

AMENDMENTS
to
2012
Manual of
STANDARD SPECIFICATIONS

Adopted by
Standard Specifications Committee

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FORWARD

This document modifies the 2012 edition of the “Manual of Standard Specifications”. All other provisions in the manual remain in full force and effect.

1. Delete the following sections in their entirety.
 - a. Section 32 12 05 entitled “Asphalt Concrete”.
 - b. Section 32 12 06 entitled “Superpave”.
 - c. Section 32 12 07 entitled “Oil Sand Concrete”.
 - d. Section 32 12.16.18 entitled “Recycled Asphalt Paving”.

2. Add the following sections (attached hereto).
 - a. Section 32 12 05 entitled “Bituminous Concrete”.
 - b. Section 32 12.16.18 entitled “Recycle Bituminous Pavement”.

SECTION 32 12 05
BITUMINOUS CONCRETE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Composition of an aggregate and Bituminous Binder mix.

1.2 REFERENCES

A. AASHTO Standards:

- M 323 Superpave Volumetric Mix Design, Single User Digital Publication.
- R 30 Mixture Conditioning of Hot-Mix Asphalt (HMA).
- T 312 Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyrotory Compactor.
- T 324 Hamburg Wheel-Track Testing of Compacted Hot-Mix Asphalt (HMA).

B. ASTM Standards:

- C 29 Unit Weight and Voids in Aggregate.
- C 88 Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
- C 117 Materials Finer Than 0.075mm (No. 200) Sieve in Mineral Aggregates by Washing.
- C 131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- C 136 Standard Method for Sieve Analysis of Fine and Coarse Aggregate.
- C 142 Clay Lumps and Friable Particles in Aggregates.
- D 75 Sampling Aggregates.
- D 140 Sampling Bituminous Materials.
- D 242 Mineral Filler for Bituminous Paving Mixtures.
- D 979 Sampling Bituminous Paving Mixtures.
- D 995 Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.
- D 2041 Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures.
- D 2419 Sand Equivalent Value of Soils and Fine Aggregate.
- D 3203 Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.
- D 3515 Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.
- D 3665 Random Sampling of Construction Materials.
- D 3666 Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials.
- D 4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- D 4552 Classifying Hot-Mix Recycling Agents.

- D 4791 Flat or Elongated Particles in Coarse Aggregate.
- D 4867 Effect of Moisture on Asphalt Concrete Paving Mixtures.
- D 5444 Mechanical Size Analysis of Extracted Aggregate.
- D 5821 Determining the Percentage of Fractured Particles in Coarse Aggregate.
- D 6307 Determining Asphalt Content of Hot-Mix Asphalt by Ignition Method.
- D 6373 Performance Graded Asphalt Binder.
- D 6927 Marshall Stability and Flow of Bituminous Mixtures.

C. AI Standards:

- MS-2 Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types.
- SP-2 Superpave Series No. 2.

1.3 DEFINITIONS

A. Aggregate and Binder Designator: An Alphanumeric code used to indicate a bituminous mix is composed of 1) a type and grade of aggregate and 2) a type or a type and grade of a Bituminous Binder. The aggregate portion of the code is specified in English units indicating a Marshall mix design is required or in metric units indicating a Superpave mix design is required. The bituminous portion of the code indicates the binder is an Asphalt Binder, a Bitumen Binder, or a Blended Binder. For example.

1. Marshall mix design.

- **DM 3/4 PG70-28:** DM 3/4 is the aggregate. PG70-28 is the Asphalt Binder.
- **DM 1/2 OS/PG:** DM 1/2 is the aggregate. OS/PG is a Blended Binder.

2. Superpave mix design.

- **12.5 PG64-22:** 12.5 is the aggregate. PG64-22 is the Asphalt Binder.
- **9.5 OS/PG:** 9.5 is the aggregate. OS/PG is a Blended Binder.

B. Bituminous Binder:

1. Asphalt Binder: Refined or manufactured asphalt cement (AC) or performance graded asphalt binder (PG or PGAB) whether virgin or contained in RAP.
2. Bitumen Binder: Natural bitumen cement contained in an Oil Sand.
3. Blended Binder: Binder comprised of both Asphalt Binder and Bitumen Binder.

C. ESAL (acronym for equivalent single axle load): Number used in designing pavement thickness. It relates axle load of any mass and number to an equivalent number (18,000 lb).

D. Mean of Deviations: Defined in Section 32 11 23.

E. Nominal Maximum Size: One sieve size larger than first sieve size retaining more than 10 percent of the sample. The nominal maximum size sieve will retain more than zero (0) percent of the sample and a maximum of 10 percent of the sample. The maximum size will be one (1) sieve size larger than the nominal maximum size.

F. Oil Sand (OS): Naturally occurring sediments or sedimentary rock containing gravel, sand, clay, water and Bitumen Binder.

G. RAP (acronym for reclaimed asphalt pavement): A granular product recovered from a bituminous pavement containing aggregate and an Asphalt Binder.

H. **ROSP** (acronym for reclaimed Oil Sand pavement): A granular product recovered from a bituminous pavement containing an aggregate and a Bitumen Binder.

1.4 SUBMITTALS

A. **General:**

1. Allow ENGINEER 10 days to evaluate mixing equipment and mix design submittals.
2. Once a mix design is accepted, a new mix design submittal is required if the following occurs.
 - a. Asphalt Binder grade is changed.
 - b. Aggregate source is changed. When this occurs, submit a physical properties report on the proposed aggregates.

B. **Independent Laboratory:** Submit names, certification levels, and years of experience of testing agency's field technicians that are assigned to the Work. Verify laboratory complies with ASTM standards.

C. **Mix Production Equipment:** Submit verification by an individual acceptable to ENGINEER, that plant equipment complies with requirements of ASTM D 995.

D. **Mix Design:** Submit the following.

1. Date of mix design. If the date exceeds the following times, the mix design is invalid and must be recertified.
 - a. One (1) year for non-commercial plants.
 - b. Two (2) years for commercial plants if there is no change in the aggregate source. A new mix design will be required if aggregate source is changed.
2. Asphalt Binder source, type, chemical composition, and grade. Disclose if RAP or ROSP is used in the mix.
3. Optimum compaction temperature at the project site.
4. Compaction density at N_{design} (for Superpave mix design).
5. Target Grading Curve for aggregate.
6. Binder target percentage, dust to binder ratio, and the following as applicable.
 - a. For Marshall mix design provide 1) tensile strength ratio (moisture sensitivity), 2) voids in the mineral aggregate (VMA), 3) stability, 4) flow and 5) voids in the bituminous mix.
 - b. For Superpave mix design provide 1) voids in the mineral aggregate (VMA), and 2) voids filled with Bituminous Binder (VFA).
7. Percentages of 1) mineral filler, 2) anti-strip, 3) reclaimed bituminous pavement (RAP or ROSP), and 4) recycle agent in the mix.
8. Aggregate physical properties (this section article 2.2). The information is for suitability of source and not for project control. A new report may be required if aggregate source is changed. Test results shall not be older than 455 days from the date of submission.

E. **Pre-approved Mix Design:** Submit name and address of Supplier.

F. **Testing Report:** If requested by ENGINEER, submit a report of source and field quality control testing performed by CONTRACTOR and Suppliers.

1.5 QUALITY ASSURANCE

- A. Use a laboratory that complies with ASTM D 3666 and follows Section 01 45 00 requirements.
- B. Do not change aggregate source or binder source until ENGINEER accepts new sources and mix design.

1.6 ACCEPTANCE

A. General:

- 1. Acceptance is by Lot. One (1) Lot is one (1) day production.
- 2. If non-complying material has been installed and no price for the material is specified, apply pay adjustment against cost of work requiring material as part of its installation, Section 01 29 00.
- 3. If test results are not within this section's limits, options include correction of production procedures or production of an alternate mix design acceptable to ENGINEER.
- 4. Observation of CONTRACTOR's field quality control testing does not constitute acceptance. Such testing; however, may be used by ENGINEER for acceptance if requirements in Section 01 35 10 are met.
- 5. Dispute resolution, Section 01 35 10.

B. Mix:

- 1. Sub-lot size is 500 tons or part thereof.
- 2. Sampling Protocol: ASTM D 3665 and ASTM D 979. Collect at least one (1) random Sample per sub-lot from the following locations:
 - a. Behind paver before compaction, or
 - b. Where sub-lot exhibits non-uniform appearance.
- 3. Testing Protocol: Field samples will be compacted in the laboratory and tested for:
 - a. Air voids, ASTM D 3203.
 - b. Dust to binder ratio.
 - c. Binder content, ASTM D 6307 and aggregate gradation, ASTM D 5444.

- C. Pay Reduction: Lot is acceptable if test deviations are within pay factor 1.00 limits in Table 1 or Table 2 as applicable. At ENGINEER's discretion a Lot with a sub-lot test deviation greater than pay factor 0.85 limits may stay in place at 50 percent pay.

Table 1 – Pay Factors – Marshall Mix Design						
Criteria	Pay Factor	Range of Mean of Deviations of Tests Results from the Binder and Gradation Targets in Percentage Points				
		500 Tons	1,000 Tons	1,500 Tons	2,000 Tons	≥2,500 Tons
Binder Content	1.00	0.00–0.70	0.00–0.54	0.00–0.46	0.00–0.41	0.00–0.38
	0.975	0.71–0.80	0.55–0.61	0.47–0.52	0.42–0.46	0.39–0.43
	0.95	0.81–0.90	0.62–0.68	0.53–0.58	0.47–0.52	0.44–0.47
	0.90	0.91–1.00	0.69–0.75	0.59–0.64	0.53–0.56	0.48–0.52
	0.85	1.01–1.10	0.76–0.82	0.65–0.69	0.57–0.61	0.53–0.56
1/2" and larger Sieve	1.00	0.0–10.9	0.0–7.3	0.0–6.5	0.0–5.6	0.0–5.2
	0.975	11.0–12.9	7.4–8.3	6.4–7.1	5.7–6.3	5.3–5.8
	0.95	13.0–13.9	8.4–9.3	7.2–7.9	6.4–7.0	5.9–6.4
	0.90	14.0–14.9	9.4–10.3	8.0–8.7	7.1–7.7	6.5–7.1
	0.85	15.0–16.0	10.4–11.3	8.8–9.5	7.8–8.4	7.2–7.7
3/8" Sieve	1.00	0.0–9.9	0.0–6.9	0.0–5.9	0.0–5.3	0.0–4.9
	0.975	10.0–10.9	7.0–7.8	6.0–6.6	5.4–6.9	5.0–5.5
	0.95	11.0–11.9	7.9–8.7	6.7–7.3	6.0–6.6	5.6–6.1
	0.90	12.0–13.9	8.8–9.6	7.4–8.0	6.7–7.2	6.2–6.6
	0.85	14.0–15.0	9.7–10.5	8.1–8.9	7.3–7.9	6.7–7.2
No. 4 Sieve	1.00	0.0–9.9	0.0–6.7	0.0–5.7	0.0–5.2	0.0–4.8
	0.975	10.0–11.0	6.8–7.6	5.8–6.3	5.3–5.8	4.9–5.4
	0.95	11.1–11.9	7.7–8.5	6.4–6.9	5.9–6.4	5.5–5.9
	0.90	12.0–12.9	8.6–9.4	7.0–7.5	6.5–7.0	6.0–6.5
	0.85	13.0–14.0	9.5–10.2	7.6–8.0	7.1–7.6	6.6–7.0
No. 8 Sieve	1.00	0.0–7.9	0.0–5.6	0.0–4.8	0.0–4.3	0.0–4.0
	0.975	8.0–8.9	5.7–6.3	4.9–5.4	4.4–4.8	4.1–4.5
	0.95	9.0–9.9	6.4–7.0	5.5–6.0	4.9–5.3	4.6–4.9
	0.90	10.0–10.9	7.1–7.7	6.1–6.6	5.4–5.8	5.0–5.4
	0.85	11.0–12.0	7.8–8.5	6.7–7.2	5.9–6.4	5.5–5.8
No. 16 Sieve	1.00	0.0–7.9	0.0–5.2	0.0–4.6	0.0–4.2	0.0–3.9
	0.975	8.0–8.9	5.3–5.8	4.7–5.1	4.3–4.6	4.0–4.3
	0.95	9.0–9.9	5.9–6.4	5.2–5.6	4.7–5.1	4.4–4.7
	0.90	10.0–10.9	6.5–7.0	5.7–6.1	5.2–5.5	4.8–5.1
	0.85	11.0–12.0	7.1–7.6	6.2–6.6	5.6–5.9	5.2–5.4
No. 50 Sieve	1.00	0.0–6.9	0.0–4.3	0.0–3.8	0.0–3.4	0.0–3.2
	0.975	7.0–7.9	4.4–4.8	3.9–4.1	3.5–3.8	3.3–3.5
	0.95	8.0–8.9	4.9–5.3	4.2–4.5	3.9–4.1	3.6–3.8
	0.90	9.0–9.9	5.4–5.8	4.6–4.9	4.2–4.4	3.9–4.1
	0.85	10.0–11.0	5.9–6.4	5.0–5.5	4.5–4.9	4.2–4.5
No. 200 Sieve	1.00	0.0–3.0	0.0–2.4	0.0–2.0	0.0–1.8	0.0–1.7
	0.975	3.1–3.5	2.5–2.7	2.1–2.2	1.9–2.0	1.8–1.9
	0.95	3.6–4.0	2.8–3.0	2.3–2.4	2.1–2.2	2.0–2.1
	0.90	4.1–4.5	3.1–3.3	2.5–2.7	2.3–2.4	2.2–2.3
	0.85	4.6–5.0	3.4–3.6	2.8–3.0	2.5–2.6	2.4–2.5

NOTES

- (a) Test binder content using a burn-off oven, ASTM D 6307.
- (b) Determine aggregate gradation by extraction, ASTM D 5444.

Table 2 – Pay Factors – Superpave Mix Design					
Criteria	Pay Factor	Range of Mean of Deviations of Tests Results in Percentage Points from Binder and Gradation Targets			
		500 Tons	1,000 Tons	1,500 Tons	≥ 2,000 Tons
Binder Content	1.00	0.0 – 0.7	0.0 – 0.54	0.0 – 0.46	0.0 – 0.41
	0.975	0.71 – 0.8	0.55 – 0.61	0.47 – 0.52	0.42 – 0.46
	0.95	0.81 – 0.9	0.62 – 0.68	0.53 – 0.58	0.47 – 0.52
	0.90	0.9 – 1.0	0.69 – 0.75	0.59 – 0.64	0.53 – 0.56
	0.85	1.01 – 1.1	0.76 – 0.82	0.65 – 0.69	0.57 – 0.61
≥ 12.5 mm Sieve	1.00	0.0 – 10.0	0.0 – 7.3	0.0 – 6.3	0.0 – 0.56
	0.975	11.0 – 12.0	7.4 – 8.3	6.4 – 7.1	5.7 – 6.3
	0.95	13.0 – 13.9	8.4 – 9.3	7.2 – 7.9	6.4 – 7.0
	0.90	14.0 – 14.9	9.4 – 10.3	8.0 – 8.7	7.1 – 7.7
	0.85	15.0 – 16.0	10.4 – 11.3	8.8 – 9.5	7.8 – 8.4
9.5 mm Sieve	1.00	0.0 – 9.9	0.0 – 6.9	0.0 – 5.9	0.0 – 5.3
	0.975	10.0 – 10.9	7.0 – 7.8	6.0 – 6.6	5.4 – 5.9
	0.95	11.0 – 11.9	7.9 – 8.7	6.7 – 7.3	6.0 – 6.6
	0.90	12.0 – 13.9	8.8 – 9.6	7.4 – 8.0	6.7 – 7.2
	0.85	14.0 – 15.0	9.7 – 10.5	8.1 – 8.9	7.3 – 7.9
4.75 mm Sieve	1.00	0.0 – 9.9	0.0 – 6.7	0.0 – 5.7	0.0 – 5.2
	0.975	10.0 – 10.9	6.8 – 7.6	5.8 – 6.3	5.3 – 5.8
	0.95	11.0 – 11.9	7.7 – 8.5	6.4 – 6.9	5.9 – 6.4
	0.90	12.0 – 12.9	8.6 – 9.4	7.0 – 7.5	6.5 – 7.0
	0.85	13.0 – 14.0	9.5 – 10.2	7.6 – 8.0	7.1 – 7.6
2.36 mm Sieve	1.00	0.0 – 7.9	0.0 – 5.6	0.0 – 4.8	0.0 – 4.3
	0.975	8.0 – 8.9	5.7 – 6.3	4.9 – 5.4	4.4 – 4.8
	0.95	9.0 – 9.9	6.4 – 7.0	5.5 – 6.0	4.9 – 5.3
	0.90	10.0 – 10.9	7.1 – 7.7	6.1 – 6.6	5.4 – 5.8
	0.85	11.0 – 12.0	7.8 – 8.5	6.7 – 7.2	5.9 – 6.4
0.075 mm Sieve	1.00	0.0 – 3.0	0.0-2.4	0.0 – 2.0	0.0 – 1.8
	0.975	3.1 – 3.5	2.5 – 2.7	2.1 – 2.2	1.9 – 2.0
	0.95	3.6 – 4.0	2.8 – 3.0	2.3 – 2.4	2.1 – 2.2
	0.90	4.1 – 4.5	3.1 – 3.3	2.5 – 2.7	2.3 – 2.4
	0.85	4.6 – 5.0	3.4 – 3.6	2.8 – 3.0	2.5 – 2.6

NOTES

- (a) Test binder content using a burn-off oven, ASTM D 6307.
- (b) Determine aggregate gradation by extraction, ASTM D 5444.

D. **Installation:** Acceptance requirements are stipulated in Section 32 12 16.13.

PART 2 PRODUCTS

2.1 BINDER

- A. Bitumen Binder. Source is CONTRACTOR's choice.
- B. Performance Graded Asphalt Binder (PGAB), ASTM D 6373:
1. Blending with polymers is allowed.
 2. Do not use acid blends without documentation supporting need.
 3. As a rule of thumb, if the two numbers in an binder designation are added together and are greater than 90, then the binder will most likely contain a polymer or natural bitumen.
 4. Performance graded asphalt binder (PGAB) should be substituted for asphalt cement (AC) as follows.

Asphalt Cement	Substitute
AC-10	PG58-22 or PG58-28
AC-20	PG64-22

- C. Blended Binder: CONTRACTOR's choice. A blended ratio of Asphalt Binder to Bitumen Binder in the range of about 1:4 to about 4:1 may require patent licensure (Reference: US RE39,289 E). CONTRACTOR to verify.

2.2 AGGREGATE

- A. Crushed stone, crushed gravel, slag, sand, or combination.

Table 3 – Aggregate Physical Properties				
Property	ASTM	ESAL	Min	Max
Coarse Aggregate				
Angularity (fractured faces), percent	D5821	less than 0.3	55	--
		0.3 to 3.0	75	--
		greater than 3.0	85/80	--
Wear (hardness or toughness), percent	C131	less than 0.3	--	40
		0.3 to 3.0	--	35
		greater than 3.0	--	35
Flats or elongates (3:1 length to width), percent	D4791	--	--	20
Fine Aggregate				
Angularity (uncompacted void content), percent (AASHTO T304)	--	less than 0.3	--	--
		0.3 to 3.0	40	--
		greater than 3.0	45	--
Sand equivalent, percent	D 2419	less than 0.3	40	--
		0.3 to 3.0	40	--
		greater than 3.0	45	--
Friable Particles, percent	C 142	--	--	2
Plasticity	Liquid limit	D 4318	--	25

	Plastic limit	D 4318	--	--	6
NOTES (a) ESAL in millions. (b) Angularity by weight retained above the No. 8 (2.38mm) sieve, with at least one fractured face. 85/80 denotes 85 percent coarse aggregate has one fractured face and 80 percent has two or more fractured faces (c) Wear of aggregate retained above No. 4 (4.76 mm) sieve unless specific aggregates have higher values are known to be satisfactory. (d) Flats or elongates retained above the 3/8 (9.5mm) sieve. (e) Friable particles passing the No. 4 (4.76) sieve. (f) Plasticity, passing No. No. 40 (0.42mm) sieve. Aggregate is non-plastic even when filler material is added to the aggregate.					

2.3 ADDITIVES

- A. Mineral Filler: ASTM D 242.
- B. Recycle Agent: ASTM D 4552.
- C. Anti-strip Agent: Heat stable cement slurry, lime slurry, or chemical liquid.
- D. RAP or ROSP: Free of detrimental quantities of deleterious materials, with a minimum sand equivalent value of 50.
 - 1. Allowed up to 15 percent by weight with no change in specified binder grade.
 - 2. Allowed from 15 to 30 percent by weight if the binder grade is adjusted according to AASHTO M 323 to meet the specified binder grade.

2.4 MIX DESIGN

A. Materials:

- 1. Bituminous Binder.
 - a. Bitumen Binder: CONTRACTOR's choice.
 - b. Asphalt Binder: Unless indicated otherwise select according to the following climate conditions. If necessary, adjust binder grade according to AASHTO M 323 to account for any binder stiffness caused by RAP or ROSP aggregate addition.
 - 1) Cold climate: PG58-28.
 - 2) Moderate climate: PG64-22.
 - 3) Hot climate: PG64-22.
 - c. Blended Binder: This section article 2.1.
- 2. Aggregate: This section article 2.2.
- 3. Additives: This section article 2.3. Add cement, hydrated lime, or chemical liquid if mix is moisture sensitive.

B. Aggregate Structure:

- 1. **Gradation – Marshall Mix Design:** Target Grading Curve must lie within one of the Master Grading Bands in the following table. Target Grading Band for each sieve is defined under pay factor 1.00 limits in Table 1.

Table 4 – Master Grading Bands – Marshall Mix Design							
Sieve	Dense				Open	Friction	
	DM-1	DM-3/4N	DM-3/4	DM-1/2	OM-1/2	FM-1	FM-2
1 inch	100						
3/4 inch		100	100			100	
1/2 inch	75 – 91	74 – 99		100	100	90 – 100	100
3/8 inch		69 – 91	75 – 91		93 – 100	60 – 100	90 – 100
No. 4	47 – 61	49 – 65	46 – 62	60 – 80	36 – 44	15 – 40	30 – 50
No. 8		33 – 47			14 – 21	4 – 12	5 – 15
No. 16	23 – 33	21 – 35	22 – 34	28 – 42			
No. 50	12 – 22	6 – 18	11 – 23	11 – 23			2 – 5
No.200	3 – 7	2 – 6	3 – 7	3 – 7	2 – 4	2 – 5	

NOTES

(a) It is assumed fine and coarse aggregate have same bulk specific gravity.
(b) Friction Mixture, ASTM D 3515.
(c) DM -3/4N is 100% crushed.
(d) Gradation is expressed in percent passing by weight, ASTM C 136.
Percentage of fines passing No. 200 sieve determined by washing, ASTM C 117.

2. **Gradation – Superpave Mix Design:** Target Grading Curve must lie within one of the Master Grading Bands in the following table. It must lie below the restricted zone if ESAL is 30 million or more, otherwise it may lie above, below, or pass through the zone. Target Grading Band for each sieve is defined under pay factor 1.00 limits in Table 2.

Table 5 – Master Grading Bands – Superpave Mix Design					
Sieve (mm)		Aggregate Grade			
		25.0	19.0	12.5	9.5
Control Sieves	37.5	100.0	–	–	–
	25	90 – 100	100.0	–	–
	19	< 90	90 – 100	100	–
	12.5	–	< 90	90 – 100	100
	9.5	–	–	< 90	90 – 100
	4.75	–	–	–	< 90
	2.36	19 – 45	23 – 49	28 – 58	32 – 6
	0.075	1 – 7	2 – 8	2 – 10	2 – 10
Restricted Zone	4.75	39.5	–	–	–
	2.36	29.8 – 30.8	34.6	39.1	47.2
	1.18	18.1 – 24.1	22.3 – 28.3	25.6 – 31.6	31.6 – 37.6
	0.6	13.6 – 17.6	16.7 – 20.7	19.1 – 23.1	23.5 – 27.5
	0.3	11.4	13.7	15.5	18.7

NOTES

(a) It is assumed fine and coarse aggregate have same bulk specific gravity.
(b) Gradation is expressed in percent passing by weight, ASTM C 136.
Percentage of fines passing No. 200 (0.075 mm) control sieve determined by washing, ASTM C 117.

3. **Blended Physical Properties:**

Table 6 – Aggregate Physical Properties			
Property	ASTM	Min	Max
Dry-rodded Unit Weight, lb/ft ³	C29	75	--
Weight Loss (Soundness), percent	C88	--	16
Clay content or cleanliness (sand equivalent), percent	D 2419	45	--
ESAL less than 0.3 million		60	--
ESAL more than 0.3 million			
Friable particles (deleterious materials), percent	C142	--	2
NOTES			
(a) Weight loss using sodium sulfate.			
(b) Sand equivalent value is after going through the dryer or before the drum mixer. The sand equivalent requirement is waived for RAP or ROSP aggregate but applies to the remainder of the aggregate blend.			
(c) Friable particles of clay lumps, shale, wood, mica, and coal passing the No.4 (2.36mm) sieve.			

C. **Mix Properties – Marshall Mix Design:** Follow AI MS-2 and the following.

1. Air void target is four (4) percent.
2. Density target is 96 percent of maximum theoretical specific gravity (ASTM D 2041).
3. Stability, Flow, Voids: ASTM D 5581. If traffic classification is not specified elsewhere, use Medium Traffic Classification.

Table 7 – Stability, Flow, Voids, VMA Limits			
Criteria	Traffic Classifications		
	Light	Medium	Heavy
Number of compaction blows each end of specimen	35	50	75
Stability, lbs., minimum	750	1200	1800
Flow, in 0.01 inch units	10 – 18	10 – 18	10 – 18
Voids in Mineral Aggregate (VMA), percent minimum			
1" maximum aggregate particle size	13	13	13
3/4" maximum aggregate particle size	14	14	14
1/2" maximum aggregate particle size	15	15	15
3/8" maximum aggregate particle size	16.5	16.5	16.5
Voids in Bituminous Mix, percent	3 – 5	3 – 5	3 – 5
NOTES			
(a) Traffic Classifications:			
Light: (ESAL <10 ⁴ per year)			
Class I: Parking lots, Driveways, light traffic residential streets, light traffic farm roads.			
Medium: (ESAL between 10 ⁴ and 10 ⁶ per year)			
Class II: Residential streets, rural farm and residential roads.			
Class III: Urban minor collector streets, rural minor collector roads.			
Heavy: (ESAL >10 ⁶ per year)			
Class IV: Urban minor arterial and light industrial and light industrial streets, rural major collector and minor arterial highways.			
Class V: Urban major arterial and heavy industrial streets.			

- | | |
|-----|--------------------------------------|
| (b) | Stability, Flow, Voids: ASTM D 6927. |
| (c) | VMA: ASTM D 3203 |

4. Dust to binder Ratio: 0.8 to 1.6.
5. Tensile Strength Ratio (moisture sensitivity): 0.80 or greater using freeze-thaw conditioning, ASTM D 4867. Compact test specimen to seven (7) percent plus or minus one (1) percent air voids.

D. Mix Properties – Superpave Mix Design: Follow AI SP-2 and the following.

1. Air void target is 3.5 percent.
2. Density target is 96.5 percent of maximum theoretical specific gravity (ASTM D 2041).at N_{design} .
3. Compaction effort is for a 20 year design ESAL.

Table 8 – Compaction Parameters			
20 Year design ESALs (Million)	$N_{initial}$ / % of G_{mm}	N_{design} / % of G_{mm}	N_{max} / % of G_{mm}
Less than 0.3	6 / ≤ 91.5	50 / 96.5	75 / ≤ 98
0.3 to <3	7 / ≤ 90.5	75 / 96.5	115 / ≤ 98
3 to <30	8 / ≤ 89	100 / 96.5	160 / ≤ 98
30 or more	9 / ≤ 89	125 / 96.5	205 / 98

NOTES

- (a) N = Number of gyrations.
- (b) G_{mm} = Maximum specific gravity of mix, ASTM D 2041 (Rice method).
- (c) Specific gravity of specimen: AASHTO T 312.
- (d) 20 year design ESALs defined as follows.
 - Less than 0.3 = Very light traffic (local / county roads; city streets where truck traffic is prohibited).
 - 0.3 to 3 = Medium traffic (collector roads; most county roadways)
 - 3 to 30 = Medium to high traffic (city streets, state routes; US highways; some rural interstates).
 - 30 or more = High traffic (most of the interstate system; climbing lanes; truck weighing stations).

4. Voids in the mineral aggregate (VMA) at N_{design} based upon the bulk specific gravity of the aggregate at surface saturated dry (SSD) condition.

<u>Nominal Maximum Size *</u>	<u>Voids (VMA)</u>
37.5 mm	11.5 to 13 percent
25.0 mm	12.5 to 14 percent
19.0 mm	13.5 to 15 percent
12.5 mm	14.5 to 16 percent
9.5 mm	16.5 percent minimum

* Maximum size is one sieve larger than the nominal maximum size.

5. Voids filled with binder (VFA) at N_{design} :

<u>20 Year Design ESALs (million)</u>	<u>Voids Filled with Binder (VFA)</u>
Less than 0.3	70 – 80 percent
0.3 to <3	65 – 78 percent
3 to < 30	65 – 75 percent
30 or more	65 – 75 percent

- a. For 9.5mm nominal maximum size mixtures, the specified VFA range is 73 percent to 76 percent for design traffic levels 3 million ESALs or greater.
 - b. For 25.0mm nominal maximum size mixtures, the specified lower limit of the VFA is 67 percent for design traffic levels less than 0.3 million ESALs.
 - c. For 37.5mm nominal maximum size mixtures, the specified lower limit of the VFA is 64 percent for all design traffic levels.
6. Dust to Binder Ratio:
- a. 0.6 to 1.2 if aggregate gradation passes through or over the restricted zone.
 - b. 0.8 to 1.6 if aggregate gradation passes under the restricted zone.
7. Moisture Sensitivity and Rutting: With testing performed at temperatures representing the specified binder grade in the Hamburg rut test (AASHTO T 234), the average rut depth of three (3) mix design test Samples is less than the following.
- Residential Streets: 15 mm at 10,000 passes.
 - Non-residential Streets: 15 mm at 20,000 passes.

2.5 SOURCE QUALITY CONTROL

- A. Collect Samples randomly, ASTM D 3665. Do not change sampling points:
 1. Sampling aggregate, ASTM D 75. Collect samples before the drum mixer or after going through the drier.
 2. Sampling binder, ASTM D 140.
 3. Sampling bituminous paving mixture, ASTM D 979.
- B. Validate binder grade received from Supplier, Section 32 12 03.
- C. Test mix every production day for the following:
 1. Combined aggregate gradation in the mix, ASTM D 5444.
 2. Binder content in the mix, ASTM D 6307.
 3. Temperature of mix placed in the transport vehicle at the production plant.
 - a. Asphalt Binder mixes.
 - 1) Hot Mix: 350 deg F maximum.
 - 2) Warm Mix: 325 deg F maximum.
 - b. Bitumen Binder mixes or Blended Binder mixes.
 - 1) Hot Mix: NOT ALLOWED.
 - 2) Warm Mix: 230 degrees maximum.
- D. Warm Mix Testing: When rutting or moisture susceptibility tests are required on plant

produced warm mix, condition the warm mix material before testing for two (2) hours at 275 plus or minus five (5) deg F per AASHTO R30 (short term aging). The material may be cooled to room temperature before conditioning.

PART 3 EXECUTION

3.1 CONSTRUCTION EQUIPMENT

A. Mixing Plant: ASTM D 995. Provide.

1. Positive means to determine the moisture content of aggregate.
2. Positive means to sample all material components.
3. Sensors to measure the temperature of the mix at discharge.
4. Ability to maintain discharge temperature of mix.
5. Capability of maintaining plus or minus five (5) percent tolerance on component percentages in final mix.
6. Oil Sand Introduction System: **Do not burn off the light oils in the Oil Sand Bitumen Binder.**

3.2 INSTALLATION

- A. Paving: Section 32 12 16.13.
B. Patches: Section 33 05 25.

END OF SECTION

SECTION 32 12 16.18
RECYCLE BITUMINOUS PAVEMENT

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Make a base, leveling, or surface course using an in-place, existing bituminous concrete pavement.
- B. Mix design requirements.

1.2 REFERENCES

A. ASTM Standards:

- D 2950 Density of Bituminous Concrete In Place by Nuclear Method.
- D 3549 Thickness or Height of Compacted Bituminous Paving Mixture Specimens.

1.3 DEFINITIONS

- A. **RAP** (acronym for reclaimed asphalt pavement): Refer to Section 32 12 05.
- B. **RAC** (acronym for recycled asphalt concrete): An bituminous mix product consisting of RAP or ROSP, new aggregates and Binder or a Binder with a recycle rejuvenating agent, the mixture of which creates a new bituminous concrete mix.
- C. **ROSP** (acronym for reclaimed Oil Sand pavement): Refer to Section 32 12 05.

1.4 SUBMITTALS

- A. Before commencing work of this section, submit:
 - 1. Traffic control plan, Section 01 55 26.
 - 2. A list of equipment to be used.
 - 3. Type of Binder to be used, Section 32 12 03.
- B. RAC Mix Design: Determine conditions and properties of existing materials. Identify recycling agent and submit the following data as applicable:
 - 1. If RAP or ROSP is 15 percent or less of the RAC, submit a mix design formula if supplier does not have a mix design formula at the plant. The formula shall be based on current test data.
 - 2. If RAP or ROSP added to the RAC is over 15 percent, submit a mix design formula.
- C. RAC Delivery Tickets: Submit according to Section 32 12 16.19.

1.5 QUALITY ASSURANCE

- A. Section 32 12 16.13.

1.6 WEATHER

- A. Section 32 12 16.13.

1.7 NOTICE

- A. Section 32 12 16.13.

1.8 ACCEPTANCE

- A. Section 32 12 16.13.

PART 2 PRODUCTS

2.1 MATERIAL

- A. Recycle asphalt (RA), Section 32 12 03.
- B. Tack coat, Section 32 12 13.13.
- C. Paving geotextile, Section 31 05 19.
- D. Paving geogrid, Section 31 05 21.
- E. RAP or ROSP. Free of detrimental quantities of deleterious materials. Graded (on a non-dried basis) as follows.

<u>Sieve</u>	<u>Percent Passing by Weight</u>
1-1/2"	100
1" 90	

PART 3 EXECUTION

3.1 CONSTRUCTION EQUIPMENT

- A. Lay-down Machine: Provide track equipment when operating on fabrics or geogrid, otherwise type of equipment is CONTRACTOR's choice.
- B. Compactors: Steel wheeled static or vibratory.

3.2 PREPARATION

- A. General:
 - 1. Locate and preserve utilities, Section 31 23 16. **Contact utility companies and other agencies, for dangerous concentration of combustible, flammable, or explosive matter.**
 - 2. Lower Street Fixtures if pavement recycler machine is not capable of releasing pavement-cutting mechanism to protect fixtures.
 - 3. Remove plant materials from cracks, edges and joints. Sweep surface clean. Blow cracks clean.
 - 4. Stabilize concrete subgrade slabs.
 - 5. Apply tack coat, Section 32 12 13.13.
 - 6. Verify surfaces are dry.
- B. Trees, Plants, Ground Cover:
 - 1. Protect trees, plants and other ground cover from damage.

2. Prune trees, Section 32 01 93 to allow equipment passage underneath. Repair tree damage at no additional cost to OWNER.

C. Traffic Control:

1. Control pedestrian and vehicular traffic, Section 01 55 26.
2. Protect pavement from traffic until mixture has cooled enough not to become marked.
3. Apply temporary lane marking tape or paint after layout has been verified with ENGINEER.

D. Milling, Section 32 01 12

3.3 PLACING RAC

- A. Hot-laid RAC, Section 32 12 16.13.
- B. Cold-laid RAC, Section 32 12 16.19.
- C. Mix and blend milled aggregate, recycling asphalt, virgin asphalt and virgin aggregate per mix design.

3.4 TOLERANCES

- A. Compaction, lift thickness, grade, cross slope, Section 32 12 16.19.
- B. Complete compaction of RAC within five (5) minutes of placing RAC and before its temperature drops below 200 deg F

3.5 PROTECTION AND REPAIR

- A. Section 32 12 16.19.

END OF SECTION