State of Illinois
DEPARTMENT OF PUBLIC WORKS AND BUILDINGS
Division of Highways
Bureau of Research and Development

EVALUATION OF A FLEXIBLE PAVEMENT IN ILLINOIS

Final Report for Project IHR-27, Flexible Base Pavement

A Research Study

by

Illinois Division of Highways
in Cooperation with
U.S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

The opinions, findings, and conclusions expressed
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June 1970

ABSTRACT

The performance of a bituminous-concrete surfaced aggregate-base pavement built in 1952-53 was observed over a 12-year period of service to primary highway traffic. The performance was not as good as anticipated by the original designers on the basis of the design procedure they had applied. This procedure was abandoned several years ago in favor of a procedure based on the AASHO Road Test findings. Information from the performance study was used where modifying the AASHO Road Test formulas to recognize practical service experience.

SUMMARY

This report describes a demonstration type of study in which a bituminous-concrete surfaced aggregate-base pavement was constructed and its service performance observed over a 12-year period. The study was designed to provide information on this type of pavement when serving primary highway traffic in Illinois. The structural design was selected by the original designers, based on information available to them at the time (1951), as having a potential for affording about the same performance as typical rigid pavements then being constructed in Illinois. Its performance was not up to expectations.

When the current Illinois flexible pavement design procedure for which the AASHO Road Test findings served as a basis was developed, the results of the study reported herein were used to provide modification that would account for the differences between service and exposure conditions at the Road Test and those existing in the more normal situation.

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EVALUATION OF A FLEXIBLE PAVEMENT IN ILLINOIS

The Illinois Division of Highways, in 1952, undertook an experimental demonstration type of project that involved the construction and subsequent evaluation of a bituminous-concrete surfaced aggregate-base pavement. The purpose of the experimentation was to assess the serviceability of this type of pavement in Illinois when subjected to a relatively high volume of heavy axle loads. The primary highway system in Illinois at the time was built almost entirely of portland cement concrete, and the project was to explore the feasibility of using the flexible-pavement alternative on this system. Considerable experience already was available in the low-volume and light-axle load situation. The structural design of the pavement was based on an empirical procedure in use at the time, involving soil classification, drainage, frost penetration, and anticipated volume of truck traffic.

The construction techniques and procedures that were used were principally those of the Illinois Standard Specifications for Road and Bridge Construction in use at the time.

To assist in the analysis of pavement behavior, special detailed observations of the construction process were made while the construction work was in progress, and numerous material samplings in addition to those made on an ordinary construction project were made during the course of the work. Condition surveys were made periodically following construction during most of the service life of the pavement.

During the first few years of its service life, the experimental pavement was not subjected to a high intensity of traffic because of the lack of suitable outlets to through routes. In the later years of service, and until its retirement in 1969, the pavement served a relatively high volume of heavy traffic. Retirement consisted of resurfacing of the two-lane pavement which had carried traffic in both directions during its service life, to serve as the southbound pavement of a divided highway (Interstate 57).

The research project under which the experimental observations have been made is identified as IHR-27, Flexible Base Pavement. The research was conducted by the Illinois Division of Highways in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads.

This project was a principal source of information on the performance of flexible pavement subjected to normal mixed traffic at the time the Illinois Division of Highways was engaged in developing its current pavement design procedure based on the results of the AASHO Road Test. Data from this project were used to modify the Road Test formulas to bring the predictions of pavement serviceability into better accord with practical experience.

This final report of the project presents details on the performance of the experimental pavement through 12 years of service, and on the many factors that were observed and believed related to this performance.

DESCRIPTION OF PROJECT

Location

The construction section under consideration is identified as FA Route 26, Section 140G, RS, FI-29(14), Kankakee County. It is 4.58 miles in length and lies immediately south of Kankakee (Figure 1).

Climate

The experimental project is located in an area having an average annual precipitation of about 34 inches, fairly evenly distributed throughout the four seasons. Temperatures at the site range from a mean average summer temperature of 76F to

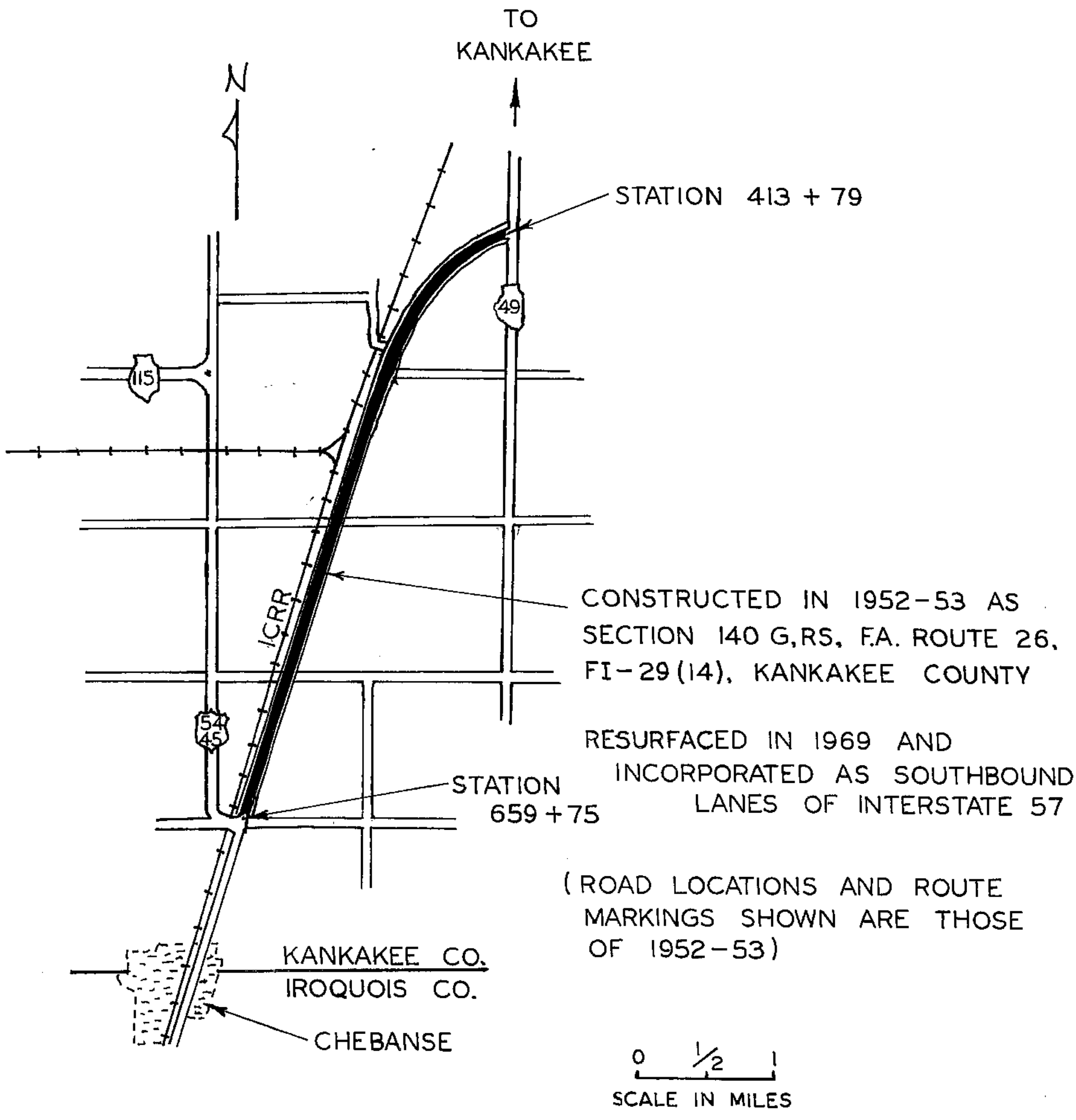

Figure 1. Location of demonstration project.

a winter mean average of 25F. Summer temperatures sometimes reach 100F or higher, while winter temperatures may drop below zero. The depth of frost penetration at the test site averages about 25 inches, with some alternate freezing and thawing at the immediate surface. Frost penetrations of over 40 inches have been known to occur during severe winters.

Physiography

The topography in the area of the demonstration project is level to gently undulating, with elevations varying from about 620 to 675 ft above sea level. The portion of the project north of about Station 610 lies within an area known geologically as the Kankakee Plain. The terrain here is quite flat except for occasional sand ridges, and bedrock lies within a few feet of the surface. The portion of the project south of Station 610 lies within what is known as the Marseilles Moraine. This area is flat to gently rolling.

Soil

The surface of the Kankakee Plain within the area of the project is covered with a variety of soils ranging from sand to clay. The low ridges that rise above the otherwise flat terrain are composed mostly of AASHO Class A-2-4(0) sand. Within the flatter areas, sandy loams, sandy clay loams, and clay loams predominate. Typically, AASHO classifications range from A-4(2) to A-6(8). Drainage is poor and often hampered by the bedrock lying close to the surface.

Fine-grained soils predominate in the Marseilles Moraine area. Drainage is considered to be only fair because of the low permeability of the glacial till soil. Clay loams and clays, ranging from A-6(10) to A-7-6(13), predominate.

Following are some typical results of routine physical test determinations for the soils of the area.

Atterberg Limits			Texture					
LL (%)	PL (%)	PI (%)	Sand (>.05 mm) (%)	Silt (.05-.005 mm) (%)	Clay (<.005 mm) (%)	CBR	Textural Class	AASHO Class
-	-	NP	84	9	7	19	Sand	A-2-4(0)
26	20	6	58	23	19	11	SdLm	A-4(2)
24	13	11	51	28	21		SdCLm	A-6(3)
35	18	17	43	35	22	7	ClLm	A-6(8)
33	15	18	31	31	28		ClLm	A-6(10)
42	20	22	11	39	50	5	Clay	A-7-6(13)

DESIGN FEATURES

The structural design of the demonstration pavement was developed as stated previously through application of a policy and procedural manual in use in Illinois at the time the pavement was designed (1951). Subgrade soil type, drainage conditions, depth of probable frost penetration, and anticipated traffic all were taken into consideration. Based on the criteria in force at the time, it was determined that the main structural elements of the pavement should total 18 1/2 inches in thickness. Individual thicknesses were set more or less arbitrarily at 4 1/2 inches for the bituminous concrete surfacing, 9 inches for the base that eventually was constructed of a dense-graded crushed stone, and 5 inches for the subbase which eventually was constructed of the same stone as used in the base. In addition, foundation courses of sand borrow 4, 5, and 7 inches in thickness, dependent on the underlying soil types and drainage conditions, were specified. The sand borrow course was identified in the construction contract as "Subbase (Special)" and the same term will be used to identify it through the remainder of this report. A typical cross section of the pavement construction is shown in Figure 2. Locations where the Subbase (Special) was used are shown in Figure 3.

Pipe drains were placed longitudinally at a number of cut locations where a high water table was anticipated. A typical cross section of the longitudinal drainage system is shown in Figure 4. The drains were installed at the following

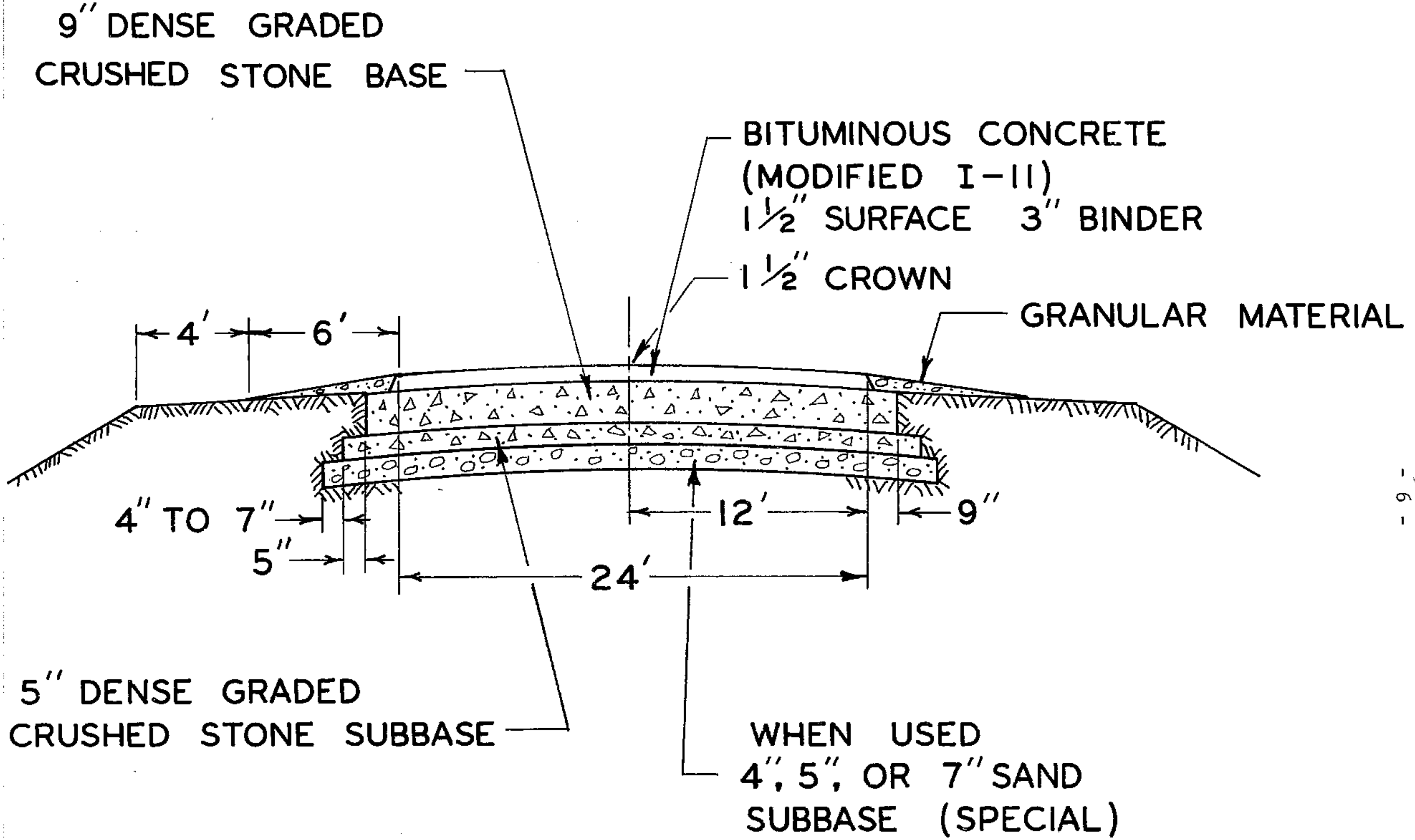

Figure 2. Typical cross section for pavement.

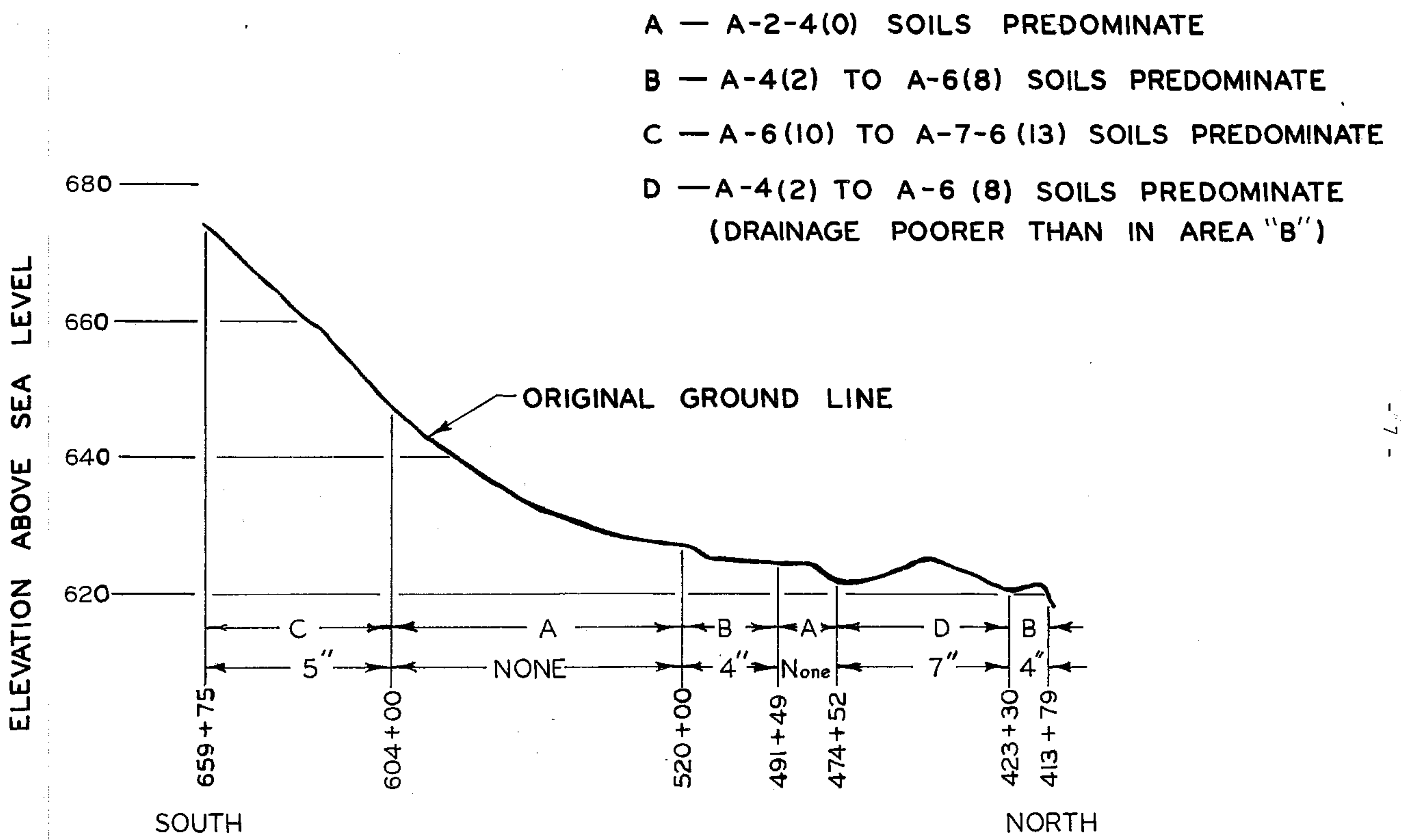

Figure 3. Subbase (Special) usage.

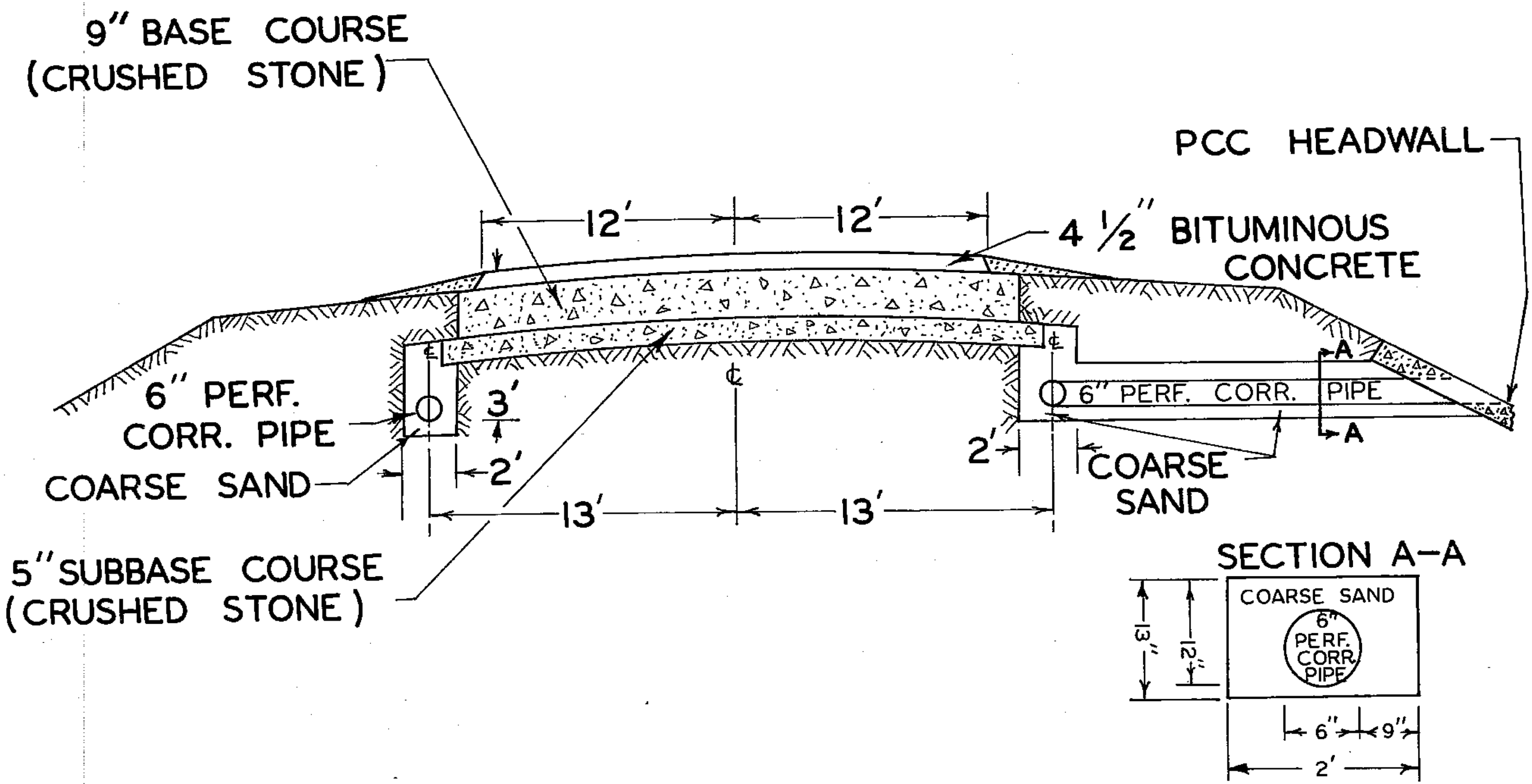

Figure 4. Typical cross section for longitudinal drainage system.

locations: Stations 479+79 to 487+50; Stations 518+50 to 533+00; and Stations 574+50 to 588+00.

Pipe drains were placed transversely at 500-ft intervals throughout the project except where the longitudinal drains were used. A typical cross section of the transverse drainage systems is shown in Figure 5.

A departure from standard Illinois practice was the use of "proof-rolling" with a super-load compactor to locate weak spots in the embankment. The compactor as shown in the photograph of Figure 6 had the following features:

(1) a hopper capacity of 448 cu ft

(2) a rolling width of 8' 10"

(3) four rolling wheels arranged to oscillate independently in pairs

(4) 18.00 x 24 24-ply tires

(5) tire pressure of 90 psi

(6) 35-ton load

Testing consisted of four passes over each unit of embankment within the pavement area. The results that were obtained with the super-load compactor will be described in a following section of the report.

During testing with the super-load compactor, an extensive area of instability was discovered between Stations 414 and 483. Correctional treatment consisted of placing an additional 6-inch thickness of crushed stone of 1 1/2- to 2-inch nominal size in three 2-inch lifts over the Subbase (Special) or natural soil subgrade. This crushed stone was choked mostly with stone screenings, but sometimes with the same sand material that was used in the Subbase (Special).

CONSTRUCTION

Embankment

Specifications required the embankment material to be compacted to not less than 90 percent of the maximum wet-weight density as determined by the procedure

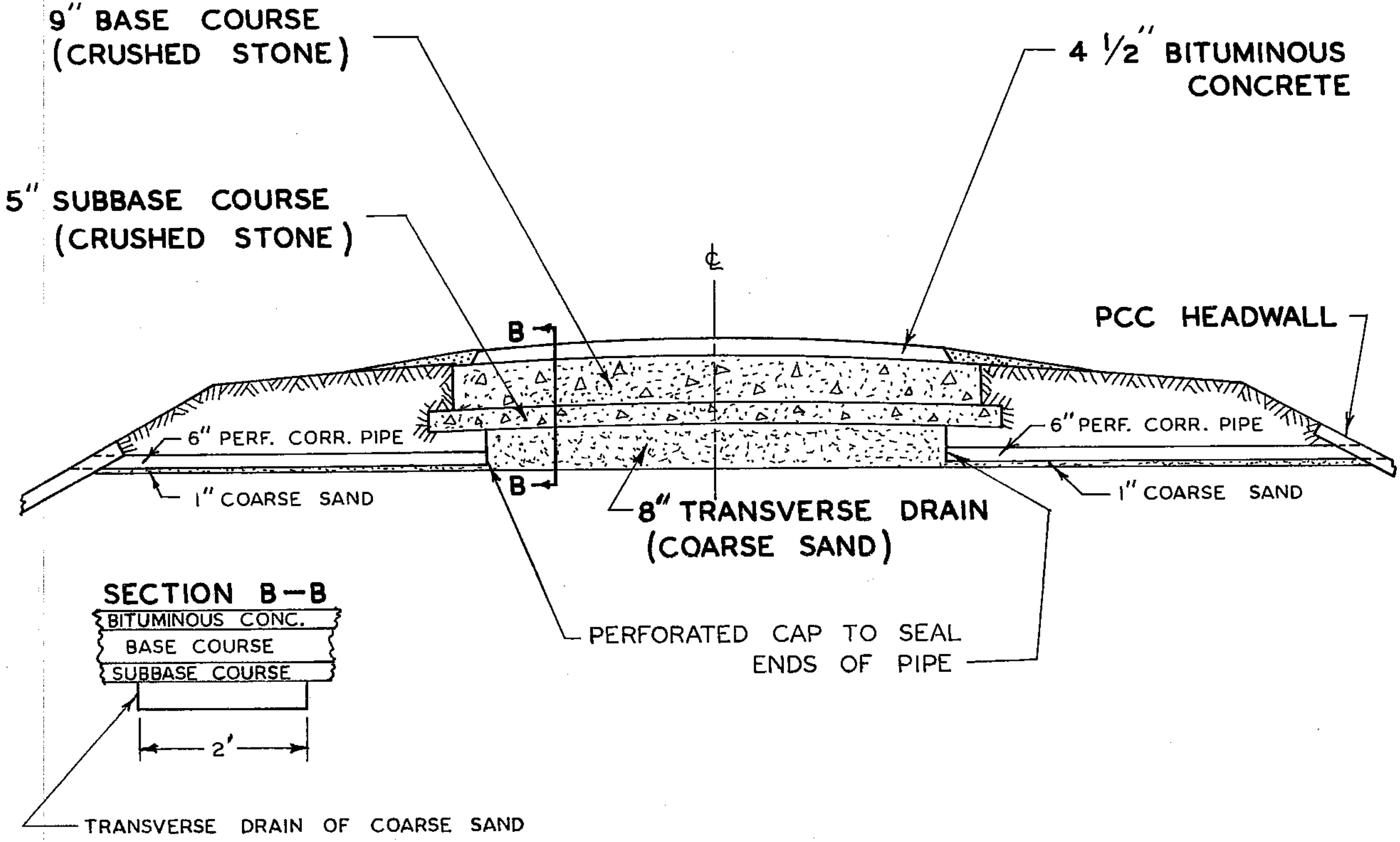

Figure 5. Typical cross section for transverse drainage system.

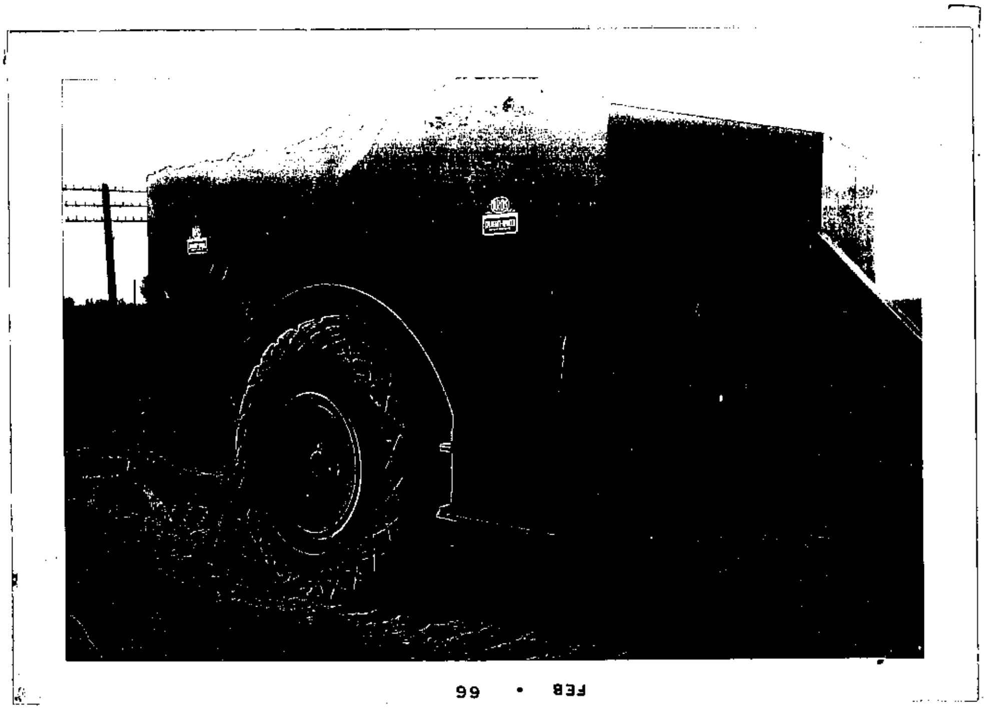

Figure 6. Super-load compactor

of AASHO T 99. Moisture content at compaction was not to exceed 110 percent of wet optimum, unless permitted by the engineer. The density specification was met without difficulty. The moisture content specification, on the other hand, was difficult to meet because of abnormally heavy rainfall during the embankment construction period, and most of the material was placed on the high side of optimum moisture content and frequently above the desired 110 percent of wet optimum. Average test results for the principal soil types were recorded to be as follow:

	Average Relative Moisture		Average Relative Wet Density	
	Percent of Optimum	No. of Samples	Percent of Optimum	No. of Samples
Mostly A-2-4(0) to A-6(8)	108.7	65	96.5	50
Mostly A-2-4(0)	85.3	7	94.3	14
Mostly A-6(10) to A-7-6(13)	111.9	33	96.6	8

Light grading predominated throughout the project, with few cut and fill areas extending over three feet in depth.

Embankment material was placed in layers not over six inches in loose thickness as required by the specifications. Each layer was compacted with tamping rollers, and the final surface compacted with a three-ton steel three-wheel roller.

Subbase (Special)

The Subbase (Special) was obtained from a sand ridge area adjacent to the right of way. The following physical test results are typical for the material:

Pass No. 40 sieve, percent	99	
Pass No. 50 sieve, percent	91	
Pass No. 200 sieve, percent	12	
Nonplastic		
Optimum moisture, percent	11.4 (dry)	12.1 (wet)
Maximum density, pcf	103.5 (dry)	124.6 (wet)
California bearing ratio (CBR)	19	

The Subbase (Special) material was placed in single lifts and compacted under the same density and moisture content specifications that covered the embankment construction. Compaction was accomplished with a ten-ton pneumatic-tired roller, followed by a steel three-wheel roller of the same weight. The material was mostly below optimum moisture content at the time of compaction.

Subbase

The subbase material furnished for the project was a dense white dolomite meeting the Illinois "Grade 8" specification for crushed stone. The following gradation test results are typical for the material:

Sieve Size	Percent Passing
1 in.	100
1/2 in.	77
No. 4	48
No. 8	35
No. 16	24
No. 200	11

Results of tests of other physical properties of the subbase aggregate are as follow:

Test	Average Results	Method	Standard Specifications
Specific gravity (dry)	2.62	AASHO T 85	-
Specific gravity (surf. dry)	2.69	"	-
Water absorption, %	2.20	"	-
Sodium sulfate, %	10.09	AASHO T 104	Not more than 25%, five cycles
Los Angeles wear, %	37.40	ASTM C 131	Not more than 45%
Maximum density (wet), pcf	147.7	AASHO T 99	-
(dry), pcf	135.0	"	-
Optimum moisture (wet), %	8.3	"	-
(dry), %	8.0	"	-
California Bearing Ratio, %	150		

The crushed stone was hauled to the job site in trucks and placed on the grade by spreader box to full-course thickness. The material contained less than three percent moisture when placed. Water was added by truck sprinkler and blended into the stone with a motor patrol. Compaction was attained with ten-ton pneumatic rollers. Moisture content at compaction varied between 4 1/2 percent and 6 percent.

Sieve analysis tests made randomly during placing of the subbase material produced results mostly within the gradation limits, and visual observations as well indicated that reasonable uniformity was being achieved. Compaction specifications for the subbase course required only that the degree of compaction be satisfactory to the engineer.

Base

The crushed stone used in the base course was the same as that used in the subbase course. The physical characteristics, therefore, are the same as those shown for the subbase material in the tabulation on page 13.

In addition to meeting the specification requirements shown for the subbase material on page 13, the base material was required to have a California Bearing Ratio value of not less than 80. The CBR value of 150 determined for the material was well above this minimum requirement.

Also, the 9-inch thickness of base course was required to be placed in three layers of approximately equal thickness. The two lower layers were required to be compacted to at least 95 percent of maximum (dry) density; the upper layer to at least 100 percent of maximum (dry) density. The maximum density and optimum moisture content were as determined by the procedure of AASHO T 99, except that the particles retained on the 1/2-inch sieve were removed and replaced with an equal weight of material sized between the 1/2-inch and No. 4 sieves.

Prior to placing the base material, the subbase was shaped with a motor patrol and compacted with a steel three-wheel roller. Stone screenings were added in spots where the subbase material had become loosened. Moisture was added as an aid to compaction.

The base course material was placed by spreader box and compacted in accordance with the specifications. Each lift was compacted with ten-ton pneumatic-tired rollers. The final lift was also compacted with a ten-ton three-wheel steel roller after shaping.

Specifications required water to be added to the aggregate at the plant site in an amount "sufficient to prevent segregation." Water was added by spraying the material as it dropped from the hopper into the transport trucks. Initially, The moisture content was brought to the optimum content of 8 percent. However, a considerable amount of free water and some of the fines were found to drain from material transported at this moisture content, and segregation was produced in the process. A reduction of the moisture content to about 6 percent resulted in considerable improvement. However, no means was found for totally preventing the segregation that tended to occur, especially at the outer edges of the spread. Segregation and some variations in moisture content notwithstanding, density tests showed the requirement of 95 and 100 percent minimum relative densities consistently being met.

Prime

Final compaction and priming of the base course with RT-2 bituminous material by pressure distributor were completed on the southern two miles of the project before the end of the 1952 construction season. This portion was primed another time when the prime coat was placed on the remainder of the base course constructed in 1953. Minor defects caused by local traffic necessitated some repair work before priming.

The prime coat, which usually was applied about two days before laying the bituminous concrete, was applied at an average rate of 0.27 gallons per sq yd. Sand was then spread at the rate of about 6 lb per sq yd to prevent pickup. Moisture content of the base when primed was between 2 and 4 1/2 percent. Penetration of the prime into the base averaged about 3/8 in.

Bituminous Concrete

The 4 1/2-inch thickness of bituminous concrete was placed in three lifts consisting of two 1 1/2-inch thicknesses of binder course and one 1 1/2-inch thickness of surface course.

Coarse aggregate for the bituminous concrete was a dense white dolomite furnished from the same source as the crushed stone used in the base and subbase construction. Fine aggregate was a blend of coarse river sand and fine dune sand. A dry limestone dust was used as mineral filler in the surface mixture. Paving grade asphalt of 70-85 penetration was used in both the binder and surface mixtures. The following job-mix formulas were established for the project:

Sieve Size Passing (%)	Sieve Size Retained (%)	Job-Mix Formula (%)	Tolerance Limits (%)	Specifications (%)
		Binder Mix Formula		
1"	1/2"	33.0	28-38	25-45
1/2"	No. 10	34.0	29-39	25-45
No. 10		28.0	25-31	20-35
Asphalt		5.0	4.4-5.4	4-7
		Surface Mix Formula		
3/4"	No. 10	57.0	54-60	45-65
No. 10	No. 200	31.7	28.7-34.7	25-40
No. 200		5.5	4-7	5-7
Asphalt		5.8	5.3-6.3	5-7

The surface-course mixture graded at the job-mix formula was found to have a Marshall stability value of 1820 (lbs) and a Marshall flow of 19 (0.01 in.). The binder-course mixture had an average Marshall stability value of 2025 and flow value of 13.

The bituminous aggregate mixtures were prepared in a batch-type mixing plant and hauled to the jobsite in insulated trucks. They were placed with a commonly-used type of self-propelled spreading and finishing machine of a width conforming to the traffic lanes.

Immediately after placing, the mixture of each layer was compacted with a ten-ton tandem roller and then given final compression with ten-ton and eight-ton three-wheel rollers.

Compacted mixtures were specified to have a density not less than 95 percent of the theoretical density of a voidless mixture composed of the same ingredients in like proportions. Although various procedures were tried, this rarely could be achieved with the binder course mixture. Greater success was obtained with the surface course mixture. Following are the averages and ranges of the results of density tests made during construction:

Mixture	No. of Tests	Percent Theoretical Density	
		Average	Range
Binder	33	93.9	96.9 - 91.6
Surface	18	95.7	97.2 - 91.9
Specifications		95.0	

Smoothness requirements established for both the binder and surface courses were met in the construction. Departures for the binder courses from a 10-ft straightedge were required not to exceed 1/4 inch; and for the surface course not to exceed 1/8 inch.

All bituminous concrete was placed between August 10 and September 22, 1953.

EXPERIMENTAL OBSERVATIONS

Research observers were assigned to the project for the construction period to observe and record details on any factors that appeared to have potential for influencing the eventual performance of the pavement. These observers conducted routine physical tests that were in addition to the tests conducted for control of the construction, and also did some nonroutine testing. Most of this effort was directed at developing information on the uniformity of the final product. This work was concentrated particularly on the embankment phase of construction, and to a lesser extent on the subbase and base phases where nonuniformity was believed less likely to develop.

Research observations were continued for many years following construction in the form of condition surveys, rut-depth measurements, and roughometer testing.

Proof-rolling

Mention was made previously of the proof-rolling that was done at subgrade level to detect, for removal, any weak spots that the super-load (35-ton) compactor showed to exist. As stated before, four passes were made over every unit area of the pavement subgrade with the compactor.

As a result of the proof-rolling, a six-inch layer of crushed stone was added to the entire length of subgrade between Stations 414 and 483. Frequent displacement of 1 1/2 inches and over under the wheels of the roller led to the decision to do this strengthening. A similar area of instability between Stations 535 and 549 was treated by replacement of the existing embankment soil with A-2-4(0) soil placed and compacted at a moisture content somewhat below optimum. A few other spots of about 100 ft and less in length were treated by removal and replacement with better material.

In a belief that a correlation between deflection under the super-load compactor and pavement performance might be found to exist, extensive records of estimated deflection were maintained by an observer walking behind the compactor as it moved along the subgrade. Deflections of up to about 1/2 inch were observed fairly frequently. In those areas where remedial treatment was undertaken, deflections of several inches were observed before treatment.

Considerable rebound occurred after each pass of the roller except in the unstable areas. The amount of rebound was difficult to estimate by the methods being employed. Typically, four passes of the roller would show individual deflections of about the same magnitude in each pass, without visually observed lowering of the surface elevation.

The effect that the super-load compactor may have had in densifying the embankment over which it passed is not known.

Analyses of pavement performance data in relation to the recorded visual observations of deflection under the super-load compactor have not produced any clear relationships. If any such relationships exist, they have been obscured by the influences of other variables.

Special Subgrade Sampling

Upon completion of the grading operation, an engineering soil survey was made to obtain information supplementary to that obtained in the preconstruction soil survey. This second survey permitted a charting of the soil profile throughout the project in the "as-constructed" condition. Principally, it revealed a rather heterogeneous subgrade support situation to exist in terms of soil texture and AASHO group classification.

An analysis of pavement performance with respect to subgrade soil type did not reveal any especially significant relationship other than a tending toward poorer pavement performance in the general area of fine-grained soils in the southern portion of the project. The method of selection of the locations for, and thicknesses of, the Subbase (Special) that was used intermittently through the project did not permit an effective analysis of the influence that the use of this item had on pavement performance. It will be recalled that the Subbase (Special) usage was made a dependent of soil type (and drainage) at the design stage.

Performance Observations

Condition surveys that involved detailed mapping of the various pavement defects that became visible under traffic service and climatic exposure were conducted periodically until 1965. Defects were measured and catalogued as to extent and severity. Among those that appeared most commonly were transverse cracking, area cracking, and rutting in the wheelpaths. When the Illinois roughometer (Bureau of Public Roads type) became available during the latter part of the research period, roughness measurements with this device were added to the program of study.

After the pavement serviceability-performance system of pavement evaluation was developed at the AASHO Road Test (1), it was applied and became the principal system of analysis for this project. The analysis that was performed by this system, and the development of the traffic data needed for the analysis, are described in following sections of this report.

Costs

Neither detailed construction cost records nor maintenance cost records were available for analysis. A comparison of the contract prices with then current prices

(1) Carey, W. N., Jr., and Irick, P. E., "The Pavement Serviceability-Performance Concept." Highway Research Board Bulletin 250 (1960).

for construction of portland cement concrete pavements such as would otherwise have been built at the location indicated reasonable accord between them. Because of the extensive patching that became necessary relatively early in the life of the pavement, it can be suspected that maintenance costs were higher than ordinary.

TRAFFIC ANALYSIS

The results of routine traffic volume and classification studies made annually by the Illinois Division of Highways and reported in "Traffic Characteristics on Illinois Highways" showed the following average traffic conditions to have existed at the site of the demonstration pavement during the study period:

	Average Annual Daily Traffic Volume			
Year	Total Traffic	Passenger Cars	Single Unit Trucks	Multiple Unit Trucks
1953	4500	3600	350	550
1954	4500	3600	350	550
1955	5000	3940	295	765
1956	5000	3940	295	765
1957	4750	3753	285	712
1958	4750	3753	285	712
1959	4450	3471	445	534
1960	4550	3549	455	546
1961	4550	3549	455	546
1962	3875	3025	375	475
1963	3975	3100	398	477
1964	4325	3374	432	519
1965	5000	3880	520	600

Concepts and procedures developed by the AASHO Road Test researchers and others[(2)(3)] to express mixed-traffic axle loadings in terms of equivalent numbers of a single-load axle were applied in exploring the load history of the project. The equivalencies are based on the load-effect relationship that was determined in the Road Test. Reference (3) reports on the development in Illinois of average load equivalencies in terms of 18,000-lb axles for passenger vehicles, single-unit

(2) Chastain, W. E., Sr., "Application of Road Test Formulas in Structural Design of Pavement." Highway Research Board Special Report 73 (1962).
(3) Chastain, W. E., Sr., and Schwartz, D. R., "AASHO Road Test Equations Applied to the Design of Bituminous Pavements in Illinois." Highway Research Board Record 90 (1965).

trucks, and multiple-unit trucks through the application of Statewide loadometer and classification count data. For these three classes of vehicles, the 18,000-lb axle equivalencies were found to be 0.0004, 0.117, and 0.947 respectively. While minor variations in these average factors are known to occur from year to year, the application of these factors to the volume and classification count data for all years of pavement service on the project was considered to be sufficiently accurate for the analysis being done.

Making use of the foregoing factors, and assuming that the volume and character of the traffic is about the same in each direction as is usually the case in Illinois, the number of equivalent 18,000-lb axles was computed for each year covered by the study and the cumulative equivalency curve of Figure 7 drawn.

PAVEMENT PERFORMANCE

Research on the demonstration project was under way and condition surveys were being made for several years prior to the development of the pavement serviceability-performance concept at the AASHO Road Test[1]. When the analytical processes of this concept became available, field studies were adjusted to produce information that would permit the performance analysis to proceed by this method.

The "Present Serviceability" of a pavement as used by the Road Test researchers is its ability to serve high-speed, high-volume mixed traffic in its existing condition. The "Present Serviceability Index" (PSI) is a mathematical combination of values from physical measurements that provides a numerical rating of how well a pavement is serving. A series of PSI ratings over a period of time provides a performance history for a pavement.

In developing a mathematical expression for determining the PSI of a pavement, a rating scale of 0 to 5 was used, in which a rating of 5 would denote a pavement giving excellent service and a rating of 0 would be indicative of very poor service.

Physical values from measurements of roughness, cracking, patching, and rutting were found to be useful in establishing the PSI of a flexible pavement. Substitution of the Illinois (Bureau of Public Roads type) roughometer for the slope variance profilometer used to measure roughness at the Road Test, required the following modification of the mathematical expression for the PSI developed at the Road Test project(4):

$$PSI = 10.91 - 3.90 \log RI - 0.01\sqrt{C + P} - 1.38D^2$$

in which

PSI = present serviceability index

RI = roughness index (by Illinois roughometer)

C = square feet of cracked area per 1000 sq ft of pavement surface

P = square feet of patching per 1000 sq ft of pavement surface

D = average rut depth in inches at deepest part of rut

Condition Survey Results

Pavement condition surveys were made once each year during most of the period of study. Observed defects were sketched on survey sheets in the manner routinely used for surveys of this nature. Rut depths during the first years of study were measured with rod and level; and during the latter years with the device used on the AASHO Road Test project. Fortunately, mapping of cracking and patching during the early years of study was in sufficient detail to permit application of the pavement serviceability-performance concept after its development midway in the course of the project.

Roughness readings with the Illinois roughometer were first made in 1957 and no roughness data are available for prior years. Engineers associated with the project during and immediately following construction believed that a reasonable

(4) Chastain, W. E., Sr., and Burke, J. E., "Experience with a BPR-Type Roadometer in Illinois." Highway Research Board Bulletin 328 (1962).

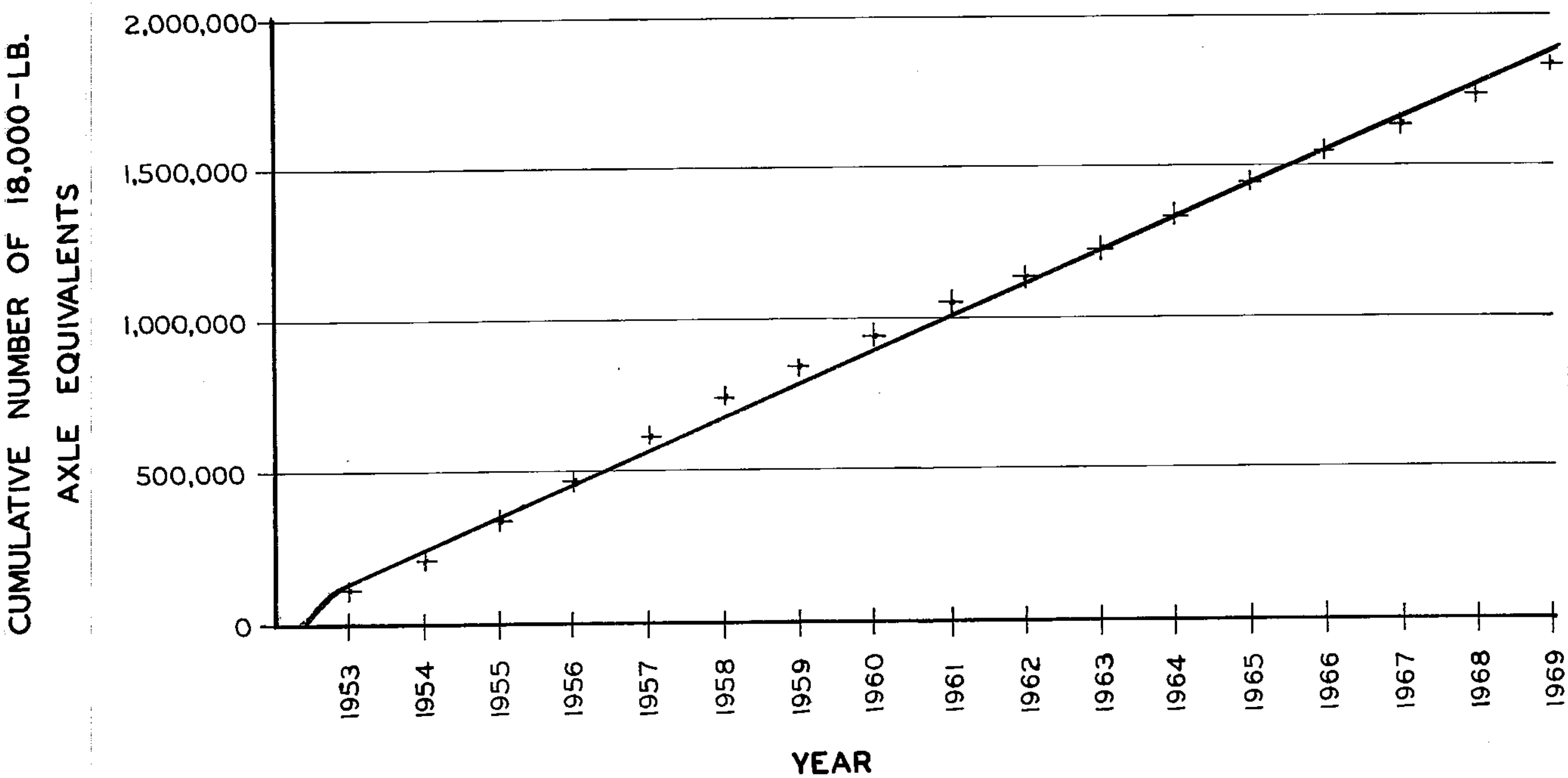

Figure 7. Cumulative 18,000-lb axle equivalents of mixed traffic loadings.

degree of smoothness was initially achieved. Roughness Index values in the 62-68 range measured the first year that the roughometer was used on the project added substantiation to this belief. A Roughness Index value of 75 is the separation point between "smooth" and "slightly rough" pavements by Illinois standards.

Alligator cracking was the most serious pavement defect found to occur on the demonstration project. This cracking usually was associated with rutting in the wheelpaths. As the years passed, the cracking increased in both extent and severity, and eventually led, first to the need for a substantial amount of patching, and later to the need for retirement of the entire section as a riding surface.

Present Serviceability Indexes (PSI's) were determined for individual sections of the project and for the project as a whole during the period of study. The results of measurements used in making the determinations, and the resultant PSI's, are shown in Table 1. This information was used in plotting the serviceability histories of Figure 8. Primary pavements in Illinois are considered ready for retirement when a PSI of 2.5 is reached, and usually are retired at about this stage. The PSI value that was recorded for the demonstration project in 1965 was 2.4. However, the progress of design and construction work that incorporated the research section as the southbound lanes of a four-lane Interstate highway by resurfacing was such that this particular section was not retired until 1969. Field work on the study covered by this report was terminated in 1965, and no performance data are available for the years following.

The similarity of the performance histories of the several sections of the project differing in foundation treatment and in predominating soil types, as shown in Figure 8, is of interest. The lack of major differences in performance is apparent. This might be attributed to a display of unusually good judgment on the part of the designers in selecting treatments to compensate for the differences in foundation support. However, the uniform distribution of deficiencies within

TABLE 1

PAVEMENT SERVICEABILITY MEASUREMENTS

Year	Station Location (1)* 413+79 to 423+30	(2) 423+30 to 474+52	(3) 474+52 to 491+49	(4) 491+49 to 520+00	(5) 520+00 to 604+00	(6) 604+00 to 659+75	Total Project
				Roughness Index (in. per mi.)			
1957				No data			65
1959	No			No data			76
1962		94	93	100	89	102	95
1963	Data	95	96	98	92	105	97
1964		114	129	123	116	151	126
1965		108	124	112	116	145	121
				Average Rut Depth (in.)			
1957				No data			0.3
1959				No data			0.3
1962	0.3	0.3	0.4	0.4	0.3	0.3	0.3
1963	0.3	0.3	0.4	0.4	0.3	0.3	0.3
1964	0.3	0.3	0.4	0.2	0.2	0.3	0.3
1965	0.3	0.3	0.4	0.4	0.3	0.3	0.3
				Major Cracking (Alligator Type) (sq ft per 1000 sq ft)			
1955				None			
1957	0	0	0	1.7	0.3	5.2	1.5
1958	3.1	11.4	16.5	14.8	12.0	30.0	16.2
1959	5.1	13.9	37.7	66.2	26.8	85.7	42.0
1960	16.0	21.3	56.8	91.9	36.3	137.7	63.3
1962	65.8	57.6	144.5	217.8	80.8	239.3	131.4
1963	233.6	489.6	349.4	569.3	213.1	365.3	356.8
1964	363.2	470.4	324.1	279.5	177.9	249.2	283.3
1965	327.5	587.0	474.0	387.0	266.8	360.9	383.9

TABLE 1 (CONCLUDED)

Year	Station Location (1)* 413+79 to 423+30	(2) 423+30 to 474+52	(3) 474+52 to 491+49	(4) 491+49 to 520+00	(5) 520+00 to 604+00	(6) 604+00 to 659+75	Total Project
			Patching (sq ft per 100 sq ft)				
1955				None			
1957	0	0	0	1.9	0	0	0.2
1958	0	0	0	21.4	0	0	2.5
1959	0	0	0	21.4	0	11.2	5.1
1960	0	0	0	21.4	0	11.2	5.1
1962	0	0	0	22.2	0	11.2	5.2
1963	0	0	73.6	113.8	0	23.2	22.7
1964	0	0	77.4	338.1	31.9	206.8	102.7
1965	0	0	77.4	338.1	31.9	206.8	102.7
			Present Serviceability Index				
1957				Insufficient Data			3.7
1959	Insuf-			Insufficient Data			3.4
1962	ficient	3.0	2.9	2.7	3.1	2.8	3.0
1963	Data	2.9	2.8	2.7	3.0	2.7	2.9
1964		2.5	2.3	2.5	2.7	2.1	2.4
1965		2.6	2.3	2.4	2.6	2.1	2.4

*Special characteristics:

(1) 6-in. crushed stone strenghtening; 4-in. Subbase (Special); A-4(2) to A-6(8) soils predominate
(2) 6-in. crushed stone strengthening; 7-in. Subbase (Special); same soils as (1) but poorer drainage
(3) 6-in. crushed stone strengthening partly; no Subbase (Special); A-2-4(0) soils predominate
(4) 4-in. Subbase (Special); A-4(2) to A-6(8) soils predominate
(5) No Subbase (Special); A-2-4(0) soils predominate
(6) 5-in. Subbase (Special); A-6(10) to A-7-6(13) soils predominate

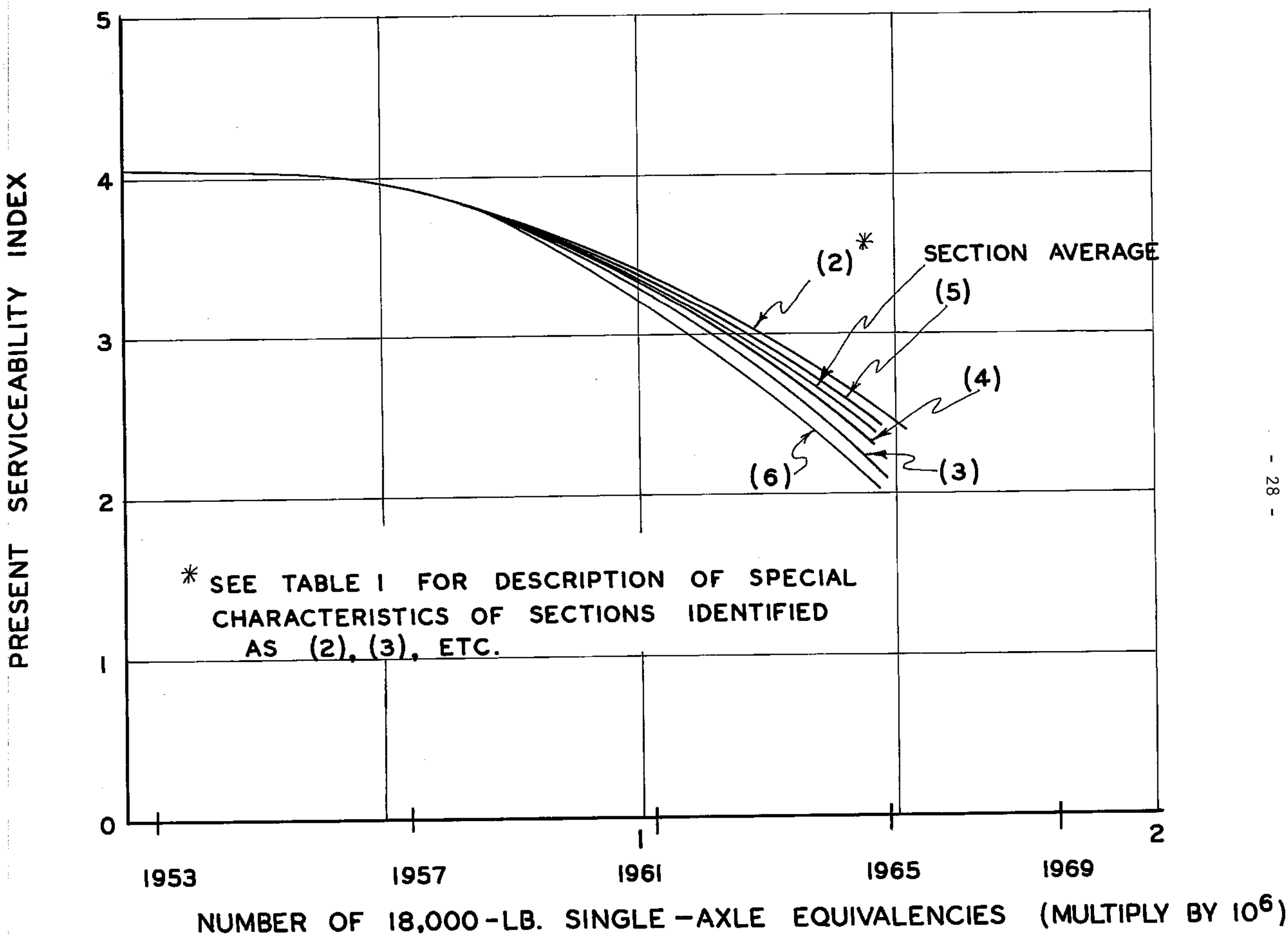

Figure 8. Present serviceability histories

sections as revealed by the detailed condition survey records, with little apparent relation shown to major variations in soil type as indicated by soil survey records, suggests the possibility of some overriding weakness in the pavement structure itself. The nature of the measurements made during the course of the study was such that whatever weakness might have been present in the pavement structure was not readily apparent.

Within the section of pavement south of Station 604+00, the northbound lane showed somewhat poorer performance than the southbound lane. Again, the reason for the difference could not be determined from available information.

Inasmuch as the structural design of the demonstration pavement was selected by a procedure that indicated it should render about the same degree of service as the 10-in. uniform thickness of conventionally reinforced pavement in common use in Illinois at the time, the performance history of this pavement was compared with the average performance history reported elsewhere(5) for about twenty 10-in. portland cement concrete pavements in Illinois. The results of the comparison are shown in Figure 9. It will be seen that the particular design of flexible pavement selected for the demonstration did not serve as well as had been hoped. This information was taken into consideration when the AASHO Road Test equations were modified to be more in accord with experience under normal service conditions and adopted for use in the Illinois procedure for the structural design of flexible pavements.

(5) Chastain, W. E., Sr., Beanblossom, J. A., and Chastain, W. E., Jr., "AASHO Road Test Equations Applied to the Design of Rigid Pavements in Illinois." Highway Research Board Record 90 (1965).

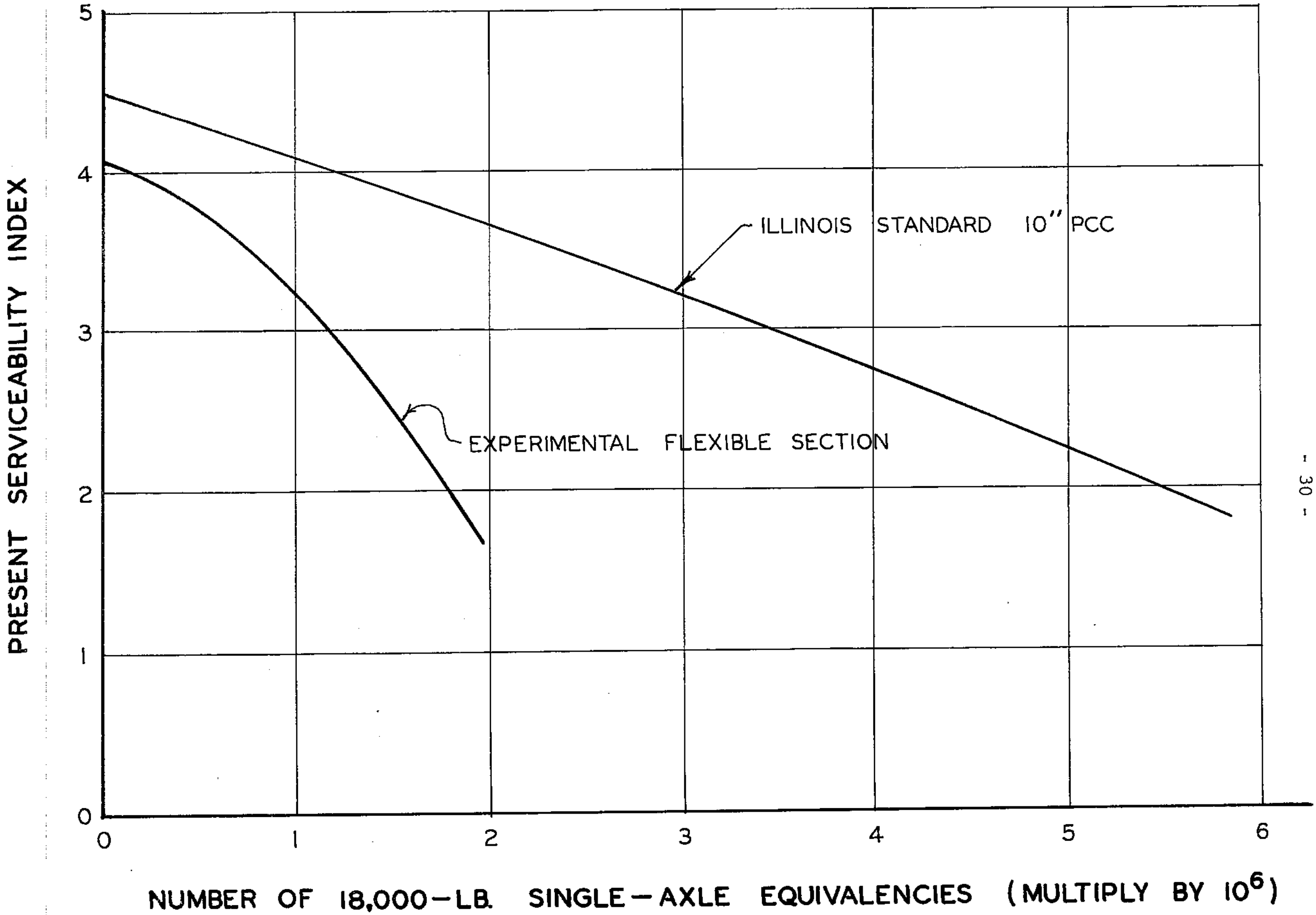

Figure 9. Comparative performance histories of experimental section and Illinois standard 10-in. portland cement concrete pavement.

RESULTS

The investigation described in this report was a demonstration type of study that involved an evaluation of the service performance under primary highway traffic of a single structural design of flexible pavement. The pavement consisted of a bituminous concrete surfacing on a crushed stone base. Various foundation treatments were employed in an effort to equalize subgrade support.

The structural design of the pavement selected for study, based on information available when the project was conceived in 1951, was presupposed to have performance capabilities about the same as the 10-in. thick conventional portland cement concrete pavements in use in Illinois at the time.

Performance comparisons made through application of the pavement serviceability-performance concept developed at the AASHO Road Test showed the performance of the demonstration pavement to be inferior to the average performance of typical 10-in. conventional portland cement concrete pavements in Illinois.

The principal deficiencies observed in the demonstration pavement were alligator cracking and rutting in the wheelpaths. The occurrence of these deficiencies was widespread, and distributed fairly uniformly throughout the project. The experiment did not produce any positive information on relationships between performance and individual factors of influence. The uniformity of distribution of deficiencies throughout the project with little relation to probable foundation variations has led to an unproven suspicion that the observed deficiencies might be related to some kind of internal weakness in the pavement structure itself.

IMPLEMENTATION

In the development of the flexible pavement design procedure currently in use in Illinois, the performance information resulting from this study was used in modifying the formulas developed at the AASHO Road Test to be more representative of the normal service situation in Illinois.

PROPOSED ADDITIONAL RESEARCH

The suspicion that the observed deficiencies might have been influenced to some degree by inadequacies within the pavement structure is not in itself a new thought. However, it serves to reinforce present thinking that more needs to be known about the structural behavior of pavement components such as those used in the demonstration pavement.