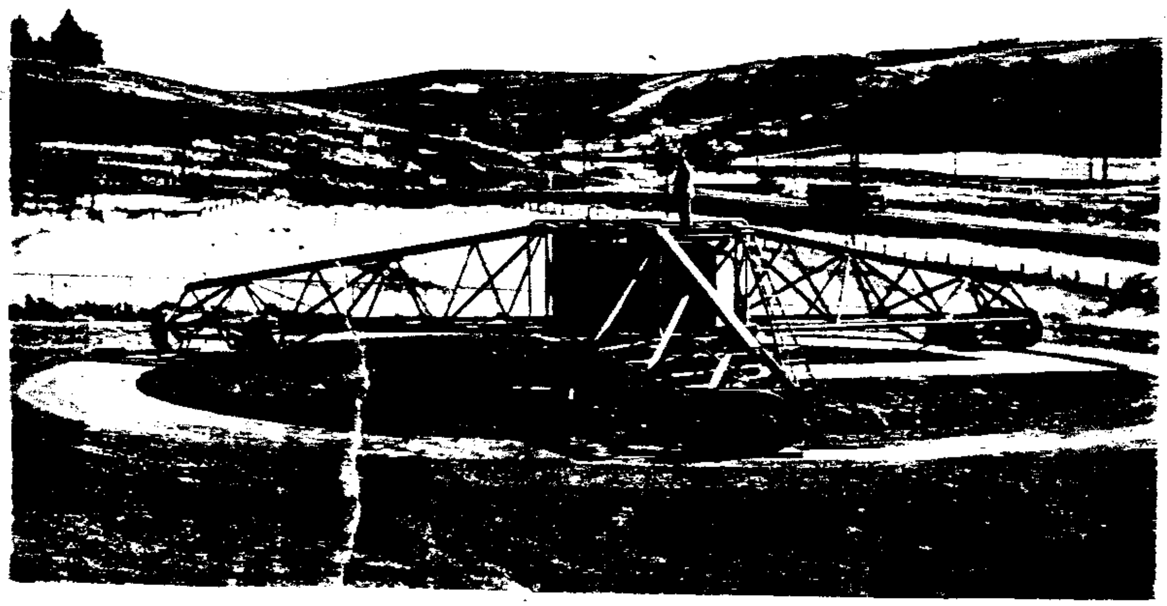
PAVEMENT RESEARCH at the WASHINGTON STATE UNIVERSITY TEST TRACK

VOLUME ONE

EXPERIMENTAL RING NO. 1: A STUDY OF CEMENT TREATED AND ASPHALTIC TREATED BASES

Research Project Y-651

Highway Research Section
College of Engineering Research Division
Washington State University
Pullman, Washington



A Federal Aid Research Project in Cooperation
with the Department of Transportation
Federal Highway Administration
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1967

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EXPERIMENTAL RING NO. 1: A STUDY OF CEMENT TREATED AND ASPHALTIC TREATED BASES

Report to the Washington State Department of Highways
on Research Project Y-651

by

G. A. Riedesel, John C. Cook and Milan Krukar

Highway Research Section
College of Engineering Research Division
Washington State University
Pullman, Washington
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In Cooperation with
U. S. Department of Transportation
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The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

(Highway Research Section Publication H-28)

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ABSTRACT

Using full-scale construction equipment and truck loadings on a circular track of 260 feet circumference, evaluation of various base thicknesses and types has been accomplished in this first of a series of tests. Fractured and non-fractured aggregate, treated and untreated bases, asphaltic and portland cement type bases are used. Results of the first ring indicate types of failure under varied environmental conditions with pavement systems subjected to millions of load applications. Difficulties in determining comparative equivalencies are discussed. Instrumentation used and possibilities for future use in rational design are reported.

PURPOSE OF THE PROJECT

The purpose of this project was to extend and apply the findings of the American Association of State Highway Officials road tests at Ottawa, Illinois, to the soils, materials, and local conditions of individual states. To accomplish this special equipment and facilities were needed that would rapidly apply full legal-limit wheel loads to full strength pavements. The project required the design and construction of such equipment and the construction and testing of two rings of experimental pavements.

A "ring" as used in this project denotes a complete pavement system extending from the subgrade through the wearing surface. The first two rings tested consisted of varying thicknesses and types of bases with equivalent subgrades, wearing surface, and environmental conditions.

The equipment will be used in a continuing series of tests in which many pavement systems will be built and subjected to full-scale loading.

The cost of a permanent plant for applying loads to a series of temporary pavements is much less than building loops of a full-width experimental highways and testing them with loaded motor trucks. The time required is less. The results, while not identical, should be practically as valuable for scientific and design purposes.

frame and of the individual wheels without taking any weight or strain. The bearing is mounted in a structural steel framework in such a way that the center of rotation of the frame moves slowly in a circle of 0- to 4-foot radius. When the radius is set at zero, the wheels travel in a fixed path on the centerline of the pavement. At any other radius up to four feet the wheels will travel over a width of pavement twice the setting of the inner radius.

This wheel tracking control mechanism was developed and constructed in the University shops. Photo 4 shows the assembly.

Observation Gallery

A six-foot wide reinforced concrete observation gallery is located on a quarter circle arc just inside the inner edge of the pavement and under the level of the pavement surface (Photo 5). The gallery wall has openings for connections to instruments located under the pavements. Future experiments may call for water, heat, and refrigeration pipe under the experimental pavements. For that purpose the gallery, with its wall openings, will accommodate the pipe and equipment used. For the initial tests the gallery housed the manometer tubes and boards from the pressure cells. Figure 1 shows a plan view of the concrete structures in relation to the ring of experimental pavements.

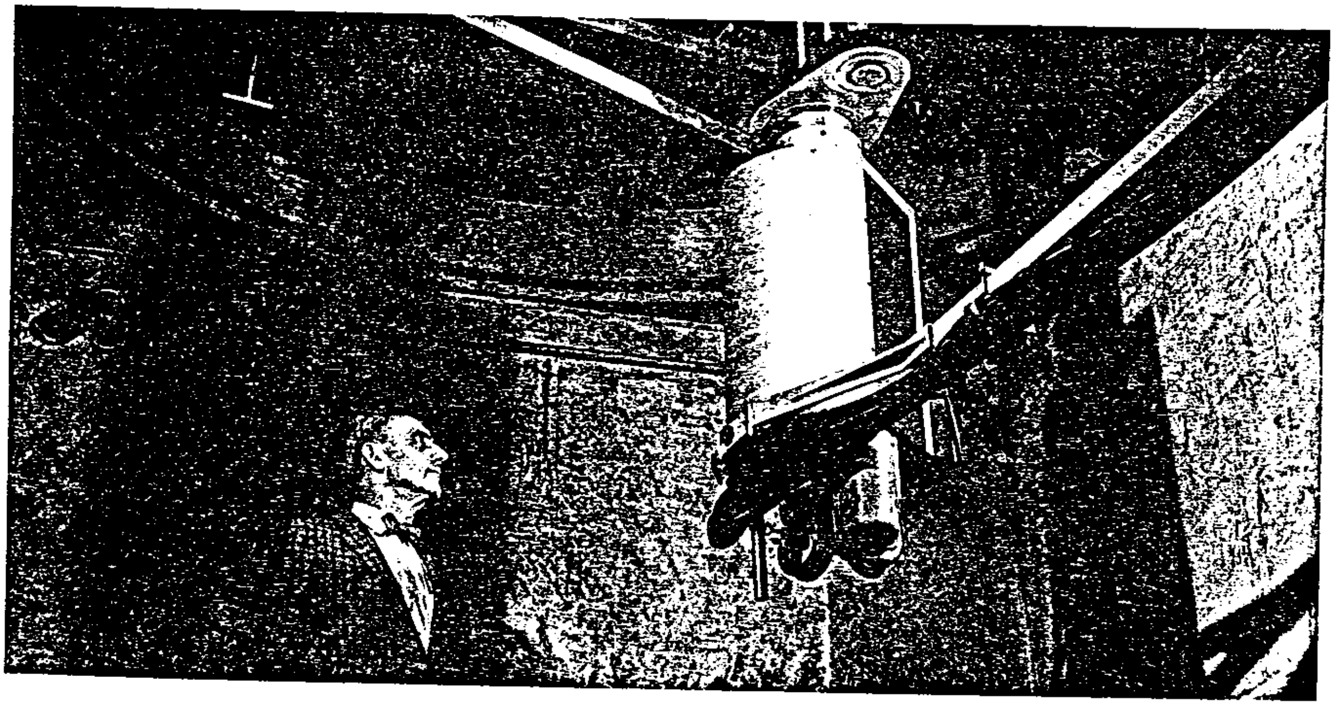


PHOTO 4.--ECCENTRICITY AND SLIP-RING ASSEMBLY.

PHOTO 5.--OBSERVATION GALLERY.

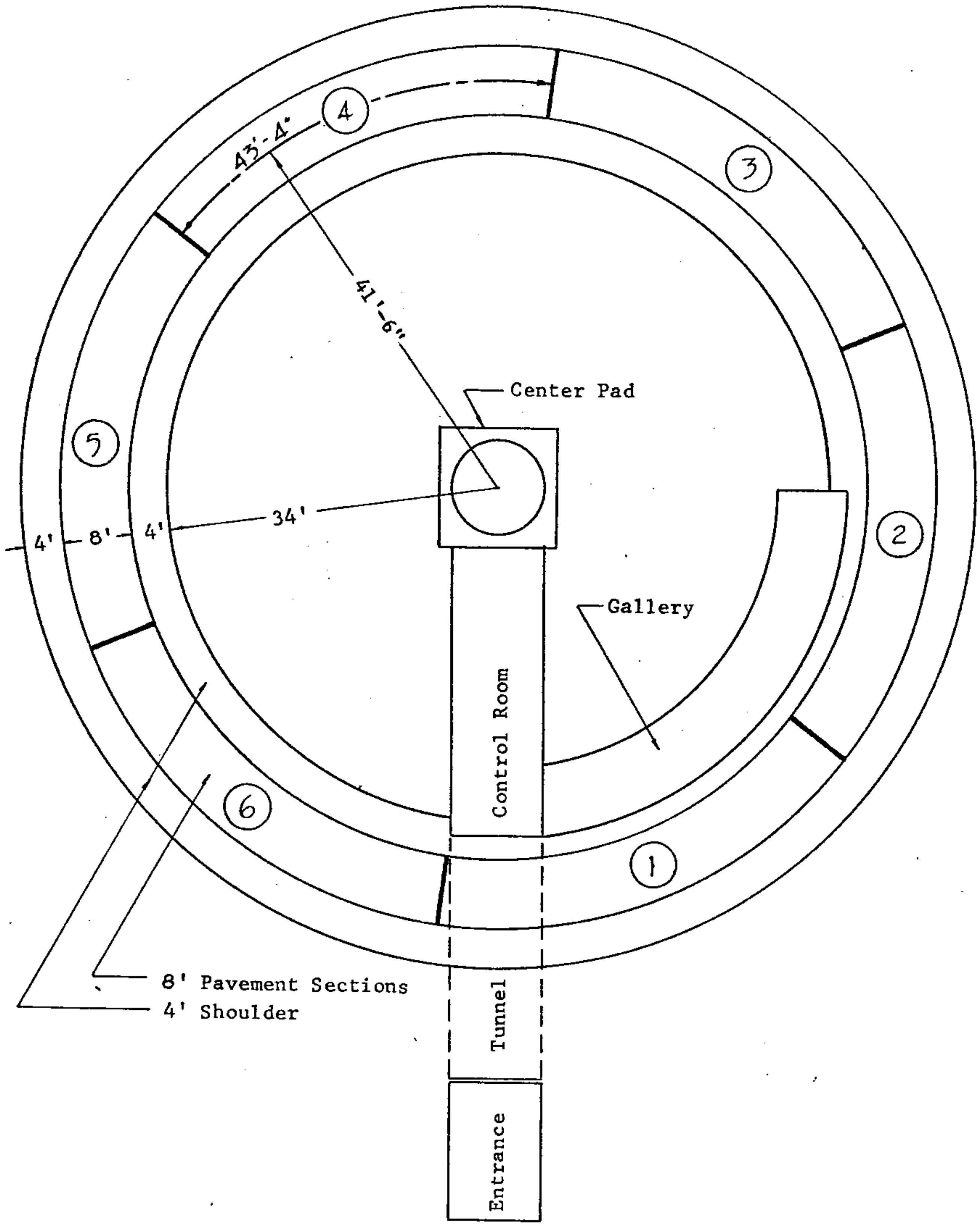


FIGURE 1.--PLAN VIEW OF PERMANENT STRUCTURE ANE THE PAVEMENT SECTIONS, RING 1.

SECTION II

EXPERIMENTAL PAVEMENT RING #1

Research Objectives

Objectives of the first experimental ring were:

1. Determine pavement system performance when non-fractured aggregate is substituted for fractured aggregate in treated base. (Coarse aggregate with a minimum of 75% by weight of particles with at least one fractured face produced by mechanical crushing is usually considered to be fractured aggregate.)

2. Determine relative performance of cement-treated base and asphalt treated base.

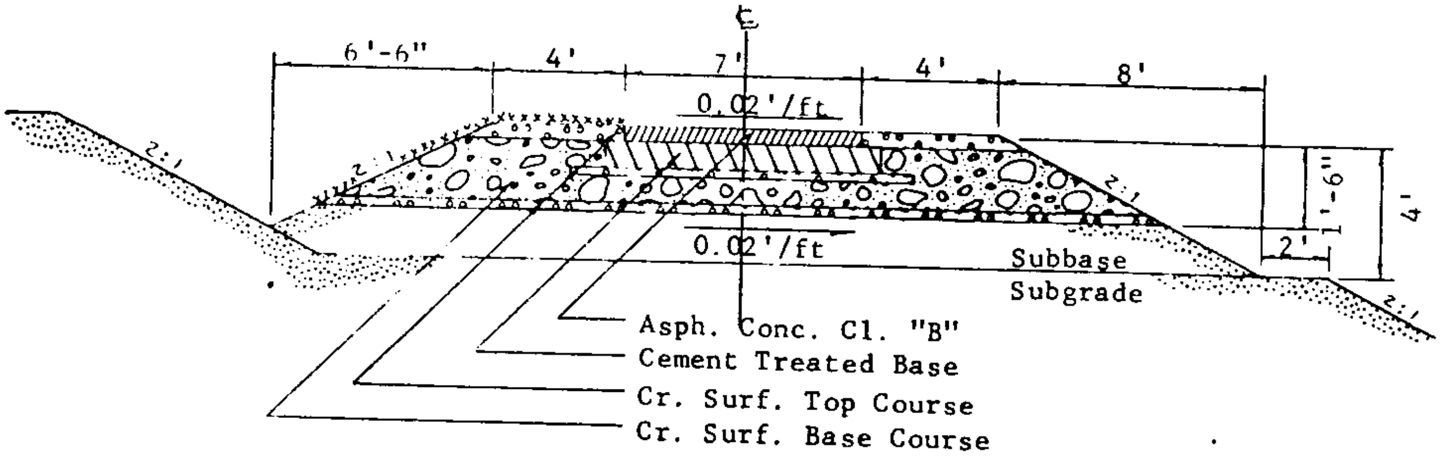
3. Develop instrumentation for load-pressure distribution in pavement system by using pressure cells placed below the wearing surface.

4. Determine durability of pavement marking enamel applied to the wearing surface and subjected to repetitive loading.

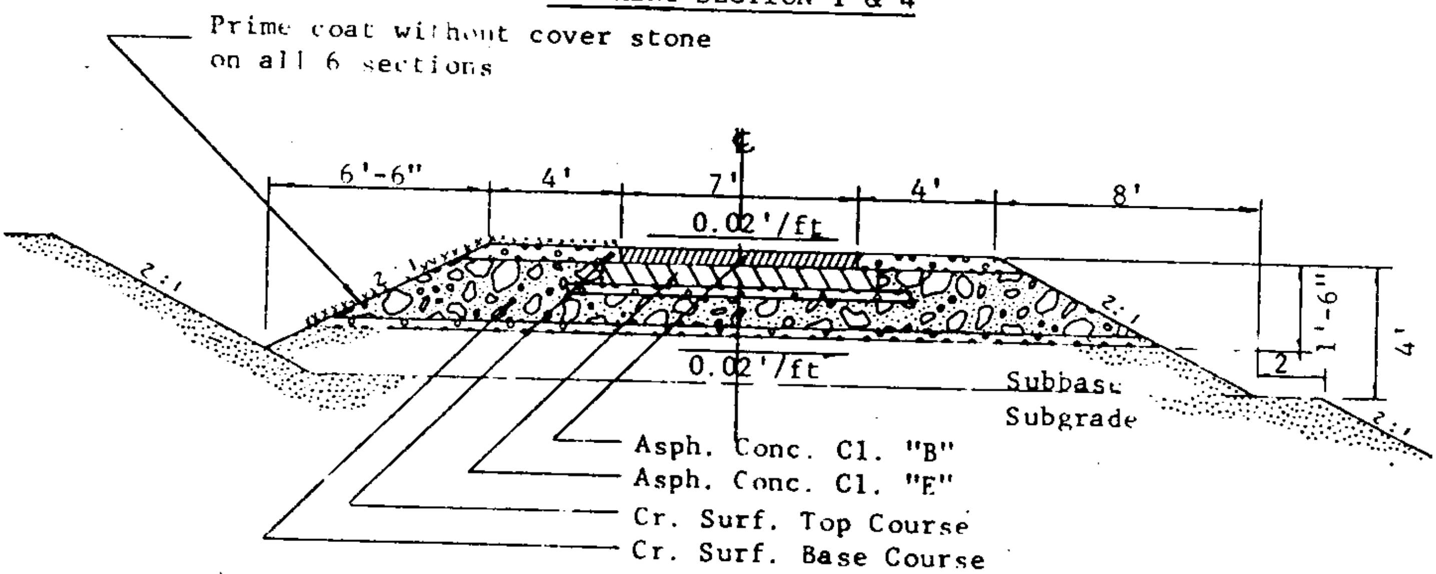
Pavement Systems Design--Ring #1

The pavement systems were designed according to Washington State Department of Highways standards for heavy traffic freeway service. In general, materials and construction procedures followed the standard specifications issued by the same agency. Pertinent excerpts from those specifications are included in Appendix A.

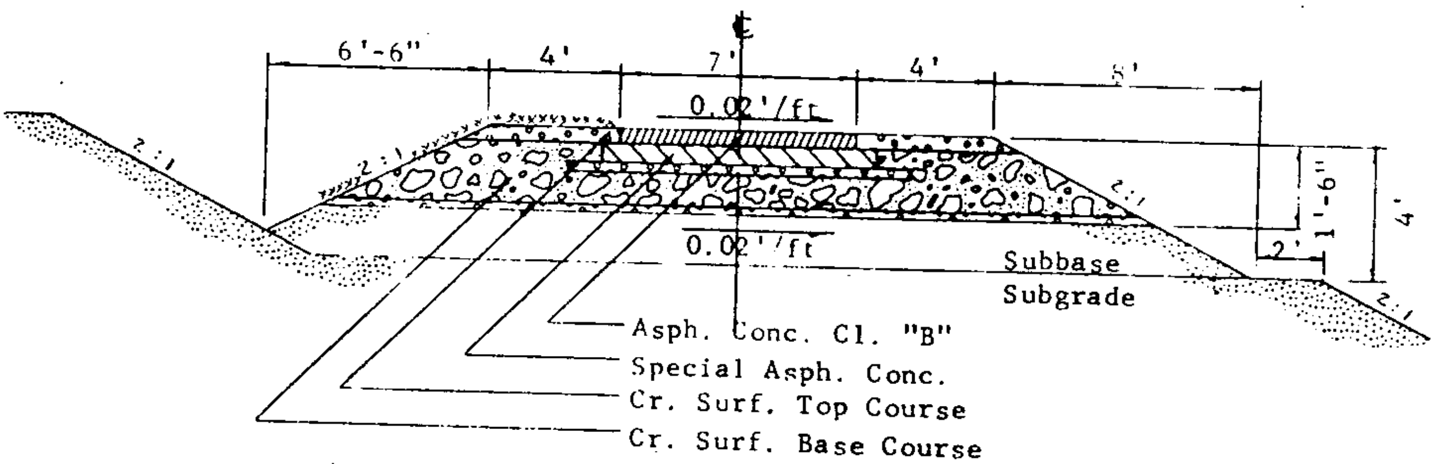
The first ring of experimental pavements involved three designs and was built in six sections. Each design was represented by two identical sections. Figure 1 shows the arrangement of the ring and the sections; Figure 2 shows cross sections of each design; and Photo 6 shows vertical sample cores from each design. The asphalt concrete cylinders of Photo 6 are actual cores drilled from the pavements. The portland cement-treated base and the crushed rock layers in



PAVEMENT SECTION 1 & 4



PAVEMENT SECTION 2 & 5



PAVEMENT SECTION 3 & 6

FIGURE 2.--TYPICAL CROSS-SECTION OF FLEXIBLE PAVEMENT TEST SECTIONS, RING 1.

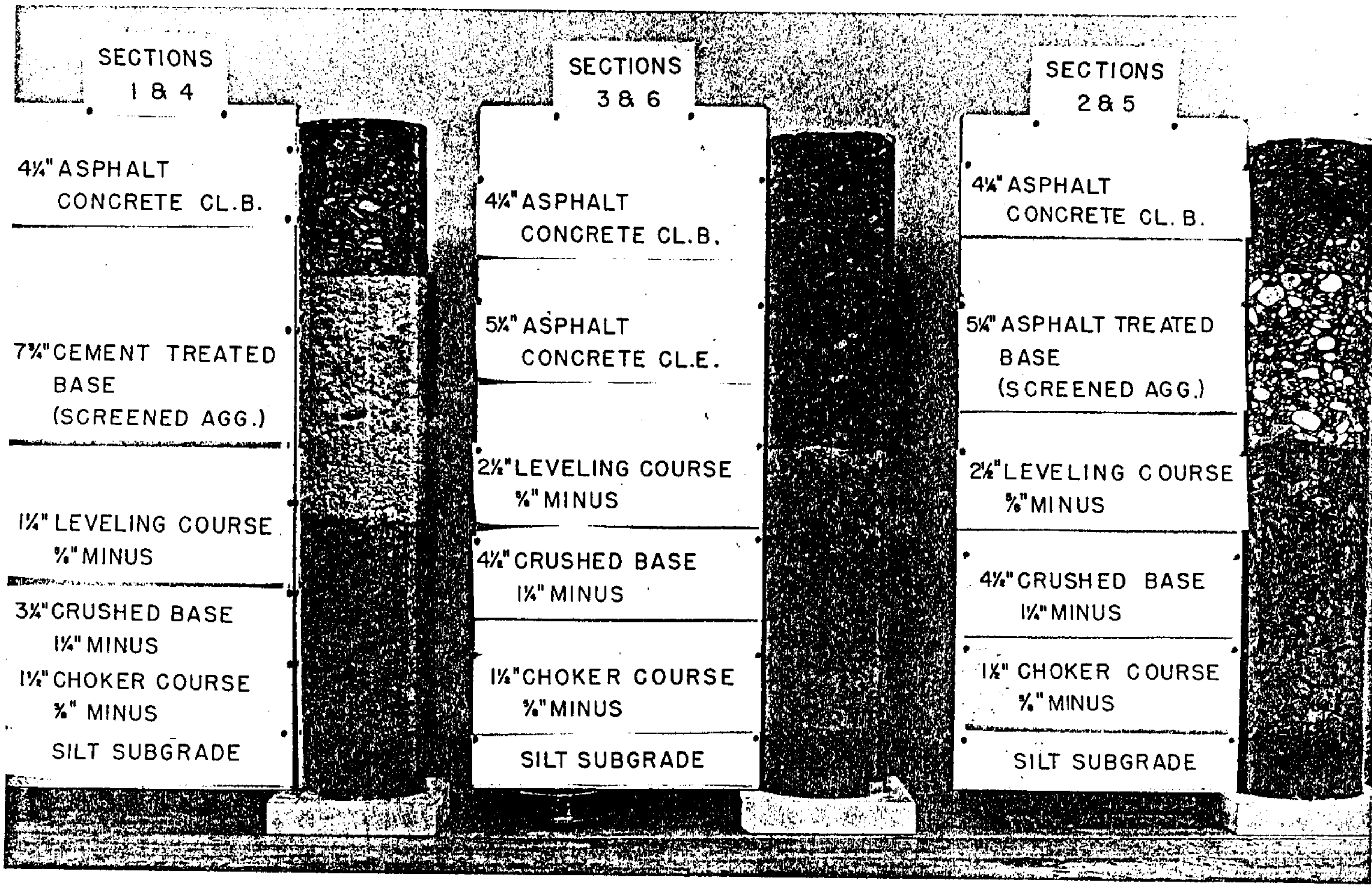


PHOTO 6.--MATERIAL TYPE AND DEPTH, RING #1.

the display are built up cylinders of the actual materials but are not representative of their condition in the roadbed insofar as density is concerned.

All three designs had the same 4¼" concrete wearing surface of Class B asphalt.

All three designs had the same depth and materials in the shoulders, leveling course, and the choker course. The crushed rock base was the same in all three designs except for depth. The thickness of this base course was varied to make the total thickness of surfacing the same in all three designs. The prepared subgrade was the same for all three designs.

The difference, therefore, in the three designs and the basis for comparison was in the treated base materials. Sections 1 and 4 had a 7 3/4" course of cement-treated aggregate base made of smooth, non-fractured gravel. Sections 2 and 5 had a 5¼" course of asphalt-treated base of smooth, non-fractured gravel; this was a low-type bituminous concrete corresponding to Class E. Sections 3 and 6 had a 5¼" course of asphalt-treated base made of fractured basalt quarry rock. This met the specifications for Class E bituminous concrete.

Instrumentation--Ring #1

The only instrumentation that was planned for the first experimental ring was a series of pressure cells. These were designed more as an experiment in pressure cell development and use than actual determination of pressures or transmittal of loads. The nature of the pavement research provided the opportunity for experimenting with pressure cells. It was intended, however, to get relative pressures from the three different designs and with regard to depths of the cells under the top surface of the pavement.

Figure 3 shows the details of this pressure cell. It consists of two 7-inch diameter steel disks welded together at the edges after being counter-sunk

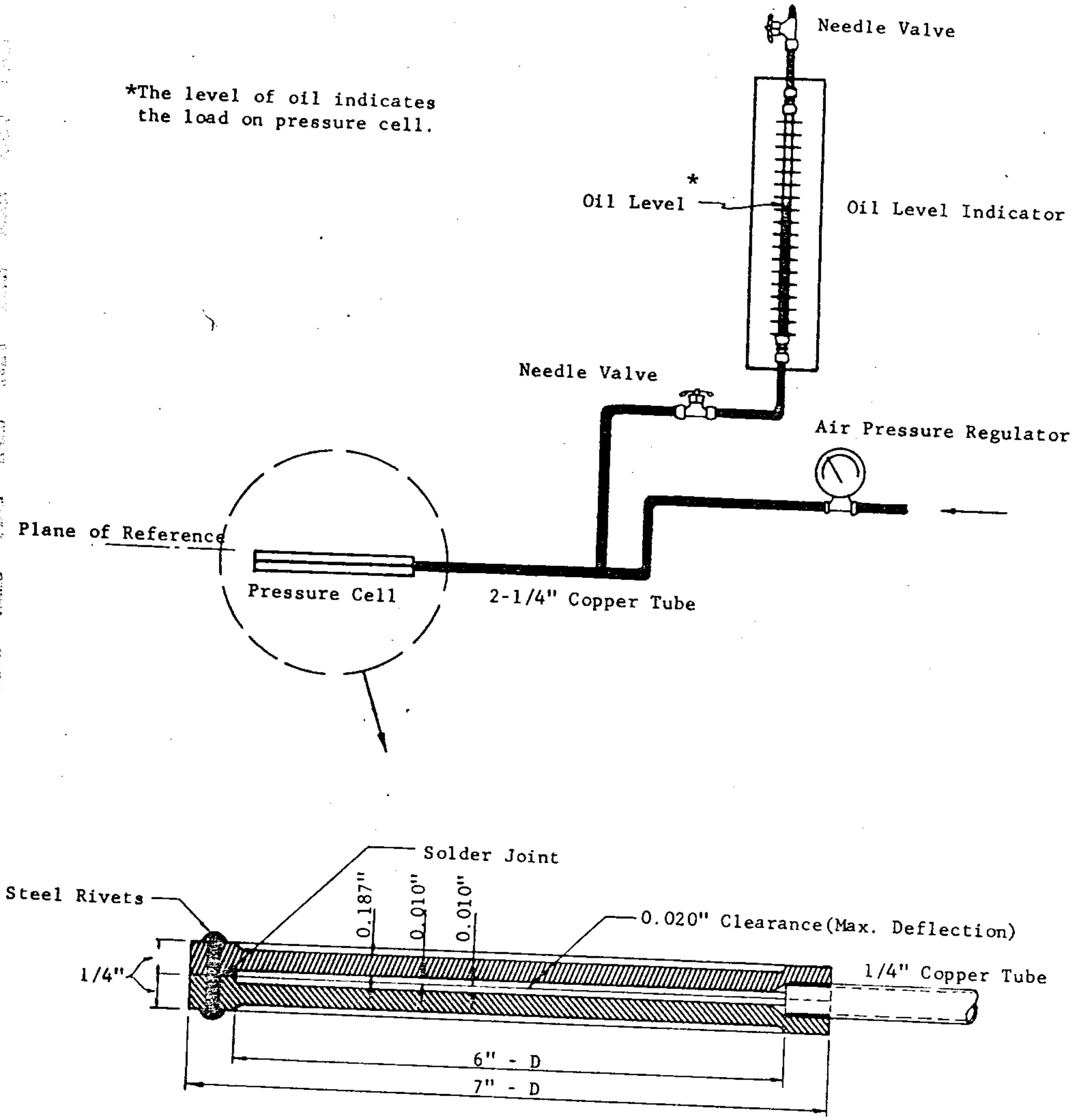


FIGURE 2.--PRESSURE CELL SECTION
(DOUBLE DIAPHRAGM-STEEL)

1/50" to provide a reservoir for oil between the disks. This reservoir is connected by copper tubing to a manometer tube. A change in the level of the oil on the manometer board registers pressure on the plates. The stiffness of the steel disks provides the resistance to the outside pressure. Photo 5 illustrates the position of the manometer tubes within the observation gallery.

Increased pressure can be applied against the exposed surface of oil in the manometer tube to supplement the stiffness of the disks. Each cell was calibrated in a compression machine for various external pressures and a range of internal pressures before it was laid in place.

In each pavement design, one cell was placed between the crushed rock ballast and the treated base; one cell was placed at sub-grade elevation between the crushed rock choker courses and the compacted soil subgrade. The third cell in each design was buried 18 inches below subgrade. Results of cell readings and the general performance of the cells are presented later in this report.

Construction Procedure--Ring #1

Subgrade

Using conventional highway construction equipment and procedures, the initial site contractor prepared the subgrade for placement of the paving system by the ring construction contractor. The latter contractor was United Paving Company, who operates a quarry, crushing plant, and hot mix bituminous concrete plant within one-half mile of the test track.

The facility is located on a side hill with a south slope. The initial subgrade preparation involved approximately equal cut and fill with a maximum cut depth of 3 feet and a maximum fill depth of 4 feet to provide a compacted subgrade at elevation 108.0 feet. Pavement surface elevation is 112.0 feet, thus additional subgrade and/or varying layers of subbase, base, and surfacing may be utilized. Soil embankment material is known as Palouse silt. It is classified as an A-6(10) soil. Test results on Palouse silt are given in Appendix B.

At elevation 95 to 98 feet the silt is interfaced with a basalt layer with approximately 2 feet of weathered basalt overlaying columnar and blocky basalt. Water is present at varying depths immediately above the basalt with resultant varying moisture contents in the subgrade.

Contractors used sheepsfoot, vibratory, and pneumatic tire rollers to achieve specified 95% compaction of the soil. (ASTM D-698.) Density measurements were made by the sand-cone method.

Base Course

The crushed rock courses were placed from end dump trucks, rolled with a tandem steel roller, a 5-ton vibratory roller, then processed and finished with a No. 12 Caterpillar patrol grader or Huber blade. The smaller blade appeared to be more easily maneuvered on the circular track. Moisture and density were controlled. Lift thicknesses were controlled by established required elevation stakes.

Asphalt Mixes

All bituminous concrete materials were mixed in a Standard 3,000-pound batch plant and delivered to the site in end dump trucks. Spreading of the asphalt-treated bases was done in two layers with a Miller spreader box attached to the end dump trucks (Photo 7). Rolling was performed with an 8-ton tandem steel roller (Photo 9) and a 12-ton 9-wheel pneumatic tired roller (Photo 8). The 4¼" Class B asphalt pavement was spread in two courses with a Blaw-Knox self-propelled rubber-tired paving machine and rolled with the steel and pneumatic rollers. A tack coat of 80 to 120 grade asphalt was applied between courses.

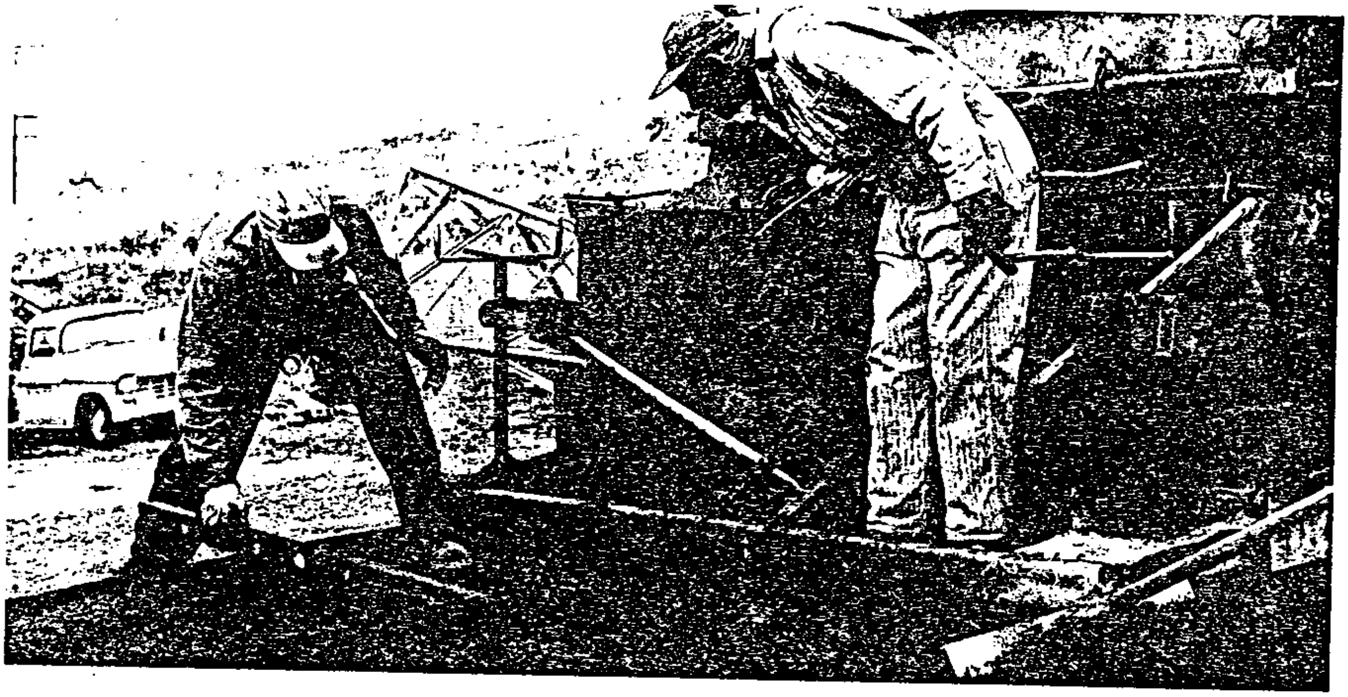


PHOTO 7.--MILLER SPREADER BOX.

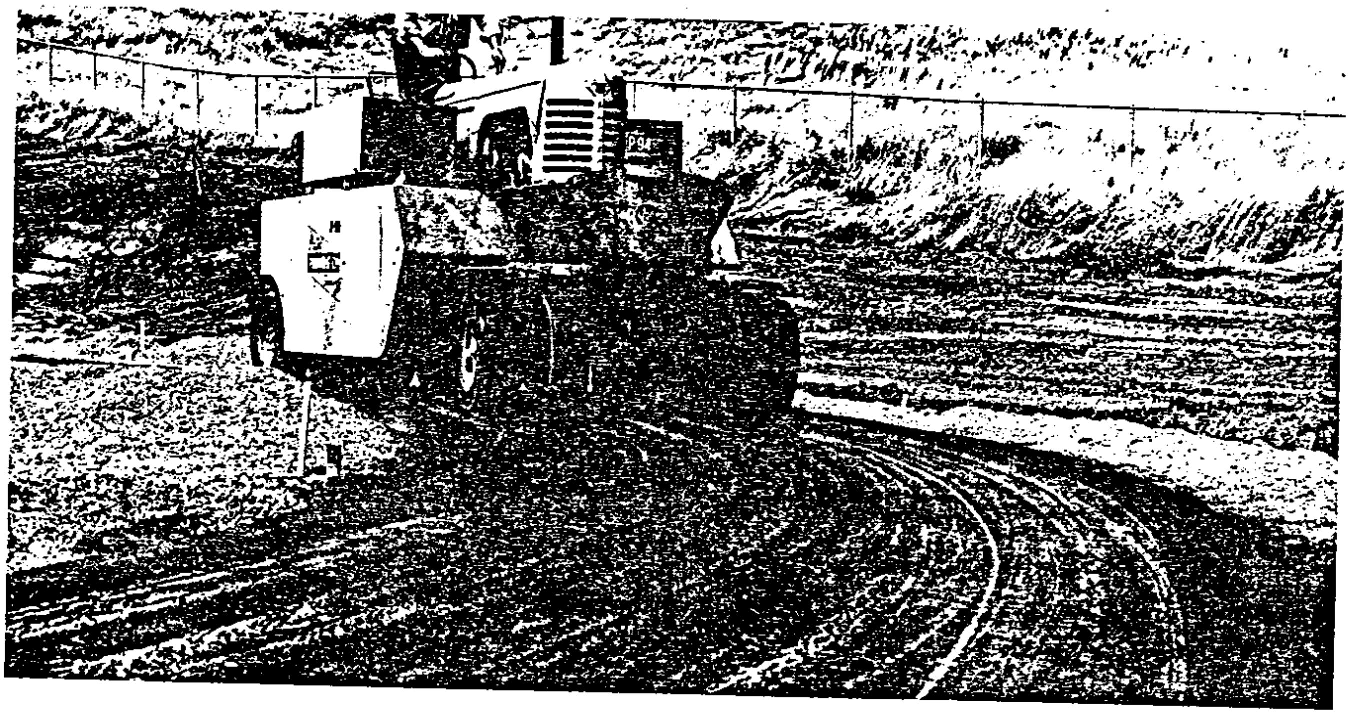


PHOTO 8.--PNEUMATIC ROLLER.

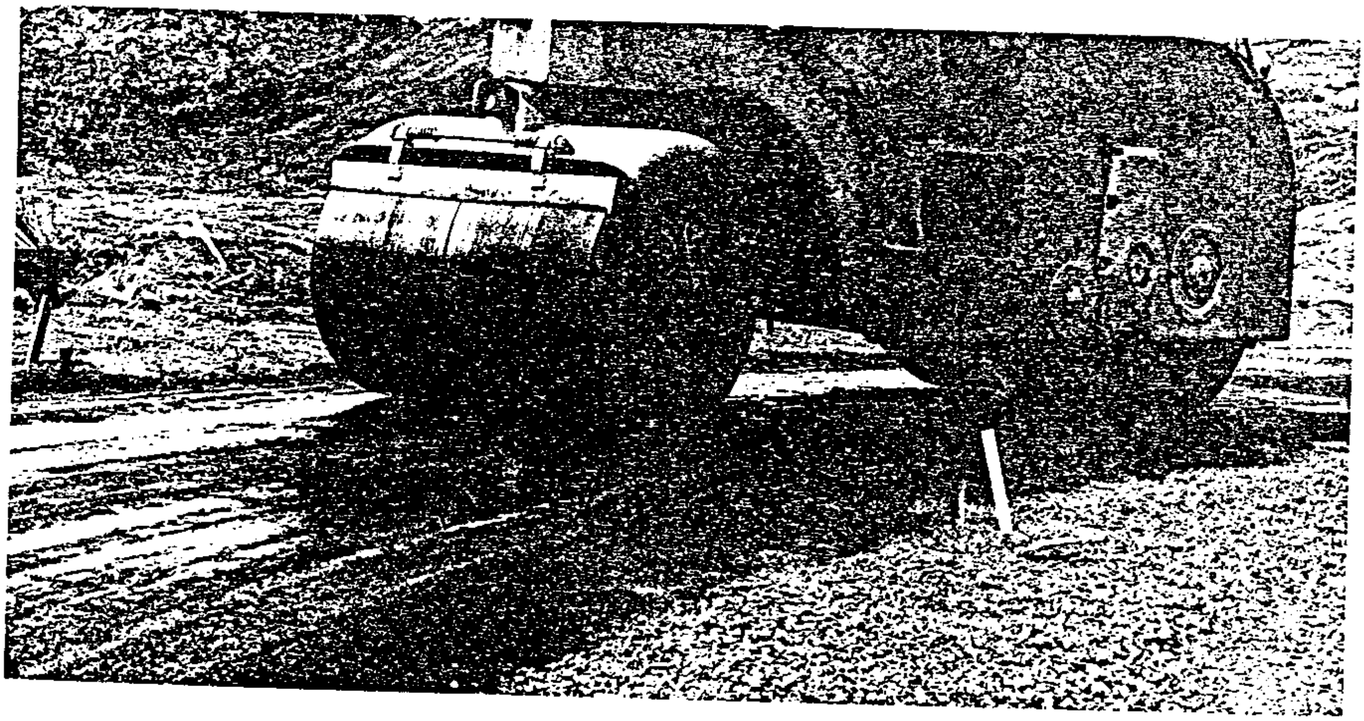


PHOTO 9.--STEEL-WHEEL ROLLER.

Environmental conditions of high humidity and low temperatures in combination with the steel wheel roller resulted in surface cracking. These cracks were radial and tended to close up after loading and warmer temperatures occurred.

Cement-Treated Base

Cement-treated base material was proportioned in the Pullman plant of the Doten Transit-Mix Concrete Company and delivered to the job site in transit-mix trucks. The contractor experienced some difficulty in placement due to the small area.

Neither spreader box on front of the tractor nor road-mix blade laying procedure was successful. Hand placement by shoveling from small stock piles with subsequent screeding was the method finally used. Screed controls were closely spaced to maintain grade.

Asphalt Tack and Prime Coat

Conventional spray bar with pressure hose and nozzle was used to apply the asphalt prime and tack coats. Precise quantity measurement was not accomplished.

Materials

Soil

Native soils in the area are poor for subgrade construction. They are described as frost susceptible, plastic, silty clay, HRB classification, and group index A-6(10). It was the intent of the first experimental ring to test for local conditions. All soil used in the subgrade was from the test site. Lab reports of several samples showing the classification, grading, optimum moisture, proctor density, and other design data are included in Appendix B.

Crushed Rock

Crushed rock used in the ballast courses and in the bituminous mixes was from the basalt rock quarry of the United Paving Company near the test site. This rock is from flows extruded during the Miocene period. These are commonly dark gray to black and frequently columnar jointed. These basalts vary from dense to vesicular. The rock used met the specifications. The material was from stock piles of different gradations that were combined to yield the grading specified. Appendix C shows lab test reports on the crushed rock used.

Material Specifications

Table I summarizes the material specifications.

Fine Aggregate

Fine aggregate used with the non-fractured aggregate in the cement-treated base was concrete aggregate from Spokane. Other filler materials used were soil from the job site and blow sand from sand dunes in Adams County, Washington.

The blow sand provided minus #40 and minus #200 material. The dunes are located on a county road about 14 miles northwest of Washtucna and one mile east of the Sand Dunes Grange Hall. Appendix C shows lab test reports on this material.

Asphaltic Materials

Asphaltic materials specified were:

Wearing surface, asphalt-treated base, and tack coat between lifts	85-100 penetration grade paving asphalt
Prime coat	SS-1 emulsion

TABLE I: MECHANICAL ANALYSIS SPECIFICATIONS

Screen Size	% Passing by Weight		
	Crushed Rock Base	Crushed Surfacing Top Course[a]	Non-Fractured Coarse Aggregate[b]
1 1/4"	100	--	--
1"	--	--	100
3/4"	--	--	90-100
5/8"	50-80	100	--
1/4"	30-50	50-65	50-80
#10	--	--	30-60
#40	3-18	5-23	13-36
#200	0-7.5	0-10	3-15
Sand Equivalent minimum	40	40	

[a] Crushed surfacing top course, 5/8" maximum size, was used as choker course on subgrade, leveling course for treated base and top course for shoulders.

[b] The coarse aggregate was used in the cement-treated base of Sections 1 and 4 in the "special" asphalt-treated base of Sections 2 and 5. It was produced from the Fort Wright Pit of Union Sand and Gravel in Spokane, Washington. Production required special screening of pit-run material since local pits normally produce high-fracture material.

Job-Mix Formulas

Material Porportions for the pavement system units are summarized in Table II.

Laboratory reports on mixes and extracted cores are included in Appendix D.

Traffic Paint

During the preliminary design and construction phase of Ring 1, a decision was made to utilize the pavement facility as a means of determining comparative performances of various types of traffic paint. Under controlled loading conditions, evaluation of paints from four states was made.

State highway departments submitting samples were California, Oregon, Idaho, and Washington. Paint characteristics are shown in Table III.

Three samples of each paint were made to be applied as follows:

No. 1 Plain paint
No. 2 Pre-mix--6-pound beads added to 1 gallon paint
No. 3 Pre-mix--6 pounds beads/gallon of paint plus 3 pounds
1 gallon "drop-on" beads

Application of the materials was by means of a sled applicator pulled across the surface. The blade was adjusted to give 26 ml clearance over plate glass which gave a net film thickness of 17-18 mls, or the equivalent of 20 gallons per mile of solid 4-inch stripe. Since surface irregularities had to be filled with paint, the actual measured application rates also included this volume of paint. The addition of beads to the paint changed the viscosity of the mixture which also affected the resultant wet film applied.

Calculation of the quantities of each paint used and the resultant gallon-per-mile application rate show that for each of the three types of application made, the comparative rate was quite close.

No. 1	Plain paint	78 ± 3 gallons per mile
No. 2	Pre-mix	66 ± 3 gallons per mile
No. 3	Combination	73 ± 3 gallons per mile

TABLE II: MATERIAL PROPORTIONS FOR PAVEMENT SYSTEM UNITS
(Percentage by Weight of Aggregate)

Materials	CTB Sections 1 & 4	Spec, ATB Sections 2 & 5	Class E ATB Sections 3 & 6	Asphalt Concrete Class B All Sections
Non-fractured Coarse Aggregate, 1" Max.	30	30	35	--
Fine Aggregate, ¼" Minus	60	60	55	--
Job-Site Silt Clay Soil	10	--	--	--
Portland Cement, Type II	4.2	--	--	--
Water	4.9	--	--	--
Blend Sand	--	10	10	10
Paving Asphalt 85-100 Pen.	--	5.1	6.0	6.6
Crushed Basalt 5/8-3/8	--	--	--	35
Crushed Basalt 3/8" Minus	--	--	--	55

TABLE III: TRAFFIC PAINT CHARACTERISTICS

State	Type Resin	Initial Viscosity KU @ 70° F	Wt/Gal After Thinning to 64 KU
California	High Polymer	64	11.62
Oregon	Alkyd	86	11.71
Idaho	Alkyd	68	11.42
Washington	High Polymer	78	11.62

Weather conditions at the time of application were somewhat unusual for such operation. The sky was overcast with a heavy cloud cover, a very strong southwest wind was blowing, and the air temperature was 34°. Standing water on the test roadway made it necessary to dry the surface with an infra-red gas heater.

Test results on traffic paint durability are given in a later section of this report.

Testing Operations, Ring 1

Chronological Summary

May, 1962	Project prospectus submitted to William Bugge, Director, Washington Department of Highways by G. A. Riedesel, P.E. of Washington State University.
August, 1963	Contract for research between Highway Department and University signed.
November 29, 1963	Construction of facilities started.
August, 1964	Facilities completed, construction of first ring started.
October 2, 1964	Construction of first ring completed.
March, 1965	Operational testing; Ring 1 started.
April 28, 1965	One million wheel load applications registered.
June 1, 1965	Two million wheel load applications registered. Subgrade saturation initiated in Sections 2, 3, 4.
August 25, 1965	Three million wheel load applications registered.
December 21, 1965	3,711,780 wheel load applications registered. Operation suspended due to cold weather.
February 10, 1966	Testing operations resumed.
May 20, 1966	Operational testing concluded on Ring 1. Total of 4,724,100 wheel load applications.

Subgrade Saturation

At the completion of two million wheel load applications, none of the sections had failed. To accelerate failure, adverse conditions were provided in sections 2, 3, 4 by saturation of the subgrade. Water was introduced in each of the three sections through a single pipe driven at subgrade level to each section centerline from the outside edge of the roadway. Using a continuous flow of water, saturation was evidenced by appearance of water on the sideslopes and shoulder surfaces (Photo 10).

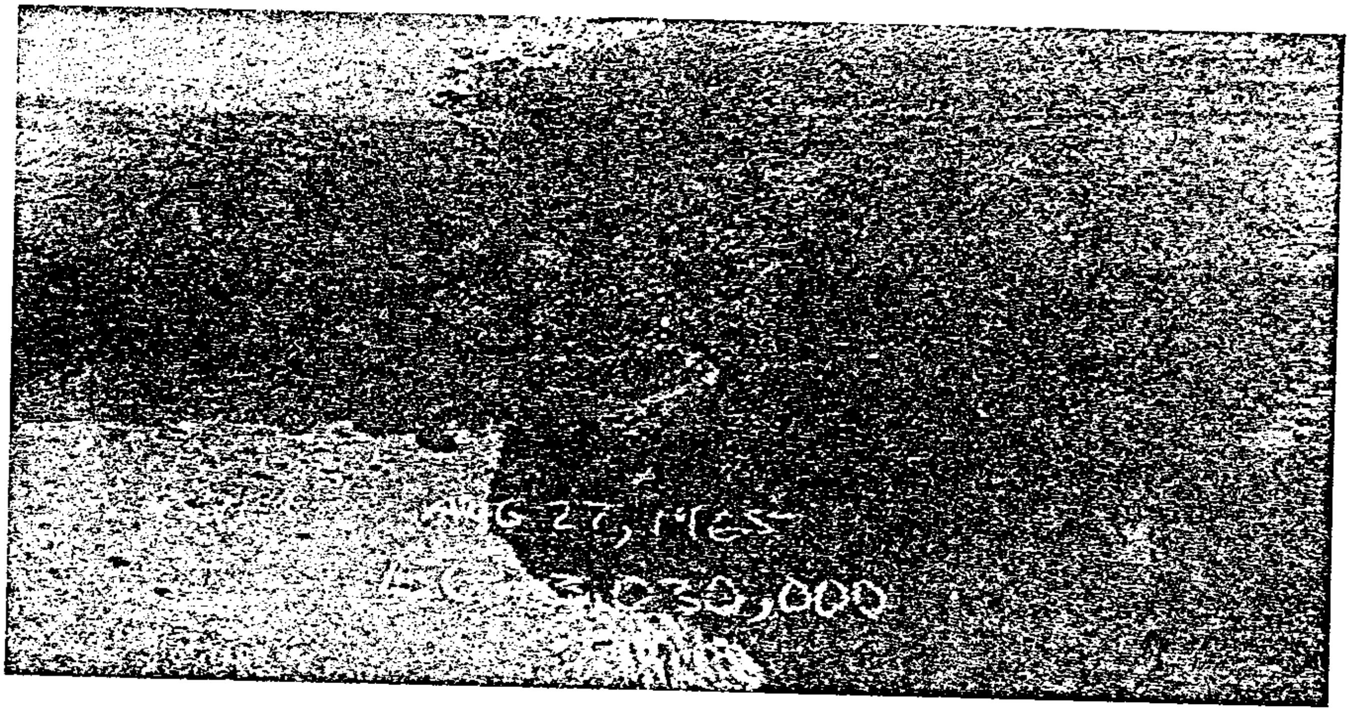


PHOTO 10.--SATURATION OF SECTION 3.

The subgrade saturation did contribute to accelerated failure, with failures occurring at different total wheel load applications. Table IV summarizes load applications to failure for the various sections.

After sections 2, 3 and 4 were taken out of service, three-foot wide trenches across the sections and of sufficient depth to examine the subgrade were excavated. Visual examination, photos, samples and laboratory tests were used to determine results of repetitive loading. Photos 11 through 14 on the following pages show the appearance of these three sections.

Operational conditions and effects are stated in the following section.

TABLE IV: SUMMARY OF LOAD APPLICATIONS TO FAILURE--RING 1

Section Number	1	2	3	4	5	6
Type of Base	Screened Aggregate cement-treated	Screened aggregate asphalt-treated	Same as 6	Same as 1	Same as 2	Fractured aggregate asphalt-treated
Thickness of Base, Inches	7.75	5.25	5.25	7.75	5.25	5.25
All sections subjected to 2,000,000 wheel-load applications during period March to June 1 of 1965. Subgrade saturation initiated sections 2, 3, 4 on June 1.						
Total Load Applications at Time of Failure	4,724,100	3,146,000	2,854,000	2,440,000	4,724,100	4,724,100
Date of Failure		Sept. 7, 1965	Aug. 17, 1965	June 21, 1965		
Testing Concluded Without Failure	May 20, 1966				May 20, 1966	May 20, 1966

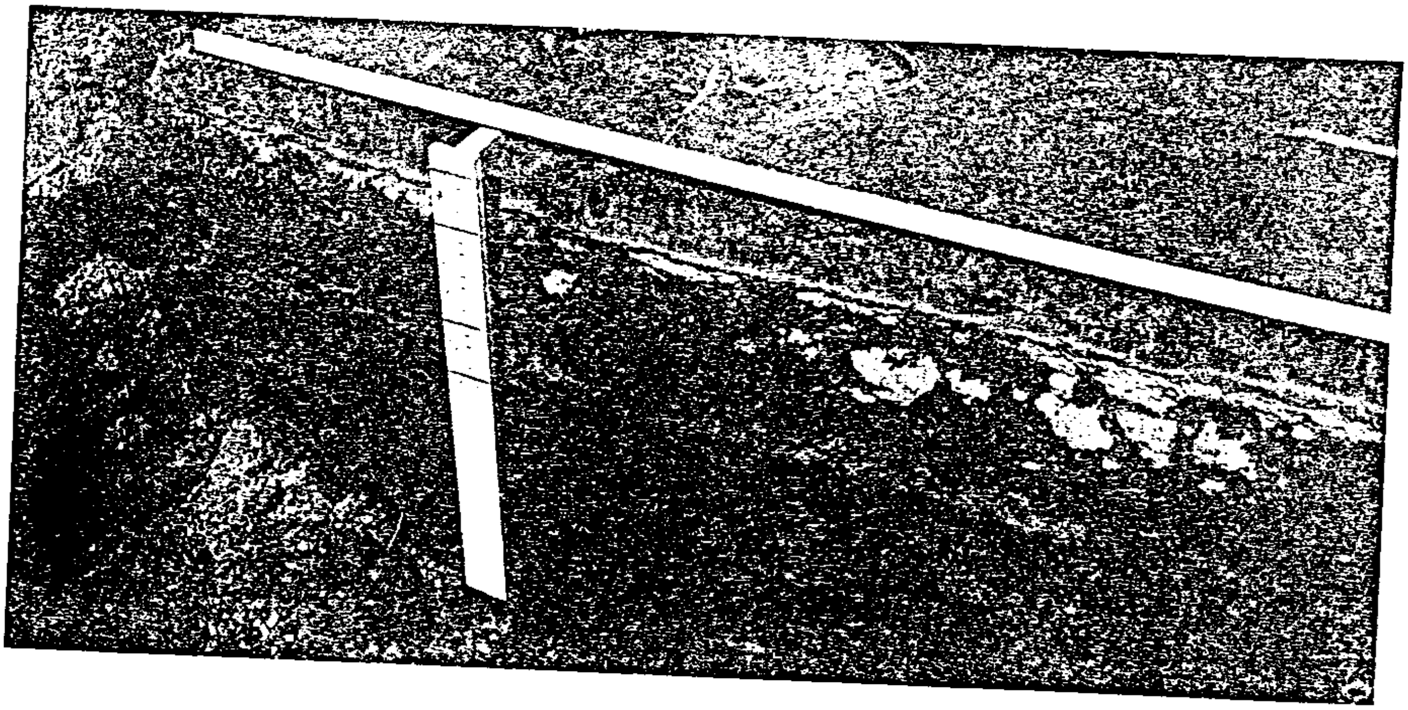


PHOTO 11.--SECTION 4, CTB, TRENCH CUT
THROUGH FAILED SECTION.

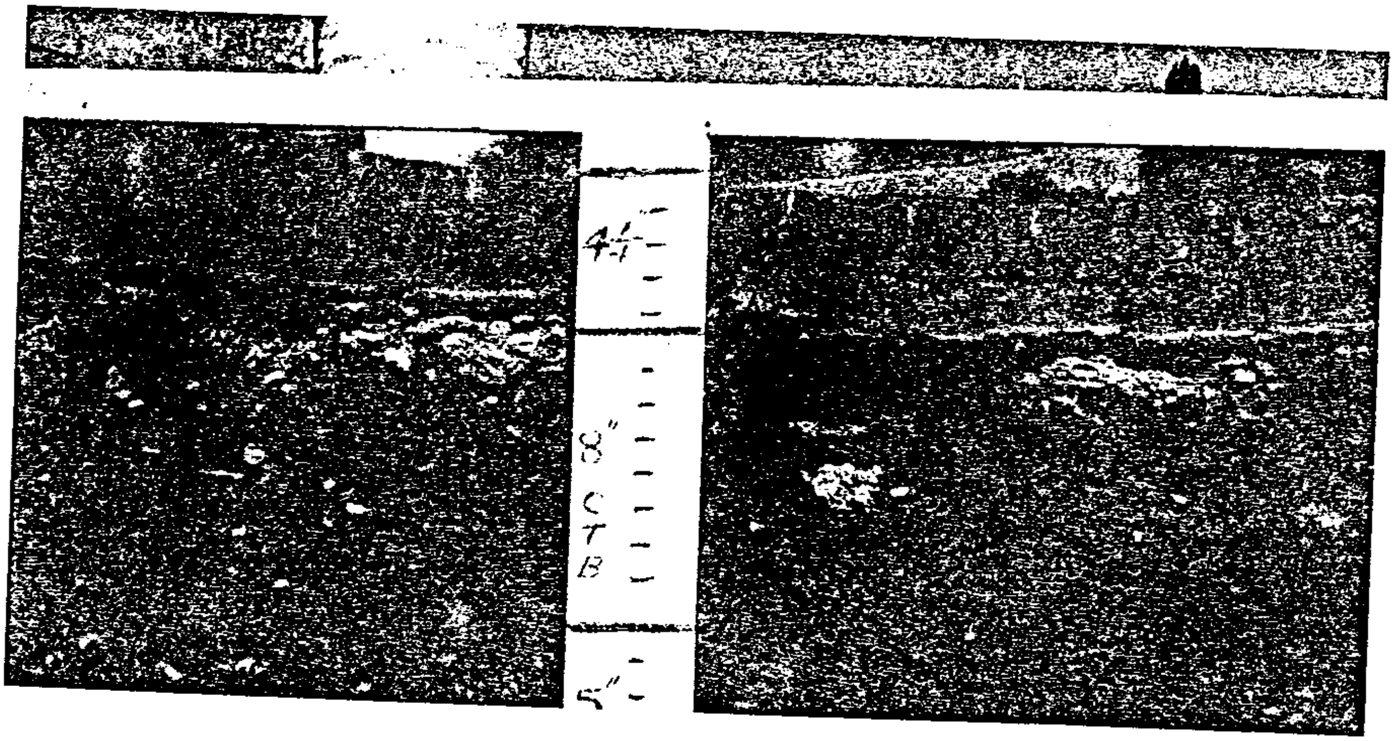


PHOTO 12.--SECTION 4, CTB UNDER WHEEL PATHS
AFTER FAILURE.

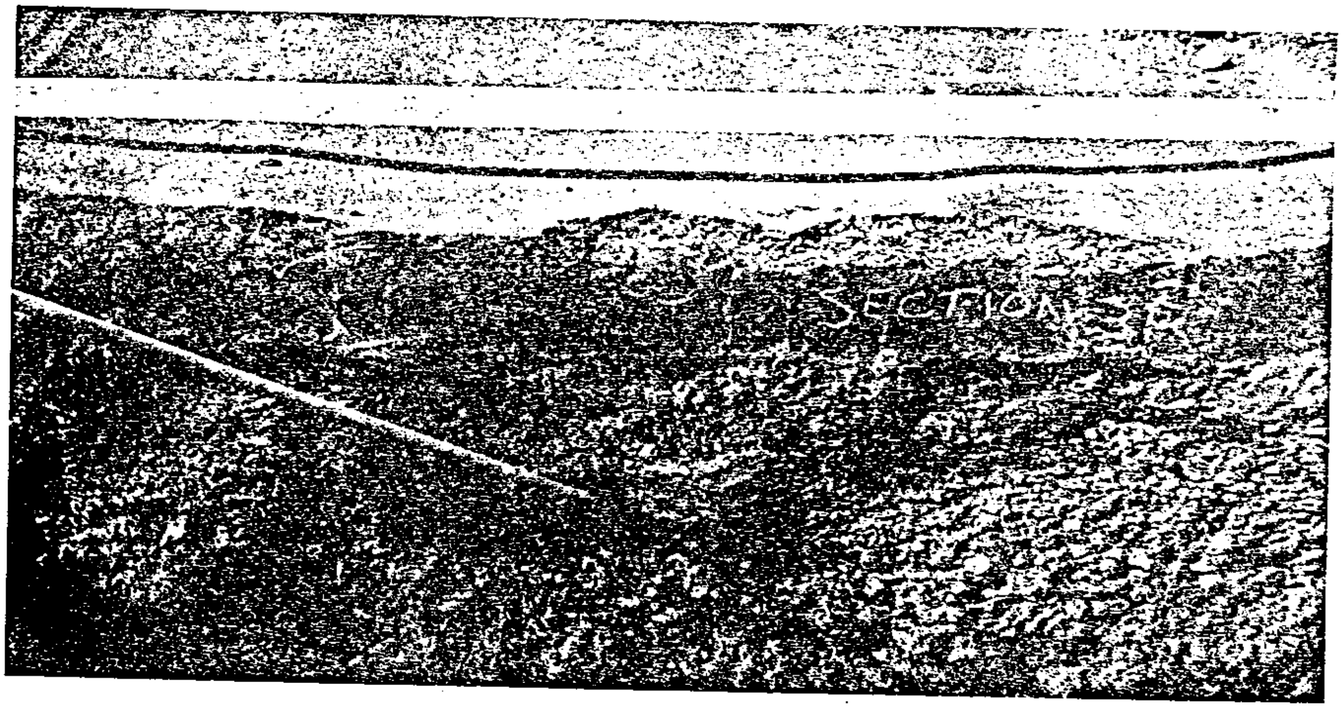


PHOTO 13.--SECTION 3 WITH THE CLASS E ATB SHOWING THE POCKET FROM WHICH FINES HAD BEEN WASHED.

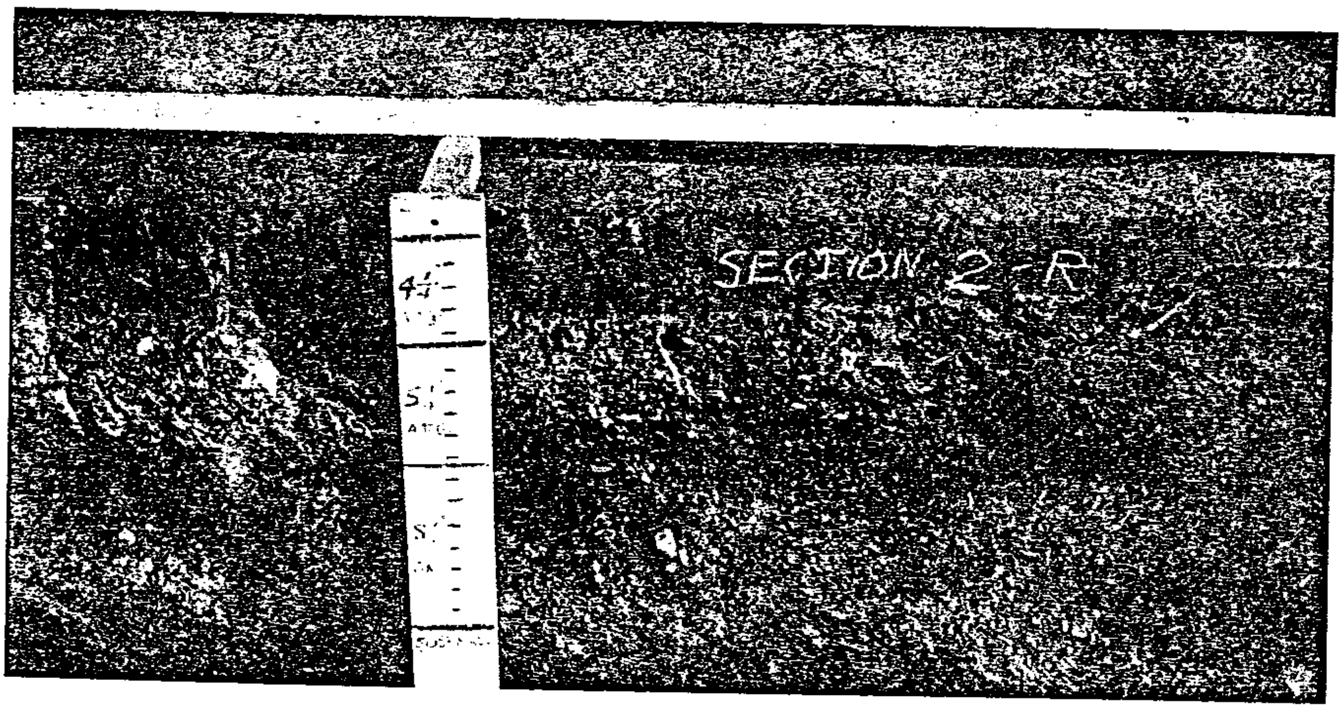


PHOTO 14.--SECTION 2 WITH SPECIAL SCREENED AGGREGATE ATB SHOWING THE TRENCH AND THE PERMANENT DEFORMATION AFTER 3,146,000 WHEEL LOADS.

Results--Ring 1

Environmental effect was apparently not a significant factor in initial operation of Ring 1. Testing started in March, 1965 and by June 1 of the same year the only visible distress was slight rutting of the surface. The artificial impressed environment of subgrade saturation did affect the sections.

Cement-treated base:--Section 4 began to show effects within 24 hours of saturation. Pumping, increased and irregular settlement, cracking and raveling developed. Cracking was increasingly extensive until fourteen days after saturation when the section was declared failed. Photos 15, 16, 17, 18 on the following pages indicate progressive surface failure and characteristic fatigue failure of the base.

It is probable that the base was cracked prior to saturation. Thus, the sections of CTB acted as stress concentrators, causing pumping with subsequent loss of fines, increased cracking and eventual surface failure. The sub-base granular material from section 4 after test showed no appreciable change in grading or increase in plasticity of the fines. Subgrade conditions in section 4 are shown in Table V.

Cement-treated base:--Section 1 continued to perform through the summer and fall of 1965, a winter shut-down, and spring operations in 1966. Total loads were 4,724,000 with surface rutting, pavement settlement and structural deformation. Photos 19, 20 and 21 show the extent of damage to section 1.

Trenching after completion of test showed the base to be cracked but stable and not easily removed. The crushed rock ballast below the CTB was in good condition. Subgrade density in section 1 had increased from traffic compaction in the upper portion. The lower portion of the subgrade showed a slight decrease in density, presumably from an undetermined cause. Moisture contents also changed in the last year of operation.

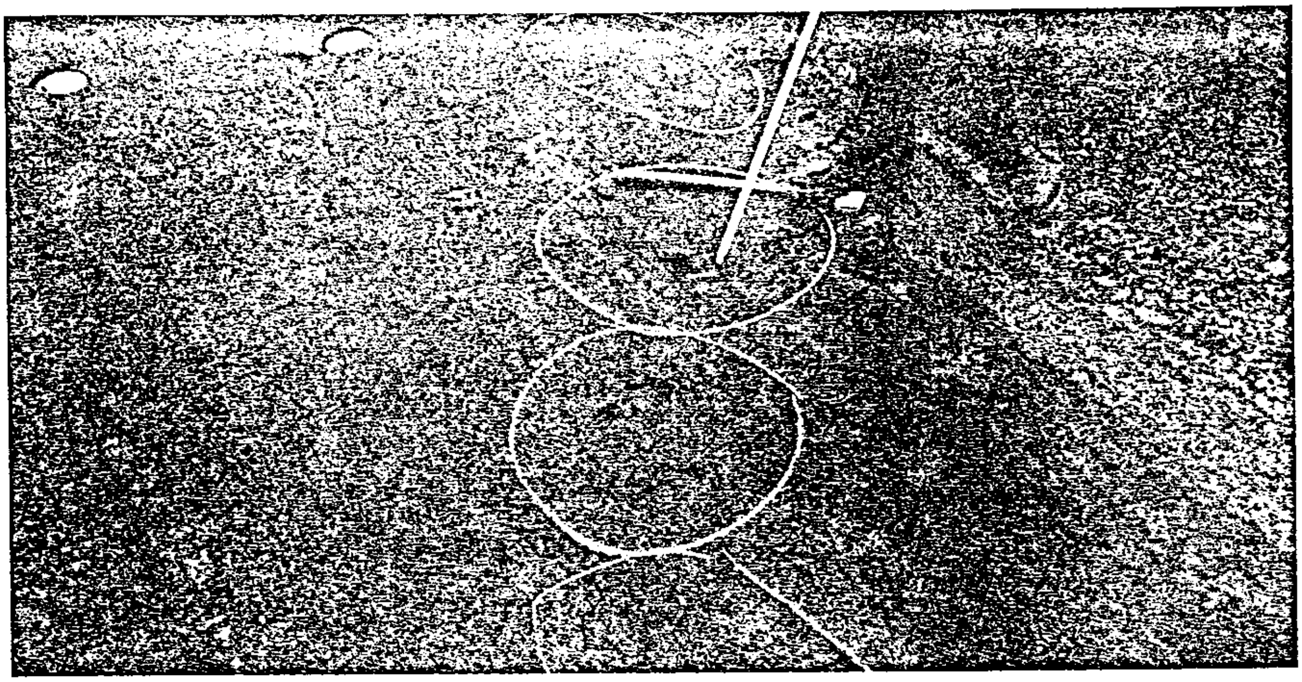


PHOTO 15.--SECTION 4 WITH CTB AFTER THREE DAYS
OF SATURATION AND 2,250,000 LOADS.

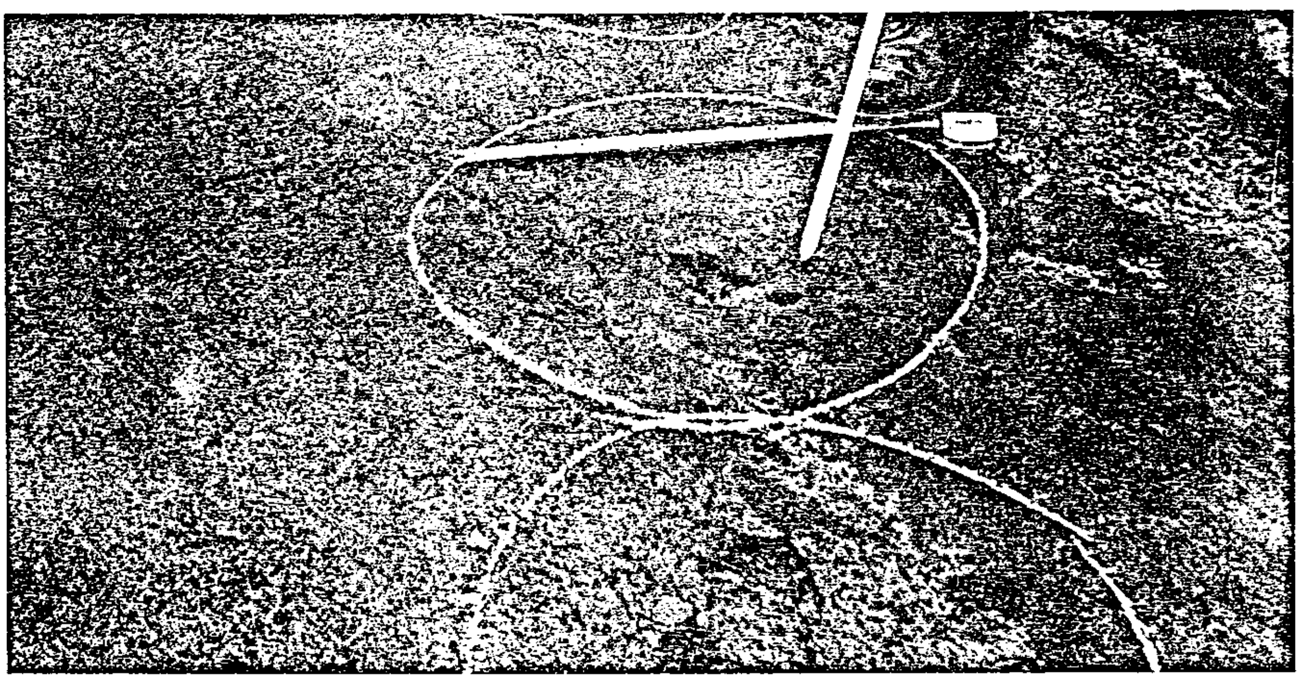


PHOTO 16.--SECTION 4 WITH CTB AFTER TWO WEEKS
SATURATION AND 2,440,000 LOADS.

PHOTO 17.--CTB, SECTION 4 UNDER WHEEL PATHS
SHOWING IRREGULAR POLYGON CHUNKS.

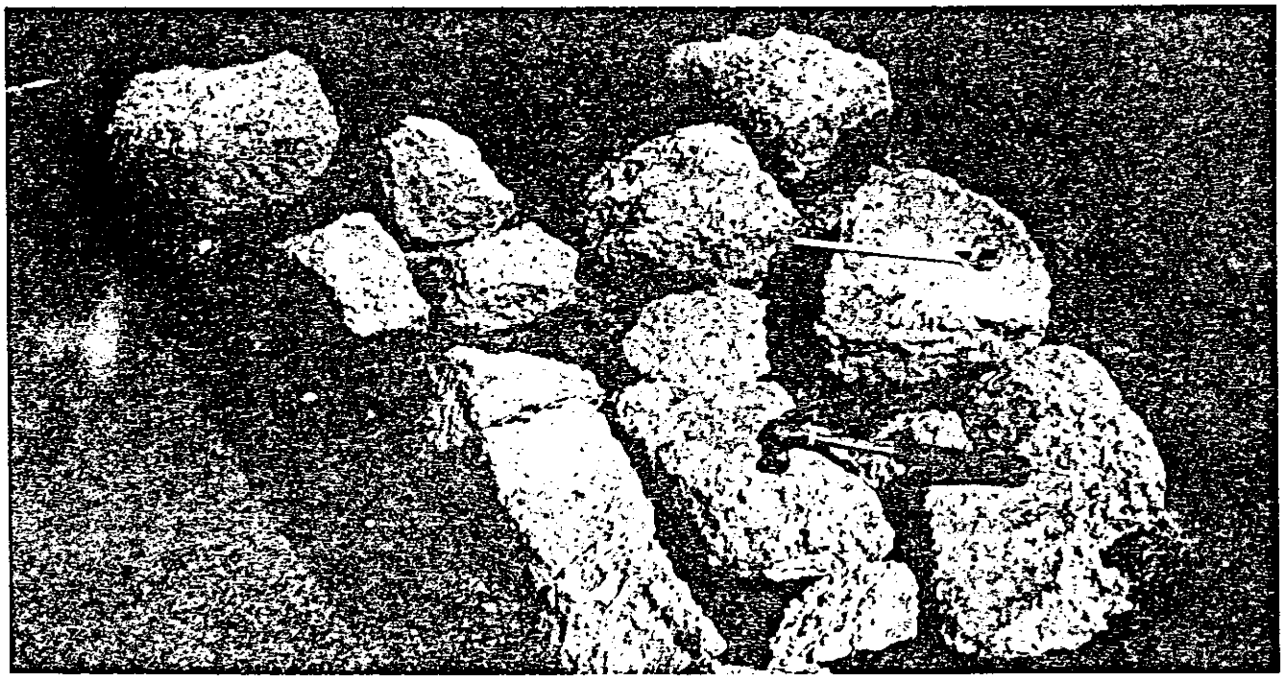


PHOTO 18.--CHUNKS OF CTB SHOW IRREGULAR BREAKAGE
UNDER SECTION 4 AFTER FAILURE.

TABLE V

MOISTURE CONTENT AND DENSITY, SECTION 4

	Pavement	Depth Below Subgrade			
		3"	12"	18"	36"
Moisture, % of dry wt.		22.6	23.1	22.4	26.0
Density, pcf. after test*	155.2	101.3			96.8
as constructed	147.0	99.0			85.0

*After test - completion of 2,440,000 wheel load applications of which 440,000 were applied after saturation of subgrade.

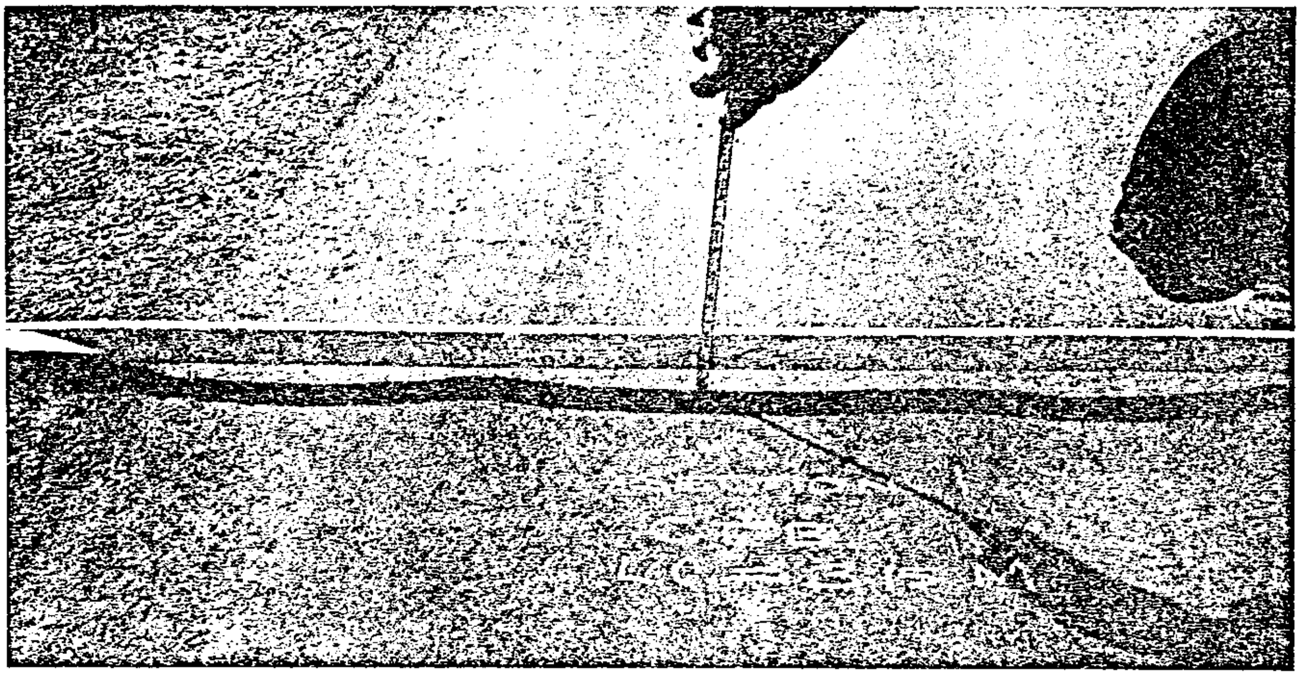


PHOTO 19.--SECTION 1 CTB AFTER 3.15 MILLION LOADS

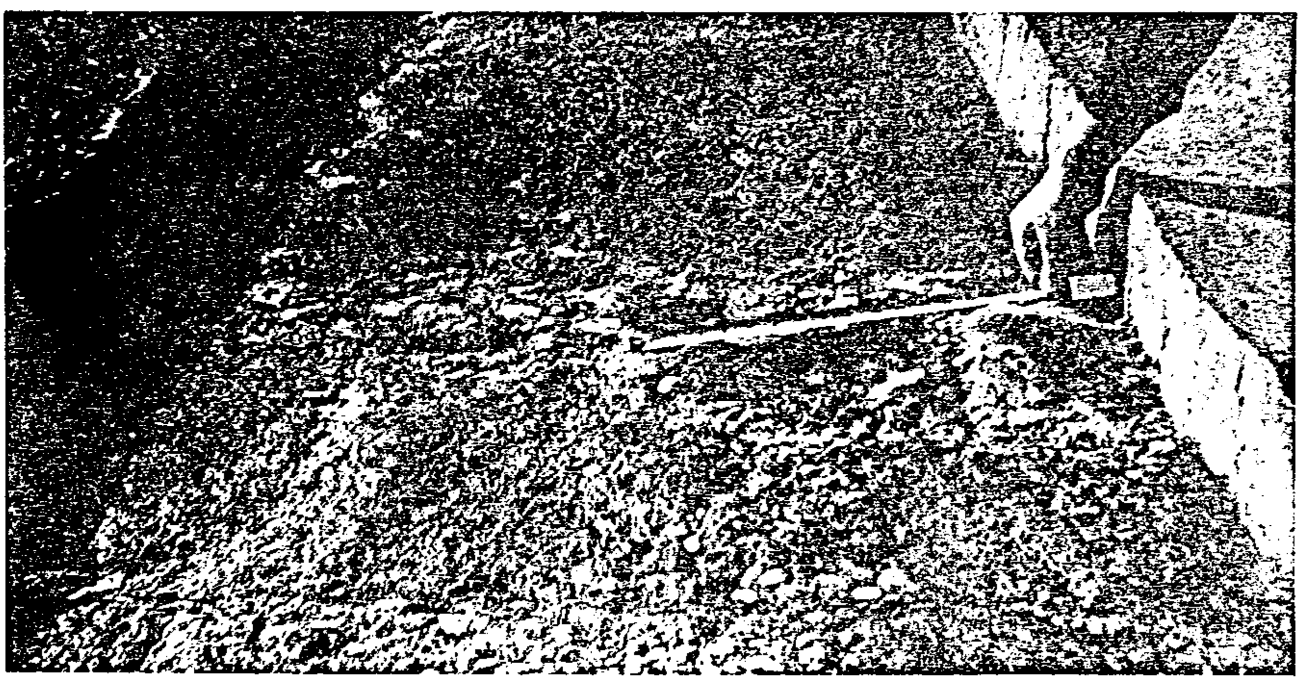


PHOTO 20.--SECTION 1, CTB, CLASS B ASPHALT
WEARING COURSE REMOVED.

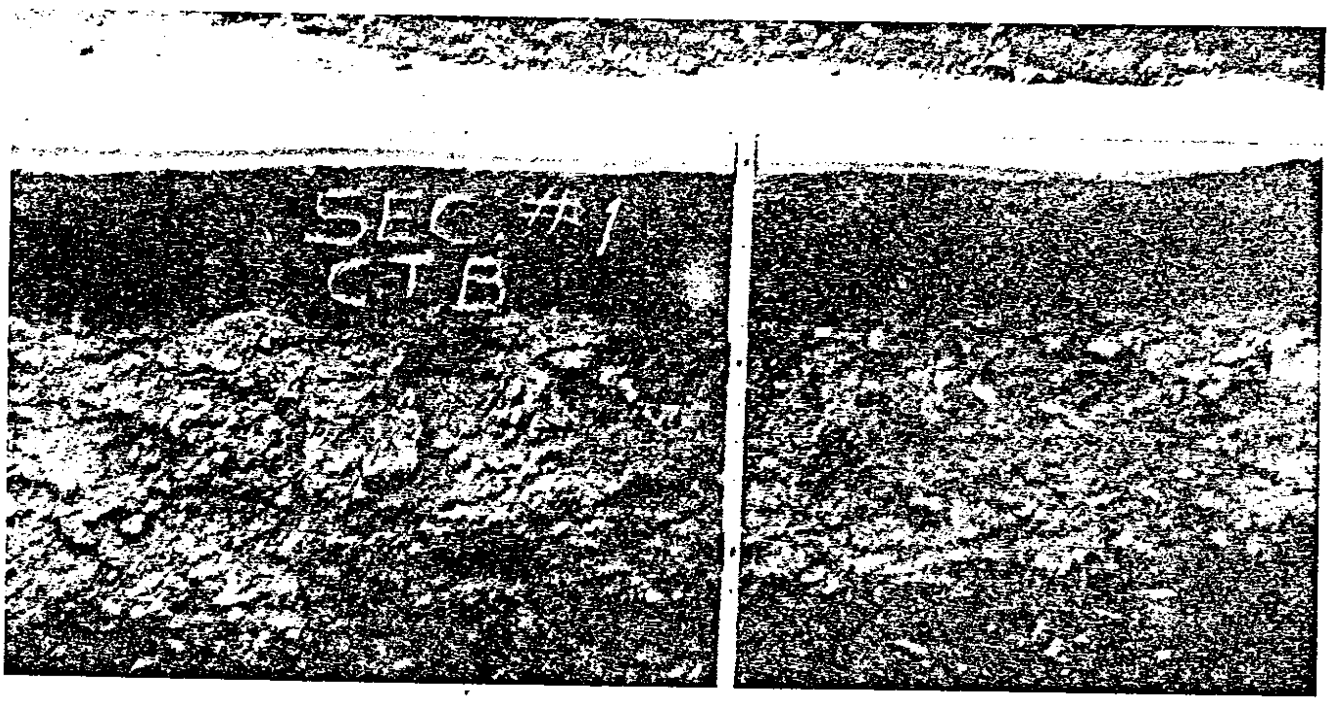


PHOTO 21.--SECTION 1, CTB, CROSS-SECTION.

Asphalt treated base:--Section 2 failed after saturation. Initial distress showed on August 30, 1965 and after 3,069,720 wheel loads (Saturation initiated June 1 with 2,000,000 wheel loads). The traveled section of the pavement had a permanent depression of 0.08'. On September 7 after 3,146,000 wheel loads rutting had increased to 0.10' and the section was declared failed. No cracks were evident at the time of failure. Photos 22 and 23 and Tables VI and VII indicate subgrade conditions.

Section 5, also of screened aggregate asphalt treated base but not subjected to saturation continued to perform with pavement settlement the only distress. No cracks developed. Testing on this section was concluded without failure in May, 1966 after 4,724,100 wheel loads. Photo #24 and Tables VI and VII indicate base and subgrade conditions.

Class E, asphaltic concrete base:--Section 3 failed in a unique manner. Quoting from the diary and quarterly reports:

> On the morning of August 17, after 2,841,900 wheel loads, evidence of distress in Section 3, of class "E" asphalt concrete base, became apparent. A marked depression of 0.18 feet depth, with excessive pavement deflections under the moving wheels, was noticed. On the same day, at 2,854,800 wheel loads, a 5-inch circular crack burst open, and water and silt began to spurt out. The cracks, along with some raveling and with pumping of water and silt, continued to increase. The section was declared to have "failed" at 3,146,000 wheel loads. At "failure," the cracks were about 30 inches in length and transverse to the direction of travel. The final settlement depth was 0.20 feet below the original elevation.

Referring to Tables VI and VII for subgrade conditions of moisture and density, and Photos 25 through 29, it can be noted that permanent deformation occurred and that fines had been washed away during the saturation process.

Section 6 also utilized Class E asphaltic concrete base, but was not subjected to saturation. It was taken out of service on May 20, 1966 after 4,724,100 wheel loads but had not failed structurally. The wearing surface did have permanent deformation and some rutting. Tables VI and VII and Photo 30 indicate conditions after testing was stopped.

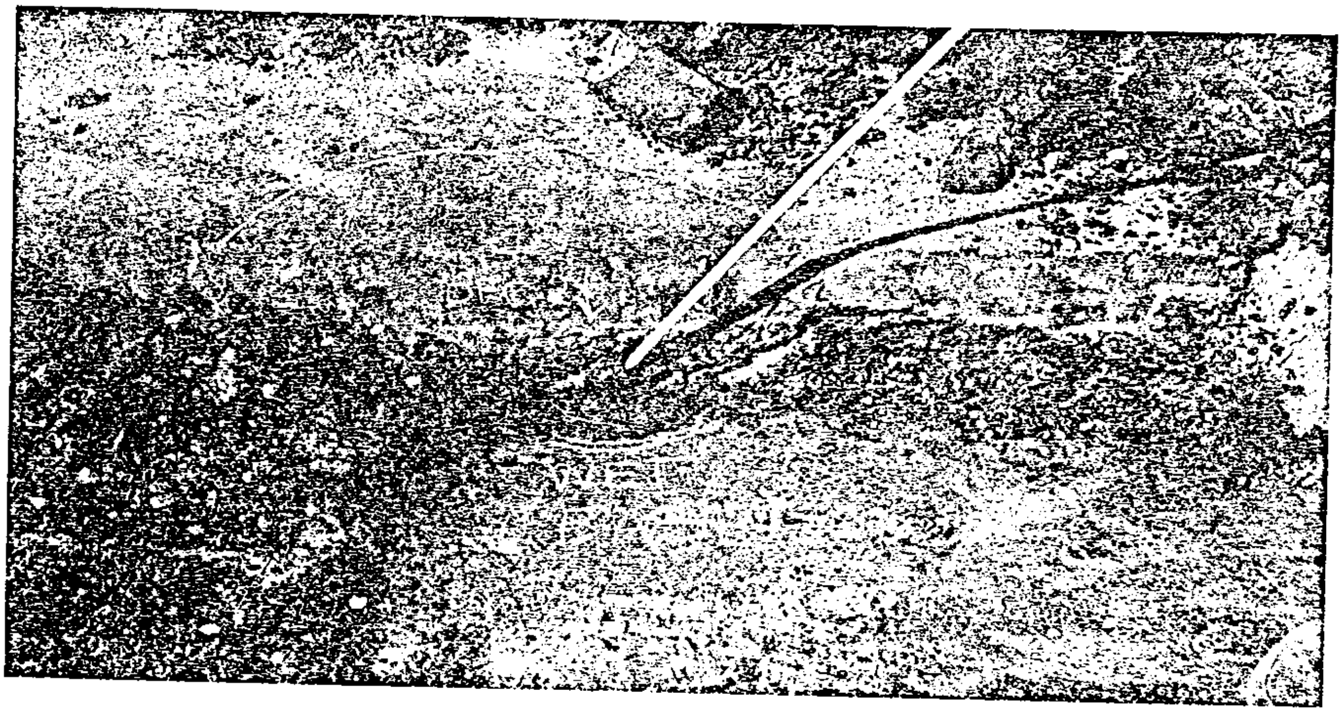


PHOTO 22.--SECTION 2 WITH SPECIAL SCREENED AGGREGATE ATB SHOWING THE TRENCH AND THE PERMANENT DEFORMATION

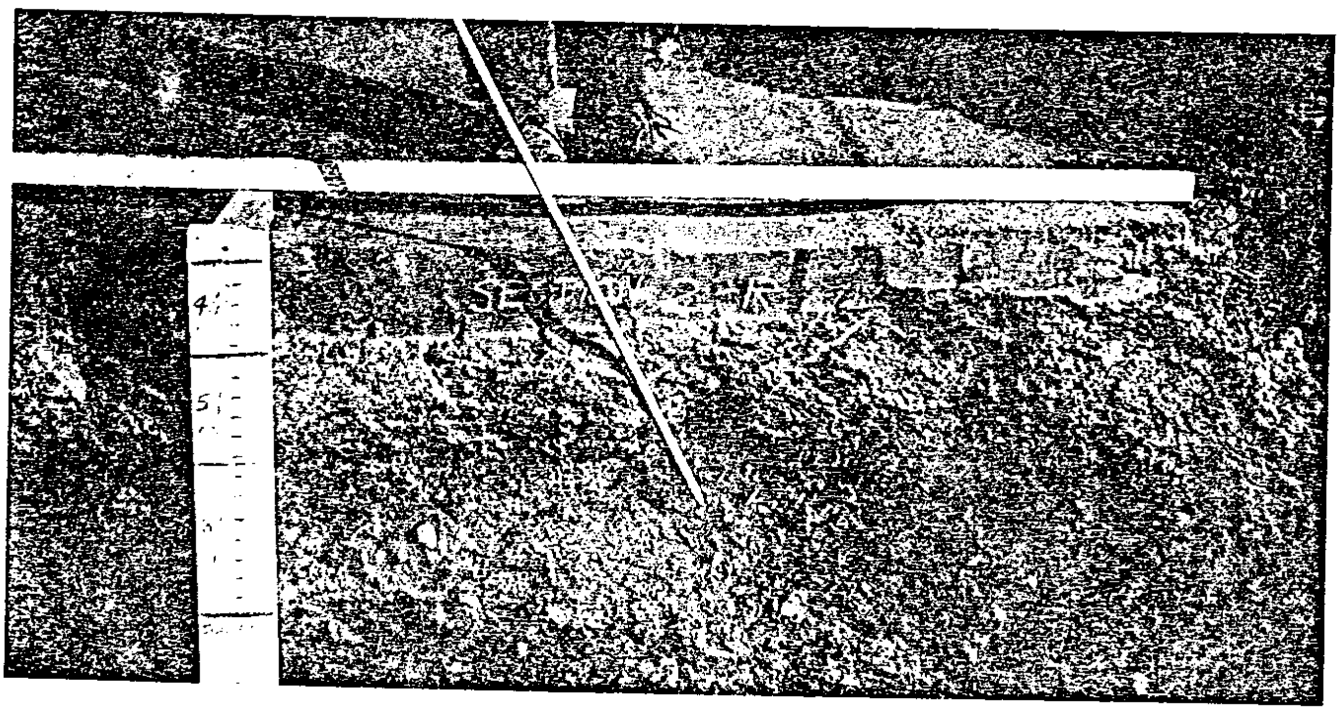


PHOTO 23.--SECTION 2 WITH SPECIAL SCREENED AGGREGATE ATB SHOWING THE TRENCH AND THE PERMANENT DEFORMATION AFTER 3,146,000 LOADS.

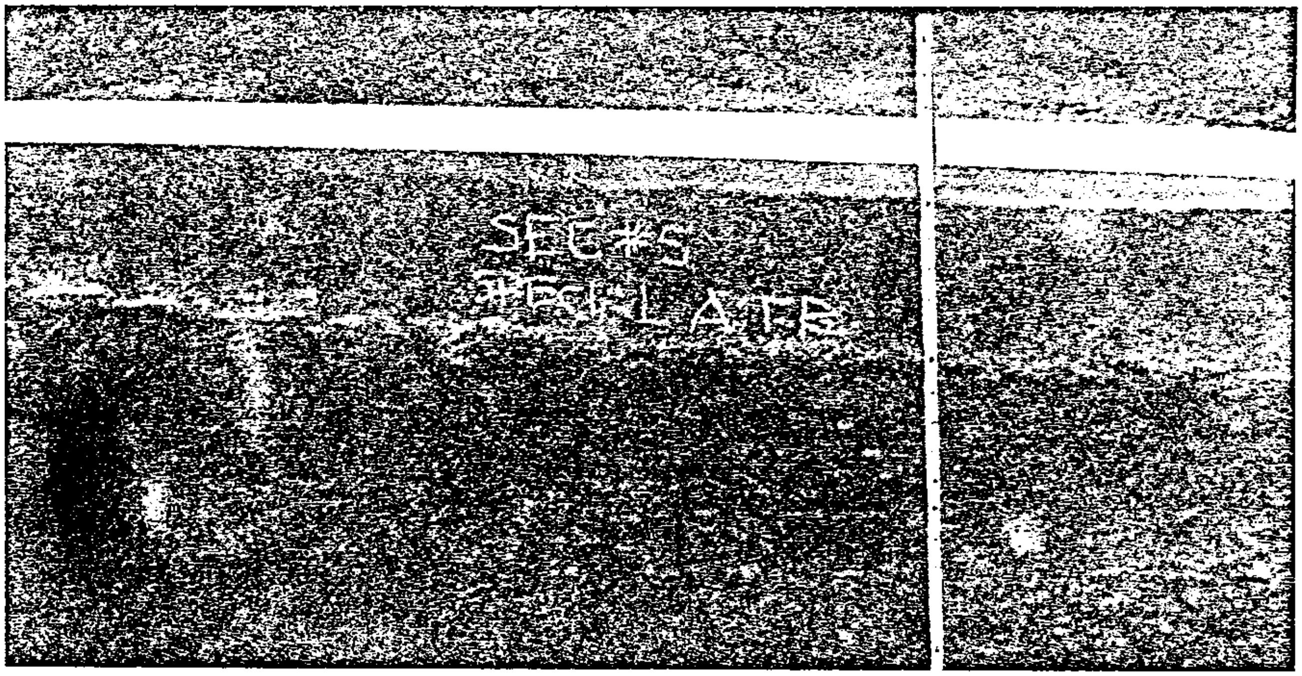


PHOTO 24.--CROSS-SECTION SECTION 5, SPECIAL ATB.

TABLE VI: DENSITY SUMMARY
(Pounds Per Cubic Foot, Dry)

Material and Elevation	Section									
	1		2		3		5		6	
	June 1965	June 1966	June 1965	June 1966	June 1965	June 1966	June 1965	June 1966	June 1965	June 1966
Asphalt Wearing Course 112.0'		155.6			152.5	154.0				
Treated Base			141.5	141.5			143.5	146.8		151.8
Top of Subgrade 110.5'	99.5	105.7					95.7	96.4	99.9	105.1
4' Below Surface 108.0'	95.8	90.3					94.2	99.3	97.6	92.3

TABLE VII: AVERAGE MOISTURE CONTENT
(% of Dry Weight)

Material and Elevation	Section							
	1		2	3	5		6	
	June 1965	June 1966	June 1966	August 1965	June 1965	June 1966	June 1965	June 1966
Crushed Rock	4.7	6.4		4.8	4.1	4.3	4.0	3.9
Top of Subgrade 110.5'	19.0	21.4	21.6	20.4	21.8	19.8	21.1	
Subgrade 110.2'	20.4	22.8	19.8	22.1	20.6	22.8	20.3	22.7
Subgrade 109.5'	19.8	21.0	23.6	21.2	21.5	21.0	20.7	17.9
Subgrade 108.5'	18.7	20.7	20.2	19.8	23.0	24.4	21.2	20.2

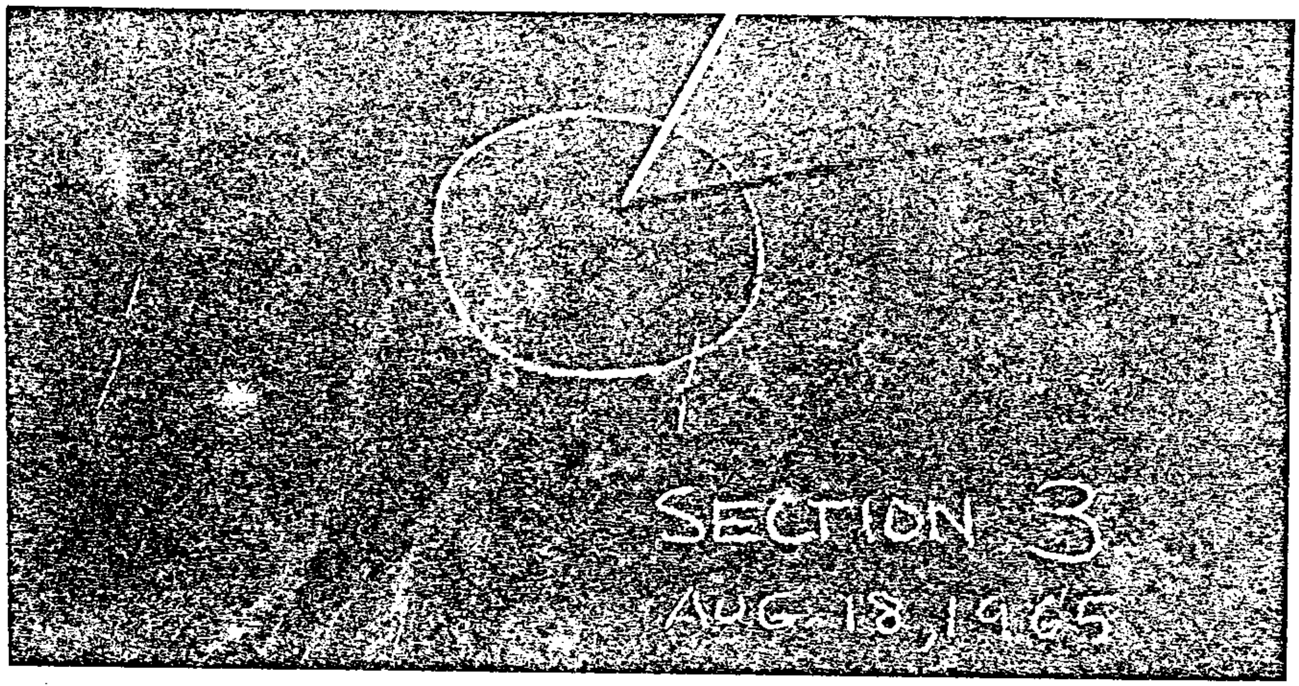


PHOTO 25.--SECTION 3 WITH THE CLASS E ASPHALT-TREATED BASE, SHOWING THE CRACK DEVELOPING AFTER 2,868,000 LOADS. NOTE THE LIGHT COLORED PAVEMENT. THIS SHOWS THE DRIED SILT ON THE PAVEMENT.

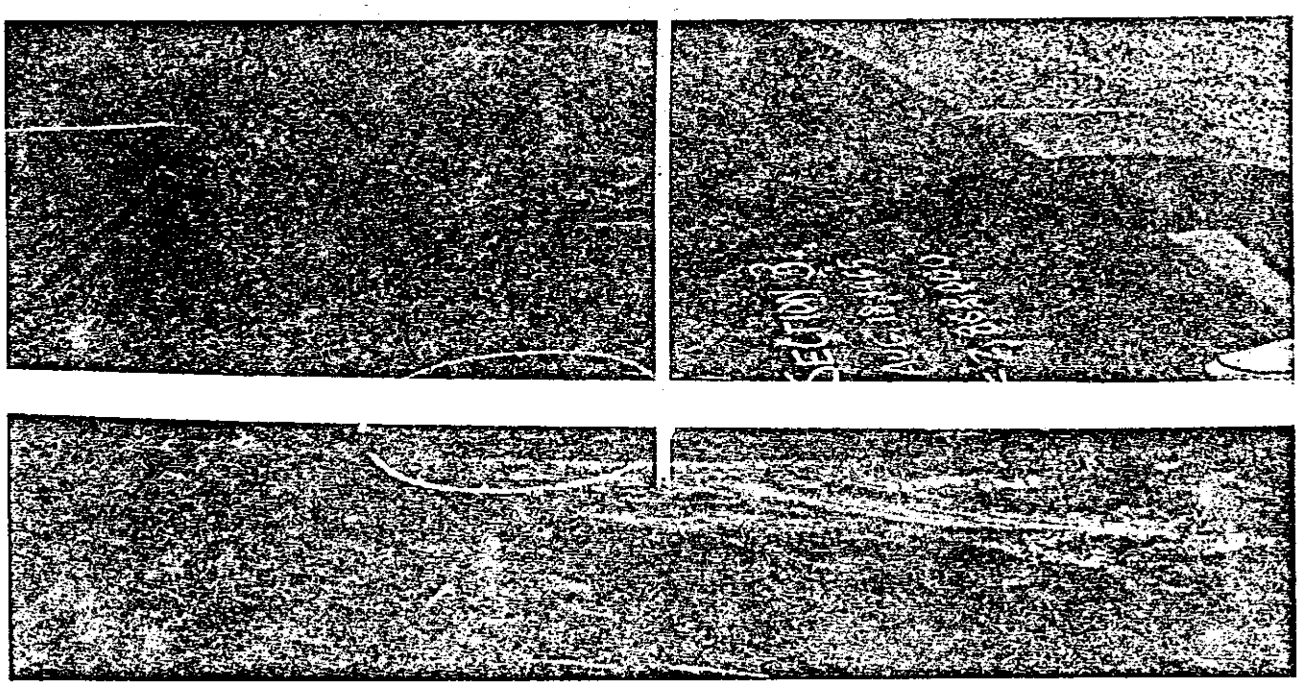


PHOTO 26.--SECTION 3 WITH THE CLASS E ASPHALT-TREATED BASE, SHOWING THE PERMANENT DEFORMATION OF THE PAVEMENT AFTER 2,868,000 LOADS.

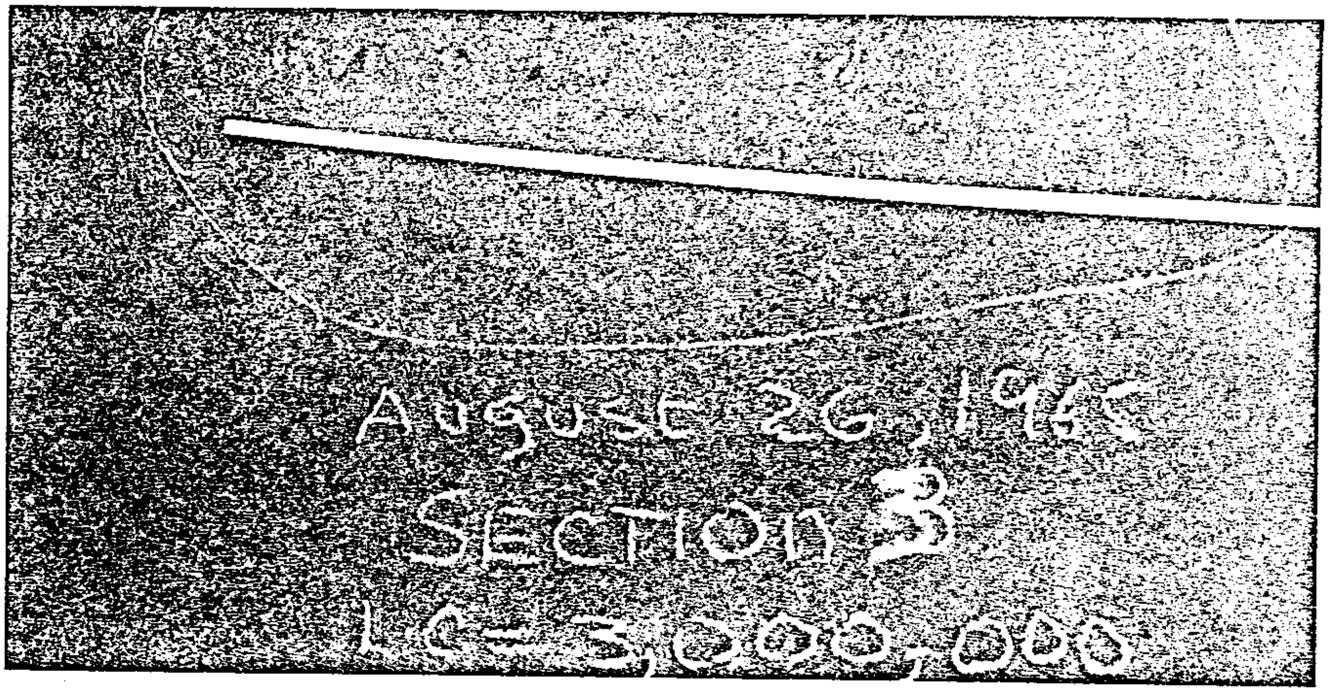


PHOTO 27.--SECTION 3 WITH THE CLASS E ATB SHOWING THE DEVELOPMENT OF CRACKS AFTER 3,000,000 LOADS.

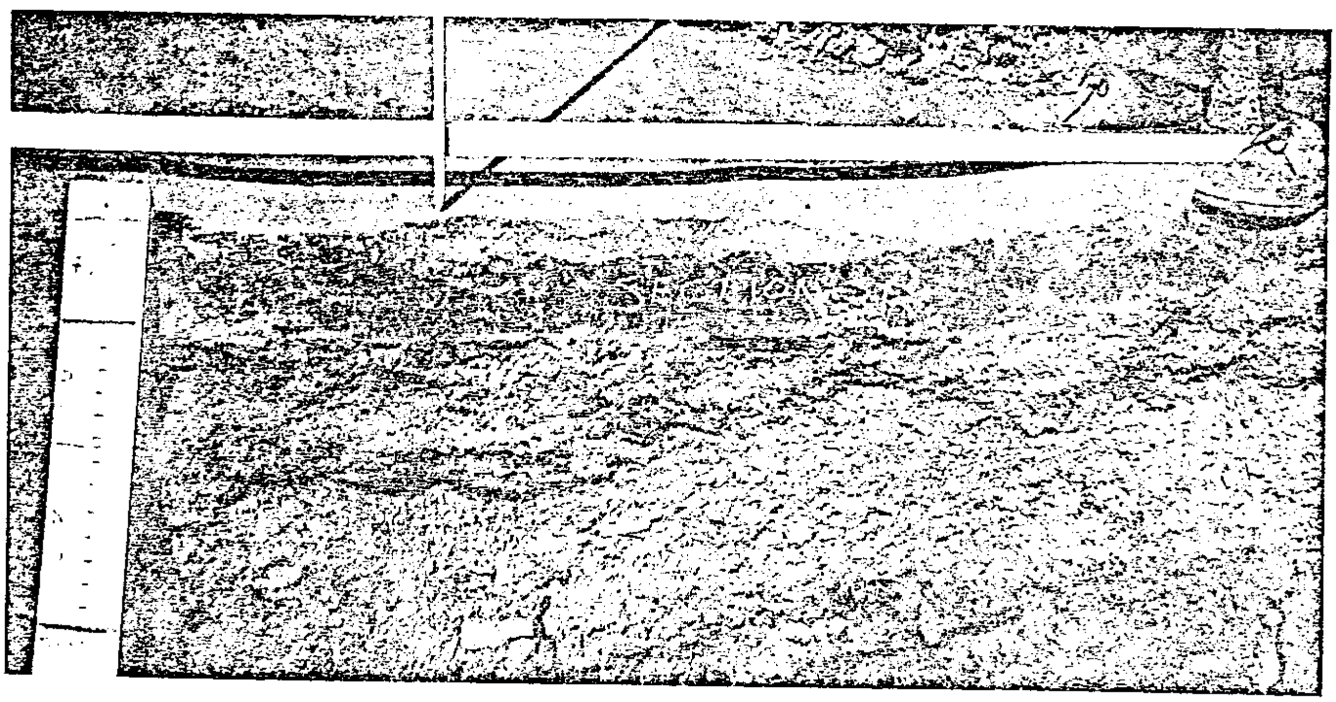


PHOTO 28.--SECTION 3 SHOWING PERMANENT DEFORMATION OF PAVEMENT.

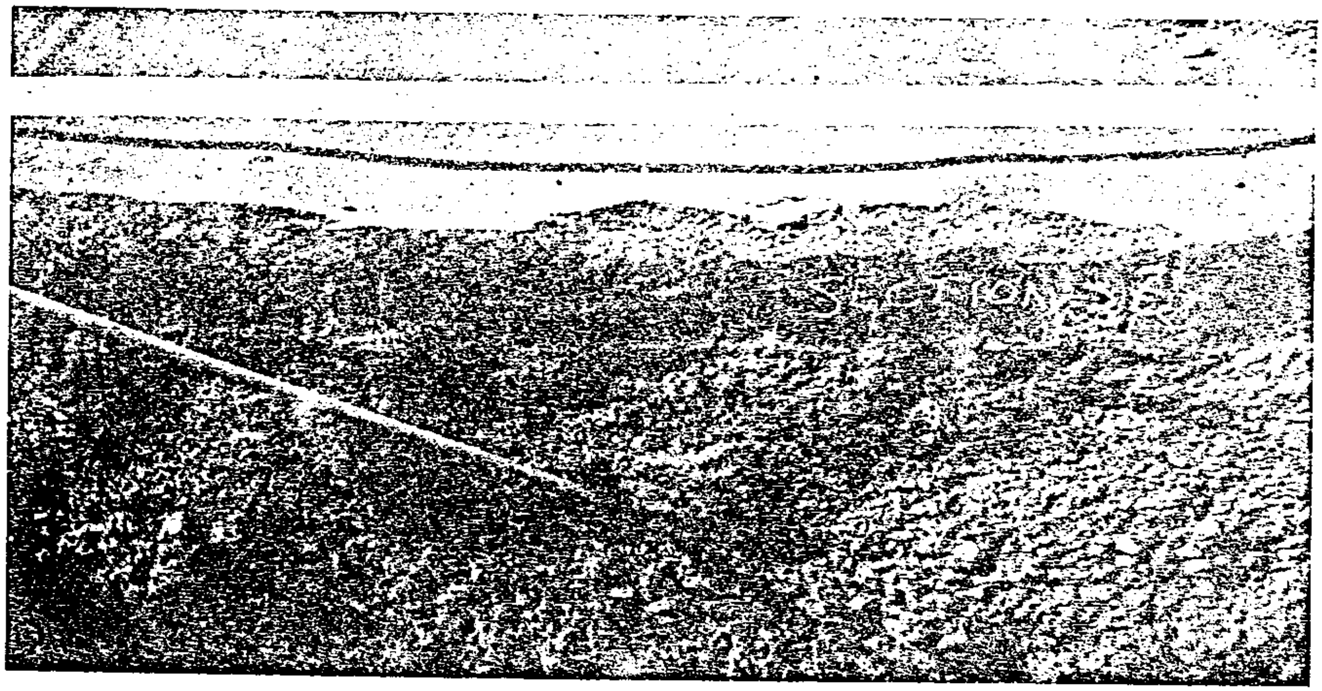


PHOTO 29.--SECTION 3 WITH THE CLASS E ATB SHOWING THE POCKET FROM WHICH FINES HAD BEEN WASHED.

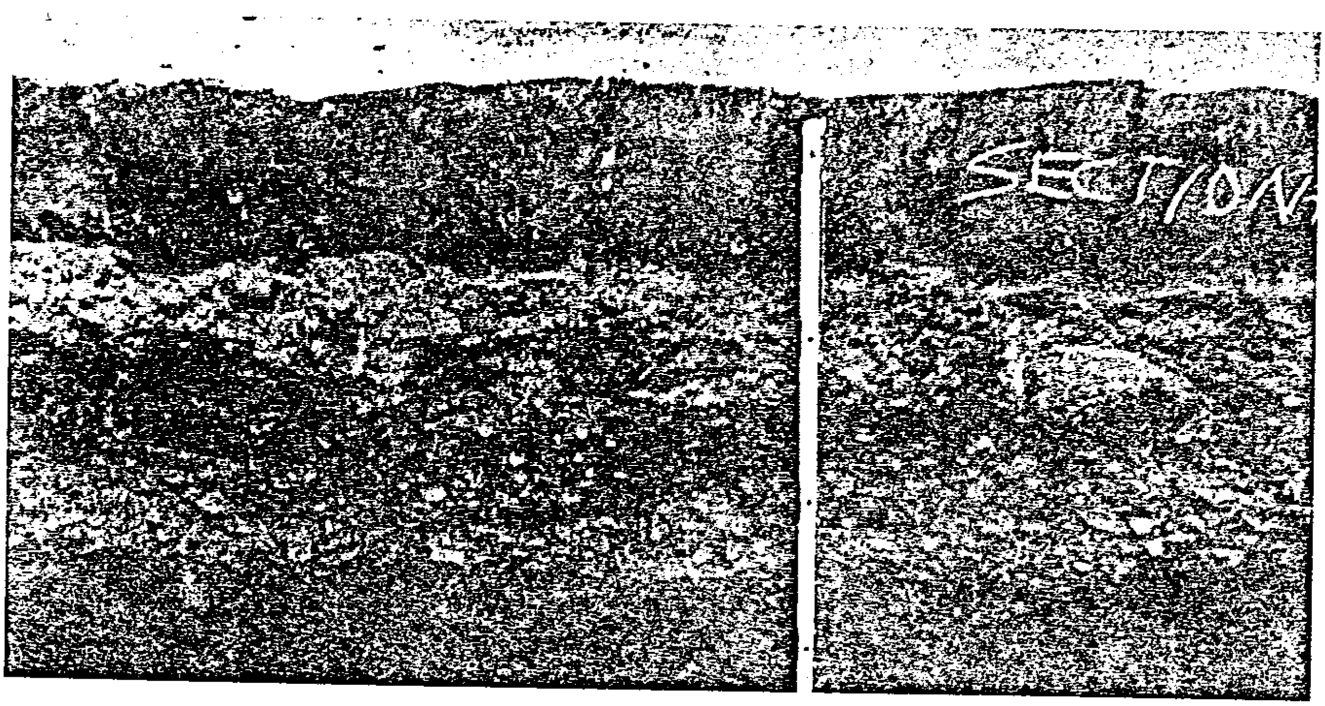


PHOTO 30.--CROSS-SECTION SECTION 6, CLASS E ATB.

<u>Pressure cells</u>:--The pressure cells in Ring 1 were used on an experimental basis. Those cells placed in the base and between the ballast and subgrade failed during the operation of the test track. Failure to function was due to leaks developing at the cell-tubing junction. The cells which were placed in the subgrade continued to function throughout the test.

A summary of maximum stresses recorded by the pressure cells is shown in Table VIII.

TABLE VIII: WSU PRESSURE CELLS
MAXIMUM READINGS, RING 1
(pounds per square inch)

Location of Cell	Elevation, Feet	Section		
		1 CTB	2 Spec. ATB	6 ATB
Below Base	111.00* 111.21**	8.92	2.85	3.55
Below Crushed Rock	100.50	1.24	1.93	1.55
Below Subgrade	109.00	0.22	0.40	0.85

*Under CTB

**Under Spec. ATB and ATB

Observations made of pressure cell operations include:

1. One of the cells under the cement treated base showed a marked increase in stress at approximately 200,000 wheel loads, indicating a changed condition in stress dispersal within the pavement system.
2. Between September and December the stresses as indicated by the pressure cells showed a marked decrease in unit pressures. Thus, stress dispersal was shown to be temperature dependent.

3. Examination of Table VIII data indicates that under the conditions of test and instrumentation, the cement-treated base did not distribute the load within the base as well as the asphalt treated bases but did distribute the load better below the base.

Paint testing:--Photos 31 through 34 show results of traffic loads on various types of traffic paints. No. 31 shows the effect of 2,250,000 loads moving over a stripe of plain paint. No.'s 32, 33 and 34 show the effect of 3,000,000 loads over plain, pre-mix, and pre-mix plus added beads.

Generally speaking, the pre-mixed bead paints had the best performance record, followed by the plain paints and the combination pre-mix plus added beads. Paints submitted from Idaho appeared to have the best durability, with Oregon, Washington and California paints following in that order.

An explanation plus a comment on paint testing is given here:

> The Wash. and Calif. paints are based on high polymer resins and cure simply by solvent evaporation so that they have attained their full strength as soon as the solvents are out of the film. The Oregon and Idaho paints are based on Alkyd resins and cure by polymerization in place. They become increasingly harder as this action proceeds but during the initial period of cure they are quite plastic and could follow the deformation of the pavement. Since these paints were placed in December the cold weather slowed down the process of cure so that they were quite plastic during the period of time that pavement deformation was taking place.
>
> The condition of the pavement, the time of painting, and the degree of cure on the paint films all led to erroneous results. The pavement flow led to as much as a 200% elongation on the paint films which they are not designed to absorb.
>
> In general, the surface to which the paints were applied made a fair or accurate determination of wear rates and visibility almost an impossibility. The real purpose of the test was not to evaluate the paints but rather to determine whether or not the track would give useable results for paint testing.*

---

* L. W. Cody, 7/9/66 letter to Roger V. LeClerc.

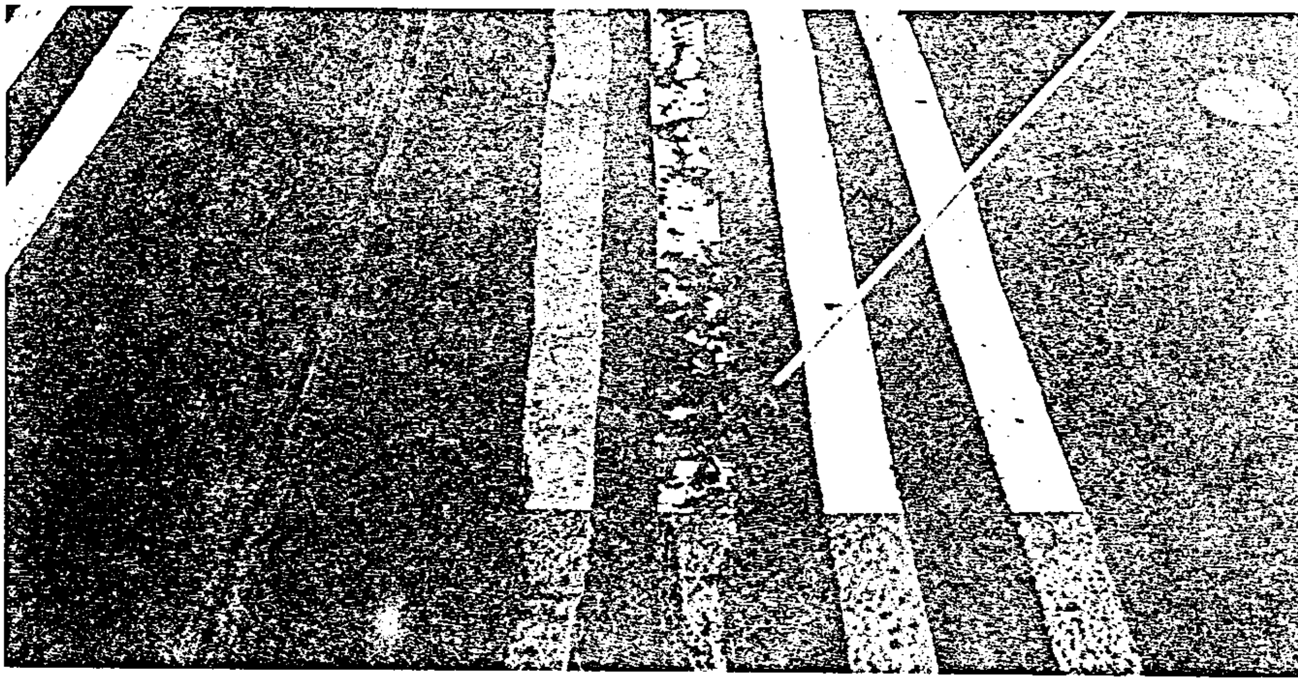


PHOTO 31.--EFFECTS OF 2,250,000 LOADS ON STRIPE PRE-MIX BEAD PAINT SAMPLES. LEFT TO RIGHT SAMPLES ARE WASHINGTON, CALIFORNIA, IDAHO & OREGON.

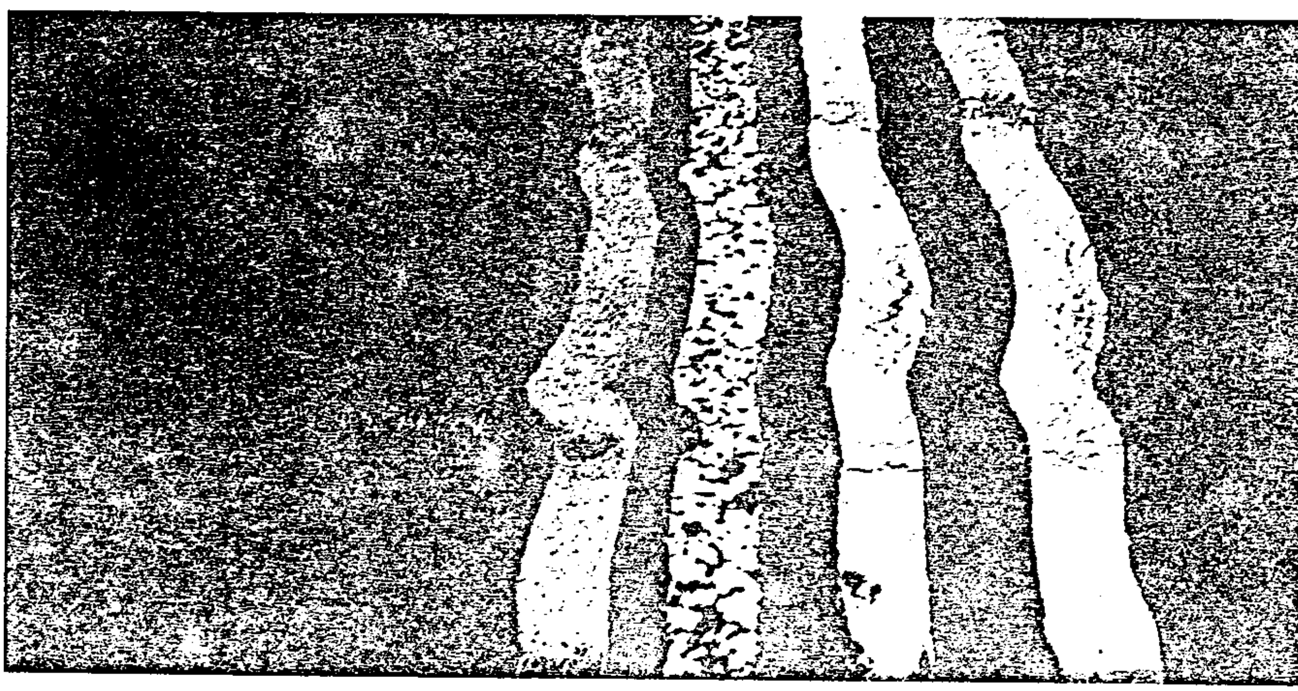


PHOTO 32.--EFFECTS OF 3,000,000 LOADS ON PLAIN STRIPE PAINT.

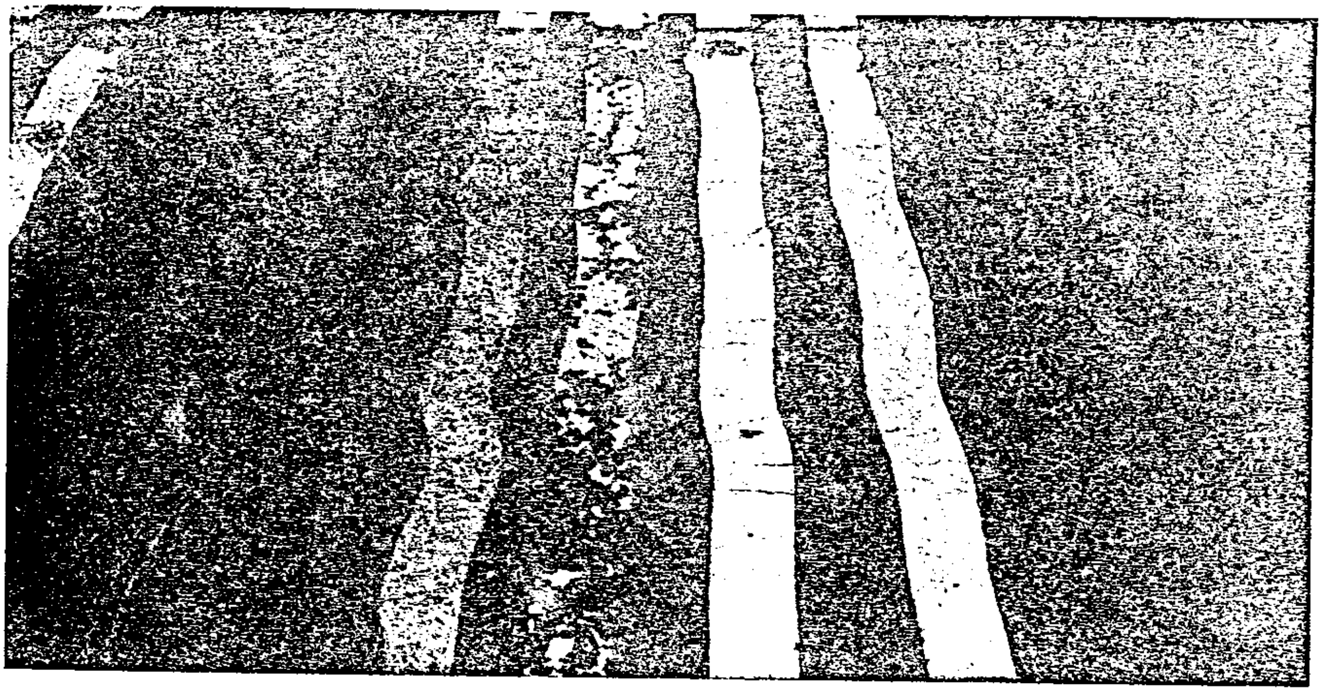


PHOTO 33.--EFFECTS OF 3,000,000 LOADS ON
PRE-MIX BEAD STRIPE PAINT.

PHOTO 34.--EFFECTS OF 3,000,000 LOADS ON
COMBINATION SPRINKLED BEAD STRIPE PAINT.

Discussion of Results, Ring 1

Objectives:--The four objectives of the first experimental ring were fulfilled in the following ways:

1. Pavement system performance using non-fractured aggregate as a substitute for fractured aggregate in treated base under test conditions was good. Certainly the results indicate that with pavement systems 18 inches in depth, the advantages of using fractured aggregate should be thoroughly checked. There is a possibility that such use is a needless expense in many cases.
2. Relative performance of cement-treated base vs. asphalt treated base was not determined. Both performed well under ordinary environment. In an artificially induced environment of saturation, the cement-treated base did fail rapidly. This effect could have been the condition rather than the type of base undergoing construction.
3. The instrumentation used in Ring 1, pressure cells, served a definite purpose in showing that meaningful results could be obtained. Also, just as stress can be measured, then concurrent instrumentation for strain, moisture, temperature and other variables can be determined for analysis, both from the theoretical and the practical viewpoints.
4. Results of tests on pavement marking show that the pavement test facility can be used as a wear machine with known limitations.
5. An incidental result of Ring 1 was accumulation of data for a report on tire wear. This is covered fully in Circular 27, "A Study of Truck Tire Wear on the Pavement Test Track" by Milan Krukar, published by Technical Extension Service, Washington State University.

Closure:--Ring 1 operation and results have definitely indicated the potential of the facility for testing pavement systems. As instrumentation is improved, as data is accumulated, as problems of environment, construction and operation are solved by experience, the facility will be a valuable research tool for the Highway Department, the University, and other sponsors for many years.

COST AND PARTICIPATION SUMMARY

Item	Amount	Participation: Washington State University	Participation: Department of Highways	Participation: Asphalt Institute	Participation: Others
Preliminary Design Prior to August 1963	8,870.00	8,870.00			
Permanent Facilities					
Site & Structure	25,730.30				
Revolving Steel Frame	6,576.96				
Electric Power Equipment	30,670.26				
Eccentric Control	2,758.84				
Running Gear	2,961.23				
Recording Equipment	1,070.16				
Miscellaneous	334.70	2,124.04	67,978.41		
Tires	1,120.00				1,120.00
Salaries & Wages	35,941.32	22,582.00	13,359.32		
Indirect Costs*	17,251.83	13,912.00	3,339.83		
Subtotals--Facilities	124,415.60	38,618.04	84,677.56		1,120.00
Build & Test Ring #1					
Construction Contract	10,687.99				
Equipment	1,650.68				
Electric Power	3,465.00				
Operation & Supplies	1,767.30	5,570.70	12,000.27		
Salaries & Wages	25,468.65	17,499.23	7,969.42		
Indirect Costs*	12,224.95	10,232.60	1,992.35		
Subtotals--Ring #1	55,264.57	33,302.53	21,962.04		

COST AND PARTICIPATION SUMMARY
Continued

Item	Amount	Participation: Washington State University	Department of Highways	Asphalt Institute	Others
Build & Test Ring #2					
Construction Contract	10,473.14		10,473.14		
Equipment	13,385.29	10,447.98	1,733.15	1,204.16	
Electric Power	772.81		772.81		
Operations & Supplies	13,663.02	799.01	10,990.54	755.28	
Travel	756.40	77.82	126.35	552.23	
Salaries & Wages	42,597.42	16,050.67	21,148.33	5,398.42	
Indirect Costs*	20,446.76	15,159.68	5,287.08		
Fund Transfer		- 9,589.91		+ 9,589.91	
Subtotals--Ring #2	100,976.65	32,945.25	50,531.40	17,500.00	
Prepare & Publish Report					
Operations & Supplies	500.00	500.00			
Salaries & Wages	700.00	700.00			
Indirect Costs*	336.00	336.00			
Subtotals--Report	1,536.00	1,536.00			
PROJECT TOTALS	291,062.82	115,271.82	157,171.00	17,500.00	1,120.00

*NOTES: Indirect costs are computed at 48% of salaries and wages. This table is from Highway Research Section records and may not agree precisely with Accounting Office figures.

APPENDIX A

SPECIFICATIONS AND CONSTRUCTION PROCEDURES

RING 1

SPECIFICATIONS

PAVING AND SURFACING
of
PAVEMENT TEST TRACK

(Revised for Change Order No. 1 - April 20, 1966)

Description of Work

The work proposed under this contract involves the construction of six experimental pavement sections in a circular test track, by grading, compacting, surfacing and paving as shown on the attached drawing, TP-1. Three pavement designs are required with two sections of each design.

The pavements are for experimental purposes in scientific research. Strict compliance to line and grade, physical dimensions, uniformity of materials and all provisions of the specifications will be required.

References

The State of Washington Standard Specifications for Road and Bridge Construction 1963, will be used as contract requirements for construction materials, methods, and workmanship, in so far as they apply. They are hereafter referred to by Section and Paragraphs.

All sections, paragraphs and provisions therein, hereinafter referred to are hereby made a part of this contract as fully set forth herein except as especially modified for individual items.

Any reference to Architect, Engineer, State, Director of Highways, Highway Commission, shall be interpreted to mean Washington State University as represented by the Board of Regents through duly appointed officials.

Samples and Tests

All sampling and testing will be done by the engineer at the expense of the University. Materials for tests and samples shall be furnished by the contractor at no added cost to the University.

Construction Details

Subbase Embankment

Subbase embankment consists of a fill to a depth of 2.5 feet above elevation 100.00 feet on the entire ring for all six sections as shown on the plans. The fill below elevation 100.00 is not a part of this contract. The subbase embankment shall be compacted to 95% of the maximum density and not more than 3% over standard proctor optimum moisture. Construction shall be according to method "C" and comply with paragraphs 3.127, 3.128A, 3.128B and 3.128E of Section II.

Borrow materials are available at the site at no cost to the contractor. Uniformity of material throughout the embankment will be required.

Base Course - Crushed Surfacing

[illegible] material shall be the same on all six [illegible], [illegible] which shall be as shown on the drawings. They shall meet the requirements of paragraph [illegible] of section [illegible] for base course. Paragraphs [illegible] and 3.16 of section 26 shall apply.

Top Course - Crushed Surfacing

The top course materials shall be used in shoulders and as a choker course over the subbase, between the base material and the treated base on all six sections as shown on the plan. The material shall meet the requirements of paragraph [illegible] of section 26 for top course and keystone. Paragraphs 3.05, 3.08, 3.12 and 3.15 of section 26 shall apply.

Cement Treated Base

Cement treated base using screened aggregate shall be placed in sections 1 and 4 as shown on the plan. Construction shall meet the requirements of paragraphs 3.02A to 3.06 inclusive, of section 31. ~~The aggregate shall [illegible] grading requirements shall be as specified in paragraph [illegible] of section 31.~~ The materials shall meet the requirements of Sec. 31-2.01 and 31-2.02B except that the aggregate shall be a screened gravel as described below:

Screened gravel aggregate is defined as naturally occuring granular materials, essentially hard and sound having not over 10% by weight, of fractured or angular pieces. It shall be free from clay, vegetable matter, and other deleterious substances. It is estimated that 5% cement will be required for the CTB, subject to confirmation by standard control tests on the aggregate.

Asphalt Concrete Class "E"

Asphalt concrete class "E", is designated as a pavement base course in sections 2 and 5 as shown on the plan, and shall be constructed as per paragraphs 2.02A thru 2.02E, 2.03, and 3.01 to 3.09 inclusive, of section 32.

Special Asphalt Concrete

This material using screened aggregates shall be used as an asphalt treated base in sections 3 and 6 as shown on the plan. Construction to be in accordance with paragraphs [illegible] 3.01 to 3.09 inclusive of section 32. Aggregates shall ~~be the same as specified for~~ meet the requirements for screened gravel as outlined under Cement Treated Base, of these specifications.

Asphalt Concrete Class "B"

Asphalt concrete class "B", finished pavement, shall be the same on all six sections, and shall be constructed as per paragraphs 2.02 through 2.02[illegible], 2.03, 3.01 to 3.07 inclusive, 3.12 and 3.13 of section 32.

Asphalt Content:

It is estimated that the asphalt content will be [illegible] of "E" asphalt concrete, special asphalt concrete and class "B" asphalt concrete respectively, subject to confirmation by [illegible] provided.

Compaction of Asphalt Concrete

All asphalt concrete shall be compacted to [illegible] as directed by the engineer.

Asphalt

The grade of asphalt used in Class "B", Class "C" and Special Asphalt Concrete shall be Grade AC-120 and shall comply with all the requirements set forth in section 25-2.01D.

Prime Coat

Prime coat, emulsified asphalt SS-1 shall be uniformly applied to the inside shoulder and top course before asphalt concrete "B" and special asphalt concrete treated bases in section 2, 3, 5 and 6 as shown on the plan. The requirements shall be in accordance with sections 25-2.01F, 25-3.01B and 32-3.01B.

Tack Coat

A tack coat of asphalt SS-1 shall be applied uniformly to all surfaces of treated base on all six sections as shown on the plan. The requirements shall comply with sections 25-2.01F and 32-3.01A. The curing seal for CTB shall serve as the tack coat unless otherwise ordered by the Engineer.

Measurement and Basis of Pay

Payment will be made on the lump sum basis, which sum will be full compensation for all costs involved in providing all material, equipment, tools and labor required for the surfacing and paving. The engineer's estimate for this project is as shown on the plan. The quantity is listed herein only for the convenience of the contractor and is not guaranteed to be accurate. Prospective bidders should verify these quantities before submitting a bid. No adjustment will be made in the lump sum bid for this project even though the actual quantity may vary from the estimated quantity, unless the scope of the work is changed by a written change order.

WSU Test Track
September 22, 1964

1. Class E Asphalt Concrete

Batch weights used:

AC -	180#	=	6.0%
3 Bin -	114#	=	4.0%
2 Bin -	1047#	=	41.0%
1 Bin -	1659#	=	55.0%
	3000#		

Aggregate proportions as recommended by materials lab. Recommended asphalt 4.1%. . Asphalt content increased because of appearance. Mix layered in 2 lifts for total depth of 5¼" with a Miller Box.

Compaction - 3 passes with steel wheel
6 passes with pneumatic roller
2 passes with steel wheel

Layered in segments 3 and 6 instead of as shown in plans.

2. Special Class E Asphalt Concrete (non-fractured)

Attempted to use 10% dirt but could not control dust after dirt went through drier. Dust hung up in bins and could not get 2 batches to look alike. Sinclair called Carl Minor at 1 P.M. in regard to dust problem. Minor recommended replacing dirt with blend sand.

Batch weights used:

AC -	153#	=	5.1%
3 Bin -	658#	=	23.0%
2 Bin -	887#	=	31.0%
1 Bin -	1302#	=	46.0%
	3000#		

Aggregate proportions as recommended by materials lab. Recommended asphalt--3.65%. Asphalt content increased because of appearance. Mix layered and compacted the same as Class E. Layered in segments 2 and 5 instead of as shown on plans.

September 30, 1964

Started laying 2" lift of Class B asphalt concrete at 9:00 A.M. Batch weights as follows:

AC -	198#	=	6.6%
3 Bin -	140#	=	5.0%
2 Bin -	1040#	=	37.0%
1 Bin -	1622#	=	58.0%
	3000		

Recommended AC = 4.7%
Asphalt content increased based on appearance.

Rolling - 2 passes with steel wheel
2 passes with pneumatic
2 passes with steel wheel

For first lift tacked with SS-1.

Laid second lift starting 3 P.M. Tacked first with 85-100 penetration liquid asphalt. Used same mix for second lift.

Report taken from Mr. A. Sinclair's log. District 6 Highway Inspector.

STATE OF WASHINGTON
ALBERT D. ROSELLINI, GOVERNOR

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
OFFICE OF DISTRICT ENGINEER
N. 2714 MAYFAIR ST.
SPOKANE 99205

October 20, 1964

Mr. G. A. Riedesel
Research Engineer
Division of Industrial Research
Washington State University
Pullman, Washington

Dear Sir: Experimental Pavements

It was suggested that I make some written comments on the construction of the treated surfacing and paving courses which I had the opportunity to observe.

The Contractor's prime problem was the placement of the various courses by standard methods because of the narrow widths of 7 and 8 feet and the short radius of 41.5 feet. The asphalt concrete courses were the easiest to lay since the Contractor had available a self-propelled, rubber-tired, paving machine that would lay an eight foot width. This method proved satisfactory. A track type paving machine would tear the surface since it would have to pave in short cords.

Normal procedure for laying cement treated base from a central plant is by a spreader-box mounted on the front of a tractor. This method did not appear workable at all in this case. On the first section of cement treated base the Contractor attempted to lay out the material with a small patrol blade from a windrow, but this was not satisfactory because the area to be worked was too small. Forms were thought of but trucks could not get between them. On the second section, screeds were set about four feet apart and the material was struck off by hand with a straight edge. The trucks deposited the material on the grade as best they could and it was then shoveled into place ahead of the strike-off. This method appeared to yield better results and it was considerably faster. To this date I cannot think of a method that would have been better.

Compaction of the various courses of cement treated base and asphalt concrete was accomplished by standard methods and equipment and no difficulties were encountered.

It was a pleasure to work with your assistants and I look forward to following the re-

Mr. G. A. Riedesel
Pullman, Washington
October 20, 1964

Page Two

sults of this experiment.

Very truly yours,

D. E. STEIN, P.E.
District Engineer

By: A. P. SINCLAIR
District
Materials Engineer

DES:nw
APS
cc: Mr. Carl Minor

APPENDIX B

LABORATORY REPORTS ON PALOUSE SILTY CLAY

RING 1

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
Olympia

SOIL TEST DATA

ob No. Y-651 S.H. No. Section Washington State University Test Track, Pullman, Wash.

Field Sample No.			22			
aboratory No.			S-9693			
ample from Station			Natural			
Offset			Deposit in test.			
epth			Track site			
extural Classification						
			Silty			
			Clay			
iquid Limit			39			
Plasticity Index			16			
rading - Maximum Size						
% Passing 1½"			100			
1"			100			
3/4"			100			
3/8"			99			
#4			99			
10			98			
40			94			
200			90			
pH factor			6.1			
RB Class. & Group Index			A-6(10)			
Proctor (ASTM D698-42T): Opt. Moist. Cont.						
Max. Density						
Density in Place						
of Max. Density						
oist. Cont. in Place						
veem Stabilometer Test: Resistance Value "R"			16			
Equilibrium Swell Pressure (psi)						
heoretical Total Surfacing and Bituminous Mat, Design traffic index						

ISTRIBUTION:
Materials Files 2
General Files x
istrict Engineer
ist. Soils Engr.
~~Plan & Contracts~~ Cont.
~~Id Loc Engr~~ BPR, Olympia
~~Adda Pub Roads~~ G. A. Riedesel
Soils Lab. x
.F. 26.02 (Rev.)
George McCusker, Planning

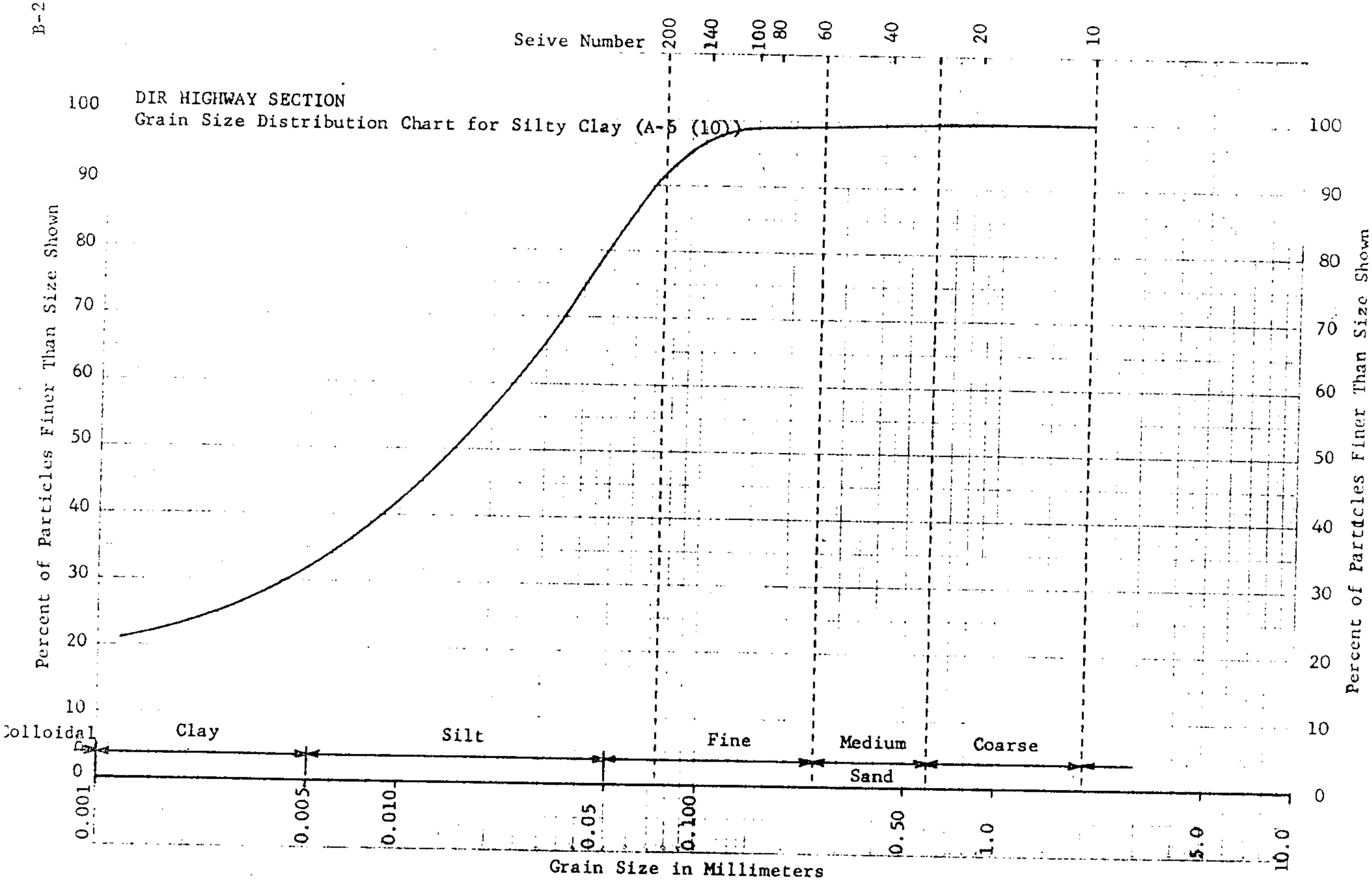
CARL E. MINOR
Principal Materials Engineer

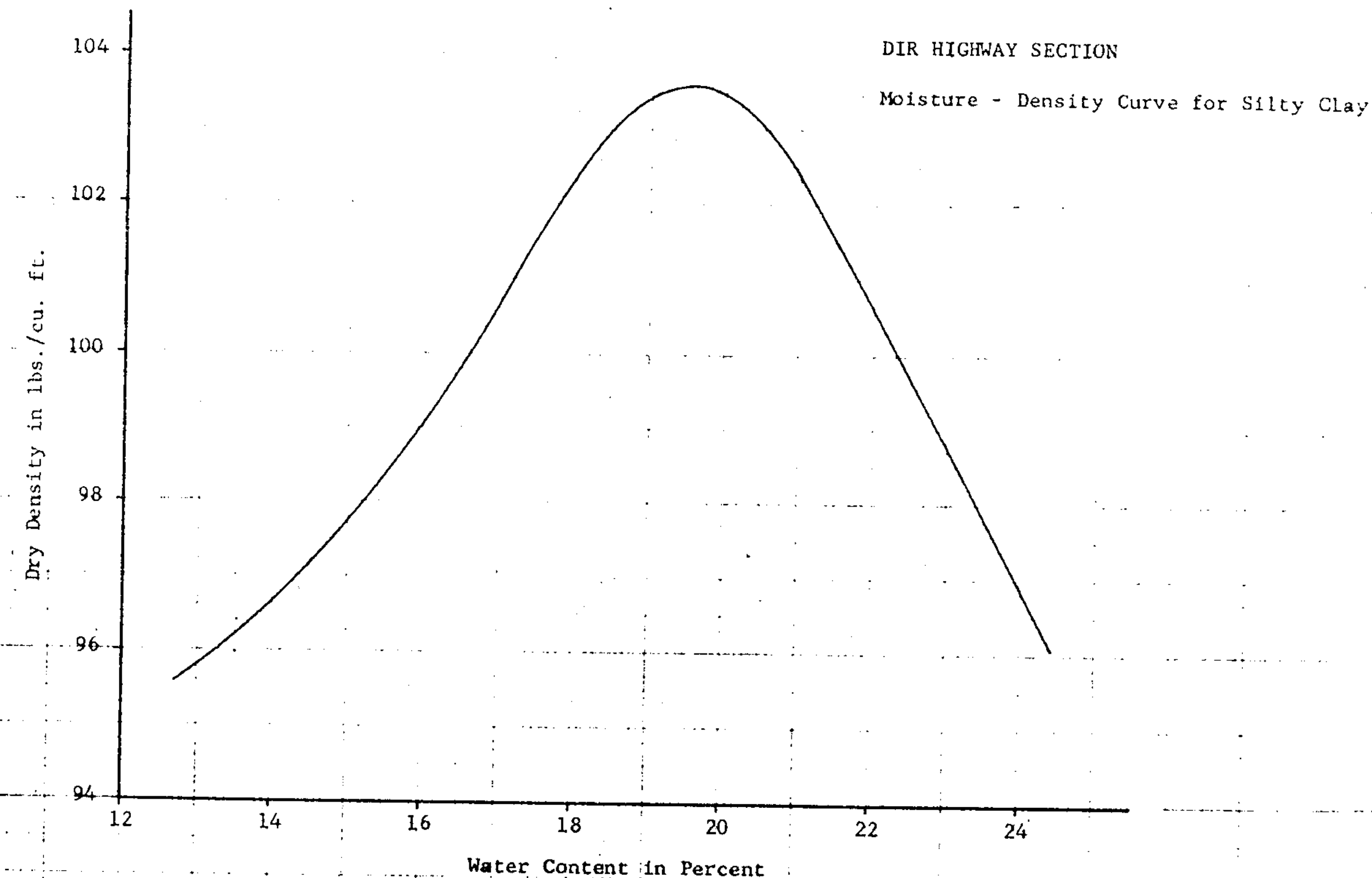
By H. E. Sandahl

Date 6-2-64

DIR HIGHWAY SECTION

Grain Size Distribution Chart for Silty Clay (A-5 (10))




DIR HIGHWAY SECTION
Moisture - Density Curve for Silty Clay
Dry Density in lbs./cu. ft.
104
102
100
98
96
94
12
14
16
18
20
22
24
Water Content in Percent

APPENDIX C

LABORATORY TESTS ON CRUSHED ROCK AND BLENDING SAND

(See Table II - page 21)

RING 1

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. } Control } Sample No. 3

Lab. No. P-2429
Pit No.

AGGREGATE for Crushed Surfacing Material in Pavement Sections

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G.A. Riedesel Sampled Received 4-30-64
Available Quantity Represented Sampled at 1¼" minus Crushed Surfacing Base Crs Stockpile, United Paving Co., Inc., Pullm
To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
	1¼	-	-	1¼	100	100
1¼	5/8	16.5	19	5/8	81	50-80
5/8	3/8	22.9	27	3/8	54	
3/8	1/4	11.0	13	1/4	41	30-50
1/4	0	36.0	41	40	13	3-18
				200	7	7.5 max.
Total		86.2	100			
Fracture: Coarse 98 %						75%

FINES FROM COARSE AGGREGATE		
Passing Sieve	%	Specif. Req'ments
¼" Sq.	100	
# 4	92	
# 10	62	
# 20		
# 40	32	
# 80	22	
# 200	17	
Liquid Limit		
Plasticity Index		
Sand Equivalent	41	40 Min.
Fracture: Fine	98 %	75%

If pit run sample: % over 2½"; % 2½"—¼"; % ¼"-O
Bulk specific gravity Breakage Factor
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. %; 500 Rev. %
Stabilometer Resistance Value "R" Swell Pressure
Drainage Characteristics

MATERIAL:

Satisfactory

Distribution:
Mat'l Files x
Gen'l Files
Dist. Engr.
Res. Engr.
G.A. Riedesel
~~George McCusker~~, Planning
BPR x

CARL E. MINOR
Principal Materials Engineer

Date 5-15-64 by W.S. Gooding

H.F. No. 26.87

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. } Control } Sample No. 16

Lab. No. P-2439
Pit No.

AGGREGATE for Asphalt Concrete, Screened Aggregate

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State Unversity Test Track, Pullman, Wash. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of 1" minus screened gravel at Union Sand & Gravel, Spokane, Wash.
To be used at Washed

COARSE AGGREGATE						Specif. Req'ments
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	
				1	100	
				3/4	92	
				3/8	36	
				1/4	7	
				4	0	
Total						

Fracture: Coarse ____ %

FINES FROM COARSE AGGREGATE		Specif. Req'ments
Passing Sieve	%	
1/4" Sq.		
# 4		
# 10		
# 20		
# 40		
# 80		
# 200		
Liquid Limit		
Plasticity Index		
Sand Equivalent		
Fracture: Fine	%	

If pit run sample: ____ % over 2½"; ____ % 2½"—¼"; ____ % ¼"-O
Bulk specific gravity ____ Breakage Factor ____
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____ %; 500 Rev. ____ %
Stabilometer Resistance Value "R" ____ Swell Pressure ____
Drainage Characteristics ____

MATERIAL:

Quality satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G. A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

H.F. No. 26.87

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W. L. Gooding

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DEPARTMENT OF HIGHWAYS
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Prelim. } Control } Sample No. 17

Lab. No. P-2440
Pit No.

AGGREGATE for Asphalt Concrete Screened Aggregate

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of ¼" minus screened gravel at Union Sand and Gravel, Spokane
To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
				1/4	100	
				4	94	
				10	54	
				40	2	
				80	0.6	
				200	0.3	
Total						

Fracture: Coarse ____ %

FINES FROM COARSE AGGREGATE		
Passing Sieve	%	Specif. Req'ments
¼" Sq.		
# 4		
# 10		
# 20		
# 40		
# 80		
# 200		
Liquid Limit		
Plasticity Index		
Sand Equivalent		
Fracture: Fine ____ %		

If pit run sample: ____ % over 2½"; ____ % 2½"—¼"; ____ % ¼"-O
Bulk specific gravity ____ Breakage Factor ____
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____ %; 500 Rev. ____ %
Stabilometer Resistance Value "R" ____ Swell Pressure ____
Drainage Characteristics ____

MATERIAL: Quality Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G. A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

H.F. No. 20.87

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W. L. Gooding

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DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim.)

Sample No. 20

Lab. No. P-2478
Pit No.

CEMENT TREATED BASE AGGREGATE

Cont. No. Y-651 F. A. No. S. H. No.

Section Washington State University Highway Test Track, Pullman, Washington

Name of Pit Location Quarry site one mile east of Pullman

Submitted By G. A. Riedesel Sampled Received 5-11-64

Sample From Overburden at quarry site Depth 8-12' of overburden over basalt ledge rock

Quantity Represented 50 cu. yds. To be used for blending sand

Passing Retained	Fractions Pounds	Fractions %	Passing Screen (Max. Size__)	As Rec'd.	Scalped on__	Crushed to__	Adjusted Grading	Specif. Req'ment
-1½"			1½"					
1½"-1"			1"					100
1"-¾"			¾"					
¾"-3/8"			3/8"					
3/8"-¼"			¼"	100				
¼"-0			#10	65				
Total			40	63				
% Pass ¼"			200	55				
#10								
40								
200								

Liquid Limit
Plasticity Index
Sand Equivalent

Fracture: Coarse %
Organic Content 150 PPM

CTB SPECIMEN TEST DATA

% Cement			
Molding H_2O			
Fabricated Wet Density			
7-Day Compressive Strength			

Recommended Design Cement Content
(by Wt. of Dry Aggregate) %
Recommended Spreading Rate
(lbs. per square yard)
DESIGN BASIS: Compressive Strength
@ % Max. Density

Remarks Blending sand, see letter dated 5-27-64.

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
Dist. Soils Engr. BPR, Olympia
Soils Lab x
G. A. Riedesel
George McCusker, Planning
Kensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by H. E. Sandahl

H. F. No. 26.14

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DEPARTMENT OF HIGHWAYS
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Prelim. }
Control { Sample No. 18

Lab. No. P-2427
Pit No.

AGGREGATE for Blending Sand

Cont. No. Y-651 F. A. No. S. H. No.

Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit

Name of Pit Location

Submitted by G. A. Riedesel Sampled 4-29-64 Received 4-30-64

Available Quantity Represented Sampled at Sand dunes, Adams Co. Rd., ROW, ½ mile east of Sand Dunes Grange Hall about 14 miles N.W. of Washtucna.

To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
				#40	100	
				#200	2	
Total						

Fracture: Coarse ____ %

FINES FROM COARSE AGGREGATE Passing Sieve	%	Specif. Req'ments
¼" Sq.		
# 4		
# 10		
# 20		
# 40		
# 80		
# 200		
Liquid Limit		
Plasticity Index		
Sand Equivalent		
Fracture: Fine ____ %		

If pit run sample: ____ % over 2½"; ____ % 2½"—¼"; ____ % ¼"-O organic clear

Bulk specific gravity ____ Breakage Factor ____

Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____ %; 500 Rev. ____ %

Stabilometer Resistance Value "R" ____ Swell Pressure ____

Drainage Characteristics ____

MATERIAL: Quality Satisfactory

See letter dated 5-27-64

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G.A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W.L. Gooding

H.F. No. 20.87

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DEPARTMENT OF HIGHWAYS
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Prelim.)
Control) Sample No. 21

Lab. No. P-2479
Pit No.

CEMENT TREATED BASE AGGREGATE

Job No.
Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Washington
Name of Pit Location E½, SW¼, Sec. 33T, 12 N., R. 45 E in Whitman County
Submitted By G. A. Riedesel Sampled Received 5-11-64
Sample From Exposed deposit of material in Steptoe Canyon, 23 miles south of Pullman. Depth 1-15 ft. thick in numerous deposits in near Steptoe Canyon.
Available
Quantity Represented 1,000 cu. yds. To be used for blending sand.

Passing Retained	Fractions Pounds	%	Passing Screen (Max. Size__)	As Rec'd.	Scalped on__	Crushed to__	Adjusted Grading	Specif. Req'ment
-1½"			1½"					
1½"-1"			1"					
1"-¾"			¾"					100
¾"-3/8"			3/8"					
3/8"-¼"			¼"					
¼"-0			#10	100				
Total			40	99				
% Pass ¼"			200	87				
#10								
40								
200								

Liquid Limit
Plasticity Index
Sand Equivalent

Fracture: Coarse %
Organic Content PPM

CTB SPECIMEN TEST DATA

% Cement			
Molding H_2O			
Fabricated Wet Density			
7-Day Compressive Strength			

Recommended Design Cement Content
(by Wt. of Dry Aggregate) %
Recommended Spreading Rate
(lbs. per square yard)
DESIGN BASIS: Compressive Strength
@ % Max. Density

Remarks

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
Dist. Soils Engr. BPR, Olympia
Plans & Contracts x
Soils Lab G. A. Riedesel
George McCusker, Planning
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by H. E. Sandahl

H. F. No. 26.14

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Prelim. / Control Sample No. 13

Lab. No. P2433
Pit No.

AGGREGATE for Asphalt Concrete, Class B & E

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of Blending Sand at quarry at 1 mile east of Pullman
To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
	1/4	-	100	1/4	100	
1/4	1			No. 4	100	
				10	100	
				40	49	85min.
				80	16	
				200	9	25max.
Total						

Fracture: Coarse ____ %

FINES FROM COARSE AGGREGATE		
Passing Sieve	%	Specif. Req'ments
¼" Sq.	100	
# 4	100	
# 10	100	
# 20		
# 40	49	
# 80	16	
# 200	9	
Liquid Limit		
Plasticity Index		
Sand Equivalent	57	40min.
Fracture: Fine	%	

If pit run sample: ____% over 2½"; ____% 2½"—¼"; ____% ¼"-O
Bulk specific gravity ____ Breakage Factor ____
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____%; 500 Rev. ____%
Stabilometer Resistance Value "R" ____ Swell Pressure ____
Drainage Characteristics ____

MATERIAL: Quality Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
~~BPR, Olympia~~
~~G. A. Riedesel~~
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W.L. Gooding

H.F. No. 26.87

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DEPARTMENT OF HIGHWAYS
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Prelim. / Control Sample No. 12

Lab. No. P-2438
Pit No.

AGGREGATE for Asphalt Concrete, Class "E"

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of Blending Sand at Quarr 1 mile east of Pullman
To be used at Washed

COARSE AGGREGATE							FINES FROM COARSE AGGREGATE	
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments	Passing Sieve %	Specif. Req'ments
	1/4			1/4	100		¼" Sq. 100	
1/4	0	40.0	100	4	100		# 4 100	
				10	100		# 10 100	
							# 20	
				40	48		# 40 48	
				80	13		# 80 13	
				200	7		# 200 7	
							Liquid Limit	
							Plasticity Index	
Total							Sand Equivalent 56	
Fracture: Coarse ___ %							Fracture: Fine ___ %	

If pit run sample: ___% over 2½"; ___% 2½"—¼"; ___% ¼"-0
Bulk specific gravity ___ Breakage Factor ___
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ___%; 500 Rev. ___%
Stabilometer Resistance Value "R" ___ Swell Pressure ___
Drainage Characteristics ___

MATERIAL:

Quality Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
~~BPR,~~ Olympia
G.A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W. L. Gooding

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DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control } Sample No. 4 Lab. No. P-2428
Pit No.

AGGREGATE for Crushed Surfacing Top Course, Leveling Course & Choker Course, Experimental Pavement Ring

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled Received 4-30-64
Quantity Available Represented Sampled at Stockpile of 5/8" minus at quarry one mile east of Pullman
To be used at Washed

COARSE AGGREGATE

Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
	5/8	--	--	5/8	100	100
5/8	3/8	9.2	13	3/8	87	
3/8	1/4	20.1	27	1/4	60	50-65
1/4	0	43.9	60	40	10	5-23
				200	5.4	10 Max
Total		73.2	100			

Fracture: Coarse 98 %

FINES FROM COARSE AGGREGATE

Sieve	Passing %	Specif. Req'ments
¼" Sq.	100	
# 4	93	
# 10	56	
# 20		
# 40	19	
# 80	12	
# 200	9	
Liquid Limit		
Plasticity Index		
Sand Equivalent	78	40 min.
Fracture: Fine	98 %	75%

If pit run sample: % over 2½"; % 2½"—¼"; % ¼".O
Bulk specific gravity Breakage Factor
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. %; 500 Rev. %
Stabilometer Resistance Value "R" Swell Pressure
Drainage Characteristics

MATERIAL: Satisfactory

Distribution:
Mat'l Files x
Gen'l Files
Dist. Engr.
Res. Engr.
G. A. Riedesel
George McCusker, Planning
BPR x

CARL E. MINOR
Principal Materials Engineer

Date 5-15-64 by W. L. Gooding

H.F. No. 26.87

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STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control Sample No. 11

Lab. No. P-2437
Pit No.

AGGREGATE for Asphalt Concrete, Class "E"

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of ½" minus crushed rock at quarry 1 mile east of Pullman
To be used at Washed

COARSE AGGREGATE							FINES FROM COARSE AGGREGATE		
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments	Passing Sieve	Passing %	Specif. Req'ments
	5/8			5/8	100		¼" Sq.	100	
5/8	1/2	0.1	2	1/2	98		# 4	86	
1/2	3/8	6.5	13	3/8	85		# 10	47	
3/8	1/4	14.0	27	1/4	58		# 20		
1/4	0	30.7	58	4	50		# 40	23	
				10	27		# 80	17	
				40	13		# 200	13	
				80	10		Liquid Limit		
				200	7.5		Plasticity Index		
Total		51.3	100				Sand Equivalent	68	
Fracture: Coarse 98 %							Fracture: Fine	98%	

If pit run sample: ____% over 2½"; ____% 2½"—¼"; ____% ¼"-O
Bulk specific gravity ____ Breakage Factor ____
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____%; 500 Rev. ____%
Stabilometer Resistance Value "R" ____ Swell Pressure ____
Drainage Characteristics ____

MATERIAL: Quality Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G. A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W. L. Gooding

H.F. No. 20.87

WASHINGTON
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DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control Sample No. 7 Lab. No. P-2432
Pit No.

AGGREGATE for Asphalt Concrete, Class "B"

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Test Track, Pullman, Washington Type of Deposit Gravel
Name of Pit Location
Submitted by G. A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of ½" minus crushed rock at quarry 1 mile east of Pullman, Wash.
To be used at Washed

COARSE AGGREGATE							FINES FROM COARSE AGGREGATE		
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments	Passing Sieve	Passing %	Specif. Req'ments
	5/8			5/8	100	100	¼" Sq.	100	
5/8	1/2	0.9	1	1/2	99	90-100	# 4	85	
1/2	3/8	9.8	15	3/8	84		# 10	48	
3/8	1/4	15.8	25	1/4	59	55-75	# 20		
1/4	0	37.2	59	No. 4	50		# 40	24	
				10	28	32-48	# 80	19	
				40	14	11-24	# 200	14	
				80	11	6-15	Liquid Limit		
				200	8.3	3-7	Plasticity Index		
Total		63.7	100				Sand Equivalent	68	
Fracture: Coarse 98 %							Fracture: Fine	98 %	

If pit run sample: ____% over 2½"; ____% 2½"—¼"; ____% ¼"-O
Bulk specific gravity Breakage Factor
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____%; 500 Rev. ____%
Stabilometer Resistance Value "R" Swell Pressure
Drainage Characteristics

MATERIAL: Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G. A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W. L. Gooding

H.F. No. 26.87

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STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control — Sample No. 5 — Lab. No. P-2430
Pit No.

AGGREGATE for Asphalt Concrete, Class "B"

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G.A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of 5/8" - 3/8" crushed rock at quarry 1 mile east of Pullman
To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
	5/8			5/8	100	100
5/8	1/2	7.8	15	1/2	85	75-100
1/2	3/8	20.1	39	3/8	46	
3/8	1/4	16.3	31	1/4	15	0-25
1/4	0	8.0	15	No. 4	10	
				10	4	
				40	2.9	
				80	2.4	
				200	2.0	
Total		52.2	100			
Fracture: Coarse 98 %						75%

FINES FROM COARSE AGGREGATE		
Passing Sieve	%	Specif. Req'ments
¼" Sq.	100	
# 4	64	
# 10	27	
# 20		
# 40	19	
# 80	16	
# 200	13	
Liquid Limit		
Plasticity Index		
Sand Equivalent	45	
Fracture: Fine	98 %	75%

If pit run sample: % over 2½"; % 2½"—¼"; % ¼"-O
Bulk specific gravity Breakage Factor
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. %; 500 Rev. %
Stabilometer Resistance Value "R" Swell Pressure
Drainage Characteristics

MATERIAL:

Satisfactory

See letter dated 5-27-64

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
~~BPR, Olympia~~
G.A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W.L. Gooding

H.F. No. 26.87

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control Sample No. 6

Lab. No. P-2431
Pit No.

AGGREGATE for Asphalt concrete, Class "B"

Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel
Name of Pit Location
Submitted by G.A. Riedesel Sampled 4-28-64 Received 4-30-64
Available Quantity Represented Sampled at Stockpile of 3/8" minus crushed rock one mile east of Pullman.
To be used at Washed

COARSE AGGREGATE						
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	Specif. Req'ments
	1/2			1/2	100	100
1/2	3/8	1.4	3	3/8	97	
3/8	1/4	9.8	19	1/4	78	70-100
1/4	0	40.2	78	No. 4	74	
				10	44	40-75
				40	20	
				80	16	
				200	12	2-12
Total		51.4	100			
Fracture: Coarse 98 %						75%

FINES FROM COARSE AGGREGATE		
Passing Sieve	%	Specif. Req'ments
¼" Sq.	100	
# 4	95	
# 10	56	
# 20		
# 40	26	
# 80	20	
# 200	15	
Liquid Limit		
Plasticity Index		
Sand Equivalent	67	45 min
Fracture: Fine	98 %	75%

If pit run sample: ____% over 2½"; ____% 2½"—¼"; ____% ¼"-O
Bulk specific gravity Breakage Factor
Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. ____%; 500 Rev. ____%
Stabilometer Resistance Value "R" Swell Pressure
Drainage Characteristics

MATERIAL: See letter dated 5-37-64

Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G.A. Riedesel
George McCusker, Planning
Soils
Rensel
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W.L. Gooding

H.F. No. 26.87

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim. / Control Sample No. 10

Lab. No. P-2436
Pit No.

AGGREGATE for Asphalt Concrete, Class "E"

Conc. No. Y-651 F. A. No. S. H. No.

Section Washington State University Highway Test Track, Pullman, Wn. Type of Deposit Gravel

Name of Pit Location

Submitted by G.A. Riedesel Sampled 4-28-64 Received 4-30-64

Available Quantity Represented Sampled at Stockpile of 3/8" minus crushed rock at quarry 1 mile east of Pullman

To be used at Washed

COARSE AGGREGATE						Specif. Req'ments
Passing Screen	Retained Screen	Fractions Pounds	Fractions %	Passing Screen	Total %	
	1/2			1/2	100	
1/2	3/8	1.1	2	3/8	98	
3/8	1/4	8.7	18	1/4	80	
1/4	0	38.8	80	4	74	
				10	54	
				40	28	
				80	20	
				200	15	
Total		48.6	100			

Fracture: Coarse 98 %

FINES FROM COARSE AGGREGATE Passing Sieve	%	Specif. Req'ments
1/4" Sq.	100	
# 4	92	
# 10	67	
# 20		
# 40	35	
# 80	25	
# 200	19	
Liquid Limit		
Plasticity Index		
Sand Equivalent	47	
Fracture: Fine	98 %	

If pit run sample: % over 2½"; % 2½"—¼"; % ¼"-0

Bulk specific gravity Breakage Factor

Wear in Los Angeles Test (ASTM Des. C-131): 100 Rev. %; 500 Rev. %

Stabilometer Resistance Value "R" Swell Pressure

Drainage Characteristics

MATERIAL: Quality Satisfactory

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR Olympia
G.A. Riedesel
George McCusker, Planning
Soils
Rensel
Cent.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by W.L. Gooding

H.F. No. 20.87

APPENDIX D

LABORATORY JOB MIX FORMULAS
MATERIAL TESTS OF CONSTRUCTION

RING 1

STATE OF WASHINGTON
ALBERT D. ROSELLINI, GOVERNOR

COMMISSIONERS
ERNEST A. COWELL, CHAIRMAN
EUREKA
ROBERT L. MIKALSON
CENTRALIA
GEORGE D. ZAHN
M. HOW
JAMES M. BLAIR, SR.
PUYALLUP
IRVING CLARK, JR.
SEATTLE

LORENZ GOETZ, SECRETARY
OLYMPIA

DISTRICT OFFICES
NO. 1 SEATTLE 8
6431 SO. CORSON AVE.
NO. 2 WENATCHEE
P. O. BOX 56
NO. 3 OLYMPIA
P. O. BOX 527
NO. 4 VANCOUVER
4200 MAIN STREET
NO. 5 YAKIMA
P. O. BOX 52
NO. 6 SPOKANE 21
N. 2714 MAYFAIR ST.
NO. 7 SEATTLE 9
509 FAIRVIEW AVE. NO.

THE SEAL OF THE STATE OF WASHINGTON 1889

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
C. G. PRAHL, DIRECTOR
HIGHWAYS-LICENSES BUILDING
OLYMPIA

May 27, 1964

Mr. G. A. Riedesel, Research Engineer
Division of Industrial Research
Washington State University
Pullman, Washington 99163

Washington State University
Highway Test Track
Project Y-651

Dear Mr. Riedesel:

Tests have been completed on samples of aggregate submitted from various sources that are intended to be used for construction of treated bases and asphalt concrete on the above test track.

Attached are copies of test data and a maximum density vs. gradation curve for use in control of compaction of the cement treated base material.

Laboratory cement treatment test cylinders were fabricated in the ratio of 1 part 1" minus coarse aggregate (sample #14, Lab. No. P-2425) to 2 parts ¼" minus fine aggregate (sample #19, Lab. No. P-2475) plus the addition of 10% overburden-soil (sample #20, Lab. No. P-2478) by dry weight of the above 2 to 1 combination. Based on the results of seven-day compressive strength tests of the cement treated cylinders, we recommend the addition of 4% cement, by dry weight of total aggregate, to produce a satisfactory cement treated base section.

Test results of special asphalt concrete specimens fabricated with the above mixture of CTB aggregate and blending material indicate that the addition of 3.5% asphalt cement, by dry weight of total mixture, should provide a satisfactory asphalt treated base.

Class "B" asphalt concrete test specimens were fabricated in a ratio of 35% 5/8" to 3/8" aggregate (sample #5, Lab. No. P-2430), 55% 3/8" minus aggregate (sample #6, Lab. No. P-2431) and 10% blending sand (sample #18, Lab. No. P-2427). Recommended asphalt content for this mixture is 4.5%, by dry weight of total mixture.

Mr. G. A. Riedesel
Page Two

As noted on the laboratory data sheet covering the above Class "B" mix design, a Class "E" design using similar aggregate should require about 3.8% to 4.0% asphalt cement.

Yours very truly,

C. G. PRAHL
Director of Highways

By: CARL E. MINOR
Materials & Research Engineer

CGP:bjs
CEM:LC
Attach.

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
OLYMPIA

Prelim.)
Sample No. 14

Lab. No. P-2425
Pit No.

CEMENT TREATED BASE AGGREGATE

Job No.
Cont. No. Y-651 F. A. No. S. H. No.
Section Washington State University Highway Test Track, Pullman, Washington
Name of Pit Location
Submitted By G. A. Riedesel Sampled Received 4-30-64
Sample From Stockpile, Union Sand & Gravel, Spokane, Washington Depth
Available Quantity Represented 100 cu. yds. To be used at CTB in Sections 1 & 4 of experimental paving ring

Passing Retained	Fractions Pounds	%	Passing Screen (Max. Size__)	As Rec'd.	Scalped on__	Crushed to__	Grading	Specif. Req'ment
-1½"			1½"					
1½"-1"			1"	100			100	100
1"-¾"			¾"	91	1 part	P-2425	97	72-100
¾"-3/8"			3/8"	35	2 parts	P-2475	80	
3/8"-¼"			¼"	7	10% sand	P-2478	71	0-25
¼"-0			#10				50	
Total			40				27	
% Pass ¼"			200				7	
#10								
40								
200								

Liquid Limit
Plasticity Index
Sand Equivalent

Fracture: Coarse %
Organic Content No test PPM

CTB SPECIMEN TEST DATA

% Cement	3	5	7
Molding H2O	6.6	7.1	6.9
Fabricated Wet Density	149.9	150.1	150.5
7-Day Compressive Strength			

Recommended Design Cement Content (by Wt. of Dry Aggregate) 4 %
Recommended Spreading Rate (lbs. per square yard)
DESIGN BASIS: Compressive Strength 850
@ % Max. Density 100

Remarks Satisfactory, see letter dated 5-27-64

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
Dist. Soils Engr.
BPR, Olympia
Soils Lab x
G. A. Riedesel
George McCusker, Planning
Rensel
Cont.

H. F. No. 2R.14

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 by H. E. Sandahl

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory

MAXIMUM DENSITY CURVE

(P-2425)
(P-2475-76-77-7

Field Sample No. 14, 19, & 20

Lab No. D-787

Cont. No. Y-651

F.A. No. ______ S.H. No. ______

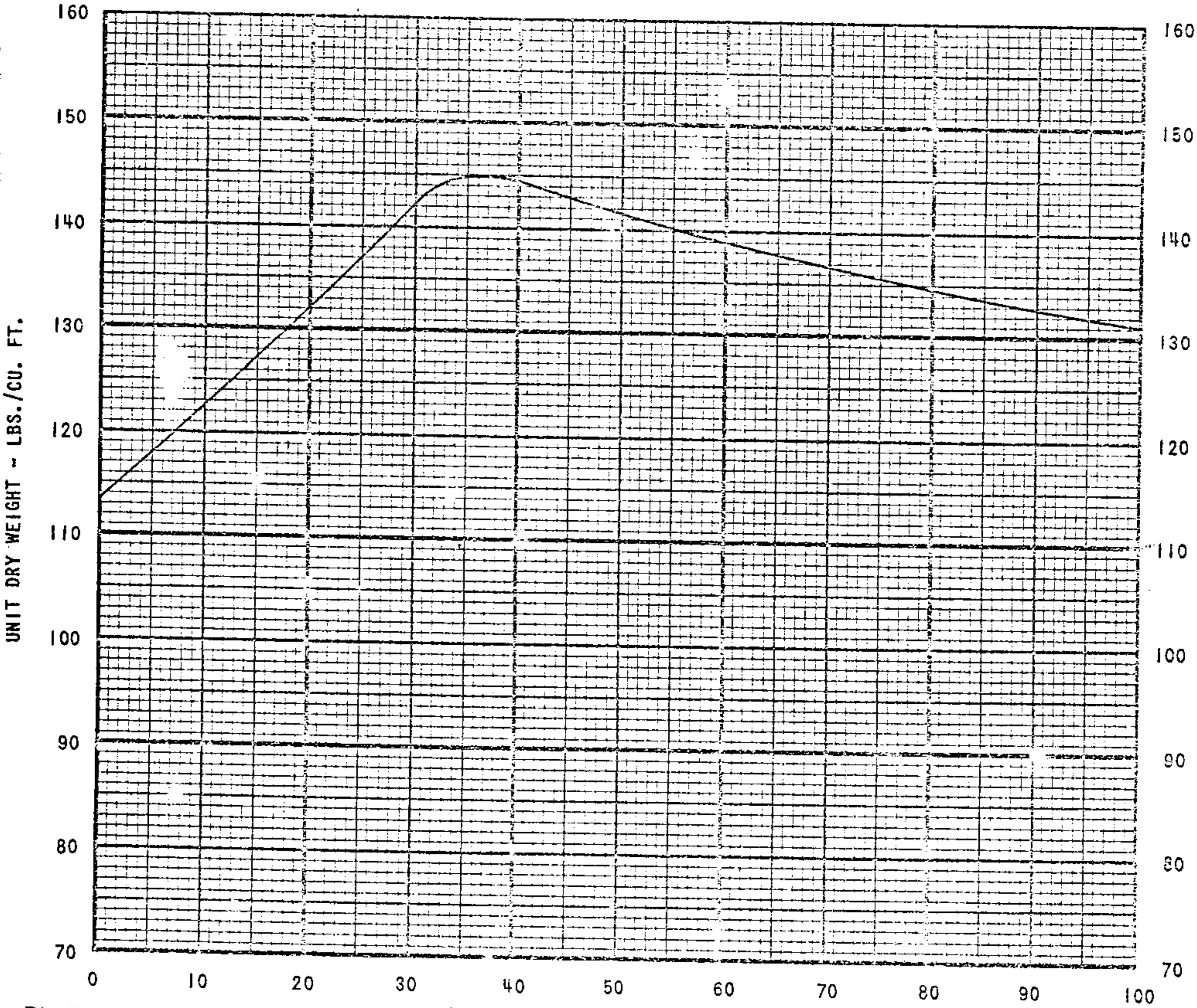
Section WSU Highway Test Track, Pullman, Wn.

Source of Mat'l. See transmittal letters

Field Description of Material Aggregrate for Cement Treated Base

Percent Passing #4 66

Date Received 5-22-64



Distribution:
Mat'l Files x 2
Gen'l Files x
McCusker
BPR, Olympia
Rensel
G. A. Riedesel
Soils Lab. x 2
Cont.

Specific Gravity Coarse 2.71
Specific Gravity Fine 2.71

Carl E. Minor,
Materials & Research Engineer
By H. E. Sandahl

Date 5-27-64

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Materials Laboratory
318 State Avenue
Olympia, Washington

Place Pullman

Date September 23, 1964

Dear Sir:

I have forwarded by today's PREPAID express cement-treated base cylinders:

Contract No. ________ F.A. WSU Test Track S.H. No. ________

Section Section #1 Contractor United Paving

Brand of Cement Permanente Type II

Source of Aggregate Union Sand & Gravel, Fort Wright

Cylinder No.	1	2	3			
Date made	9-23-64	9-23-64	9-23-64			
Sample from	Sec. 1	Sec. 1	Sec. 1			
Quantity represented						
Wt. of cylinder + can	2145.5	?118.7	1884.4			
" " can	74.8	74.5	78.1			
Net Wt. of cylinder	2070.0	2044.2	1810.3			
Height of cylinder	4.098 4.094-4.094 4.091	4.058 4.051-4.054 4.053	3.635 3.629-3.631 3.629			
Wet density	153.2	152.8	151.2			
Moisture content	10.2	10.2	10.2			
Dry density	139.02	138.66	137.21			
Design Cem't. Cont. - %						
% Passing #4 Sieve						

REMARKS:
Spec's 850 PSI @ 7 days

One copy with cylinders
One copy to addressee
One copy to District Engineer

H.F. 26.74 (Revised)

Resident Engineer

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Materials Laboratory
318 State Avenue
Olympia, Washington

Place Spokane, Washington

Date September 25, 1964

Dear Sir:

I have forwarded by today's PREPAID express cement-treated base cylinders:

Contract No. ______ F.A. ______ S.H. No. ______

Section Test Track--Section 4 Contractor United Paving

Brand of Cement Permanente Type II

Source of Aggregate Union Sand & Gravel, Fort Wright

Cylinder No.	4	5	6			
Date made	9-25-64	9-25-64	9-25-64			
Sample from						
Quantity represented						
Wt. of cylinder + can	2107.3	2020.0	2116.7			
" " can	78.9	76.4	75.0			
Net Wt. of cylinder	2028.4	1943.6	2041.7			
Height of cylinder	4.027 4.043 4.036 4.046	3.887 3.861 3.890 3.922	4.105 4.121 4.095	4.107		
Wet density	152.37	151.47	150.69			
Moisture content	9.25	9.25	9.25			
Dry density	139.47	138.54	137.93			
Design Cem't. Cont. - %	4.18%	4.18%	4.18%			
% Passing #4 Sieve						

REMARKS:

One copy with cylinders
One copy to addressee
One copy to District Engineer

H.F. 26.74 (Revised)

Resident Engineer

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Materials Laboratory
318 State Avenue
Olympia, Washington

Place Pullman, Washington

Date September 25, 1964

Dear Sir:

I have forwarded by today's PREPAID express cement-treated base cylinders:

Contract No. ________ F.A. ________ S.H. No. ________

Section Test Track--Section 4 Contractor United Paving

Brand of Cement Permanente Type II

Source of Aggregate Union Sand & Gravel, Fort Wright

Cylinder No.	7	8	9	10		
Date made	9-25-64	9-25-64	9-25-64	9-25-64		
Sample from						
Quantity represented						
Wt. of cylinder + can	1954.0	2134.2	2072.0	1921.9		
" " can	83.0	75.0	75.7	78.4		
Net Wt. of cylinder lbs.	4.125	4.540	4.401	4.064		
Height of cylinder	3.80 3.832 3.817 3.819	4.226 4.211 4.226 4.240	4.101 4.086 4.090 4.083	3.791 3.793 3.794 3.799		
Wet density	148.60	147.74	147.98	147.30		
Moisture content	7.88	7.88	7.88	7.88		
Dry density	137.74	136.95	137.17	136.54		
Design Cem't. Cont. - %	4.18%	4.18%	4.18%	4.18%		
% Passing #4 Sieve						

REMARKS:
Moisture content 2nd (last) field 4.9%

One copy with cylinders
One copy to addressee
One copy to District Engineer

H.F. 20.74 (Revised)

[illegible]

702 10-1-64

Highway Test Track

#1, CTB United Paving Co.

Permanente 2

CTB

Doten's Pre-Mix , Pullman, Washington

2107 1

CTB 9 - 23 - 64

10-1-64 8 days

≈ 15

4.094 4,000

or 0.02977 Cu.ft. or 2070.7 gms.

51.447 4.565

152.8

12.5664

12,200

970

Plaster of Paris used as capping compound.

Cliff Appling

[illegible]

[illegible] 702 [illegible] 10-2-64

Name of [illegible] Highway Test Track

[illegible] #4 CTB [illegible] United Paving Co.

[illegible] Permanente [illegible] 2

[illegible] CTB [illegible] Doten Pre-Mix, Pullman, Wash.

[illegible]

[illegible] 2113 [illegible] 7

[illegible] CTB Date Made 9-25-64

[illegible] 10-2-64 [illegible] Age 7 days

[illegible] ≈ 15 cubic yards

[illegible] inches

[illegible]

[illegible] 4.000 [illegible]

Volume [illegible] cubic inches; [illegible] pounds

[illegible] per cubic foot

[illegible]

[illegible] 12.5664 [illegible]

[illegible] 12,100 [illegible]

[illegible] 963 [illegible]

Plaster of Paris used as capping compound.

[illegible] Clifford Appling

Contract No. 702 Date 10-2-64

Name of Project Highway Test Track

Contractor United Paving Co.

Permanente 2

Source of CTB Doten Pre-Mix, Pullman, Washington

Laboratory No. 2114 Cyl. No. 8

Class of concrete CTB Date Made 9-25-64

Date Tested 10-2-64 Test Age 7 days

Quantity Represented 15 cubic yards

Slump inches

Height inches; Diameter 4.000 inches

Volume cubic inches; Weight pounds

Density pounds per cubic foot

Area 12.5664 square inches

Total compression load 10,600 pounds

Unit stress 845 pounds per square inch

Plaster of Paris used as capping compound.

Clifford Appling

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY
Olympia

BITUMINOUS JOB MIX DESIGN

Lab. No. P-2425
Pit No. P-2475-7
Type of P-2478
Deposit Gravel

For Special Asph. Conc.

Job No.) Y-651 Submitted by G. A. Riedesel FA No. ______ S.H. No. ______

Section Washington State University Highway Test Track, Pullman, Wash.

Name of Pit ______ Location Union Sand & Gravel, Spokane, & Doten Transit Mix Plant, Pullman.

Sampled ______ Received 4-30 & 5-11-64 Quantity Represented Available Overburden soil quarry one mi[le] east of Pullman.

To be used at Sections 3 & 6 of experimental paving ring. Washed ______

SIEVES	PERCENT PASSING SIEVES					SPECIFICATION REQUIREMENTS	
	PROPORTIONS OF MATERIALS				COMBINED GRADING	PERCENT PASSING	
Size Agg.	1-¼	¼-0	BLS			PLANT MIX	Asph. Conc. CL. B
Percentage	1 part	2 parts	10%				
3/4" square					97	100	
5/8" square							100
1/2" square						80-100	90-100
1/4" square					71	45-75	55-75
U.S. No. 10					50	30-50	32-48
U.S. No. 40							11-24
U.S. No. 80					27		6-15
U.S. No. 200					7	2-8	3-7

				PLANT MIX	Asph. Conc. CL. B
Asphalt Cement % by Wt. of dry aggregate	3.5	4.0	4.5		
Stabilometer "S" value	34	30	29	25 Min.	30 Min.
Cohesiometer "C" value	140	95	95	200 Min.	250 Min.
Wt. per cu. ft.	142.96	142.52	144.58		
Voids-Volume in Mix					
Voids in Mineral Aggregate					
Compacted Appearance					
Asphalt Absorption % ______ Bulk Sp. Gr. ______					
Modified Immersion Compression ______					
Recommend 3.5 % of 85/100 Asphalt Cement (% of total mixture)				4-7	4.5-7.5

REMARKS: See letter dated 5-27-64

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
Const. Engr. G. A. Riedesel
George McCusker, Planning
Bituminous Sec. x
Soils
Cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 By W. L. Gooding

H.F. 26.15 (Rev.)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY
Olympia

BITUMINOUS JOB MIX DESIGN

Lab. No. P-2430-3
Pit No. P-2427
Type of Deposit Gravel

For Asph. Conc. Class B

Job No. Y-651 Submitted by G.A. Riedesel FA No. ______ S.H. No. ______

Section Washington State University Highway Test Track, Pullman, Wash.

Name of Pit ______ Location Quarry, 1 mile east of Pullman

Available Blending sand (Sand Dunes, Adams Co.)

Sampled ______ Received 4-30-64 Quantity Represented ______

To be used at Pavement for all sections of experimental Washed ______

SIEVES	P-2430	P-2431	P-2427		PERCENT PASSING SIEVES			SPECIFICATION REQUIREMENTS	
	PROPORTIONS OF MATERIALS				COMBINED GRADING			PERCENT PASSING	
Size Agg.	5/8-3/8	3/8-0	BLS					PLANT MIX	Asph.Conc. CL. B
Percentage	35	55	10						
3/4" square								100	
5/8" square	100				100				100
1/2" square	85	100			95			80-100	90-100
1/4" square	15	78			58			45-75	55-75
U.S. No. 10	4	44			36			30-50	32-48
U.S. No. 40		20	100		21				11-24
U.S. No. 80		16	51		14				6-15
U.S. No. 200		12	2		6.8			2-8	3-7
Asphalt Cement % by Wt. of dry aggregate					5.0	5.5	6.0		
Stabilometer "S" value					19	14	8	25 Min.	30 Min.
Cohesiometer "C" value					550	650	550	200 Min.	250 Min.
Wt. per cu. ft.					161.68	161.93	161.93		
Voids-Volume in Mix						1.9			
Voids in Mineral Aggregate									
Compacted Appearance									
Asphalt Absorption % ______ Bulk Sp. Gr. 2.846									
Modified Immersion Compression OK									
Recommend 4.5 % of 85/100 Asphalt Cement (% of total mixture)								4-7	4.5-7.5

REMARKS: Class "E" Mix, if aggregate is from same source, should require about 3.8 to 4.0% asphalt for mid-line grading.

See letter dated 5-27-64

Distribution:
Mat'l Files x 2
Gen'l Files x
Dist. Engr.
BPR, Olympia
G.A. Riedesel
George McCusker, Planning
Bituminous Sec. x
Soils cont.

CARL E. MINOR
Principal Materials Engineer

Date 5-27-64 By W.L. Gooding

H.F. 26.15 (Rev.)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
MATERIALS LABORATORY
Olympia

TEST OF ASPHALT MIXTURE

Cont. No. WSU F.A. No. ______ S.H. No. ______

Section Test Track

Submitted by ______ Date Received ______ Date Tested 12-16-64

Lab. No.						SPECIFICATION REQUIREMENTS ASPHALT CONCRETE		
Field No.	8A	10B	4C	10D	1C			
Class & Course	B	B	E	E	Spec.			
Used at (Sta) (M.P.)	2	3	6	3	5			
Date Sampled	12-9	12-9	12-9	12-9	12-9			
Sieves	(Field) (Lab) EXTRACTION ANALYSIS					Percent Passing Design		
	Percent Passing Sieves					Class E	Class B	Class B
1 1/4" Square						100		
1" Square					100	90 - 100		
5/8" Square	100	100	100	100	96	67 - 86	100	100
1/2" Square	99	99	99	99	86	60 - 80	90 - 100	95
1/4" Square	84	83	83	77	64	40 - 62	55 - 75	58
US No. 10	50	50	52	47	39	25 - 40	32 - 48	36
US No. 40	39	32	30	28	19	10 - 23	11 - 24	21
US No. 80	16	20	19	19	8	6 - 14	6 - 15	14
US No. 200	9.8	11.1	11.4	10.5	4.9	2 - 7	3 - 7	6.8
Asphalt Cement %	5.6	5.9	5.2	4.9	4.3	3.5 - 7	4.5 - 7.5	4.5
LABORATORY COMPACTION RESULTS								
Stabilometer "S"	15	25	38	27	23			
Cohesiometer "C"	400	610	365	680	340			
Weight Per Cu. Ft.	159.30	159.93	160.55	160.24	150.32			
Voids-Volume in Mix.								
Compacted Appearance								

Material meets / does not meet specification requirements - except where marked

Distribution:
Mat'l Files ______
Gen'l Files ______
Dist. Engr. ______
Res. Engr. ______
Const. Engr. ______

CARL E. MINOR
Principal Materials Engineer

Date ______ By ______

December 29, 1964

To: Carl E. Minor

From: Paul E. Rensel

Subject: WSU Highway Test Track Project Y-651

Cores were taken from each of the six sections of the WSU test track on December 9, 1964. Duplicate cores were left with the WSU engineers. Since the track has yet to be used, the core analysis approximates it's "as constructed" condition. The track was placed and finished on September 22 and 30, 1964.

Test reports that are attached include:

1. Thickness of each lift
2. Density, expressed as percent total air voids compared to a voidless mass
3. Extraction, asphalt content, and grading
4. Recompaction, stabilometer, and cohesiometer

Comment:

Density (See Test Sheet #1) - First and second lifts, Class E and special A.C. near optimum density. Third lift, Class B one half (Sec. 2, 3, 4) optimum or greater, other half less than ideal. Top lift, wearing course, Class B, Sections 1 and 3 optimum density, 2 and 5 acceptable density, 4 and 6 low density.

Average Weight per Cubic Foot:

Class B	147.01#	Maximum variation 11.9#
Class E	152.47#	Maximum variation 1.5#
Special A.C.	143.49#	Maximum variation 6.6#

Mr. Carl E. Minor
December 29, 1964
Page Two

Extraction (See Test Sheet #2) - The Class B gradation does not meet specifications at any point below the 1/2" sieve nor does it agree with the design grading. Sand silt ratio (#10+#200) are in the critical range. The Class E grading is almost identical to the Class B mix, but its asphalt content is about one percent lower. The special asphalt concrete made of screened gravel is well graded. It has no grading resemblance to the design grading of May 27, 1964.

Recompaction - The Stabilometer and Cohesiometer values are in the range expected for materials with similar grading deficiencies, low Stabilometer and high Cohesiometer.

Field Notes - Field notes include this construction information:

Placing

(a) Class E and Special A.C. - Miller box

(b) Class B, both lifts, 8' wide Blaw-Knox paver

(c) CTB placed by hand, used forms Section #4.

Compaction

(a) Class E and Special A.C.

3 passes with steel wheel roller

6 passes with pneumatic tired roller

2 passes with steel wheel roller

(b) Class B, both lifts

2 passes with steel wheel roller

2 passes with pneumatic tired roller

2 passes with steel wheel roller

Mr. Carl E. Minor
December 29, 1964
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Tack Coat

SS-1 was used for tack between base and first Class B lift.

Cores were very difficult to separate at this point.

85/100 was used for tack coat between first and second lifts of Class B mix. Cores separated easily at this point.

Core separation difficulty was not related to degree of compaction.

Appearance

The wearing surface was somewhat rough and irregular in appearance. Some of the surface has been softened by oil leaking from the wheel drive mechanism. Workmanship generally reflected the difficulty of processing or constructing a project of this nature by conventional methods.

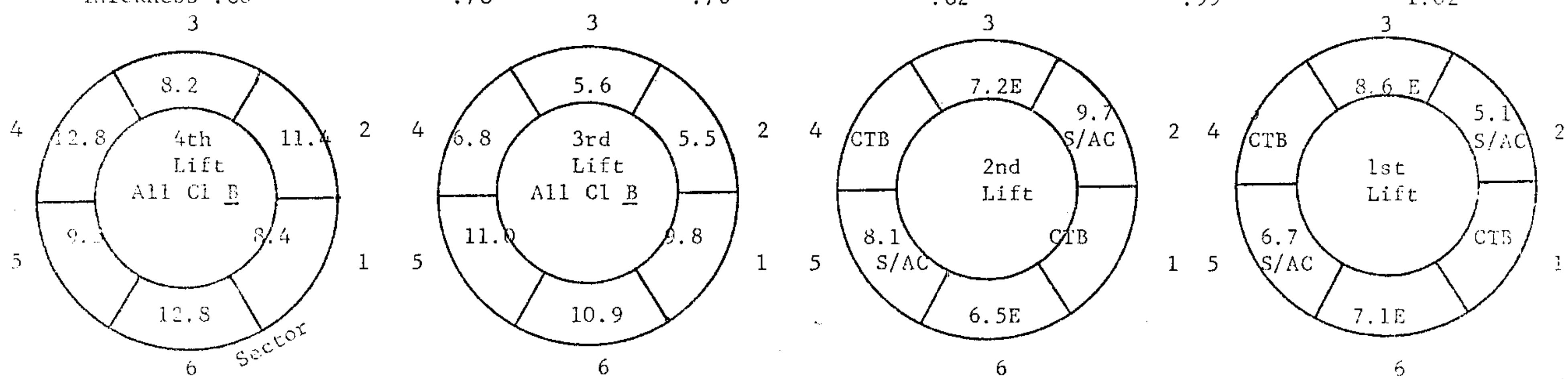
PER:bjs

Attach. Test Sheets 1 & 2

Test Sheet #1

Washington State University
Highway Test Track
Project - Y-651
Test Core Analysis 12/9/64
Materials Lab. - Olympia

Sect. #	5		2		6		3		1		4	
Core #	1	Lift Thickness	8		4		10		6		12	
Class AC / Lift #												
4	B 9.5 (% voids)	.20'	B 11.4	.16"	B 12.8	.19'	B 8.2	.20'	B 8.4	.21'	B 12.8	.19'
3	B 11.0 (% voids)	.15'	B 5.5	.19'	B 10.9	.17'	B 5.6	.18'	B 9.8	.17'	B 6.8	.20'
2	S/AC 8.1 (% voids)	.25'	S/AC 9.7	.19'	E 6.5	.21'	E 7.2	.24'	Cement Treated Base	.60'	Cement Treated Base	.63'
1	S/AC 6.7 (% voids)	.20'	S/AC 5.1	.24'	E 7.1	.19'	E 8.6	.21'				
Total Thickness		.80'		.78'		.76'		.82'		.99'		1.02'



Note: Density is expressed in % of air voids compared to a voidless mass measured by Rice Vac. Pycnometer. Optimum density presently considered to be 80% (±1.0%). Acceptable values -- 6% to 10%.