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Case 11-30

DATE: August 17, 2011

TO: MAG Specifications and Details Committee Members

FROM: Peter Kandaris, SRP Representative

RE: **Revisions to Section 702 – Base Materials**

Purpose: Update standard identified by Outside ROW WG

Revisions: The purpose of the changes is to simplify base material requirements with physical properties shown in a single table. Delete information that is redundant to Section 701 (re-defining general aggregate requirements) and remove language that is vague and cannot be enforced through objective tests.

Major changes are summarized below:

(a) Delete references to specific aggregate materials such as decomposed granite, slag, etc., as these should be covered by Section 701 requirements.

(b) Add functional descriptions for ABC and Select Material.

(c) Consolidate all material requirements into Table 702-1. This includes PI, fractured face and LA abrasion testing.

(d) Fractured face for ABC was changed from 50% to 30% to match ADOT requirements.

(e) Change from 1-1/4” sieve to 1” sieve in Table 702-1 as plants do not have the capability to separate at 1-1/4”. Modify the gradation requirement for the 1” sieve to meet the same gradation as before.

(f) Include a referee test for aggregates that exceed a PI of 5. A white paper was prepared by the Materials Working Group to give the rational for using an R-value of 70 if the PI is too high (to be provided to the committee at the next meeting).

SECTION 702 – REVISED 8/7/11

BASE MATERIALS

702.1 GENERAL:

Base materials shall be as defined in Section 701, consisting of appropriately sized coarse and fine aggregates, other inert materials, and/or aggregates that have been treated for plasticity index mitigation, as approved by the Engineer.

When base material without further qualification is specified, the Contractor shall supply Aggregate Base Course as defined in Table 702-1. When a particular classification of base material is specified, the Contractor may substitute any higher classification of base material for the specified classification.

The Contractor shall ~~notify~~ provide the Engineer, in writing, material information and the source location at least 10 days prior to use of the material unless the material is currently accept~~abl~~ed for use, as determined by the Engineer.

702.1.1 Aggregate Base Course shall be used primarily in roadway applications or where otherwise specified by project special provisions.

702.1.2 Select Material shall be primarily used, but not limited to applicable structure and pipe backfill installations, shoulders, turnouts, driveways, and tapers or where otherwise specified by project special provisions.

702.2 PHYSICAL PROPERTIES:

702.2.1 Base material shall meet the physical properties listed in Table 702-1.

Table 702-1~~2~~			
Sieve Analysis Test Methods AASHTO T-27, T-11			
Sieve Size	Accumulative Percentage Passing Sieve, by Weight		
	Select Material		Aggregate Base Course
	Type A	Type B	
3 in.	100	- -	- -
1-1/2 in.	- -	100	100
1 in.	- -	- -	90 – 100
No. 4	30 - 75	30 - 70	38 - 65
No. 8	20 - 60	20 - 60	25 – 60
No. 30	10 - 40	10 - 40	10 – 40
No. 200	0 - 12	0 - 12	3 – 12
Plasticity Index Test Methods AASHTO T-89 Method A, T-90, T146 Method A			
Maximum allowable value	5	5	5
Fractured Face, One Face Test Method ARIZ 212, ~~One Face~~Percent by Weight of the Material Retained on a #4 Sieve			
Minimum required value	30	30	30
Resistance to Degradation and Abrasion by the Los Angeles Abrasion Machine Test Method AASHTO T-96, Percent Loss by Weight			
Maximum allowable value at 100 revolutions	10	10	10
Maximum allowable value at 500 revolutions	40	40	40

702.2.2: Base material that does not meet Table 702-1 properties may be approved at the Engineer's discretion if the R-Value is at least 70 when determined by test method AASHTO T-190.

End of Section

SECTION 702

BASE MATERIALS

702.1 GENERAL:

~~Materials for use as aggregate base shall be classified in the order of preference as follows~~:

~~(A) Crushed Aggregate.~~

~~(B) Processed Natural Material.~~

~~(C) Processed Steel Slag.~~

~~(D) Decomposed Granite.~~

Delete. Materials to be used for aggregates are classified in Section 701. Include specific aggregate base limitations and allow for PI stabilized base material.

Base materials shall be as defined in Section 701, consisting of appropriately sized coarse and fine aggregates, other inert materials, and/or aggregates that have been treated for plasticity index mitigation, as approved by the Engineer.

Aggregate Base Course as defined in Table 702-1

When base material without further qualification is specified, the Contractor shall supply ~~crushed aggregate~~. When a particular classification of base material is specified, the Contractor may substitute any higher classification of base material for the specified classification.

"crushed aggregate" is not a defined material. Use ABC as it is a defined product.

~~Except where materials are being obtained from a previously approved source, the~~ The Contractor shall ~~give~~ provide the Engineer 10 days prior to use ~~advance notice, in writing, of the source~~ of the base material ~~he intends to use in order to allow sufficient time to perform the necessary tests.~~ unless the material is currently accepted for use, as determined by the Engineer.

Simplify language. No justification is needed for requiring advanced notification.

702.2 ~~CRUSHED AGGREGATE~~: PHYSICAL PROPERTIES:

~~Crushed aggregate shall consist of crushed rock or crushed gravel or a combination thereof as defined in Section 701.~~ Delete, redundant.

~~**702.2.1 Soundness:** The percentage of wear of crushed aggregate to be used as base will be determined as in Section 701, except that Grading B of ASTM C-131 shall be used. The percentage of wear of the material shall not exceed 40 after 500 revolutions.~~

~~**702.2.2. Grading:** The aggregate shall be well graded when tested in accordance with ASTM C-136 and C-117. The percentage composition by weight shall be within Table 702-1.~~

Simplify. Put test methods in Table 702-1.

~~**Table 702-1**~~

~~**CRUSHED AGGREGATE GRADATION**~~

~~Sieve Sizes (Square Openings)~~	~~Percentage by Weight Passing Sieve~~		
	~~Select Material~~		~~Aggregate Base~~
	~~Type A~~	~~Type B~~	
~~3"~~	~~100~~		
~~11/2"~~		~~100~~	
~~11/4"~~			~~100~~
~~No. 4~~	~~30-75~~	~~30-70~~	~~38-65~~
~~No. 8~~	~~20-60~~	~~20-60~~	~~25-60~~
~~No. 30~~	~~10-40~~	~~10-40~~	~~10-40~~
~~No. 200~~	~~0-12~~	~~0-12~~	~~3-12~~

Place all material grade, PI, fractured face, and abrasion with test requirements in a single table.

~~**702.2.3 Plasticity Index:** Unless otherwise noted, the Plasticity Index as tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90 shall not be more than 5.~~

702.1.1 Aggregate Base Course shall be used primarily in roadway applications or where otherwise specified by project special provisions.

702.1.2 Select Material shall be primarily used, but not limited to, applicable structure and pipe backfill installations, shoulder, turnouts, driveways, and tapers, or where otherwise specified by the project special provisions.

702.2.1 Base material shall meet the physical properties listed in Table 702-1.

Table 702-1

Sieve Analysis
Test Methods AASHTO T-27, T-11

Sieve Size	Accumulative Percentage Passing Sieve, by Weight		
	Select Material		Aggregate Base Course
	Type A	Type B	
3 in.	100	- -	- -
1-1/2 in.	- -	100	100
1 in.	- -	- -	90 – 100
No. 4	30 - 75	30 - 70	38 - 65
No. 8	20 - 60	20 - 60	25 – 60
No. 30	10 - 40	10 - 40	10 – 40
No. 200	0 - 12	0 - 12	3 – 12
Plasticity Index **Test Methods AASHTO T-89 Method A, T-90, T146 Method A**			
Maximum allowable value	5	5	5
Fractured Face, One Face **Test Method ARIZ 212, Percent by Weight of Material Retained on #4 Sieve**			
Minimum required value	~~50~~ 30	~~50~~ 30	~~50~~ 30
Resistance to Degradation and Abrasion by the Los Angeles Abrasion Machine **Test Method AASHTO T-96, Percent Loss by Weight**			
Maximum allowable value at 100 revolutions	10	10	10
Maximum allowable value at 500 revolutions	40	40	40

From 701.2

702.2.2: Base material that does not meet Table 702-1 properties may be approved at the Engineer's discretion if the R-Value is at least 70 when determined by test method AASHTO T-190.

Use the R-value as a referee test if PI is out. See the Working Group white paper analysis.
The fractured face count is indirectly referenced in 701.2.1 as 50. Use ARIZ 212 & change to 30 to match ADOT requirements.
Sieve changed from 1-1/4" to 1" since plants do not have the ability to grade at 1-1/4 inches. Gradation adjusted for smaller sieve.

SECTION 702

~~**702.3 PROCESSED NATURAL MATERIAL:**~~

~~**702.3.1 General:** Processed natural material shall consist of hard, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter. It shall be free from an excess of soft or disintegrated pieces, alkali, adobe, vegetable matter, loam, or other deleterious substances.~~

Delete. Covered in Section 701.

~~**702.3.2 Physical Requirements:** When sampled and tested in accordance with standard test methods, the aggregate shall meet the following requirements:~~

~~(A) Percentage of Wear: When tested in accordance with ASTM C-131, the percentage of wear shall not exceed 40 percent after 500 revolutions.~~

~~(B) Plasticity Index: When tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90, the plasticity index shall not be more than 5.~~

Move into Table 702-1

~~(C Liquid Limit: When tested in accordance with AASHTO T-89, the liquid limit shall not be more than 25 percent.~~

Deleted. Not realistic with PI limit of 5.

~~**702.3.3 Crushed Material:** Crushed material is not required, but may be incorporated in the finished product.~~

Meaningless – includes no enforceable standard.

~~**702.3.4 Grading:** The aggregate shall conform to the sieve analysis in this specification except that the least dimension of the maximum particle size shall not exceed 2/3 of the compacted thickness of the specified lift being placed.~~

This is a placement, not a material requirement. Table 702-1 does not provide for changing max particle size for various lift thickness.

~~**702.4 DECOMPOSED GRANITE:**~~

~~Decomposed granite shall be any granitoid igneous rock which has been weathered in place and which has as principal constituents granular fragments of quartz and feldspar. It may also contain fragments of granitic rock not yet broken down into the component minerals. This material shall remain stable when saturated with water. Particles larger than 3 inches, which will not be broken in the process of rolling and tamping during construction, shall not be used.~~

Meaningless – "stable when saturated with water" and "broken down during the process of rolling and tamping" are subjective.
Use LA abrasion testing as a measureable testing method in lieu of subjective requirements.

~~Decomposed granite shall conform to the following requirements:~~

~~(A) When tested in accordance with this specification, not more than 20 percent shall pass the No. 200 mesh sieve.~~

~~(B) The P.I. of material passing the No. 200 sieve prior to testing shall not be less than 3 nor greater than 10. The Plasticity Index shall be tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90.~~

Contradicts Table 702-1 requirements. Delete

~~**702.4.1 Preparation of Test Specimens:** A quantity of sufficient size to have a dry weight of 15 pounds shall be selected and dried to constant weight at a temperature between 215°F. and 230°F. Fifteen pounds of this material shall then be subjected to 500 revolutions in a Los Angeles abrasion machine, as described in Section 701, except that nothing shall be placed in the drum other than the material to be tested.~~

~~The material that has been subjected to the breakdown shall be tested in accordance with ASTM C-117 to determine the percentage of material finer than a No. 200 mesh sieve by washing.~~

Covered by the test requirements in Table 702-1.

End of Section

Case 11-30

DATE: July 13, 2011

TO: MAG Specification and Details Committee Members

FROM: Brian Gallimore, Materials Working Group/AGC

RE: Section 702 – Base Material

PURPOSE: Moved all ABC material to 310 section

REVISIONS: a) Removed AB order of preference

SECTION 702

BASE MATERIALS

702.1 GENERAL:

~~Materials for use as aggregate base shall be classified in the order of preference as follows:~~ Base materials shall consist of appropriately sized aggregate as defined in section 701, or other approved inert materials of similar characteristics, including recycled material, and materials that have been treated for plasticity index mitigation. Base materials shall be clean and free from vegetable matter and other deleterious substances. The Contractor shall notify the Engineer, in writing, at least 10 days prior to use of the material unless the material is currently acceptable for use as determined by the Engineer.

~~(A) Crushed Aggregate.~~

~~(B) Processed Natural Material.~~

~~(C) Processed Steel Slag.~~

~~(D) Decomposed Granite.~~

~~When base material without further qualification is specified, the Contractor shall supply crushed aggregate. When a particular classification of base material is specified, the Contractor may substitute any higher classification of base material for the specified classification.~~

702.1.1 Aggregate base course ~~material~~ shall be used primarily in roadway applications ~~except~~ or where otherwise specified by project special provisions. ~~Aggregate base shall conform to the requirements listed below.~~

702.1.2 Select material shall be primarily used, but not limited to applicable structure and pipe backfill installations, shoulders, turnouts, driveways, and tapers or where otherwise specified by project special provisions. ~~Select material shall meet the requirements listed below.~~

~~Except where base materials are being obtained from a previously approved source, the Contractor shall give the Engineer 10 days advance notice, in writing, of the source of the base material he intends to use in order to allow sufficient time to perform the necessary tests.~~

~~702.2 CRUSHED AGGREGATE~~PHYSICAL PROPERTIES~~:~~

~~Crushed aggregate shall consist of crushed rock or crushed gravel or a combination thereof as defined in Section 701.~~

~~**702.2.1 Soundness****Abrasion:** The percentage of wear of crushed aggregate to be used as base will be determined as in Section 701, except thatusing Grading B of ASTM C-131, grading B shall be used. The percentage of wear of the material shall not exceed 40 after 500 revolutions.~~

~~702.2.2 **Angularity:** The amount of coarse aggregate particles retained n the No. 4 sieve shall be a minimum of 50% as determined in accordance with test method Ariz 212.~~

Comment [DR6]: Included in table?

Comment [DR7]: Included in table?

702.2.~~2~~2 ~~13~~. ~~Grading:**~~ ~~The aggregate~~ base material shall ~~be well graded when tested in accordance with ASTM C-136 and C-117. The percentage composition by weight shall be within Table 702-1.~~ meet the physical properties listed in Table 702-2.**

Table 702-~~1~~2

Sieve Analysis
Test Methods AASHTO T-27, T-11

Sieve Size	Accumulative Percentage Passing Sieve, by Weight		
	Select Material		Aggregate Base Course
	Type A	Type B	
3 in.	100	- -	- -
1-1/2 in.	- -	100	100
1 in.	- -	- -	90 – 100
No. 4	30 - 75	30 - 70	38 - 65
No. 8	20 - 60	20 - 60	25 – 60
No. 30	10 - 40	10 - 40	10 – 40
No. 200	0 - 12	0 - 12	3 – 12
Plasticity Index Test Methods AASHTO T-89 Method A, T-90, T146 Method A			
Maximum allowable value	5	5	5
Fractured Face Test Method ARIZ 212, One Face			
Minimum required value	30	30	30~~50~~
Resistance to Degradation Test Method AASHTO T-96			
Maximum allowable value at 100 revolutions	10	10	10
Maximum allowable value at 500 revolutions	40	40	40

Table 702-1

CRUSHED AGGREGATE GRADATION

Percentage by Weight Passing Sieve

Sieve Sizes (Square Openings)	Select Material		Aggregate Base
	Type A	Type B	
3"	100		
1 ½"		100	
1 ¼"			100
No. 4	30-75	30-70	38-65
No. 8	20-60	20-60	25-60
No. 30	10-40	10-40	10-40
No. 200	0-12	0-12	3-12

702.2.2: Base material that does not meet Table 702-2 properties may be approved, at the Engineer's discretion, if the R-Value is a minimum of 70 when determined by test method AASHTO T-190.

702.2.3 Plasticity Index: Unless otherwise noted, the Plasticity Index as tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90 shall not be more than 5.

Comment [DR8]: Table to be re-written by Mike Whitman

702.3 PROCESSED NATURAL MATERIAL:

702.3.1 General: Processed natural material shall consist of hard, durable fragments of stone or gravel and a filler of sand or other finely divided mineral matter. It shall be free from an excess of soft or disintegrated pieces, alkali, adobe, vegetable matter, loam, or other deleterious substances.

702.3.2 Physical Requirements: When sampled and tested in accordance with standard test methods, the aggregate shall meet the following requirements:

(A) Percentage of Wear: When tested in accordance with ASTM C-131, the percentage of wear shall not exceed 40 percent after 500 revolutions.

(B) Plasticity Index: When tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90, the plasticity index shall not be more than 5.

(C) Liquid Limit: When tested in accordance with AASHTO T-89, the liquid limit shall not be more than 25 percent.

702.3.3 Crushed Material: Crushed material is not required, but may be incorporated in the finished product.

702.3.4 Grading: The aggregate shall conform to the sieve analysis in this specification except that the least dimension of the maximum particle size shall not exceed 2/3 of the compacted thickness of the specified lift being placed.

702.4 DECOMPOSED GRANITE:

Decomposed granite shall be any granitoid igneous rock which has been weathered in place and which has as principal constituents granular fragments of quartz and feldspar. It may also contain fragments of granitic rock not yet broken down into the component minerals. This material shall remain stable when saturated with water. Particles larger than 3 inches, which will not be broken in the process of rolling and tamping during construction, shall not be used.

SECTION ~~701~~703

~~Decomposed granite shall conform to the following requirements:~~

~~(A) When tested in accordance with this specification, not more than 20 percent shall pass the No. 200 mesh sieve.~~

~~(B) The P.I. of material passing the No. 200 sieve prior to testing shall not be less than 3 nor greater than 10. The Plasticity Index shall be tested in accordance with AASHTO T-146 Method A (Wet Preparation), T-89 and T-90.~~

~~**702.4.1 Preparation of Test Specimens:** A quantity of sufficient size to have a dry weight of 15 pounds shall be selected and dried to constant weight at a temperature between 215°F. and 230°F. Fifteen pounds of this material shall then be subjected to 500 revolutions in a Los Angeles abrasion machine, as described in Section 701, except that nothing shall be placed in the drum other than the material to be tested.~~

~~The material that has been subjected to the breakdown shall be tested in accordance with ASTM C-117 to determine the percentage of material finer than a No. 200 mesh sieve by washing.~~

End of Section

Case 11-31

DATE: July 13, 2011

TO: MAG Specification and Details Committee Members

FROM: Brian Gallimore, Materials Working Group/AGC

RE: Section 310-Untreaded Base Course

PURPOSE: Change title to clarify meaning. Addressed construction and evaluation process conflicting.

REVISIONS:
a) Classified compaction guidelines
b) Updated deficiency, corrective action and construction methods

SECTION 310

PLACEMENT AND CONSTRUCTION OF AGGREGATE BASE COURSE

310.1 DESCRIPTION:

Aggregate base course shall comply with Subsection 702 unless the use of a different type of material is specifically authorized in the special provisions.

310.2 PLACEMENT AND CONSTRUCTION:

The compacted lift thickness shall not exceed 6 inches, unless approved by the Engineer. Based on the type of material, type of equipment and compaction methods used, the Contractor may propose a greater lift thickness.

After distributing, the aggregate base course material shall first be watered and then graded to a uniform layer that will net, after compacting, the required thickness. The grading operation shall be continued to such extent as may be necessary to minimize segregation. The quantity of water applied shall be that amount which will assure proper compaction resulting in the density required by Section 310.3.

After placement, the aggregate base course surface shall be true, even and uniform conforming to the grade and cross-section specified. In no case shall the aggregate base course vary by more than ½ inch above or below required grade.

310.3 COMPACTION

The contractor is responsible for providing appropriate equipment and techniques to achieve the compaction results required by this specification. The aggregate base course shall be compacted in lift thicknesses as allowed by Section 310.2.

The laboratory maximum dry density and optimum moisture content for the aggregate base course material shall be determined in accordance with AASHTO T-99. Field 'one-point' maximum dry density and optimum moisture procedures shall only be allowed upon approval of the Engineer.

The in-place density shall be determined in the field by nuclear density testing in accordance with AASHTO T-310 or sandcone density testing in accordance with AASHTO T-191. In the event nuclear density testing is selected, a minimum of one sandcone correlation shall be performed for each 10 nuclear density tests.

A rock correction, to compensate for rock content larger than the #4 or ¾ inch sieves (as required by the laboratory maximum dry density and optimum moisture procedure selected), shall be performed in accordance with AASHTO T-224. Care should be taken to account for the specific gravity of the oversize particles particularly if recycled materials are utilized for aggregate base course. The specific gravity shall be determined in accordance with AASHTO T-85, as applicable.

For roadway construction, one field density test shall be performed per lift per 660 feet per lane. For other aggregate base course applications, a minimum of 1 field density test shall be performed for each 800 square yards. ~~More or less frequent testing may be performed at the approval of the Engineer.~~

Unless otherwise noted in the project plans or project specifications, the moisture content of the aggregate base course at the time of compaction shall be the optimum moisture content +/- 3%.

The following percent compaction is required:

(A) Below asphalt concrete pavement	100%
(B) Below Portland cement concrete pavement, curb & gutter, attached sidewalk, roadway Shoulders, and other areas of the right-of-way subject to vehicular traffic	95%
(C) All other areas not subject to vehicular traffic	85%

Areas which fail initial testing for density and/or moisture content shall be reworked until passing tests for density and/or moisture content are achieved. Lower moisture content percentages at the time of field density testing may be allowed if significant time has passed since the time of compaction and the required density has been achieved.

310.4 THICKNESS AND/OR PLASTICITY INDEX DEFICIENCY:

When in the opinion of the Engineer there is reason to believe that a deficiency in thickness, or an excess of plasticity exists, measurements or samples will be taken in the same pattern as that defined in Section 321. If the base has been covered or it is otherwise impractical to correct the deficiency, the corrective measures in Table 310-1 shall be taken by the Contractor at no additional cost to the Contracting Agency.

TABLE 310-1

THICKNESS AND PLASTICITY DEFICIENCY

Type	Deficiency	Corrective Measure
I	Less than ½ inch of the required thickness	No corrective measure required.
II	½ inch or more but less than 1inch of the required thickness	(1) The contractor may choose to add additional material and rework the grade to meet the specification requirements. (2) The contractor may choose to increase the thickness of asphalt concrete by the amount of the aggregate base course thickness deficiency at no additional cost to the Owner. Required grade shall be met.
III	Thickness deficiency by greater than 1 inch	(1) The contractor will remove the aggregate base course and regrade the subgrade to allow the required aggregate base course layer thickness to be constructed. (2) If grades allow, the contractor may propose that the thickness of asphalt concrete be increased by the amount of the aggregate base course deficiency at no additional cost to the Owner.
IV	A plasticity index of 6 to 7 inclusive	(1) An Engineering Analysis (EA) may be prepared by the contractor to evaluate the expected performance of the aggregate base course layer. The EA may provide mitigation options for the Engineer to consider. If the Engineer accepts the plasticity index as a result of the EA, the material will be accepted at full payment. If the Engineer rejects the EA, the contractor will perform either option 2 or 3

		below. (2) The contractor may choose to reprocess or treat the existing material to bring it within specification limits or remove deficient material from affected area and replace with material complying with the specifications. (3) If grades allow, the contractor may increase the thickness of asphalt concrete by ½-inch at no additional cost to the Owner.
V	A plasticity index of over 7	(1) The contractor may choose to reprocess or treat the existing material to bring it within specification limits or remove deficient material from affected area and replace with material complying with the specifications.

310.4 PAYMENT:

Payment for aggregate base course will be made on the basis of the contract unit price per ton unless an alternate basis of payment is provided in the proposal.

SECTION 310

~~UNTREATED~~ PLACEMENT AND CONSTRUCTION OF AGGREGATE BASE COURSE

310.1 DESCRIPTION:

~~Untreated base, i.e., select or a~~Aggregate base course~~,~~ shall comply with Subsection 702~~.2~~ unless the use of a different type of material is specifically authorized in the special provisions.

310.2 ~~PLACING~~PLACEMENT AND CONSTRUCTION:

The compacted lift thickness shall not exceed 6 inches, unless approved by the Engineer. Based on ~~Aggregate Untreated base course shall be placed in lifts the height of which shall not exceed that which can be effectively compacted depending on~~ the type of material, type of equipment and compaction methods used, the Contractor may propose a greater lift thickness. ~~6 inches or less in compacted thickness may be placednot to exceed 12" in a single layer. Lifts in excess ofand those more than 6 inches in thickness shall be built up in successive layers of approximately equal compacted thickness not to exceed a maximum thickness of 6 inches. . The requirements which follow are applicable to all types of material.~~

After distributing, the aggregate base course material shall first be watered and then ~~immediately~~ graded~~bladed~~ to a uniform layer that will net, after compacting~~rolling~~, the required thickness. ~~If the materials deposited are not uniformly blended together, t~~The grading~~blading~~ operation shall be continued to such extent as may be necessary to minimize~~eliminate~~ segregation. The quantity of water applied shall be that amount which will assure proper compaction resulting in the~~a relative~~ density ~~of not less than 100 percent as determined under Section 301as~~ required by Section 310.3.

~~Care shall be exercised in connection with watering operations to avoid wetting the subgrade or any lower base course to detrimental extent.~~

~~Upon completion~~After placement, the aggregate base course surface shall be true, even and uniform conforming to the grade and cross-section specified.

In no case shall the ~~Untreated~~a~~A~~ggregate base course ~~may~~ vary by~~not~~ more than ½ inch above or below required grade. ~~and cross-section.~~

310.3 COMPACTION

The contractor is responsible for providing appropriate equipment and techniques to achieve the compaction results required by this specification. The aggregate base course shall be compacted in lift thicknesses as allowed by Section 310.2.

~~The AASHTO procedures described in the section will be utilized unless the Engineer allows the corresponding ARIZ or ASTM procedure to be substituted.~~ The laboratory maximum dry density and optimum moisture content for the aggregate base course material shall be determined in accordance with ~~one of the following procedures: ARIZ 245, AASHTO T 99, or ASTM D698~~AASHTO T-99. Field 'one-point' maximum dry density and optimum moisture procedures shall only be allowed upon approval of the E~~e~~ngineer.

The in-place density shall be determined in the field by nuclear density testing in accordance with AASHTO T-310 ~~sandcone density testing and/or nuclear density testing. Sandcone density testing shall be performed in accordance with one of the following procedures: ARIZ 238, AASHTO T191, or ASTM D1556 and/~~or~~.~~ sandcone density testing in accordance with AASHTO T-191~~N~~nuclear density testing shall be performed in accordance with ARIZ 235, AASHTO T310, or ASTM D6938~~. In the event nuclear density testing is selected, a minimum of one sandcone correlation shall be performed for each 10 nuclear density tests.

A rock correction, to compensate for rock content larger than the #4 or ¾ inch sieves (as required by the laboratory maximum dry density and optimum moisture procedure selected), shall be performed in accordance with ~~one of the following procedures: ARIZ 227, AASHTO T224, or ASTM D4718~~AASHTO T-224. Care should be taken to account for the specific gravity of the oversize particles ~~especially~~particularly if recycled materials are utilized for aggregate base course. The specific gravity shall be determined –in accordance with ~~the one of the following procedures: ARIZ 210, AASHTO T85, or ASTM C127~~AASHTO T-85, as applicable.~~(How can you run C-127 on RAP or Asphalt Millings~~

~~One field density test shall be performed on each lift of aggregate base course. –~~For roadway construction, one field density test shall be performed ~~for~~per lift per~~ each~~ 6650 feet per lane~~ width (Is this consistent)~~. For other aggregate base course applications, a minimum of 1 field density test shall be performed for each 800 square yards. ~~More or less frequent testing may be performed at the approval of the Engineer.~~

Unless otherwise noted in the project plans or project specifications, the moisture content of the aggregate base course at the time of compaction shall be the optimum moisture content ~~to~~ +/- ~~2~~3% ~~of optimum moisture content~~.

SECTION 310

The following percent compaction is required:

(A) Below asphalt concrete pavement 100%

(B) Below Portland cement concrete pavement, curb & gutter, attached sidewalk, roadway Shoulders, and other areas of the right-of-way subject to vehicular traffic 95%

(C) ~~Below detached sidewalk or other flatwork~~All other areas not subject to vehicular traffic ~~85~~85~~90~~%

Areas which fail initial ~~field density~~ testing for density and/or moisture content shall be reworked until passing tests for density and/or moisture content are achieved. L~~l~~ower moisture content percentages at the time of field density testing may~~-~~ be allowed if significant time has passed since the time of compaction and the required density has been achieved.

310.~~43~~ THICKNESS AND/OR PLASTICITY INDEX DEFICIENCY:

When in the opinion of the Engineer there is reason to believe that a deficiency in thickness, or an excess of plasticity exists, measurements or samples will be taken in the same pattern as that defined in Section 321. If the base has been covered or it is otherwise impractical to correct the deficiency, the corrective measures in Table 310-1 shall be taken by the Contractor at no additional cost to the Contracting Agency.

TABLE 310-1

THICKNESS AND PLASTICITY DEFICIENCY

Type	Deficiency	Corrective Measure
I	Less than ½ inch of the required thickness	No corrective measure required.
II	½ inch or more but less than 1inch of the required thickness	~~Place asphalt chip seal using precoated chips in accordance with Section 330 for the full roadway width over the area involved but for not less than 660 feet or one City block in length.~~(1) The contractor may choose to add additional material and rework the grade to meet the specification requirements. ~~An Engineering Analysis (EA) shall be prepared by the contractor to evaluate the expected performance of the reduced aggregate base course layer. The EA may provide mitigation options for the Engineer to consider. If the Engineer accepts the in-place thickness as a result of the EA, a penalty of $1/ton shall be applied to the subject aggregate base coursethe Contractor shall reimburse the Agency for reduced aggregate base course quantities.~~ (2) The contractor may choose to ~~i~~increase the thickness of asphalt concrete by the amount of the aggregate base course thickness deficiency at no additional cost to the Owner. Required grade shall be met.
III	~~1 inch or more in t~~Thickness deficiency by greater than 1 inch	~~Place an additional asphalt concrete overlay, a 9.5 mm mix, of ½ the thickness of the deficiency in thickness for the full roadway width over the area involved, not less than 660 feet or one City block in length.~~(1) The contractor will remove the ~~A~~aggregate base course ~~removed~~ and regrade the sub~~b~~grade ~~regraded~~ to

		allow the required aggregate base course layer thickness to be constructed. (2) If grades allow, the ~~Engineer~~ contractor may propose that~~allow~~ the thickness of asphalt concrete ~~to~~ be increased by the amount of the aggregate base course deficiency at no additional cost to the Owner.
IV~~III~~	A plasticity index of 6 to 7 inclusive~~*~~	~~Place an asphalt concrete overlay ½ inch in thickness over the same total area as required for Type I and II.~~ (1) An Engineering Analysis (EA) ~~shall~~may be prepared by the contractor to evaluate the expected performance of the aggregate base course layer. The EA may provide mitigation options for the Engineer to consider. If the Engineer accepts the plasticity index as a result of the EA, the material will be accepted at full payment. If the Engineer rejects the EA, the contractor will perform either option 2 or 3 below. (2) The contractor may choose to reprocess or treat the existing material to bring it within specification limits or remove deficient material from affected area and replace with material complying with the specifications. (3) If grades allow, the contractor may increase the thickness of asphalt concrete by ½-inch at no additional cost to the Owner.~~If the Engineer accepts the in-place thickness as a result of the EA, a penalty of $1/ton shall be applied to the subject aggregate base course.~~
~~I~~V	A plasticity index of over 7~~*~~	(1) The contractor may choose to reprocess or treat the existing material to bring it within specification limits or ~~R~~remove deficient material from affected area and replace with material complying with the specifications.

~~* The plasticity index shall be in accordance with AASHTO T 146 Method A (wet preparation), T 89 and T 90.~~

310.4 PAYMENT:

Payment for aggregate ~~untreated~~ base course will be made on the basis of the contract unit price per ton unless an alternate basis of payment is provided in the proposal.

Effect of Fines Content and Plasticity on Aggregate Base Course Properties
MAG Working Group White Paper (8/17/11)

1.0 Discussion

Unbound granular aggregate road base is constructed to prevent pumping and volume change under load, have favorable drainage characteristics, and increase the structural capacity of the pavement section. This material derives its high stability, stiffness and strength from particle interlock and inter-particle friction. These engineering properties are developed from tight sand and gravel gradation ranges with particle size distributions that are well-graded and dense (Siswosoebrotho, et al, 2005).

Drainage capability is generally related to material permeability – a property that can conflict with the need for a rigid, dense section. In many regions the need for good drainage is essential to prevent volume change relating to freeze and thaw action. Moisture contents are kept very low to prevent temperature-related degradation of the aggregate base strength. Plastic fines are kept low to minimize water content, mitigate swell potential, and prevent reduction of inter-particle friction capacity.

Achieving required field compaction densities can be difficult with unbound granular aggregates having low percentages of fines (the percent passing the No. 200 sieve). However, the need for fines content must be balanced with the strength of the mix. Yoder and Witczak (1975) found that the effect of plasticity of the binder in aggregate blends has very little effect on strength when the percent passing the No. 30 sieve is relatively low. Strength is decreased as the amount of plastic binder is increased.

To determine an optimal mix for these competing properties, the stability of unbound aggregate road base mix used in flexible pavement design and construction is normally determined from the material resilient modulus value by either the California Bearing Ration test (CBR) or the resilient value (R-value) test. Compacted cylindrical molds are soaked and loaded to simulate a prototype pavement base in use. Structural coefficients for use in pavement design are estimated from resilient modulus values. ADOT's Materials Preliminary Engineering and Design Manual (ADOT, 1989) gives the relationship between R-value and base course structural coefficient in their Figure 202.02-5.

According to the ADOT manual, aggregate base course with an R-value of 79 or higher has a structural coefficient value of 0.14. For subbase material with an R-value of 70 to 78, the assigned structural coefficient is 0.11. For both materials, an R-value below 63 is considered subgrade.

Extensive regression and correlation analyses have been performed by ADOT using fines gradation, Plasticity Index (PI), liquid limit and Sand Equivalent to predict R-values of a wide range of soils and aggregates. This is done to provide a rapid method to validate index properties needed for pavement design and field construction management. The ADOT guide notes that these correlated index properties provide reasonable values when the following relationship between gradation and PI is used:

$$\log (\text{R-value at 300 psi}) = 2.0 - 0.006\,(\text{Percent passing No. 200 sieve}) - 0.017\,(\text{PI})$$

The ADOT manual provides Table 202.02-3 in their manual to represent the range of PI and gradation values developed from this equation.

MAG specifications limit aggregate base course PI to 5 and amount passing the No. 200 sieve to 12% (by weight). This correlates to an R-value of 70, or a structural number of 0.11 (when using the ADOT manual figures) and is consistent with a standard subbase material. MAG agencies use various aggregate base course structural values for their pavement design, ranging from 0.08 to 0.12, which is reasonably consistent with an R-value of 70 and the specified MAG PI and gradation limits for aggregate base course.

2.0 Application in Specifications

Most granular aggregate road base specifications limit PI to either 5 or 6 and the fines passing the No. 200 sieve from 8 to 15 percent (by weight). It is important to understand that these values vary based on region, local environmental conditions and the source/type of clay fines (swell potential). Source rock for aggregates also plays a major role in determining these index property limits.

The use of index properties for specifying ABC does not minimize the importance of the resilient modulus value and the testing of this engineering property. Index test are just that – a simple approximation of engineering properties. Direct testing of engineering properties gives a higher level of confidence than correlated index tests.

3.0 Recommendations

For agencies within Maricopa County, the importance of fines within aggregate base course is directly related to material stability, stiffness and strength. Base materials are rarely subject to freeze-thaw conditions and fines from local aggregate sources have minimal swell characteristics.

It is recommended that current plasticity index and gradation limits within MAG Section 702 remain as noted. Additional R-value referee testing should be included in the MAG section where there is the aggregate base mix has sufficient stability even though the index test values show the material in excess of the specified limits. The minimum R-value for acceptance should be 70, based on the average of 3 tests per 1000 tons, as long as no more than one test gives a low bound R-value between 70 and 67.

Other tests associated with source aggregate rock durability and angularity should remain.

This change gives the opportunity to use a wider range of aggregates blends with aggregate base course, taking advantage of the unique nature of various rock sources and offering the potential for improved placement with higher binder contents.

4.0 References

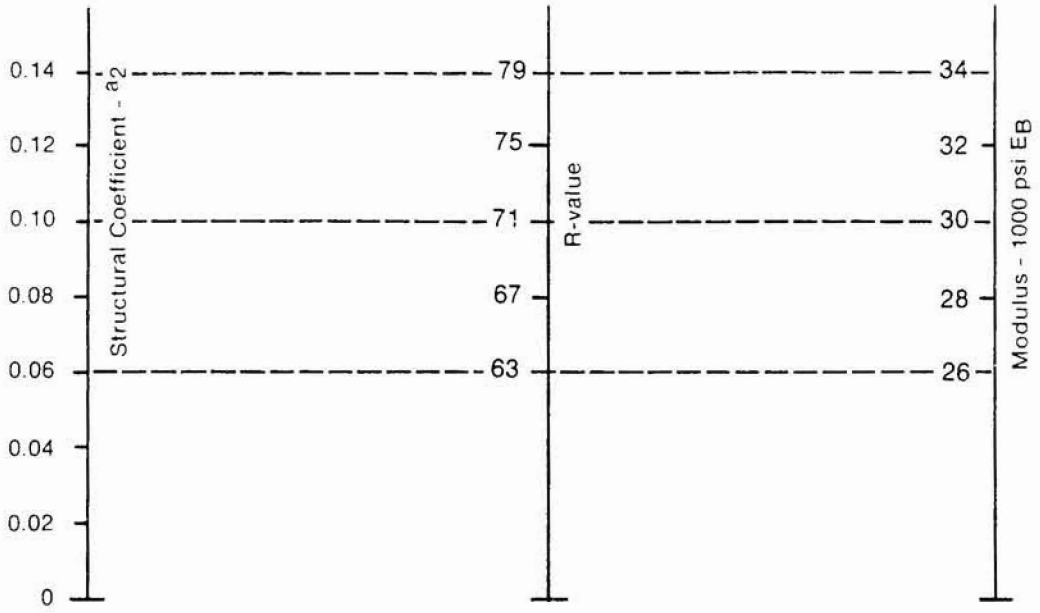
Arizona Department of Transportation Highways Department Materials Section (1989) Materials Preliminary Engineering and Design Manual, 3rd Ed.

Siswosoebrotho, B. I., Widodo, P., and Agusta, E. (2005) The Influence of Fines Content and Plasticity on the Strength and Permeabiity of Aggregate for Base Course Material, Proc: Eastern Asia Society for Transportation Studies, Vol. 5, pp. 845-856.

Yoder, E.J. and Witczak, M.W. (1975) Principles of Pavement Design, 2nd Ed., John Wiley & Sons, Inc., New York

FIGURE 202.02-5

Chart for estimating structural layer coefficient of unbound granular base determined by R-value or elastic modulus.



$a_2 = -0.2550 + 0.0050\ (R\text{-}Value)$

$a_2 = -0.20 + 1.00X10^{-5}(E_B)$

TABLE 202.02-3

BODY OF TABLE IS R-VALUE AT 300 psi EXUDATION PRESSURE

PERCENT PASSING #200 SIEVE

PI	0	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90	93	96
0	100	96	92	88	85	81	78	75	72	69	66	63	61	58	56	54	52	49	47	45	44	42	40	39	37	35	34	33	31	30	29	28	27
1	96	92	89	85	81	78	75	72	69	66	64	61	58	56	54	52	50	48	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26
2	92	89	85	82	78	75	72	69	66	64	61	59	56	54	52	50	48	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26	25
3	89	85	82	79	75	72	69	67	64	61	59	56	54	52	50	48	46	44	42	40	39	37	36	34	33	32	30	29	28	27	26	25	24
4	86	82	79	76	72	70	67	64	61	59	56	54	52	50	48	46	44	42	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23
5	82	79	76	73	70	67	64	62	59	57	54	52	50	48	46	44	42	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22
6	79	76	73	70	67	64	62	59	57	54	52	50	48	46	44	42	41	39	37	36	35	33	32	30	29	28	27	26	25	24	23	22	21
7	76	73	70	67	64	62	59	57	55	52	50	48	46	44	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20
8	73	70	67	65	62	59	57	55	52	50	48	46	44	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19
9	70	67	65	62	60	57	55	53	50	48	46	45	43	41	39	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	19
10	68	65	62	60	57	55	53	51	49	47	45	43	41	39	38	36	35	33	32	31	30	28	27	26	25	24	23	22	21	20	19	19	18
11	65	62	60	57	55	53	51	49	47	45	43	41	40	38	36	35	33	32	31	30	28	27	26	25	24	23	22	21	20	20	19	18	17
12	63	60	58	55	53	51	49	47	45	43	41	40	38	36	35	34	32	31	30	28	27	26	25	24	23	22	21	20	20	19	18	17	17
13	60	58	55	53	51	49	47	45	43	41	40	38	37	35	34	32	31	30	29	27	26	25	24	23	22	21	20	20	19	18	17	17	16
14	58	55	53	51	49	47	45	43	41	40	38	37	35	34	32	31	30	29	27	26	25	24	23	22	21	21	20	19	18	17	17	16	15
15	56	53	51	49	47	45	43	42	40	38	37	35	34	32	31	30	29	27	26	25	24	23	22	21	21	20	19	18	17	17	16	15	15
16	53	51	49	47	45	43	42	40	38	37	35	34	33	31	30	29	28	26	25	24	23	22	21	21	20	19	18	17	17	16	15	15	14
17	51	49	47	45	44	42	40	38	37	35	34	33	31	30	29	28	26	25	24	23	22	22	21	20	19	18	17	17	16	15	15	14	14
18	49	47	45	44	42	40	39	37	35	34	33	31	30	29	28	27	25	24	23	22	22	21	20	19	18	18	17	16	15	15	14	14	13
19	48	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26	24	23	23	22	21	20	19	18	18	17	16	16	15	14	14	13	13
20	46	44	42	40	39	37	36	34	33	31	30	29	28	27	26	25	24	23	22	21	20	19	18	18	17	16	16	15	14	14	13	13	12
21	44	42	40	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22	21	20	19	18	18	17	16	16	15	14	14	13	13	12	12
22	42	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22	21	20	19	18	18	17	16	16	15	14	14	13	13	12	12	11
23	41	39	37	36	34	33	32	30	29	28	27	26	25	24	23	22	21	20	19	18	18	17	16	16	15	14	14	13	13	12	12	11	11
24	39	37	36	35	33	32	30	29	28	27	26	25	24	23	22	21	20	19	19	18	17	16	16	15	14	14	13	13	12	12	11	11	10
25	38	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	19	18	17	16	16	15	14	14	13	13	12	12	11	11	10	10
26	36	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	19	18	17	16	16	15	15	14	13	13	12	12	11	11	10	10	10
27	35	33	32	31	29	28	27	26	25	24	23	22	21	20	19	19	18	17	16	16	15	15	14	13	13	12	12	11	11	10	10	10	9
28	33	32	31	30	28	27	26	25	24	23	22	21	20	19	19	18	17	17	16	15	15	14	13	13	12	12	11	11	10	10	10	9	9
29	32	31	30	28	27	26	25	24	23	22	21	20	20	19	18	17	17	16	15	15	14	13	13	12	12	11	11	10	10	10	9	9	9
30	31	30	28	27	26	25	24	23	22	21	20	20	19	18	17	17	16	15	15	14	13	13	12	12	11	11	11	10	10	9	9	9	8
31	30	29	27	26	25	24	23	22	21	20	20	19	18	17	17	16	15	15	14	14	13	12	12	11	11	11	10	10	9	9	9	8	8
32	29	27	26	25	24	23	22	21	21	20	19	18	17	17	16	15	15	14	14	13	12	12	11	11	11	10	10	9	9	9	8	8	8
33	27	26	25	24	23	22	21	21	20	19	18	17	17	16	15	15	14	14	13	13	12	12	11	11	10	10	9	9	9	8	8	8	7
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36	24	23	22	22	21	20	19	18	18	17	16	15	15	14	14	13	13	12	12	11	11	10	10	9	9	9	8	8	8	7	7	7	6
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39	22	21	20	19	18	18	17	16	16	15	14	14	13	13	12	12	11	11	10	10	9	9	9	8	8	8	7	7	7	7	6	6	6
40	21	20	19	18	18	17	16	16	15	14	14	13	13	12	12	11	11	10	10	10	9	9	8	8	8	7	7	7	7	6	6	6	6
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44	18	17	16	16	15	15	14	13	13	12	12	11	11	10	10	10	9	9	8	8	8	7	7	7	7	6	6	6	6	5	5	5	5
46	17	16	15	15	14	13	13	12	12	11	11	10	10	10	9	9	9	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4
48	15	15	14	13	13	12	12	11	11	11	10	10	9	9	9	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4
50	14	14	13	12	12	11	11	11	10	10	9	9	9	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4
52	13	13	12	12	11	11	10	10	9	9	9	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3
54	12	12	11	11	10	10	9	9	9	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3
56	11	11	10	10	9	9	9	8	8	8	7	7	7	7	6	6	6	6	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3
58	10	10	10	9	9	8	8	8	7	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3
60	10	9	9	8	8	8	7	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3
62	9	8	8	8	7	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2
64	8	8	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2
66	8	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2	2	2
68	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
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76	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1