



# Practical 2D image analysis software and standardization

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# Matlab – based software

The screenshot shows a software window titled "GV\_E10\_58-28\_USH53\_Chip\_19mm\_120C\_600KPa\_2.26%-2 (2).tif". The interface includes a toolbar with standard image manipulation icons. On the left, a vertical menu lists the following steps:

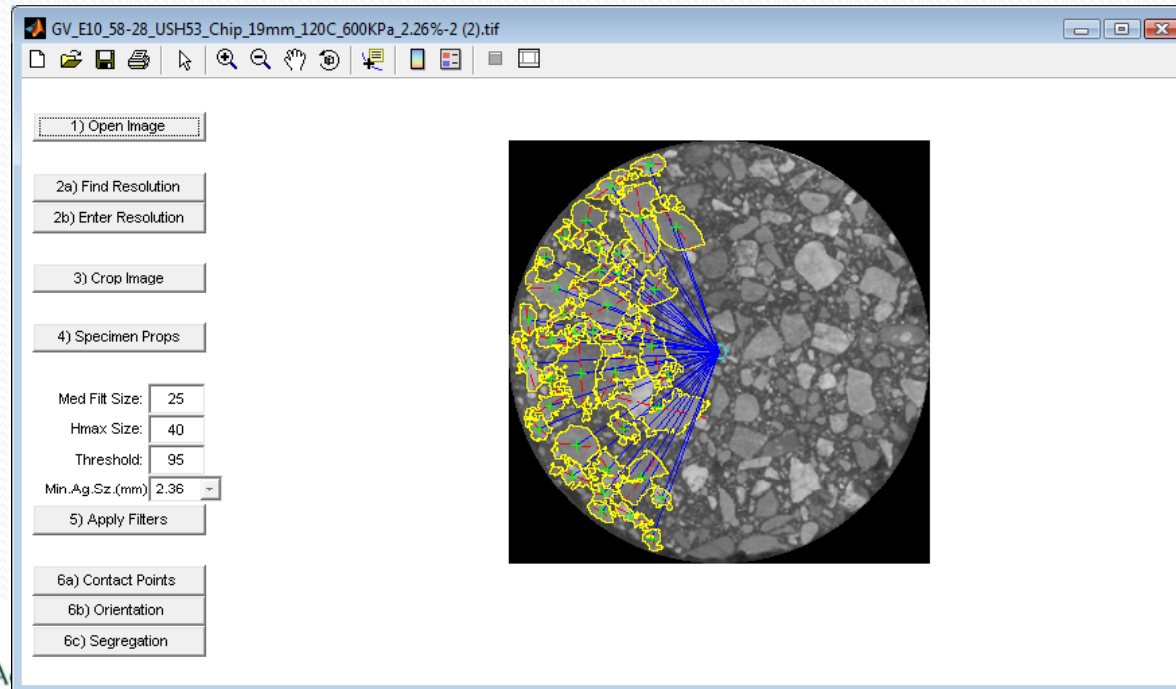
- 1) Open Image
- 2a) Find Resolution
- 2b) Enter Resolution
- 3) Crop Image
- 4) Specimen Props
- 5) Apply Filters
- 6a) Contact Points
- 6b) Orientation
- 6c) Segregation

Parameters for step 4 are displayed:

- Med Filtr Size: 25
- Hmax Size: 40
- Threshold: 95
- Min.Ag.Sz.(mm): 2.36

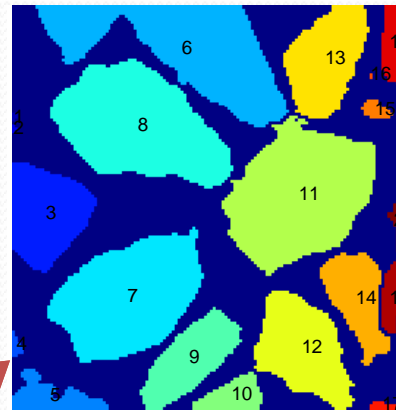
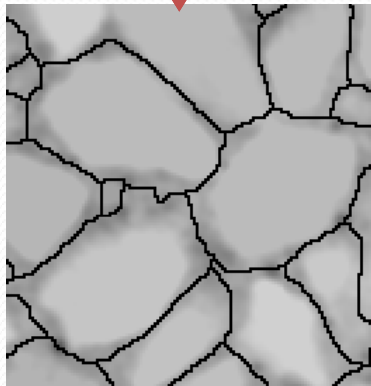
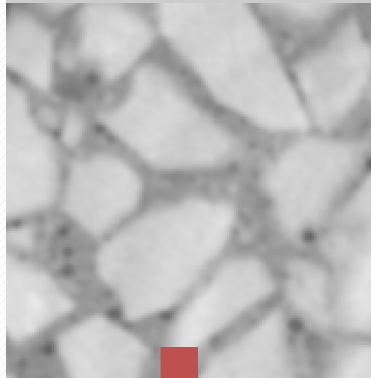
A large blue arrow points from the menu to the central image. The image is a circular grayscale micrograph of a chip surface. It features yellow outlines around various particles, with blue lines connecting these outlines to a central point, representing contact points. The text "(1) Image processing" is written in red, and "(2) Image analysis" is written in blue, with brackets indicating which menu items correspond to each stage.

# Systematic diagram of image processing & analysis software

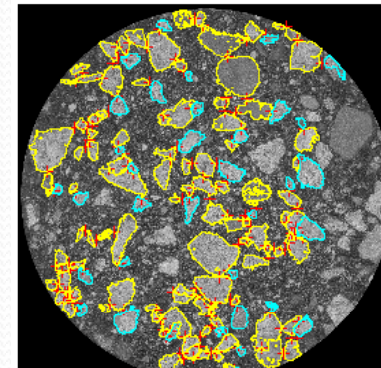


# Components of the software

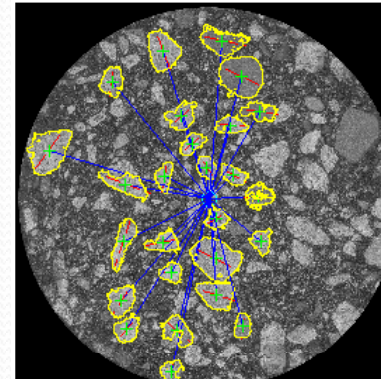
## (1) Image **processing**



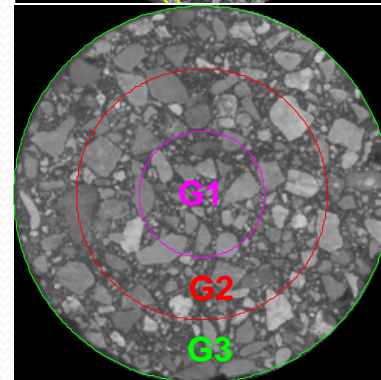
## (2) Image **analysis**



**Contact points**

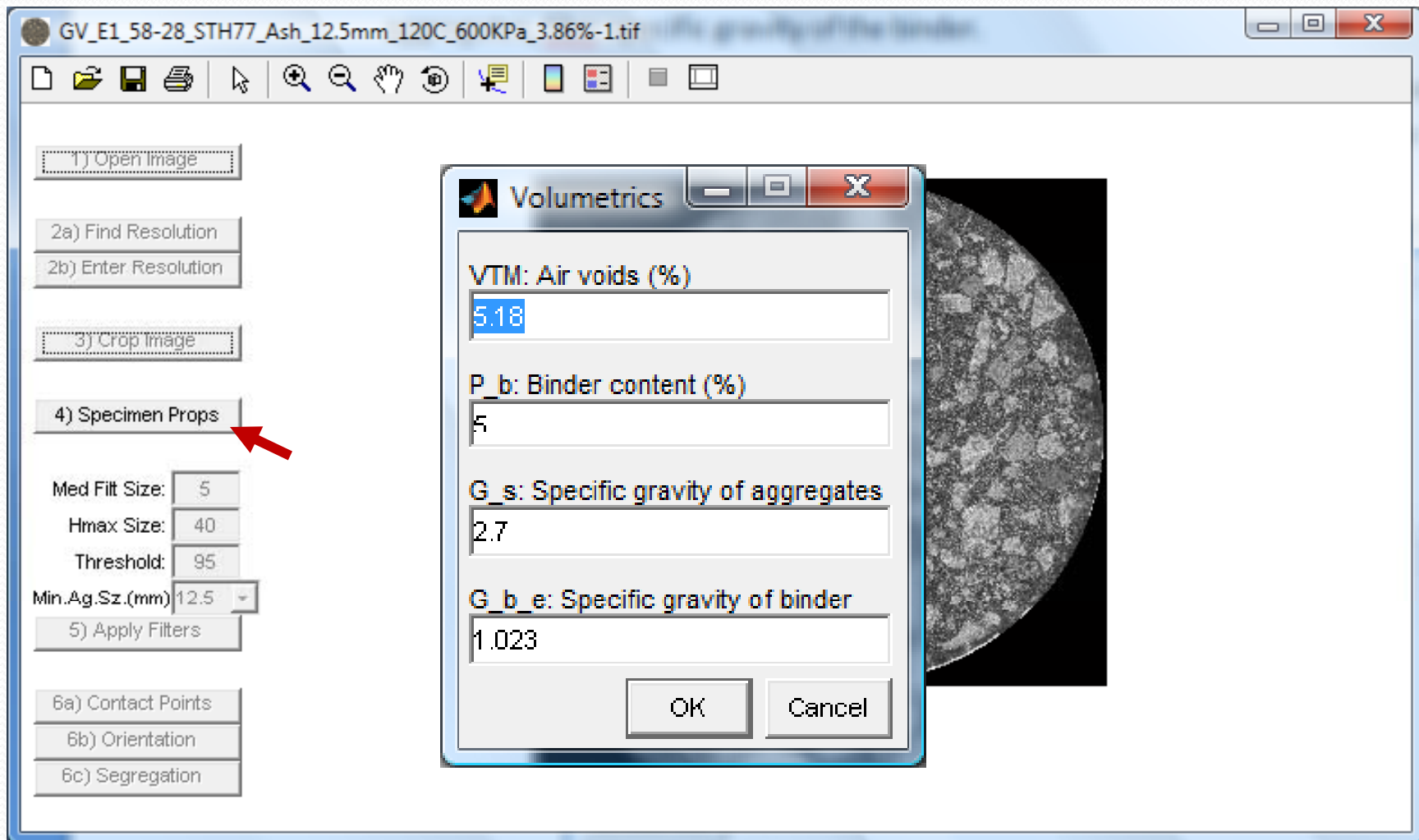


**Orientation**



**Segregation**

# Specimen properties entered



# Aggregate gradation entered

GV\_E1\_58-28\_STH77\_Ash\_12.5mm\_120C\_600kPa\_3.86%-1.tif

Select the txt file for the gradation

Look in: proc

New Folder

Angles\_LS\_E3\_58-28\_STH96\_Waup\_12.5mm\_60C\_600kPa\_4.31%-2.txt

STH96\_12.5\_1510-01-73.txt

File name: STH96\_12.5\_1510-01-73.txt

Files of type: (\*.txt)

STH96\_12.5\_1510-01-73.txt - WordPad

File Edit View Insert Format Help

25,100  
19,99.9  
12.5,95.7  
9.5,86  
4.75,68.5  
2.36,51.7  
1.18,41  
0.6,31.1  
0.3,15  
0.15,6.8  
0.075,4.5

1) Open Image

2a) Find Resolution

2b) Enter Resolution

3) Crop Image

4) Specimen Props

5) Apply Filters

6a) Contact Points

6b) Orientation

6c) Segregation

Med Fil Size: 5

Hmax Size: 40

Threshold: 95

Min.Ag.Sz.(mm) 12.5

For Help, press F1

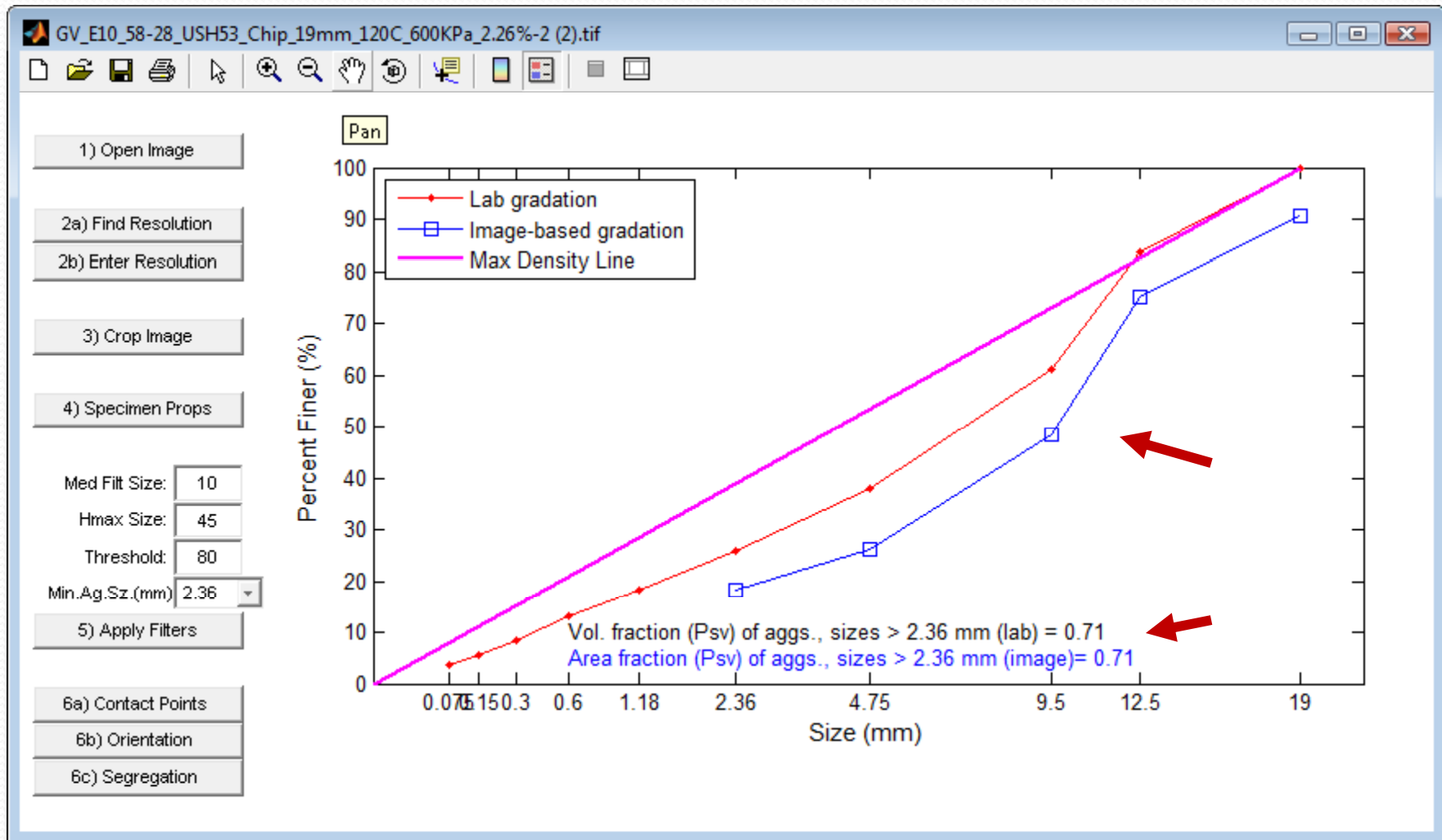
NUM

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# Aggregate gradation & percentage matched



# Volumetric percentage of aggregates ( $P_{sv}$ )

$$P_{sv} = \frac{V_s}{V_t} = \frac{(1 - VTM)}{(P_b \frac{G_s}{G_b} + 1)}$$

$V_t$  = total volume of the asphalt mixture (mix)

$V_v$  = Volume of voids in the mix

$V_b$  = Volume of binder in the mix

$V_s$  = Volume of aggregates in the mix

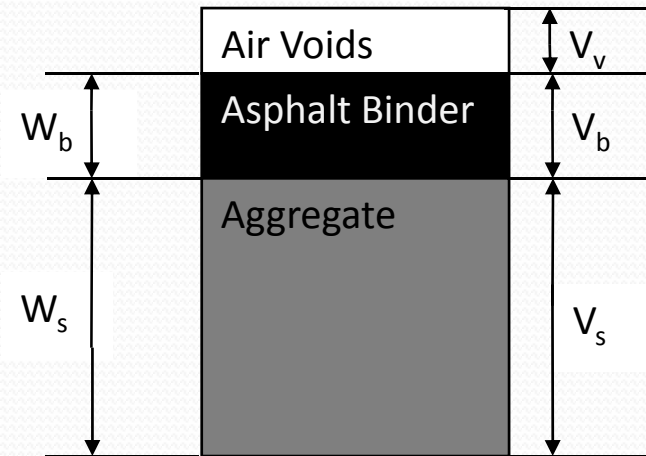
$G_b$  = Specific gravity of binder

$G_s$  = Specific gravity of aggregates in the mixture

$\gamma_w$  = Unit weight of water

$VTM$  = Voids in total mix (a.k.a,  $V_a$ )

$P_b$  = Binder content (by weight)

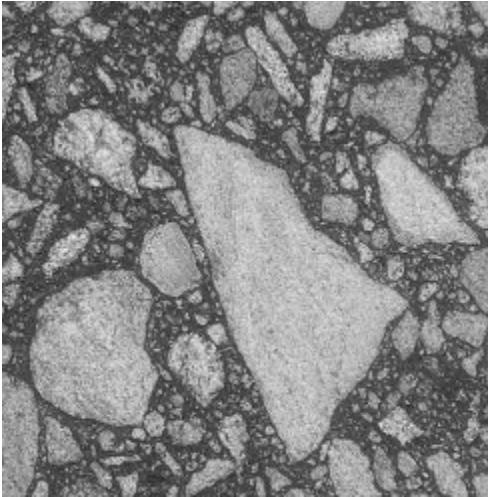


$$P_{sv} = A_{sv}$$

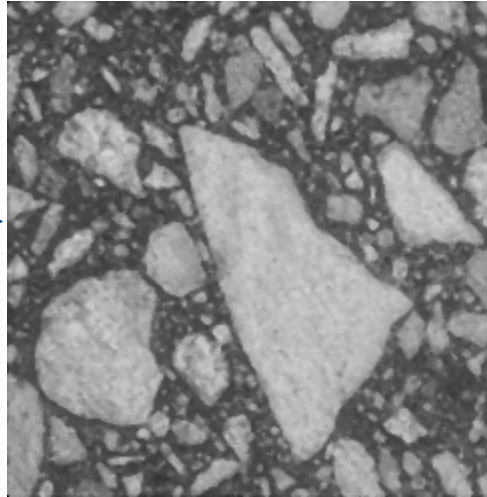


# (1) Image processing steps

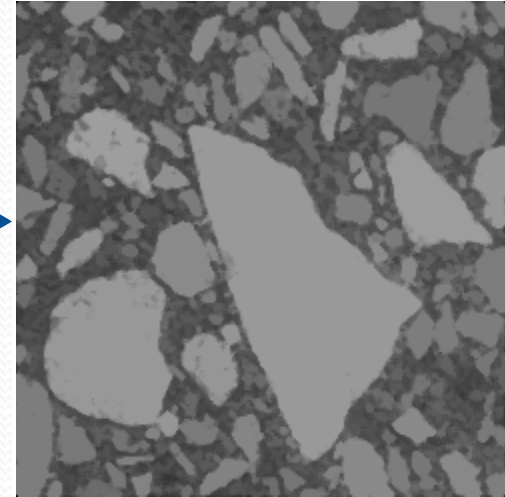
Original image



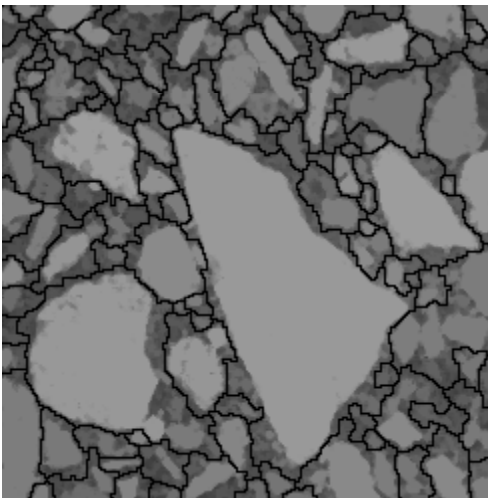
Median Filtered



Hmax Filtered



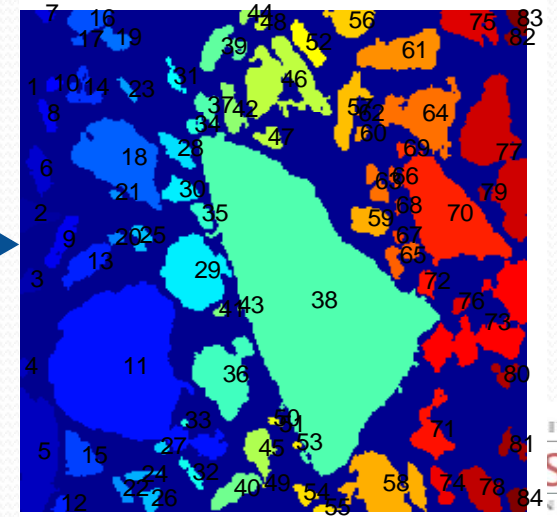
After watershed transform



After thresholding

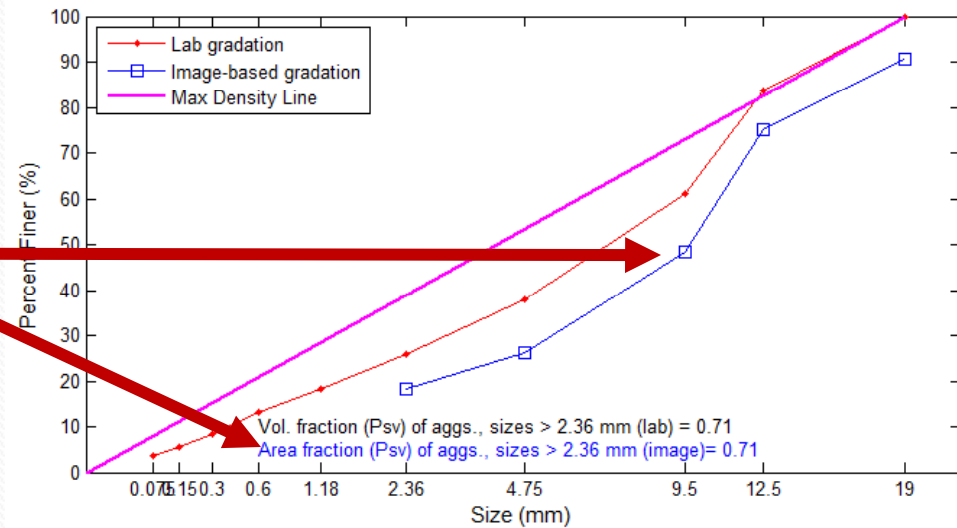
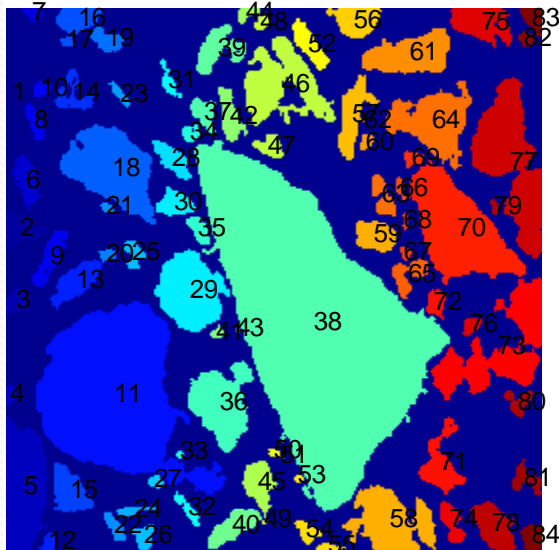


Labeled image



# Matching image-based variables to volumetrics

Labeled image



$$P_{sv} (\text{volumetrics}) = A_{sv} (\text{image})$$

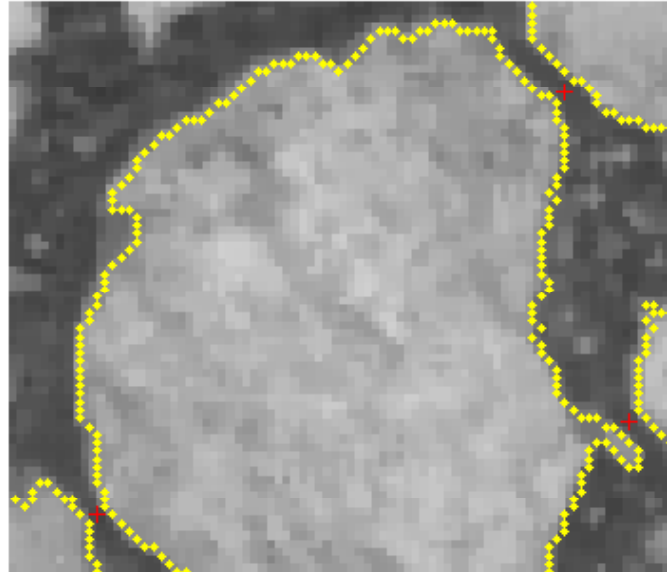
$$\frac{V_s}{V_t} = \frac{n h_i A_s}{n h_i A_t} = \frac{A_s}{A_t}$$

$A_s$  = total area of aggregates  
 $A_t$  = total area of the image

$n$  = number of slices

$h_i$  = height of each slice

## (2) Image analysis: **Contact points**



$d_s$  = shortest distance between the surfaces of two aggregates

If  $d_s < \text{SDT}$  (Surface Distance Threshold)  $\rightarrow$  contact

# (2) Image analysis: Contact points

1) Open Image

2a) Find Resolution

2b) Enter Resolution

3) Crop Image

4) Specimen Props

Med Filtr Size:

Hmax Size:

Threshold:

Min.Ag.Sz.(mm)

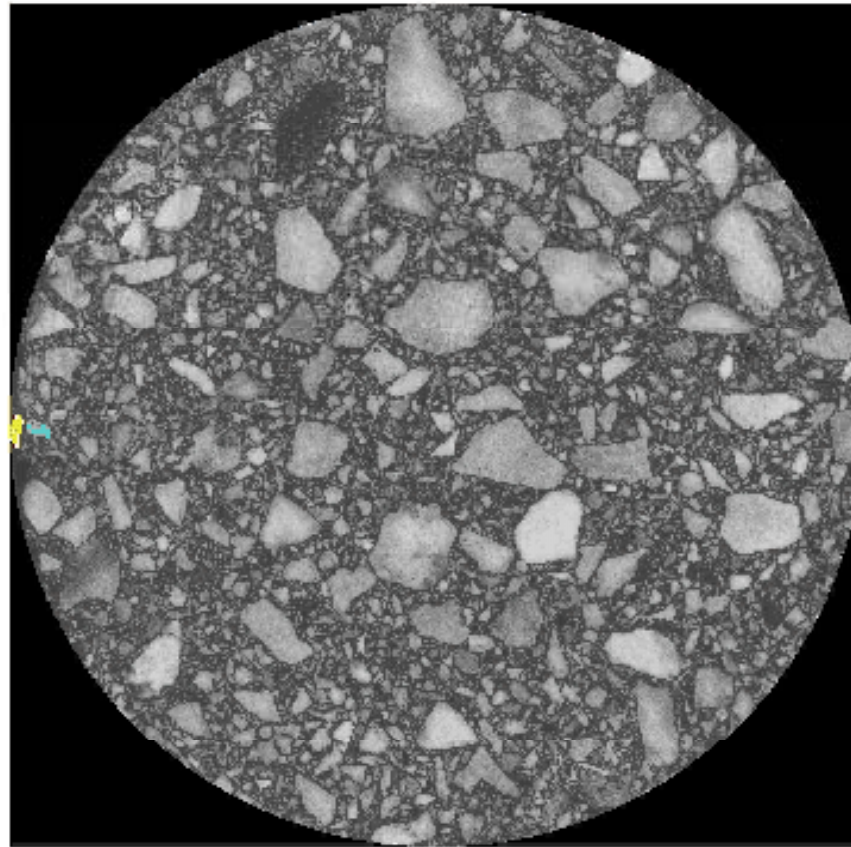
5) Apply Filters

6a) Contact Points

6b) Orientation

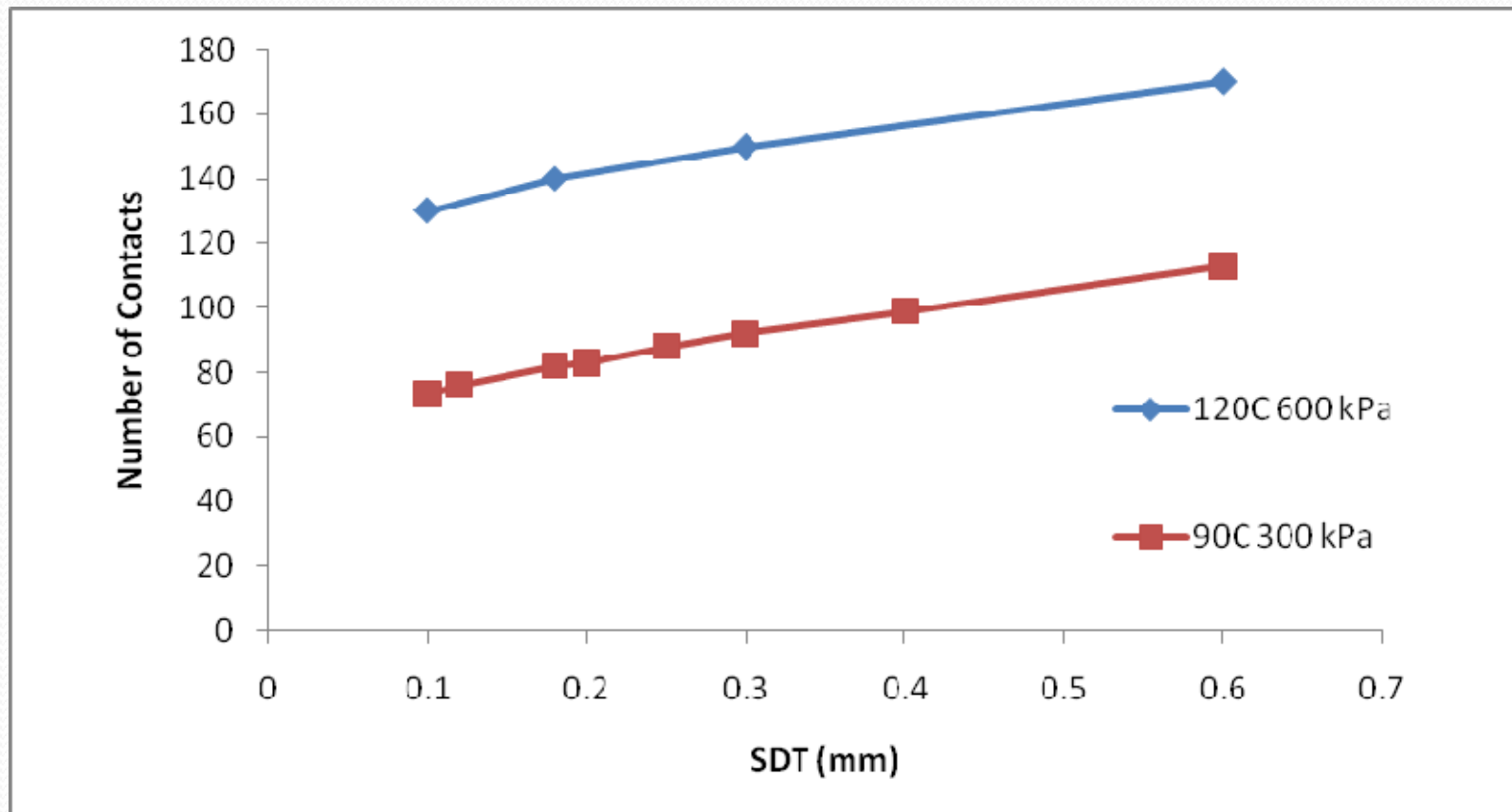
6c) Segregation

Number of contact points for aggregates  $>2.18$  mm ( $d_{\text{threshold}} < 1\text{mm}$ ) : 1

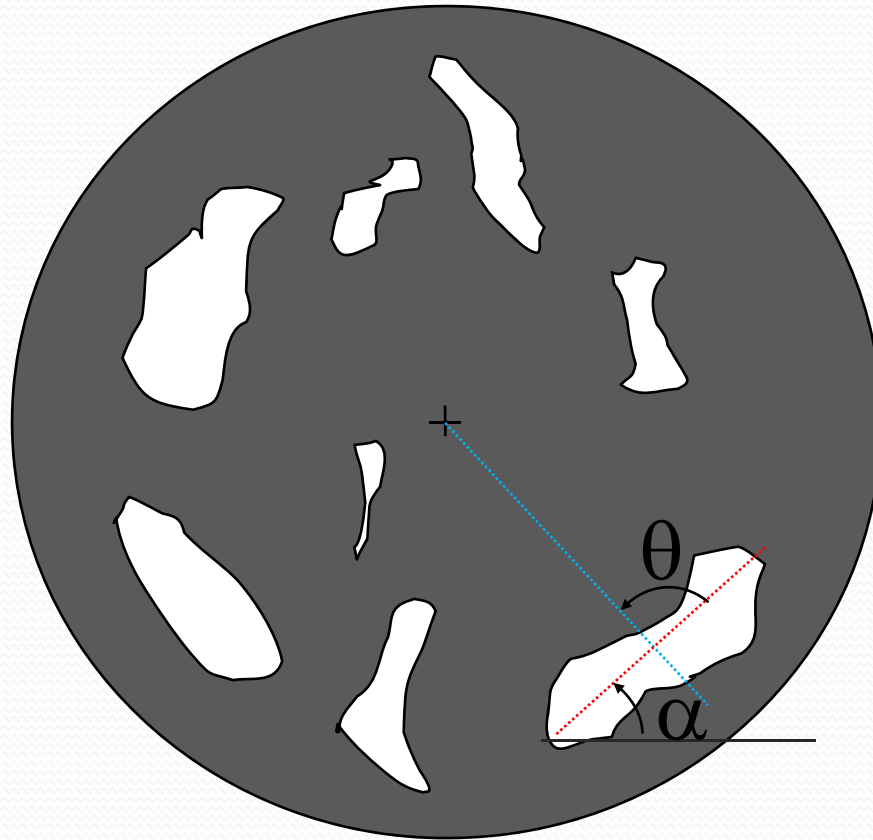


CANCEL

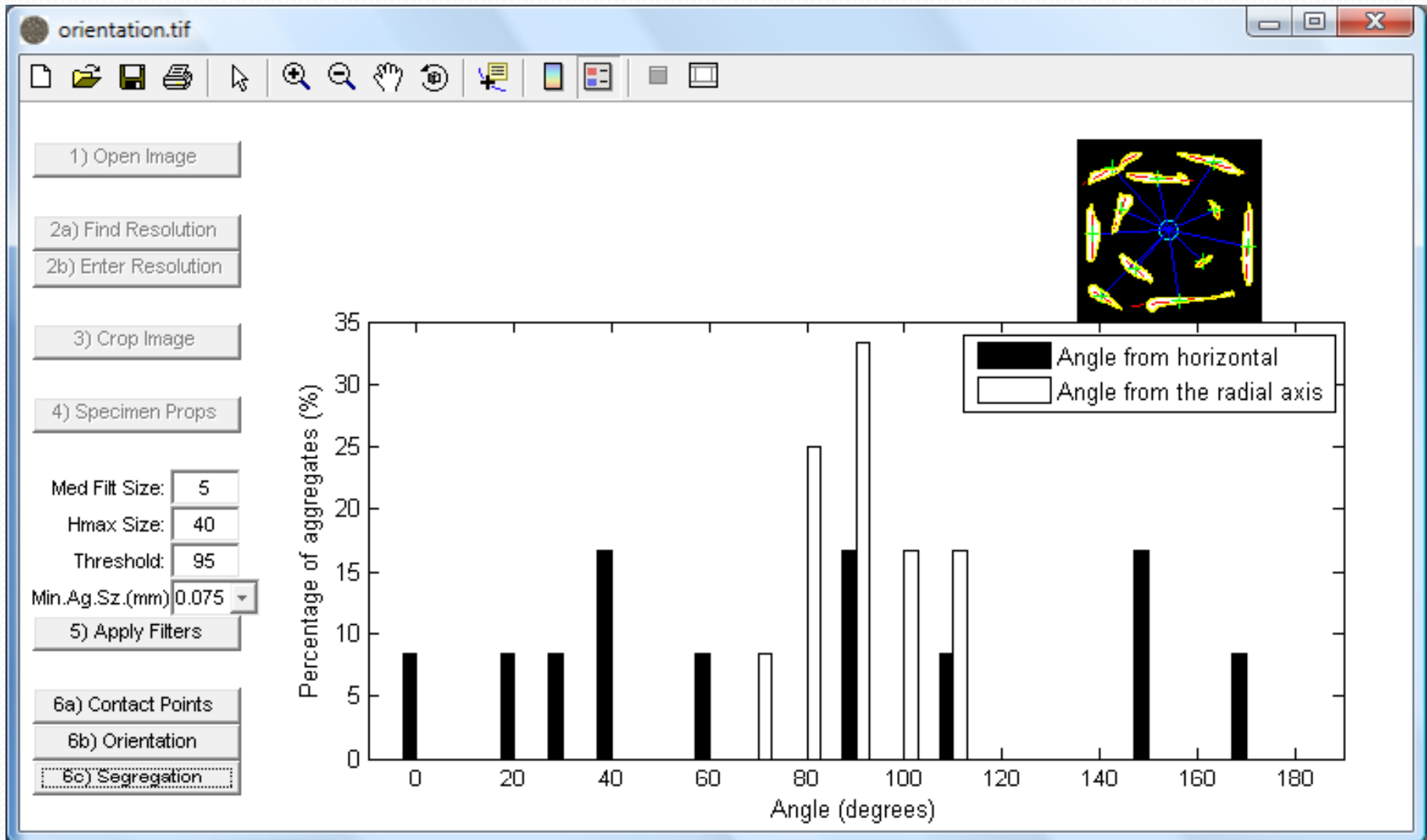
# Number of contact points vs SDT



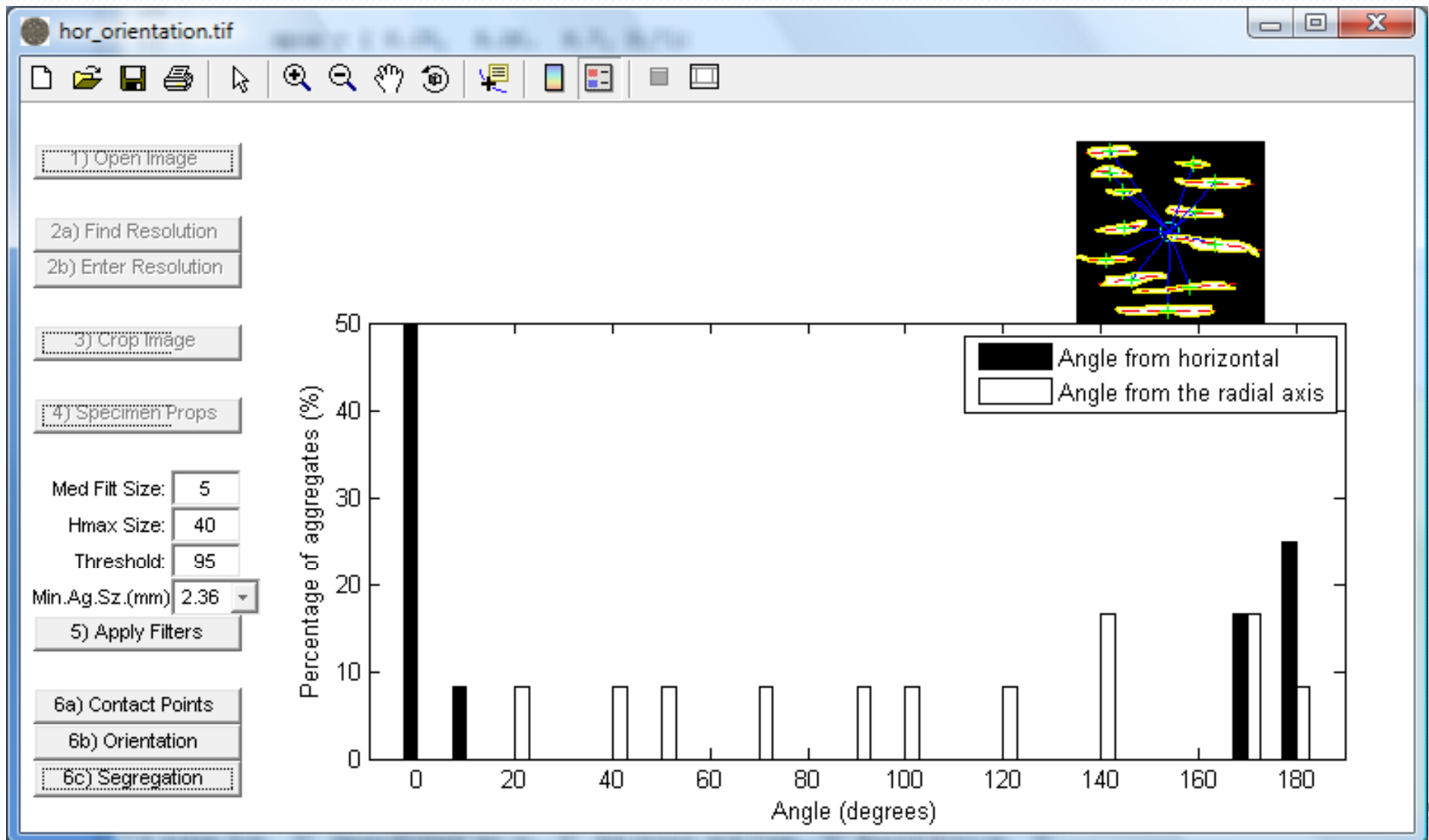
## (2) Image analysis: Orientation



# Orientation example: radial



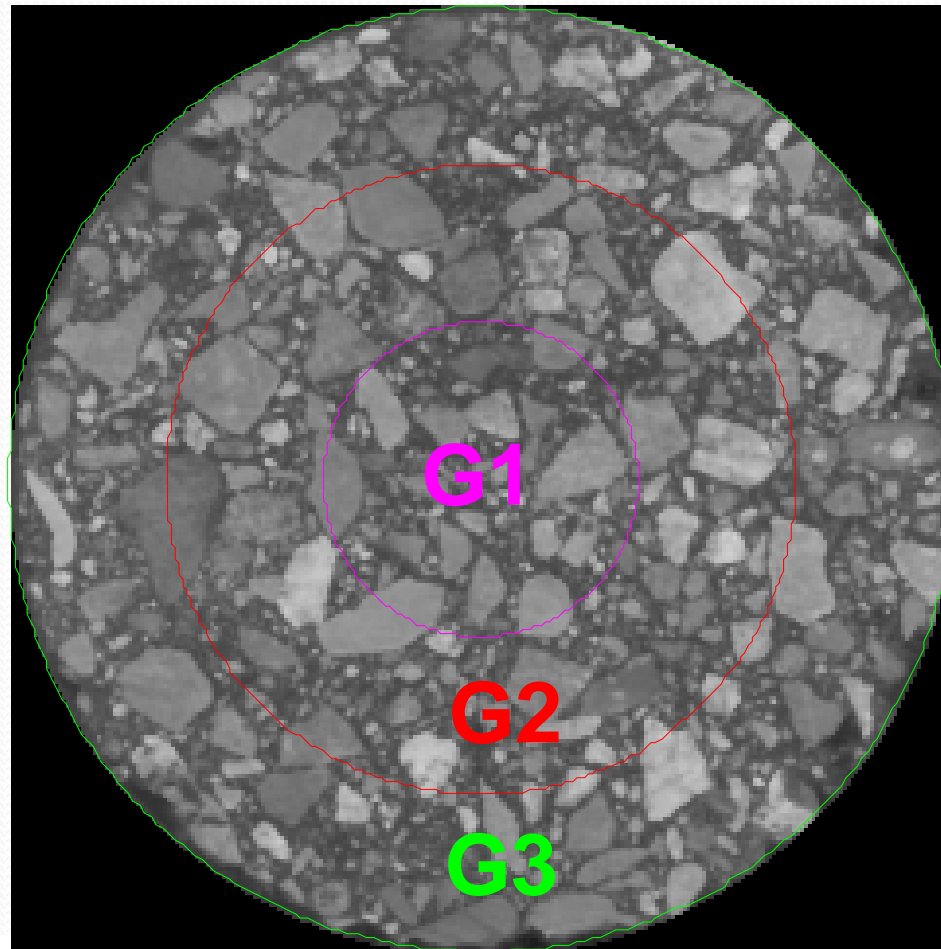
# Orientation example: horizontal



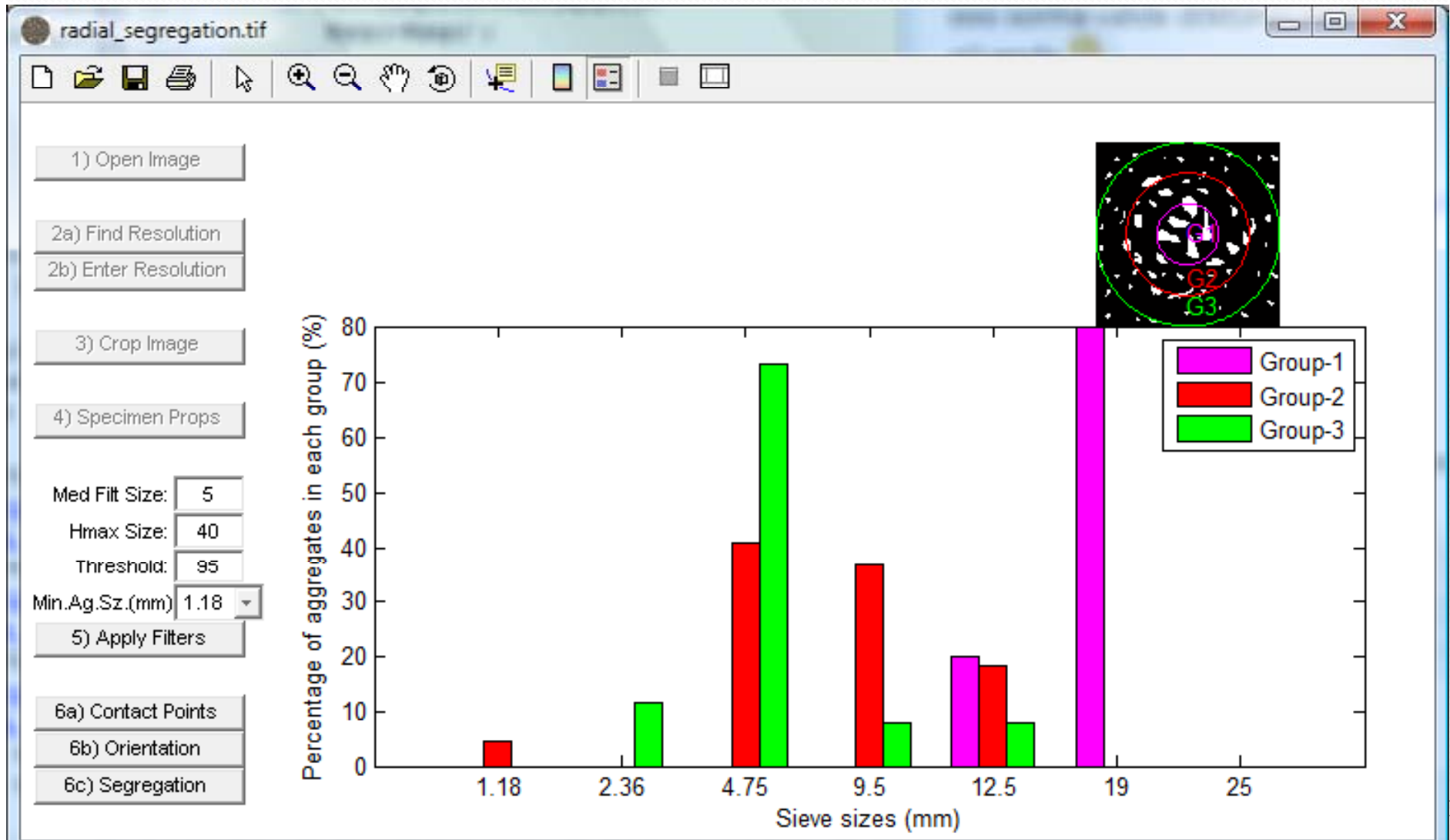


## (2) Image analysis: **segregation**

- Divide the sample three different regions: center (G<sub>1</sub>), mid (G<sub>2</sub>) and edge (G<sub>3</sub>)



# Segregation example



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## Standard Method for

# Determining Aggregate Structure in Asphalt Mixes by Means of Planar Imaging

Designation: XX-XX

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## 1. SCOPE

- 1.1. *This standard covers the measurement of aggregate structure indicators of asphalt mixes using digital image analysis techniques.*
- 1.2. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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. AASHTO Standards:

- M043 Standard Specification for Standard Sizes of Coarse Aggregate for Highway Construction
- M092 Standard Specification for Wire-Cloth Sieves for Testing Purposes
- M231 Weighing Devices Used in the Testing of Materials
- M283 Standard Specification for Coarse Aggregate for Highway & Airport Construction
- R35 Standard Practice for Superpave Volumetric Design for Hot-Mix Asphalt (HMA)
- T11 Amount of Material Finer Than 75 $\mu$ m in Aggregate
- T19 Standard Method of Test for Bulk Density ("Unit Weight") and Voids in Aggregate,
- T2 Sampling of Aggregates
- T248 Standard Method of Test for Reducing Samples of Aggregate to Testing Size
- T27 Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates
- T84 Standard Method of Test for Specific Gravity and Absorption of Fine Aggregate
- T85 Standard Method of Test for Specific Gravity and Absorption of Coarse Aggregate

### 2.2. ISO Standards:

- Scanner

### 2.3. Publications:

Haralick, Robert M., and Linda G. Shapiro, *Computer and Robot Vision, Volume I*, Addison-Wesley, 1992, pp. 28-48.

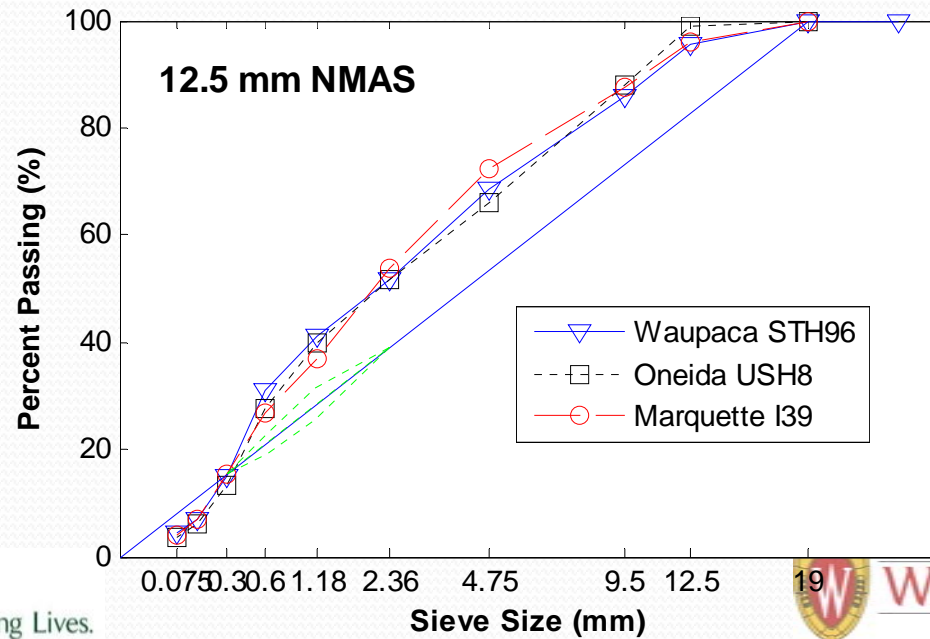
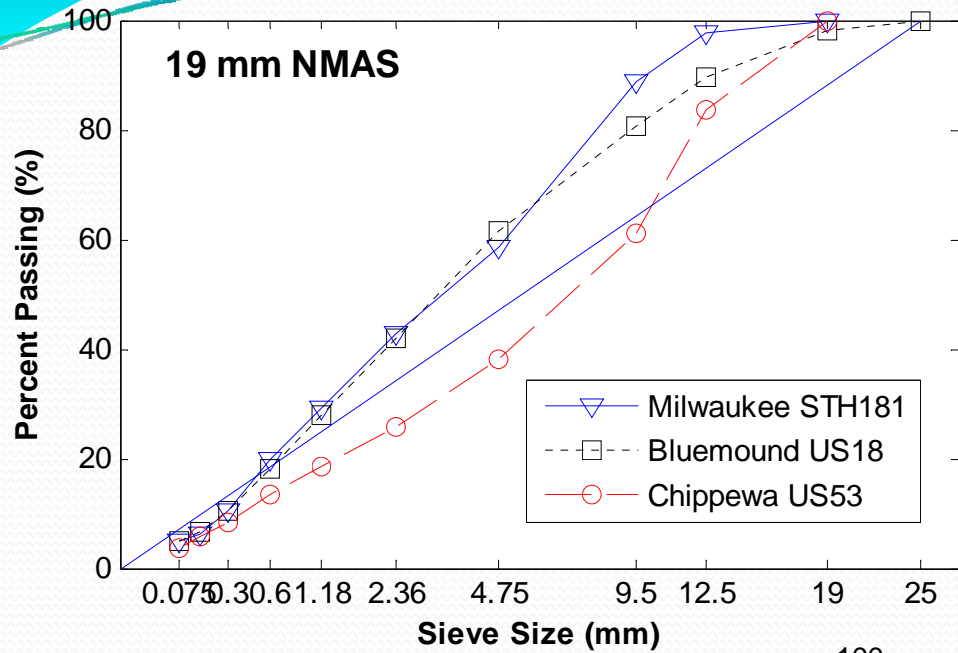
Meyer, Fernand, "Topographic distance and watershed lines," *Signal Processing*, Vol. 38, July 1994, pp. 113-125.

Soille, P., *Morphological Image Analysis: Principles and Applications*, Springer-Verlag, 1999, pp. 170-171.

# Specimen analysis matrix

- Specimen types
  - Two NMAS: **19** mm and **12.5** mm
  - Two Aggregate types : **limestone** and **gravel**
- Specimen compacted in the gyratory compactor at:
  - Two temperatures: **60** and **120° C**
  - Two pressure levels : **300** and **600** kPa

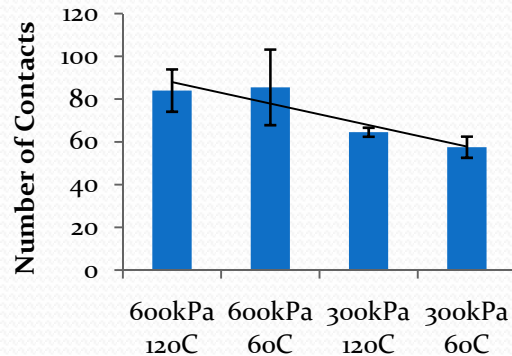
# Gradations



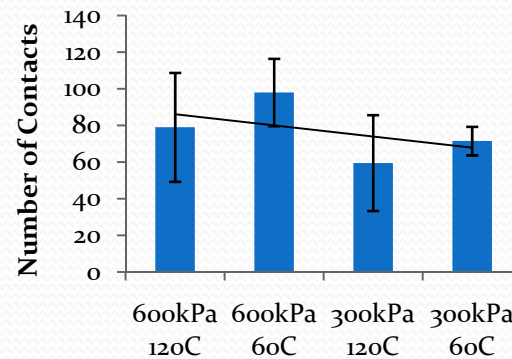
# Contact points: Effect of compaction temperature and pressure

19 mm mixtures  
(SDT = 0.1mm)

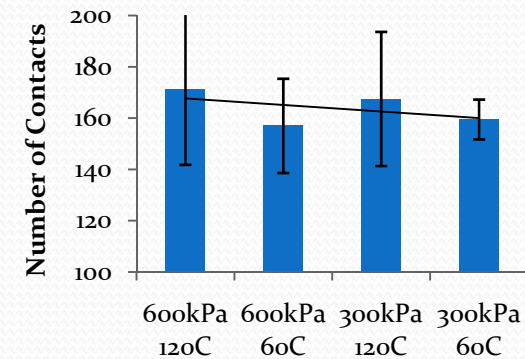
19mm Limestone  
(Racine)



19mm Limestone  
(Milwaukee)



19mm Gravel  
(Chippewa)

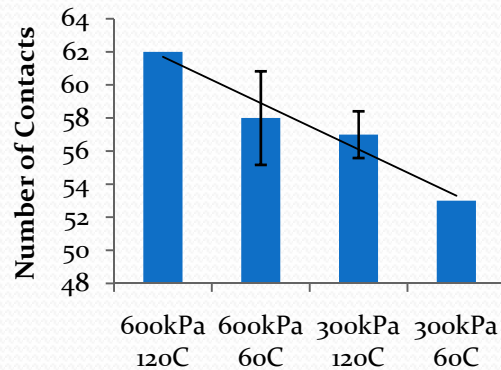


Straight line (--) is the linear best fit line to data (not an arbitrary line)

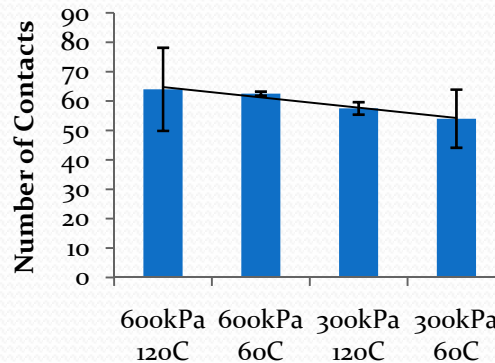
# Contact points: Effect of compaction temperature and pressure

## 12.5 mm mixtures (SDT = 0.1mm)

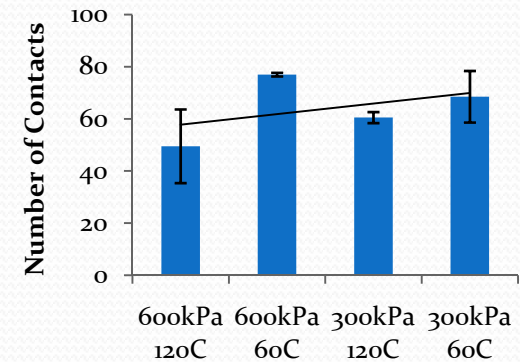
12.5mm Limestone  
(Waupaca)



12.5mm Gravel (Oneida)

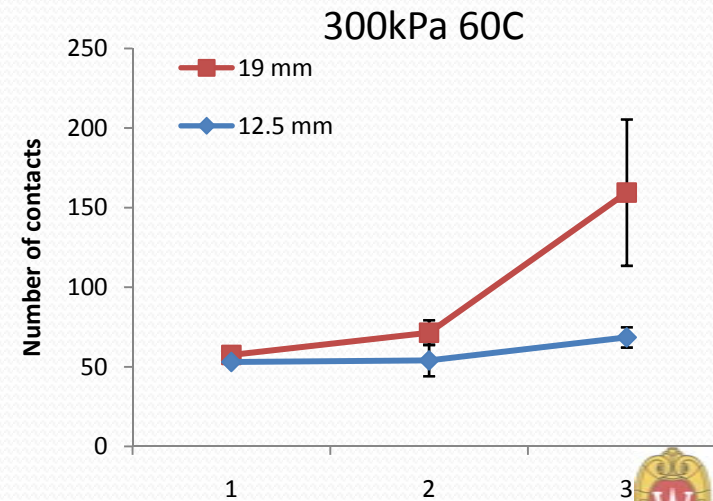
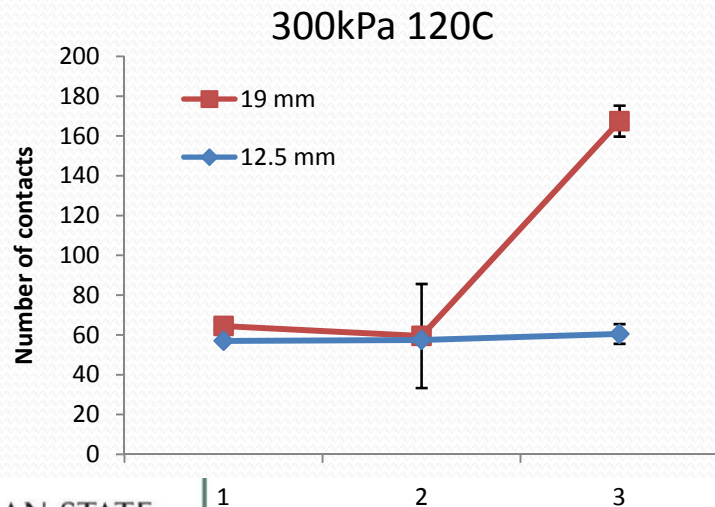
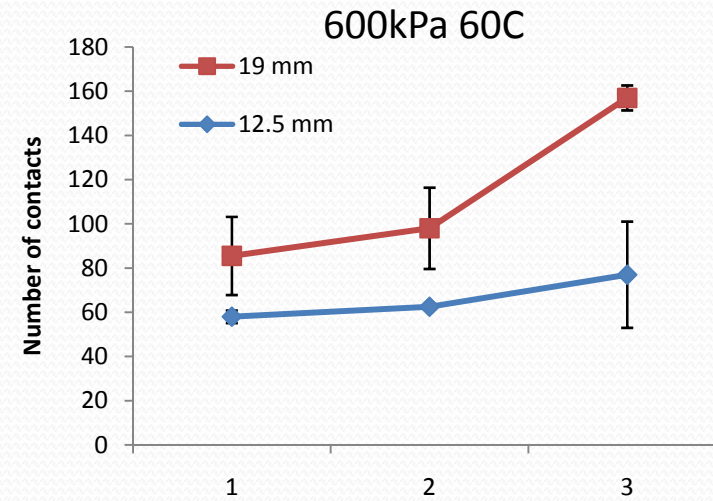
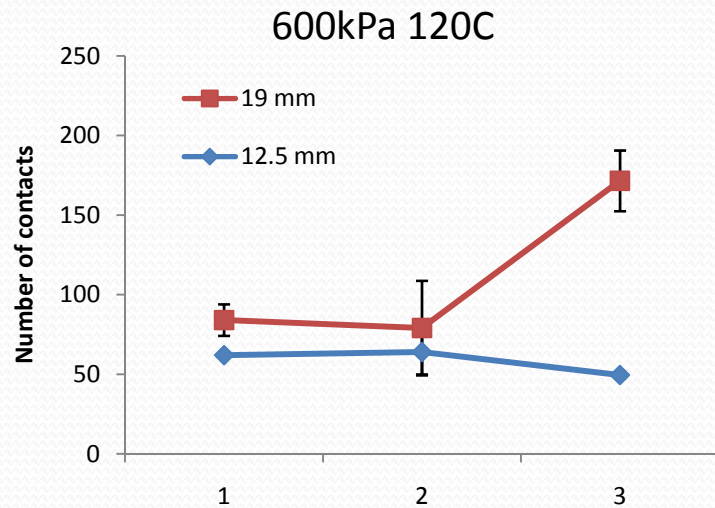


12.5mm Gravel  
(Marquette)



Straight line (--) is the linear best fit line to data (not an arbitrary line)

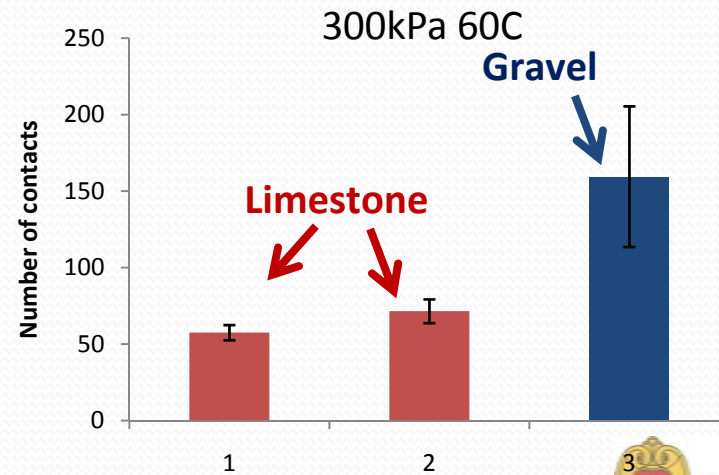
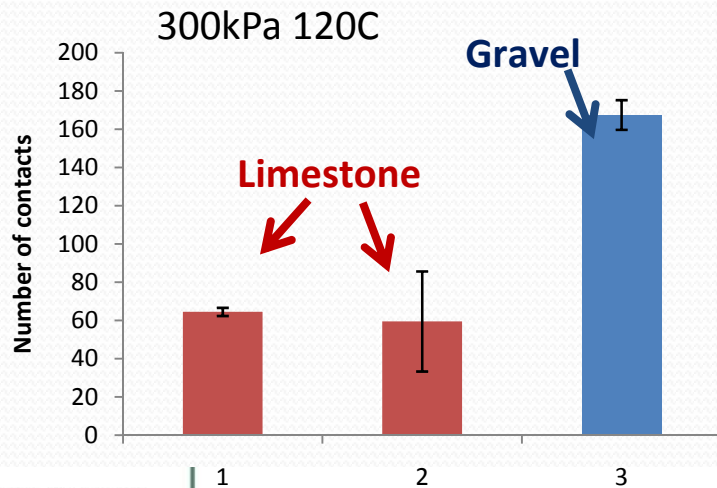
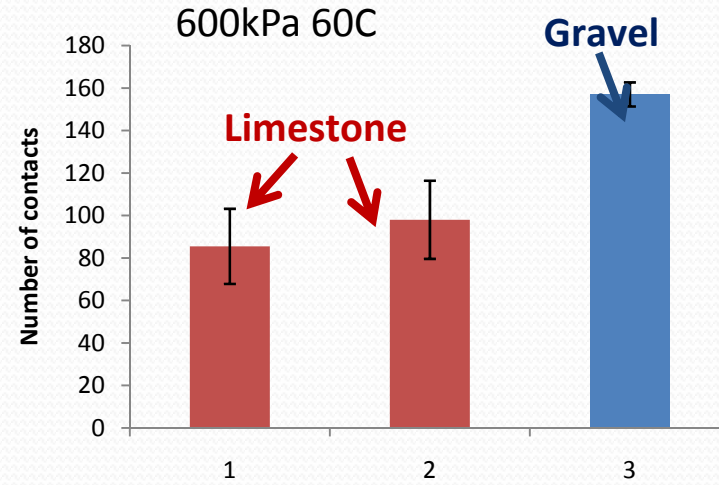
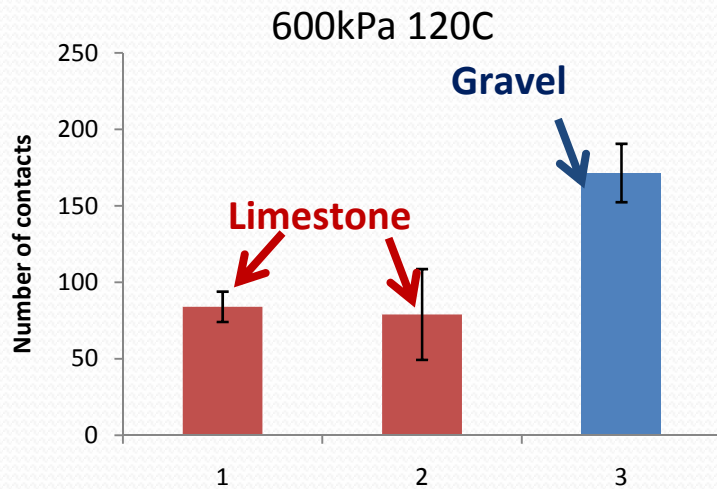
# Contact points: Effect of NMAS





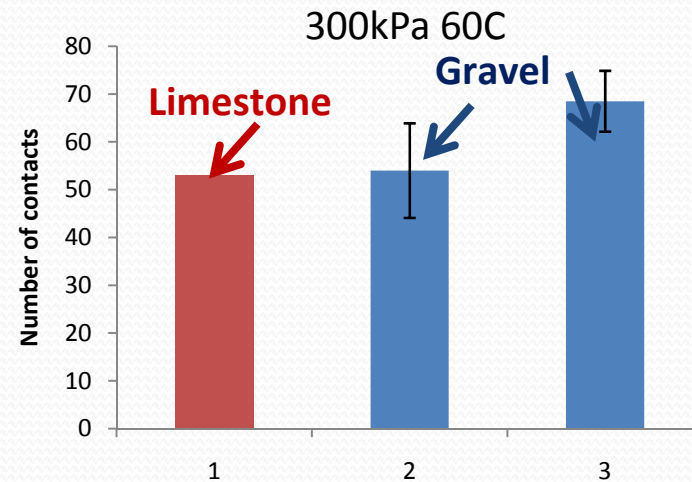
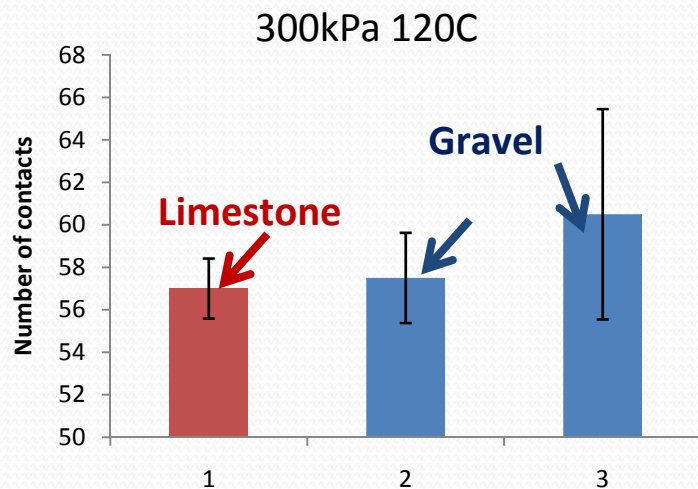
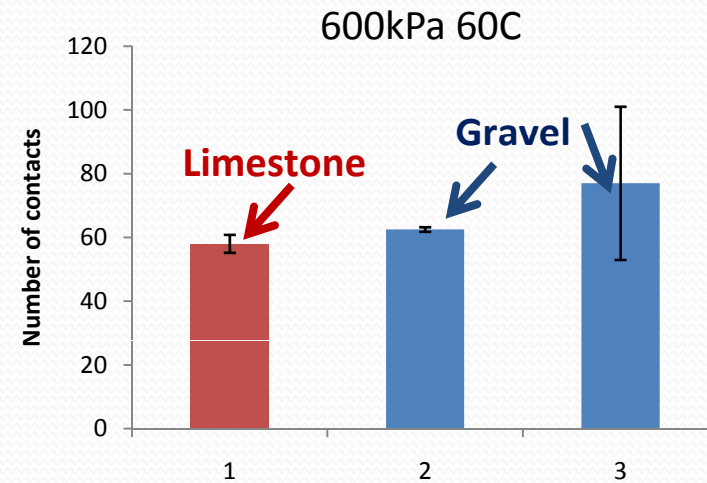
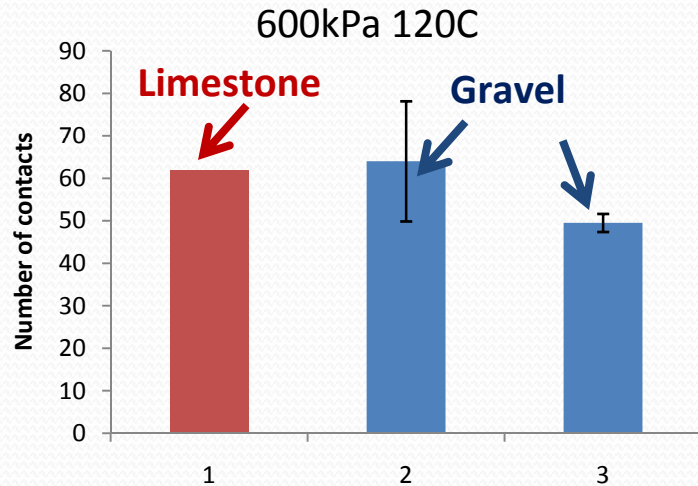
# Contact points: Effect of Aggregate type

19 mm mixtures

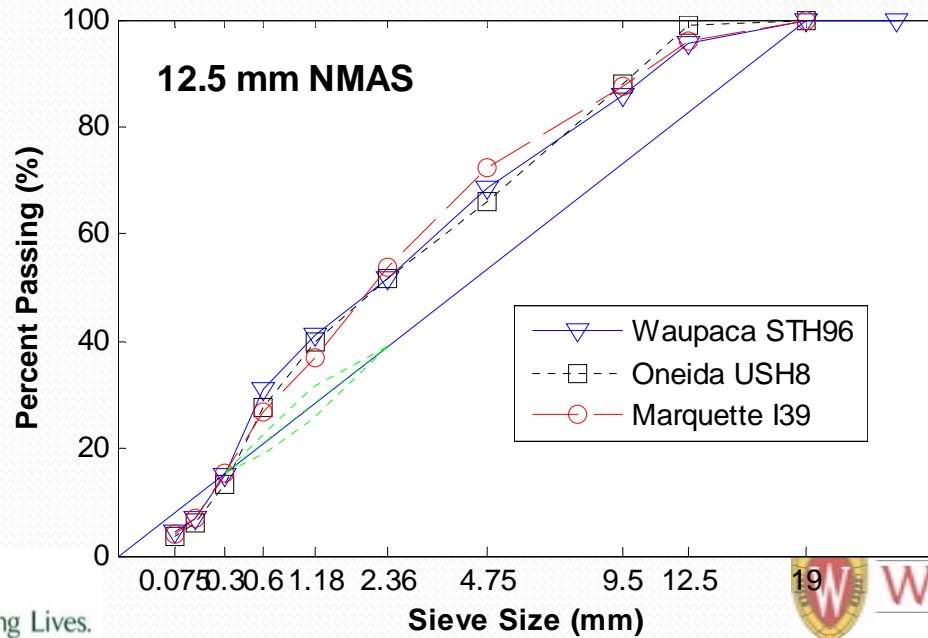
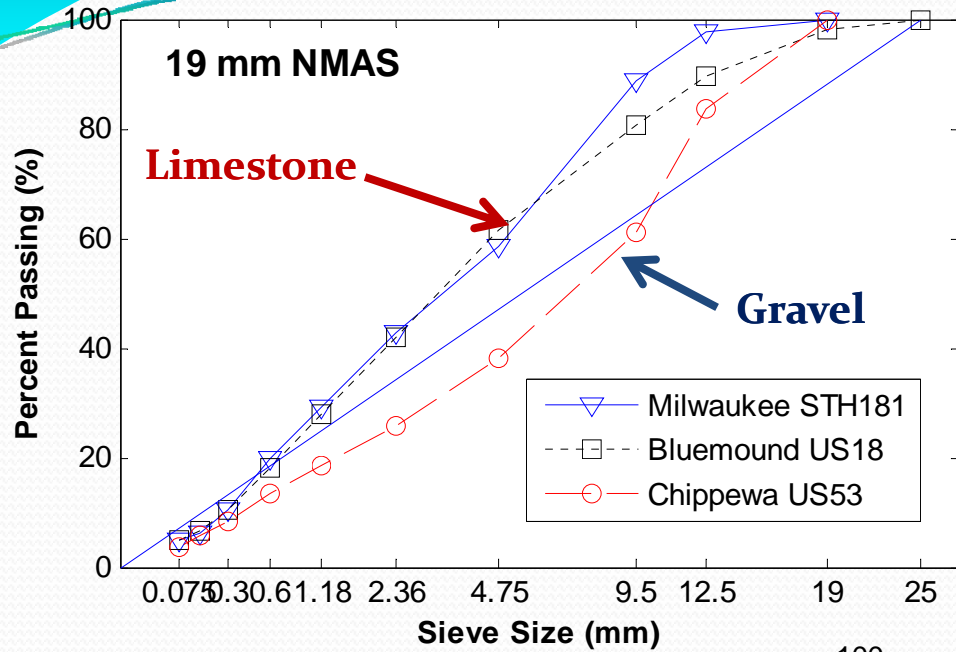


# Contact points: Effect of Aggregate type

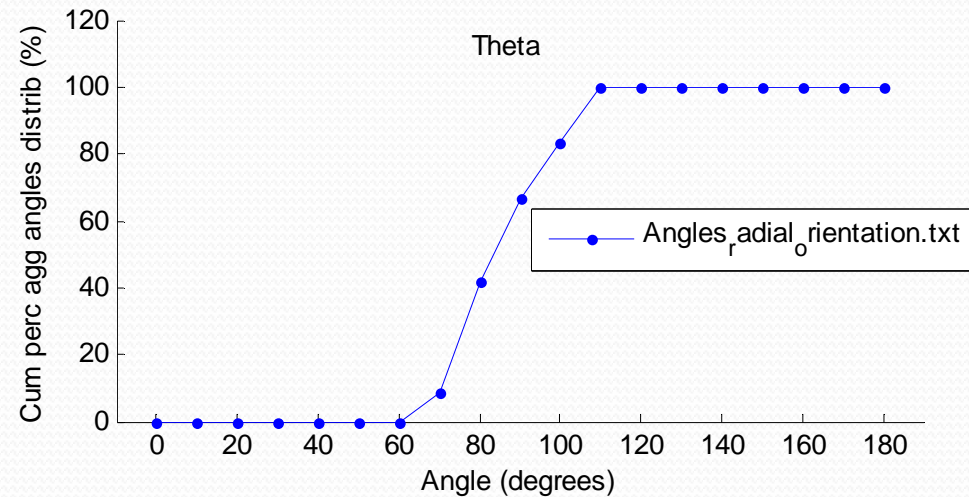
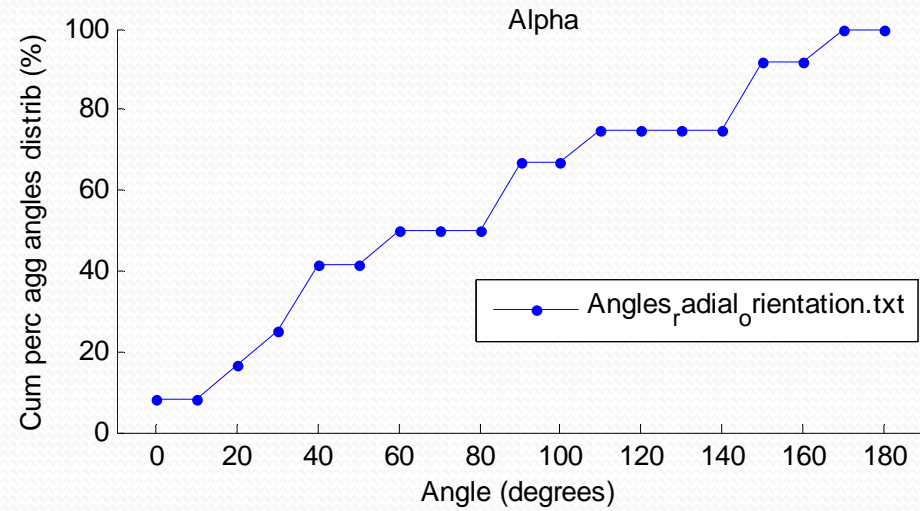
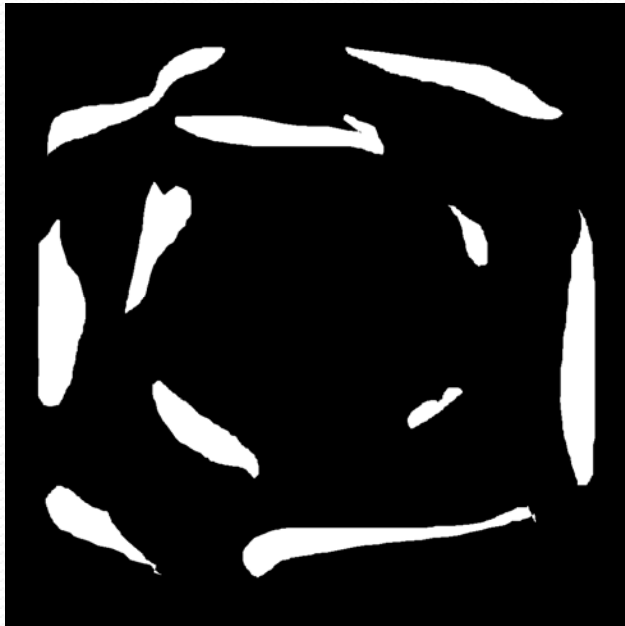
## 12.5 mm mixtures



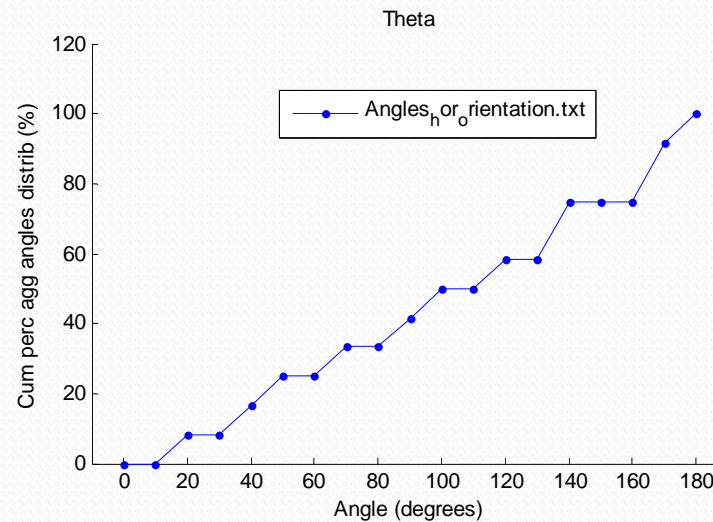
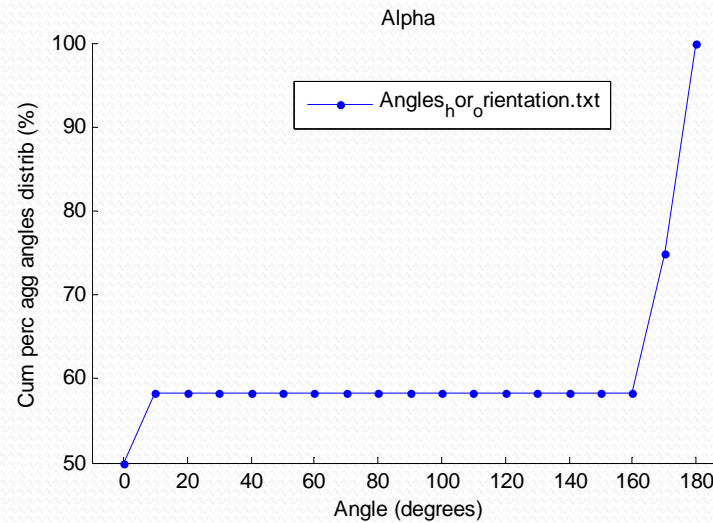
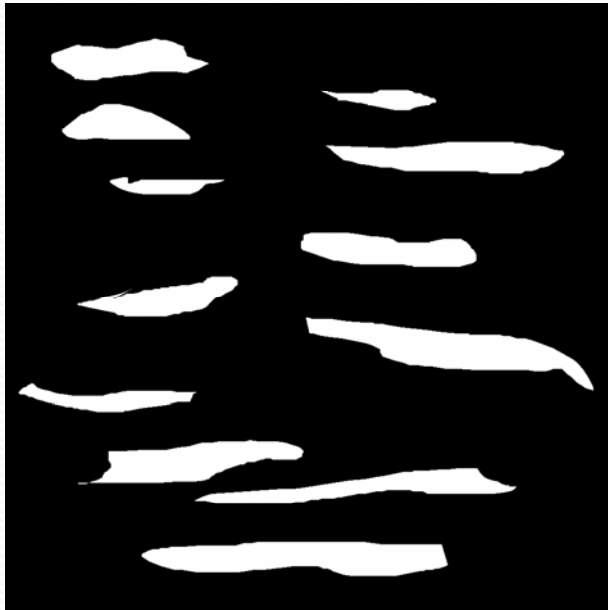
# Gradations



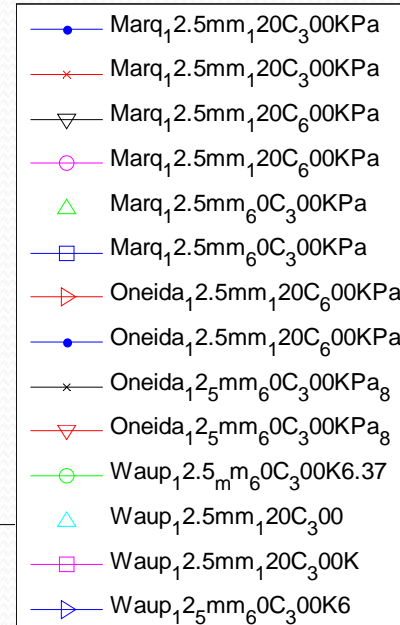
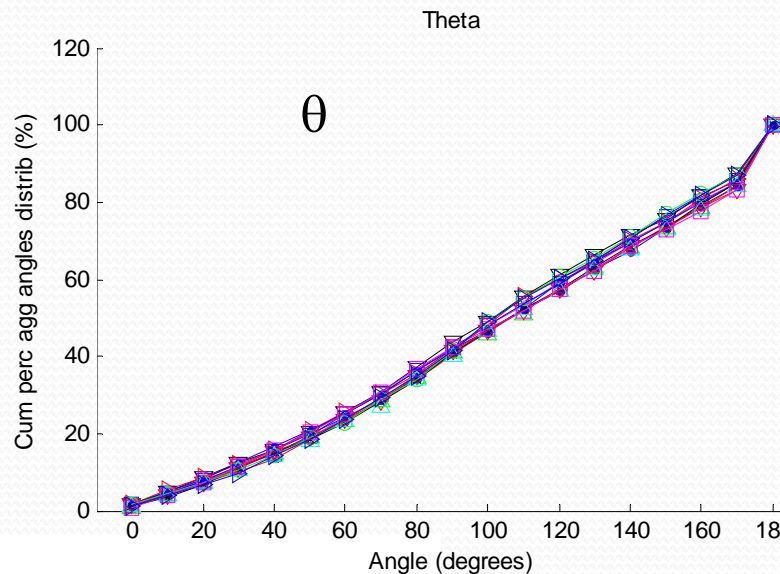
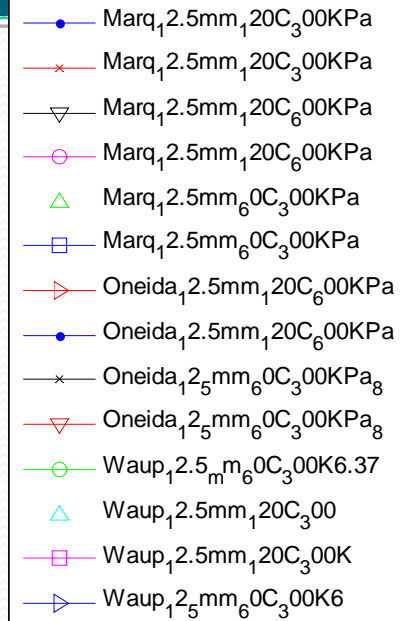
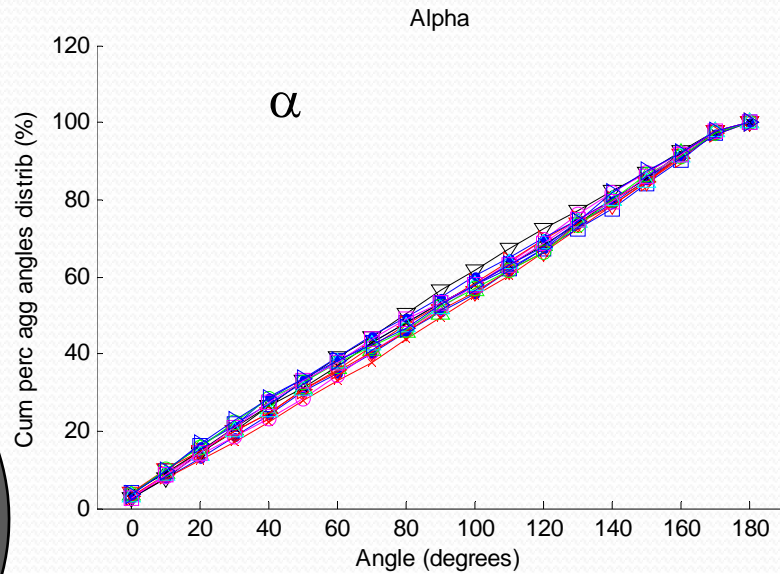
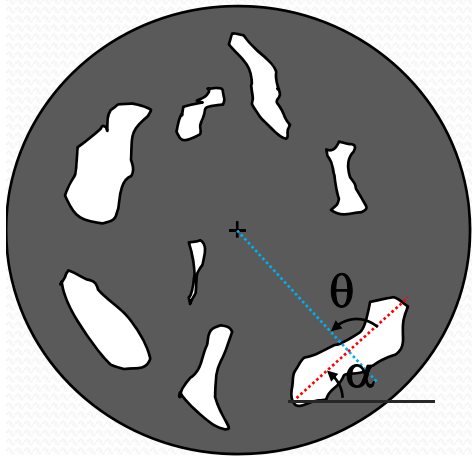
# Orientation: example-1



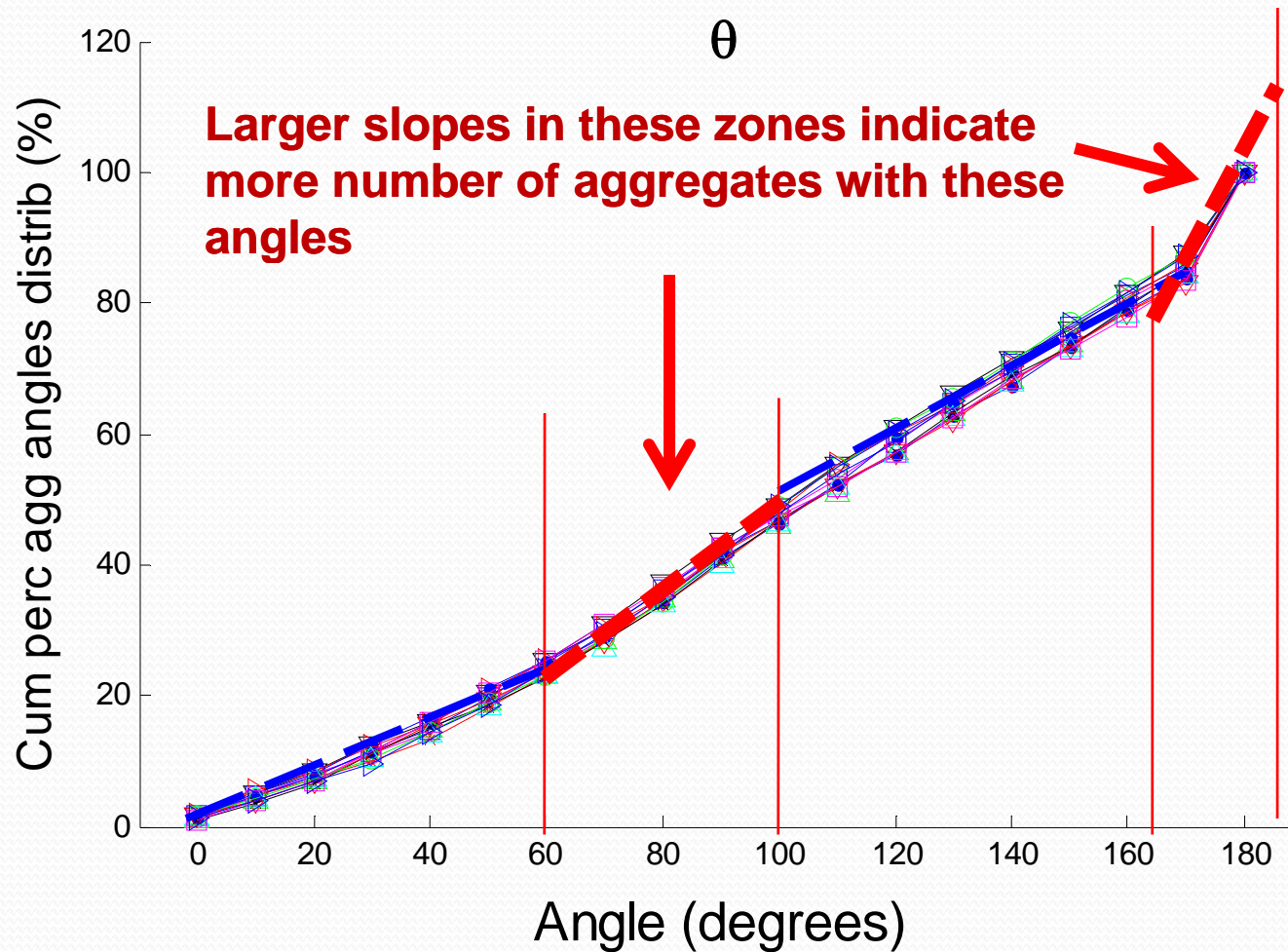
# Orientation: example-2



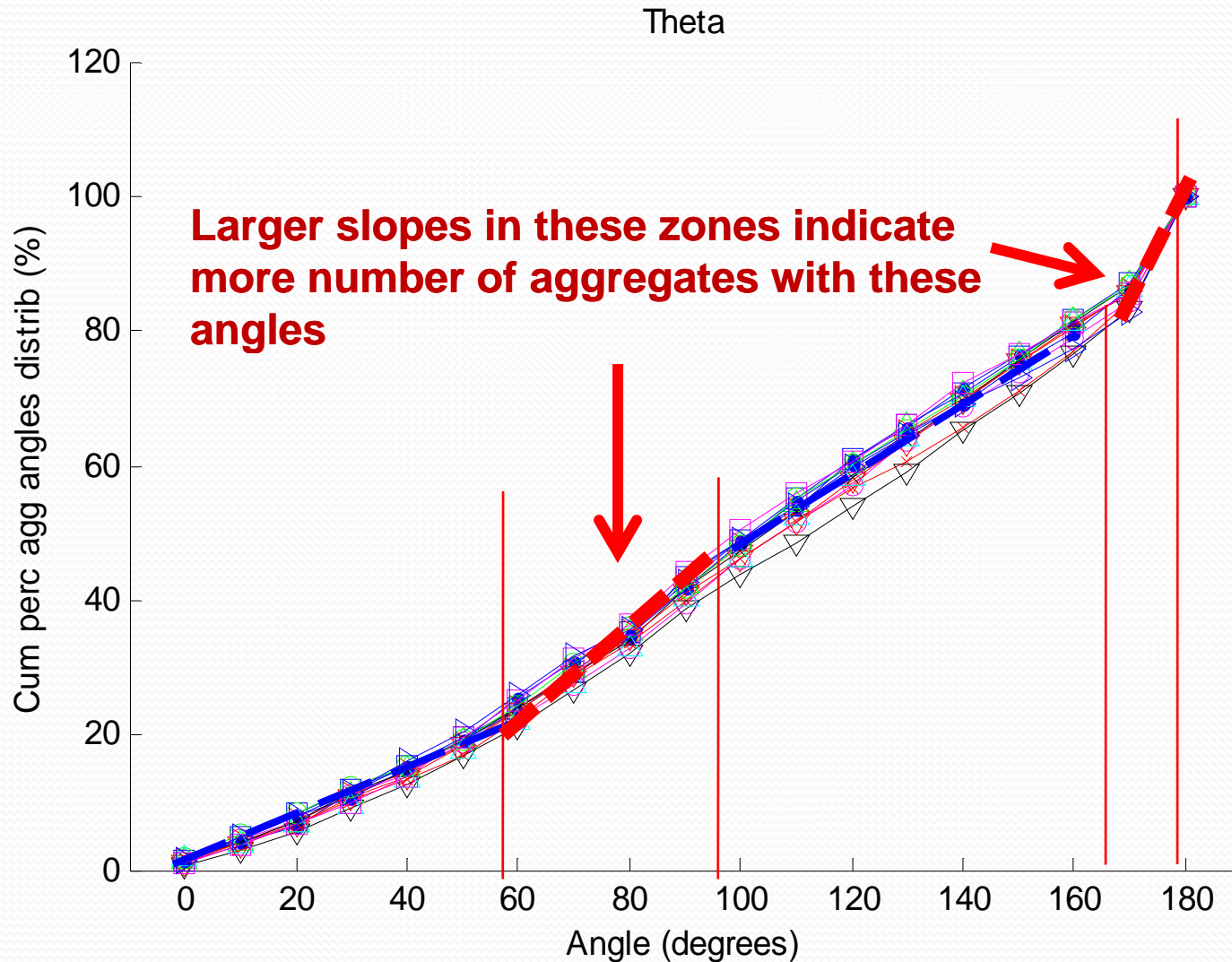
# Orientation: all 12.5 mm mixtures



# Orientation: all 12.5 mm mixtures: a closer look

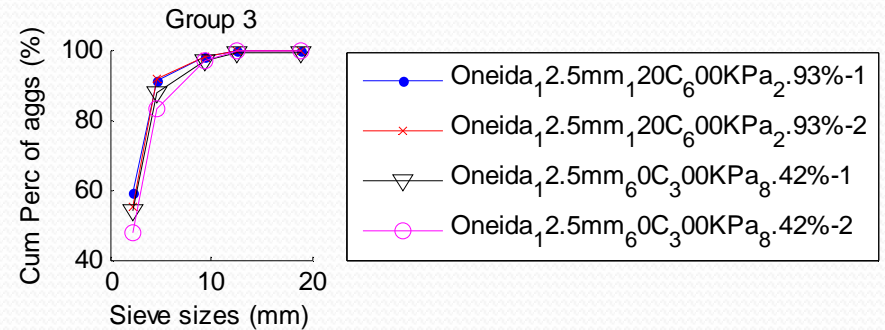
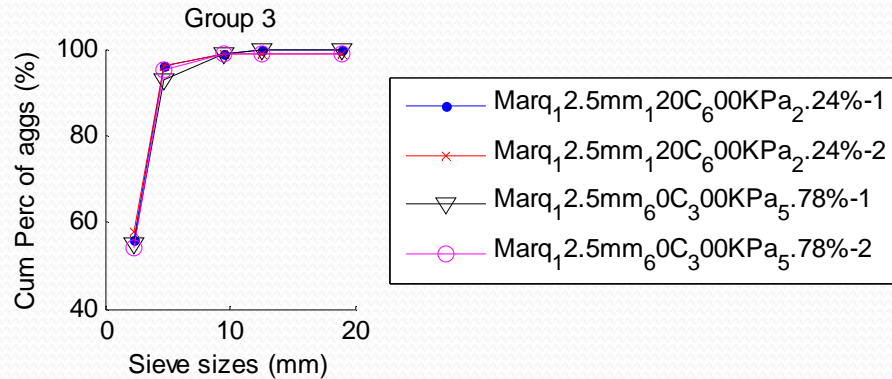
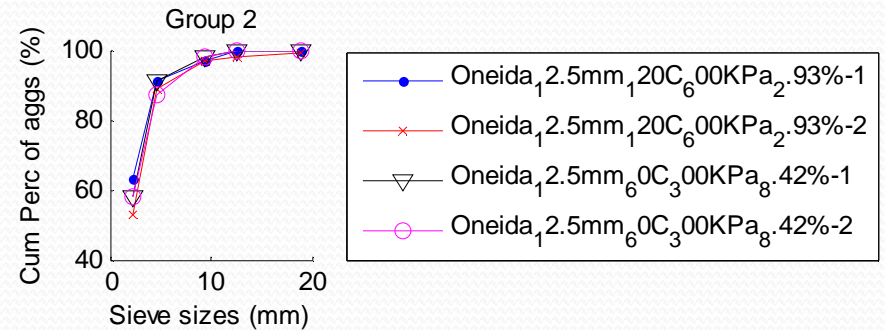
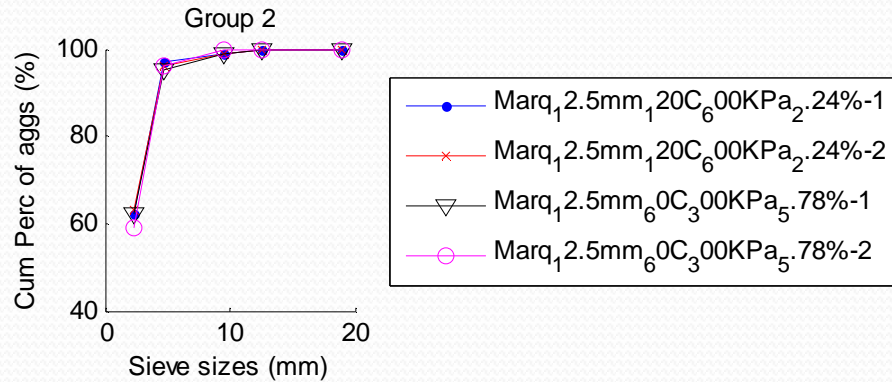
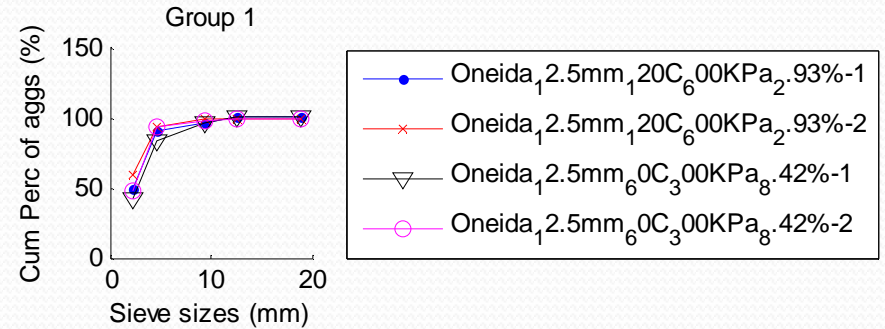
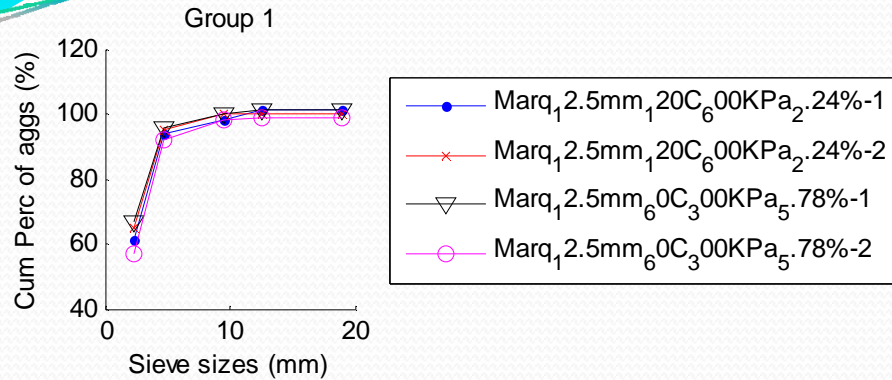


# Orientation: all 19 mm mixtures:

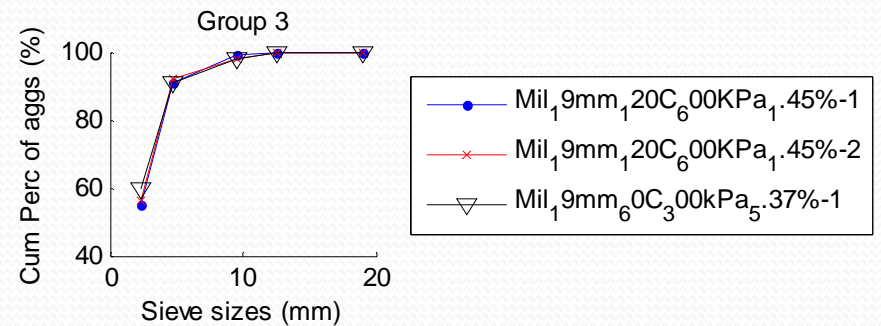
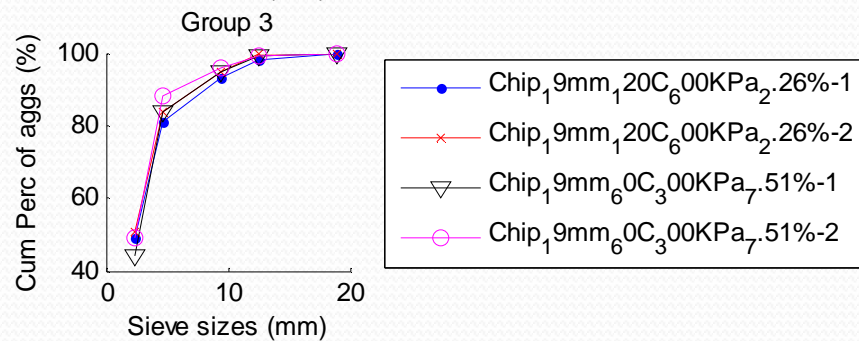
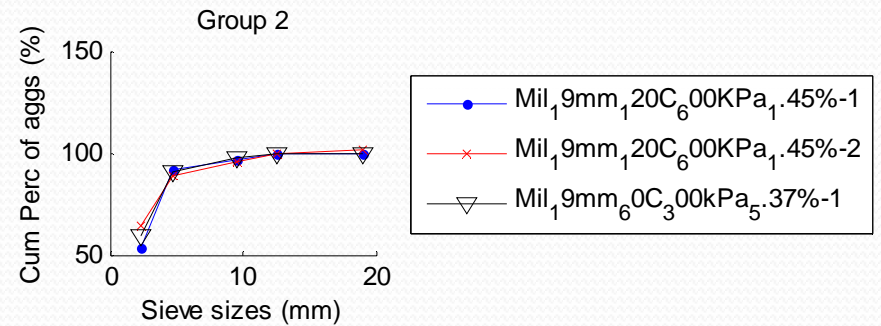
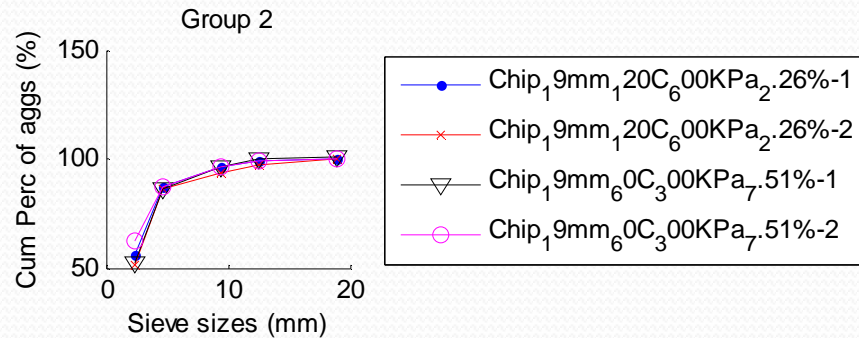
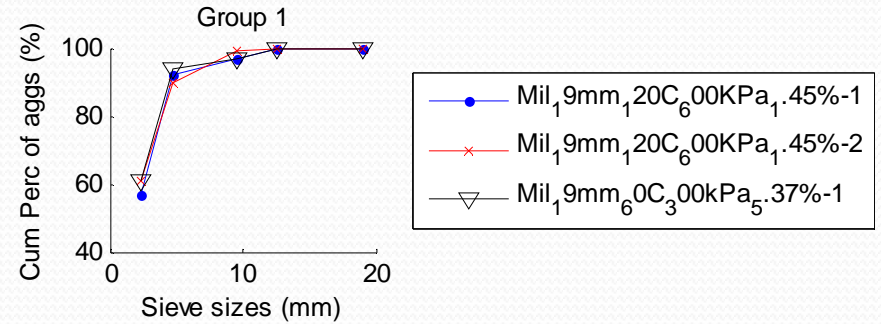
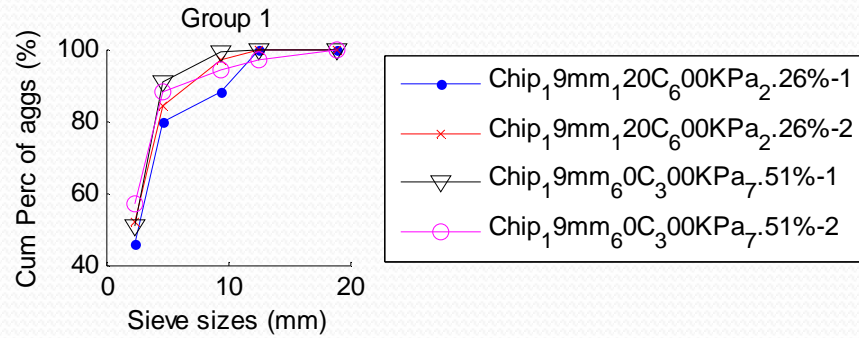




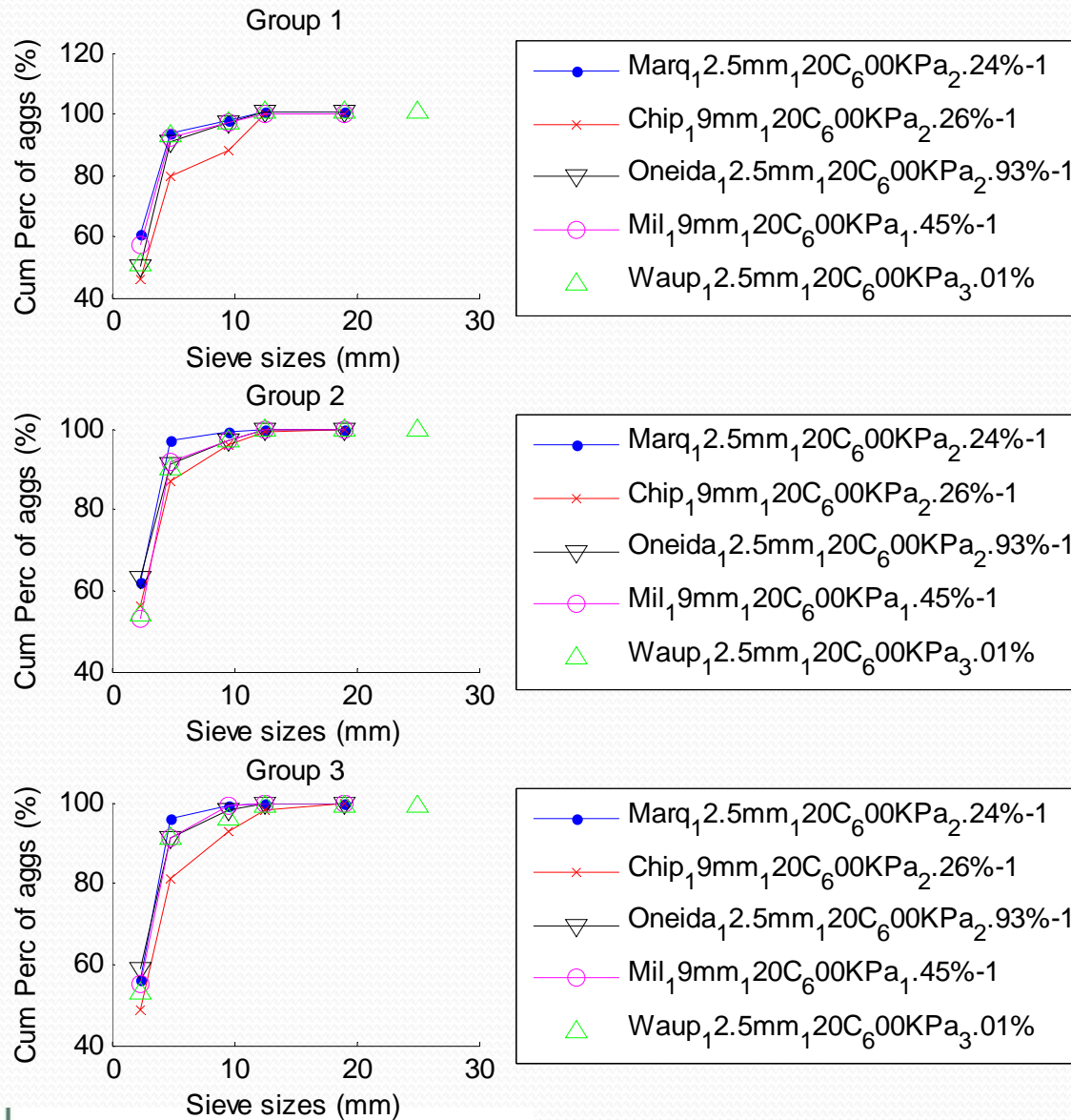
# Segregation: 12.5 mm NMAS



# Segregation: 19 mm NMAS



# Segregation:



# The End

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