PROJECT SURVEY FOR JRCP

Design Engineer: KT HALL

Date of Survey (mo/day/yr): 8 / 10 / 86

PROJECT INVENTORY DATA

Collect the following information about the project to be evaluated prior to the actual field survey.

Project Identification

Highway Designation (example I-57): I-74

State: ILLINOIS

Direction of Survey: east

Starting Milepost: 183.00

Ending Milepost: 183.90

Climate

Climatic Zone (See climatic zone map in "Supplemental Information"):

✓ wet freeze	___ wet-dry freeze	___ dry freeze
___ wet freeze-thaw	___ wet-dry freeze-thaw	___ dry freeze-thaw
___ wet nonfreeze	___ wet-dry nonfreeze	___ dry nonfreeze

Estimated Annual Temperature Range (degrees Fahrenheit): 68.5

Mean Annual Precipitation (inches) (See precipitation map in "Supplemental Information"): 37

Corps of Engineers Freezing Index (Fahrenheit degree-days) (See Freezing Index map in "Supplemental Information"): 250

Slab Construction

Year Constructed: 1957

Slab Thickness (inches): 10

Width of Traffic Lanes (feet): 12

PCC Modulus of Rupture (28 days, 3rd-point loading)(psi): 650

Area of Longitudinal Reinforcement (square inches steel/foot) (See wire size table in "Supplemental Information"): 0.17

Figure 3. Project survey sheets for I-74 example.

RGH 1: Rideability is acceptable.
RGH 2: Poor rideability is indicated by more than 50 in. of faulting per mile and an unacceptably low PSR for pavement ADT level.
RGH 3: Poor rideability is indicated by 5 in. or more of settlements per mile and an unacceptably low PSR for pavement ADT level.
RGH 4: Poor rideability is indicated by 5 heaves or more per mile and an unacceptably low PSR for pavement ADT level.
RGH 5: Poor rideability is indicated by 25 deteriorated joints per mile or more and an unacceptably low PSR for pavement ADT level.
RGH 6: Poor rideability is indicated by an unacceptably low PSR for pavement ADT level.

Longitudinal joint construction evaluation ratings are defined as follows.

JTC 1: Pavement deterioration may be accelerated by infiltration of water permitted by poor longitudinal joint sealant condition.
JTC 2: A longitudinal joint construction deficiency is indicated by longitudinal joint spalling.
JTC 3: A longitudinal joint construction deficiency, likely because of an inadequate depth of saw cut, is indicated by more than 100 ft of longitudinal cracking per mile.
JTC 4: A longitudinal joint construction deficiency, likely because of late sawing, is indicated by more than 100 ft of longitudinal cracking per mile.
JTC 5: A longitudinal joint construction deficiency, likely because of an inadequate depth of plastic insert placement, is indicated by more than 100 ft of longitudinal cracking per mile.
JTC 6: A longitudinal joint construction deficiency, likely because of use of a plastic joint forming insert, is indicated by more than 100 ft of longitudinal cracking per mile.

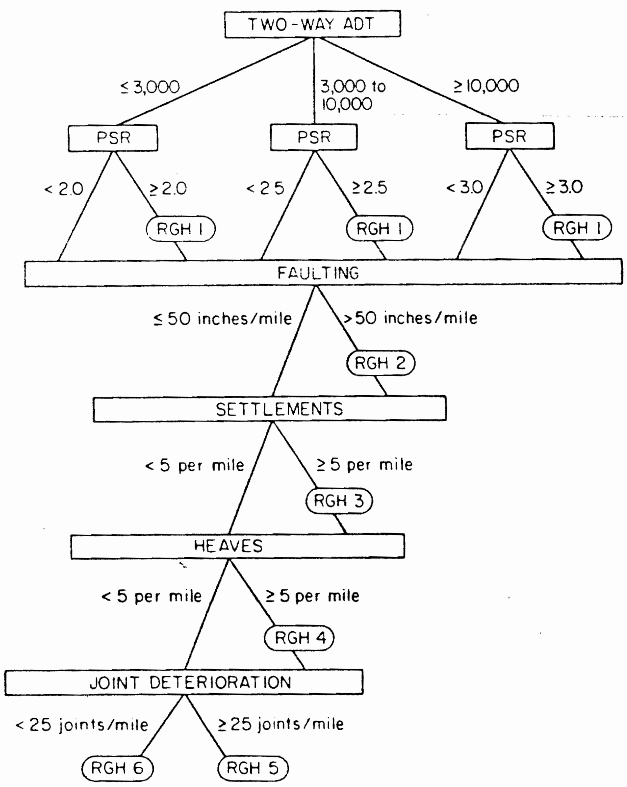

FIGURE 1 Roughness decision tree.

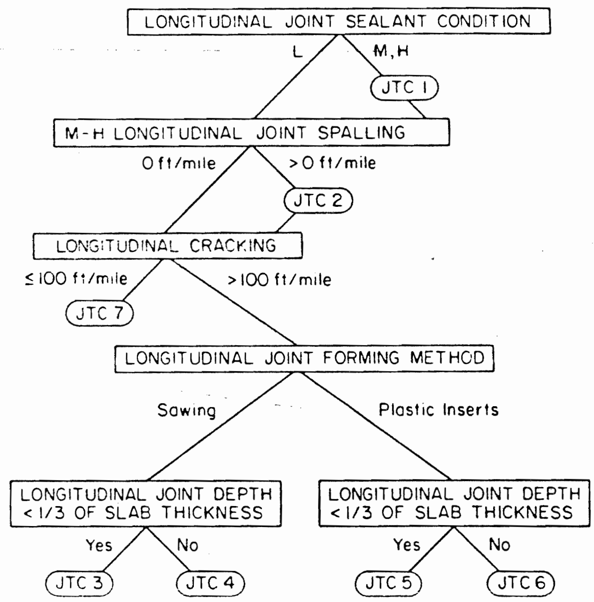

FIGURE 2 Longitudinal joint construction decision tree.

Types of Conclusions

All of the conclusions state as a minimum whether or not a deficiency is indicated by the data and, if so, what factors were significant in reaching this decision. The following conclusion from the drainage decision tree is an example:

> A drainage deficiency is indicated by a wet climate, absence or poor functioning of longitudinal subdrains, and a fine-grained soil base.

An example of multiple paths to a conclusion is the following, from the roughness decision tree. This conclusion can be reached through three different paths, because a difference minimum acceptable PSR is assigned to each of three different ranges of ADT.

> Poor rideability is indicated by 25 or more spalled joints per mile and an unacceptably low PSR for the pavement's ADT level.

The experts believed that some of the conclusions required a little more explanation to justify to the user that the deficiency

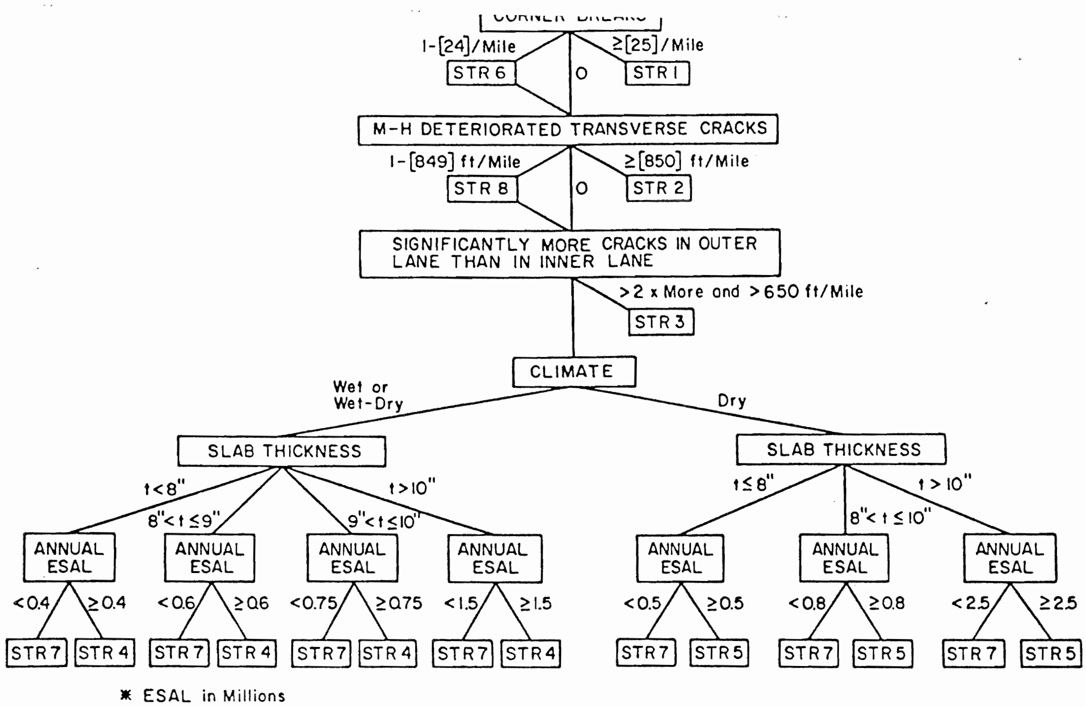

FIGURE 1 Structural deficiency decision tree for JPCP.

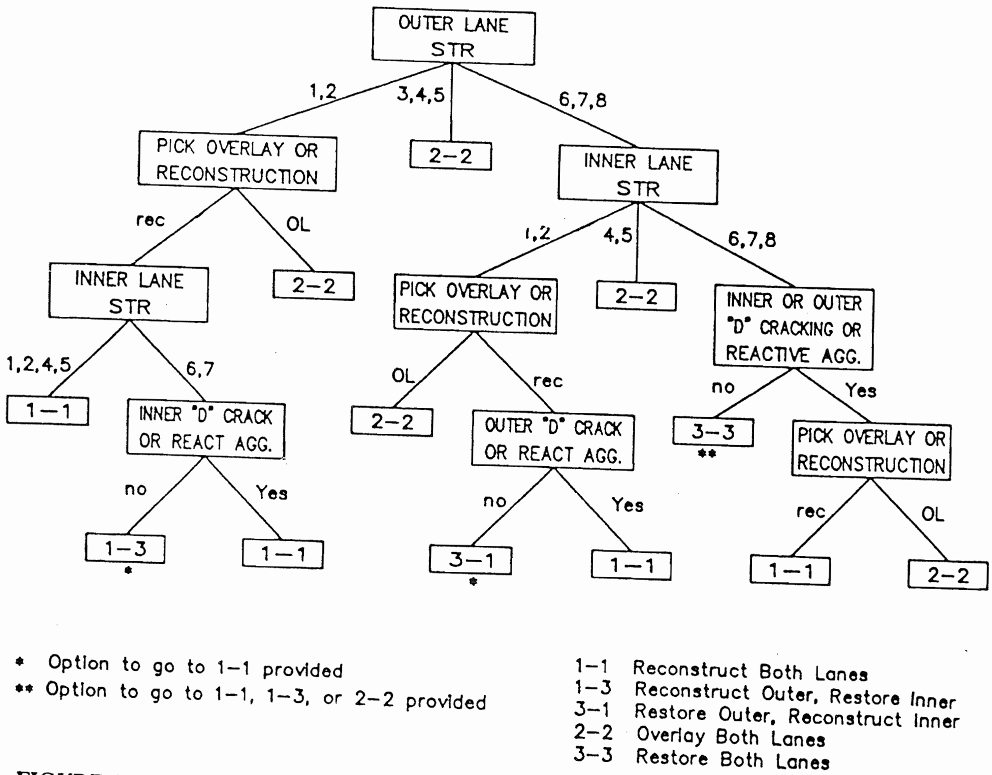

FIGURE 2 Decision tree for selecting rehabilitation approach for JPCP.

CURRENT PAVEMENT EVALUATION

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LANE 1

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JOINT CONSTRUCTION:

The pavement in lane 1 shows no indications of a longitudinal joint construction deficiency.

a. do nothing

The pavement in lane 1 shows no indications of a transverse joint construction deficiency.

a. do nothing

JOINT SEALANT:

A transverse joint sealant deficiency is indicated in lane 1 by medium- to high-severity joint sealant damage and an inadequate joint sealant reservoir shape factor for the existing sealant type.

a. reseal transverse joints

ROUGHNESS:

Poor rideability in lane 1 is indicated by an unacceptably low PSR for the pavement's ADT level.

a. grinding
b. AC nonstructural overlay

DURABILITY:

The pavement in lane 1 shows no indications of significant surface or concrete durability problems.

a. do nothing

JOINT DETERIORATION:

Joint deterioration or other pavement deterioration in lane 1 may be accelerated by water infiltration permitted by poor longitudinal joint sealant condition.

a. reseal longitudinal centerline joint

Some joint deterioration exists (between 1 and 26 joints per mile) in lane 1, likely due to poor joint sealant condition permitting infiltration of water and incompressibles, and large joint movements associated with the long joint spacing.

a. reseal transverse joints, full-depth repair of joints

Figure 4. Evaluation of present condition for I-74 example.

Table 1. Future condition predictions for I-74 example.

DISTRESS AND PSR PROJECTIONS FOR LANE 1

Cumulative ESAL	Annual ESAL	Year	Pumping	Faulting	Deter. Joints	Transverse Cracking	PSR
13.0	0.73	1986	1.0	0.27	21	63	2.6
13.8	0.76	1987	1.1	0.28	22	70	2.4
14.5	0.79	1988	1.2	0.29	23	78	2.4
15.4	0.82	1989	1.3	0.30	24	86	2.4
16.2	0.85	1990	1.4	0.31	25	96	2.3
17.1	0.89	1991	1.5	0.32	26	106	2.3
18.0	0.92	1992	1.6	0.33	27	117	2.2
19.0	0.96	1993	1.7	0.34	28	129	2.2
20.0	1.00	1994	1.8	0.35	29	143	2.1
21.0	1.04	1995	1.9	0.36	30	158	2.1
22.1	1.08	1996	2.0	0.38	32	175	2.0
23.2	1.12	1997	2.1	0.39	33	194	2.0
24.4	1.17	1998	2.2	0.40	34	215	1.9
25.6	1.22	1999	2.3	0.42	36	238	1.9
26.9	1.26	2000	2.4	0.43	37	264	1.8
28.2	1.32	2001	2.6	0.45	39	293	1.8
29.6	1.37	2002	2.7	0.47	40	326	1.8
31.0	1.42	2003	2.8	0.49	42	363	1.7
32.5	1.48	2004	2.9	0.51	44	405	1.7
34.0	1.54	2005	3.0	0.52	45	445	1.6
18-kip millions	18-kip millions		0 - none 1 - low 2 - medium 3 - high	Inches	Joints per mile	Cracks per mile	0-5

NOTE: These projections are estimates of expected performance based on predictive models. They should not be taken as exact values, but instead as relative indicators of performance.

Table 2. Restoration strategy for I-74 example including estimated quantities.

Complete Rehabilitation Strategy for Outer Lane:

Seal longitudinal centerline joint	4752 feet
Full-depth repair of cracks	456 sq yards
Full-depth repair of joints	152 sq yards
Reseal transverse joints	342 feet
Subseal at joints and cracks	78 cubic ft of grout
AC level-up settlements	267 sq yards
Diamond grinding	6336 sq yards
Install/repair longitudinal subdrains	4752 feet

Complete Rehabilitation Strategy for Inner Lane:

Full-depth repair of cracks	424 sq yards
Full-depth repair of joints	152 sq yards
Reseal transverse joints	342 feet
AC level-up settlements	267 sq yards
Diamond grinding	6336 sq yards
Install/repair longitudinal subdrains	4752 feet

Complete Rehabilitation Strategy for Outer Shoulder:

Reconstruct shoulder with PCC	5280 sq yards
Reseal lane/shoulder joint	4752 feet

Complete Rehabilitation Strategy for Inner Shoulder:

Reconstruct shoulder with PCC	3168 sq yards
Reseal lane/shoulder joint	4752 feet

[1 ft = 0.3048 m, 1 sq yard = 1.2 sq m, 1 cubic ft = 0.028 cubic m]

PSR

$$PSR = 4.5 - ESAL^{0.424} (-0.00188 + 14.417\ RATIO^{3.58}$$
$$+ 0.0399\ PUMP + 0.0021528\ JTSPACE + 0.1146\ DCRACK$$
$$+ 0.05903\ REACTAGG + 0.00004156\ FI$$
$$+ 0.00163\ SUMPREC - 0.070535\ BASETYPE)$$

where:

PSR = Present Serviceability Rating

ESAL = accumulated 18-kip [80 kN] equivalent single-axle loads since construction, millions

RATIO = Westergaard's edge stress/PCC slab modulus of rupture (see following page to calculate Westergaard's edge stress)

PUMP = pumping severity (from pumping model)
= 0, if none or low severity (≤ 1)
= 1, if medium or high severity (> 1)

JTSPACE = transverse joint spacing of pavement, ft

DCRACK = D cracking severity
= 0, if none
= 1, if low, medium, or high severity

REACTAGG = reactive aggregate distress severity
= 0, if none
= 1, if low, medium, or high severity

FI = mean Freezing Index, Fahrenheit degree-days

SUMPREC = average annual precipitation, cm (= 2.54 * inches)

BASETYPE = type of base under PCC slab
= 0, if granular base
= 1, if stabilized base (cement, asphalt, etc.)

R^2 = 0.78
n = 377
SEE = 0.30

Source: NCHRP 1-19 (6)

Table 2 — EXPEAR analysis results of AZ 1-6

Pavement design	
Highway:	Route 360 near Phoenix
Pavement type:	9 in. JPCP
Year constructed	1981
Joint spacing:	15-13-15-17
Dowels:	Undoweled
Base:	4 in. lean concrete
Subgrade:	A-6
Shoulders:	Tied PCC outer, AC inner
Drains	No drains
Traffic	
Current 2-way ADT:	97,770
Percent trucks:	3.8
Lanes each direction:	3
Accumulated Esal:	2.01 million (outer lane)
Existing pavement condition	
Year surveyed:	1987
PSR:	3.5
Deteriorated cracks:	0/ mile
Deteriorated joints:	5/ mile 20/ mile
Joint faulting:	0.01 in.
Longitudinal cracks:	0 ft/ mile
Pumping:	None
PCC surface:	Tined, not polished
Joint sealant damage:	Medium severity (resealed 1986)
"D" cracking:	None
Reactive aggregate:	None
Settlements/ heaves:	None
Shoulder condition:	Excellent
Lane/ shoulder joint:	Fair
Physical testing recommendations	
No physical testing warranted	

Future condition without rehabilitation		
Some joint deterioration is present, but no significant increase of any type of deterioration is predicted over the next 20 yr period.		
Consequence of delaying rehabilitation		
Rehabilitation may safely be delayed. Some joint resealing and joint spall repair is recommended.		
Predicted life of rehabilitation		
Alternative	Years	Unacceptable
Restoration	20+	
3 in. ACOL	7	Ref. cracking
5 in. crack/ seat AC OL	6	Rutting
3 in. saw/ seal AC OL	8	Rutting
3 in. bonded PCC OL	20+	
8 in. unbonded PCC OL	20+	
9 in. reconstruction	20+	
Results of life-cycle cost analysis		
Alternative	Initial cost	Annual cost
Restoration	59,200	3,800
3 in. AC OL	274,600	41,500
5 in. crack/ seat AC OL	273,200	47,500
3 in. saw/ seal AC OL	284,300	38,200
3 in. bonded PCC OL	368,800	23,400
8 in. unbonded PCC OL	514,200	32,600
9 in. reconstruction	506,000	32,000
Cost per 2-lane mile, based on predicted lives shown above (20 yr for bonded overlay, unbonded overlay, and reconstruction) and discount rate of 3 percent.		
Recommended rehabilitation (1989)		
Minor restoration work (spall repair and joint resealing) could be done to improve rideability and prevent water and incompressible infiltration.		
Rehabilitation techniques	Quantity	
Full-depth repair of joints	200 sy	
Reseal transverse joints	9450 ft	
Reseal lane/ shoulder	10560 ft	
Quantity per 2- lane mile and shoulders		

sesses the capabilities to do life-cycle cost analysis and delay rehabilitation up to five years.

EXPEAR was developed in the form of a knowledge-based expert system, that simulates a consultation between an engineer and an expert in concrete pavements. EXPEAR uses information about the pavement to guide the engineer through an evaluation of a pavement's present condition and development of one or more feasible rehabilitation strategies. The procedure was developed through extensive interviewing of authorities on concrete pavement performance. In addition, predictive models are used to estimate future pavement performance with and without rehabilitation.

Sections evaluated

The database developed for the RPPR study includes 95 sections of JPCP and JRCP in their first performance period.[6] Thirteen of these sections were selected for evaluation with the EXPEAR program. The sections, both JRCP and JPCP and located in all four major climatic zones, are listed in Table 1. The condition of each section was subjectively assessed as good, fair, or poor on the basis of observed distress and serviceability.

Pavements rated as "good" had little or no cracking or joint deterioration, minimal joint faulting, no pumping, and a Present Serviceability Rating (PSR) of 3.5 or more. "Fair" pavements had at least one of the following: moderate cracking and/or joint deterioration (due to "D" cracking or reactive aggregate distress), moderate to high faulting (exceeding the critical level), visible pumping, or serviceability less than 3.5.

Pavements rated as "poor" had at least two and in most cases three or four of the following: substantial cracking and/or joint deterioration (exceeding critical levels), high faulting (exceeding the critical level), visible pumping, and PSR less than 3.0.

Evaluation procedure

All EXPEAR input data required for each section were obtained from the database. The following steps were carried out for each of the 13 projects.

Table 12. Results of EXPEAR analysis of CA 6.

EXPEAR CASE STUDY: **CA 6**

PAVEMENT DESIGN

Highway:	Route 14 near Solemint
Pavement type:	9-in JPCP
Year constructed:	1980
Joint spacing:	12-13-15-14 ft
Dowels:	Nondoweled
Base:	4.2-in lean concrete
Subgrade:	A-2
Shoulders:	AC
Drains:	Drains present

TRAFFIC

Current 2-way ADT:	46,000
Percent trucks:	9.0
Lanes each direction:	3
Accumulated ESAL:	4.43 million (outer lane)

EXISTING PAVEMENT CONDITION

Year surveyed:	1987
PSR:	3.4
Deteriorated cracks:	0/mi
Deteriorated joints:	2/mi
Joint faulting:	0.15 in
Longitudinal cracks:	51 ft/mi
Pumping:	None
PCC surface:	Tined, not polished
Joint sealant damage:	High severity (not sealed)
D-cracking	None
Reactive aggregate:	Low severity
Settlements/heaves:	None
Shoulder condition:	Excellent
Lane/shoulder joint:	Poor

PHYSICAL TESTING RECOMMENDATIONS

Coring at representative deteriorated transverse joints. Coring at longitudinal joint and crack. Test strength of PCC surface and lean concrete base.
Observe erosion at top of lean concrete base.
Petrographic exam of PCC for aggregate reactivity.

1 in = 25.4 mm
1 ft = 0.3048 m
1 mi = 1.609 km

FUTURE CONDITION WITHOUT REHABILITATION

Faulting:	> 0.12 in in 1987
Cracking:	No problem
Joint deter.	No problem

CONSEQUENCE OF DELAYING REHABILITATION

Faulting is currently unacceptable.

PREDICTED LIFE OF REHABILITATION

Alternative	Years	Unacceptable
Restoration	6	Joint deterioration
3-in AC OL	8	Rutting and refl. crk.
5-in AC OL (crack & seat)	9	Rutting
3-in AC OL (saw & seal)	12	Rutting and refl. crk.
7-in UB PCC OL	20+	

RESULTS OF LIFE-CYCLE COST ANALYSIS

Alternative	Initial Cost	Annual Cost
Restoration	248,843	43,299
3-in AC OL	312,893	42,015
5-in AC OL (crack & seat)	406,812	49,249
3-in AC OL (saw & seal)	335,809	31,799
7-in UB PCC OL	619,443	39,246

Based on predicted lives shown above and discount rate of 3 percent.

RECOMMENDED REHABILITATION (1989)

3-in AC overlay with sawed and sealed joints is the most cost-effective alternative with a life of about 12 years (rutting reaches 0.5 in 11 years and reflection cracking reaches 75/mi in 15 years).

Rehabilitation Technique	Quantity*
Full-depth repair of joints	434 sy
Full-depth repair of cracks	10 sy
Reseal transverse joints	9910 ft
Reseal lane/shoulder joint	10560 ft
3-in AC OL and saw & seal jts.	22293 sy