FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance
Specific Pavement Studies

ARIZONA SPS-9P

Construction Report on Site 040900/04A900
Arizona Department of Transportation

FINAL

Prepared by

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December 1997

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INTRODUCTION

The SPS-9 experiment program is the first part of a multi-stage approach to validate the Strategic Highway Research Program's (SHRP) Superpave Asphalt Binder Study. Premature pavement failure due to numerous site specific variables is a common problem across the country. Most highway agencies have developed a standard asphalt paving mix that they use for most highway construction throughout the state/province. This study is designed to develop a method that will produce guidelines for pavement design that is site-specific, taking into account the traffic, environment, and pavement type. An asphalt pavement mix that utilizes site specific variables should decrease the risk of many premature pavement failures.

When this project was constructed, the SPS-9 experiment was in the pilot stages of implementation. The goal at that time was to evaluate the Superpave mixture as compared to the agency standard mixture. In addition, the experiment was intended to provide the highway agencies with hands-on experience with the Superpave mixture design procedures.

Since that time, the SPS-9 experiment has been refined and is identified as SPS-9A. The Arizona section described in this report is referred to as an SPS-9P, as it was a pilot study and does not meet all of the current SPS-9A project requirements.

SPS-9 Objectives

The primary objectives of the original Superpave Asphalt Binder Study experimentation were to:

- Evaluate and improve the practical aspects of implementing the Superpave program through hands-on field trials by highway agencies.
- Compare the performance of the Superpave mixes with mixes designed using current highway agency practices.
- Provide long-term performance data for evaluation and refinement of the Superpave specifications and design procedures.
- Provide highway agencies the opportunity to evaluate the performance of other experimental modifications by the construction of supplemental sections.

The SPS-9P experiment required construction of a minimum of two test sections at each site: the highway agencies' standard mix and the Superpave Level 1 designed mix. The pavement structure and thicknesses of layers containing the two experimental mixtures were to be the same on all test sections.

Project Background

This report documents the construction of an SPS-9P project in Arizona, 040900/04A900. This project was assigned duel numbers as two different gradations were utilized and replicate sections were constructed. Details of the construction are provided in the sections to follow. The project was a portion of an additional two lanes on US Highway 93 north of Kingman, Arizona. The experimental project consists of five test sections, each constructed at least 300 m in length on the newly built lanes. This project was constructed in conjunction with an SPS-1 project for which the construction has previously been documented.(1) In addition, a summary of the project construction was reported in the Arizona Transportation Research Center Research Notes.(2)

Construction of the SPS-9P test sections occurred between November 1992 and August 1993. As mentioned, the SPS-9P sections are located on two newly constructed lanes and thus, this report covers the construction from the embankment through the surfacing.

The five test sections consist of two sections of Superpave Level 1 mixtures having a 25 mm nominal maximum aggregate, two sections of Superpave Level 1 mixtures contained a 19 mm nominal maximum aggregate and one section of the agency standard mixture comprised of 19 mm aggregate utilizing the 75 blow Marshall mixture design. All mixtures contain the same asphalt cement, an AC-30 supplied by Conoco, that also meets the requirements of a Superpave PG graded binder, PG 64-16.

PROJECT DESCRIPTION

Figure 1 illustrates the location of the SPS-9P project. The project is located on the two newly constructed northbound lanes of US Highway 93, approximately 32 km north of Kingman, Arizona. The test sections are located entirely on a shallow fill of native material. The subgrade and embankment material are a coarse grained material of silty sand with gravel and cobbles. The terrain in the immediate area of the test sections is slightly rolling and the roadway is straight. Of the five test sections, two Superpave sections having varying aggregate size were constructed near the beginning of the project, the agency standard sections was constructed 5.8 km further north and the replicated Superpave sections were constructed an additional 4.5 km north.

Based upon the SHRPBIND program developed by LTPP and climatic data from nearby weather stations, the mean annual low air temperature is -8°C, the mean 7-day high air temperature is 39°C, the freezing index (C-Days) is 1 and the average annual precipitation is 140 mm. Thus, the site is classified as being in a Dry No-Freeze climatic zone.

The designed pavement structure consists of 102 mm granular base and 178 mm of asphalt concrete placed in three lifts (64 mm, 50 mm, 64 mm). All three lifts consisted of identical mixtures. Design traffic rates as reported by the Arizona Department of Transportation (ADOT) are:

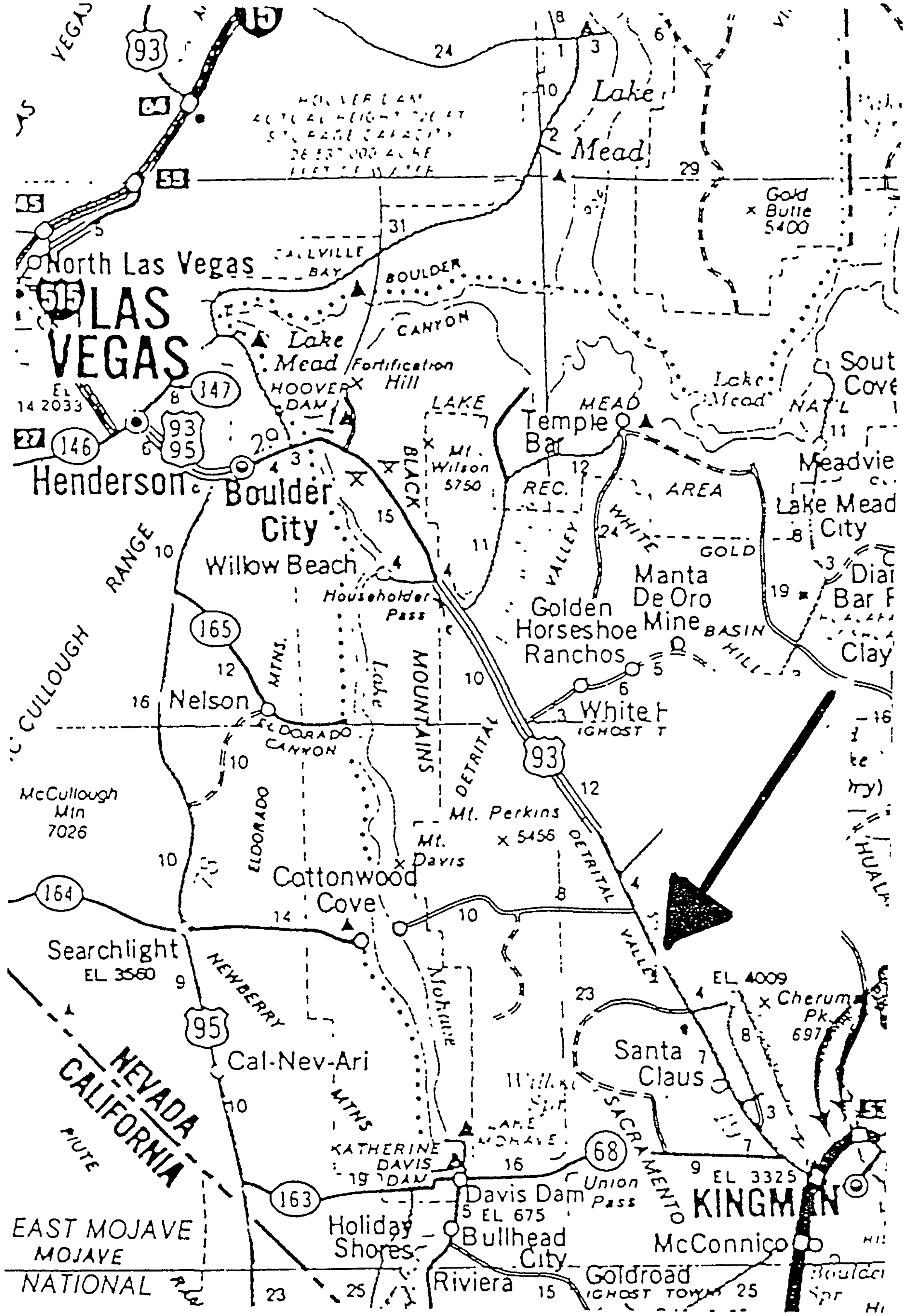


Figure 1. Arizona SPS-9P project location.

Annual Average Daily Traffic (two directions)	9550
Percent Heavy Trucks and Combinations (of AADT)	33.5
Est. 18K ESAL Rate in Study Lane (1,000 ESAL/Year)	247
Total Design 18K ESAL Applications in Design Lane	3.7×10^6
Design Period (Years)	15

Figure 2 indicates the layout of the test sections. Each test section was constructed between 300 m and 580 m in length, with no transitions between adjacent sections. Section 040902 (Superpave 19 mm) and 04A902 (Superpave 25 mm) are located at the south end of the project, section 04A901 (agency standard, originally numbered 040159) is located in the middle of the project and sections 04A903 (Superpave 25 mm) and 040903 (Superpave 19 mm) are located at the north end of the project. Each section was paved in one day, with the sections at the north and south ends being paved on consecutive days. The actual monitoring portions of the test sections are located as illustrated figure 2 and documented in table 1.

Table 1 Test section layout

<table>
<tr><th>Site</th><th>Location</th><th>Construction Stationing (ft)</th><th>Test Section (ft)</th><th>Description</th></tr>
<tr><td colspan="5">Transition 969+50 to 970+00</td></tr>
<tr><td rowspan="4">040902</td><td>Begin sampling area</td><td>970+00</td><td>-2-00</td><td rowspan="4">Superpave Level 1
19 mm</td></tr>
<tr><td>Begin monitoring</td><td>972+00</td><td>0+00</td></tr>
<tr><td>End monitoring</td><td>977+00</td><td>5+00</td></tr>
<tr><td>End sampling area</td><td>979+00</td><td>7+00</td></tr>
<tr><td colspan="5">Transition 981+00 to 982+50</td></tr>
<tr><td rowspan="4">04A902</td><td>Begin sampling area</td><td>983+00</td><td>-2-00</td><td rowspan="4">Superpave Level 1
25 mm</td></tr>
<tr><td>Begin monitoring</td><td>985+00</td><td>0+00</td></tr>
<tr><td>End monitoring</td><td>990+00</td><td>5+00</td></tr>
<tr><td>End sampling area</td><td>992+00</td><td>7+00</td></tr>
<tr><td colspan="5">Transition 1000+00 to 1162+00</td></tr>
<tr><td rowspan="4">04A901</td><td>Begin sampling area</td><td>1162+00</td><td>-0-75</td><td rowspan="4">Agency Standard
19 mm</td></tr>
<tr><td>Begin monitoring</td><td>1162+75</td><td>0+00</td></tr>
<tr><td>End monitoring</td><td>1167+75</td><td>5+00</td></tr>
<tr><td>End sampling area</td><td>302+33</td><td>7+00</td></tr>
<tr><td colspan="5">Transition 302+33 to 441+00 (Equation 1167+93 75 back = 300+51 82 ahead)</td></tr>
<tr><td rowspan="4">04A903</td><td>Begin sampling area</td><td>441+00</td><td>-1-00</td><td rowspan="4">Superpave Level 1
19 mm</td></tr>
<tr><td>Begin monitoring</td><td>442+00</td><td>0+00</td></tr>
<tr><td>End monitoring</td><td>447+00</td><td>5+00</td></tr>
<tr><td>End sampling area</td><td>449+00</td><td>7+00</td></tr>
<tr><td colspan="5">Transition 451+00 to 451+50</td></tr>
<tr><td rowspan="4">040903</td><td>Begin sampling area</td><td>452+00</td><td>-1-00</td><td rowspan="4">Superpave Level 1
25 mm</td></tr>
<tr><td>Begin monitoring</td><td>453+00</td><td>0+00</td></tr>
<tr><td>End monitoring</td><td>458+00</td><td>5+00</td></tr>
<tr><td>End sampling area</td><td>460+00</td><td>7+00</td></tr>
<tr><td colspan="5">Transition 461+00 to End of Project</td></tr>
</table>

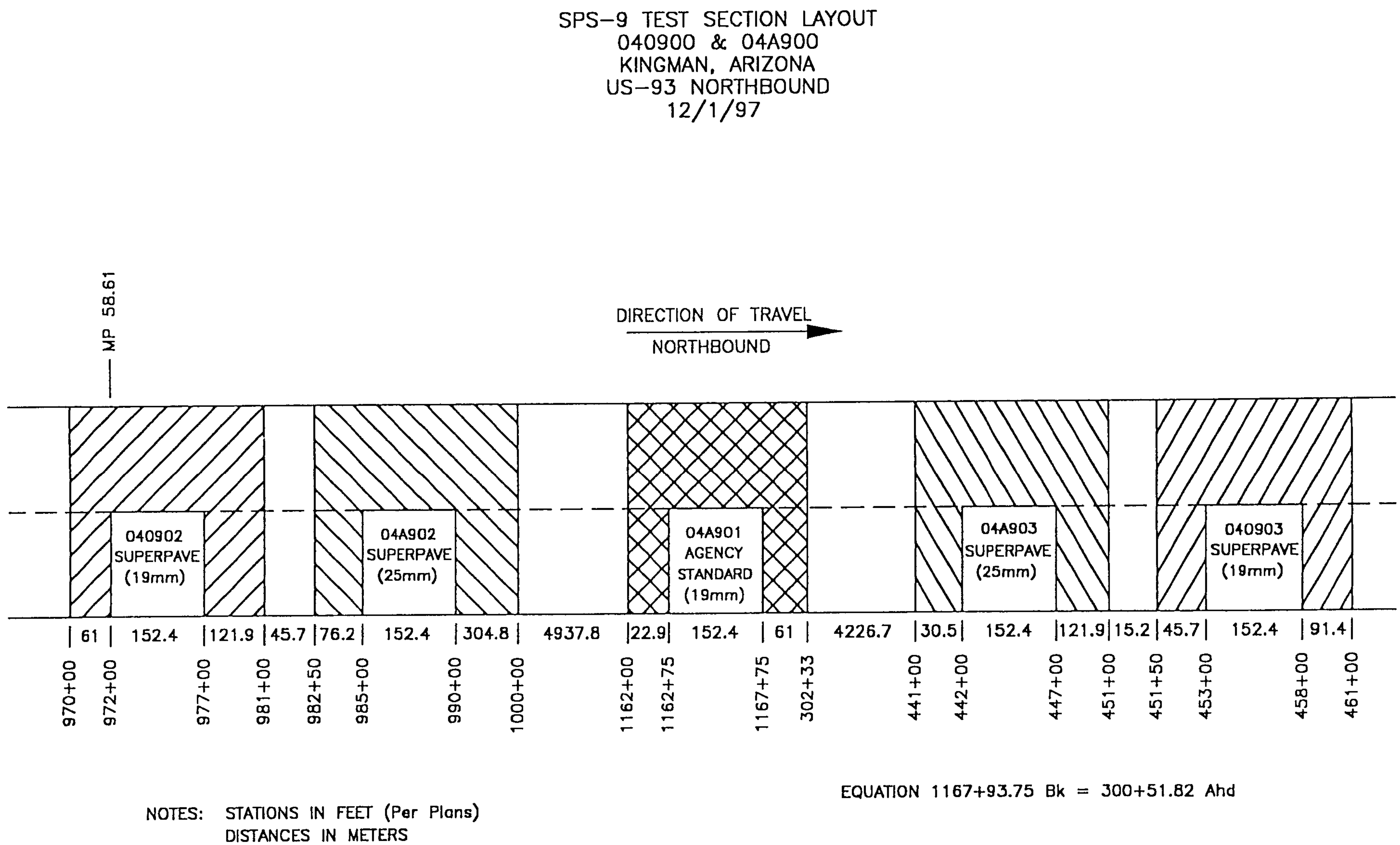


Figure 2. Arizona SPS-9P test section layout.

CONSTRUCTION OPERATIONS

A summary of the complete paving operation is provided in this section of the report. Detailed below are the pre-paving operations, discussions regarding the AC mixture designs, summaries of the paving operation, and information concerning the additional materials sampling and testing performed on the test sections. The contractor on this job was F-N-F Construction, Inc. of Tucson, Arizona.

Mr. Will Garrison served as the contractor's project superintendent and Kajima Engineering and Construction, Inc. of Phoenix was a subcotractor providing quality control testing. ADOT project personnel consisted of Mr. Gordon Senzek, Resident Engineer and Mr. George Cisney, Project Supervisor. The ADOT LTPP coordinator was Mr. Larry Scofield and Mr. Lonnie Hendrix served as the ADOT LTPP field representative. Mr. Pete Pradere and Mr. Doug Frith, representing Nichols Consulting Engineers and the LTPP Western Region, were on-site during all Superpave paving operations.

Pre-Paving Operations

Subgrade

Preparation of the subgrade began November 5, 1992. The natural ground was prepared by clearing off the vegetation, undesirable soil and large rocks, then scarifying with scrapers to a depth of 150 mm to 200 mm. A shallow embankment (1 to 2 m) was placed for all SPS-9P test sections. The embankment was built with roadway excavation and borrow material. Generally, the first two lifts of backfill were roadway excavation and the balance was borrow material from F-N-F borrow #1. F-N-F #1 was located in the vicinity of project station 1095+00. The borrow material consisted of overburden material from the roadside borrow.

The roadside borrow material was hauled to the fill in belly-dumps. Scrapers were used to excavate, haul and spread the roadway excavation. It was then spread into 200 mm loose lifts. Graders processed the material and water was added where necessary. Compaction was performed by loaded scrapers and haul truck traffic. Quality control density tests, using a Troxler 3440 Direct Transmission Nuclear Densometer and quality assurance subgrade density tests using the volumeter method were conducted. In all cases, the embankment material passed the volumeter density requirements prior to additional lifts being placed.

Aggregate Base

An aggregate base (AB) 102 mm thick was constructed on each of the test sections. Placement of the AB began on June 8, 1993, and continued until June 12. Belly-dump trucks were used to spread the AB in a windrow. The material was then bladed and water was added. The AB was placed in one lift. Compaction was obtained using a pneumatic caterpillar PS-180 roller. In addition, heavy construction equipment was also used for compaction. The pneumatic roller made three passes over each section.

AB material was processed through a crushing and screening plant. The material from the borrow was first dumped onto a Pioneer 1.1 m x 1.0 m feeder that fed into a Cedar Rapids 3648 Jaw Crusher set at 140 mm. The material fed out of the crusher onto a feeder belt to an Eljay 1316 screening plant with a 1.8 m x 6.1 m 3-deck screen. After screening, all +25 mm material was fed to an Eljay 1.4 m cone crusher, set at 22 mm. The -25 mm material from the screening was sized and then dumped onto a feeder belt to the AB stockpiles. All of the cone-crushed material was fed back to the screening plant, sized and then dumped onto the feeder belt to the AB stockpiles.

Asphalt Concrete Mixture Designs

The Asphalt Institute in Lexington, Kentucky, performed the Superpave mix designs for this project. Project samples of mineral aggregate and asphalt cement were sent to the Asphalt Institute. The traffic design level of nearly 4 million ESALs on US 93 warranted a Level 2 mix design, but only a Level 1 (volumetric) design was possible due to a lack of equipment and testing protocols.

The agency standard mixture was designed by the ADOT central materials laboratory using the Marshall mixture design method. In addition, ADOT also performed a parallel Marshall mixture design using the Superpave aggregate gradation to develop a "feel" for the new mixture.

Complete mixture designs for all three mixes are provided in appendix A.

Superpave Mixture Designs

During the initial Superpave mixture designs, the Asphalt Institute provided ADOT with their design. ADOT then attempted to develop a Marshall mixture to confirm some of the properties. ADOT was unable to compact the mixture as presented from the Asphalt Institute. At this point, it was discovered the angle of the gyratory compactor being used at the Asphalt Institute needed to be adjusted 0.25 degrees to be compatible with the original gyratory compactor used during the Superpave mixture design development. This adjustment was a major finding in the SPS-9P project.

Once the gyratory compactor was modified, two Superpave mixture designs were performed. One for a 25 mm nominal mixture and the other for the 19 mm nominal mixture Both mixtures utilized the same asphalt cement. The Superpave mixture designs were performed by the Asphalt Institute in Lexington, Kentucky.

Only level 1 mixture designs (volumetric) were performed. The mixture designs utilized the following number of gyrations:

- N Initial (N_i) - 8
- N Design (N_d) - 13
- N Maximum (N_m) - 230

A gyratory compactor was utilized for the mixture designs.

Aggregate for each mixture is comprised of mineral aggregate produced from the material deposit to the east of the project at milepost 51 (approximately project station 1085+00). This deposit is an ancient alluvial fan with an overburden of approximately 2 m that was removed and utilized for borrow. The remaining portion was mined to approximately 10 m in depth. All natural material passing the 25 mm screen was stockpiled with a portion being washed and split into washed chips and washed sand. The material retained on the 25 mm screen was sent to either an impact crusher or a cone crusher depending upon the size of the material. From these crushers, the material was then screened and stockpiled. A second finishing screen ("pep screen") was added to screen the "bottom end" of the crusher fines in an effort to utilize as many of these as possible in the mixtures.

The 19 mm nominal mixture design aggregates were blended as follows:

- 50 percent coarse aggregate
- 14 percent intermediate aggregate
- 16 percent crusher fines
- 10 percent course crusher fines
- 10 percent washed sand
- no natural sand

A blended gradation is provided in figure 3. The gradation is on the coarse side of the curve and falls below the forbidden zone. This aggregate combination resulted in 72 percent fractured faces.

Aggregate comprising the 25 mm nominal mixture design were blended as follows:

- 45 percent coarse aggregate
- 20 percent intermediate aggregate
- 10 percent crusher fines
- 9 percent course crusher fines
- 9 percent washed sand
- 7 percent natural sand

A blended gradation is provided in figure 4. The gradation is on the coarse side of the curve and falls below the forbidden zone. A total of 98 percent of the aggregate contained at least one fractured face for this aggregate combination.

As mentioned, a Superpave performance graded binder (PG 64-16) was selected as the appropriate binder for this location, based upon a 98 percent reliability factor. The project asphalt, designated as an AC-30 met the required PG 64-16 specifications. The asphalt cement was supplied by Conoco and did not contain any additional modifiers or anti-stripping agents.

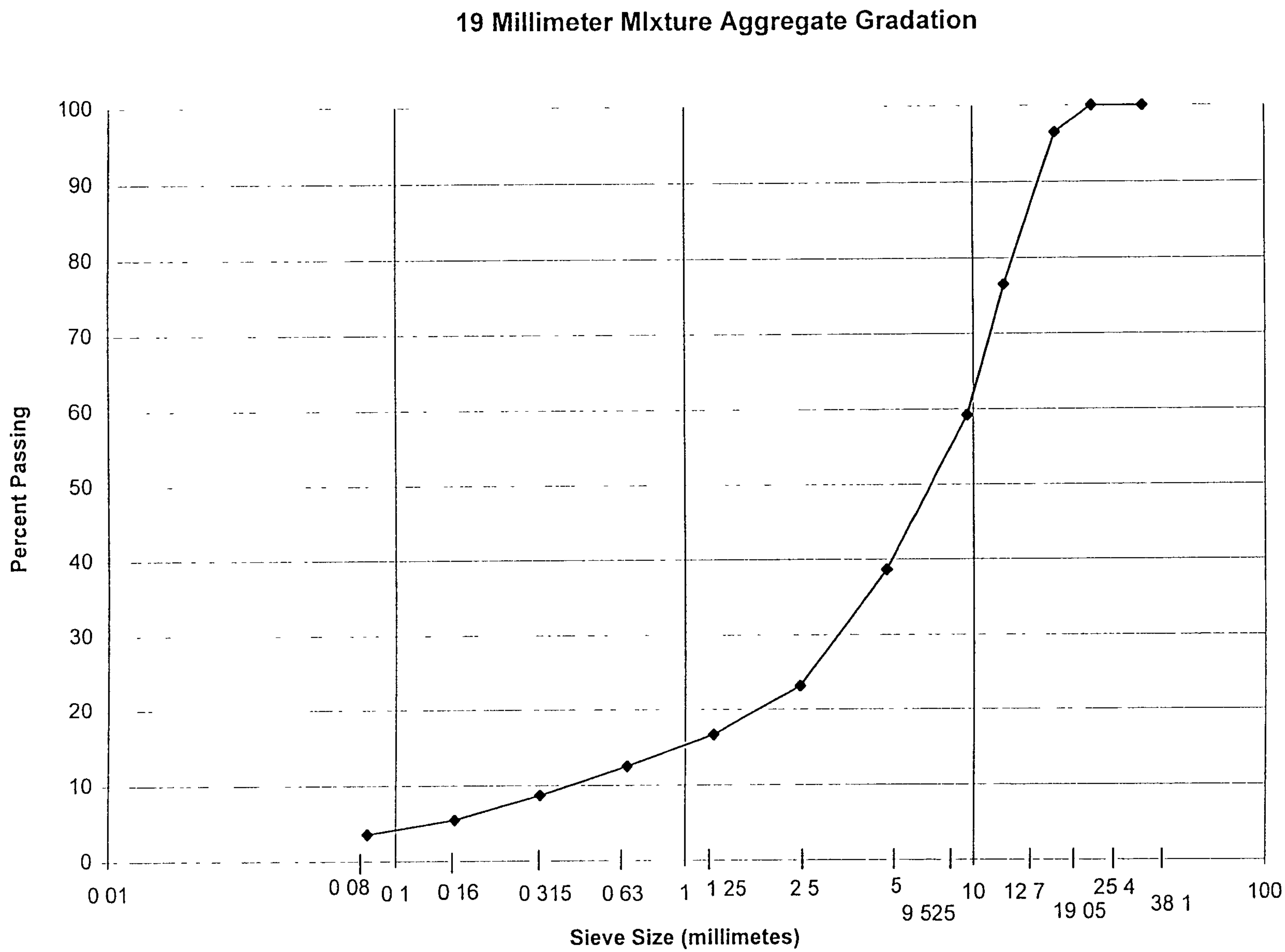


Figure 3. Combined 19 mm nominal Superpave aggregate gradation.

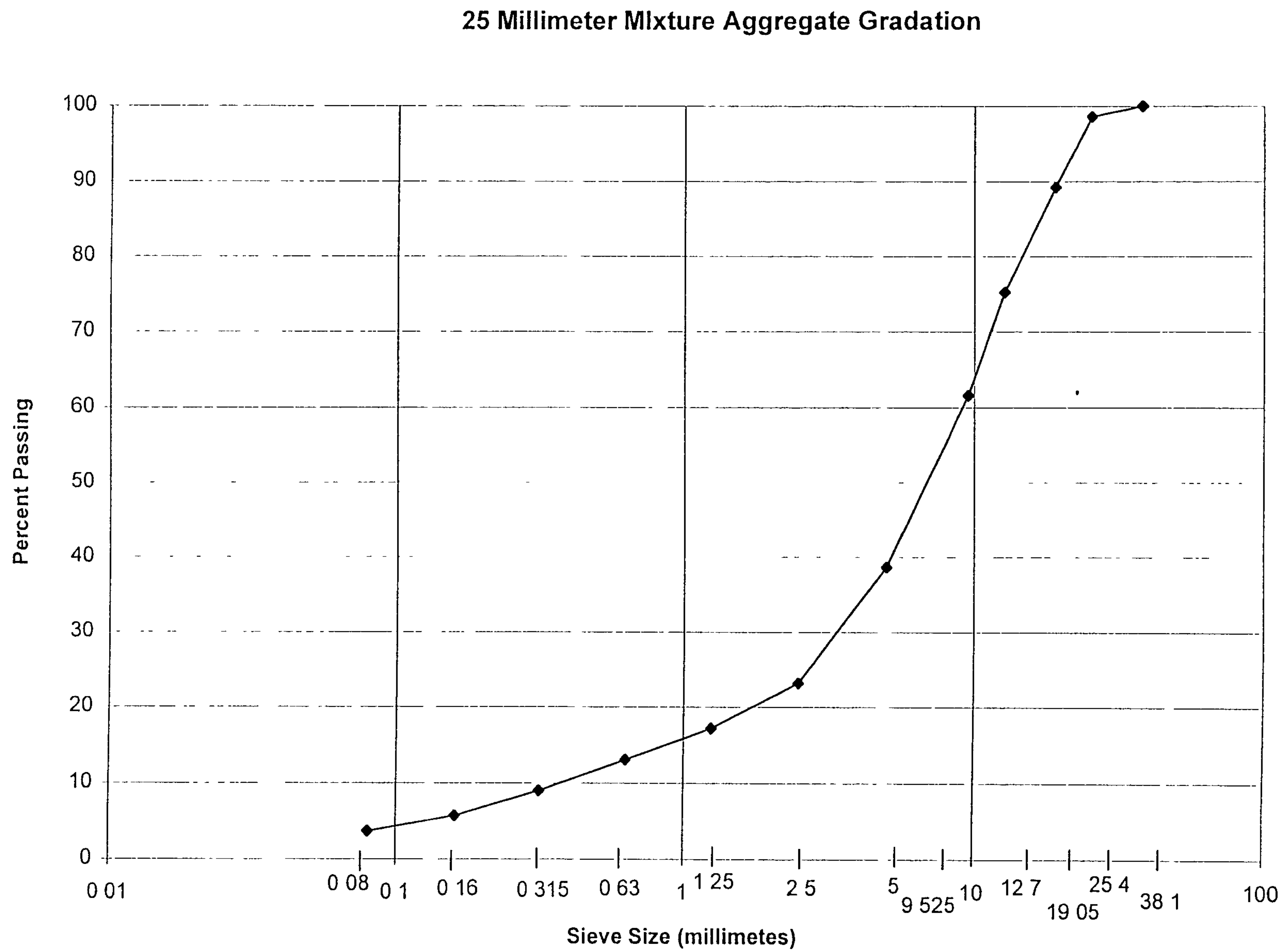


Figure 4. Combined 25 mm nominal Superpave aggregate gradation.

Using the gradations provided above and a PG 64-16 binder, the 19mm mixture required 5.2 percent asphalt cement, while the 25mm mixture required 4.9 percent asphalt cement. "As designed" mixture properties for each mix are presented in table 2.

Table 2. Summary of Superpave mixture properties.

Mixture Summary as Designed		
	19 mm Mix	25 mm Mix
Property	Result	Result
Asphalt Content (%)	5.2	4.9
Density (kg/m^3)	2406	2423
Air Voids (%)	4.1	4.0
VMA (%)	14.6	14.2
VFA (%)	73.0	72.0
% Gmm @ Nini	86.7	86.0
% Gmm @ Nmax	98.3	98.2
Tensile Strength Ratio (%)	--	82.6
Rice Total Sp. Gravity	2.509	2.523
Sp. Gravity of Aggregate Blend	2.670	2.683
Aggregate Effective Sp. Gravity	2.724	2.727
Sp. Gravity of Binder (Gb)	1.03	1.03
Asphalt Absorption (%)	0.8	0.6

Agency Standard Mixture Design

Section 04A901 (Agency Standard) was designed following the standard practices of ADOT; that is, a Marshall Method of mix design as outlined in the latest edition of the Asphalt Institute Manual Series No. 2 (MS-2) and ASTM D 1559 (75 blow). This test section was meant to serve as a control section and represent standard mixtures, materials, and construction practices typically utilized for highway construction in Arizona.

Aggregate for this mixture is comprised of coarse aggregate, intermediate aggregate, 9.5mm minus sand, washed sand, crusher fines and course crusher fines. In addition, a type II Portland cement supplied by Phoenix Cement was used as a mineral admixture. All aggregate was produced from the same borrow source as the Superpave aggregates. Mix design aggregates were blended as follows:

- 27.5 percent coarse aggregate
- 13.7 percent intermediate aggregate
- 4.9 percent 9.5 mm minus sand
- 32.4 percent washed sand
- 14.7 percent crusher fines
- 4.9 percent course crusher fines
- 2.0 percent mineral admixture

A blended gradation is provided in figure 5. Table 3 presents the mineral aggregate properties and the specification values.

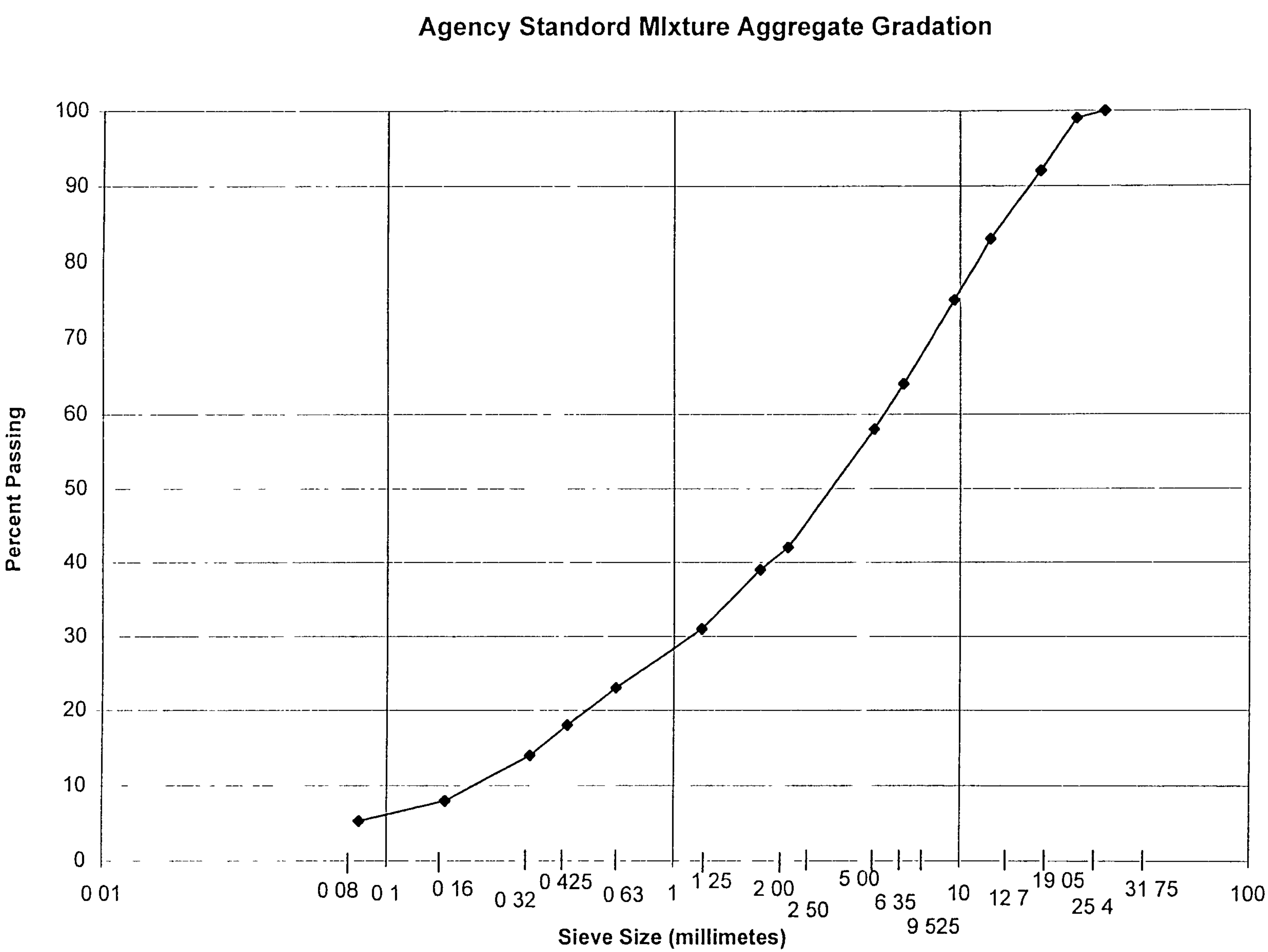


Figure 5. Combined agency standard aggregate.

Table 3. Properties of combined mineral aggregate, agency standard mixture design.

Mineral Aggregate Properties		
Property	**Result**	**Criteria**
Bulk Oven Dried Sp Gravity (combined)	2 673	2.35-2.85
Saturated Surface Dry Sp Gravity (combined)	2 693	--
Apparent Sp Gravity (combined)	2.72	--
Absorption (combined)	0 756	0-2 50
Sand Equivalent	64	45 min
Plasticity Index	Non-Plastic	--
Crushed Faces	98	70 min
LA Abrasion - 100 Rev % loss	6	9 max
LA Abrasion - 500 Rev % loss	25	40 max

An AC-30 grade asphalt cement was specified as the standard asphalt for this project. As mentioned, this same asphalt met the required PG grading and therefore was used in all three mixtures.

According to the Marshall mixture design, 4.1 percent asphalt concrete was required for the gradation provided in figure 4. Mixture properties based upon this aggregate and asphalt combination are presented in table 4.

Table 4. Summary of agency standard Marshall mixture properties.

Marshall Property	Mix Design Results	Specifications
A C Content (% dry wt agg)	4 1	--
Density (kg/m^3)	2385	--
Marshall Stability (kN)	22.3	13 3 min.
Flow (mm)	2 5	2 0 to 4 0
Air Void (%)	5 6	5 3 to 5 7
VMA (%)	14 5	14 5 to 17 0
Voids Filled (%)	61 4	--
Immersion Compression Retention	83 9	50 min
Eff Asphalt Total Mix (%)	3 88	--

Paving Operation

Detailed in this section of the report are the hot-mix plant, the paving equipment utilized and the paving sequencing used to complete the operation. Standard paving equipment and techniques were utilized in the completion of these test sections.

Construction of the AC surface course was completed on section 04A901 between May 16 and May 25, 1993. Several miles of paving were completed at this time and this section was one small portion of the mixture placed. The Superpave test sections were constructed August 2 and 3, 1993. The weather was consistently clear, sunny and hot with ambient temperatures ranging from the mid 20°C in the early mornings to near 38°C in the afternoons.

Hot-Mix Plant

A state-of-the-art CMI PVM-10X portable drum mix plant was utilized in producing all hot-mixed asphalt used on the project. The plant consisted of a venturi shaped parallel flow drum, a CMI baghouse, six feeder bins, a cement silo and was fired using a propane fueled burner. The plant was located in the aggregate borrow source, which resulted in minimal haul distances of one to two miles.

Paving Equipment

Paving of the AC was accomplished using a Blaw Knox PF200 paver. A tack coat was placed between all AC lifts. A prime coat was placed on the aggregate base prior to placing the AC layer. Mix was transported to the roadway via belly dump trucks. The mixture was wind-rowed ahead of the paver and a Cedar Rapids pick-up machine was used to convey the mix into the paver hopper. Breakdown rolling was accomplished using one 12-ton Catapillar CB614 double smooth drum roller making four passes in the vibration mode. Two pneumatic tired rollers, an Ingram 25-ton 9-5500 SB and an 18-ton Catapillar PS180, each made six passes for a total of twelve passes of intermediate rolling. Intermediate rolling occurred with the Ingram roller leading the way, then the Catapillar roller would following right behind. Six passes were completed in this manner. Finish rolling was accomplished with two passes of a 12-ton Catapillar CB614 double smooth drum roller without vibration. Paving grades were generally controlled using an electronics box with a 9.1 m ski on one side of the paver and the electronics box off the adjacent mat on the other side.

Paving Sequencing

Each of the five test sections was paved utilizing three passes on each of three consecutive lifts. Figure 6 identifies the paving widths for each pass and each lift and illustrates the offset of the longitudinal construction joints between lifts. Also demonstrated in this figure are the designed compacted lift thicknesses.

Section 04A901 was paved between May 16 and May 25, 1997. This section was in the middle of 4.5 km of roadway receiving the same mixture. Therefore, each lift was constructed on a different day and often, different passes of the same lift were completed on separate days.

Placement of the Superpave mixtures was designed so that the replicate sections would be constructed on different days, thus ensuring the plant would have to be shut down and restarted. Also, the sections were much longer than the monitoring sections so paving always began on the innermost pass to ensure a uniformly produced mixture would be placed in the actual monitoring portion of the test section and that the start-up and shut down mixtures would not exist in the monitoring locations.

Therefore, all lifts were constructed on sections 04A903 and 040903 (the northern most sections) August 2, 1993. Paving began on 040903 (19 mm mix) and all three lifts were

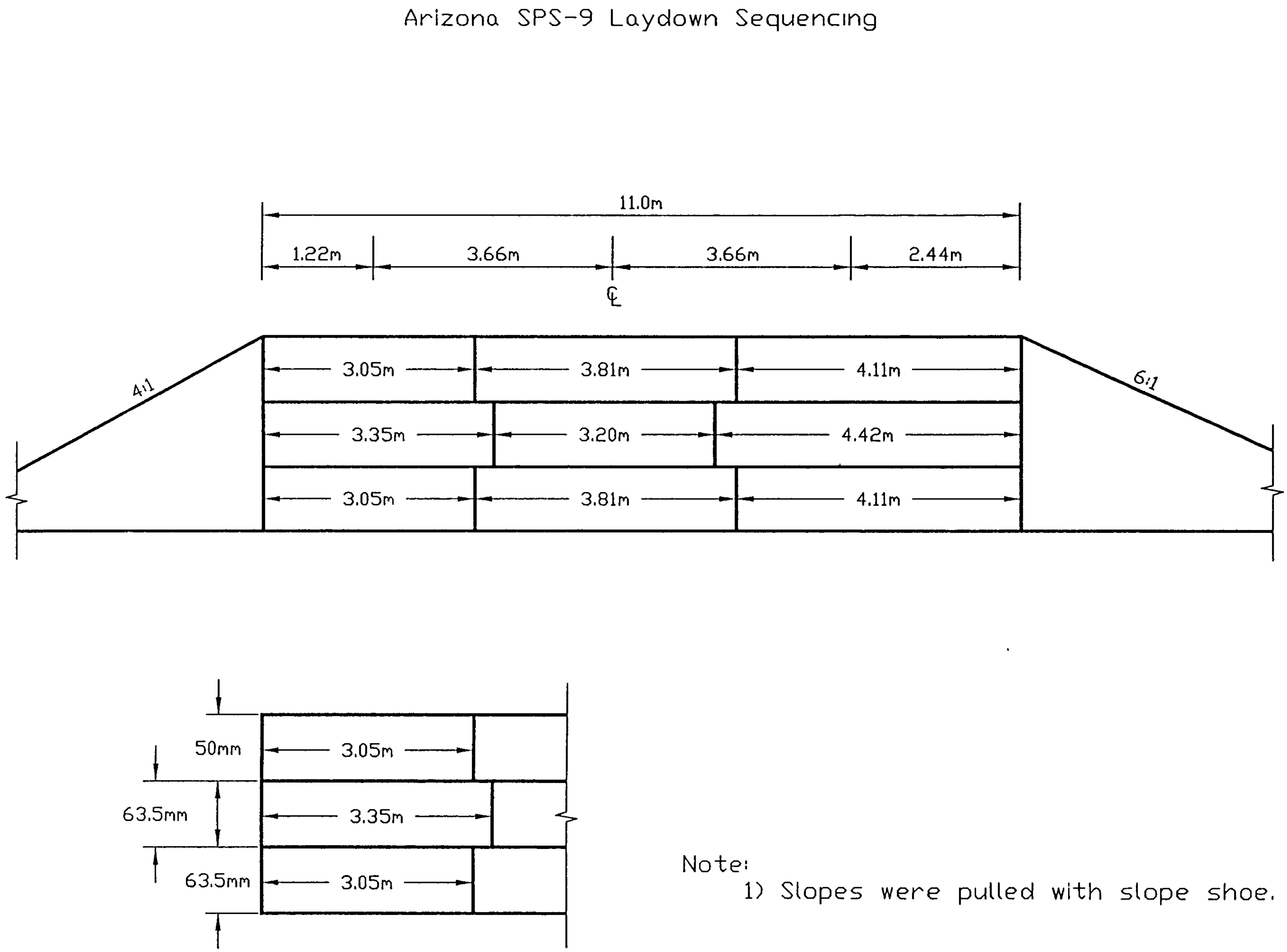


Figure 6. Lift thicknesses, pass widths, and longitudinal cold joint offsets as constructed.

placed. As mentioned, the innermost pass was pulled first, then the middle, then the outer shoulder. After changing the gradation and asphalt content at the plant, and thus changing the mixture, section 04A903 (25 mm mix) was paved following the same sequence. As expected, both mixtures appeared much coarser than the agency standard mixture.

The following day, the paving process was repeated at the south end of the project. Sections 040902 and 04A902 were paved August 3, 1993. Paving was completed utilizing the same equipment and sequencing as the other sections.

During paving, both Superpave mixtures seemed to be susceptible to segregation. This segregation was attributed to the coarseness of the mixtures. Segregation was occurring in the windrow and resulted in random areas of significant surface voids. In addition, the kickback paddles on the paver appeared to be worn, thus causing a segregated area in the middle of each paving pass. Immediately after construction, ADOT reported that both Superpave mixtures "resulted in a mat behind the paver that appeared very rich and shiny and very 'bony' especially compared to the mats observed on the rest of the project." However, according to ADOT personnel, after three months of traffic the surface of the Superpave mixtures appeared less "bony" and were no longer rich looking. At this point, segregation did not seem to be a problem.

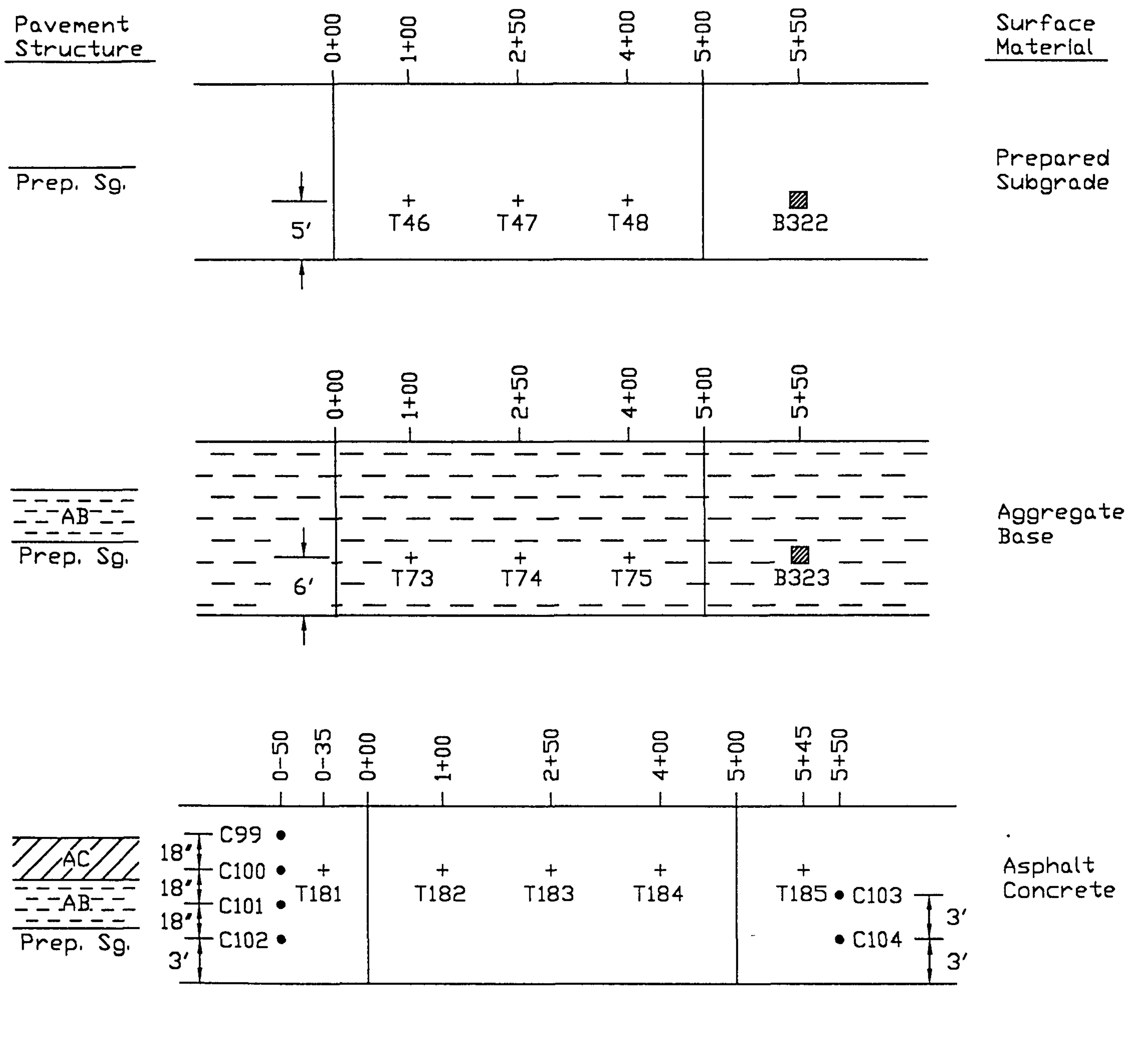
Generally, the mixtures were stable during laydown and compaction. At times, the 19mm mixture appeared tender, particularly the first lift laid on the aggregate base. Compaction effort was similar to the agency standard mix with the addition of more pneumatic passes in an attempt to reduce the surface voids. Final mat densities, determined from cores, ranged from 92 to 94 percent of maximum theoretical density.

Material Sampling and Testing

Sampling and testing on this SPS-9P project varied significantly from the SPS-9A sampling plan. Since the project was constructed in conjunction with an SPS-1 project, extensive sampling and testing was performed on the subgrade and base material. However, unlike current SPS-9A guideline requirements, only limited testing was performed on the asphalt surfacing. The types and quantities of samples, as well as the tests performed on them are discussed in detail in the following sections. Figures 7 through 11 show the location of each sample collected.

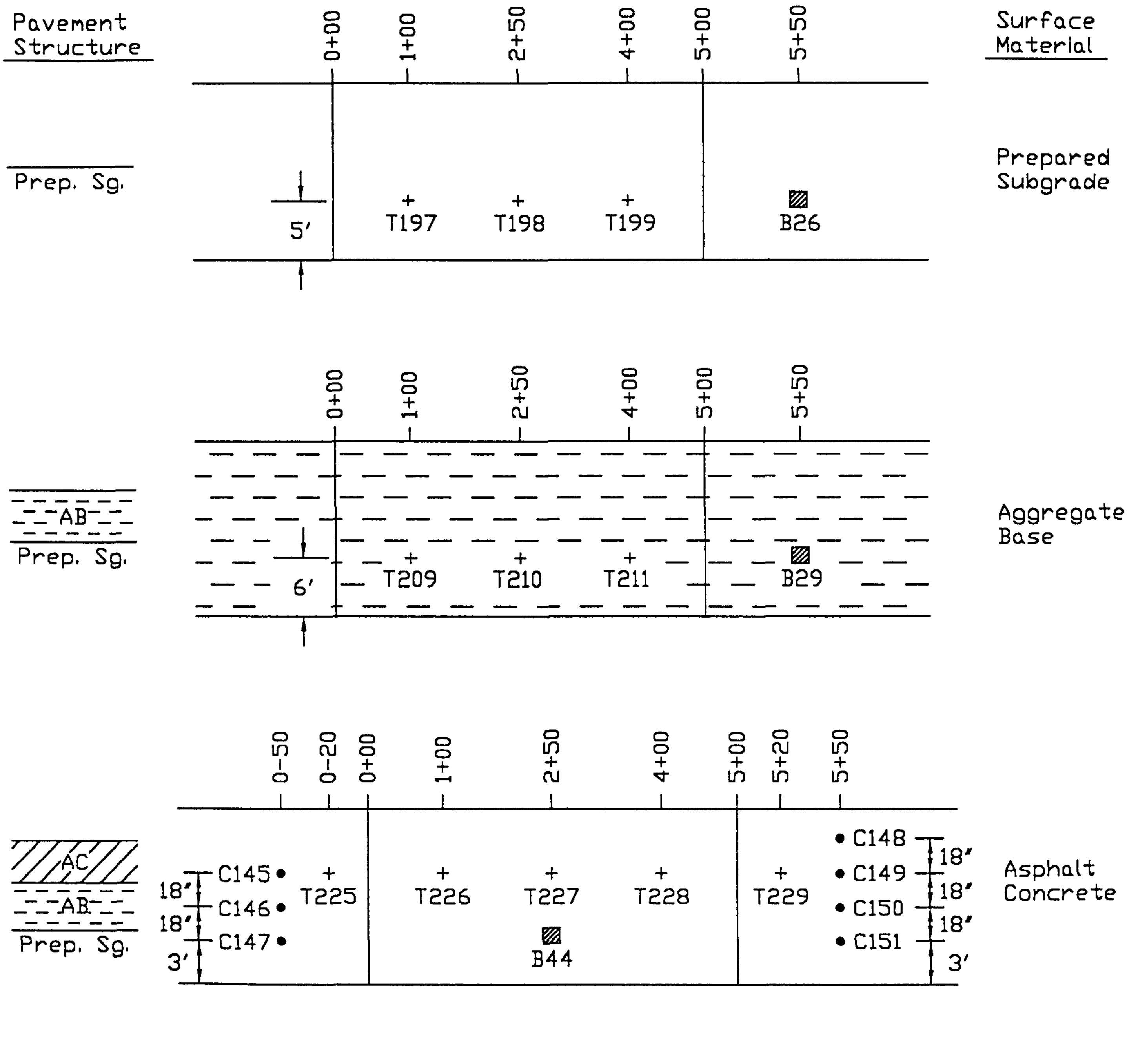
Subgrade Sampling and Testing

Sampling of the subgrade material consisted of bulk material samples from each of the five sections. In addition, moisture jar samples were collected at each bulk sampling location. Table 5 identifies the material tests performed and the results for each section. Nuclear density measurements were recorded at the four locations illustrated in figures 7 through 11.



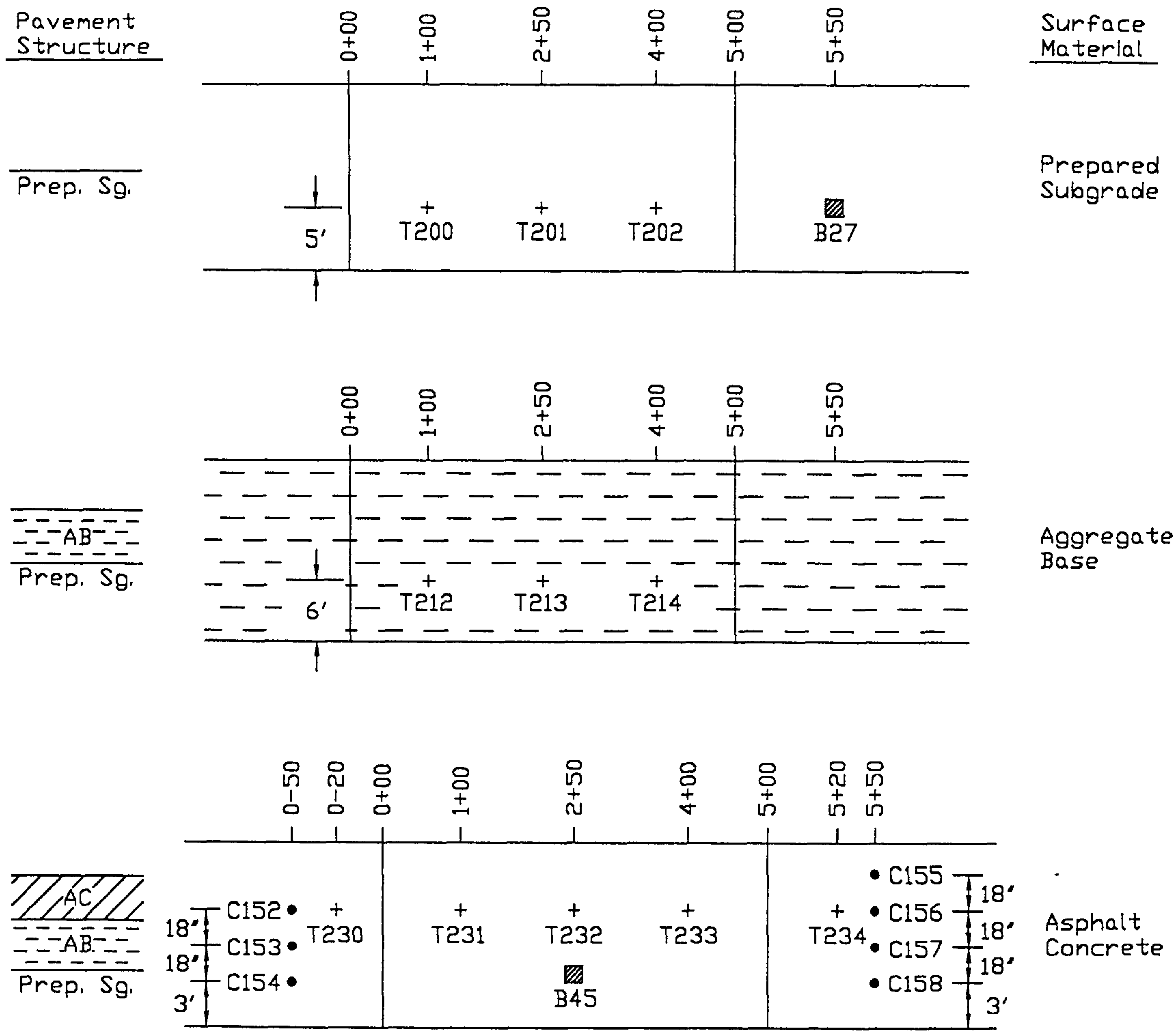
T46-48 - Moisture-density tests on subgrade
B322 - Bulk sample of subgrade
T73-75 - Moisture-density tests on AB
B323 - Bulk sample of AB
T181-185- Density tests on AC
C99-104- Cores of AC layer

Figure 7. Sampling and test plan for test section 04A901.



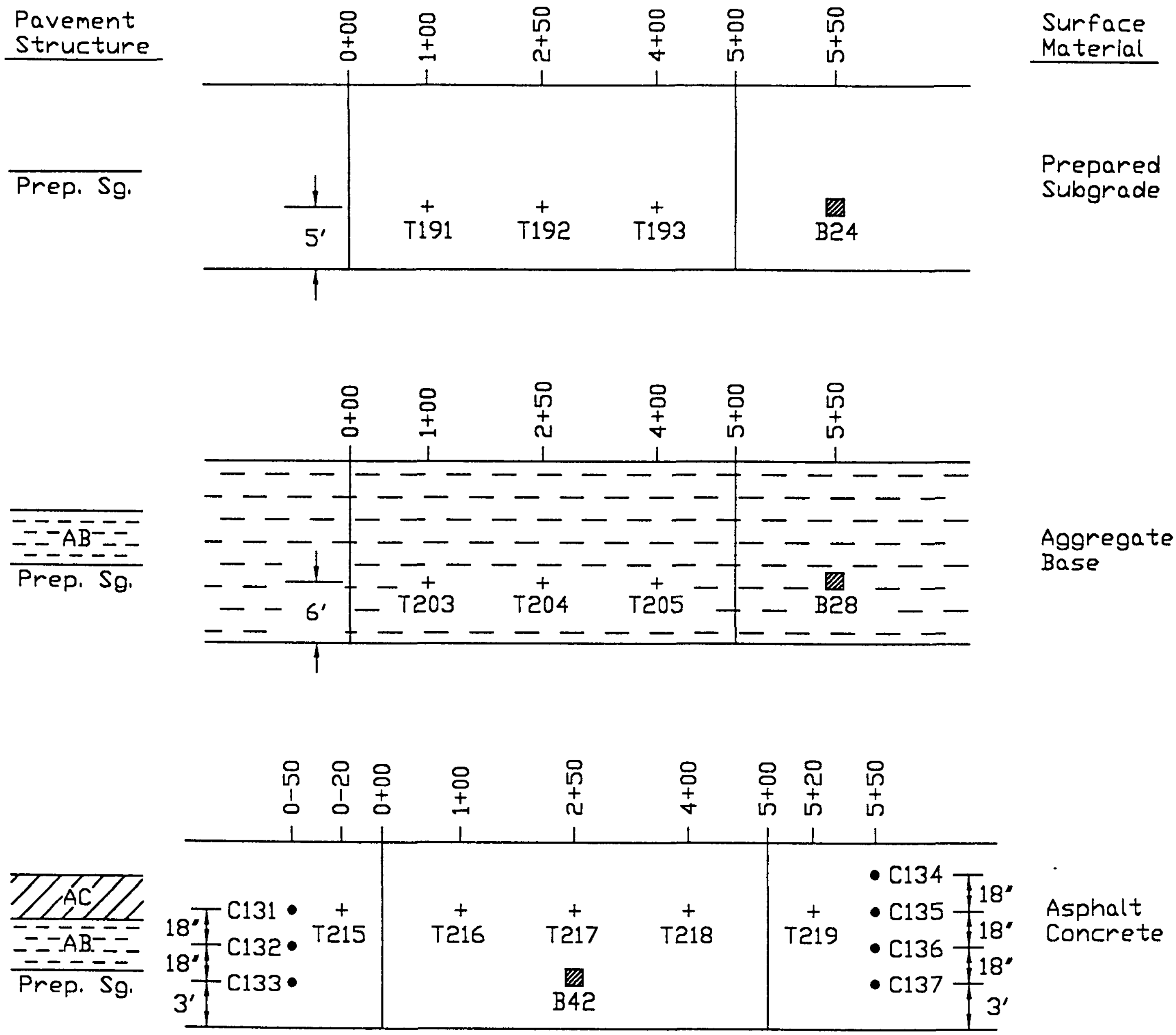
T197-199 - Moisture-density tests on subgrade
B26 - Bulk sample of subgrade
T209-211 - Moisture-density tests on AB
B29 - Bulk sample of AB
T225-229- Density tests on AC
C145-151 - Cores of AC layer
B44 - Bulk sample of AC

Figure 8. Sampling and test plan for test section 040902.



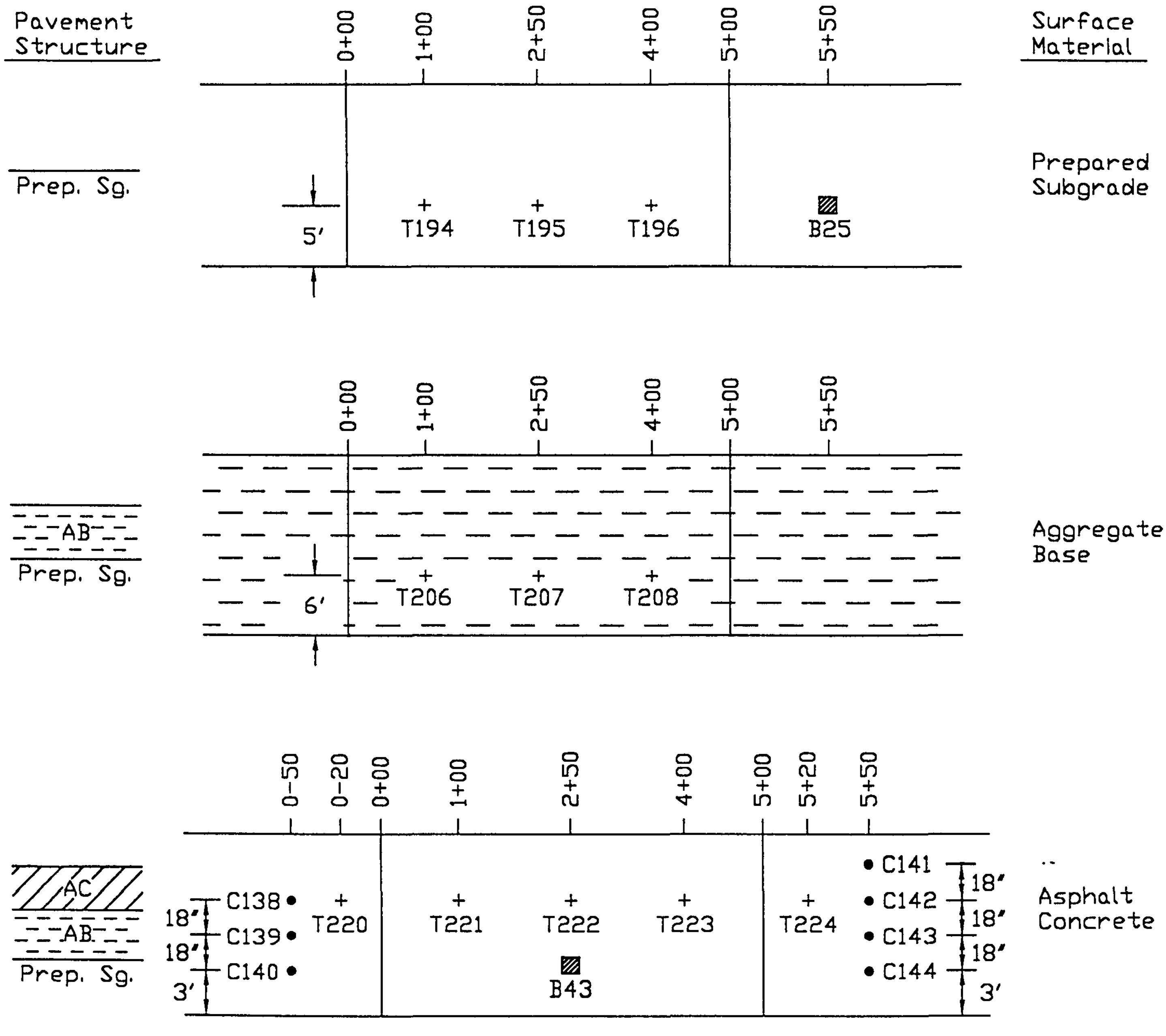
T200-202 - Moisture-density tests on subgrade
B27 - Bulk sample of subgrade
T212-214 - Moisture-density tests on AB
T230-234 - Density tests on AC
C152-158 - Cores of AC layer
B45 - Bulk sample of AC

Figure 9. Sampling and test plan for test section 04A902.



T191-193 - Moisture-density tests on subgrade
B24 - Bulk sample of subgrade
T203-205 - Moisture-density tests on AB
B28 - Bulk sample of AB
T215-219 - Density tests on AC
C131-137 - Cores of AC layer
B42 - Bulk sample of AC

Figure 10. Sampling and test plan for test section 04A903.



T194-196 - Moisture-density tests on subgrade
B25 - Bulk sample of subgrade
T206-208 - Moisture-density tests on AB
T220-224 - Density tests on AC
C138-144 - Cores of AC layer
B43 - Bulk sample of AC

Figure 11. Sampling and test plan for test section 040903.

Table 5. Subgrade tests and results.

Test Methods	Test Results (averaged when appropriate)				
	04A901	**04A902**	**04A903**	**040902**	**040903**
In Situ Density (kg/m^3)- Nuclear	1846	1989	2035	2047	2081
In Situ Moisture (%) - Nuclear	11 4	7 0	3 8	5 6	5 8
Moisture Content (%) - Oven dried	4 8	7 4	3 6	4 6	6 0
Proctor Moisture (%)	10 7	10	8	10	9
Proctor Density (kg/m^3)	2040	2022	2183	2034	2074
Atterberg Limits - Liquid Limit		25		27	21
- Plastic Limit		20		21	--
- Plasticity Index	NP	5	NP	6	NP
Hydraulic Gradient (cm/sec)	$1.5x10^{-5}$	--	$3.8x10^{-4}$	$1 3x10^{-5}$	--
AASHTO Classification	A-1-b	A-1-b	A-1-a	A-1-b	A-1-b
Gradation (Metric Sieves)					
75 0mm	100	100	100	100	100
37 5mm	100	97	100	100	100
50 0mm	97	96	100	97	98
25 0mm	92	93	98	95	97
19 0mm	90	90	92	91	94
12.5mm	86	86	82	89	87
9 5mm	82	84	76	86	82
4.75mm	68	76	58	78	71
2 00mm	57	66	50	68	54
0 425mm	33	40	29	42	33
0 180mm	22	29	24	31	24
0 075mm	14 3	20 3	11 6	22 5	16 1

Aggregate Base Sampling and Testing

Sampling of the aggregate base material consisted of bulk material samples from three of the five sections. Table 6 identifies the material tests performed and the results for each section. Nuclear density measurements were recorded at the four locations illustrated in figures 7-11.

Asphalt Concrete Sampling and Testing

Since these test sections were constructed prior to the FHWA LTPP guidelines on SPS-9A materials sampling and testing, the amount of samples and types of test vary significantly from the current guidelines. For example, the material tests currently required can be divided into five categories, 1) Material Verification, 2) Mixture Design Conformation, 3) Quality Control Tests, 4) As-Built Tests, and 5) Performance Prediction Tests. Of these, only some quality control tests and as-built tests were completed on the SPS-9P. The Asphalt Institute did retain the additional mixture design samples for later use and a large bulk sample of each Superpave mixture was shipped to the Materials Reference Library.

Table 6. Aggregate Base tests and results.

Test Methods	Test Results (averaged when appropriate)				
	04A901	**04A902**	**04A903**	**040902**	**04090 3**
In Situ Density (kg/m^3)- Nuclear	2267	2120	2126	2105	2110
In Situ Moistue (%) - Nuclear	3 3	2 3	1 9	2 5	2.7
Proctor Moisture (%) Proctor Density (kg/m^3)	5 2259		6 2227	6 2243	
Atterberg Limits - Liquid Limit - Plastic Limit - Plasticity Index	NP		NP	NP	
Hydraulic Gradiaent (cm/sec)	$6\ 9 \times 10^{-5}$		$3\ 4 \times 10^{-5}$	$1\ 7 \times 10^{-4}$	
Gradation (Metric Sieves)					
75 0mm	100		100	100	
37 5mm	100		100	100	
50 0mm	100		100	100	
25.0mm	100		100	100	
19 0mm	96		97	97	
12 5mm	82		91	79	
9 5mm	75		86	73	
4 75mm	59		74	59	
2 00mm	45		68	50	
0 425mm	24		43	28	
0 180mm	15		28	18	
0 075mm	8 9		16 8	9 3	

General sampling of the asphalt concrete material consisted of bulk material samples from each of the five sections and 102mm full depth cores after construction. Table 7 identifies the material tests performed and the results for each section. Nuclear density measurements were recorded at the locations illustrated in Figures 7-11.

Table 7. Asphalt Concrete tests and results.

Test Methods	**Test Results** (averaged when appropriate)				
	04A901	**04A902**	**04A903**	**040902**	**040903**
In Situ Density (kg/m^3)- Nuclear	2191	2302	2311	2335	2345
Average Core Thickness (mm)	174 5	165 4	170 9	180 3	168 7
Average Bulk Specific Gravity of Cores	2 328	2.369	2 365	2 355	2.324
Maximum Specific Gravity		2 520	2.524	2 555	2 507
AASHTO T-283 Tensile Strength Ratio		0 611	0 670	0 616	0 750
Asphalt Content (%) Abson Ash Content (%)		4 7 0 3	4 9 0 2	4.3 0 4	4 2 0.2
Coarse Aggregate Bulk Specific Gravity Absorption		 2 73 0 6	 2 69 0 7	 2 66 0 7	 2 67 0 9
Fine Aggregate Bulk Specific Gravity Absorption		 2.62 1 3	 2 63 1 3	 2 64 1 0	 2 62 1 1
Recovered Asphalt Cement Penetration @ 25°C (mm) Penetration @ 46°C (mm) Penetration Index Kinematic Viscosity @ 135°C (Centistokes) Absolute Viscosity @ 60°C (Poise)		 54 258 1 5 482 4144	 35 150 2 0 668 8947	 31 144 1 6 686 10824	 33 161 1 4 -- --
Specific Gravity of Asphalt Cement		1 043	1 039	1 040	1 042
Gradation (Metric Sieves) 37 5mm 25 0mm 19 0mm 12 5mm 9 5mm 4 75mm 2 00mm 0 425mm 0 180mm 0 075mm		 100 96 84 70 62 43 24 12 7 4 0	 100 95 88 74 65 46 24 11 6 4 0	 100 100 97 67 51 33 17 8 5 2 6	 100 100 96 69 54 35 19 10 6 3 6

In addition to the LTPP sampling and testing listed above, ADOT collected mixture samples from behind the paver (plate samples) and cold feed samples for every 500 tons of plant mix produced. The project lab would then perform Marshall tests on these samples. Results of these Marshall tests for the two Superpave mixtures are presented in table 8.

Table 8. Average Marshall test results on Superpave mixtures during construction

Average Marshall Test	25 mm Superpave Mix	19 mm Superpave Mix
Stability (kN)	16.9	15.6
Flow (mm)	4.3	3.8
Asphalt Content (%)	5.0	5.0
Air Voids (%)	3.3	4.3

SUMMARY

Five 300 m test sections were constructed during the summer of 1993 as a pilot SPS-9 project. All test sections are located on the newly constructed northbound lanes of US-93 north of Kingman, Arizona. The SPS-9P test sections are co-located with an SPS-1 project. Traffic and loading information is being captured utilizing a PAT bending plate weigh-in-motion system.

Replicate sections were completed for the Superpave sections, although only one agency standard section was constructed. Superpave Level 1 mixture design criteria were utilized to design both Superpave mixtures. The agency standard section was designed using the Marshall 75 blow mixture design method. The asphalt binder in each of the sections was identical, having a performance graded binder of PG 64-16 that also met the project required AC-30.

Typical construction practices were utilized throughout the project. Initial indications were the Superpave mixtures had significant areas of slight segregation. This segregation was attributed to the coarseness of the mix, windrowing the material and the "kickback" paddles being worn on the paver. After three months of traffic, this no longer appeared to be much of a problem. Both Superpave mixtures were easily constructed, however, the 19 mm mix appeared to be tender at times, especially for the first lift. Post construction sampling revealed the final asphalt concrete thicknesses varied slightly between sections, with the maximum difference between any two sections being 15 mm.

Because of the pilot nature of the project, the test sections do not conform to the current guidelines, although they should continue to provide valuable information regarding the performance of the Superpave mixture designs. In addition, because of attributed to this project, the angle on the gyratory compactor was corrected.

REFERENCES

1. Arizona SPS-1, Construction Report on Site 040100, Final Version, April 1996, prepared by Nichols Consulting Engineers, Chtd.

2. Arizona Transportation Research Center, Research Notes, November 1993.

Appendix A

Asphalt Concrete Mixture Designs

Coronado Engineering & Consulting

127 South Weber Drive, Suite B-1, Chandler, AZ 85226 Phone 602 940-0276 Fax 602-940-0263

TECHNICAL REPORT

MARSHALL MIX DESIGN

CLIENT	FNF CONSTRUCTION INC	DATE	6/1/93
PROJECT	HOOVER DAM - KINGMAN HWY (US 93)	PROJECT NO	F-039-1-509
MIX DESIGNATION	ADOT BASE MIX	SOURCE OF MAT'L	0
SAMPLE SOURCE	STOCKPILES	SAMPLED BY	CLIENT
LAB NO	9305080	% MINERAL ADMIX	2 0

COMPOSITE GRADATION

MATERIAL I D		% USED W/O ADMIX	% USED W/ADMIX
COARSE	CRUSH F	5	4 9
CRUSHER	FINES	15	14 7
WASHED	SAND	33	32 4
3/8 MINUS	SAND	5	4 9
INTER	AGG	14	13 7
COARSE	AGG	28	27 5
ADMIX			2 0

SIEVE	W/O ADMIX % PASSING	W/ADMIX % PASSING	SPEC LIMITS
1-1/4	100	100	100
1"	99	99	90-100
3/4	92	92	85-95
1/2"	82	83	
3/8	74	75	60-75
1/4"	63	64	
#4	57	58	
#8	41	42	36-46
#10	38	39	
#16	30	31	
#30	21	23	
#40	17	18	10-18
#50	13	14	
#100	7	8	
#200	3 4	5 3	2 0-5 5

AGGREGATE PROPERTIES

	COARSE	FINE	COMBINED	SPEC
BULK OD SP GR	2 705	2 649	2 673	2 35-2 85
SSD SP GR	2 728	2 668	2 693	
APPARENT SP GR	2 768	2 700	2 728	
ABSORPTION	0 838	0 705	0 756	0-2 50
SAND EQUIVALENT			64	45 min
PLASTICITY INDEX			NP	
CRUSHED FACES			98	70 min
L A ABRASION				
100 REV % LOSS			6	9 max
500 REV % LOSS			25	40 max

DESIGN DATA

SPECIMEN	1	4	2	3	SPEC
BIT GRADE/SP GR	AC 30	1 044			
% OF BITUMEN	4 0	4 1	4 5	5 0	
BULK DENSITY (pcf)	148 5	148 9	150 6	151 7	
MARSHALL STABILITY (lb)	4955	5013	5246	5590	3000 min
FLOW	10	10	9	12	8-16
% AIR VOIDS	6 0	5 6	3 9	2 5	5 3-5 7
% VMA	14 6	14 5	13 9	13 7	14 5-17 0
% AIR VOIDS FILLED	59 0	61 4	71 6	81 4	
% EFF ASP TOTAL MIX	3 78	3 88	4 29	4 79	

IMMERSION COMPRESSION

SAMPLE	AIR PSI	H2O PS	RETENTION	% AC	% ADMIX
NO 1	426 0	357 5	83 9	4 1	2 0
NO 2					
SPEC	250 min	150 min	50 min		

RECOMMENDED BITUMEN CONTENT (%) = 4.1

ADDITIONAL DATA

MAXIMUM DENSITY =	157 7 PCF @ 4 1 %
ASPHALT ABSORPTION ON DRY AGG (%) =	0 23
ASPHALT TYPE	AC-30
ASPHALT SOURCE	CONOCO
ADMIX TYPE	TYPE II PORTLAND
ADMIX SOURCE	PHOENIX CEMENT

Registered Professional Engineer (Civil) Certificate No. 23216 DONALD L. CORNELISON 6-7-93 ARIZONA, USA

Donald L. Cornelison

SHRP MIX DESIGN
Arizona SPS-9 Mixture
25.4 mm Nominal
1" base mix

SUMMARY OF DATA

Design

Air Voids	4.0% →	Density	2423
Asphalt %	4.9%	Rice TSG	2.523
VMA	11.2%		
VFA	72.0%		

Properties at Design Gyrations

	AC (%)	Weight kg/m3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S G	Effective AC (%)
DESIGN	4.5%	2412	5.0%	14.2%	65%	2.539	3.9%
→	5.0%	2421 151.14	3.9%	14.3%	73%	2.519 157.26	4.4%
	5.5%	2429	2.9%	14.5%	80%	2.500	4.9%
	6.0%	2413	2.8%	15.5%	82%	2.482	5.4%

AC (%)	Density 8 gyrations	Density 113 gyrations	Density 230 gyrations
4.5%	85.6%	95.0%	97.0%
5.0%	86.1%	96.1%	98.3%
5.5%	87.0%	97.1%	99.2%
6.0%	87.0%	97.2%	99.4%

Aggregate Blend BSG	2.683
Aggregate Effective SG	2.727
Asphalt Absorption	0.6%
Asphalt Specific Gravity	1.03

Aggregates

Percent	Aggregate	Bulk SG
45.0%	1" Coarse	2.720
20.0%	Intermediate	2.724
10.0%	Original Crusher Fines	2.630
9.0%	Coarse Crusher Fines	2.642
9.0%	Washed Sand	2.614
7.0%	Natural Sand	2.558

Binder PG 64-16

AC-30

6/10/93

1" Base Mix

4.7% AC

AGGREGATE BLENDING

	Coarse-1	Inter.	CF	CCF	Wash Sand	Nat Sand	Blend 1 Gradation	Blend 2 Gradation	Blend 3 Gradation	Marshall Gradation	Max Dens Gradation
→ Blend 1	45 0%	20.0%	10 0%	9 0%	9 0%	7.0%					
Blend 2	60 0%	10.0%	0 0%	10.0%	20 0%	0.0%					
Blend 3	50 0%	15 0%	12 0%	15.0%	8 0%	0 0%					
Marshall	28.0%	14 0%	15.0%	5.0%	33 0%	5 0%					
Sieve #											
1.5 in	100.0	100 0	100.0	100.0	100 0	100 0	100.0	100 0	100.0	100 0	100 0
1 in	96 9	100.0	100 0	100.0	100.0	100.0	98 6	98 1	98.5	99.1	100 0
3/4 in	76 0	100 0	100.0	100.0	100.0	100.0	89 2	85 6	88 0	93 3	88.4
1/2 in	44.8	100.0	100.0	100 0	100.0	100.0	75.2	66.9	72 4	84.5	73 2
3/8 in	16 8	95.2	100 0	100 0	100 0	99 7	61.6	49.6	57 7	76.0	64 7
No. 4	1.5	24.1	92.6	97.7	93 9	95.8	38.7	31 9	37 6	58 3	47 4
No. 8	1.4	2 4	71.3	22.7	78 4	83.5	23 2	19.0	19 3	42 6	34 6
No.16	1 4	2.1	52.7	6 0	61.3	69.2	17 2	13 9	13 1	32 6	25 3
No.30	1 4	2.0	39.6	5 2	43.1	53.4	13.1	10 2	10.0	23.8	18 7
No.50	1.3	1.9	28.8	4.8	23.6	37.6	9.0	6.2	7 0	14.9	13.7
No.100	1.2	1.7	19 2	4.2	8 3	24.8	5.7	3.0	4 5	7 6	10 0
No.200	1.0	1 5	12.3	3.2	3 3	16.6	3 7	1.7	2 9	4 4	7 3

SHRP MIX DESIGN
Arizona SPS-9 Mixture
19.0 mm Nominal

SUMMARY OF BLEND INFORMATION

Design

Air Voids	4.1%	Density (kg/m3)	2406
Asphalt %	5 2%	Rice TSG	2.509
VMA	14.6%	Density @ 8 gyrations	86 7%
VFA	73.0%	Density @ 230 gyrations	98 3%
% Retained Tensile Strength	Not Reported		

Properties at Design Gyrations

AC (%)	Weight kg/m3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.7%	2346	7.2%	16 2%	56%	2.529	4.0%
5.2%	2415	3.8%	14 3%	74%	2.509	4 5%
5 7%	2429	2.5%	14.2%	83%	2.491	5.0%
6.2%	2432	1.6%	14.6%	89%	2.472	5 5%

AC (%)	Density 8 gyrations	Density 113 gyrations	Density 230 gyrations
4.7%	83 6%	92.8%	94.9%
5 2%	86.7%	96.2%	98.3%
5.7%	87.6%	97.5%	99.5%
6.2%	88.3%	98.4%	99.7%

Aggregate Blend BSG	2.670
Aggregate Effective SG	2.724
Asphalt Absorption	0.8%
Asphalt Specific Gravity	1.03

Aggregates

Percent	Aggregate	Bulk SG
50 0%	3/4" Coarse	2.685
14 0%	Intermediate	2 724
16.0%	Original Crusher Fines	2 630
10 0%	Coarse Crusher Fines	2.642
10.0%	Washed Sand	2.614

Binder PG 64-16

6/10/93

3/4" mix   4.9% AC

AGGREGATE BLENDING WITH CRUSHED SAND

	Coarse-2	Inter.	CF	CCF	Wash Sand	Nat Sand	Blend 1 Gradation	Blend 2 Gradation	Blend 3 Gradation	Max Dens Gradation
Blend 1	22.0%	22 0%	25.0%	21.0%	5.0%	5.0%				
Blend 2	50 0%	14 0%	16 0%	10 0%	10.0%	0.0%				
Blend 3	40 0%	20 0%	20.0%	10 0%	10.0%	0 0%				
Sieve #										
1 5 in	100.0	100.0	100.0	100 0	100 0	100 0	100.0	100 0	100 0	
1 in	100 0	100.0	100.0	100.0	100 0	100 0	100 0	100 0	100 0	100 0
3/4 in	93 0	100 0	100.0	100 0	100 0	100 0	98.5	96.5	97.2	88 4
1/2 in	52 9	100.0	100.0	100.0	100.0	100.0	89.6	76 5	81.2	73 2
3/8 in	19.8	95 2	100.0	100 0	100.0	99.7	81.3	59 2	67.0	64 7
No. 4	2 5	24.1	92 6	97 7	93.9	95 8	59.0	38.6	43 5	47 4
No. 8	2.4	2.4	71.3	22 7	78 4	83 5	31.7	23.1	25 8	34 6
No.16	2 2	2.1	52.7	6.0	61 3	69.2	21.9	16 6	18 6	25 3
No.30	2.1	2 0	39.6	5.2	43 1	53 4	16 7	12.5	14 0	18 7
No.50	1 9	1 9	28.8	4.8	23.6	37.6	12.1	8.7	9.7	13 7
No.100	1 7	1.7	19 2	4 2	8.3	24.8	8.1	5 4	6 1	10 0
No 200	1.3	1.5	12.3	3 2	3 3	16 6	5.4	3 5	3 9	7 3