

SECTION 32 12 05
BITUMINOUS CONCRETE

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Composition of a bituminous concrete mix.
- B. For placement of a bituminous concrete mix, refer to Section 32 12 16.13.

1.2 REFERENCES

A. AASHTO Standards:

- M323 Superpave Volumetric Mix Design, Single User Digital Publication
- R18 Standard Recommended Practice for Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R30 Mixture Conditioning of Hot-Mix Asphalt (HMA)
- T324 Hamburg Wheel-Track Testing of Compacted Hot-Mix Asphalt (HMA)

B. Asphalt Institute Standards:

- SP-2 SUPERPAVE Mix Design Series No. 2

C. ASTM Standards:

- C29 Unit Weight and Voids in Aggregate.
- C88 Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
- C117 Materials Finer Than 0.075mm (No. 200) Sieve in Mineral Aggregates by Washing.
- C131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
- C136 Standard Method for Sieve Analysis of Fine and Coarse Aggregate.
- C142 Clay Lumps and Friable Particles in Aggregates.
- D75 Sampling Aggregates.
- D140 Sampling Bituminous Materials.
- D242 Mineral Filler for Bituminous Paving Mixtures.
- D979 Sampling Bituminous Paving Mixtures.
- D995 Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving

Mixtures.

- D2041 Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures.
- D2419 Sand Equivalent Value of Soils and Fine Aggregate.
- D3203 Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures.
- D3665 Random Sampling of Construction Materials.
- D3666 Minimum Requirements for Agencies Testing and Inspecting Bituminous Paving Materials.
- D4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- D4552 Classifying Hot-Mix Recycling Agents.
- D4791 Flat or Elongated Particles in Coarse Aggregate.
- T283 Effect of Moisture on Asphalt Concrete Paving Mixtures (Lottman Test).
- D5444 Mechanical Size Analysis of Extracted Aggregate.
- D5821 Determining the Percentage of Fractured Particles in Coarse Aggregate.
- D6307 Determining Asphalt Content of Hot-Mix Asphalt by Ignition Method.
- D6373 Performance Graded Asphalt Binder.

1.3

DEFINITIONS

A. **Mix Designator:** An alphanumeric code that identifies binder grade, aggregate grade, and compaction level for a bituminous concrete mix. For example, in *PG64-34, SP-1/2, 75Nd*:

1. Binder grade (PG64-34): The alpha portion represents Performance Graded Asphalt Binder. The numerical portion represents the grade of the binder.
2. Aggregate gradation (SP-1/2): The alpha portion represents Superpave mix. The numerical portion represents the nominal maximum sieve size. aggregate gradation.
3. Compaction level (75Nd): This is the compaction level using Superpave mix design process.

B. **Bituminous Binder:** A graded bituminous cement composed of any of several viscous or solid mixtures of hydrocarbons and their nitrogen and sulfur derivatives, whose combined properties meet a defined standard.

1. Virgin Asphalt Binder: A refined or manufactured bituminous cement known as performance graded asphalt binder (PG or PGAB).
2. Recycled Asphalt Binder: A bituminous cement contained in

recycled asphalt pavement known as performance graded asphalt binder (PG or PGAB).

C. Binder Grades:

1. Virgin Binder Grade: The grade of asphalt binder received from binder supplier and added to the mix.
2. RAP Binder Grade: The grade of recycled asphalt binder contained in recycled asphalt pavement.
3. Resultant Binder Grade: The resultant grade of binder in the mix based on blending of virgin binder and RAP binder grades.
4. Design Binder Grade: The required grade of binder for the pavement based on environmental conditions, also the virgin asphalt binder specified when using 15% or less RAP.

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](#). One hundred percent of the aggregate might be able to pass through the nominal maximum size sieve but not more than 10 percent will be retained on the sieve below. The **maximum size** sieve will be one (1) sieve size larger than the nominal maximum size.

F. RAP: Acronym for reclaimed asphalt pavement. A granular product recovered from a bituminous pavement containing aggregate and an Asphalt Binder.

G. Quality Control: Sampling, testing and inspection efforts performed by the Contractor to control the mix production and placement operations. Locations, times, practices and personnel (other than Lab AMRL Accreditation and minimum requirements in Article 3.3) are the contractor's decision.

1. Requirements for Quality Control that may/will be used in acceptance decisions will be defined by the Owner in Section 32 12 05S - Project Specific Surfacing Requirements.

H. Owner Verification Testing: Sampling, testing and inspection efforts, and personnel/laboratory qualifications that are utilized by the Owner to verify compliance of the mix production and placement with specifications. Locations, times, practices and personnel are at the Owner's decision.

I. Road Class: Road Class as identified in Section 32 12 05S – Project Specific Surfacing Requirements, or as defined in section 32 01 31 Pavement Smoothness if not in 32 12 05S.

1.4 **SUBMITTALS**

A. General:

1. Pre-approved Mix Design: Submit name and address of [Supplier](#).

2. Allow ENGINEER 10 days to evaluate mixing equipment and mix design submittals.
3. 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. Quality Control:

1. Certified Laboratory: Submit names, certification levels, and years of experience of Quality Control field technicians that are assigned to the Work. Verify laboratory complies with ASTM D3666 or AASHTO R-18, and follows [Section 01 45 00](#) requirements.
2. Mix Production Equipment: Submit verification by an individual acceptable to ENGINEER, that plant equipment complies with requirements of ASTM D995.
3. Testing Report: If identified by contract requirements, submit a report of source quality control testing performed by [CONTRACTOR](#) and Suppliers.
4. Testing Report: If identified by Section 32 12 05S – Project Specific Surfacing Requirements, submit Quality Control data to the Engineer within 3 working days after completion of each day of paving or prior to the start of the next paving day, whichever is sooner.
5. Plant Production Report: If identified by Section 32 12 05S – Project Specific Surfacing Requirements, submit daily plant production records to the Engineer within 1 working day after completion of each day of paving and prior to the start of the next paving day.
 - a. Plant report must include weights of all individual aggregates, bitumens, water and other additives incorporated in mix, including RAP, lime, mineral filler, fiber or other additives.

C. Mix Design: Submit the following.

1. Valid mix design.
 - a. Mix designs dated from the previous paving season (calendar year) are invalid unless accompanied by a letter from the Asphalt Supplier certifying that the mix design is still valid for the current paving season.
 - b. Mix designs dated prior to the previous paving season are invalid.
 - c. Mix designs are invalid if aggregate source or binder grade are

changed.

- d. Invalidated mix designs must be revalidated for volumetric properties (minimum 4 pucks, $\pm 0.2\%$ from targets), or a replaced with a new mix design.
2. Virgin Binder source and grade, and Resultant Binder grade.
3. Optimum compaction temperature at the project site.
4. Theoretical maximum specific gravity.
5. Compaction density at design target air voids.
6. [Target Grading Curve](#) for aggregate.
7. Binder target percentage.
8. Dust to binder ratio.
9. Voids in the mineral aggregate (VMA).
10. Voids filled with Asphalt (Bituminous Binder), also known as VFA.
11. Hamburg Wheel Tracker results, if required
12. Percentages of 1) mineral filler, 2) anti-strip (if required), 3) reclaimed bituminous (asphalt) pavement (RAP), 4) recycle agent in the mix, and 5) virgin aggregate.
13. 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 two (2) calendar years from the date of submission.1.5

1.5 MATERIALS QUALITY

- A. Do not change aggregate source or binder grade until [ENGINEER](#) accepts new grades and new or revalidated mix design.
- B. HMA Mixing Plant: Capable of meeting ASTM D995 requirements or use UDOT Qualified Plant.

1.6 ACCEPTANCE

A. General:

1. Acceptance is by [Lot](#). One (1) Lot is one (1) days' production. At Engineer's discretion and in concurrence with the contractor, multiple small lots may be combined into one lot. Obtain concurrence prior to placement of lots.
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.

B. Mix Sampling and Testing:

1. Sub-lot size is 500 tons or part thereof.
 2. Sampling Protocol: ASTM D3665 and ASTM D979. Collect at least one (1) random Sample per sub-lot from behind paver and before compaction. For placements with a design thickness of 2 inches or less, samples may be taken at the plant. Any sample collected because of non-uniform appearance shall not be used in determining a pay factor for the Lot.
 - a. Sampling binder, ASTM D140. At owner's request, take 1 qt sample and provide to owner's representative.
 3. Testing Protocol (Performed by Owner's Verification Testing Organization):
 - a. Project Less than 1000 tons – At Owner's discretion, mix samples will be compacted in the laboratory and tested for:
 - 1) Binder content, ASTM D6307.
 - 2) Aggregate gradation, ASTM D5444.
 - 3) Maximum Specific Gravity (Rice), ASTM D2041
 - b. Project greater than 1000 tons - Mix samples will be compacted in the laboratory and tested for:
 - 1) Air voids, ASTM D3203.
 - 2) Voids in the mineral aggregate, AI MS 2.
 - 3) Binder content, ASTM D6307.
 - 4) Aggregate gradation, ASTM D5444.
 - 5) Maximum Specific Gravity (Rice), ASTM D2041
 4. Reporting: The Owner or the Owner's Verification Testing organization will provide the contractor with acceptance results within 3 working days after completion of each day of paving, or prior to the start of the next paving day, whichever is sooner.
- C. Lot Acceptance:** A Lot is acceptable if binder content and aggregate gradation test average deviations are within pay factor 1.00 limits in Table 1 and no sub-lot deviation exceeds 0.85 pay factor limit.
- D. Un-Accepted Lots (Contracts Issued by Someone Other Than The Ultimate Owner of The Pavement):** Provide recommended corrective measures based on Engineering Analysis, described below, based on durability and serviceability relative to the specified product requirements, including expected performance compared to design life.

The ultimate owner of the pavement or a representative of such will review and either approve corrective measures or provide basis for rejection.

E. **Un-Accepted Lots (Contracts Issued by The Ultimate Owner of The Pavement):** At the Engineer’s discretion, a lot with an average deviation that does not meet 1.00 pay factor and does not have a sub-lot test deviation greater than pay factor 0.85 limits may be accepted with a pay factor in accordance with Table 1.

1. Lots with a pay factor lower than 0.85 or with a sub-lot with a test deviation greater than the pay factor 0.85 limits, and with Engineer and Contractor concurrence, are subject to an Engineering Analysis.

Table 1 – Pay Factors					
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 – 0.46	0.0 – 0.41	0.0 – 0.38	0.0 – 0.35
	0.95	0.47 – 0.58	0.42 – 0.52	0.39 – 0.58	0.36 – 0.52
	0.90	0.59 – 0.64	0.53 – 0.56	0.59 – 0.64	0.53 – 0.56
	0.85	0.65 – 0.69	0.57 – 0.61	0.65 – 0.69	0.57 – 0.61
Nominal Sieve	1.00	0.0 – 6.3	0.0 – 5.6	0.0 – 5.3	0.0 – 5.0
	0.95	6.4 – 7.9	5.7 – 7.0	5.4 – 7.9	5.1 – 7.0
	0.90	8.0 – 8.7	7.1 – 7.7	8.0 – 8.7	7.1 – 7.7
	0.85	8.8 – 9.5	7.8 – 8.4	8.8 – 9.5	7.8 – 8.4
No. 8 Sieve	1.00	0.0 – 4.8	0.0 – 4.3	0.0 – 4.0	0.0 – 3.8
	0.95	4.9 – 6.0	4.4 – 5.3	4.1 – 5.0	3.9 – 4.3
	0.90	6.1 – 6.6	5.4 – 5.8	5.1 – 5.6	4.4 – 4.8
	0.85	6.7 – 7.2	5.9 – 6.4	5.7 – 6.2	4.9 – 5.4
No. 50 Sieve	1.00	0.0 – 3.8	0.0 – 3.3	0.0 – 3.0	0.0 – 2.8
	0.95	3.9 – 5.0	3.4 – 4.3	3.1 – 4.0	2.9 – 3.3
	0.90	5.1 – 5.6	4.4 – 4.8	4.1 – 4.6	3.4 – 3.8
	0.85	5.7 – 6.2	4.9 – 5.4	4.7 – 5.2	3.9 – 4.4
No. 200 Sieve	1.00	0.0 – 2.0	0.0 – 1.8	0.0 – 1.8	0.0 – 1.8
	0.95	2.1 – 2.4	1.9 – 2.2	1.9 – 2.2	1.9 – 2.2
	0.90	2.5 – 2.7	2.3 – 2.4	2.3 – 2.4	2.3 – 2.4
	0.85	2.8 – 3.0	2.5 – 2.6	2.5 – 2.6	2.5 – 2.6
NOTES					
(a) Test binder content using a burn-off oven, ASTM D6307.					
(b) Determine aggregate gradation by extraction, ASTM D5444.					

F. **Engineering Analysis:**

1. Submit an Engineering Analysis, performed and stamped by a Utah Registered Professional Engineer or Mix Supplier QC Manager with commensurate experience in materials and pavements performance, for approval within one week of receipt of test results or at least one working day (M-F) before performing any work that may prevent the evaluation, correction, or removal of the lot in question.
2. The engineering analysis shall include the following:

- a. Reasons for disputing the acceptance or verification test results.
- b. The Contractor's project quality control test results, including any split sample test results.
 - 1) Test results must be from a UDOT qualified laboratory using UDOT qualified technicians, or results must be verified and certified (stamped) by a Utah Registered Professional Engineer.
 - 2) Include all supporting test data and calculations for reported values.
- c. Successful laboratory correlation information when required by material specification.
- d. Statistical analysis or identification of potential outliers.
- e. Procedures or issues leading to disputed acceptance test results.
- f. Impact of results on pavement performance and recommended cost adjustment to impacted materials based on impact to pavement performance.

G. **Installation:** See [Section 32 12 16.13](#) acceptance requirements.

PART 2 PRODUCTS

2.1 BINDER

A. **Performance Graded Asphalt Binder (PGAB):** See ASTM D6373.

1. Use the following minimum virgin mix binder grades unless otherwise specified.

Table 2 – Minimum Virgin Binder Grade		
Road Class	Elevation	
	Above 4000 Feet	Below 4000 Feet
Class I & II	PG 58-28 (\leq 15% RAP) PG 64-34 ($>$ 15% RAP) (a)	PG 64-22 (\leq 15% RAP) PG 58-28 ($>$ 15% RAP)
Class III	PG 64-34 (a) (Up to 30% RAP)	PG 70-28 (\leq 15% RAP) PG 64-34 ($>$ 15% RAP)
a. Blending chart limitations for mixes exceeding 15% RAP must meet -28 for low end PG temperatures.		

2. Adjust virgin binder grade to accommodate RAP contents in excess of 15% as identified in Table 2. Do not use grades lower than xx-34. Use M323 Appendix X1 Blending chart to determine acceptable RAP content up to maximum allowed based on virgin binder grade selected or additives incorporated. Submit RAP binder grading and

blending charts with mix design.

3. Use of Virgin Binder Grades exceeding the minimums, i.e. grades with ranges encompass greater temperature ranges than required for virgin binder, is acceptable.

2.2 AGGREGATE

- A. Crushed stone, crushed gravel, slag, sand, or combination.
- B. Use Table 3 to determine suitability of aggregate source.

Table 3 – Aggregate Physical Properties				
		Standard	Road Class	
			I & II	III
Coarse Aggregate				
Angularity, percent, minimum	One Fractured face	D5821	90	95
	Two Fractured faces		90	90
Wear (hardness or toughness), percent, maximum		C131	35	35
Flats or elongates (3:1 length to width), percent, maximum		D4791	--	20
Fine Aggregate				
Angularity (uncompacted void content), percent, minimum		T304	40	45
Sand equivalent, percent, minimum		D2419	45	60
Plastic limit, maximum		D4318	0	0
Blended Physical Properties				
Dry-rodded Unit Weight, lb/ft ³ , minimum		C29	75	75
Weight Loss (Soundness), percent, maximum		C88	16	16
Friable particles, percent, maximum		C142	2	2
NOTES				
(a) Coarse aggregate is material retained on No. 4 sieve.				
(b) Fine aggregate is material passing No. 4 sieve.				
(c) Angularity is determined by weight.				
(d) Wear of aggregate may have higher values if aggregate source is known to have higher values.				
(e) Sand equivalent is waived for RAP aggregate but applies to the remainder of the aggregate blend.				
(f) Plastic limit, passing No. 40 sieve. Aggregate is non-plastic even when filler material is added to the aggregate.				
(g) Weight loss, using sodium sulfate.				
(h) Friable particles are clay lumps, shale, wood, mica, coal passing the No. 4 sieve, and other deleterious materials.				
(i) Road class as identified in project documents and as defined in Section 32 01 31				

2.3 ADDITIVES

- A. Mineral Filler: ASTM D242.

- B. Recycle Agent: ASTM D4552.
- C. Anti-strip Agent: Heat stable cement slurry, lime slurry, or chemical liquid as required to meet Tensile Strength Ratio (Lottman) or Hamburg test requirements.
- D. **RAP**: Free of detrimental quantities of deleterious materials.
 1. Use RAP Content as requirements of Table 2.
 2. Determine RAP binder content by chemical extraction.

2.4 MIX DESIGN

A. Preparation:

1. Road Class as defined by Section 32 12 05S – Project Specific Surfacing Requirements.
2. Determine submittal requirements from [paragraph 1.4C](#).

B. Aggregate Gradation: See Table 4. The [Target Gradation Curve](#) for the specified aggregate grade must lie within the [Master Grading Band](#) limits. The target grading band limits for the Target Grading Curve are the appropriate grading limits for pay factor 1.00 in Table 1. The target grading band limits are allowed to extend outside of the Master Grading Band limits.

Table 4 - Master Grading Bands - Superpave Mix Design		
Sieve	Gradation Limits of Target Gradation	
	SP-1/2	SP-3/8
3/4 inch	100	–
1/2 inch	90.0 – 100	100
3/8 inch	< 90.0	90.0 – 100
No. 4	–	< 90.0
No. 8	28.0 – 58.0	32.0 – 67.0
No. 200	2.0 – 10.0	2.0 – 10.0
NOTES		
(a) Gradation is expressed in percent passing by weight per ASTM C136. Percentage of fines passing No. 200 sieve determined by washing per ASTM C117.		
(b) The numerical portion of the grade designator (1/2, 3/8) represents the <i>nominal maximum</i> sieve size. Comparable <i>maximum</i> mix designs would be one sieve size larger, i.e. ½” nominal (superpave) maximum is comparable to ¾” maximum (Marshall).		

C. Design Parameters: Determined by AI SP-2 and in accordance with Table 5.

Table 5 - Mix Design Parameters	
Compaction Level (a)	Asphalt Institute SP-2
<i>Road Class I/II</i>	50Nd
<i>Road Class III</i>	75Nd
Design Air Void Target, percent (b)	3.5
Voids in Mineral Aggregate (VMA) relative to nominal sieve size grading and calculated using Gsb(dry), percent, minimum	ASTM D3203
Class II and III: SP-1/2	14.2
Class I: SP-3/8	15.2
RAP specific gravity for calculations	Gsb (dry) by chemical extraction
Dust to Binder Ratio, maximum	1.6
Tensile Strength Ratio (moisture sensitivity), minimum (a,c)	AASHTO T283
<i>Road Class I (e)</i>	80% or HWT
Rutting (Hamburg Rut Test) (a,d)	AASHTO T324
<i>Road Class II</i>	15 mm/10,000 passes
<i>Road Class III</i>	10 mm/20,000 passes
NOTES	
<p>(a) Road Class as identified in project documents and as defined in Section 32 01 31.</p> <p>(b) Design Density Target: ASTM D2041. Percent of maximum theoretical specific gravity.</p> <p>(c) Tensile Strength Ratio (moisture sensitivity): Use one cycle of Freeze-thaw conditioning. Compact test specimen to seven (7) percent plus or minus one (1) percent air voids. Applicable to Road Class I only.</p> <p>(d) With testing performed at temperatures representing the specified binder grade in the Hamburg rut test, the average rut depth of two (2) mix design test samples is less than the amount shown for the respective Road Classes.</p> <p>(e) Lottman not required if passing Hamburg Wheel Tracker</p>	

PART 3 EXECUTION

3.1 CONSTRUCTION EQUIPMENT

- A. Mixing Plant: Capable of meeting ASTM D995 or UDOT Qualified Plant. 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. Ability to document control efforts.

3.2 **INSTALLATION**

- A. [Pavement placement, Section 32 12 16.13.](#)
- B. [Pavement restoration, Section 33 05 25](#)

3.3 **QUALITY CONTROL**

Perform the following:

- A. For all projects, test temperature of mix placed in the transport vehicle at the production plant.
 - a. Reject mixes exceeding the limits identified in the mix design.
- B. For projects requiring testing, collect mix [samples](#) randomly from the plant (from truck or hot-drop) or the field (windrow or behind paver), ASTM D3665.
 1. Sampling bituminous paving mixture, ASTM D979, minimum one sample per sub-lot.
- C. If Quality Control is required by Section 32 12 05S – Project Specific Surfacing Requirements or project documents, submit Quality Control data to the Engineer. Submit data within 3 working days after completion of each day of paving or prior to the start of the next paving day, whichever is sooner.
- D. For projects less than 500 tons, if identified as required by Section 32 12 05S – Project Specific Surfacing Requirements, provide one of the following:
 1. Plant Report; or
 2. Test results for binder content and combined gradation of mix
- E. For projects between 500 and 1500 tons, provide the following:
 1. Combined aggregate gradation in the mix, ASTM D5444.
 2. Binder content in the mix, ASTM D6307.
 3. Maximum Specific Gravity (Rice), ASTM D2041.
- F. For projects greater than 1500 tons, provide the following:
 1. Combined aggregate gradation in the mix, ASTM D5444.
 2. Binder content in the mix, ASTM D6307.
 3. Air voids, ASTM D3203.
 4. Voids in the mineral aggregate, AI MS 2.
 5. Maximum Specific Gravity (Rice), ASTM D2041.
- G. Warm Mix Testing: When rutting or moisture susceptibility tests are

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

END OF SECTION