (75 mm) of AC. On a 10-mile (16 km) segment of USH 41, an existing PCP has been successfully rehabilitated through the placement of a nominal 3-inch (75 mm) AC mat. Pavement serviceability has been restored to a value equal to (or greater than) the average PSI value (4.2) for newly constructed concrete pavement (Figure 8).

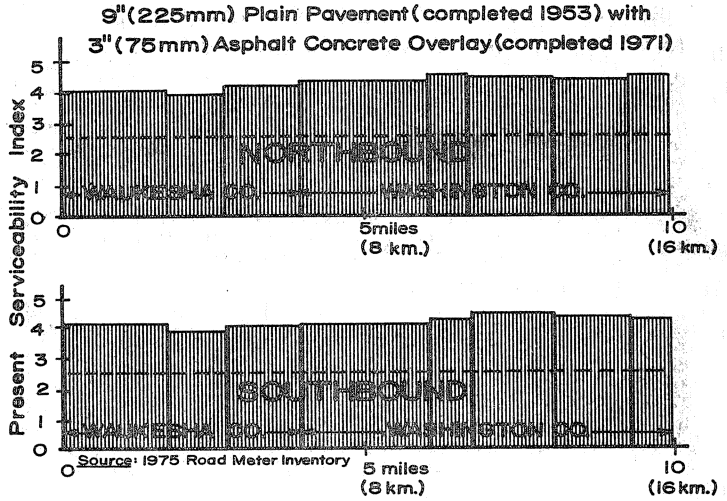


FIG. 8 U.S.H. 41 Serviceability Index of Asphaltic Concrete Overlay on Plain Concrete.

Grinding is also considered a practical technique for the restoration of riding quality on faulted PCP (13). Future concrete pavement maintenance and rehabilitation techniques may focus upon the use of recycled crushed aggregate materials to economically reconstruct pavements in lieu of resurfacing. PCP is better suited to recycling operations, due to the absence of reinforcing steel.

Selection of Pavement Design

To select the pavement design for I-43, the results of the comparative (plain versus reinforced pavement) analysis were considered. Selection criteria included cost, pavement serviceability, traffic, and maintenance (as previously detailed). Cost date indicated that PCP could be constructed for about $1.6 million less than CRCP. Pavement serviceability data indicated that no significant difference in PSI trends exist between comparable PCP and RCP (mesh and dowel) evaluation segments. Traffic analysis data indicated that I-43 is forecasted to experience axle loadings similar, in aggregate, to those recorded on the USH 41 evaluation segment (plain versus reinforced pavement). Maintenance data indicated that the RCP on the evaluation segment had significantly more blowup failures than the PCP. In addition, on both the USH 41 and the I-43 segments the soils displayed similar support values. Upon consideration of this data, it was concluded that a PCP of satisfactory quality could be constructed at less cost.

After selecting a PCP design for I-43, efforts were focused upon the identification and specification of desired design (construction) details. From Brokaw's method (8), an 11-inch (275 mm) pavement thickness on a 6-inch (150 mm) aggregate base (providing the required service life) was selected. In an attempt to attain both optimum rideability and performance, transverse joint design featured:

1. A 9.6° (1 in 6) skew (to reduce instantaneous load transfer).

2. A randomized (13'-19'-18'-12') (3.9 m-5.7 m-5.4 m-3.6 m) spacing (to suppress rhythmic suspension oscillations).

3. An elastomeric compression seal (to insure continued functionality by precluding the accumulation of debris).

Incorporation of these features, not in widespread use when USH 41 was designed, were expected to maximize the PCP performance on I-43. Final estimated cost reductions of a PCP remained at $1.6 million over a comparable CRCP design, even though the final pavement design incorporated all of the above features. While confident that the performance objectives would be satisfied, only upon opening of the bids would the anticipated cost reductions be realized.

BID LETTING

The selection of a PCP design can be economically justified if contract unit bid prices approximate the engineering estimates.

Specifications

The WDOT specifications require that the bid price for concrete paving be submitted on a square yard (Yd^2) unit area basis. It includes supply of all necessary materials and labor to complete the paving exclusive of reinforcement. The standard specifications read as follows:

"This work shall consist of a pavement of Portland cement concrete, with or without reinforcement as shown on the plans... either slip-form or form methods may be used for pavements with rural type or urban type cross sections. ... the yardage completed and accepted shall be paid for at the contract unit price per square yard for concrete pavement, which price shall be full compensation for furnishing, hauling, preparing, placing, curing and protecting of all materials, including cement, concrete masonry, joints and joint materials, dowels, tie bars and spacer bars; for preparing foundation, unless otherwise provided; for filling core holes; and for all labor, equipment, tools and incidentals necessary for constructing the pavement complete, exclusive of reinforcement."

Generally, standard materials and concrete mix specifications were prescribed for I-43 with the exception of the transverse joint seals which were specified to be of the preformed elastomeric compression type (AASHO designation: M220).

An "open to traffic" date of Fall, 1975 for I-43 was specified. The date was selected with the anticipation that the contractors would use standard production rates and equipment normal to a major paving project.

Bid Results

To insure that competition would be spirited and to allow a wider group of contractors an opportunity to bid, the 20 miles (32 km) of paving was divided into four separate projects. Bids were opened on April 15, 1975 and May 20, 1975. PCP bid prices received for each project are listed on Table 5.

Table 5 - 11" (275 mm) PLAIN CONCRETE PAVEMENT BID PRICES - 1975

Contractor	Bid Quantity Yd^2	Bid Quantity m^2	Unit Rate Yd^2	Unit Rate m^2	Total Price
Bonness - Wis.*	106,500	89,000	$7.35	$8.79	$ 782,775
Bonness - Wis.	93,530	78,190	7.41	8.86	693,057
Arcon - Minn.*	202,200	169,060	6.82	8.16	1,379,004
Arcon - Minn.	191,900	160,450	6.82	8.16	1,308,758

*Joseph D. Bonness Co. of Wauwatosa, Wisconsin and Arcon Construction of Mora, Minnesota

All bid prices were within estimated values of $7.45 per Yd^2 ($8.91/m^2). Thus, when compared with the estimates for reinforced concrete pavements, cost reductions were also in close agreement with the amount predicted ($1.6 million).

Bid prices for concrete paving were influenced by the raw material costs. For these projects, cement prices were about $34/ton ($37.50/tonne), F.O.B. Milwaukee and aggregate costs were about $0.85/$Yd^2$ ($1.03/$m^2$) on the job.

Having realized the predicted cost reductions, two vital tasks remained; assurance that the construction schedule would be maintained and assurance that a quality pavement would result.

PAVING OPERATIONS

The low bidders were well equipped contractors with considerable experience in major paving operations.

Rex dual drum continuous batch plants with automatic controls and a production capacity of 9 Yd^3 (7 m^3) per minute were used. Maintaining an average day's production required delivery of 1400 ton (1300 tonne) (74 tanker trucks) of cement, 7500 ton (6400 tonne) of washed aggregate, and 150,000 gallons (468 m^3) of water.

Tri-axle dump trucks were used to transport concrete from the batch plants to the pavers. Slip-form pavers (CMI and Rex) were used attaining a daily output of 6000 feet (1800 m) of 24-foot (7.2 m) pavement. The maximum production rate achieved by one paver was more than 7700 feet (2341 m) per day. Surface texturing on the Arcon projects was accomplished by transverse tining (Figure 9), while on the Bonness projects an Astro-turf drag was used.

The contraction joints were randomly spaced and skewed 4 feet (1.2 m) across the pavement. The contractors were able to saw the 11,250 contraction joints at the rate of 40 joints per hour. Prior to the installation of the 13/16 inch x 1 inch (20 x 25 mm) neoprene seal, the concrete was white sawn to a 3/8-inch x 1-1/2 inch (10 x 38 mm) size. The longitudinal joint was sawn to a 1/8 inch x 2-1/2 inches (3 x 64 mm) size but not sealed.

The riding surface of the pavement produced high PSI readings. The average initial PSI reading of 4.57 was significantly in excess of the 1975 statewide initial PSI average of 4.12 for rural concrete pavement. An unusually high 4.99 PSI value was recorded for one segment.

The WDOT 1975 award for outstanding paving was presented to Arcon Construction for their performance on the I-43 projects. Project completion dates were met and the I-43 projects opened to traffic in the Fall, 1975 (Figure 10).

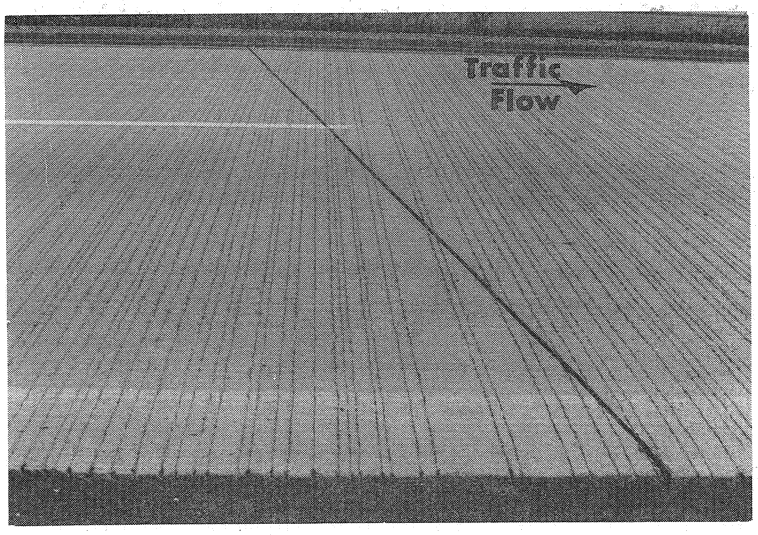


FIG. 9 Contraction Joint and Surface Texture.

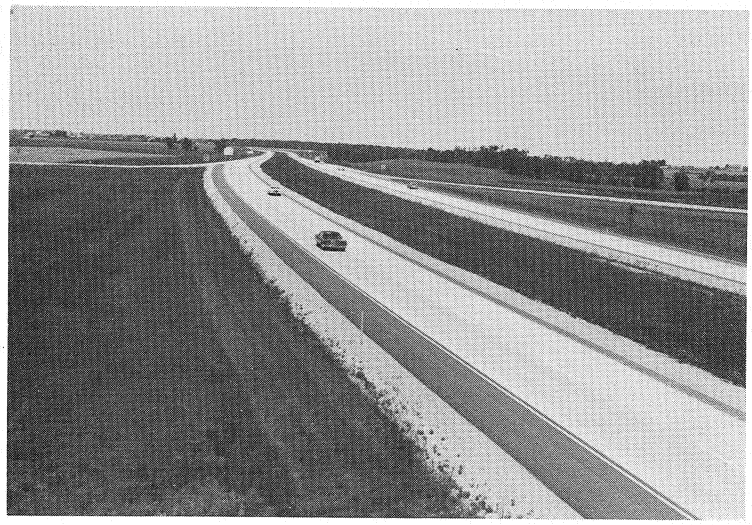


FIG. 10 Interstate Highway 43.

POST I-43 PAVEMENT COSTS

A number of major paving projects were let subsequent to the I-43 projects. Examination of the unit bid prices for PCP and reinforced pavements on the respective projects (Figure 11) revealed that significant cost reductions continue to be realized with each square yard of PCP constructed. On one 1976 project, the STH 15 Freeway, contracts for 755,000 Yd^2 (631,000 m^2) of 10-inch (250 mm) PCP were awarded at an average price of \$5.82/Yd^2 (\$6.96/m^2). Total cost reductions realized by specifying the PCP for STH 15 were estimated to be in excess of \$2 million.

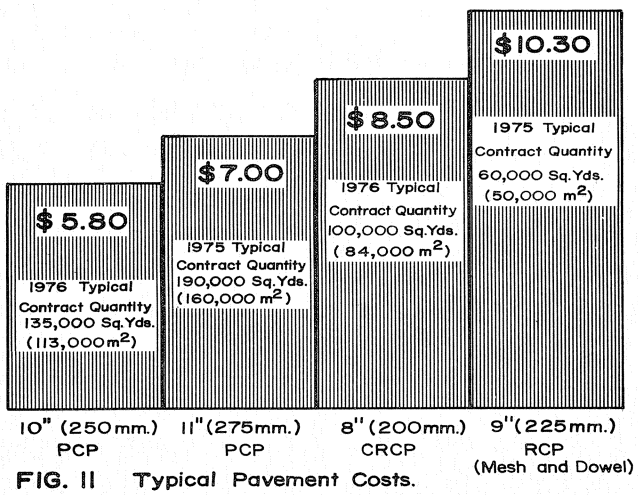
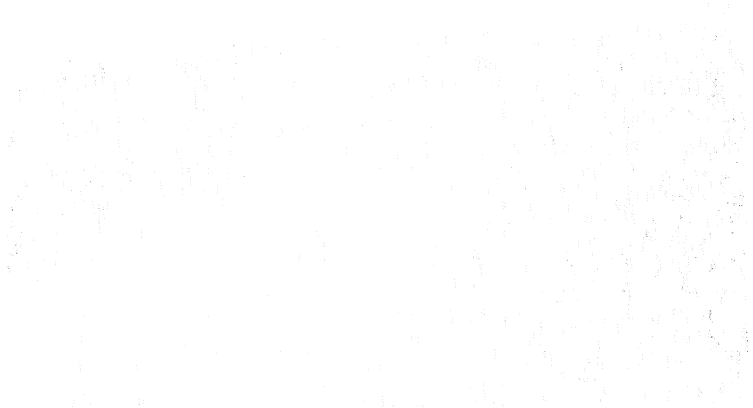


FIG. 11 Typical Pavement Costs.



CONCLUSIONS

Increasing highway costs, coupled with the decreasing construction dollars, have necessitated the search for innovative design alternatives that optimize economies while preserving or enhancing the operational and maintenance characteristics of the facility. Highway engineers in Wisconsin have responded to the acute costs/dollars situation by specifying an 11-inch (275 mm) PCP design as an alternative to the traditional reinforced pavement on a 20-mile (32 km) segment of I-43.

An examination and analysis of the specific aspects of this project reveals the following:

1. The selection of the 11-inch (275 mm) plain concrete pavement design reduced the project cost by $1.6 million.

2. The employment of this design permitted total project funding and completion on schedule, yielding timely accrual of user benefits generated by this interstate highway facility.

3. The 11-inch (275 mm) plain concrete pavement design, featuring skewed, random spaced, neoprene sealed joints, is projected to exhibit satisfactory rideability and serviceability characteristics.

4. This design, employing neoprene sealed joints, is expected to largely eliminate the expensive maintenance repair of pavement blowups by precluding the intrusion of incompressible materials into the contraction joints.

5. The utilization of this design has and is expected to further stimulate additional research of both plain and reinforced concrete pavement designs, the results of which may yield yet greater innovative and economical applications.

6. Finally, plain concrete pavement designs are expected to have a future recycling potential that is more feasible due to the absence of reinforcement.

Cost reductions similar to those achieved on I-43 have also been realized in 1976 by specifying a 10-inch (250 mm) plain concrete pavement on a 26-mile (42 km) segment of STH 15 Freeway. In conclusion, it has been demonstrated that through the use of a modern plain concrete pavement design, the Wisconsin Department of Transportation stretched highway construction dollars. Plain Pavement is indeed an Economical Alternative.

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The opinions, findings, and conclusions expressed in this paper are those of the authors and not necessarily those of the Wisconsin Department of Transportation. The Wisconsin Department of Transportation does not endorse products, manufacturers or contractors. Trade names, manufacturers', and contractors' names appear herein because they are considered essential to the object of the paper.

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