STATE OF FLORIDA

EXPERIENCE WITH SUPERPAVE IMPLEMENTATION IN 1996

Research Report
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Over the past 10-15 years, Interstate pavements in north Florida have experienced a significant number of failures, primarily due to rutting. As a result, it was believed that the current fine-graded, 50-blow Marshall mix designs used in Florida were inadequate to withstand current loading conditions. The development of the Superpave System under the Strategic Highway Research Program (SHRP) with its superior mix design methodology, and improved binder specifications represented an opportunity to address a number of Florida's asphalt pavement problems. Consequently, the Florida Department of Transportation (FDOT) made a concerted effort to implement Superpave technology in 1996. During this period, a total of eight projects were changed from the traditional Marshall mix designs to Superpave. While the new procedure offers potential for improved pavement performance, there has been a very little experience nationally with its field application. This report documents some of Florida's early experiences with the field implementation of Superpave.

INTRODUCTION

Over the past 10-15 years, a significant number of asphalt pavements on Interstate projects in north Florida have experienced premature failures, primarily due to rutting. As a result of these failures, it was believed by many that the current fine-graded, 50-blow Marshall mix designs used in Florida were inadequate to withstand current loading conditions. The development of the Superpave System under the Strategic Highway Research Program (SHRP) with its superior mix design methodology, and improved binder specifications represented an opportunity to address a number of Florida's asphalt pavement problems.

Consequently, the Florida Department of Transportation (FDOT) made a concerted effort to implement the new Superpave technology in north Florida in 1996. This effort resulted in the placement of approximately 295,000 metric tons (325,000 tons) of Superpave mix during this period. As with any new technology, Superpave represented a significant departure from the more traditional methods of designing, producing, placing and compacting asphalt mixtures. While this new technology offers potential for improved pavement performance, there has been a very little experience nationally with its field application. As such, Florida had the opportunity to learn a great number of things in terms of design and construction of Superpave pavements. This report documents some of Florida's early experiences with the implementation of Superpave.

BACKGROUND

To accelerate the Superpave implementation process, FDOT decided to change on-going projects through the use of Supplemental Agreements. Such an implementation manner would give the asphalt contracting industry in Florida the opportunity to gain experience with Superpave and would reduce the likelihood of "blindly" bidding on future Superpave projects, thereby sharing some of the risks that may be associated with accelerated implementation. It would also further FDOT's stated goal of implementing Superpave on all Interstate projects beginning with the January 1997 letting to improve the rut resistance of Interstate pavements.

In 1996, a total of eight resurfacing projects were changed from traditional Marshall mix designs to Superpave. The location of these projects are shown in Figure 1. The majority of the projects typically consisted of milling the existing asphalt pavement to a depth of 75 to 125 mm (3 to 5 in.), placement of an Asphalt Rubber Membrane Interlayer (ARMI layer), followed by the placement of two layers of a coarse-graded Superpave mix. In general, few problems were encountered while producing the mix, however, obtaining density on the roadway proved to be a consistent problem.

Shortly after, or in some cases, during construction, it was frequently noted that water appeared to be penetrating into the pavement. Initially this phenomenon was assumed to be restricted to the surface of the Superpave mix, where the coarse texture of the pavement seemed to be the obvious source. A subsequent investigation determined that the coarse-graded Superpave pavements were significantly more permeable than traditional fine-graded Marshall pavements. As a result of these problems, in 1997, FDOT made a number of significant changes to their Superpave specifications in order to address this issue.

Three projects proved to play an important role in the evolution of Superpave implementation in Florida: I-75 in Columbia County, I-10 in Columbia County, and I-10 in Suwannee County. The following sections describe the initial specification development, as well as some of the more significant issues related to the construction of these projects.

SPECIFICATION DEVELOPMENT

Prior to changing any projects over to Superpave, FDOT developed a specification based on their existing standard specifications. Highlights of this initial Superpave specification *(1)* included the following:

Mix Design

The Superpave mixes were designed by the Contractor, verified by FDOT, and had to meet the requirements for a Superpave Level I mix design as outlined in two SHRP publications: A-379 "The SUPERPAVE Mix Design System Manual of Specifications, Test Methods, and Practices" and A-407, "The Superpave Mix Design Manual for New Construction and Overlays". This required that all volumetric properties (N_{ini}, N_{des}, N_{max}, V_a, VMA, VFA, Dust-to-Effective), aggregate consensus properties (coarse aggregate angularity, fine aggregate angularity, flat & elongated particles, and clay content) and moisture susceptibility (AASHTO T-283 without freeze-thaw) meet the Superpave criteria. Further, the mixes for high traffic areas (Interstate) were required to be coarse graded (below the restricted zone).

Production

Prior to full-scale production of the Superpave mix, the Contractor was required to produce 90 metric tons (100 tons) of the mix in order to demonstrate the capability of producing, placing, and compacting the mix as specified. As part of their Quality Control Program, during production, the Contractor was required to monitor the volumetric properties of the mix at a minimum frequency of twice per day and take appropriate actions to maintain the air void content at N_{des} (V_a) between 3.0 and 5.0 percent. The Contractor was to stop operations if V_a dropped lower than 2.50 percent or exceeded 6.50 percent on any one test. In addition, the Contractor was also required to perform an extraction gradation analysis once per day. Acceptance and payment of the mix was based on extracted asphalt content and gradation on samples taken randomly at a frequency of one test per 900 metric tons (1000 tons). FDOT also monitored the volumetric properties of the mix at a minimum frequency of one test per 3600 metric tons (4000 tons), as part of their Independent Assurance activities.

Placement

During placement of the mix, all standard FDOT density requirements were applicable. The standard density requirement utilizes a nuclear density gauge in the backscatter mode to establish a control strip, with a minimum control strip density of 96 percent of laboratory density. The control strip is correlated to the actual in-place density by six inch diameter roadway cores. Acceptance is then based on average Lot density as a percentage of nuclear control strip density, with each Lot having to meet a minimum of 98 percent of nuclear control strip density for full pay.

PROJECT DESCRIPTIONS

I-75 Columbia County

The first large project that was changed to Superpave was on I-75 in Columbia County in February 1996. This project was 15.597 km (9.692 miles) long, with a total of six traffic lanes (four existing lanes to be resurfaced and two widening lanes). The resurfacing portion of this project consisted of milling an average depth of 130 mm (5.25"), followed by the placement of 13 mm (0.5 in.) of an ARMI layer, 50 mm (2 in.) of 19.0 mm and 30 mm (1.25 in.) of 12.5 mm coarse-graded Superpave mixes, and 15 mm (0.5 in.) of an open-graded friction course. The widening portion consisted of placing 120 mm (4.75 in.) of 19.0 mm and 30 mm (1.25 in.) of 12.5 mm coarse-graded Superpave mixes, as well as 15 mm (0.5 in.) of an open-graded friction course. The Superpave mixes were designed using the standard Superpave mix design methodology, with the exception that the binder used was an AC-30 rather than a Performance Graded binder. The AC-30 would have met the requirements for a PG 67-22. The Contractor, Anderson-Columbia Co., Inc., designed the mix using granite coarse aggregate from Georgia, limestone screenings from north Florida, and RAP milled from the project. The design ESALs for the project was 86 million, with a pavement temperature of less than 39°C, resulting in an N_{des} of 126. The 0.45 power gradation curves for these mixes are shown in Figures 2 & 3. The total amount of mix placed on this project was approximately 110,000 metric tons (120,000 tons).

The mix was produced with an Astec Six-Pak portable drum-mix plant with a coater unit. The production rate was approximately 250 TPH, with a mix temperature of 149°C (300°F) *(2)*. During production, the P-75μm (P-200) of the mix increased approximately 0.8% from the target shown on the approved mix design. With the exception of higher P-75μm (P-200) contents, no other significant problems were encountered. Production test data is shown in Table 1.

The mix was placed with a tracked Roadtec paver with hydraulic screed extensions, and compacted with two 12-ton Dynapac rollers, a pneumatic roller, and a 10-ton finish roller *(2)*. Placement of the mix was accomplished with little difficulty, with the only problems encountered related to compaction. After attempting various combinations of compacting the pavement in static and vibratory modes, the Contractor eventually settled on a combination of static and vibratory compaction, and was able to obtain passing densities *(2)*. For the project, the Contractor was able to obtain the minimum specified density (98 percent of control strip density) on all Lots. Density results are summarized in Table 2.

Historically, post-construction in-place air voids in Florida have typically been in the range of 7 to 9 percent. For 100 percent pay, FDOT specifications require that each Lot have a minimum density of 98 percent of the control strip density. Based upon a control strip with a minimum density of 96 percent of laboratory density, and a laboratory density set at 96 percent of G_{mm}, this translates to a minimum density of 90.3 percent of G_{mm}, or a maximum in-place air void content of 9.7 percent. Past experience in Florida with this specification has generally resulted in density levels greater than minimum. In order to determine the actual in-place air void content on this Superpave project, FDOT cut and tested a number of roadway cores for determination of bulk and maximum specific gravities. These values indicated that the actual in-place air voids ranged from 10 to 13 percent, which was considerably higher than anticipated based on the nuclear density testing method, as well as historical experience. As a result of these high in-place air voids, FDOT changed the density specification from the nuclear density gauge/control strip method to a core-based density specification. This specification required that the pavement be cored at a frequency of one core taken randomly per 300 m (1000 feet). The target density of the mix was set at 91% of the maximum specific gravity of the mix (as-produced G_{mm}) *(3)*. With this new specification, FDOT negotiated changes on two additional Superpave projects on I-10 with the same Contractor. Discussion of these projects follow:

I-10 Columbia County

This was a 17.107 km (10.63 mile) long, four-lane resurfacing project, that consisted of milling 100 mm (4 in.) of the existing pavement, followed by the placement of 13 mm (0.5 in.) of ARMI layer, 50 mm (2 in.) of a 19.0 mm and 30 mm (1.25 in.) of a 12.5 mm coarse graded Superpave mixes, respectively, as well as 15 mm (0.5 in.) of an open-graded friction course. Construction began on this project in early June 1996. The 0.45 power gradation curves for these designs are shown in Figures 2 & 3. Again, the Superpave mixes met all of the Superpave design criteria, with an N_{des} of 109, using an AC-30 (PG 67-22). Specifications for this project were virtually identical to the I-75 project, with the exception that the density requirement was changed as referenced above, and the pertinent requirements of SHRP A-379 and A-407 were incorporated directly into the specification to eliminate references to the SHRP publications. The total quantity of mix placed on this project was approximately 54,000 metric tons (60,000 tons).

While production and placement encountered little difficulty, compaction and density was, again, a problem. Density and production data is shown in Tables 2 and 3, respectively. Using virtually the same Superpave mix used on the I-75 project as well as the same compaction equipment, the Contractor was unable to meet the 91% of G_{mm} criteria on approximately 67% of the density Lots for the 30 mm (1.25 in.) layer of 12.5 mm mix, and 35% of the density Lots for the 50 mm layer of 19.0 mm mix. The Contractor repeatedly made changes to the compaction process, but was still unable to consistently meet the density requirements.

Several significant observations were made during the construction of this project. First, it was noted that the mix seemed to experience a "tender zone" during compaction when the mat temperature was between 90 and 120°C (190 and 250°F). The pavement could generally be densified when the mat temperature was above 120°C (250°F), but any attempt to compact the mat below this temperature was generally counter-productive. Once the temperature of the mat dropped below 90°C (190°F), some additional densification was possible. This resulted in the back or finish roller being able to increase the pavement's density. However, since this concept seemed to defy conventional approaches to the compaction of asphalt pavements, it was initially discounted.

Another issue was the use of roadway cores for determining density rather than using nuclear density gauge. Coring the roadway and testing the cores proved to be major tasks that impacted the operations of both the Contractor and FDOT. The Contractor had to allocate additional personnel to core the roadway at the specified frequency (one core per 300 m (1000 ft.)), while FDOT had to assign additional Acceptance personnel to the plant in order to coordinate and test the roadway cores. In addition, density results were typically not available until the following day, leaving the Contractor in the unenviable position of not knowing whether his compactive effort was adequate or not until the day after it was compacted.

An additional finding was that there seemed to be a relationship between lift thickness and density. In areas where the spread rate and thickness increased, it was noted that the pavement generally had a higher density. This information was then carried over to the next project.

I-10 Suwannee County

This was a 16.7 km (10.376 mile) long, four-lane resurfacing project, that consisted of milling 100 mm (4 in.) of the existing pavement, followed by the placement of 13 mm (0.5 in.) of ARMI layer, 50 mm (2 in.) of a 19.0 mm and 40 mm (1.5 in.) of a 12.5 mm coarse-graded Superpave mixes, respectively, as well as 15 mm (0.5 in.) of an open-graded friction course. Construction began on this project in late June 1996. The same mixes and specifications as those used on the I-10 Columbia County project were used on this project. The total quantity of mix placed was approximately 54,000 metric tons (60,000 tons).

One significant change to this project was that the layer thickness of the 12.5 mm mix was increased from 30 to 40 mm (1.25 to 1.5 in.) based on the previously discussed I-10 Columbia County project. In addition, at this point the Contractor had gained enough experience with the compaction of Superpave mixes to establish a rolling procedure that resulted in a higher level of densification. The combination of these changes resulted in the Contractor obtaining the specified density of 91% of G_{mm} for the majority of the 19.0 mm lift, although there were still problems with the 12.5 mm layer. The mix continued to exhibit some tenderness at intermediate temperatures. Placement and production data for this project are shown in Tables 2 & 4, respectively.

POST-CONSTRUCTION PERMEABILITY

Following the placement of the Superpave mixes on each of the previously described projects, it was frequently noted that, after rain fall, water seemed to be “weeping” from the Superpave pavement onto the fine-graded Marshall designed shoulder. Initially this was assumed to be moisture contained in the surface texture of the Superpave layer. Due to the number of areas that were experiencing this phenomenon, FDOT investigated the problem to determine its severity.

Six-inch diameter roadway cores were dry cut from various locations of the three Superpave projects described above. These core holes were then monitored for any signs of moisture. It was quickly noted that the cores holes immediately filled with water that had been trapped in the recently completed Superpave layers. The water appeared to be passing completely through the Superpave layers until it reached the asphalt rubber membrane interlayer. At that point the water would move laterally through the pavement until it reached the fine-graded Marshall mix that had been placed on the shoulder. With the shoulder acting like a dam, the water would over-flow onto the paved shoulder. The level of saturation in the pavement was a significant concern, as it was felt that it could very likely lead to a stripping failure of these multi-million dollar projects within a very short period.

By this time, several other Superpave projects were also underway throughout the state. In order to determine if the permeability problem was limited to these three north Florida projects or was a wider problem, FDOT first developed a method of measuring the permeability of pavement cores, then cored all eight of the Superpave jobs completed to that point in time in order to assess each project's permeability. In addition, several fine-graded Marshall pavements were also sampled and their respective permeabilities were determined in order to establish a "benchmark" of current pavement permeability *(4)*. Samples of fine- and coarse-graded Superpave mixes were also compacted in the laboratory and tested for permeability.

The air void content and permeability were measured on each of the Superpave cores in order to establish a relationship between void content and permeability. These results are shown in Table 5. Testing of existing fine-graded Marshall pavements was also conducted, which indicated that the Marshall mixes used in Florida are relatively impermeable even at air voids above 9 percent. These results are shown in Table 6. Fine-graded Marshall permeability values are typically less than

100 x 10^{-5} cm/s when tested with the Florida apparatus. The results of the permeability tests on coarse-graded Superpave cores, summarized in Table 5, indicate that six of the eight Superpave projects were excessively permeable, as compared to existing fine-graded Marshall pavements. The results also indicate that an in-place air void content of less than 6-7 percent is needed to reduce the permeability of coarse-graded Superpave mixes to the level found in fine-graded Marshall pavements. The lower permeability values of the fine-graded Marshall pavements suggests that the relationship between air voids and permeability of fine-graded Marshall mixes is different from that found in coarse-graded Superpave mixes. The air voids of coarse-graded Superpave mixes appear to have a greater amount of interconnection than fine-graded Marshall mixes *(4)*. Laboratory fabricated specimens, however, seem to indicate that the permeability of fine-graded Superpave mixes is similar to that of fine-graded Marshall mixes.

These data indicate that excessive water may infiltrate a coarse-graded Superpave pavement if the compaction during construction is not effective in reducing the amount of voids to at least seven percent.

One of the Superpave projects with relatively lower permeability values was the I-95 project in Brevard county. On this project, a 12.5 mm mix was placed in two 50 mm (2 in.) lifts, and the Contractor had little difficulty obtaining the specified density level. This seemed to reinforce the concept that thicker lifts were beneficial in obtaining density in coarse-graded Superpave pavements. A subsequent meeting with representatives of FHWA confirmed that FDOT's currently specified lift thicknesses could lead to compaction difficulties. Their recommendation was to increase the lift thicknesses to a minimum of four times the nominal maximum aggregate size of the mix.

Based on these findings, along with the recommendations of FHWA, FDOT constructed three 900 m (3000 ft.) test sections on I-75 in Columbia County with 19.0, 12.5, and 9.5 mm coarse-graded Superpave mixes using a combination of increased lift thicknesses, compactive effort, mat temperature, and lower air voids at the plant during production. Cores were obtained from each of the test sections and tested for in-place air voids and permeability. Results from these tests, given in Table 7, indicated that obtaining impermeable coarse-graded Superpave pavements was possible. These results provided FDOT with enough comfort to proceed cautiously with Interstate Superpave projects in north Florida in 1997.

In order to reduce the likelihood of a premature failure on the three projects discussed in this report, FDOT directed the Contractor to saw-cut transverse weep-slots at 4.5 m (15 foot) spacing across the width of the paved shoulder. These weep-slots allow the water to drain from the Superpave layer, and should hopefully minimize the stripping potential of the pavement. FDOT is also monitoring the pavement's density, permeability, tensile strength (dry and conditioned), and frictional resistance every three months. After seven months of heavy traffic the pavement has yet to experience any rutting or moisture-related distress. The weep-slots are still draining, however.

CONCLUSIONS AND RECOMMENDATIONS

Based on their experience with Superpave in 1996, FDOT reached the following conclusions:

- Compaction of coarse-graded Superpave mixes is (as expected) significantly more difficult than the compaction of fine-graded Marshall mixes.
- The nuclear density gauge in the backscatter mode as used by FDOT is not as accurate in establishing the relative density level of coarse-graded Superpave mixes, as compared with its previous use with fine-graded Marshall mixes, particularly with higher in-place air void contents.
- There appears to be a distinct relationship between lift thickness and compactibility of coarse-graded Superpave mixes. Existing lift thickness criteria of fine-graded Marshall

mixes is not adequate for the coarse-graded Superpave mixes.

- Coarse-graded Superpave mixes require a higher level of density to reduce the water permeability to a level that is comparable with existing fine-graded Marshall pavements. This level appears to equate to an in-place air void content of 6 - 7 percent. This is notably lower than that required for existing fine-grade Marshall mixes.
- The maximum acceptable coefficient of permeability, based upon permeability levels of fine-graded Marshall mixes, is $100x10^{-5}$ cm/s when measured with the Florida apparatus.
- Laboratory testing indicates that fine-graded Superpave mixes appear to have the same permeability characteristics as fine-graded Marshall mixes.

At this point, FDOT will still require the use of coarse-graded Superpave mixes on Interstate projects in north Florida (FDOT specifies the use of coarse-graded Superpave mixes on all projects with design ESAL's greater than 10 million. Projects with lower traffic levels are permitted to use fine-graded Superpave mixes). The remainder of the state will use Superpave primarily on an as-needed basis until 1998.

In order to address the permeability problems encountered on the 1996 projects, FDOT has made the following changes to its existing Superpave specifications:

- The density requirement for coarse-graded Superpave mixes has been increased to a minimum of 94.0% of G_{mm} as determined from cores taken from the pavement. The target G_{mm} value is based on the daily average of the Contractor's maximum specific gravity tests (AASHTO T- 209). Should the density drop below 93.0% of G_{mm}, FDOT will evaluate the pavement's permeability, and if it is found to be excessive, removal and replacement will be required. FDOT has also introduced a 5% bonus for higher density levels.
- If the required in-place density is not achieved, then the pavement coefficient of permeability

as measured with the Florida apparatus must not exceed 100 x 10^{-5} cm/s.

- The minimum TSR required when tested in accordance with AASHTO T-283 has been increased to 85%.
- The Contractor shall control air voids V_A during production in the range of from 2.5 to 5.0 percent. Plant operations shall be be stopped if a single test is below 2.0 or above 5.5 percent or when two consecutives tests are below 2.5 percent.
- The minimum lift thicknesses for coarse-graded Superpave mixes has been increased as follows: 40 mm (1.5") for the 9.5 mm mix, 50 mm (2") for the 12.5 mm mix and 80 mm (3") for the 19.0 mm mix. Fine-graded Superpave mixes will continue to have the same lift thickness criteria as fine-graded Marshall mixes.
- During the first 500 tons of production of all Superpave mixes, the Contractor will have to demonstrate the ability to produce, place and compact the mix as designed. This includes acceptable volumetric properties, acceptable gradation and asphalt content, acceptable density values, and acceptable, in-place permeability values.

In 1996 Florida constructed 317,000 metric tons (350,000 tons) of Superpave. In 1997, Florida has an additional 770,000 metric tons (850,000 tons) of Superpave completed or under contract. As of July 1997, the changes identified above have so far successfully resolved the permeability issue. As an AASHTO Lead State in Superpave Implementation, Florida is a very strong advocate of the Superpave system, and believes this new technology will address most, if not all of the pavement problems encountered in Florida. As such, any problems that are encountered with its implementation need to be quickly resolved with the understanding that complete implementation will lead to a longer-lasting and safer highway system in the State of Florida and the rest of the nation.

REFERENCES

1. Florida Department of Transportation, "Technical Special Provisions for Superpave Asphaltic Concrete Mixtures", State Project Number 29180-3446, January 1996.

2. Murphy, K. H., "Summary of Superpave Project on I-75 in Columbia County, Florida", Unpublished report, 1996.

3. Florida Department of Transportation, "Technical Special Provisions for Superpave Asphalt Concrete", State Project Number 29170-3405, I-10 Columbia County, June 1996.

4. Choubane, B., G. C. Page, and J. A. Musselman, "Investigation of Water Permeability of Coarse Graded Superpave Pavements", Research Report FL/DOT/SMO/97-416, Florida Department of Transportation, July 1997.

Table 1 Mix Design and Production Characteristics for I-75 Columbia Co.

Mix Characteristics	12.5 mm Mix			19.0 mm Mix		
	Design Values	Production Average	Production Standard Deviation	Design Values	Production Average	Production Standard Deviation
Number of Tests		40			65	
25.0 mm	100	100.00	0.00	100	100.00	0.00
19.0 mm	100	99.96	0.18	98	98.05	1.40
12.5 mm	98	98.95	0.54	89	90.17	2.88
9.5 mm	89	89.76	1.92	84	83.04	6.22
4.75 mm	47	46.94	3.14	41	41.00	3.17
2.00 mm	27	27.65	1.83	21	21.44	3.43
425 μm	16	16.99	1.11	13	13.97	0.96
180 μm	10	10.27	0.89	8	8.81	0.57
75 μm	4.0	4.52	0.61	4.0	4.61	0.43
AC, %	5.7	5.64	0.24	4.9	4.93	0.34
Gmb @ Ndesign	2.367	2.380	0.021	2.413	2.388	0.040
Lab Density, kg/m^3	2367	2380	21	2413	2388	40
Gmm	2.470	2.470	0.011	2.514	2.508	0.014
Air Voids, %	4.2	3.75	1.04	4.0	4.77	1.76
VMA, %	14.4	13.87	0.64	13.2	14.33	1.52
VFA, %	70.8	73.17	6.36	69.7	67.35	8.40
Effective AC, %	4.4	4.38	0.25	3.93	4.12	0.32
Dust to Eff. AC Ratio	0.91	1.03	0.15	1.02	1.12	0.12
Gmm @ Ninitial, %	85.3	86.13	1.03	85.6	84.7	1.29
Gmm @ Ndesign,%	95.8	96.25	1.04	96.0	95.2	1.76
Gmm @ Nmax,%	97.4	97.78	1.02	97.4	96.9	1.43

Table 2 Field Density Values

Density Values for I-75 Columbia Co. - 12.5 mm Mix		
Percent of Control Strip Density	Percent Pay	Number of LOTs
98.0 and above	100	56
97.0 to less than 98.0	95	0
96.0 to less than 97.0	90	0
less than 96.0	75	0
Density Values for I-75 Columbia Co. - 19.0 mm Mix		
Percent of Control Strip Density	Percent Pay	Number of LOTs
98.0 and above	100	42
97.0 to less than 98.0	95	0
96.0 to less than 97.0	90	0
less than 96.0	75	0
Density Values for I-10 Columbia Co. - 12.5 mm Mix		
Percent of Maximum Specific Gravity	Percent Pay	Number of LOTs
91.0 and above	100	22
90.0 to less than 91.0	95	11
89.0 to less than 90.0	90	14
Less than 89.0	75	19
Density Values for I-10 Columbia Co. - 19.0 mm Mix		
Percent of Maximum Specific Gravity	Percent Pay	Number of LOTs
91.0 and above	100	33
90.0 to less than 91.0	95	14
89.0 to less than 90.0	90	4
Less than 89.0	75	0
Density Values for I-10 Suwannee Co. - 12.5 mm Mix		
Percent of Maximum Specific Gravity	Percent Pay	Number of LOTs
91.0 and above	100	23
90.0 to less than 91.0	95	27
89.0 to less than 90.0	90	17
Less than 89.0	75	1
Density Values for I-10 Suwannee Co. - 19.0 mm Mix		
Percent of Maximum Specific Gravity	Percent Pay	Number of LOTs
91.0 and above	100	46
90.0 to less than 91.0	95	0
89.0 to less than 90.0	90	0
Less than 89.0	75	0

Table 3 Mix Design and Production Characteristics for I-10 Columbia Co.

Mix Characteristics	12.5 mm Mix			19.0 mm Mix		
	Design Values	Production Average	Production Standard Deviation	Design Values	Production Average	Production Standard Deviation
Number of Tests		19			35	
25.0 mm	100	100.00	0.00	100	100.00	0.00
19.0 mm	100	100.00	0.00	98	98.48	0.89
12.5 mm	98	98.19	0.61	89	89.12	4.54
9.5 mm	89	86.74	2.47	82	82.30	3.24
4.75 mm	45	46.26	3.45	39	41.61	2.98
2.36 mm	29	28.53	1.43	24	23.37	1.58
1.18 mm	23	22.59	0.96	18	18.57	1.25
600 μm	19	18.51	0.77	15	15.49	1.17
300 μm	13	14.45	0.62	11	12.20	1.04
150 μm	8	8.58	0.47	8	7.61	0.86
75 μm	4.2	4.81	0.36	4.0	4.64	0.75
AC, %	5.3	5.39	0.15	5.2	5.35	0.35
Gmb @ Ndesign	2.374	2.378	0.011	2.409	2.398	0.029
Lab Density, kg/m^3	2374	2378	11	2409	2398	29
Gmm	2.473	2.473	0.007	2.505	2.492	0.022
Air Voids, %	4.0	3.87	0.66	3.8	3.79	1.09
VMA, %	14.0	13.89	0.34	13.1	13.64	1.16
VFA, %	71.4	72.21	4.20	71.0	72.40	7.21
Effective AC, %	4.3	4.34	0.17	4.0	4.23	0.49
Dust to Eff. AC Ratio	1.0	1.11	0.09	1.0	1.11	0.20
Gmm @ Ninitial, %	86.1	85.5	0.73	84.6	84.97	0.97
Gmm @ Ndesign, %	96.0	96.1	0.66	96.2	96.21	1.09
Gmm @ Nmax, %	97.5	97.7	0.64	97.8	97.85	1.04

Table 4 Mix Design and Production Characteristics for I-10 Suwannee Co.

Mix Characteristics	12.5 mm Mix			19.0 mm Mix		
	Design Values	Production Average	Production Standard Deviation	Design Values	Production Average	Production Standard Deviation
Number of Tests		29			26	
25.0 mm	100	100.00	0.00	100	100.00	0.00
19.0 mm	100	100.00	0.00	98	98.05	0.97
12.5 mm	98	98.42	0.38	89	88.37	2.31
9.5 mm	89	87.24	1.57	82	80.73	4.29
4.75 mm	45	46.19	2.35	39	39.80	2.86
2.36 mm	29	29.07	1.10	24	22.91	1.31
1.18 mm	23	23.11	0.69	18	17.98	0.87
600 μm	19	18.95	0.61	15	15.27	0.80
300 μm	13	14.50	0.72	11	12.17	0.66
150 μm	8	8.69	0.39	8	7.84	0.52
75 μm	4.2	4.76	0.31	4.0	4.91	0.43
AC, %	5.3	5.35	0.19	5.2	5.33	0.16
Gmb @ Ndesign	2.374	2.373	0.014	2.409	2.403	0.018
Lab Density, kg/m^3	2374	2373	14	2409	2403	18
Gmm	2.473	2.476	0.008	2.505	2.498	0.007
Air Voids, %	4.0	4.20	0.72	3.8	3.79	0.81
VMA, %	14.0	14.06	0.45	13.1	13.44	0.63
VFA, %	71.4	70.25	4.42	71.0	71.97	4.91
Effective AC, %	4.3	4.28	0.10	4.0	4.13	0.15
Dust to Eff. AC Ratio	1.0	1.12	0.18	1.0	1.19	0.12
Gmm @ Ninitial, %	86.1	85.4	0.68	84.6	84.75	0.65
Gmm @ Ndesign, %	96.0	95.8	0.72	96.2	96.21	0.81
Gmm @ Nmax, %	97.5	97.4	0.70	97.8	97.93	0.80

Table 5 Permeability Test Results

19 mm Mix			
Project	Sample	Air Voids,%	k, E-5 cm/s
29180-3446 I-75 Columbia	5R19	4.0	0
	5R19	5.4	3
	6R19	5.9	22
	3L19	6.9	526
	4L	7.0	111
	5L2B19	7.3	51
	6L19	7.7	270
	8R19	8.2	245
	4R19	8.2	625
	2L19	8.9	741
	5L19	9.0	720
	IL19	9.4	764
	8L19	9.9	587
	2R19	10.4	1014
	IR19	10.9	872
	7L19	12.1	976
29170-3405 I-10 Columbia	1R19	1.9	2
	4R19	3.0	0
	7C19	3.6	0
	3L19	3.7	8
	7R19	3.8	0
	1L19	4.6	50
	5R19	5.0	82
	8R19	5.4	5
	4C19	5.8	301
	6C19	5.9	251
	8C19	6.1	110
	5C19	6.5	262
	2L19	8.4	861
	6R19	8.5	370
	3R19	8.7	638
48260-3463 I-10 Escambia	419	6.3	13
	8B19	6.6	95
	319	6.7	25
	719	6.7	26
Project	Sample	Air Voids, %	k, E-5 cm/s
48260-3463 I-10 Escambia (Cont.)	619	7.1	1
	819	7.2	58
	219	7.3	35
	519	7.3	3
	119	7.4	102
	5S19	8.3	125
	2B19	8.9	559
	3B19	9.1	223
	5B19	9.2	84
	1B19	9.6	804
	3S19	10.7	964
	4B19	11.1	533
	9B19	11.6	916
	1S19	11.8	927
74040-3529 A1A Nassau	2C19.0	2.3	0
	2X19.0	4.1	1
	2R19.0	4.9	1
	1C19	6.6	405
	15R19.0	6.8	487
	14C19.0	7.2	539
74060-3534 A1A Nassau	4R19	4.5	25
	9R19	5	43
	10R19	6.2	117
	9C19	7.2	520
	12R19	7.4	384
	6R19	8.5	385
57002-3419 I-10 Okaloosa	119	7.2	264
	519	7.2	78
	719	7.6	116
37120-3426 I-10 Suwannee	7R19	6.3	121
	6C19	6.7	294
	4R19	6.8	110
	3R19	7.2	205
	8R19	7.8	243

Table 5 -- Continued

12.5 mm Mix							
Project	Sample	Air Voids ,%	k, E-5 cm/s	Project	Sample	Air Voids, %	k, E-5 cm/s
70220-3443	2bot12.5	3.5	0	48260-3463	9B	8.1	131
I-95 Brevard	1bot12.5	4.8	23	I-10	7B	8.4	90
	1top12.5	4.8	1	Escambia	2B12.5	8.8	184
	712.5	5.1	3		3B	10.4	215
	312.5	5.1	1		1B12.5	11	490
	412.5	5.6	19		1B	11.2	489
	2top12.5	6.1	1		11B	11.7	500
	812.5	6.4	50	74040-3529	2C12.5	3.9	9
	612.5	6.8	5	A1A Nassau	2R12.5	6.9	262
	512.5	6.9	9		31R12.5	7.9	458
	212.5	7.0	60		3R12.5	8.2	347
	112.5	8.3	107		2X12.5	8.8	515
29180-3446	5R12.5	4.2	1		1C12.5	9.4	384
I-75	5L2T12.5	6.3	102		14R12.5	9.4	463
Columbia	8R12.5	8.7	546		1X12.5	10.5	773
	6R12.5	9.3	359	74060-3534	12C12.5	4.3	0
	5R12.5	9.9	444	A1A Nassau	11R12.5	4.9	7
	2L12.5	11.0	452		7C12.5	5.7	6
	4L12.5	11.3	761		7R12.5	5.9	5
	4R12.5	11.3	591		12R12.5	6	14
	7R12.5	11.5	615		9R12.5	7.1	109
	6L12.5	12.2	919		11C12.5	7.3	119
	5L12.5	12.5	537		6R12.5	7.7	357
	8L12.5	12.6	434	57002-3419	712.5	4.5	10
	7L12.5	12.6	413	I-10	112.5	4.9	8
	2R12.5	12.7	722	Okaloosa	312.5	5.2	60
	3L12.5	12.8	628		512.5	6.3	38
	3R12.5	13.6	544	37120-3426	6C12.5	7.5	384
	IL12.5	13.6	598	I-10	3C12.5	7.7	302
	1R12.5	14.6	575	Suwannee	2C12.5	8.3	436
29170-3405	3R12.5	2.1	0		6R12.5	8.4	405
I-10	1L12.5	6.8	152		5R12.5	8.5	318
Columbia	4R12.5	6.8	183		7C12.5	8.5	575
	IR12.5	7.3	474	79002-3435	A9	6.1	69
	4C12.5	8.2	369	I-95 Volusia	A12	6.5	155
	3L12.5	8.4	373		A11	6.9	106
	2L12.5	8.5	419		RLSB12.5T	7.4	36
	8R12.5	8.9	381		A7	7.9	306
	7R12.5	9.2	469		RLSB12.5B	8.8	273
	7C12.5	9.6	496		A19	10.1	657
	5R12.5	10.3	311		A18	10.2	584
	6R12.5	10.3	470		A8	11.5	1002
	6C12.5	10.3	360				
	8C12.5	11.8	580				

Table 6 Marshall Mix Permeability Test Results

Sample	Air Voids, %	k, E-5 cm/s
Field Samples		
1	5.9	14
2	7.7	7
3	8.5	7
4	9.5	32
5	10.9	152
6	11.9	17
7	6.5	1
8	7.0	1
9	7.3	2
10	8.3	52
Laboratory Fabricated Samples		
1	7.1	6
2	7.8	5
3	7.9	8
4	8.4	15

Table 7 I-75 Superpave Test Sections Permeability Test Results

Sample	Air Voids, %	k, E-5 cm/s
19 mm Mix		
1	3.1	0
2	4.5	0
3	5.6	0
4	5.9	24
5	5.6	1
12.5 mm Mix		
6	3.8	337*
7	4.7	0
8	4.0	0
9	5.3	34
10	4.8	1
9.5 mm Mix		
11	4.8	5
12	6.8	170
13	7.8	203
14	7.9	179
15	5.0	14

* Sample damaged before testing.

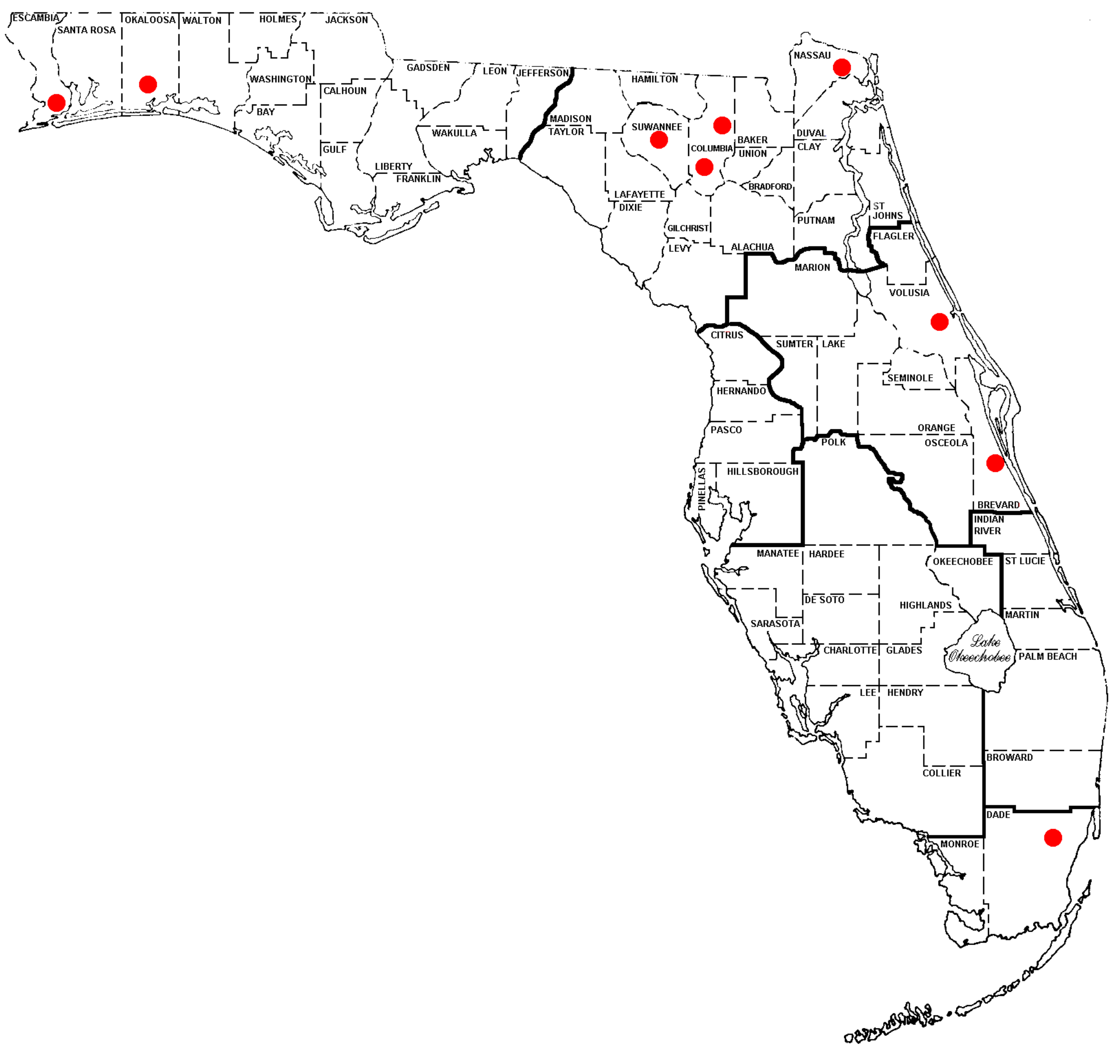

Figure 1 Superpave Project Locations

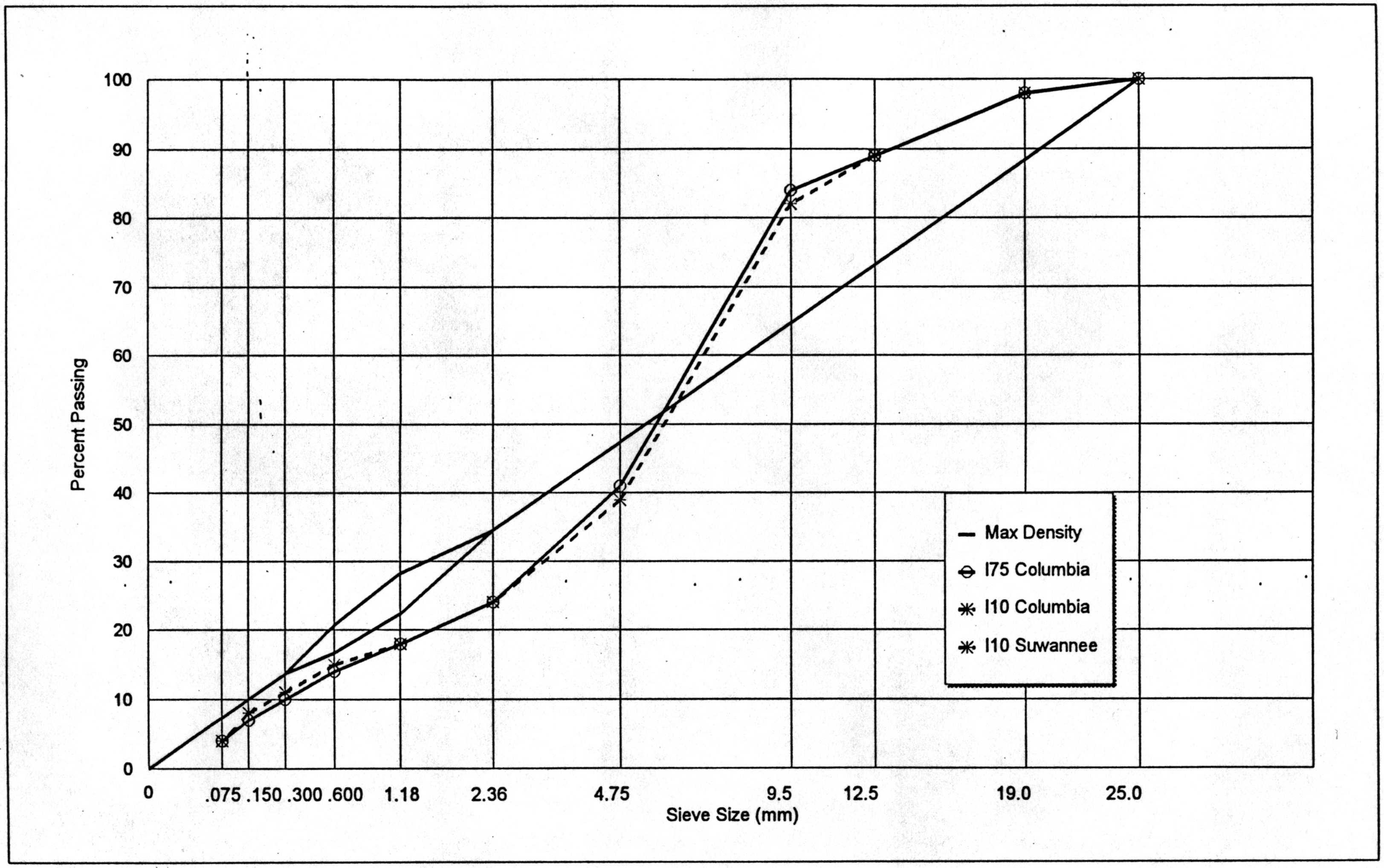

Figure 2 19.0 mm Superpave Mix Aggregate Gradations

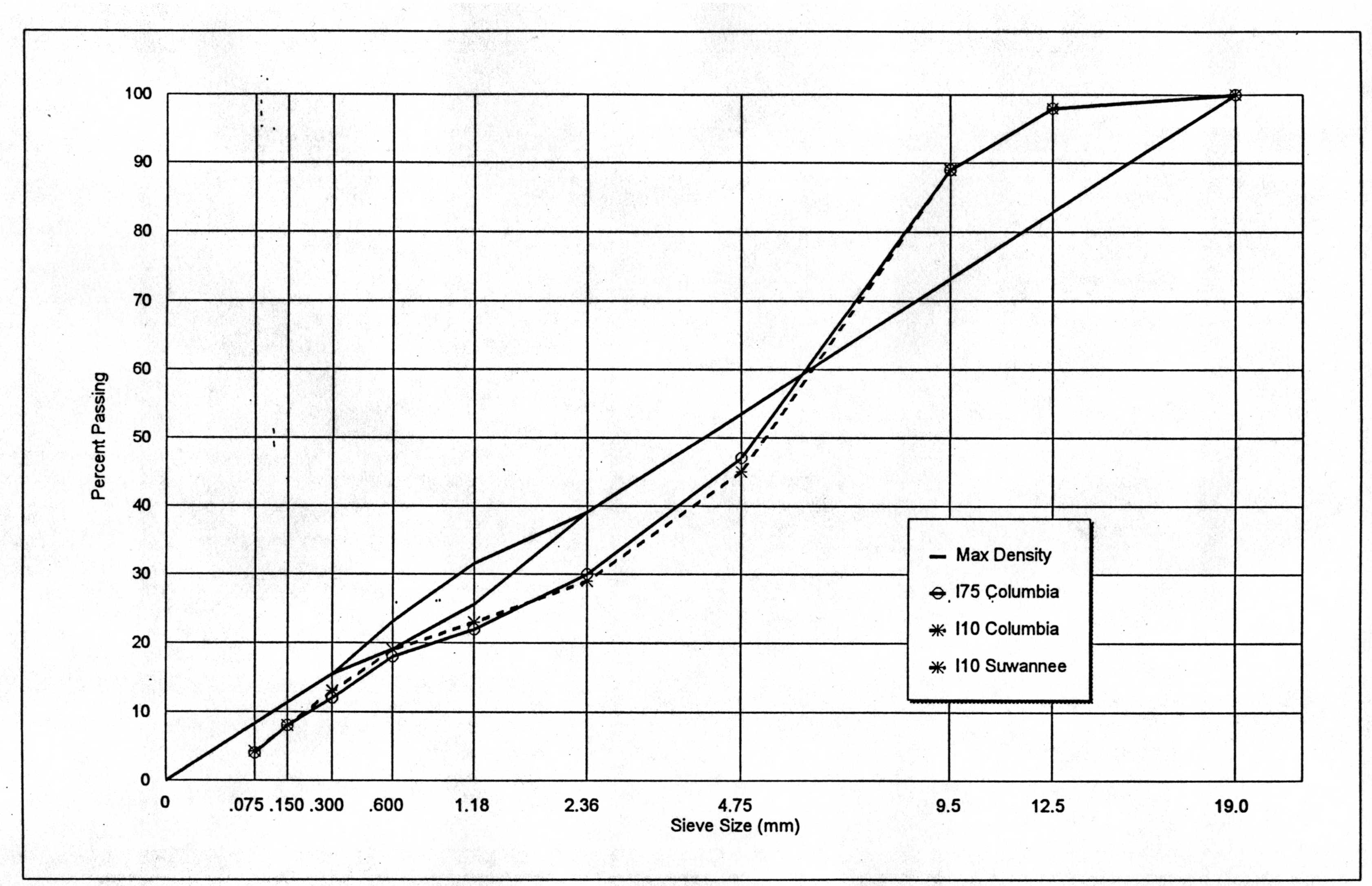

Figure 3 12.5 mm Superpave Mix Aggregate Gradations