

# Development of a “standard” image analysis software for determination of aggregate characteristics in HMA

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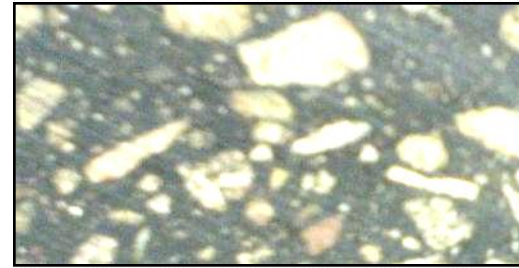
*Hussain Bahia, Ph.D.*  
Professor  
University of Wisconsin, Madison

*Carl Johnson*  
Highway Research Engineer  
University of Wisconsin, Madison

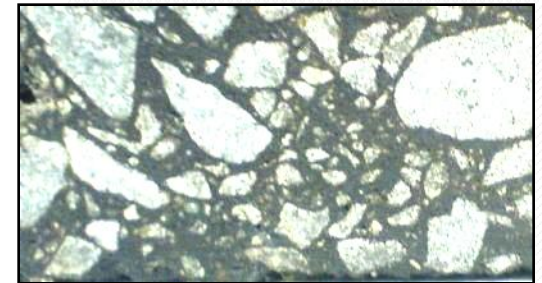
Presented at “RILEM Task Group 2 - Mixture Design and Compaction” Meeting  
January 14, 2009 - Washington, DC

# Internal structure of HMA pavements

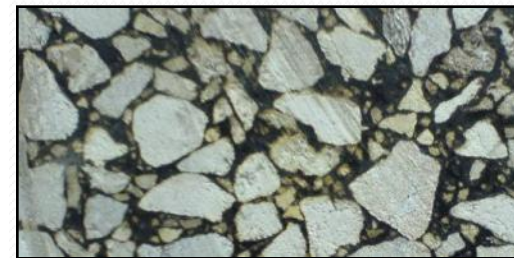
- Significantly affect the **long-term performance**
- Includes many volumetric properties other than Air Voids, VMA and VFA
  - Individual aggregate characteristics & packing
  - Air void size distribution and connectivity



**Fine** graded HMA mix



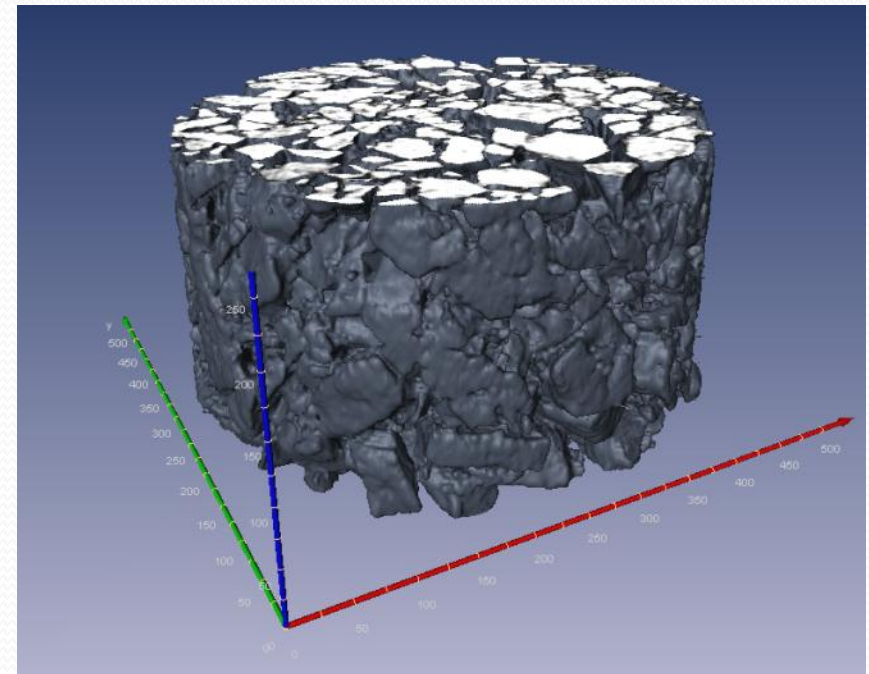
**Coarse** graded HMA mix



**SMA** graded HMA mix

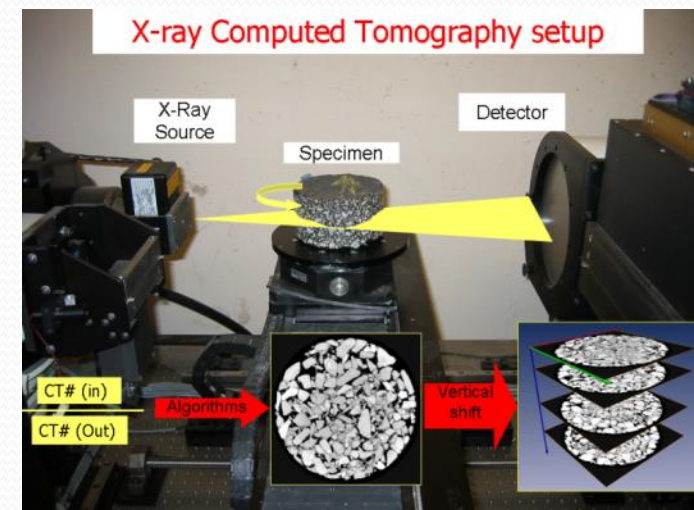
# Characteristics of aggregates packed in an asphalt mixture

- Contact points (or influence zone)
- Orientation
- Segregation
  - Spatial distribution of different sizes
- Angularity, sphericity, specific surface area and texture



# Imaging methods

- X-ray Computed Tomography
  - **Advantages:**
    - Fully three-dimensional (3D)
    - Non-destructive
  - **Disadvantages**
    - Cost of the equipment (~\$750K)
    - Slow image capturing (~3 hrs per sample)
    - Resolution (0.3 mm/ voxel)



# Imaging methods

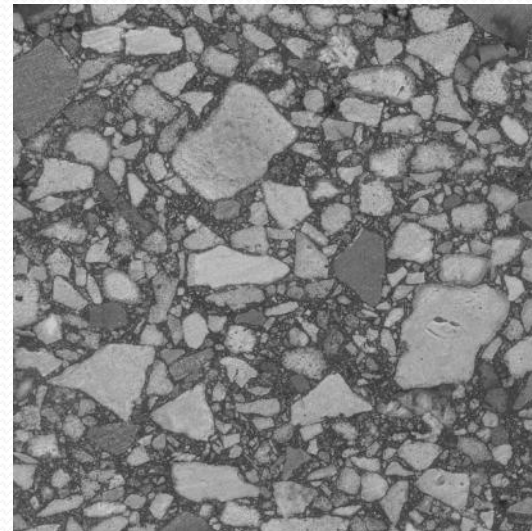
- Digital Imaging

- **Advantages:**

- Inexpensive equipment
      - Digital camera or a scanner
    - Very high resolution (up to 10 Megapixel)
    - Fast

- **Disadvantages**

- Destructive
    - Two dimensional (2D)



# Need for a Customized Image Analysis Procedure

- Numerous generic image analysis softwares available
  - ImagePro, Amira, ImageJ, Blob3D...etc.
  - For accurate extraction of quantitative information
    - Strong **knowledge** in **computer vision** techniques may be needed
  - It is important not to **over-process** the images and **lose** many of the **detail**, while trying to eliminate noise from the image.

# In order to promote the use of valuable image analysis methods:

- Simple



- Straightforward



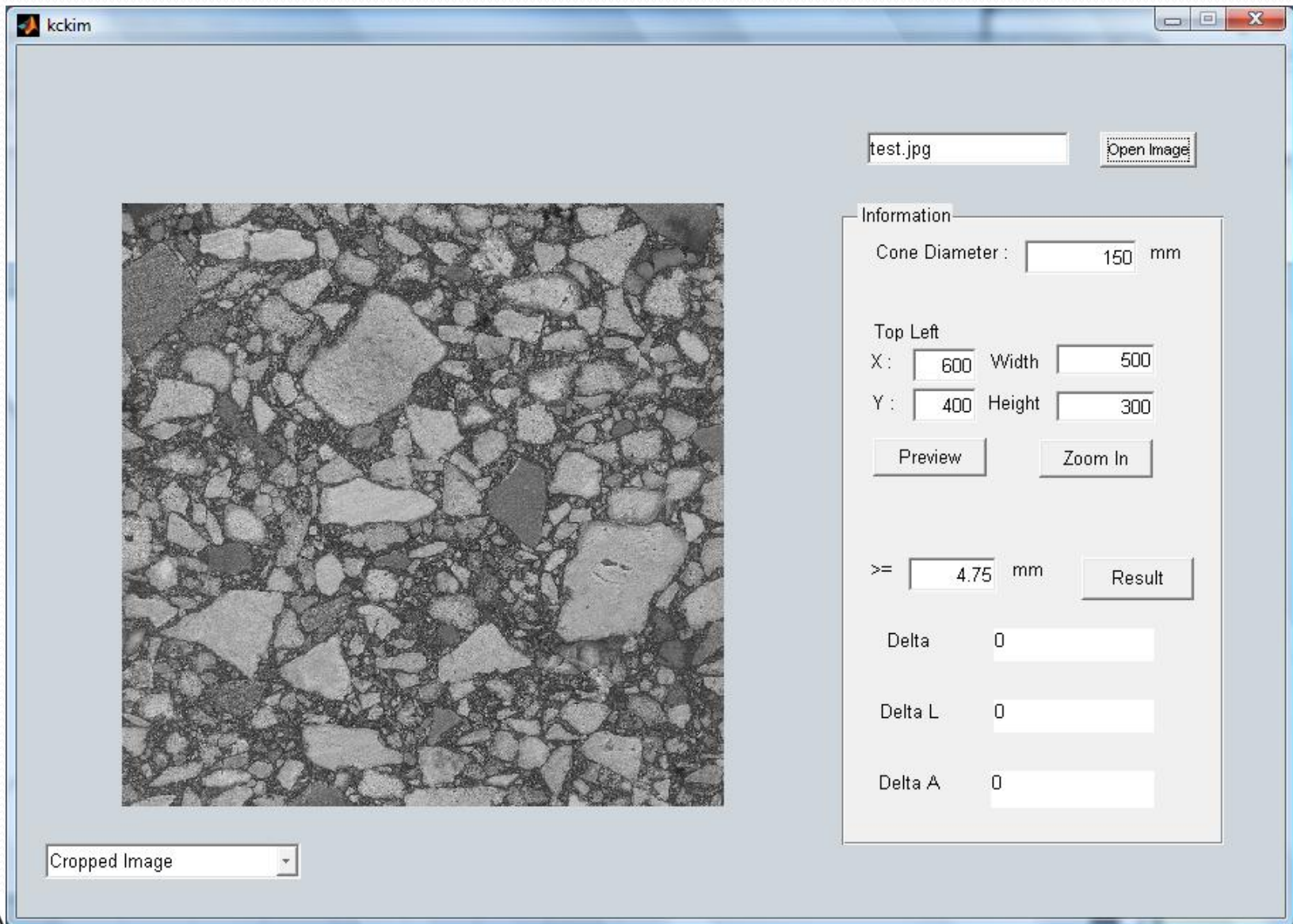
- Possibly automated software



- A standard methodology



# KCKim software – UW-Madison



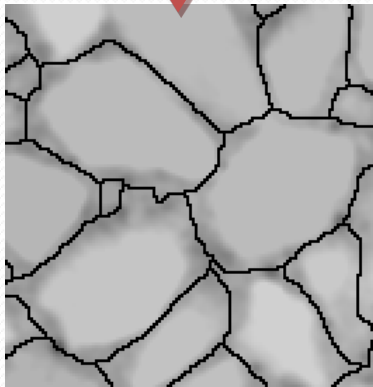
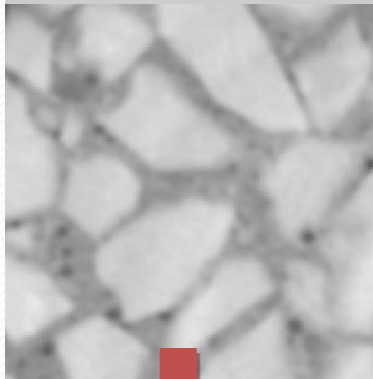


# Three main components of the software

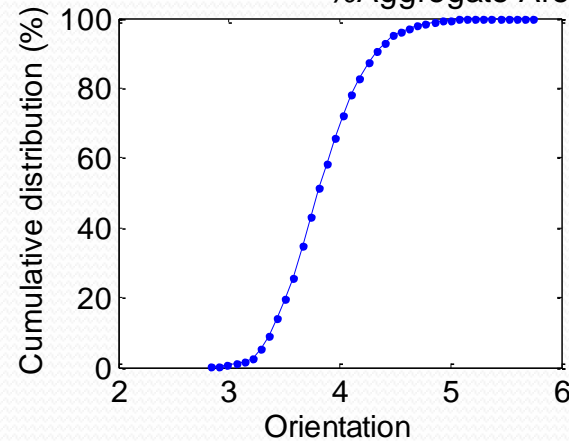
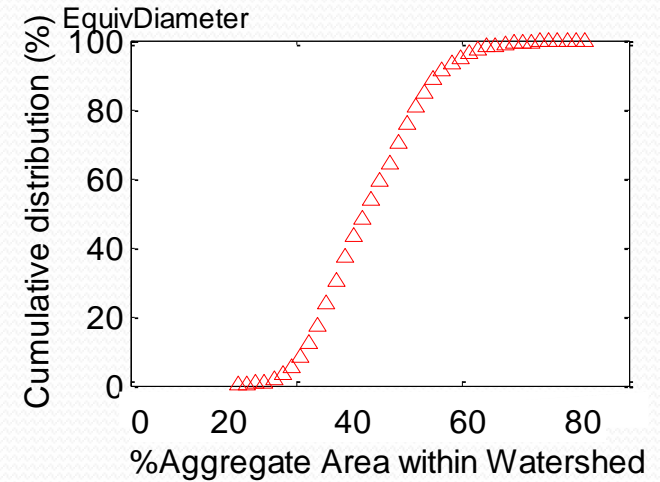
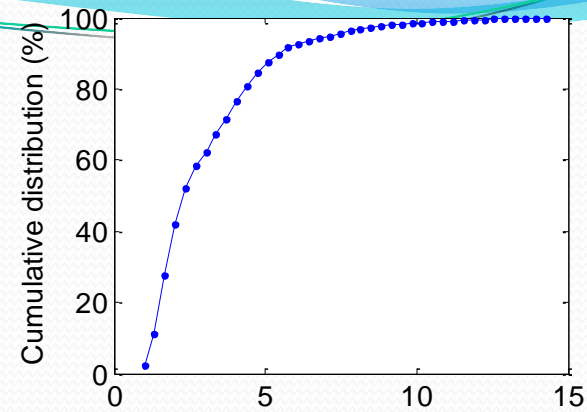
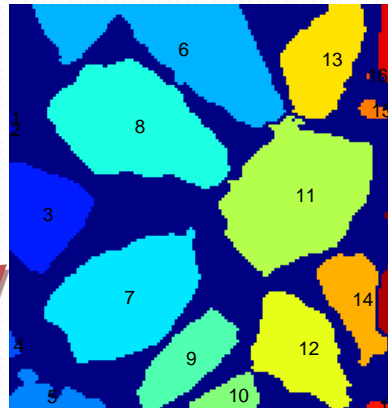
1. Image processing
2. Image analysis, and
3. Automated analysis using artificial neural networks (ANNs)

# (2) Image analysis

## (1) Image processing



## (3) ANN

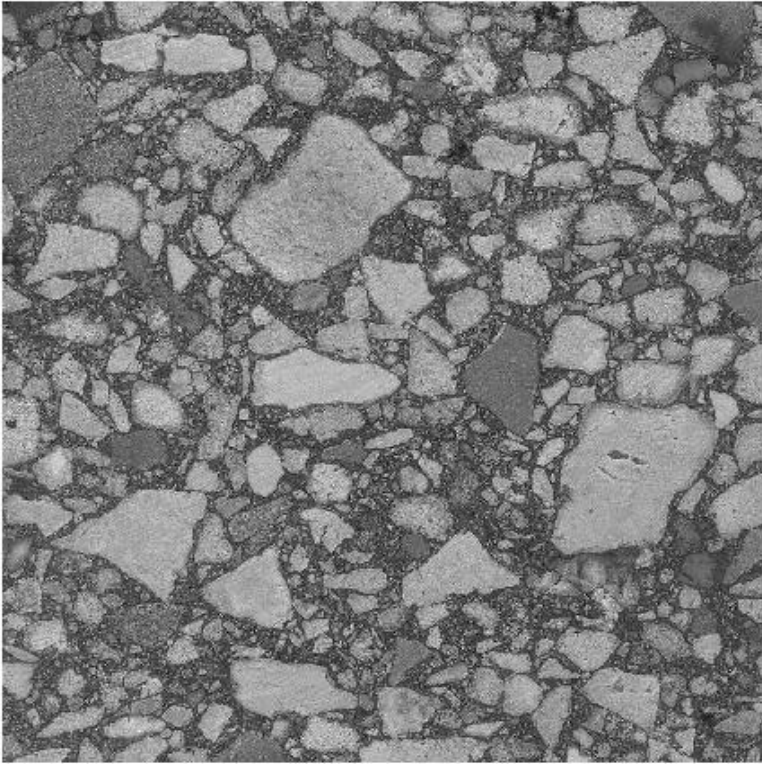


# Updated KCKim software

K\_kckim

File Image Processing Image Analysis A.N.N.

test.jpg Open Image



Information

Cone Diameter : 150 mm

Top Left  
X : 600 Width 500  
Y : 400 Height 300

Preview Zoom In

$\geq$  4.75 mm Result

Delta 0

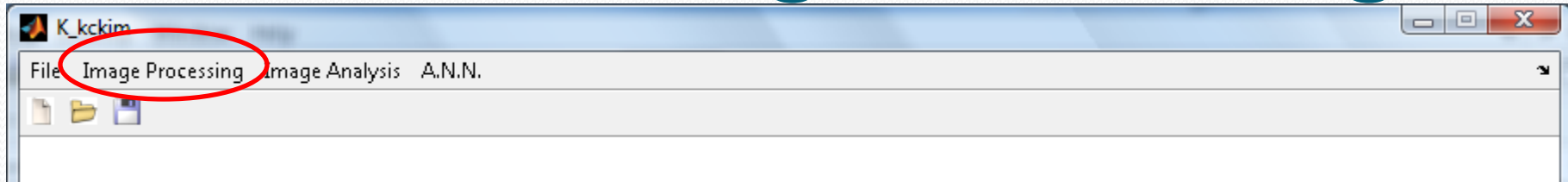
Delta L 0

Delta A 0

Cropped Image

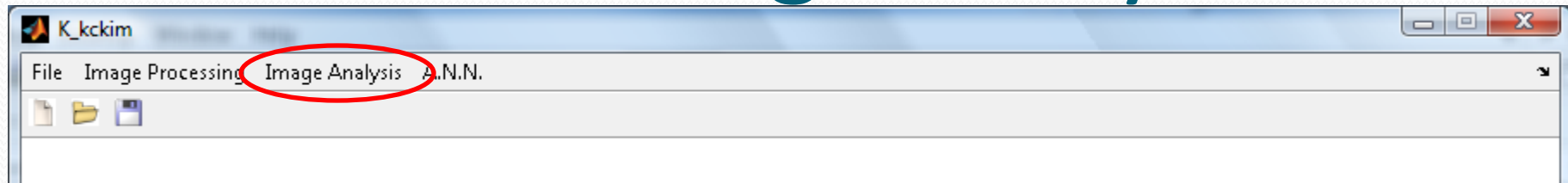
MICHIGAN UNIVERSITY

# Menu item: 'Image Processing'



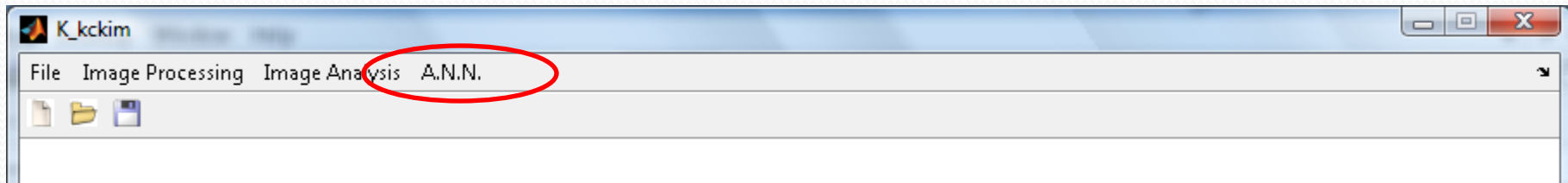
- Gaussian smoothing
- Median filtering
- Regional maxima (hmax) and minima (hmin) filters
- Watershed transformation
- Basic image operations including thresholding, adding, and inverting images
- Advanced “variable thresholding” algorithm
- Image gradient computation
- Others, e.g., applying zeros of one image to another

# Menu item: 'Image Analysis'



- **Basic region properties:** Labeling separate regions (i.e., aggregates) and calculation of bounding box, area, perimeter and centroid of each aggregate.
- **Advanced region properties:** Specific surface area, equivalent diameter, min and max axes, orientation, passing sieve size and percent aggregate area within each watershed.
- **Contact points:** Aggregate-to-aggregate contact points based on a proximity criterion.
- **Aggregate properties:** Angularity, sphericity, flat/elongation ratio...etc.

# Menu item: 'A. N. N.'



- First goal → to speed up (or totally skip) the image processing step by training an ANN to detect locations of aggregate pixels and to convert the image into a binary image.
- Second goal → to process challenging images which include asphalt specimens with aggregates that has specific reflectance characteristics (e.g., multi-colored or shiny aggregates).

# The End

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