Determining Aggregate Characteristics of HMA: 3D Processing of X-ray CT Images

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Effect of aggregate properties

- **Fine graded HMA mix**
  - Coarse Aggr: Little or no contact points
  - Fine Aggr: Very important

- **Coarse graded HMA mix**
  - Coarse Aggr: Some contact points
  - Fine Aggr: Important

- **SMA Mix**
  - Coarse Aggr: Many contact points
  - Fine Aggr: Less important
Steps of Image-based Aggregate Extraction

1. Specimen Prep. (Lab compacted / field core)
2. Varying aggregate type, compaction characteristics
3. Measurement of 3D internal geometry
4. X-ray CT imaging
5. Rigorous image processing & analysis
6. Separation of aggregates
7. Individual aggregate props: 3D orientation, angularity, Specific surface area ... etc.
8. Calculation of contact points
Direct measurement of aggregate characteristics: 3D image analysis
Characteristics of **aggregates** packed in an **asphalt** mixture

- 3D **Contact points** (or influence zone)
- 3D **Orientation**
- **Segregation:**
  - Spatial distribution of different sizes
- 3D **Angularity, sphericity, specific surface area and texture**
Aggregate contact points

• **Given**: gradation and compaction level
  - Variation of *contact points* for different aggregates: **rectangular, flat, elongated and round**

• **Locking point**

• **Effect of number of contact points on HMA performance**

• **Mix design considering contact points and packing**
Challenge in experimentation:
separation of aggregates

Ideal vs Real
Thresholding and labeling (2D description)

Grayscale image

Thresholded binary image

Intensity Distribution

0 181 255
Thresholding and labeling
(2D description)

Binary image

Labeled image
Filtered watershed transformation

Original → Gaussian smoothed → Hmax filtered

Inverted → Watershed lines → Watershed transformed image
Original Gaussian smoothed Hmax filtered

Watershed transformed image Watershed transformed image Watershed transformed image

Not good Not good Good
Thresholding and labeling

Image after watershed

Labeled image

Intensity Distribution

0 255

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Separation of aggregates:
3D image processing steps

Original 3D image

3D Gaussian smoothing

3D Hmax filtering

3D Watershed surfaces (lines)

Thresholding & labeling
Thresholding Issues...

Different intensities

![Intensity Distribution Image](image-url)
Dynamic thresholding in 2D

Original image

Intensity histogram

peak

Grayscale intensity

# of pixels
Dynamic thresholding in 3D

Intensity histogram

peak
Calculation of aggregate properties

- 3D Contact points
- 3D Orientation
- 3D Volume, Angularity, Specific surface area
- Segregation:
  - Spatial distribution of different sizes
Calculation of contact points

Shortest distance between surface voxels
Example calculations

N35

N160
Example calculations

Cumulative distribution (%)

EquivDiameter

N35

N160
X-ray CT Image 3D Analysis Tool
Thank You!

Try to catch the rotating snake with your eye!
The End

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