Case 11-22

DATE: July 13, 2011

TO: MAG Specification and Details Committee Members

FROM: Jeff Benedict, Asphalt Working Group/AGC

RE: Section 325 and 717

PURPOSE: Separate material and construction methods and give guidance to rubber specification

REVISIONS:
a) Updated required equipment and density procedures
b) Compaction procedures clarified
c) Updated rubber materials along with physical properties

SECTION 325

PLACEMENT AND CONSTRUCTION OFASPHALT-RUBBER CONCRETE OVERLAY, GAP GRADED

325.1 DESCRIPTION:

Asphalt-rubber concrete consists of supplying, placing and compaction of plant-mixed, gap-graded asphalt-rubber concrete over asphalt surfaces. The thickness of the finished asphalt-rubber concrete overlay shall be within the range of one to two inches as shown on the plans or as specified in the special provisions. ~~Asphalt-Rubber Concrete Mixes may be used for low or high traffic conditions, as determined by the agency. Low traffic conditions are conditions where the asphalt mix will be subject to low volume and low weight vehicle usage. Examples of this condition are residential streets, most parking lots and residential minor collector streets. High traffic conditions are conditions where the asphalt mix will be subject to high volume and/or heavy weight vehicle usage as found on major collector, arterial and commercial streets. Street classifications (i.e. minor collector and major collector) shall be determined by the specifying agency.~~

325.2 MATERIALS:

Asphalt-rubber concrete shall consist of a mixture of aggregate, mineral admixture and asphalt-rubber binder as specified in Section 717.

325.2.1 Mixing of Asphalt-Rubber: The temperature of the asphalt-cement shall be between 375°F and 425°F prior to the addition of rubber. No agglomerations of rubber particles in excess of 2" in the least dimension shall be allowed in the mixing chamber. The ground rubber and asphalt-cement shall be accurately proportioned in accordance with the asphalt-rubber binder design and thoroughly mixed prior to the beginning of the one-hour reaction period. Reaction time may be decreased to 45-minutes if documentation is provided that the physical properties of the mix design requirements are consistently met using a 45-minute reaction period. The Contractor or supplier shall document that the proportions are accurate and that the rubber has been uniformly incorporated into the mixture. Additionally, the Contractor or supplier shall demonstrate that the rubber particles have been thoroughly mixed such that they have been "wetted." The occurrence of rubber floating on the surface or agglomerations of rubber particles shall be evidence of insufficient mixing. The temperature of the asphalt-rubber immediately after mixing shall be between 350°F and 400°F. Reaction time shall start after all of the material for the batch has been mixed and the minimum reaction temperature of 350°F has been achieved.

Prior to use, the viscosity of the asphalt-rubber shall be tested by the use of a rotational viscometer, which is to be furnished by the Contractor or supplier. The Contractor or supplier shall provide a qualified person to perform the testing.

325.2.2Handling of Asphalt-Rubber: Once the asphalt-rubber binder has been mixed, it shall be kept thoroughly agitated during periods of use to prevent settling of the rubber particles. During the production of asphaltic concrete the temperature of the asphalt-rubber binder shall be maintained between 163°C (325°F) and 204°C (400°F). However, in no case shall the asphalt-rubber binder be held for more than 10 hours at these temperatures. It shall be allowed to cool to a temperature of 121°C (250°F) or less and held at that temperature for not more than four days. The process of cooling and reheating shall not be allowed more than one time for a batch of asphalt rubber binder.

For each load or batch of asphalt-rubber binder, the Contractor or supplier shall provide the Engineer with the following documentation:

(A) The source, grade, amount and temperature of the asphalt cement prior to the addition of rubber.

(B) The source and amount of rubber and the rubber content expressed as percent by the weight of total asphalt rubber binder.

(C) Times and dates of the rubber additions and resultant viscosity test.

(D) A record of the temperature, with time and date reference for each load or batch. The record shall begin at the time of the addition of rubber and continue until the load or batch is completely used. Readings and recordings shall be made at every temperature change in excess of 20°F, and as needed to document other events which are significant to batch use and quality.

325.3 WEATHER AND MOISTURE CONDITIONS:

Asphalt-rubber concrete shall be placed only when the surface is dry, and when the atmospheric temperature in the shade is 55°F or above. No asphalt-rubber concrete shall be placed when the weather is foggy or rainy. Asphalt-rubber concrete shall be placed only when the Engineer determines that weather conditions are suitable.

325.4 APPLICATION OF TACK COAT:

A tack coat shall be applied to all existing and to each new course of asphalt concrete prior to the placing of a succeeding lift of asphalt-rubber concrete. The tack coat may be deleted when a succeeding layer of asphalt-rubber concrete is being applied over a freshly laid course that has been subjected to very little traffic when approved by the Engineer.

The application of the tack coat shall comply with Section 329. The grade of emulsified asphalt shall be SS-1h or CSS-1h as specified in Section 713.

The same material that is specified above for the tack coat shall be applied to the vertical surfaces of existing pavements, curbs, and gutters, against which asphalt concrete is to be placed.

The surface to be covered may require repair or patching as directed by the Engineer. This shall be addressed in the project specifications prior to the bidding of the project.

325.5 MIX PRODUCTION:

All materials shall be proportioned by weight in a hot mix asphalt plant in the proportions required by the mix design to provide a homogeneous and workable mass. Each hot mix asphalt plant shall be inspected in accordance with the provisions contained in the 'Hot Mix Asphalt Production Facilities' by the Arizona Rock Products Association and shall have a current inspection certificate. All measuring devices shall be calibrated at least annually by a technician licensed by the Arizona Bureau of Weights & Measures. Mixing plants shall conform to the requirements of AASHTO M-156, except as modified herein.

325.6 TRANSPORTATION:

Petroleum distillates or other substances that will have a detrimental effect on the asphalt concrete shall not be used as a release agent.

The beds of all transportation units shall be clean and smooth to allow the free flow of material into the paving machine's hopper.

Tarpaulins shall be furnished on all trucks and used when weather condition warrant, or if directed by the Engineer.

325.7 PLACEMENT:

325.7.1 Surface Preparation:

Before placing asphalt-rubber concrete on existing pavements, severely raveled areas or cracked areas that are depressed more than 3/4" from the adjoining pavement shall be cut out and patched at least 48 hours prior to the resurfacing operation. Over-asphalted (bleeding or flushing) areas or rough high spots shall be removed by burning

or blading. Large shrinkage cracks shall be filled with asphalt sealing compound acceptable to the Engineer. The entire surface shall be cleaned with a power broom. Raveled areas that do not require removing shall be cleaned by hand brooming. The above surface cleaning requirements are included as part of the Asphalt-Rubber Concrete paving operations, and the cost thereof shall be included in the Asphalt-Rubber Concrete pay item. Pavement repairs and crack sealing when required are to be compensated for by other appropriate contract pay items.

Prior to placing the asphalt-rubber concrete on milled surfaces, pot-holes left by the milling operation shall be repaired by the Contractor, as a related non-pay item and as required by the Engineer. The milled area shall be swept.

After surfaces have been prepared to the satisfaction of the Engineer, they shall receive a tack coat as specified in Section 325.~~5~~4.

Traffic will not be permitted over surfaces which have received a tack coat. When the overlay is to extend onto a concrete surface, the concrete surface shall be thoroughly cleaned of loose dust and cement particles and shall be tack coated.

325.7.2 Placing and Construction Methods:

All courses of asphalt-rubber concrete shall be placed and finished by means of a self-propelled paving machine equipped with an automatically actuated control system, except under certain conditions or at locations where the Engineer deems the use of a self-propelled paving machine impracticable.

The control system shall control the elevation of the screed at each end by controlling the elevation of one end directly and the other end indirectly either through controlling the transverse slope or alternatively when directed, by controlling the elevation of each end independently.

The control system shall be capable of working with one of the following devices:

(A) Ski or non-contact device of not less than 30 feet in length, supported throughout its entire length
(B) Taut stringline or wire set to grade
(C) Short ski or sonar sensing units from curb control
(D) Joint matching shoe

Failure of the control system to function properly shall be cause for the suspension of asphalt concrete production. In order to achieve a continuous operation, the speed of the paving machine shall be coordinated with the hot mix plant and transport units.

If the asphalt-rubber concrete is dumped from the hauling vehicles directly into the paving machine, care shall be taken to avoid jarring the machine or moving it out of alignment. No vertical load shall be exerted on the paving machine by the truck.

If asphalt-rubber concrete is dumped upon the surface being paved and subsequently loaded in the paving machine, the loading equipment shall be self-supporting and shall not exert any vertical load on the paving machine. Substantially all of the asphalt concrete shall be picked up and loaded into the paving machine. If asphalt-rubber concrete is placed in a windrow during paving, the windrow shall not exceed a distance greater than 150 feet in front of the paving machine.

Self-propelled paving machines shall spread the mixture without segregation or tearing, true to line, grade and crown indicated on the Project plans. Pavers shall be equipped with hoppers and augers that will distribute the mixture uniformly in front of an adjustable floating screed. The raising of the hopper wings must be minimized and the paving machine will not be operated when in an empty condition.

Screeds shall include any strike-off device operated by tamping or vibrating action which is effective, without tearing, shoving or gouging the mixture and which produces a course with a uniform texture and density for the full width being paved. Screeds shall be adjustable as to height and crown and shall be equipped with a controlled heating device for use when required. In the case of the screed, auger extensions and vibrators shall be installed wherever the screed is extended more than one (1) foot beyond the end of the base auger or auger extension.

However, when placing material against an extremely uneven curb or edge over a short distance, the Engineer may waive the auger extensions and vibrators.

325.7.3 Compaction: It is the contractor's responsibility to perform any desired Quality Control monitoring and/or testing during compaction operations to achieve the required compaction. The temperature of the asphalt-rubber concrete immediately behind the laydown machine shall be at least 275 °F. A probe type electronic thermometer with a current calibration sticker attached will be used to measure the temperature of the asphalt concrete mixture. When measuring the temperature of the mat, the probe shall be inserted at mid-depth and as horizontal as possible to the mat. When the pavement lift is less than 1.5-inches, the temperature of the material shall be measured in the truck by inserting a calibrated probe type electronic thermometer, or other approved measuring device, to a point at least 6" below the surface of material.

Asphalt compaction equipment shall be of sufficient size and weight to accomplish the required compaction. All compaction equipment shall be operated and maintained in accordance with the manufacturer's recommendations and the project requirements. Pneumatic tired compactors shall not be used.

The Engineer will determine the acceptability of the pavement compaction in accordance with Section 325.10. At any place not accessible to the roller, the mixture shall be thoroughly compacted with tampers to provide a uniform and smooth layer over the entire area compacted in this manner.

325.7.4 Lime Water: An application of lime water shall be applied by the Contractor to the compacted asphalt rubber concrete surface after final compaction, prior to opening the roadway to traffic, or when requested by the Engineer to cool the pavement to prevent tracking and pick-up. The lime water solution shall be applied at the rate of approximately ½ gallon/square yard. The lime shall be mixed using a minimum of (1) one 50-pound bag per 3,000 gallons of water.

325.7.5 Adjustments: After installation of an overlay course all necessary frame and cover adjustments for manholes, valve boxes, survey monuments, sewer clean-outs, etc., shall be completed by the Contractor within the given segments being surfaced.

On roads without curb and gutter, the existing shoulder elevation shall be adjusted by the Contractor to match the elevation at the edge of new overlay and slope away from the new pavement surface at a rate that the existing quantity of shoulder material will allow. Shoulder material includes the existing shoulder, millings, untreated base materials, or a granular material approved by the Engineer. Shoulder material shall be compacted to a minimum of 95% of maximum density, determined in accordance with section 301.3.

325.8 QUALITY CONTROL:

It is the contractor's responsibility to perform Quality Control monitoring and/or testing during asphalt-rubber concrete production to achieve the required compaction and to perform Quality Control monitoring and/ or testing during asphalt-rubber concrete production to achieve the required mix properties. The Engineer may obtain samples of any portion of any material at any point of the operations for his own use. Also, the Engineer may order that the use of any drying, proportioning and mixing equipment or the handling of any material be discontinued which, in his/her opinion, fails to produce a satisfactory mixture.

The asphalt-rubber concrete produced shall conform to the requirements of the production tolerances established in section 325.~~10~~9. When the asphalt-rubber concrete does not conform to the production tolerances, it shall be reported to the Engineer, and corrective quality control measures shall be implemented, or production shall cease immediately at no additional cost to the contracting Agency or Engineer.

325.9 ACCEPTANCE:

325.9.1 Acceptance Criteria: Unless otherwise specified, asphalt-rubber concrete will be divided into 500 ton increments for the purpose of acceptance. Generally, a minimum of one sample will be obtained from each 500 tons of production or fraction thereof for determination of binder content and gradation. Tests used to determine acceptance will be performed by the Engineer or a laboratory employed by the Engineer. In either case the laboratory shall be accredited by the AASHTO Accreditation Program (AAP), for the tests being performed. All acceptance samples shall be taken using random tonnages, locations or times as designated by the Engineer in

accordance with ASTM D 3665. Acceptance testing results will be furnished to the contractor within five working days of receipt of samples by the acceptance laboratory.

325.9.2 Gradation, Binder Content and Air Voids:

325.9.2.1 Mineral Aggregate Gradation: For each approximate 500 tons of asphalt-rubber concrete produced, at least one sample of mineral aggregate will be taken. Samples will be taken in accordance with the requirements of Arizona Test Method 105 on a random basis. For batch plants, the sample shall be taken from the hot bins. For plants other than batch plants, the sample shall be taken from the cold feed belt. Samples will be taken by means of a sampling device which is capable of obtaining representative samples. The device, which shall be approved by the Engineer, shall be furnished by the contractor. In any shift that the production of asphalt-rubber concrete is less than 500 tons, at least one sample will be taken.

Samples will be tested for conformance with the mix design gradation, with or without mineral admixture as appropriate, in accordance with the requirements of Arizona Test Method 201.

During production, the allowable deviations from the mix design gradation targets are listed in ~~the t~~Table~~s~~ 325-1 below. The allowable production tolerances may fall outside of the mix design gradation bands.

~~**TABLE 325-1**~~
~~**GRADATION ACCEPTANCE LIMITS FOR ASPHALT-RUBBER MIXES**~~

TABLE 325-1		
GRADATION ACCEPTANCE LIMITS FOR ASPHALT-RUBBER MIXES		
Sieve Size	1" & 1 ½" Lift Thickness	~~Asphalt-Rubber Mix~~2" Lift Thickness
1 inch	100%	~~±7~~100%
¾ inch	100%	±6%
~~⅜~~ ½ inch	±6%	±6%
⅜ inch	±6%	±6%
No. 4	±6%	±6%
No. 8	±6%	±6%
No. 30	±4%	±4%
No. 200	±2%	±2%

If the results from a single acceptance sample fall outside of the acceptance limits in Table 325-~~4~~1 a second sample shall be taken and if the second acceptance sample is also outside of the acceptance limits in Table 325-~~4~~1 the Contractor shall cease production of asphalt concrete. Production shall not begin again until calibration test results verify that adjustments made to materials or proportions yield a gradation that falls within acceptance limits in Table 325-~~4~~1.

325.9.2.2 Binder Content: During production of asphalt-rubber concrete, the contractor shall maintain at the plant site a nuclear asphalt content gauge calibrated and operated in accordance with Arizona Test Method 421. At the discretion of the Engineer, the Owner may choose to prepare the calibration samples for use by the contractor. Under the observation of the Engineer, the contractor shall determine the asphalt-rubber binder content by means of the nuclear asphalt content gauge a minimum of four times per full shift. The Engineer shall determine the times that the samples are taken. The contractor's technicians performing the testing, including the calibration of the nuclear gauge, shall meet the technician requirements given in the Arizona Department of Transportation (ADOT) System for the Evaluation of Testing Laboratories. The requirements may be obtained from ADOT Materials Group, 1221 North 21st Avenue, Phoenix, AZ 85009.

Production of asphalt-rubber concrete shall cease immediately and the plant and/or the nuclear asphalt content gauges re-calibrated if any single test result varies by an amount greater than ± 0.60, or the average of three consecutive test results varies by an amount greater than ± 0.40, from the amount determined by the mix design. Material that has already been produced may be used on the project if the single test value representative of that material varies by an amount from ± 0.61 to ± 0.75, inclusive, from the amount determined by the mix design. Material that has already been produced may not be used on the project if the single test value representative of that

material varies by an amount greater than ± 0.75 from the amount determined by the mix design unless, by retesting, the material is found to be acceptable.

When there is cause to question the asphalt-rubber binder content being obtained via nuclear asphalt content gauge, or if approved by the Engineer, the asphalt-rubber binder content may be determined using inventory data provided by the supplier as detailed in the following paragraphs. This will only apply for plants providing asphalt-rubber concrete exclusively for the subject project or if an asphalt cement tank is dedicated for the shift of asphalt-rubber concrete production.

The determination of the actual asphalt-rubber binder content by inventory methods may include weighing of asphalt cement deliveries, invoice quantities, volumetric tank measurements using a calibrated rod (tank stickings) corrected for temperature, computerized mass-flow meter, and accounting for wasted materials. If a computerized mass-flow meter is used, documentation of its calibration shall be submitted to the Engineer prior to asphalt-rubber concrete production. At any time during asphalt-rubber concrete production, the Engineer may require that a new calibration of the mass-flow meter be performed.

If there is a difference of greater than 0.2 percent asphalt-rubber binder between the asphalt-rubber binder content measured by nuclear asphalt content gauge testing and the actual asphalt-rubber binder content as determined by inventory, the contractor may request that the asphalt-rubber binder content be determined by inventory. The contractor must make such a request in writing within two working days after receiving the test results for the first day of asphalt-rubber concrete production.

325.9.2.3 Marshall Air Voids: For purposes of determining Marshall air voids, the acceptance laboratory will take one sample of the asphalt-rubber concrete in accordance with the requirements of Section 2(h) of Arizona Test Methods 104 or AASHTO T168 for each day's production or as directed by the Engineer's. The minimum weight of the sample shall be 45 pounds. The bulk density shall be tested in accordance with AASHTO T245. The maximum theoretical density shall be tested in accordance with the requirements of AASHTO T209, including fan drying per AASHTO T-209 Section 11. Effective voids determined on the laboratory compacted specimens will be determined in accordance with the requirements of AASHTO T269. Should the testing for effective air voids not meet the "Full Payment" or "No Corrective Action" requirements of Table 325-~~5~~2, additional testing for laboratory air voids on additional samples will be performed as necessary to determine the extent of the deficiency.

TABLE 325-2		
LABORATORY VOIDS ACCEPTANCE AND PENALTIES		
Marshall Air Voids (Measured at 75 blows) Deviation from Mix Design Target	When the contracting agency is the owner: Payment Reduction ($ per ton of asphalt concrete)	When the contracting agency is not the owner (i.e. permits): Corrective Action
± 0% to 1.8%	Full Payment	No corrective action
± 1.9% to 2.9%	$1.00	EA (see 321.10.6)
± 3.0% to 4.0%	$2.50	EA (see 321.10.6)
± Greater than 4.0%	Removal* or EA per 325.10.4	Removal* or EA per 325.10.4

Comment [DL1]: Consider expanding this to ±0 to2.0% due to the touchy nature of rubberized mixes.

Comment [DL2]: If the above is agreed upon, change this to ±2.1 to ±2.9%

325.~~10~~9.3 Density: The temperature of asphalt-rubber concrete just prior to compaction shall be at least 275 °F. ~~The wheels of compactors shall be wetted with water, or if necessary soapy water, or a product approved by the Engineer to prevent the asphalt-rubber concrete from sticking to the steel wheels during rolling.~~ The Engineer may change the rolling procedure if in the Engineer's judgment the change is necessary to prevent picking up of the asphalt-rubber concrete.

325.~~10~~9.3.1 Equipment: Asphalt compaction equipment shall be of sufficient size and weight to accomplish the required compaction. All compaction equipment shall be operated and maintained in accordance with the manufacturer's recommendations and the project requirements. ~~For courses greater than one inch in nominal thickness, a minimum of one static steel-wheel compactor and two vibratory steel-wheel compactors shall be provided; however, sufficient vibratory steel-wheel compactors shall be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine. For courses of one inch or less in nominal thickness, a minimum of three static steel-wheel compactors shall be provided; however, sufficient~~

~~compactors must be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine on the initial forward pass while a static compactor remains to complete final rolling. If the asphalt-rubber concrete production rate exceeds 250 tons per hour, an additional static steel-wheel compactor shall be provided. The compactors shall weigh not less than eight tons.~~

The compactors shall be self -propelled and shall be operated with the drive wheel in the forward position. The compactors shall weigh not less than eight tons. ~~Vibratory rollers shall be used in the mode required by the Engineer. Vibratory c~~Compactors shall not be used in the vibratory mode for courses of one inch or less in nominal thickness. The wheels of compactors shall be wetted with water, or if necessary soapy water, or a product approved by the Engineer to prevent the asphalt-rubber concrete from sticking to the steel wheels during rolling.
~~Pneumatic rollers shall not be used.~~

325.~~10~~9.3.2 Compaction Procedures

325.9.3.2.1 Pavement Lift Thickness 1 ½ Inches or Less: A minimum of three static steel-wheel compactors shall be provided; however, sufficient compactors must be provided so that the drums of the compactors when staggered will cover the entire width of the paving machine on the initial forward pass while a static compactor remains to complete final rolling. The roller(s) for final compaction shall follow as closely behind the initial breakdown as practical, such that a uniformly smooth surface is achieved. As many passes as are possible shall be made with the compactors before the temperature of the asphalt-rubber concrete falls below 220 °F.

325.9.3.2.2 Pavement Lift Thickness Greater than 1 ½ Inches:~~Rolling Procedure:~~ Achieving the required compaction is the responsibility of the contractor. The number and types of rollers is the contractor's responsibility and shall be sufficient to meet these requirements. ~~Vibratory compactors shall be used for initial breakdown on courses greater than one inch in nominal thickness. Static steel wheel compactors, or vibratory compactors in the static mode, shall be used for initial breakdown on courses one inch or less in nominal thickness.~~ Initial breakdown rollers shall follow as closely behind the ~~be maintained no more than 300 feet behind the~~ paving machine as practical. The roller~~-~~(s) for final compaction shall follow as closely behind the initial breakdown as practical~~-~~, such that a uniformly smooth surface is achieved. ~~As many passes as are possible shall be made with the compactors before the temperature of the asphalt-rubber concrete falls below 220 °F~~.

~~325.9.3.3~~ Compaction will be determined using a correlated thin lift n~~N~~uclear d~~D~~ensity g~~G~~auge and will be monitored for acceptability continuously during construction. The density of the compacted mixture shall not be less than 95% of the laboratory unit weight composed of the same mixture compacted by the 75 blow method of AASHTO T245 at the job mix design specified compaction temperature. The outside one foot of each pass of the pavement course or any unconfined edge will be excluded from testing. The Engineer may exclude areas from the compaction lot that are not accessible by normal compaction equipment. ~~Correlation for Compaction:~~

Nuclear Density Gauge Correlation - ~~On~~ During placement of the test strip or on the first day of paving~~lacement and compaction~~, the pavement surface shall be tested with a thin lift nuclear density gauge at a minimum of four locations. These same locations shall ~~immediately~~ then be cored, using a 4-inch diameter core barrel, and tested for bulk density (AASHTO T166-A, or T275) and a correlation value developed between the nuclear density gauge and the asphalt cores. ~~Remaining compaction of the asphalt rubber concrete shall be based upon the correlated thin lift nuclear density gauge.~~

~~The density of the compacted mixture shall not be less than 95% of the laboratory unit weight composed of the same mixture compacted by the 75 blow method of AASHTO T245 at the job mix design specified compaction temperature.~~

Comment [pdf3]: I decided to use Marshall compaction, based on all the problems ADOT had with their 415 End Product using in-place air voids.

~~All edges shall be compacted by methods approved by the Engineer, while the mixture is still hot.~~

325.~~10~~9.3.~~3~~34 Compacting Miscellaneous Items and Surfaces: Asphalt-rubber concrete used in the construction of miscellaneous items and surfaces shall be compacted using compactors, hot-hand tampers, smoothing irons, mechanical vibrating hand tampers, or with other devices to the extent considered necessary by the Engineer.

325.~~10~~9.4 Engineering Analysis (EA): Within 10 working days after receiving notice that a lot or sublot of asphalt-rubber concrete is deficient and is found to fall within the "Removal or EA" band per Table(s) 325-~~5~~2, the contractor may submit a written proposal (Engineering Analysis) to accept the material in place at the applicable penalties along with possible remediation(s) listed in the "Removal or EA" category. An Engineering Analysis can

also be proposed for non-removal categories of "Corrective actions" when the contracting agency is not the owner (i.e. permits).

The Engineering Analysis shall contain an analysis of the anticipated performance of the asphalt-rubber concrete if left in place. The Engineering Analysis shall also detail the effect of any proposed corrective action to the material(s) in place as it relates to the in-place material's performance. The Engineering Analysis shall be performed by a professional engineer experienced in asphalt concrete testing and mix designs. If the lot or sublot is submitted for referee testing by the contractor, the ten working days allowed to prepare an engineering analysis will begin upon notification of referee test results.

When an Engineering Analysis recommends that a specific lot or sublot should not be removed, the Engineering Analysis will recommend that the following penalties (Table 325-~~6~~3) be paid when the contracting agency is the owner, for the specific criteria being reviewed by the EA.

TABLE 325-3~~6~~

ENGINEERING ANALYSIS PENALTIES for REMOVAL* LOTS/SUBLOTS LEFT IN-PLACE

Acceptance Criteria	Acceptance Limits	Penalty When Contracting Agency is the Owner ($/Ton)
Laboratory Air Voids (Measured at 75 blows)	Deviation from Target Greater Than ± 4.0%	$3.75

Within 15 working days, the Engineer will determine whether or not to accept the contractor's proposed Engineering Analysis.

325.11 REFEREE:

In the event the contractor elects to question the acceptance test results for laboratory air voids, the Contractor may make a written request for additional testing of the affected material. Any request for referee testing must describe the contractor's reasons for questioning the validity of the original acceptance results and must clearly describe which set of acceptance tests are in question. The Contractor will engage an independent laboratory who is accredited by AAP in all of the acceptance test methods. The independent laboratory shall be acceptable to the Engineer and shall perform a new set of acceptance tests as required by Section 325.~~10~~9.2.3 representing the area or set of tests in question. The results of these determinations will be binding on both the contractor and the agency. If the test results obtained by the independent laboratory result in elimination or reduction of the magnitude of the applicable penalty the contracting Agency will bear the cost of the referee testing. If the applicable penalty remains unchanged or increases, the cost for verification testing will be deducted from payments that were to be made to the contractor.

These tests will include Marshall unit weight, maximum theoretical unit weight, and laboratory air voids. Samples for referee testing shall come from representative samples obtained from the completed pavement, as directed by the Engineer.

The number of samples taken will be the same as specified in Section 325.~~10~~9.2.3. The independent laboratory shall compile the test results and transmit them to both the Engineer and the contractor. The independent laboratory shall include a report signed by an Engineer registered in the State of Arizona, who is experienced in asphalt concrete testing and mix design development. The signed report shall give an opinion that the material evaluated either does or does not comply with project specifications, shall clearly describe any deficiencies, and the results will be binding between all parties.

325.12 MEASUREMENT:

Asphalt-Rubber Concrete shall be measured by the ton, for the mixture actually used, which shall include the required quantities of mineral aggregates, filler material, asphalt-rubber binder and admixture.

Application of Lime Water shall be measured by the square yard. The measured area shall be the area of asphalt-rubber pavement to which the lime water is applied. The measured area shall only be counted one time regardless of the number of applications applied to the asphalt-rubber pavement section.

Shoulder adjustment to match the new pavement surface elevation shall not be measured. The cost of this work shall be included in the price paid for Asphalt-Rubber Concrete or other related pay items.

325.13 PAYMENT:

Payment for Asphalt Milling will be as specified in Section 317.

Payment for tack coat will be by the ton diluted, based on the rate of application, as directed by the Engineer.

Payment for Asphalt-Rubber Concrete will be at the contract unit price, complete in place.

Application of Lime Water as approved by the Engineer will be paid at the contract unit price.

Payment for frame and cover adjustments will be at the contract unit prices specified in the proposal.

SECTION 717

ASPHALT- RUBBER ASPHALT CONCRETE

717.1 DESCRIPTION:

The work under this section shall consist of furnishing, proportioning and mixing all the ingredients necessary to produce an asphalt-rubber material. Asphalt-Rubber Concrete Mixes may be used for low or high traffic conditions, as determined by the agency. Low traffic conditions are conditions where the asphalt mix will be subject to low volume and low weight vehicle usage. Examples of this condition are residential streets, most parking lots and residential minor collector streets. High traffic conditions are conditions where the asphalt mix will be subject to high volume and/or heavy weight vehicle usage as found on major collector, arterial and commercial streets. Street classifications (i.e. minor collector and major collector) shall be determined by the specifying agency.

717.2 MATERIALS:

717.2.1 Asphalt-Rubber Binder:

717.2.1.1 Asphalt Cement: Asphalt cement shall conform to the requirements of Section 711.

717.2.1.2Crumb Rubber: Crumb Rubber shall meet the gradation requirements as shown in Table 717-1 below when tested in accordance with Arizona Test Method 714.

TABLE 717-1	
GRADATION REQUIREMENTS~~Ts~~ OF CRUMB RUBBER	
Sieve	Percent Passing
Size	Type B
2.36 mm (#8)	
2.00 mm (#10)	100
1.18 mm (#16)	65 - 100
600 µm (#30)	20 - 100
300 µm (#50)	0 - 45
75 µm (#200)	0 - 5

The rubber shall have a specific gravity of 1.15 ± 0.05 and shall be free of wire or other contaminating materials, and shall contain not more than 0.5 percent fabric. Calcium carbonate, up to four percent by weight of the granulated rubber, may be added to prevent the particles from sticking together.

Certificates of Compliance conforming to Arizona State Department of Transportation Standard Specifications for Road and Bridge Construction Section 106.05 shall be submitted. In addition, the Certificates shall confirm that the rubber is a crumb rubber, derived from processing at ambient temperature, whole scrap tires or shredded tire materials; and the tires from which the crumb rubber is produced is taken from automobiles, trucks, or other equipment owned and operated in the United States. The Certificates shall also verify that the processing does not produce, as a waste product, casings or other round tire material that can hold water when stored or disposed of above the ground.

717.2.1.3 Asphalt-Rubber Proportions and Properties: Ground rubber in asphalt-rubber binder shall be a minimum of 18 percent by weight of total binder, and processed by ambient grinding.

Asphalt-rubber binder shall be Type 1 unless otherwise specified and conform to the requirements of Table 717-2 below:

TABLE 717-2	
PHYSICAL PROPERTIES OF ASPHALT RUBBER BINDER	
Property	Requirement

	Type I	Type 2	Type 3
Grade of base asphalt cement	**PG 64-16**	**PG 58-22**	**PG 52-28**
Rotational Viscosity*; ~~177°C (3510°F),~~; Pascal seconds ~~(cps)~~	1.5-4.0 ~~(1500-4000)~~	1.5-4.0 ~~(1500-4000)~~	1.5-4.0 ~~(1500-4000)~~
Penetration; 4°C (39°F), 200g, 60 sec. (ASTM D 5); dmm ~~(in)~~, min	10 ~~(0.04)~~	15 ~~(0.06)~~	25 ~~(0.10)~~
Softening Point; (ASTM D 36); ~~°C (°F)~~, min.	~~57~~ ~~(135)~~	~~54~~ ~~(129)~~130	~~52~~ ~~(126~~125~~)~~
Resilience; ~~25°C (77°F)~~ (ASTM D 3407); %,min	25	20	15

* The Viscometer used must be a hand held rotational viscometer, such as a Rion (formerly Haake) Model VT – 04, or an equivalent, using Rotor No. 1 . The rotor, while in the off position, shall be completely immersed in the binder at a temperature from 350 to 355 degrees F for a minimum heat equilibrium period of 60 seconds, and an average viscosity determined from three separate constant readings (± 0.5 pascal-seconds) taken within a 30 second time frame with the viscotester level during testing and turned off between readings. Continuous rotation of the rotor may cause thinning of the material immediately in contact with the rotor, resulting in erroneous results.

717.2.1.4 Asphalt-Rubber Binder Design: At least two weeks prior to the use of asphalt-rubber, the Contractor shall submit an asphalt-rubber binder design prepared by an ADOT approved laboratory. Such design shall meet the requirements specified herein. The design shall show the values obtained from the required tests, along with the following information: percent, grade and source of the asphalt cement used; and percent, gradation and source(s) of rubber used.

~~**325.2.1 Asphalt-Rubber Binder:** The asphalt-rubber binder shall conform to Section 717.~~

~~**325.2.2**~~**717.2.2 Aggregate:** Coarse and fine aggregates shall conform to the applicable requirements of ~~this section~~Tables 325-3 and 325-4 below. Coarse mineral aggregate shall consist of crushed gravel, crushed rock, or other approved inert material with similar characteristics, or a combination thereof, conforming to the requirements of these specifications.

Coarse aggregate is material retained above the Number 8 sieve and fine aggregate is material passing the Number 8 sieve. Aggregates shall be free of deleterious materials, clay balls, and adhering films or other material that prevent thorough coating with the asphalt cement. Mineral aggregate shall conform to the following requirements when tested in accordance with the applicable test methods.

Comment [DLC4]: Coarse & fine aggregates based on #8 or #4 sieve? Note difference in FFC vs. UV & SE.

Table ~~325-1~~717-3 ~~**Mix Design Gradation Requirements**~~		
MIX DESIGN GRADATION REQUIREMENTS		
Overlay Thickness	**1" & 1- ½"**	**2"**
Sieve Size	**Percent Passing**	**Percent Passing**
1" (25 mm)	100	100
¾" (19 mm)	100	95-100
½" (12.5 mm)	95-100	78-92
⅜" (9.5 mm)	78-92	61-75
No. 4 (4.75 mm)	28-45	30-40
No. 8 (2.36 mm)	15-25	15-25
No. 30 (600 µm)	5-15	5-15
No. 200 (75 µm)	3.0-7.0	2.0-6.0

The combined aggregate properties shall conform to the requirements of Table 325-2 below.

~~**Table 325-2**~~
~~**Coarse/Fine Aggregate Requirements**~~

Table 717-4
COARSE/FINE AGGREGATE REQUIREMENTS

Characteristics	Test Method	Requirements
Fractured Faces, % (Plus No. 8 ~~mat'l~~)	~~Ariz~~ ARIZ 212	85, 1 or more
Uncompacted Voids, %	~~Ariz~~ ARIZ 247	45.0 (High Traffic Volume) 42.0 (Low Traffic Volume)
Sand Equivalent (Minus No. 4 ~~mat'l~~)	AASHTO T-176	65 minimum
Plasticity Index	AASHTO T89 & T-90	Non Plastic
L.A. Abrasion, % Loss	AASHTO T-96	9 max. @ 100 Rev. 40 max. @ 500 Rev.
Combined Bulk Specific Gravity	AI MS-2	2.35-2.85
Combined Water Absorption, %	AI MS-2	0-2.5

Comment [DL5]: Consistent with 710

Comment [DL6]: Consistent with 710

~~325~~717.2.3 Mineral Admixture: Mineral admixture used in asphalt-rubber concrete shall be dry hydrated lime conforming to the requirements of ASTM C 1097 or Portland cement conforming to ASTM C 150 for Type II, or ASTM C 595 for Type IP. The minimum mineral admixture content will be 1.~~000~~percent, by weight of total aggregate.

Comment [DL7]: Some discussion about requiring 1.5% admix. Is this necessary considering there is now a TSR specification in the design process?

Comment [DL8]: Consistent with 710

~~325~~717.3 MIX DESIGN REQUIREMENT:

~~325~~717.3.1 General: The mix design for asphalt-rubber concrete shall be prepared by a laboratory that is accredited through the AASHTO Accreditation Program (AAP) in Hot Mix Asphalt Aggregates and Hot Mix Asphalt. The laboratory shall be under the direct supervision of a Civil Engineer, registered by the State of Arizona, and who is listed by ADOT as a "Qualified Asphalt Concrete Mix Design Engineer" within ADOT's latest list of approved laboratories. The latest list of approved laboratories is available on ADOT's web page http://www.azdot.gov/highways/materials/quality_assurance.asp. The date of the design shall not be older than two years from the date of submittal, unless supportive documentation is provided and approved by the Engineer.

Comment [DL9]: Consistent with 710

The mix design method used shall be in accordance with the Marshall Mix procedure, 75 blows, as described in Arizona Test Method 832 "Marshall Mix Design Method for Asphalt-rubber Concrete (Asphalt Rubber)". Mix designs are subject to approval by the Engineer.

~~325~~717.3.2 Mix Design Criteria: The mix shall comply with the criteria in Table 325-~~3~~5 below.

Table ~~325-3~~717-5 **~~Marshall Mix Design Criteria~~** **MARSHALL MIX DESIGN CRITERIA**		
Criteria	Low Volume Traffic	High Volume Traffic
Asphalt Rubber Binder Content 1" and 1-1/2" Overlay Thickness 2" Overlay Thickness	 8.4% minimum N/A	 8.0% minimum 7.0% minimum
Mixture Air Voids, %	3.5-4.5	4.5-5.5
Voids in Mineral Aggregate, %	19.0 min	19.0 min
Tensile Strength Ratio, AASHTO T-283	65% minimum	65% minimum
Marshall Stability, pounds minimum	600	600
Marshall Flow, 0.01 inch minimum	16	16

Comment [DL10]: Slightly wider mixture void range due to the nature of ARAC compared to conventional mix.

The mix design report shall include the following elements as a minimum.

(1) The name and address of the testing organization and the person responsible for the mix design report.

(2) The mix plant identification and/or location, as well as the supplier or producer name.

(3) The traffic condition (low or high traffic) and lift thickness.

(4) A description of all products that are incorporated in the asphalt-rubber concrete along with the sources of all products, including asphalt binder, crumb rubber, mineral aggregate, and admixtures.

(5) The results of all testing, determinations, etc., such as: specific gravity and gradation, water absorption, sand equivalent, loss on abrasion, fractured coarse aggregate particles, Tensile Strength Ratio (AASHTO T–283), Marshall bulk density, stability and flow, asphalt absorption, percent air voids, voids in mineral aggregate. Historical abrasion values may be supplied on existing sources. The submittal should include a plot of the

gradation on the Federal Highway Administration's 0.45 Power Gradation Chart and plots of the compaction curves.

(6) The laboratory mixing and compaction temperature ranges for the supplier and grade of asphalt binder used within the mix design.

(7) A specific recommendation for design asphalt-rubber binder content and any limiting conditions that may be associated with the use of the design, such as minimum percentages of crushed or washed fine aggregate.

(8) The supplier's product code, the laboratory Engineer's seal (signed and dated), and the date the design was completed.

(9) The Asphalt-Rubber Binder (ARB) blend design.

The mix design shall be submitted to the Agency or Engineer by the Contractor/Supplier for which it was developed as part of his project submittals. Once the mix design has been approved by the agency or Engineer, the Contractor and/or his supplier shall not change plants nor utilize additional mixing plants without prior approval of the Engineer. Any changes in the plant operation, the producer's pit, the asphalt binder, including modifiers in the asphalt binder, or any other item that will cause an adjustment in the mix, shall be justification for a new mix design to be submitted.

End of Section