MODIFIED ASPHALT RESEARCH CENTER

Characterization of Damage Resistance to Rutting Using IPAS^2 Software

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ARC Deliverables/Products Presentation and Workshop

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Outline

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- Background
  - Aggregate structure role in Asphalt Concrete (AC) performance
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- iPas^2
- Internal structure analysis
  - Aggregate structure and rutting performance
  - Factors affecting aggregate structure
    - Gradation
    - Binder rheology
    - Compaction conditions on
- Conclusions and future work

Aggregate structure role in AC performance

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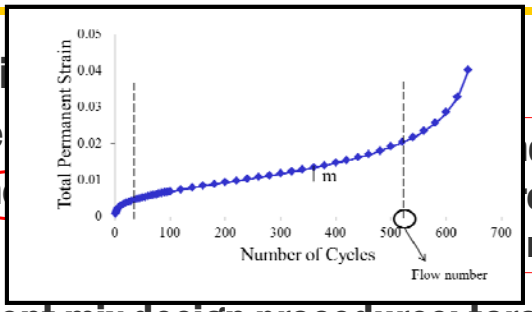

ding on
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rlock

- Current mix design procedures: target density

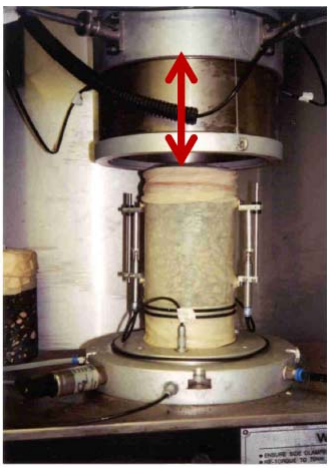
Flow Number at Equal Density		
Sample	Stress (kPa) = 1034	% AV
Coarse Mix	210	7
Fine Mix	400	7

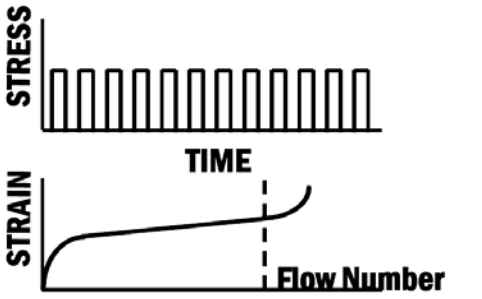
Almost 100% difference

Image analysis of AC: *Background*

- **Yue et al. 1995:** Primary indices, major and minor axis, orientation
- **Ma** anis
- **Ma** initi … hy,
- **Tas** base … tures … n
- **Zelew and Papagiannakis (2009, 2011) :** focused on automation of processing and analysis

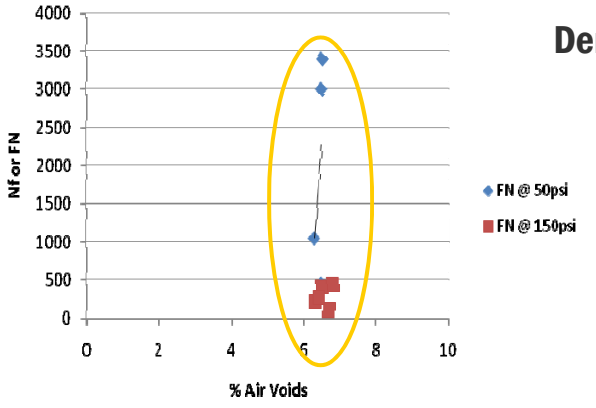
However, there is no agreement on how to quantify and describe aggregates' structure





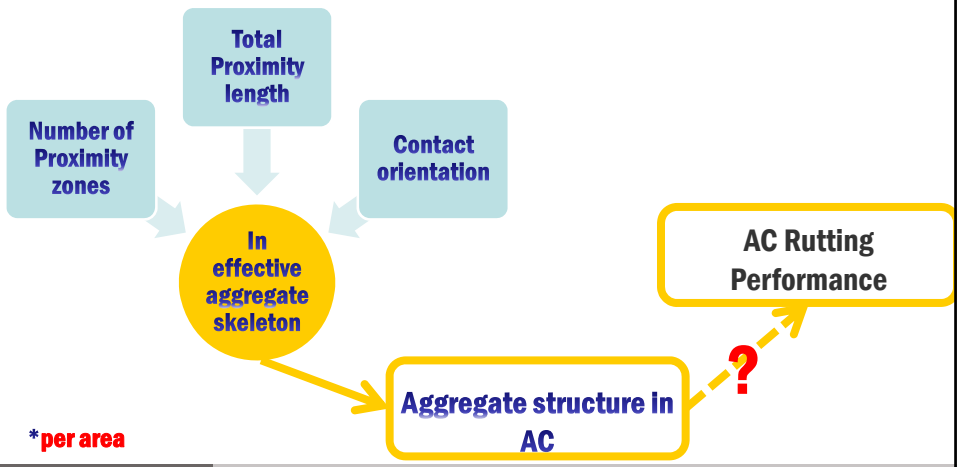
Flow Number (FN) at High Temperatures

Flow Number (Rutting) vs. Density



Density ≠ Performance

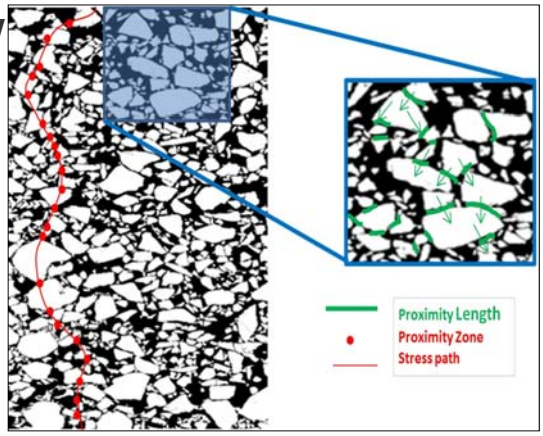
Defining Aggregate Structure



Can we measure aggregate structure?

iPas^2 (Image analysis and processing software)

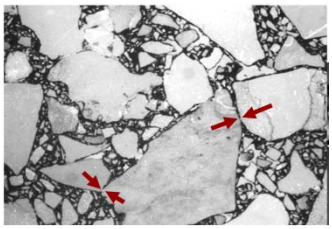
- iPas^2 is tool to identify aggregate proximity during and after compaction.
- Outputs:
  - Packing
  - Connectivity
  - Orientation
  - Spatial Distribution



Introduction

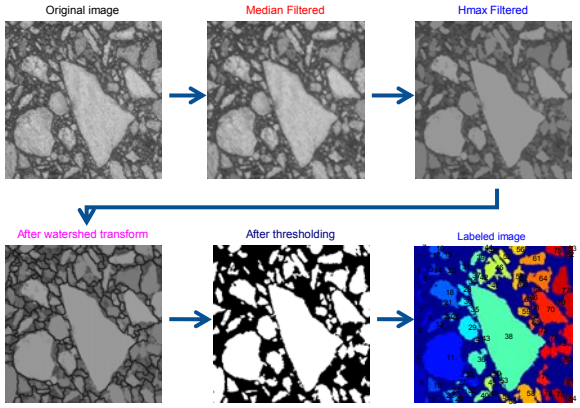
iPas^2 Image Processing & Analysis System

- **iPas** : Image Processing and Analysis System
- Two components:
  - Image Processing
    - Filters
    - Enhancing
    - Result: Black and White Image
  - Microstructure Analysis
    - Area Fraction
    - Gradation
    - Other Micromechanical Characteristics
      - > Proximity zones, total proximity length, contact orientation, aggregate orientation, segregation



iPas overview

Step 1 -Image processing



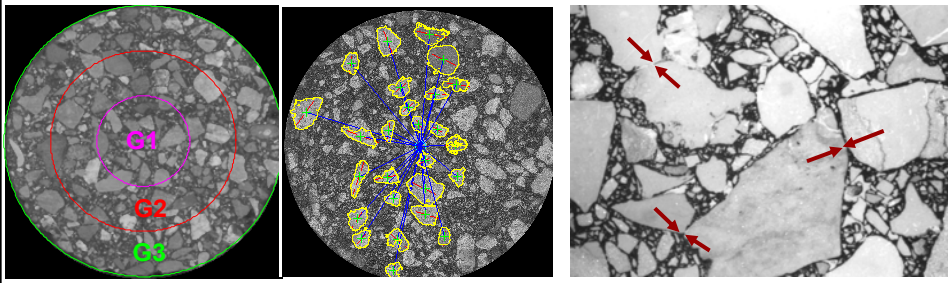
After Coenen et al. 2011

iPas
Image Processing & Analysis System

iPas overview

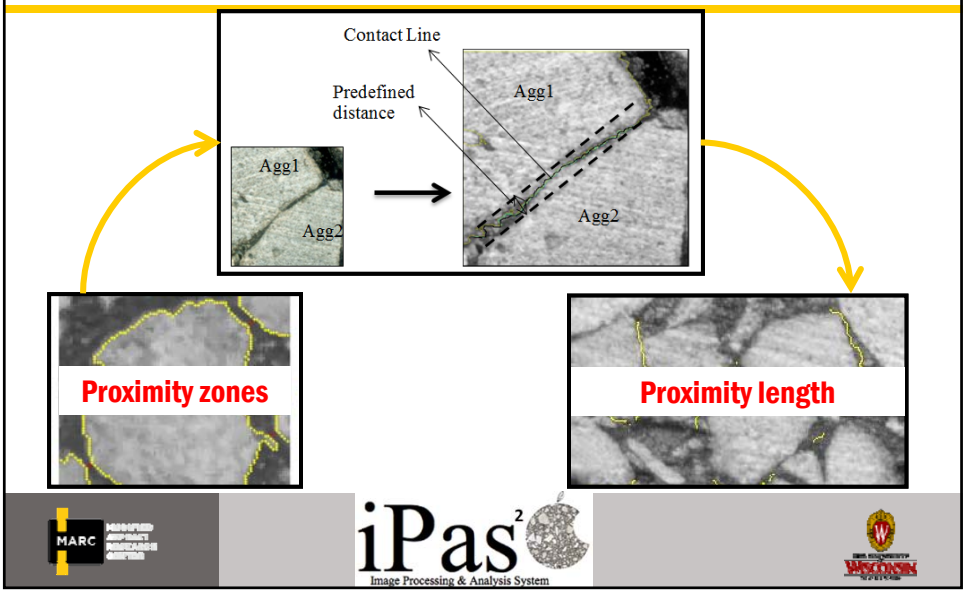
Step 2- Microstructure analysis

Segregation **Orientation** **Number of proximity zones**

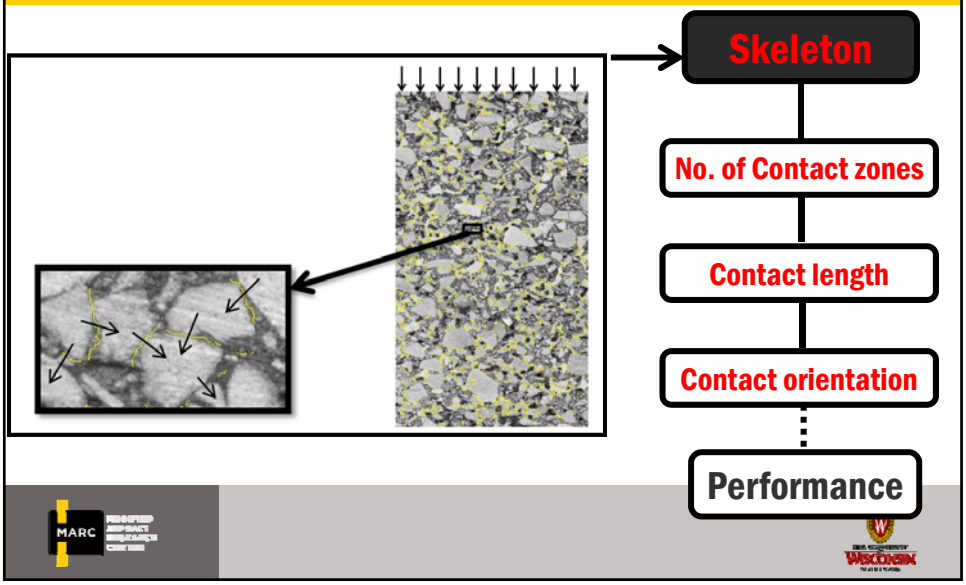


iPas
Image Processing & Analysis System

New approach for aggregate skeleton characterization: iPas²

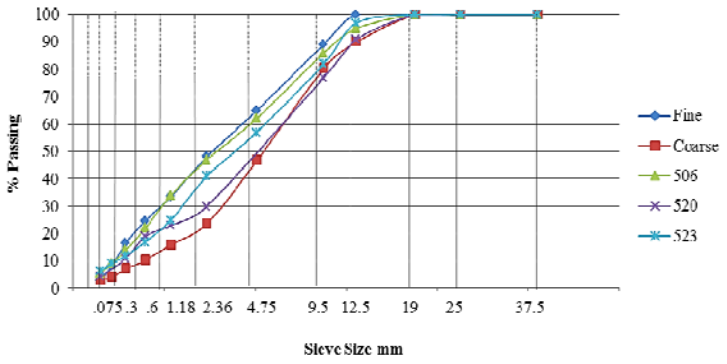


New approach for aggregate skeleton characterization: iPas²

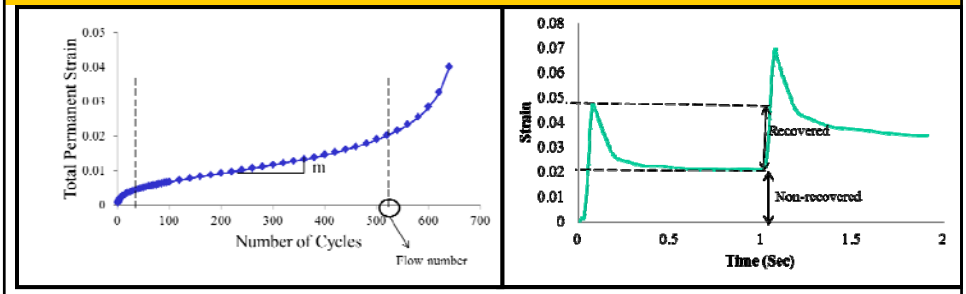


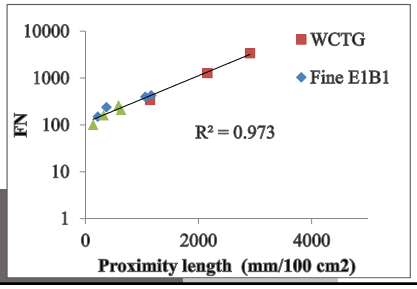
Example 1: Effect of aggregate Gradation on Rutting

Wide range of gradations used



Effect of aggregate structure on rutting: *Testing*

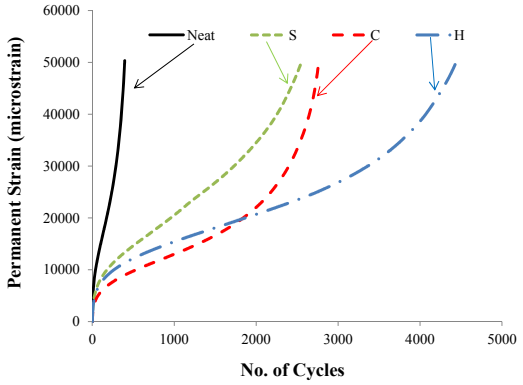


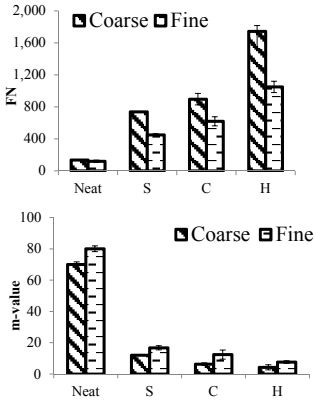


Mixture	Flow Number (1034 kPa)
506	340
520	3400
523	1275
F-CBE	400
F-SBS	430
F-GTR	240
F-Neat	150
C-CBE	210
C-SBS	260
C-GTR	160
C-Neat	100

Range of rutting performance

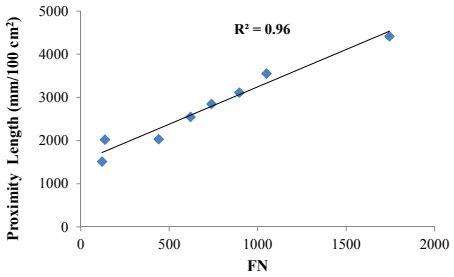
Example 2: Effect of Binder Modification on Rutting





- H mixture has the best mixture performance
- Lower m-value implies a lower rate of permanent deformation accumulation with number of cycles

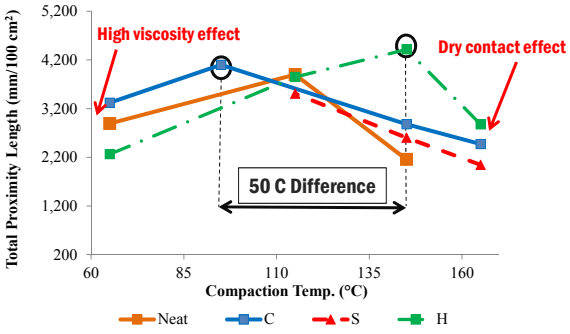
Effect of Aggregate Structure on Rutting



- Structure dictates how load is carried through mix
- Targeting density (AV at N_{des})as indicator of performance is not effective
  - Mixes of the same air voids have very different laboratory performances

Effect of Compaction Temperature on Evolution of Aggregate Structure

- Different binders show a peak at different temps
  - Optimum compaction – Optimum mastic viscosity



Different mixtures could achieve similar packing levels, but at different temperatures

Remarks: Effect of Aggregate Packing on Performance

- Density is not sufficient to estimate packing of aggregates
- Internal structure of mixtures have significant effect on performance
- Mixture with low connectivity generally show poor rutting and thermal performance

Conclusions

- Aggregate structure of asphalt mixtures can be characterized successfully using analysis of 2D images
- Rutting resistance ~ Aggregate structure
- Effect of compaction effort and method, temperature, gradation, binder rheology on inherent aggregate structure is successfully captured

Thank you