

**Sulfur in Asphalt:
The Missouri Experience
(Mix Design Perspective)**

By

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Missouri Mix Bid Item SP095C w/PG 70-22

- Contractor-Ideker, Inc.
- Project: Missouri Highway US 71
- 9.5mm Superpave Surface
- 100 gyration compactive effort
- PG 70-22 Polymer Modified Binder
- Design Per MoDOT specs. Section 403
– AASHTO R35

INITIAL CONSIDERATIONS

- **AGGREGATE AVAILABLE:**
 - Limestone 1/2" clean chip
 - Limestone 3/8" chip
 - Limestone mfg. sand
 - Drag sand (chert tailings from mine operation)

INITIAL CONSIDERATIONS

- AGGREGATE SPECIFIC GRAVITIES:
 - ½" clean chip, $G_{sb}=2.546$, Absorption=2.9 %
 - 3/8" chip, $G_{sb}=2.658$, Absorption=0.6 %
 - Mfg. sand, $G_{sb}=2.495$, Absorption=2.9 %
 - Drag Sand, $G_{sb}=2.560$, Absorption=1.2 %



DESIGN AGGREGATE STRUCTURE

- COLD FEED %'s:

- 1/2" clean chip @ 21 % (Gsb=2.546, Abs.=2.9%)

- 3/8 chip @ 38 % (Gsb=2.658, Abs.=0.6%)

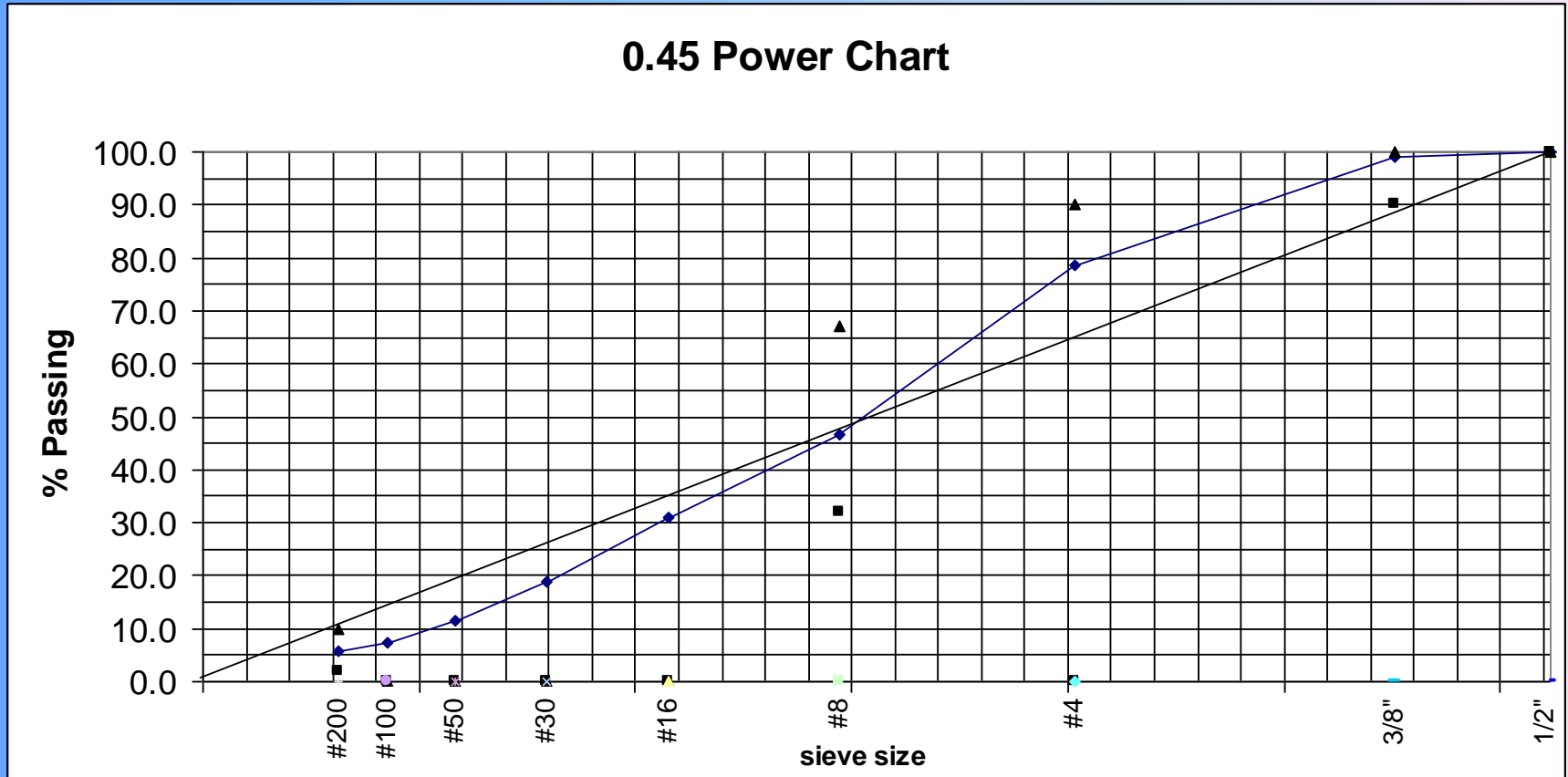
- Mfg. Sand @ 18 % (Gsb=2.495, Abs.=2.9 %)

- Drag Sand @ 23 % (Gsb=2.560, Abs.=1.2%)

COMBINED Gsb=2.581

Weighted Absorption=1.6 %

0.45 Power Chart



Conventional Mix Design Values

- **Bitumen Content:** 6.0 % PG 70-22
- **Air Voids:** 4.0 %
- **VMA:** 15.5 %
- **VFA:** 73.8 %
- **Tensile Strength Ratio:** 97.7 %
- **Mix Temp.:** 325 F
- **Compaction Temp.:** 295 F
- **Max. Specific Grav.:** 2.419

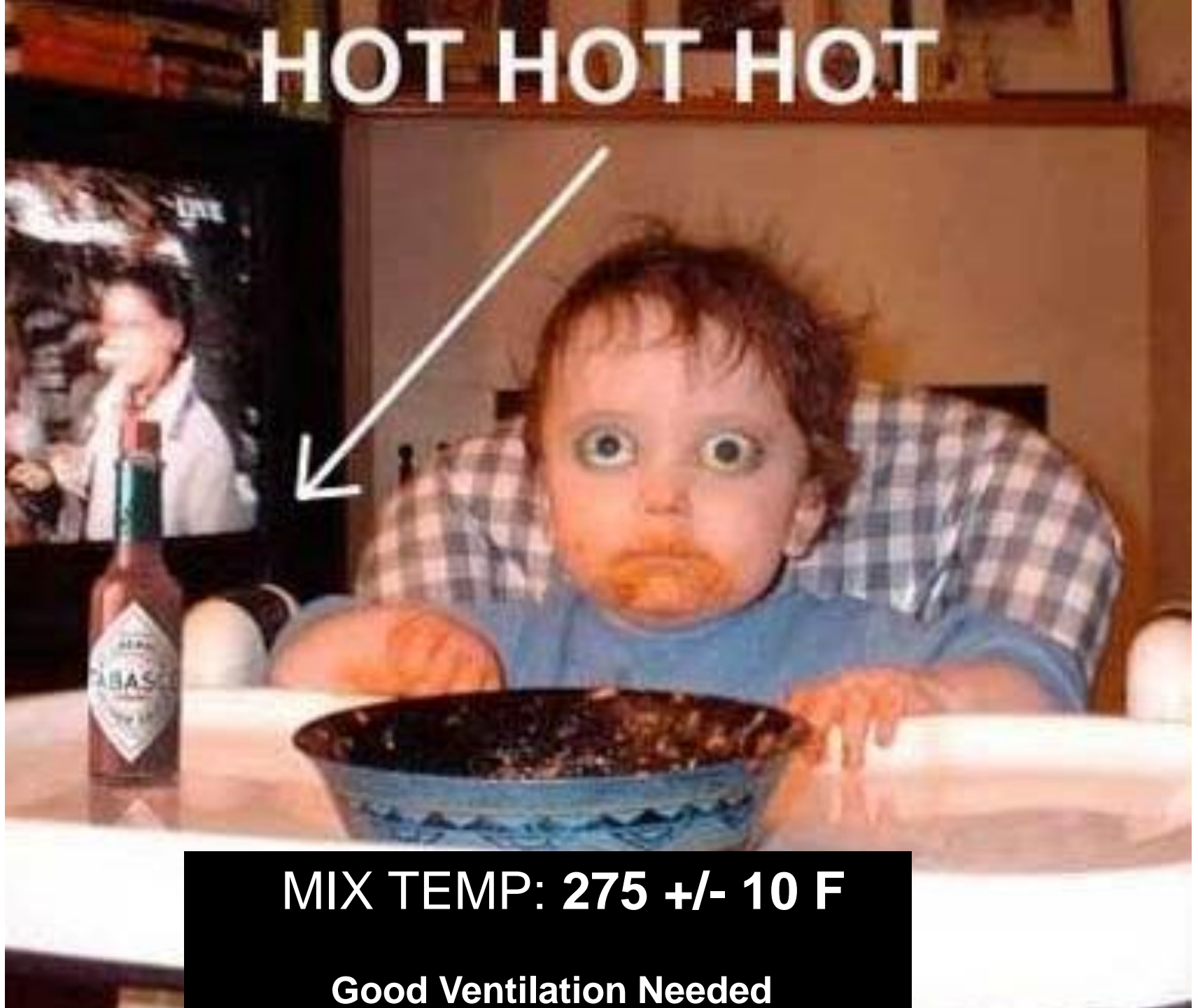
Shell Thiopave

- Thiopave is a material developed as a bitumen substitute in the production of asphalt mixtures
- Thiopave is used to replace 20-25 % of the mass (weight) of the bitumen required by the mixture design with at least the same volume of Thiopave
- Used to enhance stiffness and rut resistance while maintaining ductility and resistance to cracking

Shell Thiopave

- Shell supplied the:
 - Thiopave pellets
 - Sarawax SX 100 compaction agent
 - Technical information (MSDS, mix design)
 - Technical staff to provide oversight and make recommendations on our first sulfur mix design

HOT HOT HOT



MIX TEMP: 275 +/- 10 F


Good Ventilation Needed



Thiopave pellets

SARAWAX SX100 (Organic Compaction Agent)



A close-up photograph showing a gloved hand holding a metal can under a machine. The machine is dispensing a dark, thick liquid into the can. The background is a dark, industrial-looking surface with some perforations. The glove is white with a red pattern. The can is silver and cylindrical. The machine is dark and has a vertical tube leading into the can.

SARAWAX SX100 blended with
asphalt binder (PG 64-22)

THIOPAVE PELLETS

- Thiopave pellets are preheated at 140 F
- Aggregate was preheated at 290 F
- Asphalt/Sarawax blend then weighed into preheated aggregate
- Mixing begins then pre-weighed quantity of Thiopave pellets are added
- Thiopave pellets melt at 245 F

NEW TOTAL BINDER CONTENT

- Thiopave + Bitumen Wt. %=

$$A = \frac{(100) * R}{100 * R - P_s * (R - G_{\text{bitumen}})}$$

A=Weight % bitumen in Conventional Mix=6.3

R=Thiopave to bitumen substitution ratio
= $G_{\text{Thiopave}}/G_{\text{bitumen}}=1.92/1.03=1.86408$

P_s =Weight % Thiopave in Binder=38.5%

A=7.6 % (NEW TOTAL BINDER CONTENT)

Bitumen to Thiopave Ratio

- Bitumen Weight % of TOTAL: 61.5 %
- Thiopave Weight % of TOTAL: 38.5 %
- SARAWAX @ 1.5 %

TOTAL BINDER CONTENT

- NEW TOTAL BINDER CONTENT=7.6 %
 - Bitumen Ratio %=61.5 %
 - % Bitumen of New TOTAL BINDER=
 - $7.6 \% * (61.5/100) \sim 4.67 \%$
 - % Thiopave of New TOTAL BINDER=
 - $7.6 \% * (38.5/100) \sim 2.93 \%$

Thiopave Mix Design Values

TOTAL NEW BINDER %:	7.6 %
-4.67 % PG 64-22 (22 % reduction)	
-2.93 % Thiopave	
Air Voids:	4.0 %
VMA:	16.0 %
VFA:	74.8 %
TSR:	90.4 %
Max. Specific Grav.:	2.445