



Investigations and Implementation of Internal Angle in Illinois

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- Brief history of internal angle and technology
- Investigations
- What we've learned
- Implementation

Internal Angle

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What is internal angle?

- Measuring the angle of gyration from inside the specimen mold instead of on the outside.
- Concept and technology were developed by FHWA with assistance from industry

Why is it important?

- “The verification of the angle of gyration is essential to ensure comparable results from different...compactors.”
- “...measurement of the internal angle may lead to better comparability between compactors than using the external angle measurement.”

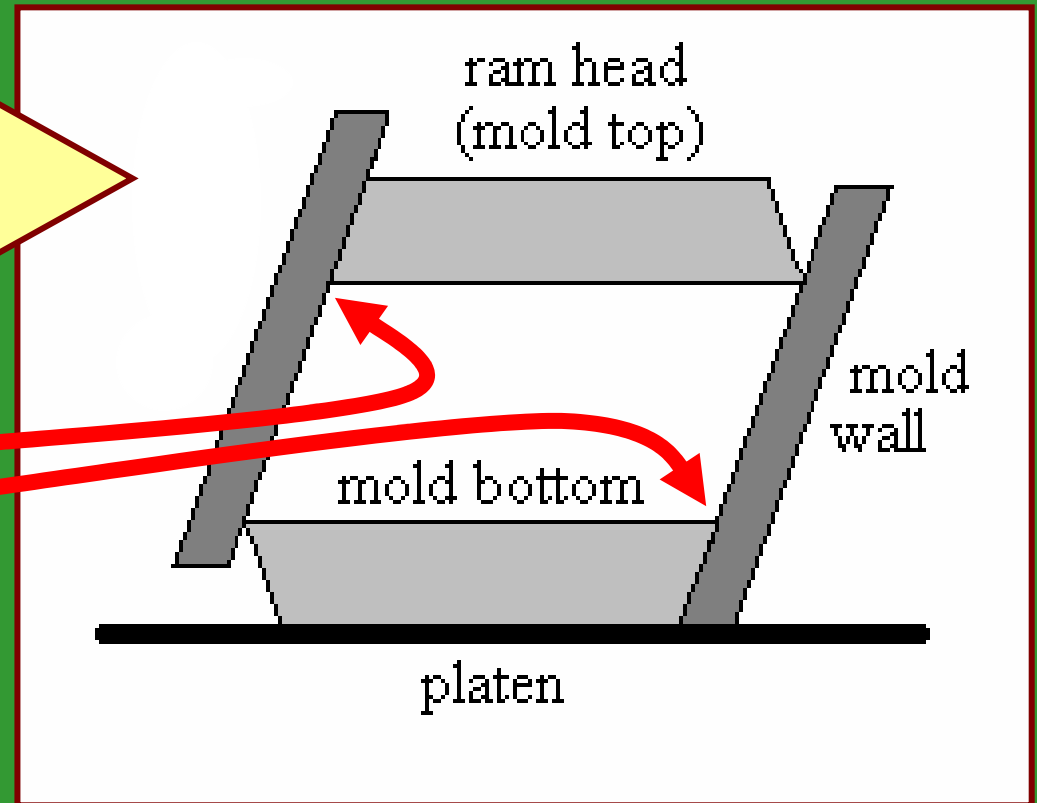
From the Fall 2005 *Asphalt Technology News*,
a publication by NCAT at Auburn University

How is it measured?

We don't measure mold wall angle...

We measure two different angles - between the plates and the mold wall at the top and bottom.

The average of the top and bottom angles is the angle that is used for calibration.



The Technology



- Original Dynamic Angle Validator (DAV)
- Developed for testing with HMA at compaction temperatures
- First generation devices manufactured by Pine Instrument Company



- Pine Instrument Company's Rapid Angle Measurement Device (RAM)
- Developed for completely "mixless" testing in a cold mold



- Updated version of the Dynamic Angle Validator (DAV-II)
- Developed for testing with HMA or "mixless" with the Hot Mix Simulator attachment (HMS)

IDOT

Investigations

- **Decision to look at internal angle came from IDOT's December 2001 TWG meeting**
- **Investigations began in 2002 and have carried on up to the present**
- **The Internal Angle Spec. Committee formed in 2003 with FHWA and IDOT (BMPPR and district) personnel involved to steer research and make decisions on specifications, procedures, and implementation**
- **Good participation from industry**

August - September 2002

- First real experience with internal angle calibration
- Focused mainly on IDOT owned SGCs
- Used first generation DAV borrowed from Tom Brovold of Test Quip, Inc. and a 19.0 mm N90 non-polymer binder mix for calibrations
- Used an internal angle of $1.10^{\circ} \pm 0.01^{\circ}$ as a target for calibration – data from earlier in 2002 indicated that this was the average internal angle for IDOT SGCs, and a drastic change in angle was to be avoided
- Tied in with that year's IDOT uniformity study that used a N70 polymer "D" surface mix

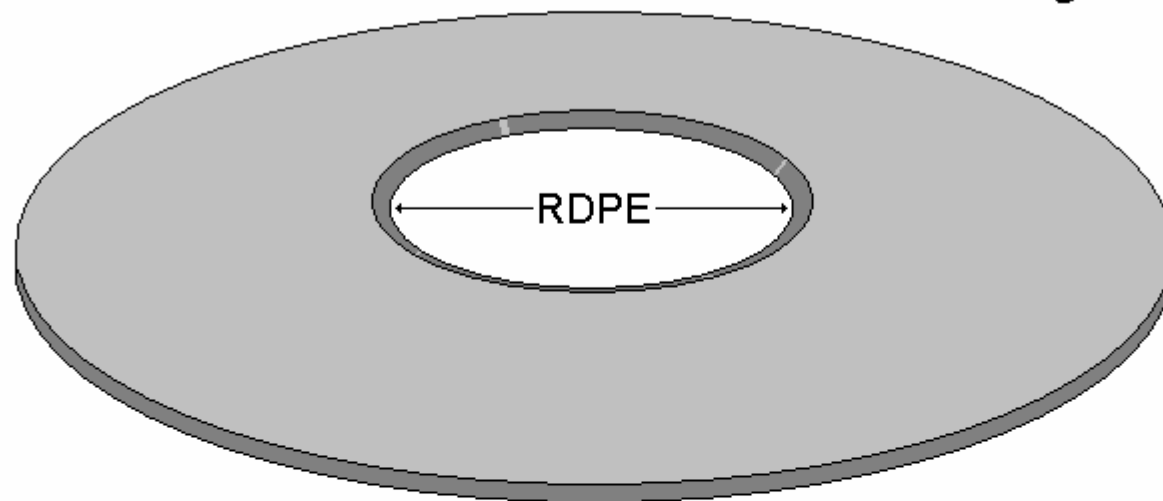
Conclusions

- **SGCs easily calibrated to target internal angle**
- **Uniformity study showed a reduction in standard deviation of G_{mb} from previous years' testing**
- **Gyratory specimen densities followed the trend with internal angle as related to known issues with specific SGCs**

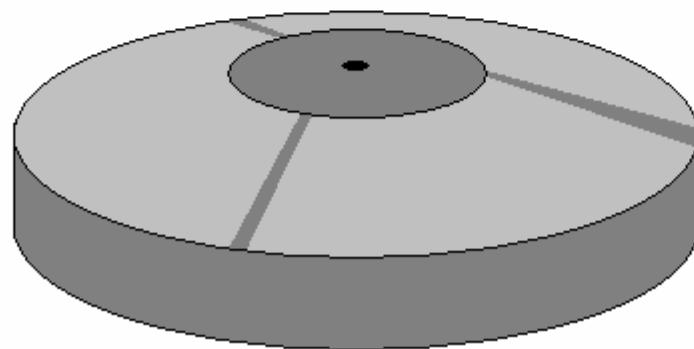
September 2003

- **First attempt at using a mixless “load simulator” apparatus for internal angle calibration**
- **Used newly developed “rings and cones” mixless attachment retrofitted to a first generation DAV purchased by District 1 (Chicago area)**

Ring



Cone



September 2003

- First attempt at using a mixless “load simulator” apparatus for internal angle calibration
- Used newly developed “rings and cones” mixless attachment retrofitted to a first generation DAV purchased by District 1 (Chicago area)
- Focused on IDOT owned SGCs
- First attempt at HMA characterization using a mixless apparatus and a N90 polymer “D” surface mix
- Used an internal angle of $1.10^\circ \pm 0.02^\circ$ as a target for calibration
- Tied in with that year’s IDOT uniformity study; the same mix was used for all aspects of testing (N90 polymer “D” surface mix)

Conclusions

- **Mixless testing easy, repeatable, much faster than using mix**
- **Mix characterization procedure simple, effective, and repeatable**
- **Results from the uniformity study were similar to that from the previous year – almost the same standard deviation was achieved**

December 2003 - March 2004

- Mixless calibration with new “sphere and plates” mixless attachment (named the Hot Mix Simulator, or HMS) retrofitted to District 1’s DAV



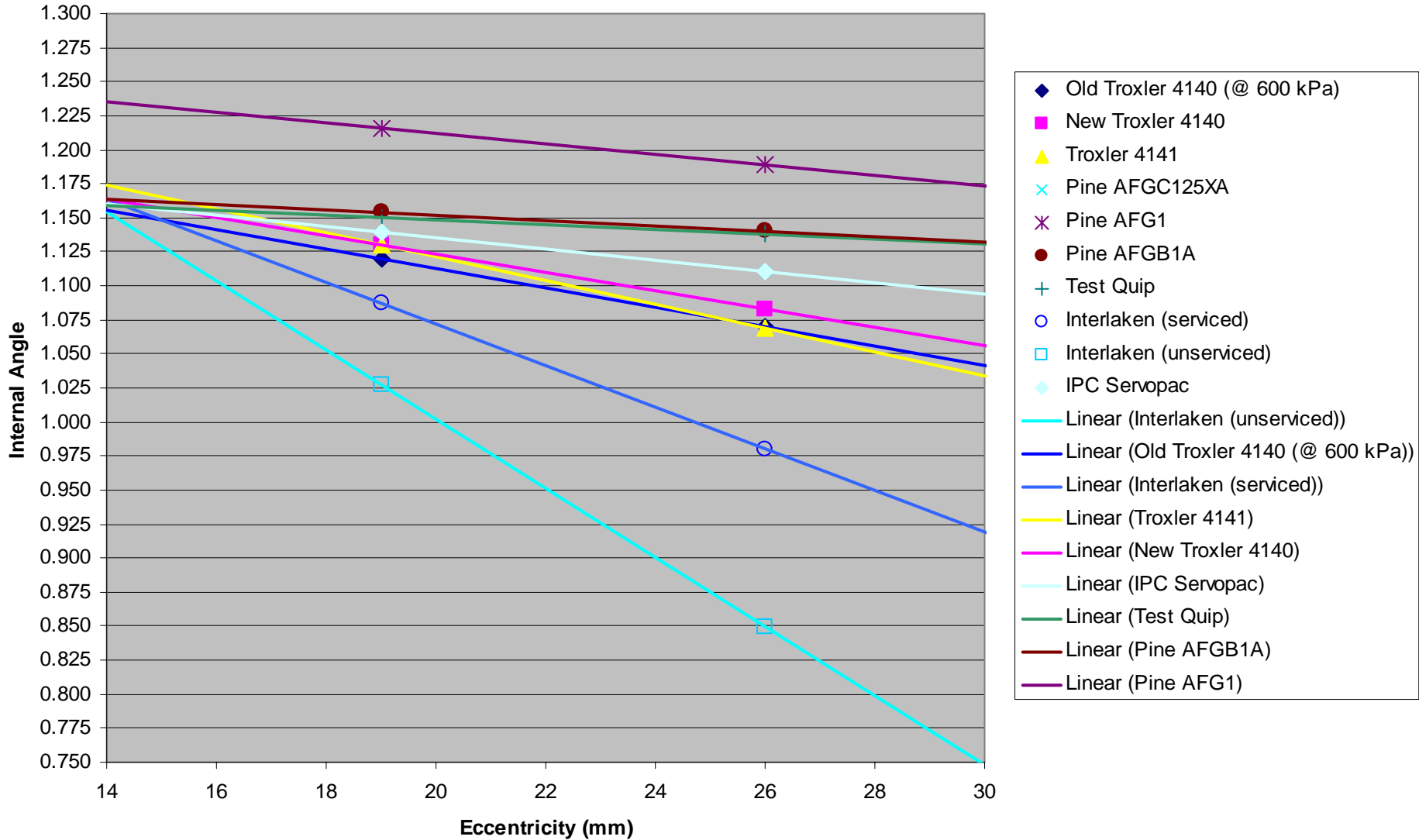
December 2003 - March 2004

- Mixless calibration with new “sphere and plates” mixless attachment (named the Hot Mix Simulator, or HMS) retrofitted to District 1’s DAV
- Conducted testing that included six different commonly used models of SGCs, both IDOT and contractor owned
- Adjusted the angle on a Troxler 4141 for the first time
- Used an internal angle of $1.16^{\circ} \pm 0.02^{\circ}$ as a target for calibration (as specified in AASHTO T-312)
- All testing (calibration, sample prep, densities) done by one technician
- Loaned a RAM device by Pine Instrument Co. and conducted testing along with DAV for comparison

Conclusions

- New “sphere and plates” a definite improvement from the “rings and cones” mixless attachment
- An internal angle of 1.16° is achievable on all models of SGCs
- Results from testing were similar to that from the previous year’s uniformity study – a slightly lower standard deviation was achieved due to single operator
- Internal angle calibration does help improve comparisons between different models of SGCs
- DAV and RAM compare pretty well
- First data collected documenting pressure issue with older Troxler 4140 SGCs
- Good graph of SGC model frame stiffness

SGC Frame Stiffness Analysis

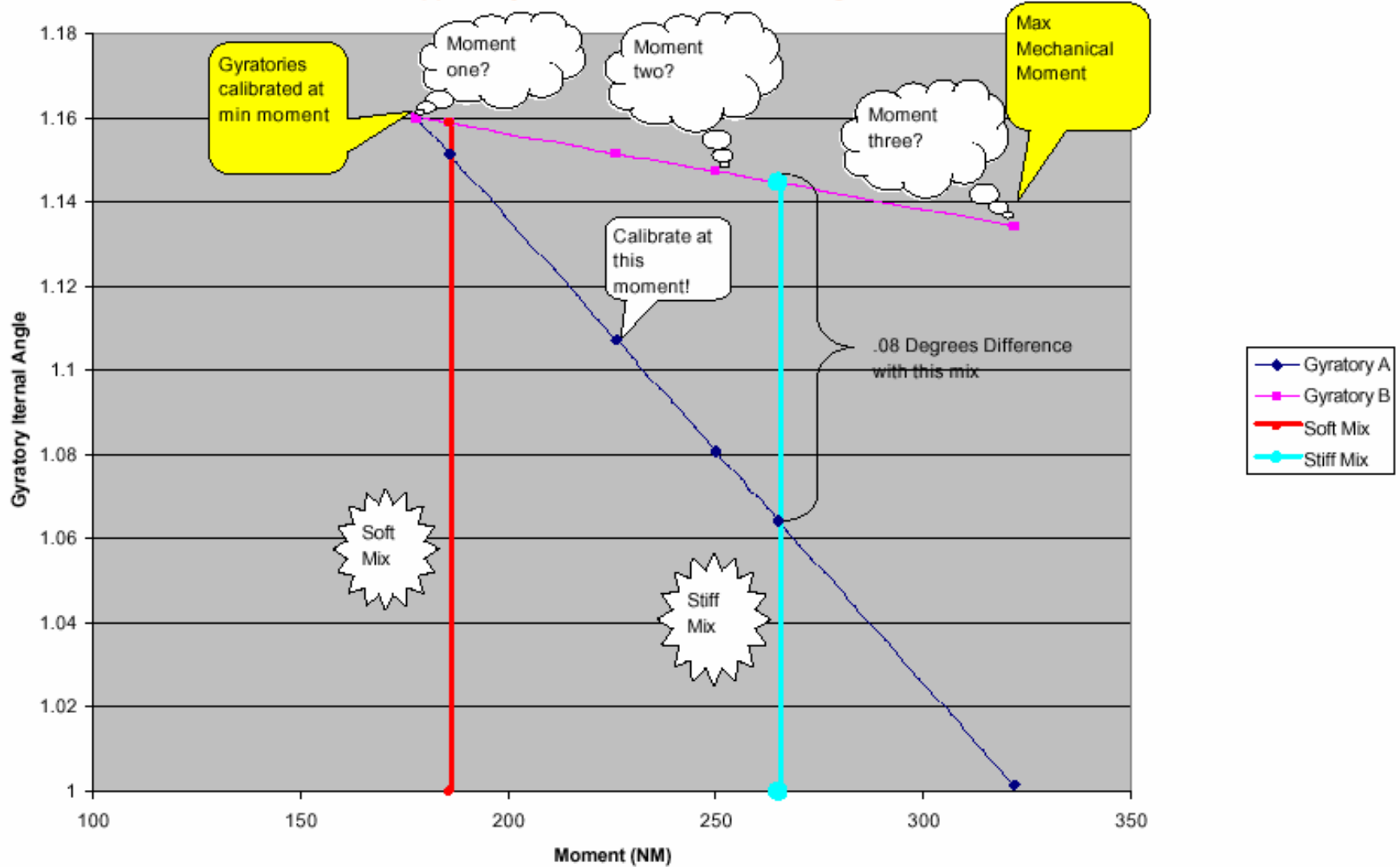


September 2004 - December 2004

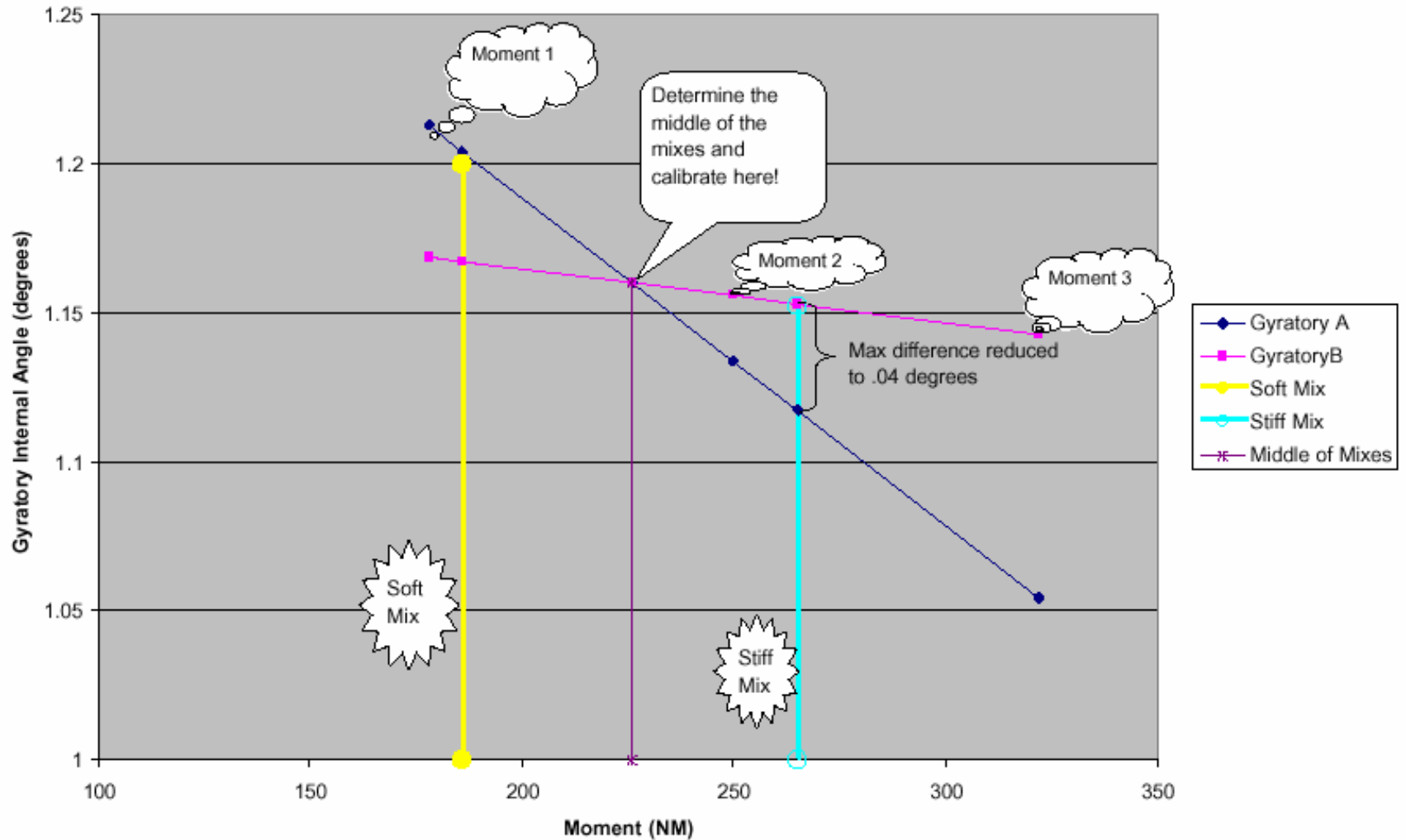
- Mix characterization using various N70 and N90 surface mixes (different gradations and AC types) as well as other mixes (N50 SMA, N105) to find a good mid point for internal angle calibration

Which Moment To Calibrate At ?

Moments are applied by the new mixless internal angle devices instead of mix.



Calibrate in the Middle of the Mix By Measuring the Mix With the DAV2!



September 2004 - December 2004

- Mix characterization using various N70 and N90 surface mixes (different gradations and AC types) as well as other mixes (N50 SMA, N105) to find a good mid point for internal angle calibration**
- Used a first generation DAV retrofitted with the HMS and a new DAV-II prototype with the HMS**
- All testing done on IDOT BMPR's Troxler 4140 by one technician**
- Ran some mixes with both the DAV and DAV-II for comparison**

Conclusions

- Internal angles from N70 and N90 mixes very similar
- N90 surface mix chosen as the calibration mix
- DAV and DAV-II compare very well

Summer 2005 Troubleshooting

- Excessive pressure in older Troxler 4140 SGCs
- Comparison problems in District 8 (Collinsville)
- Comparison problems in District 9 (Carbondale and Buncombe)
- Inconsistencies with some Troxler 4141 SGCs

Conclusions

- **Work-around for older Troxler 4140 excessive pressure developed with Tom Brovold**
- **District 8 comparison problem attributed to one under-compacting SGC (low internal angle); excessive pressure not a factor with newer Troxler 4140 SGCs**
- **District 9 comparison problem attributed to one under-compacting SGC (low internal angle) and one over-compacting SGC (high internal angle)**
- **Troxler 4141 issues still being researched**

Fall 2005

- Mass purchase of DAV-IIs by IDOT for BMPR and all nine districts
- HMS sphere radius changed from 45 mm to 54 mm to aid in comparison to the RAM device
- Class developed and taught by BMPR to train district technicians on use of the DAV-II
- Tied in with that year's uniformity study; districts used a N90 "C" surface mix to calibrate IDOT SGCs themselves to an internal angle of $1.16^\circ \pm 0.02^\circ$
- Essentially a test run for implementation

Conclusions

- **BMPR's class well received by districts and gave them the necessary information for internal angle calibration**
- **Districts were able to calibrate their SGCs with minimal problems**
- **Results from the uniformity study showed a similar reduction in G_{mb} standard deviation as in previous years' internal angle studies tied to uniformity studies - probably as low as it will get**
- **Internal angle of mix found to be virtually the same as the internal angle of the 22 mm HMS plate**

What Have We Learned?

- Does internal angle calibration work?
 - YES!
 - Effective in reducing the standard deviation of G_{mb} between non-comparing SGCs and SGCs of different makes and models
 - Not a substitute for poor lab practice!
- Is it perfect?
 - Not yet, but we're getting there

Implementation

Procedure

- Procedure being developed by IDOT BMPR
- An internal angle of $1.16^{\circ} \pm 0.02^{\circ}$ will be used (as stated in AASHTO T-312)
- Completely mixless internal angle calibration using the 22 mm HMS plate due to its similarity to a N90 surface mix
- Calibration will use specimen molds heated to compaction temperature
- Four angles will be taken; two top and two bottom angles with starting points 90° from each other
- SGCs will be run for 25 gyrations for each test point

District Responsibilities

- All state SGCs will be calibrated immediately
- District personnel will start checking contractor and consultant SGCs this winter on a volunteer basis
- All contractor and consultant SGCs will be required to be calibrated by the 2007 construction season
- All physical adjustments on contractor and consultant SGCs will be made or arranged by the contractor/consultant and NOT by IDOT

Questions???