Determining RAP Gsb

Matt Beeson, PE

Asphalt Engineer

Indiana Department of Transportation

Determining RAP Gsb

- Gsb of aggregates in RAP is not typically known

- Gse of RAP has historically been used as a substitute for Gsb in mix designs

The Problem

- Gse > Gsb

$$\text{VMA} = 100 - \left[\frac{Gmb(100 - P_b)}{G_{sb}} \right]$$

- When Gsb value goes up, VMA goes up
  - Artificially

The Problem

- For each 0.010 change in Gsb
  - 0.3 % change in VMA

- Typical difference between Gse and Gsb
  - 0.075 to 0.100

The Problem

- Acceptable VMA Error at low RAP
  - 10% RAP, ~0.3 %

- VMA Error too large at high RAP
  - 40% RAP, ~1.3 %

The Problem

- Inflated VMA results in lower binder content

- Many reports of mixtures with high RAP being stiffer, "dryer"

- Way to derive estimated Gsb from Gse

Determining a Relationship

- Want an "offset" from Gse to Gsb

- Why not just look at JMFs and determine relationship between Gse and Gsb?
  - Many Gsb values reported on JMFs are inflated!

Determining a Relationship

- Statistical analysis was performed on aggregate absorption values
  - 2005-2009 data
  - INDOT quality samples
  - About 1000 data points

Determining a Relationship

- Analysis showed 4 groups of aggregates
  - BF Slag = 3.8% abs
  - SF Sand, BF Sand = 3.0% abs
  - Stone, Gravel, M. Sand, SF = 1.8% abs
  - Natural Sand = 1.4% abs

Determining a Relationship

- 294 JMFs with no RAP
- Gse determined
- Average absorption values from analysis applied based on agg blend
- For example:
  - 60% limestone coarse agg (1.8% abs)
  - 40% natural sand fine agg(1.4% abs)

  (0.6 x 1.8%) + (0.4 x 1.4%) = 1.64% abs

Determining a Relationship

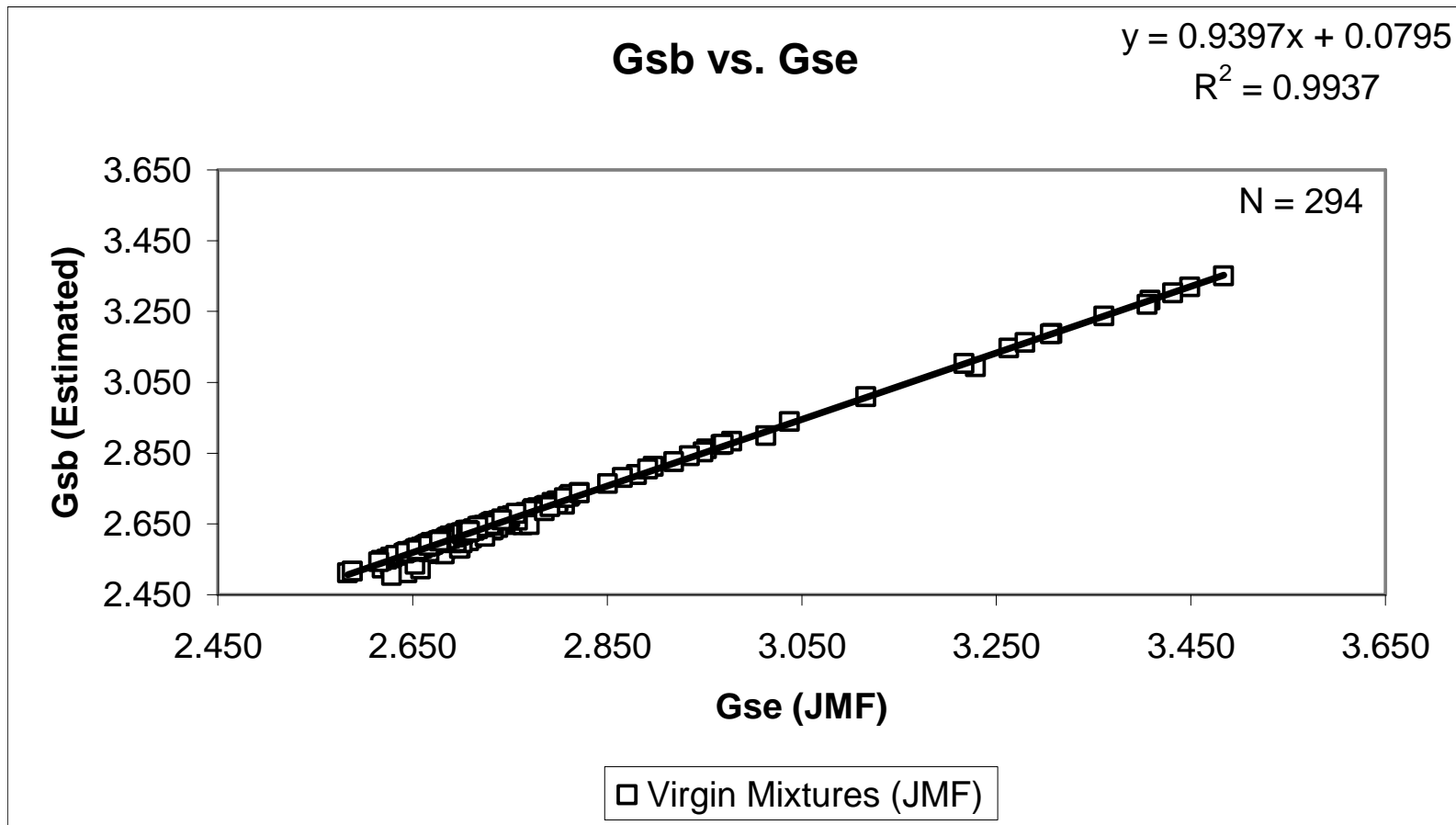- Assuming Pba is 65% of absorption:

  0.65 x 1.64% = 1.07% Pba

- Solve for Gsb

$$Pba = 100 \ x \ \frac{Gse \ - \ Gsb}{Gse \ x \ Gsb} \ x \ Gb$$

Estimated Gsb vs. Gse

Gsb vs. Gse

$y = 0.9397x + 0.0795$
$R^2 = 0.9937$

N = 294

Gsb (Estimated)

Gse (JMF)

□ Virgin Mixtures (JMF)
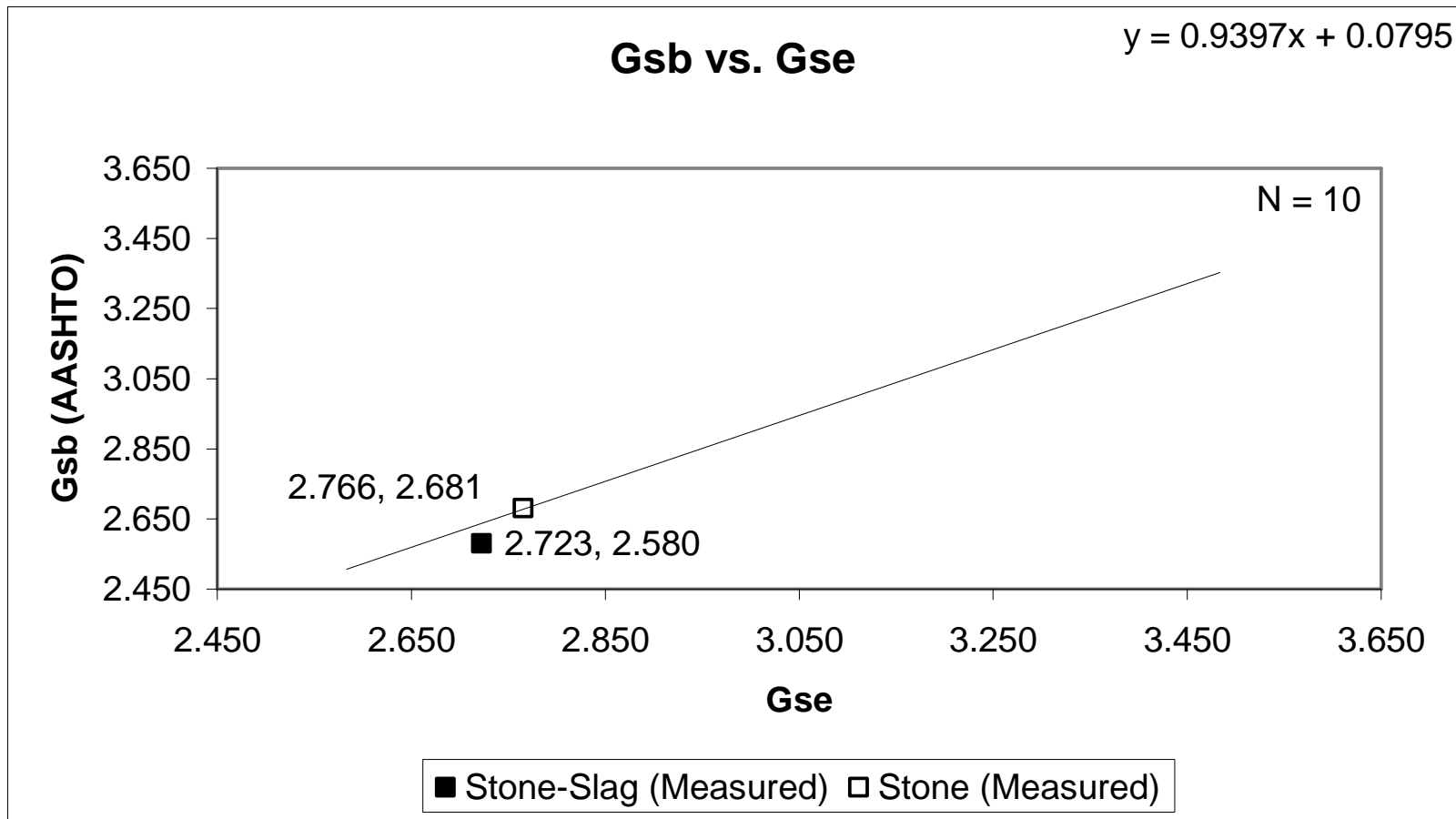
Check with Independent Data

- Blended aggregate samples prepared
  - 10 with limestone coarse agg
  - 10 with limestone/BF slag blend

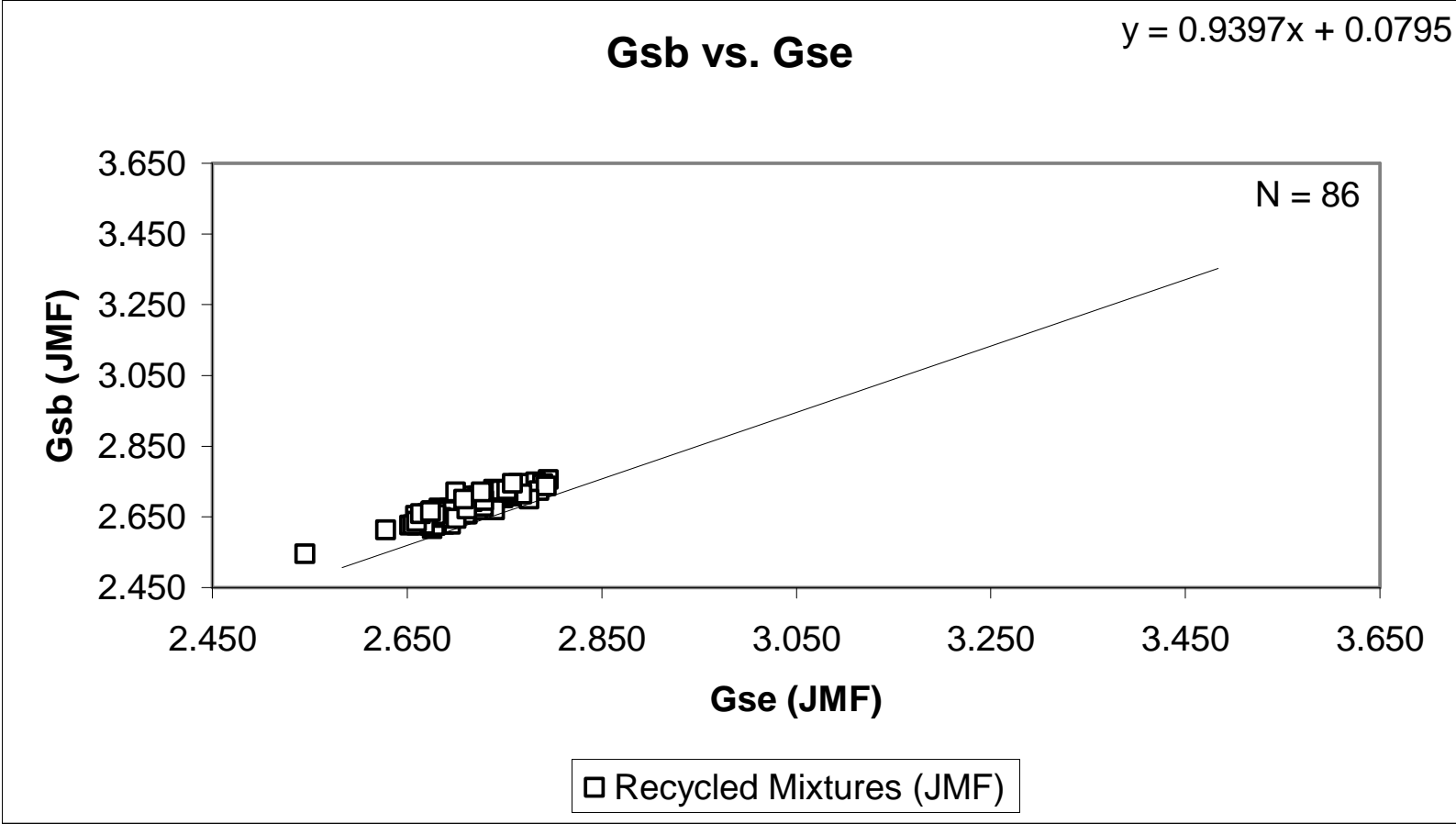- Accurate for all limestone, not as much for blend

Check with Independent Data

Check with Independent Data

- Data from JMFs using RAP were plotted

- All points should be above line since Gse was used to estimate Gsb

Check with Independent Data

Gsb vs. Gse

y = 0.9397x + 0.0795

N = 86

Check with Independent Data

- 30 of original 294 JMFs were selected to check data
- Actual absorption values used to estimate Gsb (rather than pooled Gsb values)

Check with Independent Data

Gsb vs. Gse

y = 0.9397x + 0.0795

N = 30

Gsb (Estimated) vs. Gse (JMF)

Measured ABS (Blended)
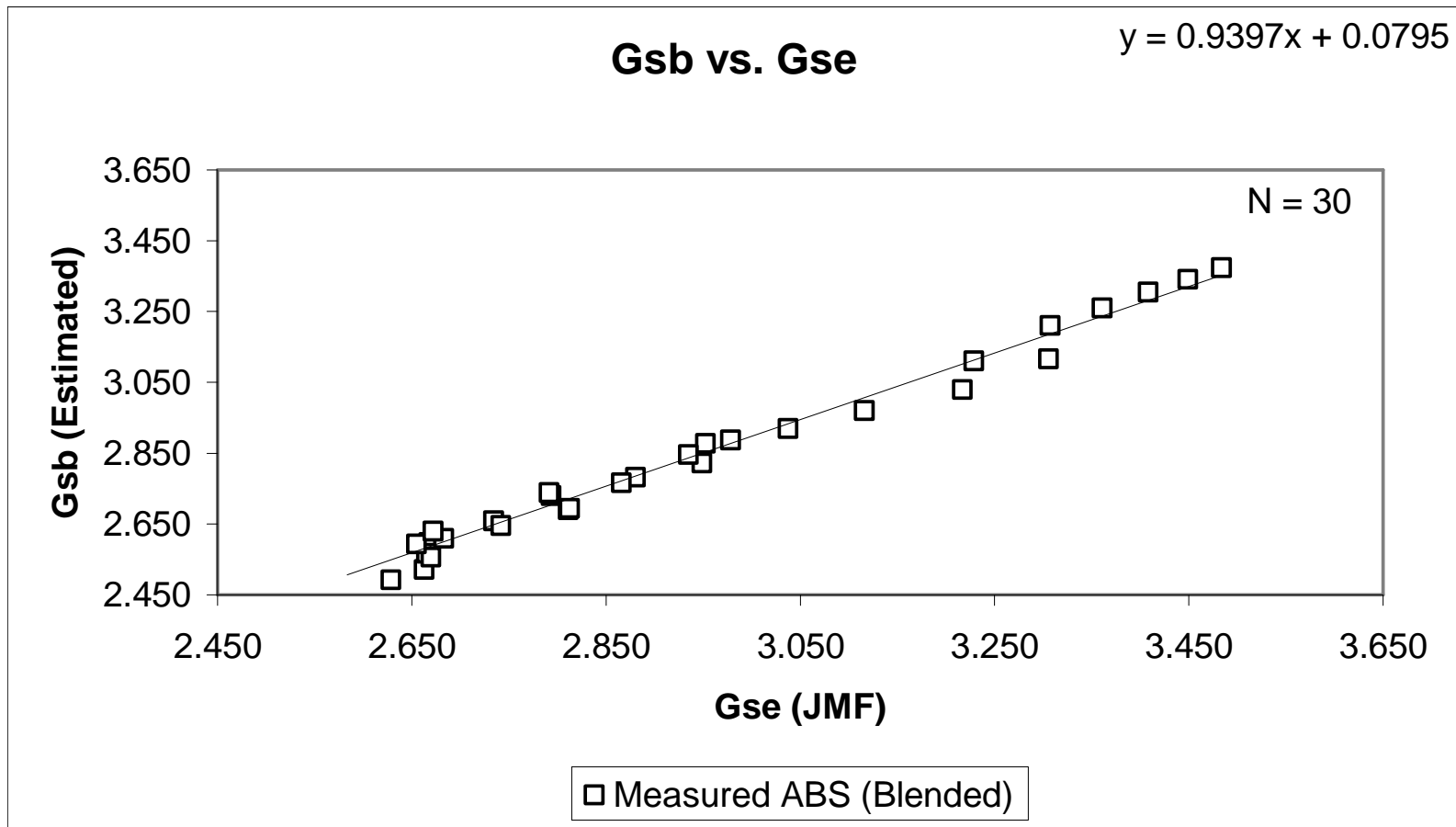
Conclusions

- Use equation to calculate estimated Gsb of RAP from Gse

$$Gsb = (0.9397 \times Gse) + 0.0795$$

- Not perfect

- Better than what we've been doing!

Conclusions

- Changes made to ITM 584

- Currently being implemented

Questions?

Matt Beeson, PE

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mbeeson@indot.in.gov

317-610-7251x215