An Aggregate Asphalt Absorption Calculator

A Tool for Economic Evaluation

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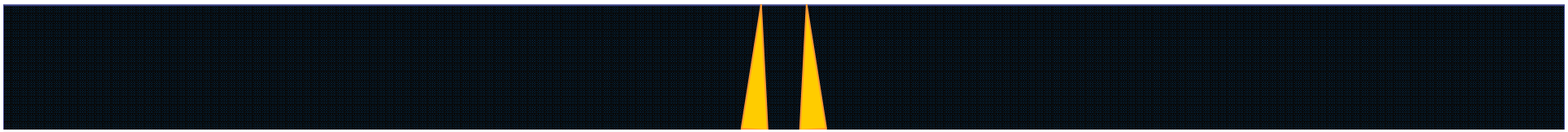
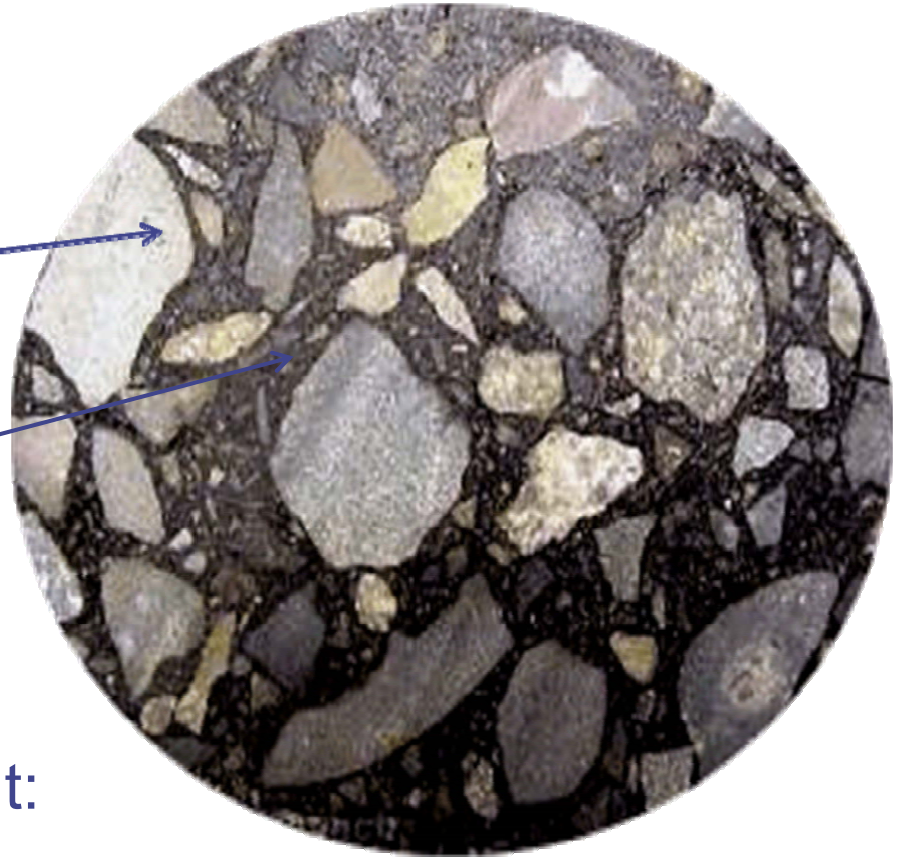
Ohio Transportation Engineering Conference – 2011



Asphalt Pavement



Asphalt pavement by weight:

- Aggregate ≈ 92% - 95%
- Binder ≈ 5% - 8%

Aggregate Cost / Ton

$12.00 to
$25.00
Per Ton

Monthly Price Indices for Asphalt Cement

Month	Price Indices		
	PG 64-22	PG 70-22M	PG 76-22M
	$/Ton	$/Ton	$/Ton
1/1/2011	445	515	569
2/1/2011	464	534	585
3/1/2011	472	550	600
4/1/2011	512	595	642
5/1/2011	561	656	702
6/1/2011	598	702	758
7/1/2011	593	697	746
8/1/2011	578	674	722
9/1/2011	574	675	722

$574.00 per Ton

Example taken from: Louisiana DOT:

http://www.dotd.louisiana.gov/lettings/lac_price_index/priceindices.asp

≈ 95% at $20 per ton

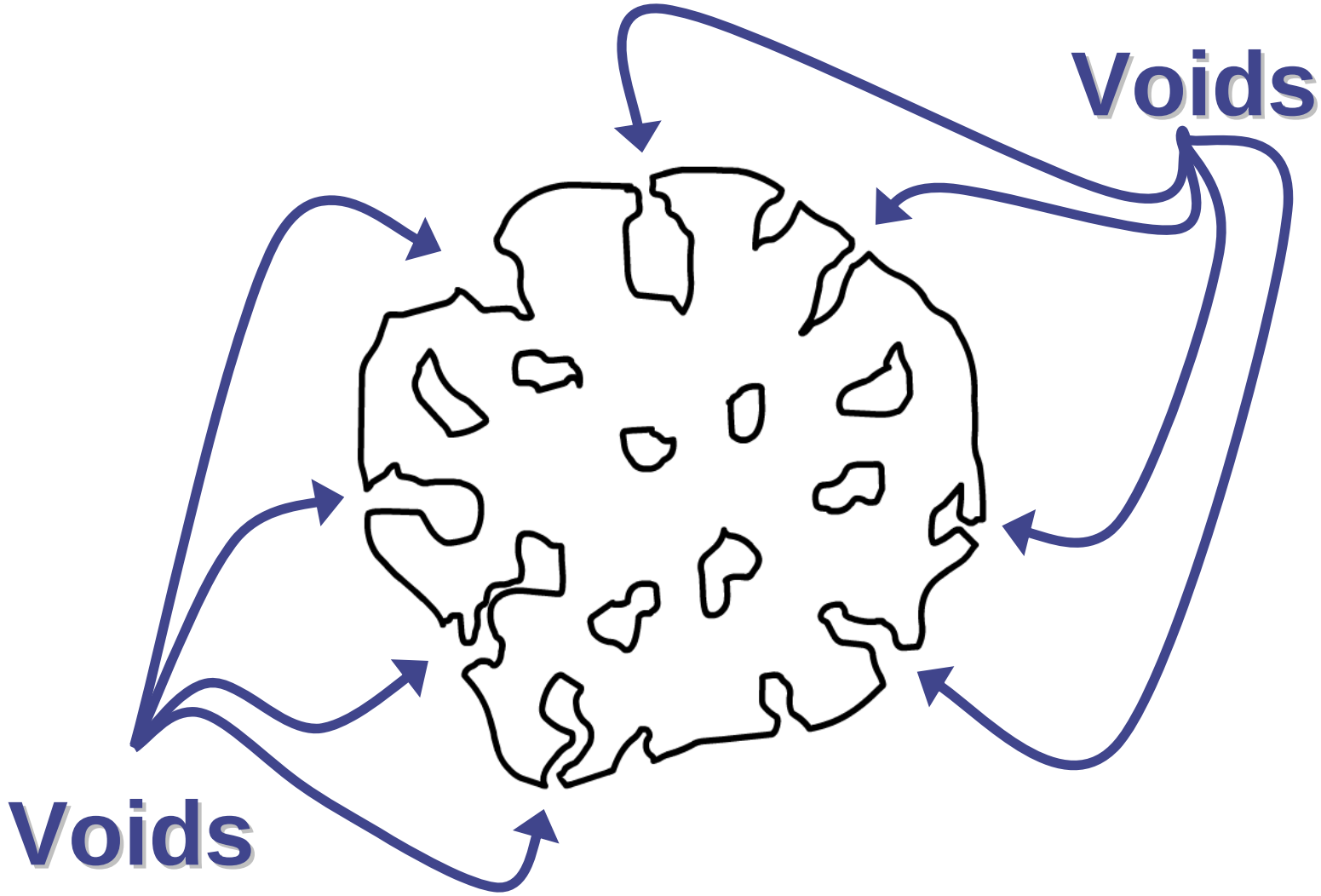
≈ 5% at ≈ $550.00 per ton

Asphalt Pavement Material Cost:

- Aggregate ≈ 40%
- Binder ≈ 60%

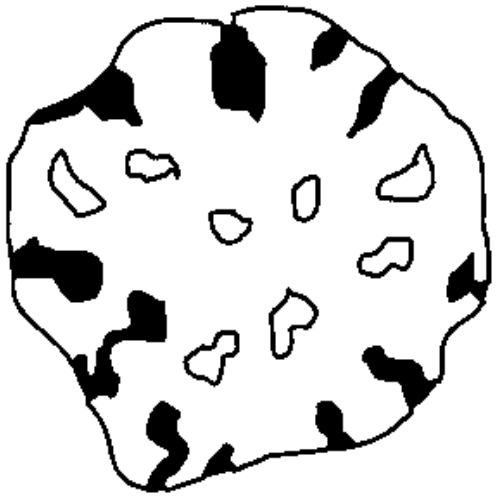
Coarse Limestone Aggregate

Limestone – Up Close and Personal



Interpretation of Limestone Under Magnification

Asphalt cement binder that is taken up by the voids offers no benefit to the asphalt pavement…



… but can significantly effect the cost of the mix, and is particularly important when comparing the economics of alternate aggregate sources.

Asphalt Absorption

Amount of asphalt absorption depends on the aggregate:

- Pore void fraction
- Pore void size
- Size
- Surface roughness
- Chemical composition
- Mineral composition

Asphalt Absorption ≠ Water Absorption

$$\text{Water Absorption} = \frac{\text{SSD - OD}}{\text{OD}}$$

1. Liquid asphalt is less viscous than water.
2. Aggregate asphalt absorption should be determined by lab testing.
3. Rules of thumb for asphalt absorption may not be adequate for economic comparisons.
4. Asphalt absorption is best determined by lab testing

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American Society for Testing and Materials

D-4469

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
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T-85

ASTM INTERNATIONAL

Designation: D4469 – 01 (Reapproved 2006)

Standard Practice for Calculating Percent Asphalt Absorption by the Aggregate in an Asphalt Pavement Mixture[1]

This standard is issued under the fixed designation D4469; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers equations for calculating percent asphalt absorption by the aggregate in an asphalt paving mixture, expressed as percent of the oven-dry mass of the aggregate in the paving mixture. This calculation is based on measured values for components and properties of an oven-dry asphalt paving mixture.

1.2 *This practice does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C127 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
C128 Test Method for Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
C136 Test Method for Sieve Analysis of Fine and Coarse Aggregates
D1560 Test Methods for Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus
D2041 Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
D2172 Test Methods for Quantitative Extraction of Bitumen From Bituminous Paving Mixtures
D3289 Test Method for Density of Semi-Solid and Solid Bituminous Materials (Nickel Crucible Method)

3. Summary of Test Method

3.1 The percent asphalt absorption for an oven-dry paving mixture (expressed as percent of the oven-dry mass of the total aggregate in the paving mixture) can be calculated by means of equations in which measured values for the theoretical maximum specific gravity of an oven-dry paving mixture, its asphalt content (expressed either as percent of the total mass of a sample of oven-dry paving mixture, or as percent of the mass of oven-dry aggregate in a sample of oven-dry paving mixture), the apparent specific gravity of the asphalt and the weighted average ASTM bulk specific gravity of the oven-dry total aggregate in the paving mixture (Note 1), has been substituted.

NOTE 1—Whenever it is referred to in this practice, the phrase, "weighted average ASTM oven-dry bulk specific gravity of the aggregate," refers to the weighted average of the ASTM oven-dry bulk specific gravities of the coarse and fine aggregates as determined by Test Methods C127 and C128. The fine aggregate ordinarily includes the mineral dust portion of the fine aggregate that passes the No. 200 sieve. The weighted average ASTM oven-dry bulk specific gravity of the total aggregate is to be calculated by means of the equation given in the calculation section of Test Method C127.

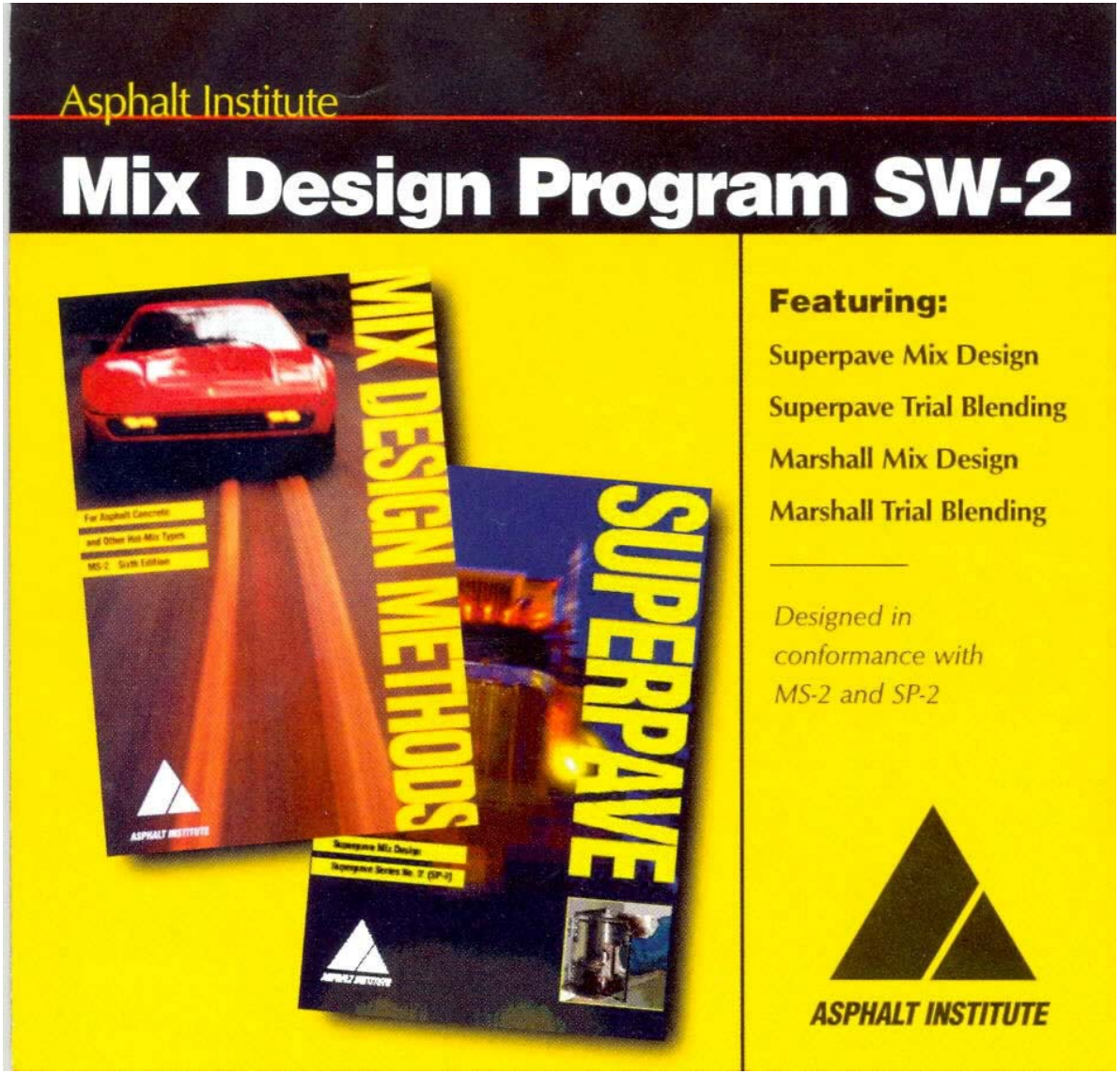
4. Significance and Use

4.1 The amount of asphalt absorbed by the aggregate contributes little or nothing to the durability of an asphalt pavement in service other than possibly providing greater resistance to stripping in the presence of water.

4.2 Percent asphalt absorption can be an indicator of changes that may occur in plant mix production during construction.

Aggregate Asphalt Absorption - Laboratory Testing				
Quarry	Bulk Specific Gravity	Water Absorption	Asphalt Absorption	Asphalt-to-Water Ratio
A	2.773	0.71	0.66	93%
B	2.557	2.50	2.50	100%
C	2.634	0.96	0.66	69%
D	2.534	1.68	1.33	79%

Asphalt Mix Design



CALCULATOR – Impact of Asphalt Absorption on Cost

A Comparison Calculator of Coarse Aggregate Absorption's Effect on Overall Cost of an Asphalt Mix

Liquid Asphalt Parameters

Liquid Asphalt Cement (AC) Unit:	Tons
Unit Cost per ton of AC:	
Percent of AC required per Mix Design:	%
Percent of Coarse Aggregate used in the Mix:	%

Typically between 3.5% and 7% of total wt. of mix

Aggregate A Parameters

Aggregate A Source:	Stone A
Reported Water Absorption:	%
Was **Aggregate A** Laboratory Tested to Determine the Actual AC Absorption Value?	No
Assumed Ratio of AC Absorption to Water Absorption:	%

Aggregate B Parameters

Aggregate B Source:	Stone B
Reported Water Absorption:	%
Was **Aggregate B** Laboratory Tested to Determine the Actual AC Absorption Value?	No
Assumed Ratio of AC Absorption to Water Absorption:	%

Percents below represent the percent of AC per ton of HMA

Percent AC abosrobed by Aggregate A:	0.00 %	Percent AC abosrobed by Aggregate B:	0.00
Total AC % req. including absorption:	0.00 %	Total AC % req. including absorption:	0.00

A Mix using Aggregate A Requires 0 pounds more AC per ton of HMA than a Mix using Aggregate A

Impact on Cost due to Aggregate Absorption of AC

Cost of Additional AC Absorbed by Aggregate A per Ton of HMA = $0.00

Cost Impact of Asphalt Absorption (Coarse Agg)

A Comparison Calculator of Coarse Aggregate Absorption's Effect on Overall Cost of an Asphalt Mix

Liquid Asphalt Parameters

Liquid Asphalt Cement (AC) Unit:	Tons	
Unit Cost per ton of AC:	$ 550.00	
Percent of AC required per Mix Design:	6.0 %	Typically between 3.5% and 7% of total wt. of mix
Percent of Coarse Aggregate used in the Mix:	58.0 %	Must not exceed 94%; Typically less than 60%

Aggregate A Parameters

Aggregate A Source:	Stone A
Reported Water Absorption:	0.71 %
Was **Aggregate A** Laboratory Tested to Determine the Actual AC Absorption Value?	No
Assumed Ratio of AC Absorption to Water Absorption:	50 %

Aggregate B Parameters

Aggregate B Source:	Stone B
Reported Water Absorption:	2.50 %
Was **Aggregate B** Laboratory Tested to Determine the Actual AC Absorption Value?	No
Assumed Ratio of AC Absorption to Water Absorption:	50.00 %

Percents below represent the percent of AC per ton of HMA

Percent AC abosrobed by Aggregate A:	0.21 %	Percent AC abosrobed by Aggregate B:	0.73
Total AC % req. including absorption:	6.21 %	Total AC % req. including absorption:	6.73

A Mix using Aggregate B Requires 10.38 pounds more AC per ton of HMA than a Mix using Aggregate A

Impact on Cost due to Aggregate Absorption of AC

Cost of Additional AC Absorbed by Aggregate B per Ton of HMA = $2.85

Cost Impact of Asphalt Absorption (Coarse Agg)

A Comparison Calculator of Coarse Aggregate Absorption's Effect on Overall Cost of an Asphalt Mix

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Liquid Asphalt Parameters

Liquid Asphalt Cement (AC) Unit:	Tons	
Unit Cost per ton of AC:	$ 550.00	
Percent of AC required per Mix Design:	6.0 %	Typically between 3.5% and 7% of total wt. of mix
Percent of Coarse Aggregate used in the Mix:	58.0 %	Must not exceed 94%; Typically less than 60%

Aggregate A Parameters

Aggregate A Source:	Stone A
Reported Water Absorption:	%
Was **Aggregate A** Laboratory Tested to Determine the Actual AC Absorption Value?	Yes
Actual AC Absorption Percent:	2.5 %

Aggregate B Parameters

Aggregate B Source:	Stone B
Reported Water Absorption:	%
Was **Aggregate B** Laboratory Tested to Determine the Actual AC Absorption Value?	Yes
Actual AC Absorption Percent:	0.71 %

Percents below represent the percent of AC per ton of HMA

Percent AC abosrobed by Aggregate A:	1.45 %	Percent AC abosrobed by Aggregate B:	0.41
Total AC % req. including absorption:	7.45 %	Total AC % req. including absorption:	6.41

A Mix using Aggregate A Requires 20.76 pounds more AC per ton of HMA than a Mix using Aggregate B

Impact on Cost due to Aggregate Absorption of AC

Cost of Additional AC Absorbed by Aggregate A per Ton of HMA = $5.71

Example – for Illustration Only

HMA Producer:

- Local supply of sand
- Purchases coarse aggregate at a delivered cost of $25.00/ton

New supplier propose:

- Local supply of sand
- Provide coarse aggregate at a delivered cost of $20.00/ton

Example – for Illustration Only

A Comparison Calculator of Coarse Aggregate Absorption's Effect on Overall Cost of an Asphalt Mix

CARMEUSE NATURAL CHEMICALS

Liquid Asphalt Parameters

Liquid Asphalt Cement (AC) Unit:	Tons	
Unit Cost per ton of AC:	$ 550.00	
Percent of AC required per Mix Design:	6.0 %	Typically between 3.5% and 7% of total wt. of mix
Percent of Coarse Aggregate used in the Mix:	55.0 %	Must not exceed 94%; Typically less than 60%

Aggregate A Parameters

Aggregate A Source:	Stone A
Reported Water Absorption:	0.71 %
Was **Aggregate A** Laboratory Tested to Determine the Actual AC Absorption Value?	Yes
Actual AC Absorption Percent:	0.71 %

Aggregate B Parameters

Aggregate B Source:	Stone B
Reported Water Absorption:	2.50 %
Was **Aggregate B** Laboratory Tested to Determine the Actual AC Absorption Value?	Yes
Actual AC Absorption Percent:	2.50 %

Percents below represent the percent of AC per ton of HMA

Percent AC abosrobed by Aggregate A:	0.39 %	Percent AC abosrobed by Aggregate B:	1.38
Total AC % req. including absorption:	6.39 %	Total AC % req. including absorption:	7.38

A Mix using Aggregate B Requires 19.69 pounds more AC per ton of HMA than a Mix using Aggregate A

Impact on Cost due to Aggregate Absorption of AC

Cost of Additional AC Absorbed by Aggregate B per Ton of HMA = $5.42

Mix A

$Binder_A$ + Agg A + ~~Sand~~

$Binder_A$ + Agg A

(.0639 x $550) + .(5461 x $25)

$35.14 + $13.65

Mix B

$Binder_B$ + Agg B + ~~Sand~~

$Binder_B$ + Agg B

(.0738 x $550) + .(5362 x Agg B)

$40.59 + .(5362 x Agg B)

Agg B = $15.90 per ton

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