U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

REPRINT OF CHANGES 1 THROUGH 23 FOR AC 150/5370-10, STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS

FILING INSTRUCTIONS

Follow the Instructions on Each of the 23 Page Control Charts that Precede the Specific Change

CHANGE

AC NO: 150/5370-10 CH 1

DATE: May 31, 1977

ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SUBJECT: CHANGE 1 to AC 150/5370-10, STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS

1. PURPOSE. This change transmits revised pages incorporating the changes cited in paragraph 2.

2. EXPLANATION OF CHANGES. Item P-401, Bituminous Surface Course, has been extensively revised to reflect current research and developments in the field of bituminous paving mixtures. Major revisions include:

   a. Design and testing of the bituminous mix by Marshall method procedures contained in The Asphalt Institutes's Manual Series No. 2.

   b. Clarification of tolerances applied to the job mix formula.

   c. Use of state highway department specifications for pavements designed to serve aircraft under 12,500 pounds (5 662 kg) gross weight.

   d. Addition of a section on dryer-drum mixers.

   e. Addition of a paragraph on use of test sections.

   f. Clarification of density requirements.

   g. Optional use of nuclear devices to determine field density.

   h. Optional use of sliding scale pay factors.

3. HOW TO OBTAIN THIS PUBLICATION. Additional copies of this Change 1 to AC 150/5370-10, Standards for Specifying Construction of Airports, may be obtained from the Department of Transportation, Publications Section, TAD-443.1, Washington, D. C. 20590.

Initiated by: AAP-580

PAGE CONTROL CHART

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ITEM P-401 BITUMINOUS SURFACE COURSE
(Central Plant Hot Mix)

Description

401-1.1 This item shall consist of a surface course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans.

Each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

Materials

401-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 8 sieve shall be known as coarse aggregate, the portion passing the No. 8 sieve and retained on the No. 200 sieve as fine aggregate, and the portion passing the No. 200 sieve as mineral filler.

(a) Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent coatings of clay, organic matter, and other deleterious substances. It shall show no more wear than 40 percent when tested in accordance with ASTM C 131, nor shall the sodium sulfate soundness loss exceed 9 percent, or the magnesium soundness loss exceed 12 percent, after five cycles, when tested in accordance with ASTM C 88.

> NOTE TO THE ENGINEER. In certain specific cases, where aggregates complying with these requirements cannot economically be obtained, aggregates with a higher percentage loss or wear may be specified, provided a satisfactory service record under similar conditions of service and exposure shall have been demonstrated. END NOTE.

Crushed aggregate shall contain at least 75 percent by weight of crushed pieces having two or more fractured faces. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of fractures shall be at least 30 degrees to count as two fractured faces.

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The aggregate shall not contain more than 8 percent, by weight, of flat or elongated pieces. A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than five.

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 Mg/m^3) when tested in accordance with ASTM C 29.

(b) Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended filler, shall have a plasticity index of not more than six when tested in accordance with ASTM D 424, and a liquid limit of not more than 25 when tested in accordance with ASTM D 423.

If necessary to obtain the gradation of aggregate blend or workability, natural sand may be used. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification.

NOTE TO THE ENGINEER. The addition of natural sand to a mix containing coarse and fine aggregates of excessive angularity and harshness will normally increase its workability and compactability. Wherever possible the percentage of natural sand should be kept below 15 percent to obtain optimum pavement properties, as the addition of natural sand tends to decrease stability of the pavement. END NOTE.

(c) Sampling and Testing. All aggregate samples required for testing shall be furnished by the Contractor. ASTM D 75 shall be used in sampling coarse aggregate and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler. All tests for initial aggregate submittals necessary to determine compliance with requirements specified herein will be made by the Engineer at no expense to the Contractor. Costs for testing additional sources shall be borne by the Contractor. Sampling will be observed and supervised by the Engineer. No aggregate shall be used in the production of mixtures without prior approval.

NOTE TO THE ENGINEER. The Engineer should carefully supervise the taking of samples to ensure that they are taken in accordance with procedures prescribed in ASTM D 75 and ASTM C 183 and that the samples are large enough to provide ample material for all the tests that will be conducted. END NOTE.

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(d) Sources of Aggregates. Sources of aggregates shall be selected well in advance of the time the materials are required in the work. When the aggregates are obtained from a previously approved source or an existing source producing aggregates that has a satisfactory service record in airport bituminous pavement construction for at least five years, samples shall be submitted 14 days prior to start of production. An inspection of the producer's operation will be made by the Engineer. When new sources are to be developed, the Contractor shall indicate the sources and shall submit a plan for operation 30 days in advance of starting production. Samples from test pits, borings, and other excavations shall be submitted at the same time. Approval of the source of aggregate does not relieve the Contractor in any way of the responsibility for delivery at the job site of aggregates that meet the requirements specified herein.

NOTE TO THE ENGINEER. The time periods may be varied; however, sufficient time should be allowed for shipping and testing. END NOTE.

(e) Samples of Aggregates. Samples of aggregates shall be furnished by the Contractor at the start of production and at intervals during production of bituminous mixtures. The intervals and points of sampling will be designated by the Engineer. The samples will be the basis of approval of specific lots of aggregates from the standpoint of the quality requirements of this section.

401-2.2 FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

401-2.3 BITUMINOUS MATERIAL. The types, grades, and controlling specifications and maximum mixing temperatures for the bituminous materials are given in Table 1.

NOTE TO THE ENGINEER. The Engineer shall specify the type and grade of bituminous material to be used, based on geographical location and climatic conditions. END NOTE.

The Contractor shall furnish vendor's certified test reports for each carload or equivalent of bitumen shipped to the project. The report shall be delivered to the Engineer before permission is granted for use of the material. The furnishing of the vendor's certified test report for the bituminous material shall be the basis for final acceptance.

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TABLE 1. BITUMINOUS MATERIAL

Type and Grade		Specification	Maximum Mixing Temperature °F	°C
Asphalt Cement				
Penetration Grade	60-70	ASTM D 946	335	170
	85-100		325	165
	100-120		310	155
Viscosity Grade	AC-5	AASHTO M-226	295	145
	AC-10		315	155
	AC-20		330	165
Viscosity Grade	AR-2000	ASTM D 3381	325	165
	AR-4000		325	165
	AR-8000		325	165
Tar				
	RT-10	ASTM D 490	250	145
	RT-11		250	145
	RT-12		250	145

Composition

401-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of aggregate, filler if required, and bituminous material. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula.

401-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved by the Engineer. The formula shall be submitted in writing by the Contractor to the Engineer at least 15 days prior to the start of paving operations and shall indicate the definite percentage of each sieve fraction of aggregate, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. All test data used to develop the job mix formula shall also be submitted. The job mix formula for each mixture shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula shall be established before the new material is used.

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NOTES TO THE ENGINEER.

1. Alternatively, the specification may require the Contractor to submit samples of materials intended for use and the job mix formula to be established by the Engineer.

2. The name of the testing laboratory proposed to be used, an accompanying certification that it is capable of performing all the tests required by this section, and a listing of available equipment shall be submitted to the appropriate Airports office for review.
END NOTES.

The bituminous mixture shall be designed using procedures contained in Chapter III, MARSHALL METHOD OF MIX DESIGN, of The Asphalt Institute's Manual Series No. 2 (MS-2), current edition, and shall meet the requirements of Tables 2 and 3.

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory screens, will conform to the gradation or gradations specified in Table 4 or 5, when tested in accordance with ASTM Standard C 136 (dry sieve only). The percentage by weight for the bituminous material shall be within the limits specified.

TABLE 2. MARSHALL DESIGN CRITERIA

Test Property	Pavementsdesigned for aircraft gross weights of 60,000 lbs. or more or tire pressures greater than 100 psi	Pavements designed for aircraft gross weights less than 60,000 lbs. or tire pressuresless than 100 psi
Number of Blows	75	50
Stability, minimum pounds (newtons)	1800 (8000)	1000 (4450)
Flow, 0.01 in. (0.25 mm)	8-16	8-20
Percent air voids	3-5	3-5
Percent voids in mineral aggregate	See Table 3	See Table 3

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TABLE 3. MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE

U. S. A. Standard Sieve Designation in.	Nominal Maximum Particle Size in.	mm	Minimum Voids in Mineral Aggregate percent
1/2	0.500	12.5	15
3/4	0.750	19.0	14
1	1.000	25.0	13

TABLE 4. AGGREGATE - BITUMINOUS SURFACE COURSE

Pavements designed to accommodate aircraft with gross weights of 60,000 pounds (27 000 kg) or greater, or with tire pressures of 100 psi (690 kPa) or more.

Sieve	Percentage by Weight Passing Sieves		
Size	1" maximum	3/4" maximum	1/2" maximum
1 in. (25.0 mm)	100	----	----
3/4 in. (19.0 mm)	84-100	100	----
1/2 in. (12.5 mm)	74-88	82-96	100
3/8 in. (9.5 mm)	68-82	75-89	79-93
No. 4 (4.75 mm)	53-67	59-73	59-73
No. 8 (2.36 mm)	40-54	46-60	46-60
No. 16 (1.18 mm)	30-44	34-48	34-48
No. 30 (600 μm)	20-34	24-38	24-38
No. 50 (300 μm)	13-25	15-27	15-27
No. 100 (150 μm)	9-17	8-18	8-18
No. 200 (75 μm)	3-6	3-6	3-6
Bitumen percent: Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	6.0-9.0	6.5-9.5	7.0-10.0

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TABLE 5. AGGREGATE - BITUMINOUS SURFACE COURSE

Pavements designed to accommodate aircraft with gross weights less than 60,000 pounds (27 000 kg), or with tire pressures less than 100 psi (690 kPa)

Sieve	Percentage by Weight Passing Sieves		
Size	1" maximum	3/4" maximum	1/2" maximum
1 in. (25.0 mm)	100	------	-------
3/4 in. (19.0 mm)	82-100	100	-------
1/2 in. (12.5 mm)	70-90	82-100	100
3/8 in. (9.5 mm)	60-82	68-90	82-100
No. 4 (4.75 mm)	42-70	50-79	56-88
No. 8 (2.36 mm)	32-62	39-69	43-77
No. 16 (1.18 mm)	24-54	29-59	32-65
No. 30 (600 μm)	18-45	20-49	23-55
No. 50 (300 μm)	13-35	14-38	15-42
No. 100 (150 μm)	7-22	8-25	8-27
No. 200 (75 μm)	3-8	3-8	4-9
Bitumen percent: Stone or gravel	4.5-7.0	5.0-7.5	5.5-8.0
Slag	6.0-9.0	6.5-9.5	7.0-10.0

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The gradations in Tables 4 and 5 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The selection of any of the gradations shown in Tables 4 and 5 shall be such that the maximum size aggregate used shall not be more than one-half of the thickness of the layer of the course being constructed. The aggregate, as finally selected, shall have a gradation within the limits designated in Table 4 or 5 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

NOTE TO THE ENGINEER. Tables 4 and 5 are based on aggregates of uniform specific gravity, and the percentages passing the various sieves will be subject to appropriate correction by the Engineer when aggregates of varying specific gravity are used. See The Asphalt Institute's Manual Series No. 2 (MS-2), Appendix A. END NOTE.

The job mix tolerances shown in Table 6 shall be applied to the job mix formula to establish a job control grading band. The full tolerances still will apply if application of the job mix tolerances results in a job control grading band outside the master grading band.

TABLE 6. JOB MIX FORMULA TOLERANCES
(Based on a Single Test)

Material	Tolerance Plus or Minus
Aggregate passing No. 4 sieve or larger	7 percent
Aggregate passing Nos. 8, 16, 30, and 40 sieves	4 percent
Aggregate passing Nos. 100 and 200 sieves	2 percent
Bitumen	0.40 percent
Temperature of mix	20 degrees F (-7°C)

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The aggregate gradation may be adjusted within the limits of Tables 4 and 5, as directed, without adjustments in the contract unit prices.

Should a change in sources of materials be made, a new job mix formula shall be established before the new material is used. Deviation from the final approved design for bitumen content and gradation of aggregates shall not be greater than the tolerances permitted and shall be based on daily plant extraction. Extraction tests for bitumen content and aggregate gradation will be made at least twice daily. The mixture will be tested for bitumen content in accordance with ASTM D 2172 and for aggregate gradation in accordance with AASHTO T 30.

Tests on Marshall specimens shall be made at least twice daily to retain job control. The mixture shall comply with the requirements of Tables 2 and 3 when tested in accordance with the Marshall method procedures contained in Chapter III of The Asphalt Institute's Manual Series No. 2 (MS-2), current edition. Failure to meet the design criteria will be cause for the Engineer to halt production until the problem is identified and corrected. Acceptance or rejection of the material will not be based on stability, flow, voids, or percent voids in the mineral aggregate.

If the index of retained strength of the specimens of composite mixture, as determined by ASTM D 1075, is less than 75, the aggregates shall be rejected or the asphalt shall be treated with an approved antistripping agent. The amount of antistripping agent added to the asphalt shall be sufficient to produce an index of retained strength of not less than 75.

NOTES TO THE ENGINEER.

1. For airport pavements designed to accommodate aircraft gross weights of 12,500 pounds (5 662 kg) or less, this section may be modified to permit the use of state highway department specifications for high-quality, hot-mix bituminous pavements that have a satisfactory performance record under equivalent loadings and exposure, including design criteria, gradations, and density requirements. The Engineer may wish to specify stability, percent air voids, and density values when not required by state specifications.

2. The Engineer will specify the appropriate gradation and design criteria according to the gross weight or tire pressure of the aircraft.

3. Where locally available aggregates cannot economically be blended to meet the grading requirements of Table 4 or 5, the gradations may be modified to fit the characteristics of such local aggregates. The modified gradation must produce a paving mixture that satisfies the mix design requirements of Table 2.

4. Mixes designed with stabilities greater than 2,500 pounds (1 125 kg) may result in mixtures difficult to compact to the required density. END NOTES.

401-3.3 TEST SECTION. Prior to full production, the Contractor shall prepare a quantity of bituminous mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section at least 50 feet (15.2 m) long and 20 feet (6.1 m) wide placed in two sections and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

If the test section should prove to be unsatisfactory, the necessary adjustments to the mix design, plant operation, and/or rolling procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. When test sections do not conform to specification requirements, the pavement shall be removed and replaced at the Contractor's expense. Full production shall not begin without approval of the Engineer. Test sections will be paid for in accordance with Section 401-6.1.

NOTE TO THE ENGINEER. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment. Wherever possible, the test section should be placed in an area where it will receive little or no traffic so that marginal quality trial runs can be safely left in place. END NOTE.

Construction Methods

401-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 7. The temperature requirements may be waived, but only when so directed by the Engineer.

401-4.2 BITUMINOUS MIXING PLANT. If the supplier is equipped with an automated plant the automation feature shall be used in the production of bituminous material for the project. If the supplier is equipped with a recordation feature, it also shall be used. Sufficient storage space shall be provided for each size of aggregate. The different aggregate sizes shall

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TABLE 7. BASE TEMPERATURE LIMITATIONS

Mat Thickness	Base Temperature (Minimum) °F	°C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

be kept separated until they have been delivered to the cold elevator feeding the drier. The storage yard shall be neat and orderly, and the separate stockpiles shall be readily accessible for sampling.

Plants used for the preparation of bituminous mixtures shall conform to all requirements under (a), except that scale requirements shall apply only where weight proportioning is used. In addition, batch mixing plants shall conform to the requirements under (b), continuous mixing plants shall conform to the requirements under (c), and drum mixers shall conform to the requirements under (d).

(a) Requirements for All Plants. Mixing plants shall be of sufficient capacity to adequately handle the proposed bituminous construction.

NOTE TO THE ENGINEER. The Engineer shall specify the minimum hourly production rate of the plant. END NOTE.

(1) Plant scales. Scales shall be accurate to 0.5 percent of the required load. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales, the Contractor may provide an approved automatic printer system to print the weights of the material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weigh ticket for each load. Scales shall be inspected for accuracy and sealed as often as the Engineer may deem necessary. The Contractor shall have on hand not less than ten 50-pound (22.6 kg) weights for testing the scales.

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(2) Equipment for preparation of bituminous material. Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. Heating shall be accomplished by approved means so that flames will not contact the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring quantities and for sampling the material in the storage tanks.

(3) Cold feeders. The plant shall be provided with accurate mechanical or electrical means for uniformly feeding the aggregates into the drier to obtain uniform production and temperature. When added mineral filler is specified, a separate bin and feeder shall be furnished with its drive interlocked with the aggregate feeders.

(4) Drier. The plant shall include a drier(s) which continuously agitates the aggregate during the heating and drying process.

(5) Screens. Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

(6) Bins. The plant shall include storage bins of sufficient capacity to supply a mixer operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. When used, separate dry storage shall be provided for filler or hydrated lime, and the plant shall be equipped to feed such material into the mixer. Each bin shall be provided with overflow pipes of such size and at such location to prevent backup of material into the compartments or bins. Each compartment shall be provided with its individual outlet gate to prevent leakage. The gates shall cut off quickly and completely. Bins shall be constructed so that samples may be obtained readily. Bins shall be equipped with adequate tell-tale devices which indicate the position of the aggregates in the bins at the lower quarter points.

(7) Bituminous control unit. Satisfactory means, either by weighing or metering, shall be provided to obtain the specified amount of bituminous material in the mix. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

(8) Thermometric equipment. An armored thermometer of adequate range shall be placed in the bituminous feed line at a suitable location near the charging valve of the mixer unit. The plant shall also be equipped with an approved thermometric instrument placed at the discharge chute of the

drier to indicate the temperature of the heated aggregates. The Engineer may require replacement of any thermometer by an approved temperature-recording apparatus for better regulation of the temperature of aggregates.

(9) Dust collector. The plant shall be equipped with a dust collector to waste any material collected or to return all or any part of the material uniformly to the mixture as directed.

(10) Truck scales. Unless an automatic batching plant with automatic printers is used, the bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. Scales shall be inspected for accuracy and sealed as often as the Engineer deems necessary.

(11) Safety requirements. Adequate and safe stairways to the mixer platform and sampling points shall be provided, and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a suitable device to enable the Engineer to obtain sampling and mixture temperature data. Means shall be provided to raise and lower scale calibration equipment, sampling equipment, and other similar equipment between the ground and the mixer platform. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded. Ample and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free of drippings from the mixing platform.

(12) Testing laboratory. The Contractor or producer shall provide a testing laboratory for control and acceptance testing functions during periods of mix production, sampling, and testing and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall provide adequate equipment, space, and utilities as required for the performance of the specified tests.

(b) Requirements for Batching Plants.

(1) Weigh box or hopper. The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

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(2) Bituminous control. The equipment used to measure the bituminous material shall be accurate to within ±0.5 percent. The bituminous material bucket shall be of a nontilting type with a loose sheet metal cover. The length of the discharge opening or spray bar shall be not less than three-fourths the length of the mixer and it shall discharge directly into the mixer. The bituminous material bucket, its discharge valve(s), and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained, and all connections shall be so constructed that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15 percent in excess of the weight of bituminous material required in any batch. The plant shall have an adequately heated, quick-acting, nondrip charging valve located directly over the bituminous material bucket.

The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used per batch. The controls shall be constructed to lock at any dial setting and automatically reset to that reading after each additional batch of bituminous material. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically controlled to begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has begun. The size and spacing of the spray-bar openings shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and the spray bar shall have a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

(3) Mixer. The batch mixer shall be an approved type capable of producing a uniform mixture within the job mix tolerances. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of blades from all fixed and moving parts shall not exceed 1 inch.

(4) Control of mixing time. The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh-box gate after the charging of the mixer and keep it locked until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh-box gate and the introduction of bituminous material. The wet mixing period is the interval of time between the introduction of bituminous material and the opening of the mixer gate.

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The timing control shall be flexible and shall be capable of settings of 5-second intervals or less throughout a 3-minute cycle. A mechanical batch counter shall be installed as a part of the timing device and shall be designed to register only completely mixed batches.

The setting of time intervals shall be at the direction of the Engineer who shall then lock the case covering the timing device until a change is made in the timing periods.

(c) Requirements for Continuous Mix Plants.

(1) Aggregate proportioning. The plant shall include means for accurately proportioning each size of aggregate.

The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for the volumetric measuring of material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means and provided with a lock.

Indicators shall be provided for each gate to show the respective gate opening in inches.

(2) Weight calibration of aggregate feed. The plant shall include a means for calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples of not less than 200 pounds (90 kg). Accurate scales shall be provided by the Contractor to weigh such test samples.

(3) Synchronization of aggregate feed and bituminous material feed. Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control shall be by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

(4) Mixer. The plant shall include an approved continuous mixer adequately heated and capable of producing a uniform mixture within the job mix tolerances. It shall be equipped with a discharge hopper with dump gates to permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and shall be reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate

giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts shall be provided showing the rate of feed per minute for each aggregate used.

(d) Requirements for Drum Mixers.

(1) Exclusions. Paragraphs 401-4.2(a)(4) through 401-4.2(a)(9) do not apply to drum mixers.

(2) Aggregate delivery system. An automatic plant shutoff shall be provided to operate when any aggregate bin becomes empty. Provisions shall be provided for conveniently sampling the full flow of materials from each cold feed and the total cold feed. Total cold feed shall be weighed continuously. The weighing system shall have an accuracy of 0.5 percent when tested for accuracy. The plant shall provide positive weight control of the cold aggregate feed by use of a belt scale, or other appropriate device, which will automatically regulate the feed gate and permit instant correction of variations in load. The cold feed flow shall be automatically coupled with the asphalt flow to maintain the required proportions of each material. Provisions shall be made for introducing the moisture content of the cold feed aggregates into the belt weighing signal and correcting wet aggregate weight to dry aggregate weight. Screens or other suitable devices which will reject oversize particles or lumps of aggregate that have been cemented together shall be installed in the feeder mechanism between the bins and the dryer drum.

Dry weight of the aggregate flow shall be displayed digitally in appropriate units of weight and time and totalized.

(3) Bituminous material and additive delivery systems. Satisfactory means of metering shall be provided to introduce the proper amount of bituminous material and additives into the mix. Delivery systems shall prove accurate to plus or minus 1 percent when tested for accuracy. The bituminous material and additive delivery shall be interlocked with the aggregate weight. The bituminous material and additive flow shall be displayed digitally in appropriate units of volume (or weight) and time shall be totalized.

(4) Thermometric equipment. A recording thermometer of adequate range shall be located to indicate the temperature of the bituminous material in storage. The plant shall also be equipped with approved recording thermometers, pyrometers, or other approved recording thermometric instruments at the discharge chute of the drum mixer.

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(5) Drum mixer. A drum mixer of satisfactory design shall be provided. It shall be capable of drying and heating the aggregate to the moisture and temperature requirements set forth in the paving mixture requirements and capable of producing a uniform mixture. If the quality requirements of Section 401-3.2 cannot be met, the Contractor will be required to utilize either batch or continuous mix plants.

(6) Temporary storage of bituminous mixture. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

(a) The bituminous mixture may be stored in surge bins for a period of time not to exceed 3 hours.

(b) The bituminous mixture may be stored in insulated and heated storage bins for a period of time not to exceed 12 hours, provided an inert gas atmosphere is maintained in the bin during the storage period.

If the Engineer determines that there is an excessive amount of heat loss, segregation and/or oxidation of the mixture due to temporary storage, use of surge bins or storage bins will be discontinued.

(e) Inspection of Plant. The Engineer or his authorized representative shall have access, at all times, to all parts of the paving plant for checking adequacy of equipment; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking the temperatures maintained in the preparation of the mixtures.

401-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds. To prevent the mixture from adhering to them, the beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, so that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated and covers shall be securely fastened.

401-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-contained, power-propelled units with an activated screed or strike-off assembly, heated if necessary, and shall be capable of spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the plans.

ITEM P-401 BITUMINOUS SURFACE COURSE

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed. The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

The paver shall be capable of operating at forward speeds consistent with satisfactory laying of the mixture.

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the screed elevation as specified herein. The control system shall be automatically actuated from either a reference line or surface through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface.

The controls shall be capable of working in conjunction with any of the following attachments:

(a) Ski-type device of not less than 30 feet (9.14 m) in length or as directed by the Engineer.

(b) Taut stringline (wire) set to grade.

(c) Short ski or shoe.

NOTE TO THE ENGINEER. For pavements serving aircraft over 60,000 pounds (27 000 kg) gross weight, it is recommended that the specifications require the use of automatic grade controls. END NOTE.

401-4.5 ROLLERS. Rollers may be of the vibratory, steel wheel, or pneumatic-tired type. They shall be in good condition, capable of reversing without backlash, and operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density without detrimentally affecting the compacted material.

401-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated to the specified temperature in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material

delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed the applicable maximum temperature set forth in Table 1 and not be more than 25°F (4°C) above the temperature of the aggregate as specified in Section 401-4.7.

401-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be dried and heated to the temperature designated by the job formula within the job tolerance specified. The maximum temperature and rate of heating shall be such that no permanent damage occurs to the aggregates. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

401-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be measured or gauged and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the bituminous material throughout the aggregate are secured. Wet mixing time shall be approved by the Engineer for each plant and for each type aggregate used. Normally, the mixing time after introduction of bituminous material should not be less than 30 seconds. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer.

$$\text{Mixing time (seconds)} = \frac{\text{Pugmill dead capacity in pounds (kg)}}{\text{Pugmill output in pounds (kg) per second}}$$

NOTE TO THE ENGINEER. For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill harden the asphalt film on the aggregate. Mixing time, then, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material. END NOTE.

ITEM P-401 BITUMINOUS SURFACE COURSE

401-4.9 TRANSPORTING, SPREADING, AND FINISHING. The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Section 401-4.3. Deliveries shall be scheduled so that spreading and rolling of all mixture prepared for one day's run can be completed during daylight, unless adequate artificial lighting is provided. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

Immediately before placing the bituminous mixture, the underlying course shall be cleared of all loose or deleterious material with power blowers, power brooms, or hand brooms as directed.

The mix shall be placed at a temperature of not less than 225°F (107°C) when asphalt cement is used, and not less than 150°F (65°C) when tar is used. Moisture content of the mix shall not exceed 1 percent.

Upon arrival, the mixture shall be spread to the full width by an approved bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and shall conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placing shall begin along the centerline of areas to be paved on a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet (3 m), except where edge lanes require strips less than 10 feet to complete the area. The longitudinal joint in one layer shall offset that in the layer immediately below by at least 1 foot (30 cm); however, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least 2 feet (60 cm) from transverse joints in the previous layer. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread, raked, and luted by hand tools.

401-4.10 COMPACTION OF MIXTURE. After spreading, the mixture shall be thoroughly and uniformly compacted with power rollers. Rolling of the mixture shall begin as soon after spreading as it will bear the roller without undue displacement or hair checking. Rolling shall be initiated with the drive wheel toward the paving machine. The sequence of rolling for the first paving lane should be to first roll the lower edge (with reference to the transverse slope) of the lane and then roll the upper edge. The interior of the lane should then be rolled from the lower side toward the upper with overlapping roller paths. On adjoining paving lanes rolling shall begin by

overlapping the joint (with the previous lane) by 6 to 8 inches (15 to 20 cm) and then rolling the outside edge of the new lane. The interior is rolled from the outside edge toward the compacted joint with overlapping wheel paths. Alternate paths of the roller shall be of slightly different lengths.

The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once by rakes and fresh mixture.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until all roller marks are eliminated, the surface is of uniform texture and true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers.

Any mixture which becomes loose and broken, mixed with dirt, or in any way defective shall be removed and placed with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

401-4.11 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between old and new sections of the course. All joints shall present the same texture, density, and smoothness as other sections of the course.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint.

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401-4.12 SHAPING EDGES. While the surface is being compacted and finished, the Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be beveled while still hot with the back of a rake or a smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

401-4.13 ACCEPTANCE SAMPLING AND TESTING OF BITUMINOUS MIXTURE (COMPACTION). Bituminous concrete will be accepted for density on a lot basis. A lot will consist of __ tons and will be divided into 4 equal sublots. One test shall be made for each sublot.

Pavement density will be determined by taking, for each lot, the average density of four laboratory-prepared specimens, taken from trucks delivering mixture to the site. The specimens will be compacted in accordance with ASTM D 1559, Section 3.5, except that the temperature of the mixture immediately prior to compaction shall be 250°F ±5° (120°C). The sample of mixture can be placed in an oven for not more than 30 minutes to maintain the heat, but it shall not be reheated if it cools before use.

Each lot of compacted pavement will be accepted, with respect to density, when the average field density is equal to or greater than 98 percent of the average density of the laboratory-prepared specimens, and when no individual determination deviates more than 1.8 percent from the average field density. Four field density determinations will be made for each lot. Cores taken from the pavement will be used to test the field density. The density of the laboratory-prepared specimens and the cored samples will be determined in accordance with ASTM D 2726 or D 1188, whichever is applicable.

Bituminous mixture sampled for laboratory specimens and the location of sampling sites within a lot's placement area shall be chosen on a random basis in accordance with procedures contained in Appendix C of The Asphalt Institute's Specification Series No. 1 (SS-1), Fifth Edition. Cores will be taken in accordance with the requirements of Section 401-4.15.

NOTES TO THE ENGINEER.

1. A lot is the quantity of material to be controlled and may represent a specified tonnage or a specified number of truckloads. The lot size, to be determined by the Engineer, should for the most part, depend on the operational capacity of the plant, but shall in no case exceed 2,000 tons (900 kg). The Engineer will specify the lot size in the specifiations.

ITEM P-401 BITUMINOUS SURFACE COURSE

2. In lieu of the core method of density determination, acceptance testing may be accomplished with a nuclear device in accordance with ASTM D 2950. The following procedures shall be followed: Compaction of the test section, described in Section 401-3.3, shall be continued until no discernible increase in density can be obtained by additional rolling. Upon completion of compaction, the mean density of the test section shall be determined by averaging the results of 10 nuclear density tests taken at randomly selected sites within the test section. The nuclear density shall then be correlated with the density of cored samples. If the mean density of the test section, determined from cored samples, is at least 98 percent of the average density of laboratory-compacted specimens, as determined by testing procedures contained elsewhere in these specifications, the remainder of the course which the test section represents will be accepted on the basis of nuclear tests without further correlation by cores. If the mean density is less than 98 percent, the Engineer may order the construction of another test section.

A new test section may also be ordered by the Engineer or requested by the Contractor when:

(a) A change in the material or job mix formula is made.

(b) Ten days of production have been accepted without construction of a new test section.

(c) There is reason to believe that the test section density is not representative of the material being placed.

3. Sliding scale pay factors (SSPF) for pavements which fail to meet specified densities may be incorporated into the specification at the Engineer's or sponsor's option. Recommended SSPFs are listed in Table 8 and shall be applied to each lot. END NOTES

401-4.14 SURFACE TESTS. Tests for conformity with the specified crown and grade shall be made by the Contractor immediately after initial compression. Any variation shall be corrected by the removal or addition of materials and by continuous rolling.

The finished surface shall not vary more than 1/4 inch (6.35 mm) for the surface course when tested with a 16-foot (4.8 m) straightedge applied parallel with, or at right angles to, the centerline.

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After the completion of final rolling, the smoothness of the course shall again be tested; humps or depressions exceeding the specified tolerances shall be immediately corrected by removing the defective work and replacing with new material, as directed by the Engineer. This shall be done at the Contractor's expense.

The finished surfaces of bituminous courses shall not vary from the gradeline, elevations, and cross sections shown on the contract drawings by more than 1/2 inch (12.70 mm). The Contractor shall correct pavement areas varying in excess of this amount by removing and replacing the defective work. Skin patching will not be permitted.

TABLE 8. SLIDING SCALE PAY FACTORS

Average Percent Density1/	Recommended Percent Payment
98.0 and greater	100
97.0 - 97.9	98
96.0 - 96.9	90
95.0 - 95.9	75
Less than 95.0	reject

Deviation from Average Percent Density1/	Recommended Percent Payment
0 - 1.8	100
1.9 - 2.3	98
2.4 - 2.7	95
2.8 - 3.1	90
3.2	2/

1/ For 4 samples

2/ If the deviation from the average percent density is greater than 3.2 percent, it will be the Engineer's option to accept or reject at 90 percent payment.

ITEM P-401 BITUMINOUS SURFACE COURSE

401-4.15 SAMPLING PAVEMENT. Samples for determination of thickness and density of completed pavements shall be obtained by the Contractor at no extra cost. The size, number, and locations of the samples will be as directed by the Engineer. Samples shall be neatly cut with a saw, core drill, or other approved equipment. The Contractor shall furnish all tools, labor, and materials for cutting samples and replacing pavement.

All tests necessary to determine conformance with requirements specified herein will be performed without cost to the Contractor.

METHOD OF MEASUREMENT

401-5.1 Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

BASIS OF PAYMENT

401-6.1. Payment for bituminous surface course shall be made at the contract unit price per ton (kg). The price shall be full compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-401-6.1 Bituminous Surface Course - Per Ton (kg).

NOTE TO THE ENGINEER. When sliding scale pay factors are used to accept pavements for density, payment for the material in that lot will be made at a reduced price arrived at by multiplying the contract unit price by the pay factor. If two pay factors are used for any given lot, the reduced price will be determined by successively multiplying the contract unit price by all such pay factors. Use of sliding scale pay factors is described in Section 401-4.13. END NOTE.

ITEM P-401 BITUMINOUS SURFACE COURSE

TESTING REQUIREMENTS

ASTM C 29	Unit Weight of Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C 183	Sampling Hydraulic Cement
ASTM D 75	Sampling Aggregates
ASTM D 423	Liquid Limit of Soils
ASTM D 424	Plastic Limit and Plasticity Index of Soils
ASTM D 1075	Effect of Water on Cohesion of Compacted Bituminous Mixtures
ASTM D 1188	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1559	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2726	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Method
AASHTO T 30	Mechanical Analysis of Extracted Aggregate
The Asphalt Institute's Manual No. 2 (MS-2)	Mix Design Methods for Asphalt Concrete

ITEM P-401 BITUMINOUS SURFACE COURSE

MATERIAL REQUIREMENTS

ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 490	Tar
ASTM D 946	Asphalt Cement for Use in Pavement Construction
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction
AASHTO M 226	Viscosity Graded Asphalt Cement

SPECIFICATION REQUIREMENTS

The Asphalt Institutes's Specification Series No. 1 (SS-1)	Model Construction Specifications for Asphalt Concrete and Other Plant-Mix Types

AC 150/5370-10

CHANGE 2

DATE December 28, 1978

ADVISORY CIRCULAR

CHANGE

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Washington, D.C.

Subject: CHANGE 2, STANDARDS FOR SPECIFYING CONSTRUCTION OF AIRPORTS -- Updates Item P-501, Portland Cement Concrete Pavement

1. PURPOSE. Item P-501, Portland Cement Concrete, has been revised to reflect recent research and current practices in the field of concrete pavement construction.

The change number and date of changed material is indicated at the top of each page.

2. PRINCIPAL CHANGES. The major changes are:

a. Elimination of design mix based on predetermined cement content. The design mix is now based only on the specified flexural strength.

b. Addition of paragraphs concerning slip-form pavement construction.

c. Optional use of pay factors for flexural strength determination.

d. Use of ASTM standards in lieu of AASHTO standards.

e. Changeover to guide specification format.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
319-362	10/24/74	319-362	12/28/78

William V. Vitale

WILLIAM V. VITALE
Acting Assistant Administrator
Office of Airports Programs

Suggest filing this transmittal at the back of the AC. It will provide a reference authority for changes, a method of determining that all Changes have been received, and a check for determining if the AC contains the proper pages.

Initiated by: AAP-580

ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT

1. DESCRIPTION

1.1 This work shall consist of pavement composed of portland cement concrete, [with reinforcement] [without reinforcement] constructed on a prepared subgrade or subbase course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans.

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The Engineer shall specify with or without reinforcement.

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2. MATERIALS

2.1 FINE AGGREGATE. Fine aggregate for concrete shall conform to the requirements of ASTM C33 and shall meet the requirements of Table 1.

TABLE 1. GRADATION FOR FINE AGGREGATE

Sieve Designation (Square Openings)	Percentage by Weight Passing Sieves
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (600 micro-m)	25-60
No. 50 (300 micro-m)	10-30
No. 100 (150 micro-m)	2-10

2.2 COARSE AGGREGATE. Coarse aggregate shall conform to the requirements of ASTM C33. Gradation shall be in accordance with Table 2.

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1.6

TABLE 2. GRADATION FOR COARSE AGGREGATE 49

Sieve Designations (square openings)		*	*
		Percentage by Weight Passing Sieves	
in.	mm	*	*
2-1/2	63	*	*
2	50.8	*	*
1-1/2	38.1	*	*
1	25.0	*	*
3/4	19.0	*	*
1/2	12.5	*	*
3/8	9.5	*	*
No. 4	4.75	*	*
No. 8	2.36	*	*

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The Engineer shall specify the aggregate to be furnished from the table shown in this note. The appropriate gradation shall be inserted into Table 2. Insert points are denoted by asterisks. Where locally available aggregates cannot be economically blended to meet the grading requirements, the gradations may be modified to fit the characteristics of such locally available aggregates.

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TABLE 2. GRADATION FOR COARSE AGGREGATE 92

Sieve Designations (square openings)		From 2" to No.4 (50.8mm - 4.75mm)	From 1-1/2" to No.4 (38.1 mm - 4.75 mm)			From 1" to No.4 (25.0mm-4.75mm)
		Percentage by Weight Passing Sieves				
in.	mm	2"-1"	1"-No.4	1-1/2"-3/4"	3/4"-No.4	1"-No.4
2-1/2	63	---	---	---	---	---
2	50.8	90-100	---	100	---	---
1-1/2	38.1	35-70	100	90-100	---	100
1	25.0	0-15	95-100	25-55	100	95-100
3/4	19.0	---	---	0-15	95-100	---
1/2	12.5	0-5	25-60	---	---	25-60
3/8	9.5	---	---	0-5	20-55	---
No. 4	4.75	---	0-10	---	0-10	0-10
No. 8	2.36	---	0-5	---	0-5	0-5

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The percentage of wear shall be no more than [**_____] when tested in accordance with [**_____.]

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The Engineer shall specify the percentage of wear. It should not exceed 40 percent. In certain cases where aggregate of this quality cannot be obtained economically, aggregate with a higher percentage of wear may be used if a satisfactory service record of at least 5 years' duration under similar conditions of service and exposure has been demonstrated. The Engineer shall specify ASTM C131 for aggregates smaller than 1 1/2 inches (38.1 mm) and ASTM C535 for aggregates larger than 3/4 inch (19.05 mm).

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ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT 1.5
1.6

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, crushed slag, or natural sand. The aggregate shall be composed of sound, tough, durable particles and shall meet the requirements for deleterious substances given in ASTM C33. The aggregate in any size group shall not contain more than 8 percent by weight of flat or elongated pieces. A flat or elongated particle is one having a ratio between the maximum and the minimum dimensions of a circumscribing rectangular prism exceeding 5 to 1.

2.3 CEMENT. Cement shall conform to the requirements of [**_____,] Type [**_____.]
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The Engineer shall specify one of the following: ASTM C150 - Type I, IA, II, IIA, III, IIIA; ASTM C595 - Type IP, IP-A, IS, IS-A.
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If, for any reason, cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

2.4 PREMOLDED JOINT FILLER. Premolded joint filler for expansion joints shall conform to the requirements of ASTM [**_____] and shall be punched to admit the dowels where called for on the plans. For contraction joints, the filler shall be a resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.
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****
The Engineer shall designate either ASTM D1751 or ASTM D1752.
****
$*

2.5 JOINT SEALER. The joint sealer for the joints in the concrete pavement shall meet the requirements of Item P-604 and shall be of the type(s) specified in the plans.

2.6 STEEL REINFORCEMENT. Reinforcing shall consist of [**_____] conforming to the requirements of [**_____.]

ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT 1.5 1.6

$* 225
********** 226.1
The Engineer shall designate one of the following: 227

Welded steel wire fabric ASTM A185 229

Welded deformed steel fabric ASTM A497 231

Bar mats ASTM A184 or A704 233

Delete this section when not applicable to the project. 235
********** 236.2
$* 237

2.7 DOWEL AND TIE BARS. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615 or ASTM A616, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or restraightened during construction. Tie bars designated as Grade 40 in ASTM A615 can be used for construction requiring bent bars. 242 244 246 247 248 249

Dowel bars shall be plain steel bars conforming to ASTM A617 and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the construction site, a minimum of two-thirds of the length of each dowel bar shall be painted with one coat of lead or tar paint. If plastic or epoxy-coated steel dowels are used, no lead or tar paint coating is required, except when specified for a particular situation on the contract plans. Coated dowels shall conform to the requirements given in AASHTO M254. 251 252 254 255 257 258 259 261 261

The sleeves for dowel bars used in expansion joints shall be metal, of an approved design to cover 2 to 3 inches (50 mm to 75 mm) of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch (25 mm) from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction. 263 264 265 266 267 268

2.8 WATER. Water used in mixing or curing shall be as clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product as possible. Water will be tested in accordance with the requirements of AASHTO T26. Water known to be of potable quality may be used without testing. 271 277 278 278 279

2.9 COVER MATERIAL FOR CURING. Curing materials shall conform to one of the following specifications: 282 282

(a) Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309, Type 2. 284 286

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(b) White polyethylene film for curing concrete shall conform to the requirements of ASTM C171. 288 289

(c) White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C171. 291 292

(d) Waterproof paper for curing concrete shall conform to the requirements of ASTM C171. 294 295

2.10 ADMIXTURES. The use of any material added to the concrete mix shall be approved by the Engineer. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests will be made of samples taken by the Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved. 298 299 300 302 302 303 304 305 306 307 308

(a) Pozzolanic Admixtures. Pozzolanic admixtures shall be fly ash or raw or calcined material pozzolans meeting the requirements of ASTM C618 with the exception of loss of ignition, where the maximum should be less than 6 percent. 311 312 313 314

(b) Air-Entraining Admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260 and shall be added to the mixer in the amount necessary to produce the specified air content. The air-entrainment agent and the water reducer admixture shall be compatible. 317 318 319 320 320

(c) Water-Reducing Admixtures. Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, water-reducing or Type D, water-reducing and retarding. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. 324 324 327 328 329 330

3. CONSTRUCTION METHODS 332

3.1 EQUIPMENT. Equipment and tools necessary for handling materials and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site before the start of construction operations for examination and approval. 335 336 338 339 340

(a) Batching Plant and Equipment. 342

ITEM P-501 PORTLAND CEMENT CONCRETE PAVEMENT 1.5
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(1) General. The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and coarse aggregate. If bulk cement is used, a bin, hopper, and separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dusting during operation.

(2) Bins and hopper. Bins with adequate separate compartments for fine aggregate and coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is approached, the material may be added slowly and shut off with precision. A port or other opening for removing an overload of any one of the several materials from the hopper shall be provided. Weighing hoppers shall be constructed to eliminate accumulations of materials and to discharge fully.

(3) Scales. The scales for weighing aggregates and cement shall be of either the beam or the springless dial type. They shall be accurate within 0.5 percent throughout their range of use. When beam-type scales are used, provisions such as a "telltale" dial shall be made for indicating to the operator that the required load in the weighing hopper is being approached. A device on the weighing beams shall clearly indicate critical position. Poises shall be designed to be locked in any position and to prevent unauthorized change. The weight beam and "telltale" device shall be in full view of the operator while charging the hopper, and the operator shall have convenient access to all controls.

Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than ten 50-pound (23 kg) weights for testing of all scales when directed by the Engineer.

(b) Mixers.

(1) General. Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

A device accurate within 3 percent and satisfactory to the Engineer shall be provided at the mixer for determining the amount of air-entraining agent or other admixture to be added to each batch requiring such admixtures.

Mixers shall be examined daily for the accumulation of hard concrete or mortar and the wear of blades.

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(2) Central plant mixer. Mixing shall be in an approved mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period, and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4 inch (19 mm) or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) Truck mixers and truck agitators. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C94.

(4) Nonagitator trucks. Nonagitating hauling equipment shall conform to the requirements of ASTM C94.

(c) Finishing Equipment.

(1) Finishing machine. The finishing machine shall be equipped with one or more oscillating-type transverse screeds.

(2) Vibrators. For side-form construction, vibrators may be either the surface pan type for pavements less than 8 inches (20 cm) thick or the internal type with either immersed tube or multiple spuds, for the full width of the concrete slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, load-transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 vibrations per minute, and the frequency of the internal type shall not be less than 7,000 vibrations per minute for spud vibrators. When spud-type internal vibrators are used adjacent to the side forms, they shall have a frequency of not less than 3,500 vibrations per minute. Hand vibrators should be used to consolidate the concrete along forms and other isolated areas.

For slip-form construction, the paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators with a frequency range variable between 7,000 and 12,000

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vibrations per minute. The amplitude of vibration shall be between 0.025 (0.6 mm) and 0.06 (1.5 mm) inches.

The number, spacing, frequency, and eccentric weights shall be provided as necessary to achieve an acceptable concrete density and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the concrete. The frequency of surface vibrators shall not be less than 3,500 vibrations per minute. The Contractor shall furnish a tachometer or other suitable device for measuring the frequency of the vibrators. The vibrators and tamping elements shall be automatically controlled so that they shall be stopped as forward motion ceases. Any override switch shall be of the spring-loaded, momentary contact type.

(d) Concrete Saw. When sawing of joints is specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and at all times during concrete placement.

(e) Forms. Straight side forms shall be made of steel having a thickness of not less than 7/32 inch (6 mm) and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the prescribed edge thickness of the concrete without horizontal joint, and a base width equal to the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of 100-foot (31 m) radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than two-thirds the height of the form. Forms with battered top surfaces and bent, twisted, or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting.

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(f) Slip-form Pavers. The paver shall be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross section. It shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the plans, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The paver should be equipped with electronic or hydraulic horizontal and vertical control devices.

3.2 FORM SETTING. Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than 3 pins for each 10-foot (3 m) section. A pin shall be placed at each side of every joint.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch (6 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

3.3 CONDITIONING OF UNDERLYING COURSE, SLIP-FORM CONSTRUCTION. The compacted subgrade or subbase on which the pavement will be placed shall be widened approximately 3 feet (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the subgrade or subbase has been placed and compacted to the required density, the areas which will support the paving machine and the area to be paved shall be trimmed to the proper elevation and profile by means of a properly designed machine. The grade of the subbase on which the concrete pavement is to be placed shall be controlled automatically by steel guide wires erected and maintained by the Contractor. If the density of the base is disturbed by the trimming operations, it shall be corrected by additional compaction before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor or the damaged areas filled with concrete integral with the pavement. The grading operations should be delayed as long as possible and immediately precede paving insofar as practical,

particularly if the base course is subjected to haul traffic. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be well moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. In cold weather the underlying subbase shall be protected so that it will be entirely free of frost when concrete is placed.
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Stabilized subbase is required to accommodate dual tandem gear aircraft with gross weights in excess of 200,000 pounds (90700 kg).
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3.4 CONDITIONING OF UNDERLYING COURSE, SIDE-FORM CONSTRUCTION. The prepared grade shall be well moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Ruts or depressions in the subgrade or subbase caused by hauling or usage of other equipment shall be filled as they develop with suitable material (not with concrete or concrete aggregates) and thoroughly compacted by rolling. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor, or the damaged areas filled with concrete integral with the pavement. A multiple-pin templet weighing not less than 1,000 pounds (454 kg) per 20 feet (6.1 m) or other approved templet shall be provided and operated on the forms immediately in advance of the placing of the concrete. The templet shall be propelled only by hand and not attached to a tractor or other power unit. Templets shall be adjustable so that they may be set and maintained at the correct contour of the underlying course. The adjustment and operation of the templet shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed. Low areas may be filled and compacted to a condition similar to that of the surrounding grade, or filled with concrete integral with the pavement. In cold weather, the underlying subbase shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying material will not be permitted. The templet shall be maintained in accurate adjustment, at all times by the Contractor, and should be checked daily. The work described under the foregoing paragraphs does not constitute a regular subgrading operation, but rather a final accurate check of the underlying course.

3.5 HANDLING, MEASURING, AND BATCHING MATERIAL. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than 3 feet (1

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m) in thickness. Each layer shall be completely in place before beginning the next layer and shall not be allowed to "cone" down over the next lower layer. Aggregates from different sources and of different grading shall not be stockpiled together. Improperly placed stockpiles will not be accepted by the Engineer.

Aggregates shall be handled from stockpiles or other sources to the batching plant in such manner to secure the specified grading of the material. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. The fine aggregate and coarse aggregate shall be separately weighed into hoppers in the respective amounts set by the Engineer in the job mix. Cement shall be measured by weight. Separate scales and hopper, with a device to positively indicate the complete discharge of the batch of cement into the batch box or container, shall be used for weighing the cement.

When required by the contract or when permitted, batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other approved device, to prevent loss of cement. The device shall be arranged to provide positive assurance of the actual presence in each batch of the entire cement content specified.

When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1 1/2 hours of such contact. Batching shall be conducted so that the results in the weights of each material required will be within a tolerance of 1 percent for cement and 2 percent for aggregates.

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within plus or minus 1 percent of required amounts. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

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Methods and equipment for adding air-entraining agent or other admixtures to the batch, when required, shall be approved by the Engineer. All admixtures shall be measured into the mixer with an accuracy of plus or minus 3 percent.

3.6 PROPORTIONS. Proportioning requirements for concrete shall be designed for a flexural strength of [**_____.]
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The Engineer shall designate the design flexural strength. The minimum flexural strength allowable for airport pavements is 600 psi (4136 kPa) and the minimum allowable cement content is 5.2 bags of cement per cubic yard. Higher flexural strengths should be specified when local materials make this economically feasible.
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Prior to the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit test data showing the proportions and actual flexural strength obtained from the concrete. Flexural strength shall be as specified at 28 days using test specimens prepared in accordance with ASTM C31 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a slump for side-form concrete between 1 and 2 inches (25 mm and 50 mm) as determined by ASTM C143. For vibrated slip-form concrete, the slump shall be between 1/2 inch (13 mm) and 1 1/2 inches (38 mm).
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Low slump concrete is a necessity for slip-form pavement, particularly for pavement with keyways or for pavement in excess of 10 inches (25 cm) thick.
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The minimum cement content shall be maintained to produce concrete of suitable durability and workability. The maximum water-cement ratio specified for concrete shall not be exceeded. Entrained air shall be required to increase durability and provide workability.

For slip-form construction, a high degree of uniformity in the plastic concrete is required. Caution should be exercised in establishing the air-entrainment percentage, as excessive air entrainment will aggravate edge slumping and insufficient air entrainment will result in poor concrete durability. Batches with slump in excess of 1 1/2 inches (38 mm) shall be wasted. Some edge slump of the wet concrete behind the side form on the paving machine will occur, even with low slump concrete. This may continue, though very slowly, until initial set has taken

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place. Provision for adequate compensating adjustment in the side form and in the final screed must be incorporated in the paver.

The cement content shall not be less than 5.2 sacks per cubic yard nor shall the water-cement ratio, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates, be more than 6 gallons per sack of cement. The cement content shall be determined in accordance with ASTM C138.

Air-entraining admixture shall be added in such a manner that will insure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air entrainment in the mix shall be [**_____] percent plus or minus 1 1/2 percentage points. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.
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The Engineer shall specify the appropriate air content as determined from the table in this note.

ENTRAINED AIR TOLERANCES

Maximum Size Coarse Aggregate	Air Content Percent by Volume
1 1/2 in. (38.1 mm), 2 in. (51 mm), 2 1/2 in. (63 mm)	5 1/2
3/4 in. (19.1 mm), 1 in. (25.0 mm)	6
3/8 in. (9.5 mm), 1/2 in. (12.5 mm)	7 1/2

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3.7 FIELD TEST SPECIMENS. Concrete samples shall be furnished by the Contractor and shall be taken in the field to determine the consistency, air content, and strength of the concrete. Flexural test beams shall be made each day that the concrete is placed. Each group of test beams shall be molded from the same batch of concrete and shall consist of a sufficient number of specimens to provide two flexural strength tests at each test age. One group of specimens will be made during the first half of each shift, and the other during the last portion of the shift. The specimens shall be made in accordance with ASTM C31. However, at the start of paving operations and when the aggregate