

# Update on status of X-ray CT imaging and associated work at TFHRC

*RILEM TG2 Mixture Design and Compaction*

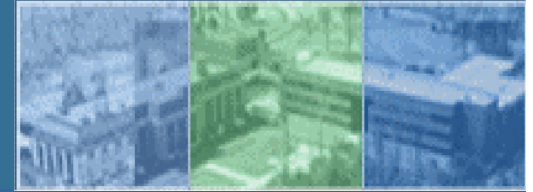
*TRB Meeting*

*January 14, 2008*



U.S. Department of Transportation  
Federal Highway Administration

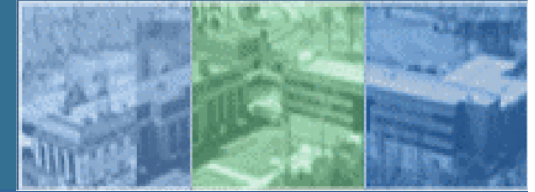




## TFHRC Participants

- Katherine Petros
  - Pavement Design and Performance Prediction Team Leader
- Jack Youtcheff
  - Pavement Materials and Construction Team Leader
- Nelson Gibson
  - Pavement Materials and Construction Team, Asphalt
- Chichun Hu
  - Visiting Scholar
- David Heldt
  - Pavement Materials and Construction Team, PCC
- *\*M. Emin Kutay*
  - *Michigan State University Assistant Professor*
  - *Former TFHRC researcher, maintaining ties*



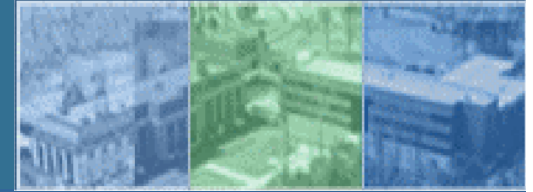


## Chichun Hu is performing bulk of hands-on work



- Pursuing PhD
- Visiting scholar from South China University of Technology
- Department of Civil and Traffic Engineering
- Will be leaving TFHRC and returning June 2009
- Will be working with new CT aystem to come on line at SCUT



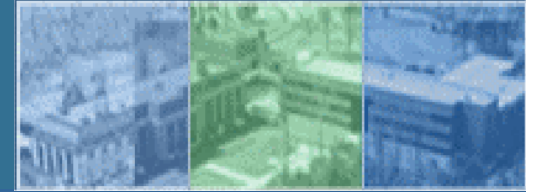


## CT Equipment at TFHRC

- Primarily a MACRO CT system with limited “micro” capabilities
- Manufactured by BIR
- Actis control and reconstruction software
- Now supported by Varian
- TFHRC will be receiving a System Audit and Full Training Session in early spring



# TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

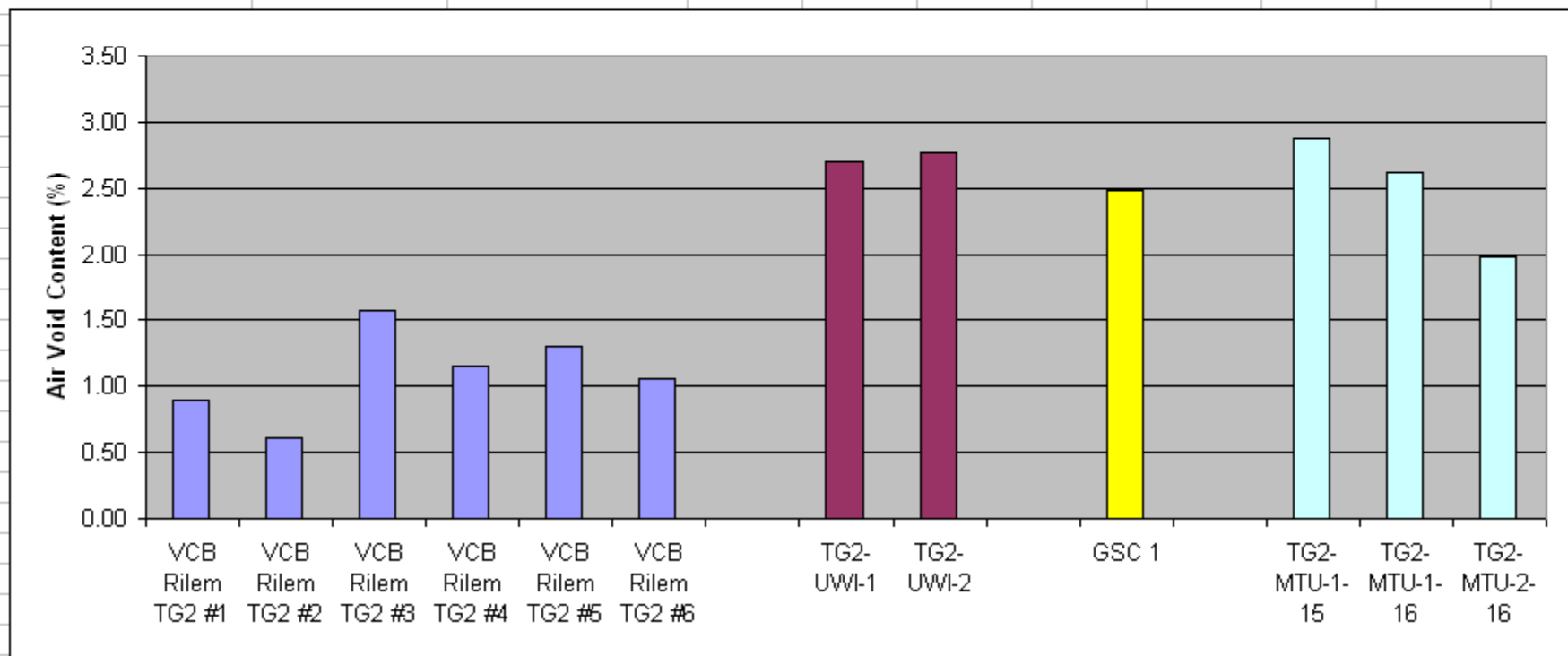


Dedicated cabinet to store, track and manage RILEM samples which are received and taken to and from CT system



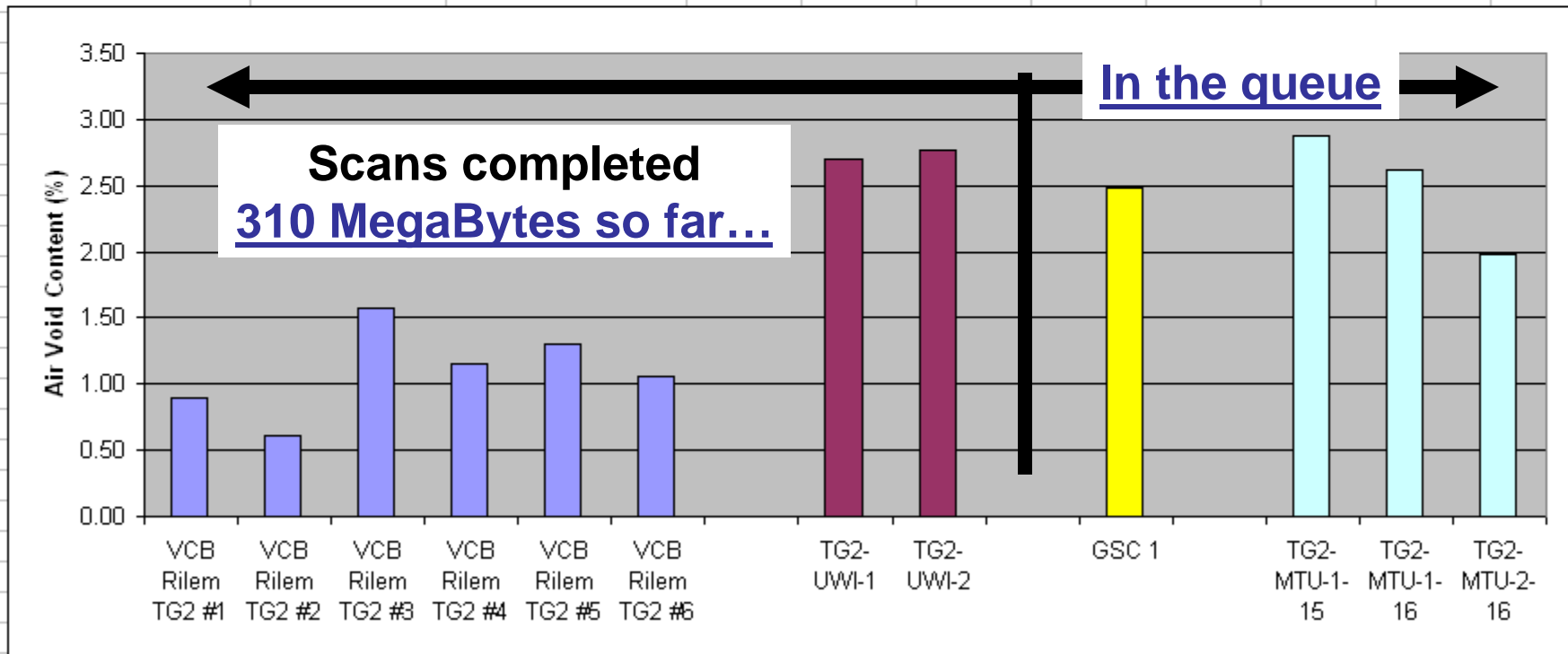
# TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

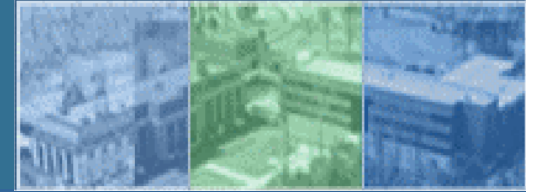
Compaction Method	Institution	SAMPLE ID	Wt Air	Wt H2O	SSD	Bulk Vol	BSG	Max SG	% Voids	Unit WT
Kneading Compactor	UC Davis	VCB Rilem TG2 #1	1249.6	762.6	1250.4	487.8	2.562	2.585	0.90	159.85
		VCB Rilem TG2 #2	1252.8	765.8	1253.4	487.6	2.569	2.585	0.61	160.33
		VCB Rilem TG2 #3	1196.6	726.7	1197.0	470.3	2.544	2.585	1.57	158.77
		VCB Rilem TG2 #4	1203.5	733.3	1204.3	471.0	2.555	2.585	1.15	159.44
		VCB Rilem TG2 #5	1247.9	759.6	1248.7	489.1	2.551	2.585	1.30	159.21
		VCB Rilem TG2 #6	1252.8	763.8	1253.6	489.8	2.558	2.585	1.05	159.61
Marshall	AIT	TG2-UWI-1	1252.5	755.8	1253.8	498.0	2.515	2.585	2.71	156.94
		TG2-UWI-2	1245.2	751.4	1246.8	495.4	2.514	2.585	2.77	156.84
German Steel Sector	TU Braunschweig	GSC 1	1299.2	785.1	1300.5	515.4	2.521	2.585	2.49	157.30
Superpave Gyratory	Michigan Tech	TG2-MTU-1-15	3128.9	1884.8	3,132.90	1248.1	2.507	2.581	2.87	156.43
		TG2-MTU-1-16	3137.7	1896.8	3,145.20	1248.4	2.513	2.581	2.62	156.83
		TG2-MTU-2-16	3151.4	1909	3,154.60	1245.6	2.530	2.581	1.97	157.87



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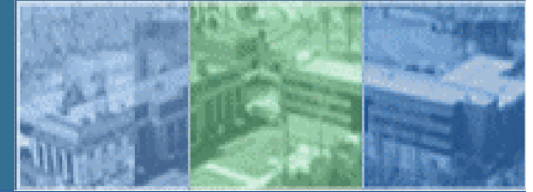


## Minor Set-Backs and Refinements to Procedure

- Ring Artifacts
  - Wedge Calibration
    - Difficulties and Drawbacks with Asphalt + Aggregate Mastic Technique
      - Need to heat
      - Cools fast
    - New Polyester Resin + Cement Powder Sample
      - Allows much better image quality
      - More convenient
- Unix Computer Hard Drive Failure
  - We have recovered

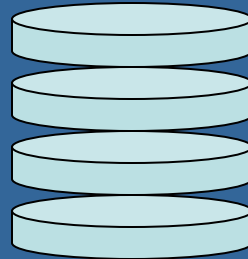
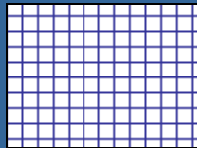




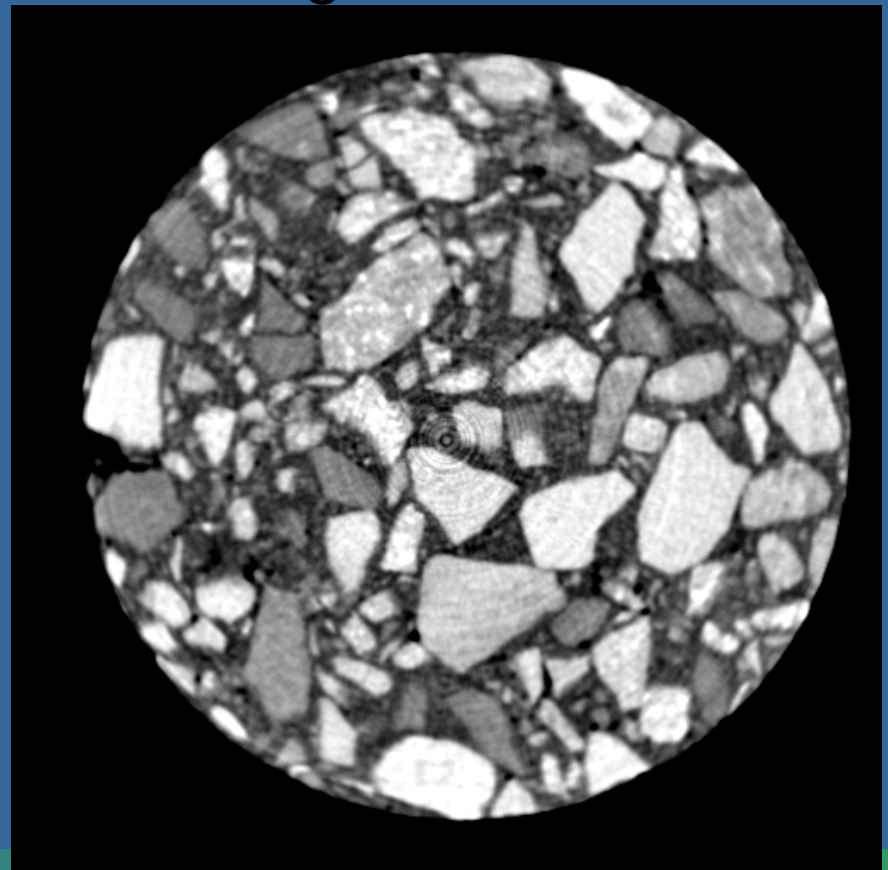


## Characteristics of Images

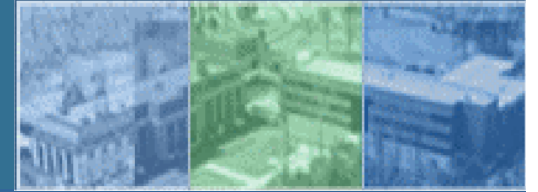
- \*.tiff
- 512 pixels x 512 pixels
- 0.4 mm slice thickness



$$\frac{mm}{pixel_x} = \frac{mm}{pixel_y} = 0.2 mm / pixel$$

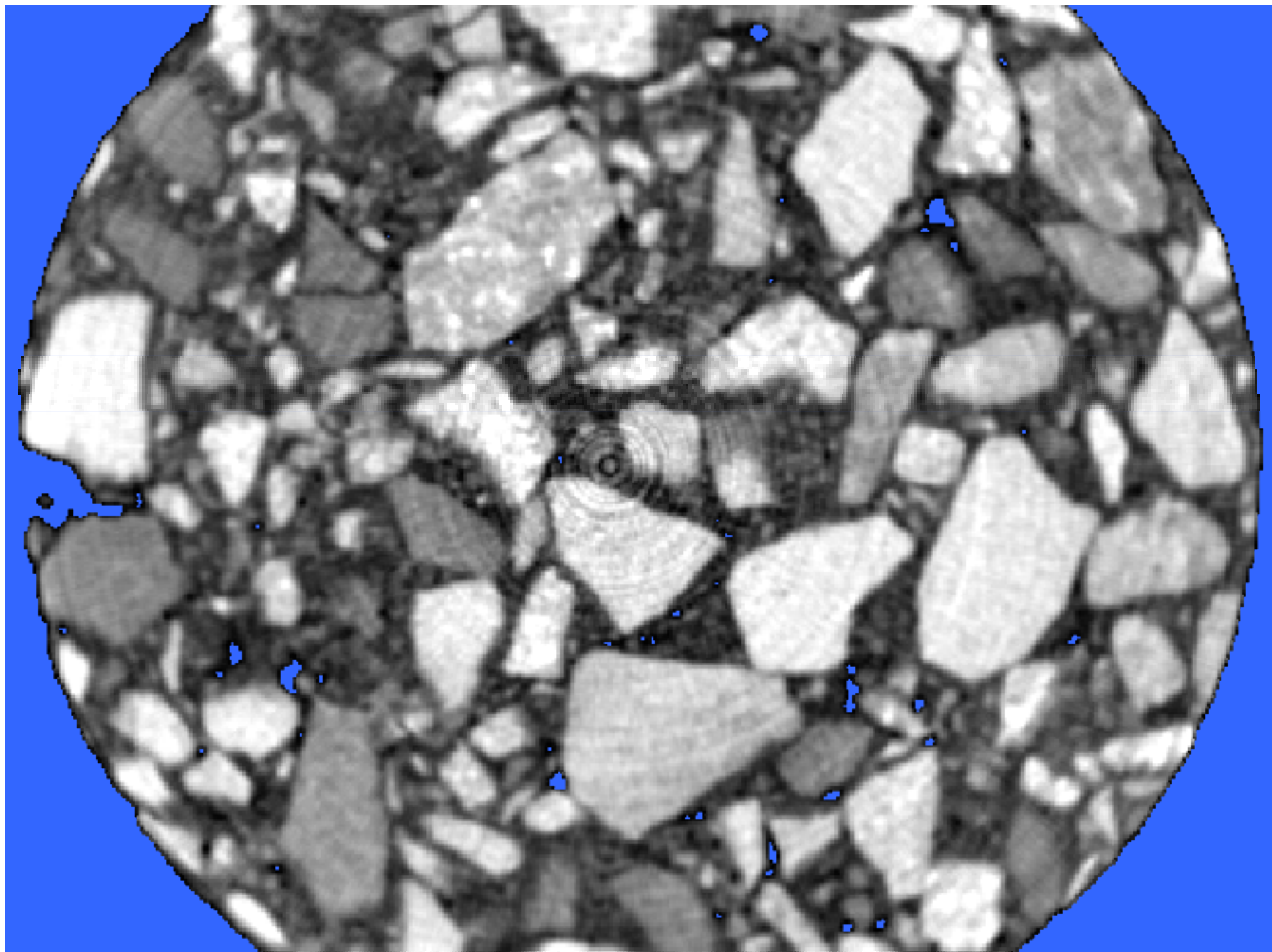


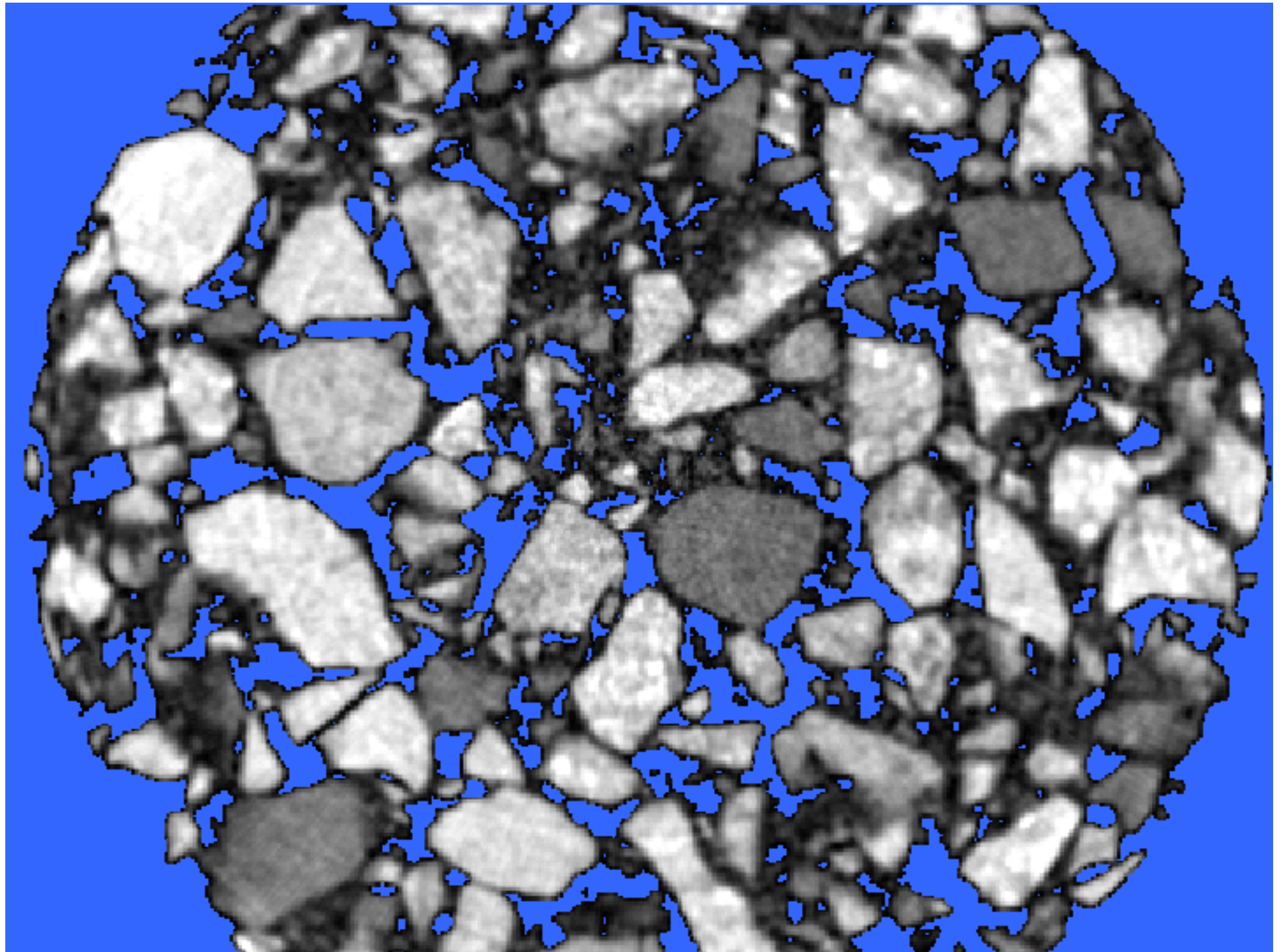
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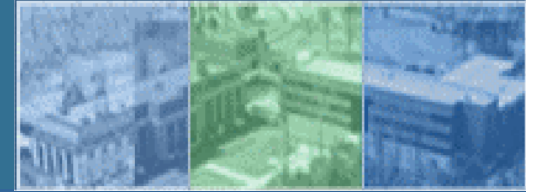


## Two Random Typical Images for Qualitative Review





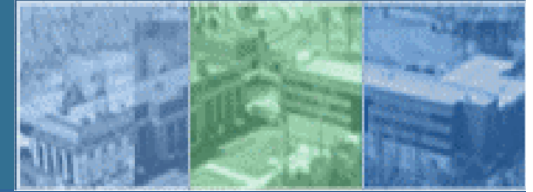




## Analysis Actions since Last Meeting

- Elementary Exercises
  - Loose Aggregate in Cement Powder
  - “Blind” Dummy Sample
- Rehearsal of Iterative Compact and Scan in SGC



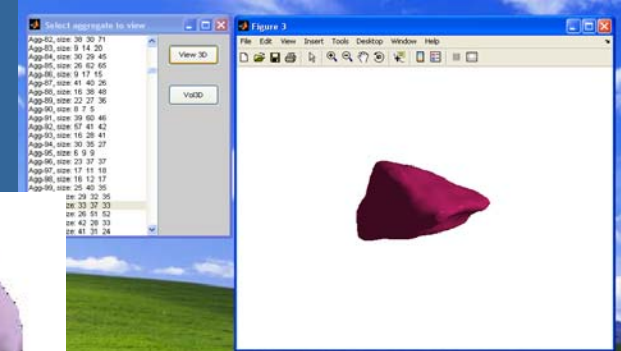
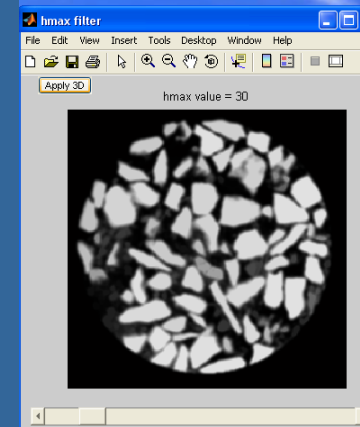
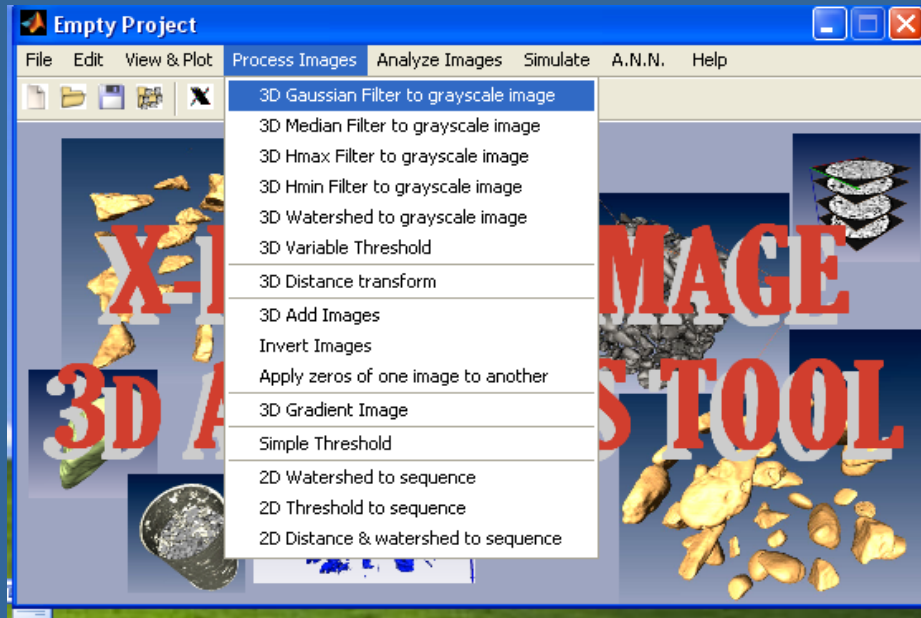
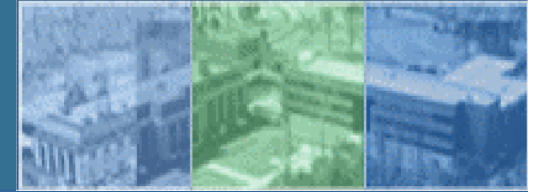


## Elementary Exercise

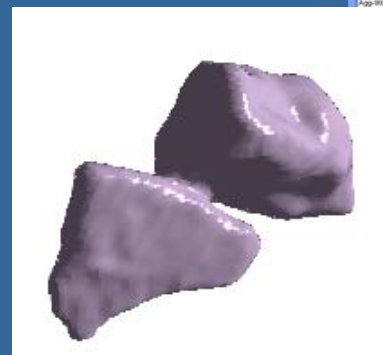
- Simple Two-Phase material
- Are we proficient in numerically separating coarse aggregates from one another for the simplest of conditions (in the absence of Emin)?
- Manual count of aggregate particles before placing in cement powder
- Scan and analysis with Kutay/FHWA XRay CT Tool Software
  - GUI written in Matlab
  - Share with TG2?
  - Compiled vs. Not Compiled



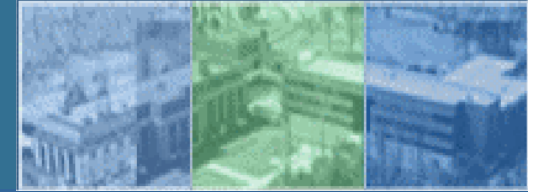
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Agg No	Volume	Surface Area	Specific Surface Area	Equivalent diameter
1	5480.0	2204.9	0.402	21.9
2	2841.7	1346.5	0.474	17.6
3	5802.6	2158.3	0.372	22.3
4	3436.9	1588.7	0.462	18.7

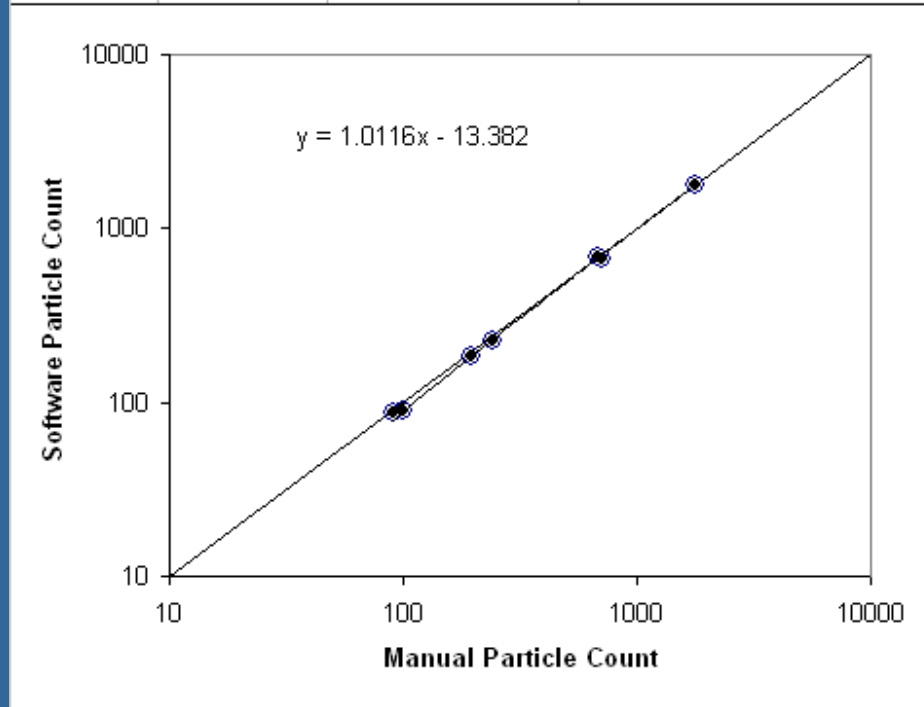


# TURNER-FAIRBANK HIGHWAY RESEARCH CENTER

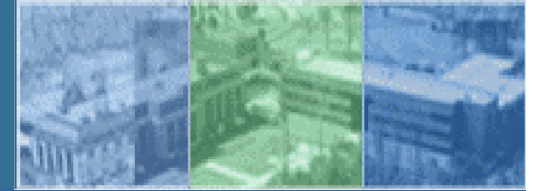


Sieve Size	Manual Count	Software Count	
		Output from Software	Manually Adjusted Count for Touching Aggregates
1~3/4 (1)	100	89	98
1~3/4 (2)	90	87	89
3/4~1/2 (1)	196	182	194
3/4~1/2 (2)	241	227	237
1/2~3/8	703	672	691
1/2~3/8 mix	680	692	695
3/8~#4	1781	1792	1792

Aggregate Size	Volume from AASHTO T85 (SSD) cm <sup>3</sup>	Volume from the Software cm <sup>3</sup>	Volume Ratio
1 - 3/4	473.7	390.3	82.4%
1 - 3/4	485.4	411.5	84.8%
3/4 - 1/2	481.4	405.5	84.2%
3/4 - 1/2 <2>	483.2	410.5	85.0%
1/2 - 3/8	483.0	405.2	83.9%
1/2 - 3/8 some mixed	480.1	408.0	85.0%
3/8 - #4	477.0	396.6	83.1%

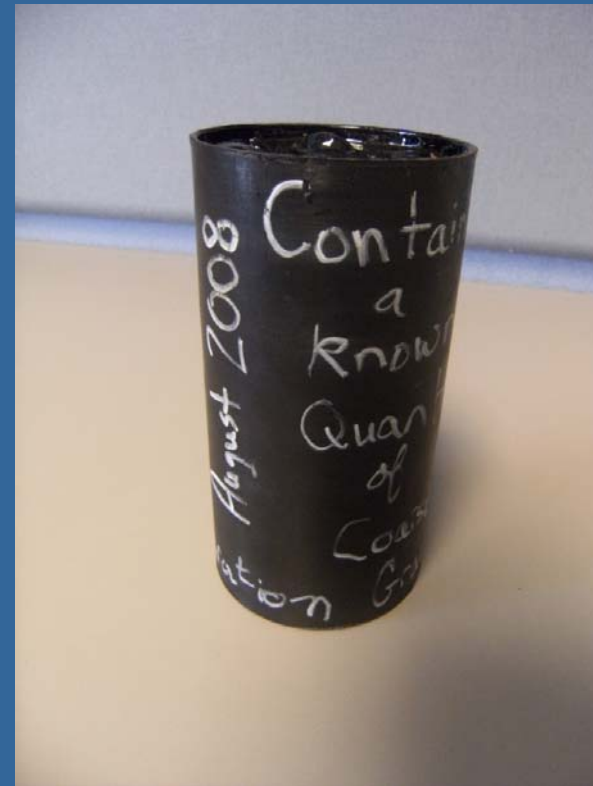


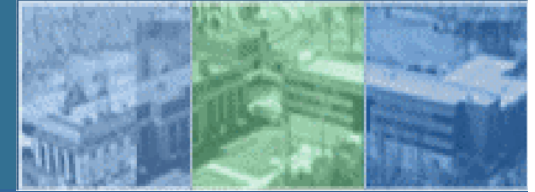




## "Blind" Dummy Sample

- Coarse gravel mixed with epoxy to create a loose state then filled with asphalt binder
- Did not tell Hu how many particles were counted going into the mold

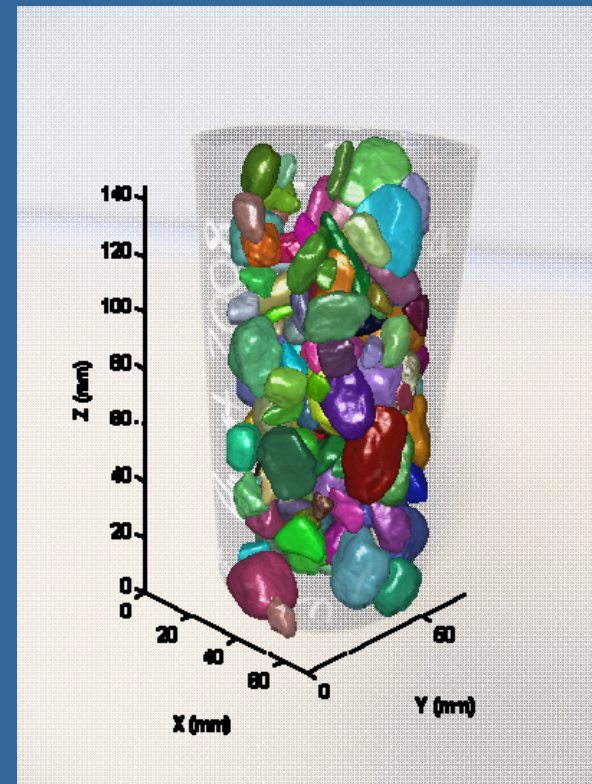


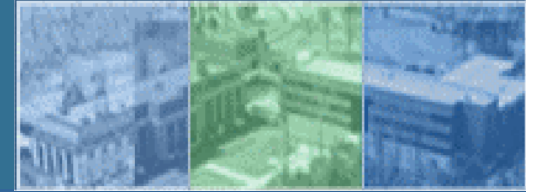


## "Blind" Dummy Sample

- *Would any institution be interested in sharing blind dummy samples like this or raw image sequences like this to compare different analysis algorithms and approaches?*

Filter	% Particles Identified	% Particles Bonded
Hmax20	92.7%	9.7%
Hmax25	80.6%	23.0%
Hmax22	86.7%	14.5%
Hmax18	95.8%	7.3%
Hmax16	97.6%	6.1%
H14	101.2%	3.6%



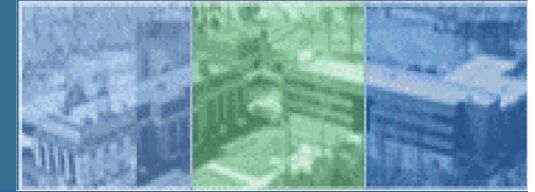


# Iterative Compact and Scan Activities

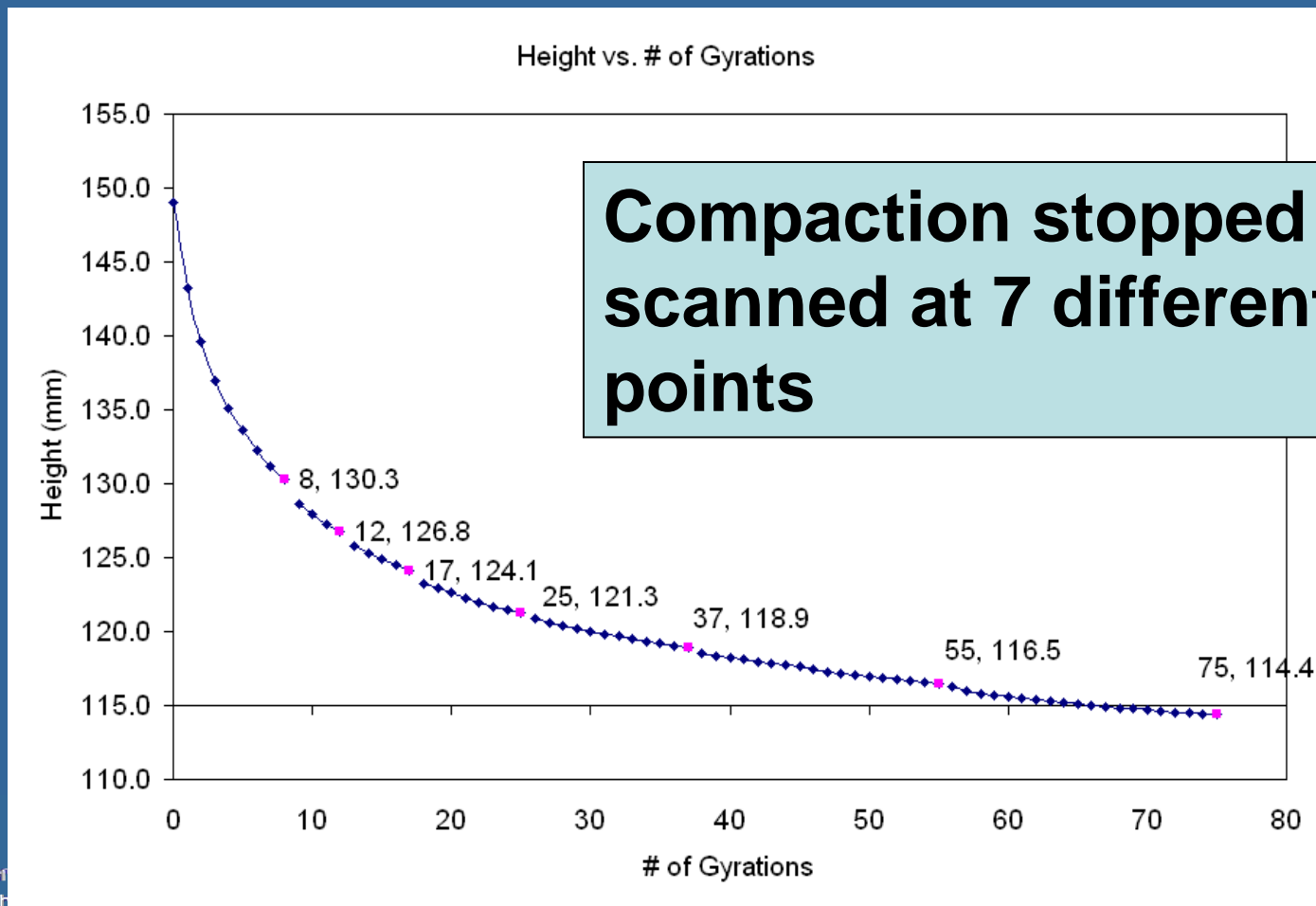
- Acknowledge

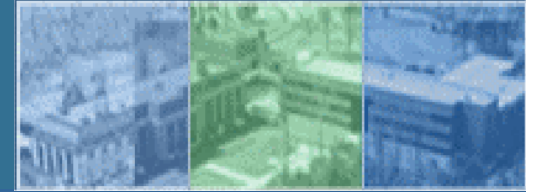
- *Partl, M.N., Flisch, A., Jonsson, M., (2003) "Gyratory Compaction Analysis with Computer Tomography." Int. J. of Road Materials and Pavement Design, Hermes Science Publications, Vol. 4, No. 4, pp. 401-422.*





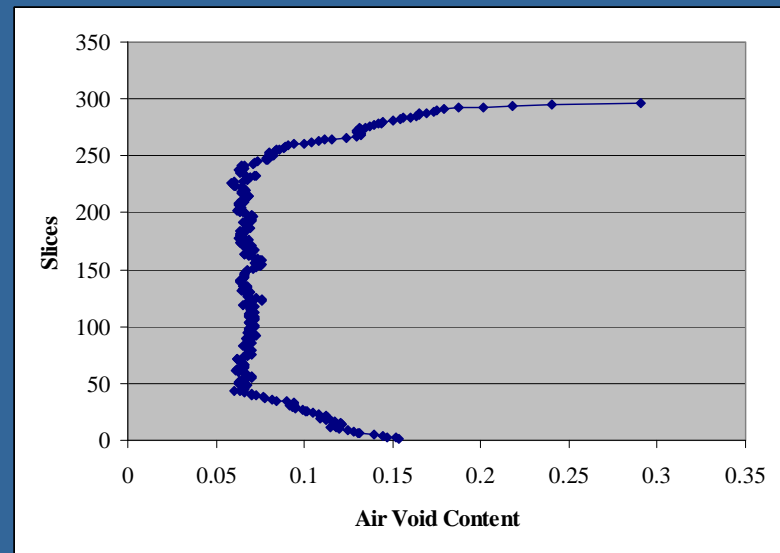
# Iterative Compact and Scan Activities





## Iterative Compact and Scan Activities

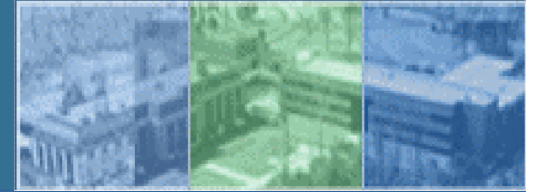
- We have learned for ourselves the limitations of tracking all three phases
  1. Coarse Aggregate
    - 4.75 mm and larger
  2. Air Void
    - Some will be too small to detect
  3. Bitumen + Fine Aggregate Mastic



**Work Continues!**



# TURNER-FAIRBANK HIGHWAY RESEARCH CENTER



Thank You

Questions?



U.S. Department of Transportation  
Federal Highway Administration