



Slurry/Microsurface - Mix Design Procedure

Jim Moulthrop, P.E. (PA, AZ)



Outline

Introduction

Project objective and review

Preliminary results

Phase II activities

Mix Design characteristics

Automated tests

Proposed mix design

Strawman specification

What's next



Introduction

- Slurry seals and Microsurfacing wide-use as preservation treatments
- Extend pavement's life
- Becoming more and more popular as agencies incorporate them into pavement preservation strategies
- Currently, designing and testing slurry seals and micro-surfacing is more of an art than science



Project Objective

- **To update current design method and testing practices**
 - Current ISSA and ASTM methods originated before polymer modified emulsion were used in slurry seals
 - Tests and design methods are empirical
 - Limited relation to performance in the field
- **FHWA Pooled Fund Study conducted by Fugro with 14 participating states:**

California, Delaware, Georgia, Illinois, Kansas, Maine, Michigan, Minnesota, Missouri, New Hampshire, New York, North Dakota, Texas, and Vermont.



Project Review

- **PHASE 1**
 - Review Literature
 - Survey industry
 - Develop plans for Phases 2 and 3



Project Review

- **PHASE 2**

- Evaluate current mix design procedures
- Consider potential tests and methods
- Develop new rational mix design procedure
- Ruggedness testing
- Summary report, findings, and recommendations



Project Review

- **PHASE 3**

- Development of guidelines

- Specifications

- Training

- Field trials (validation)



Preliminary Results

After reviewing current recommended laboratory test methods and design practices it was found that:

- 1. Poor repeatability**
- 2. Limited relation to field performance**
- 3. Important factors (temperature, humidity) are not considered**



Phase II Activities

A single mix design procedure will be developed for both, slurry seals and microsurfacing systems. Proposed specification:

S3

“Slurry Surfacing Systems”



DESIRABLE FEATURES

- Repeatable
- Relate to field performance
- Representative of field conditions
(temperature, humidity)
- Mixable
- Workable





DESIRABLE FEATURES

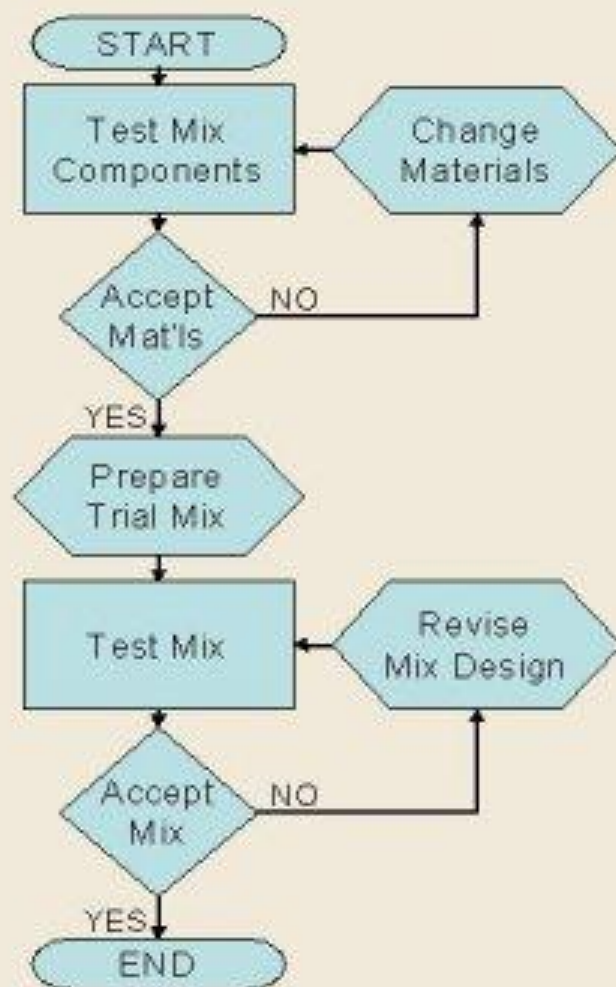
- Performance
- Ease of use
- Cost
- Ease of implementation





Rational Mix Design Process

- Test for material properties
- Test for mixing, spreading, and setting properties
- Long-term performance tests



Schematic of typical mix design process



Experimental Mix Matrix

- A1: George Reed, Inc. Table Mountain, Sonora, CA (ISSA Type III)
- A2: Lopke Gravel Prod. Lounsberry Pit, Nichols, NY (ISSA Type III)
- A3: Delta Materials, Marble Falls, TX
- E1: SEM Materials (Koch), Tulsa, OK, Ralumac
- E2: VSS Emultech, Polymer Modified LMCQS-1h, Sacramento, CA
- E3: Ergon Asphalt & Materials, Waco, TX

System	Aggregate + Emulsion Combination
M1	A1+E1
M2	A1+E2
M3	A2+E1
M4	A2+E2
M5	A3+E3

Current specifications for material testing were adopted with minor modifications to acceptance thresholds. Additional tests for some of the components of the mix were also incorporated (e.g. Methylene blue test for aggregates).

System components:

- **Aggregate**
- **Mineral filler**
- **Emulsified asphalt**
- **Control additives**
- **Water**





Automated Tests

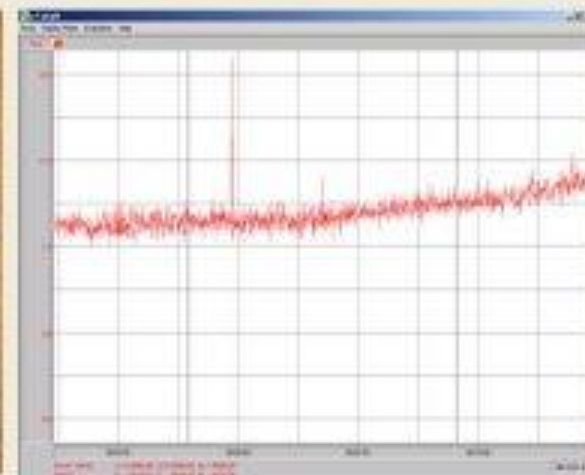




New Mix Design: Test for mixing, spreading, and setting

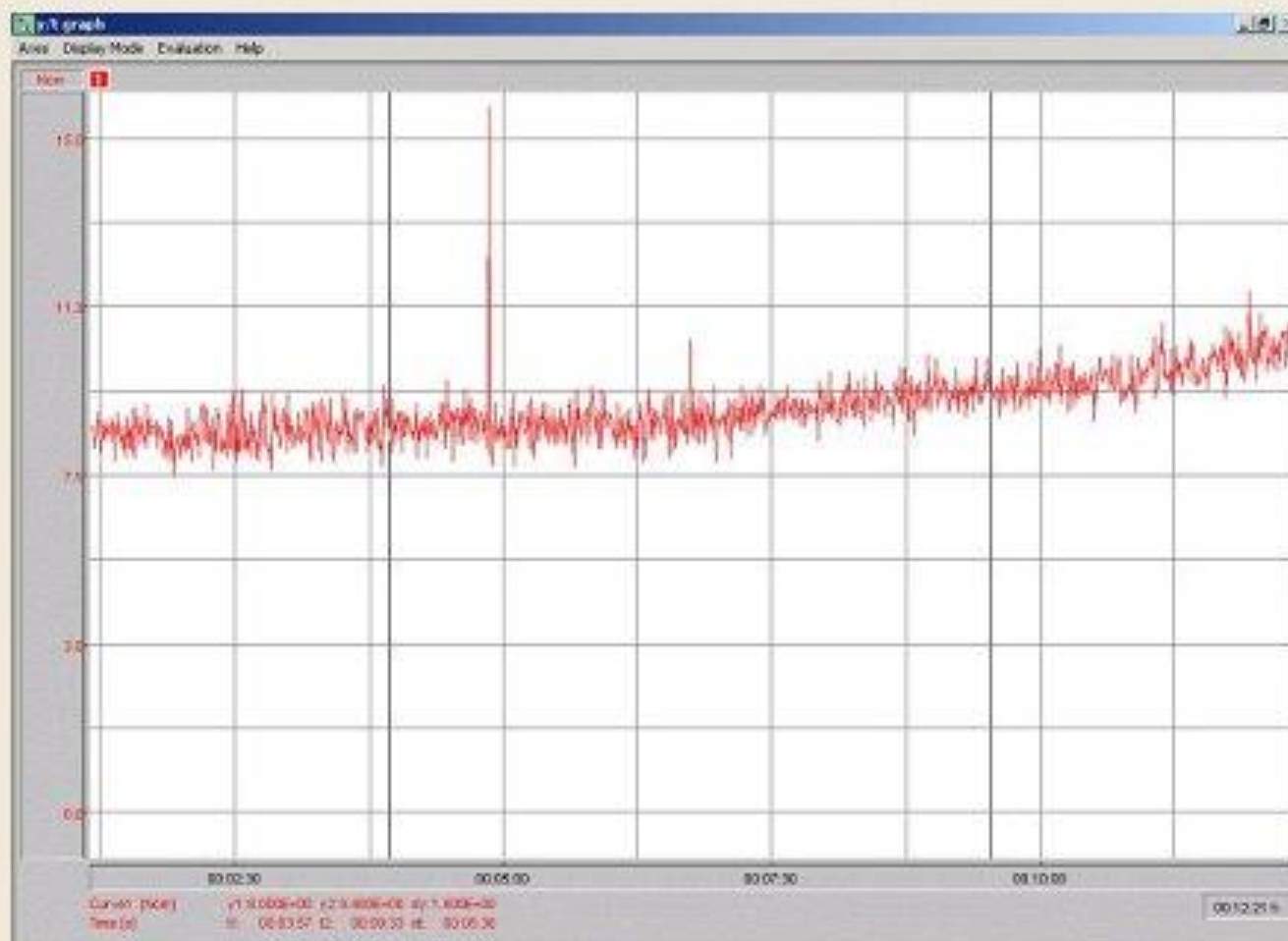
Current test for slurry seals and microsurfacing are operator dependent. To overcome this deficiency, automated tests were developed.

- **Automated Mixing Test (AMT):** determines mixability and workability. Records change in viscosity (torque) with time.





AMT Trace for Mix M2 (Moderate Viscosity System)





New Mix Design: Test for mixing, spreading, and setting

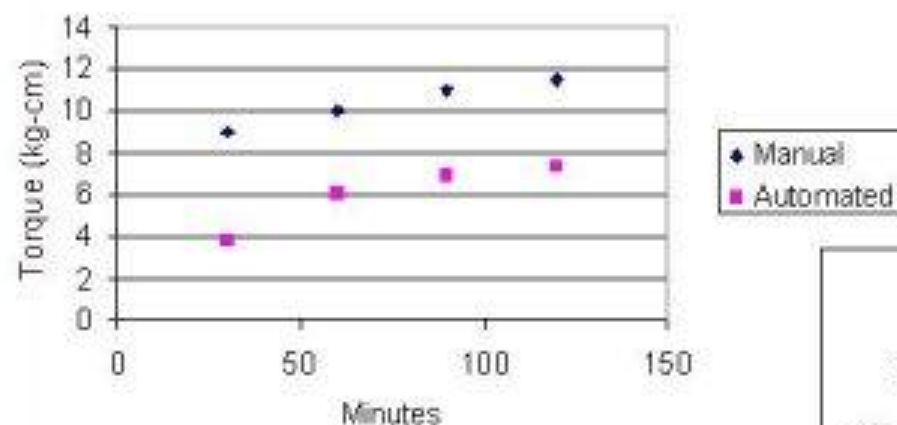
- **Automated Cohesion Test (ACT):** determines time to allow traffic. Applies torque after one hour cure to measure resistance to shear force.



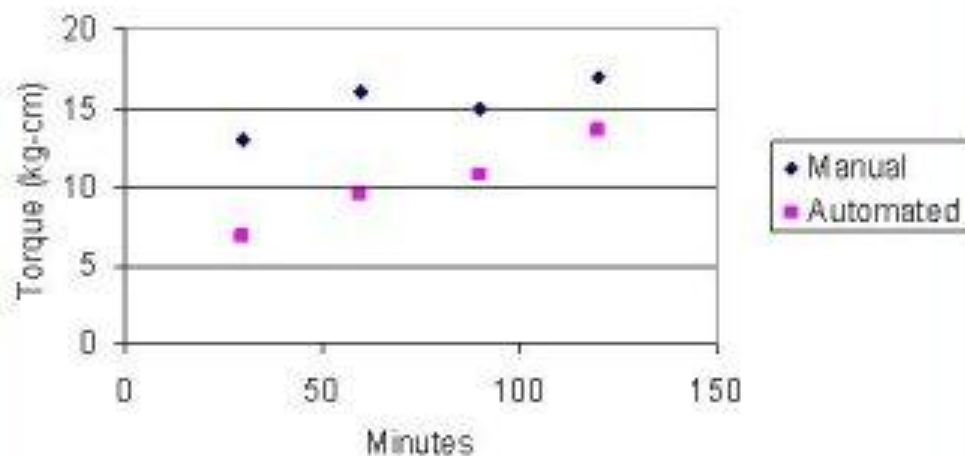


Example ACT testing results

Temple Systems - Granite Mix



Temple Systems - Limestone Mix



- **Cohesion Abrasion Test (CAT):** modified Wet Track Abrasion Test (WTAT). Incorporates wheels instead of abrasion head to measure abrasion loss and short-term stone retention.





Long term performance tests

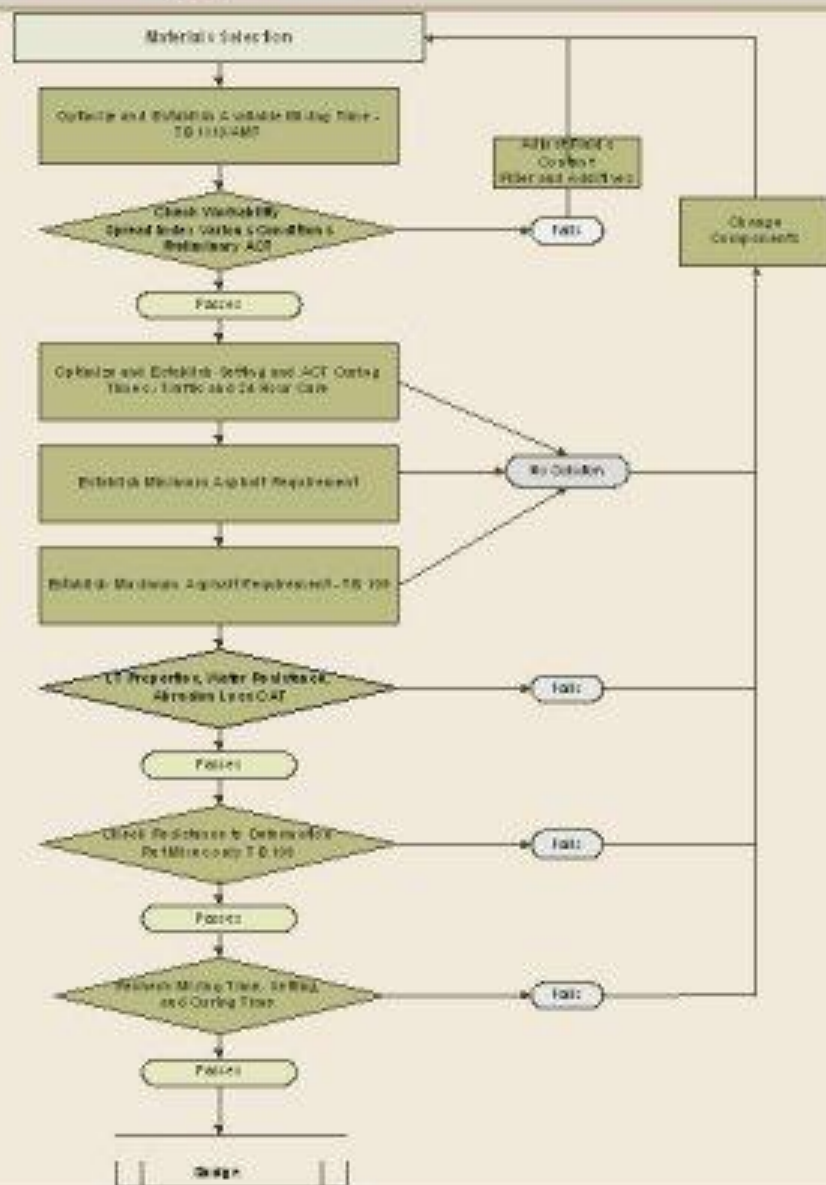
Main properties of interest:

- Abrasion Resistance (raveling)
- Water resistance (stripping)
- Deformation resistance (rutting)

S3 specifications proposed the **CAT** to quantify abrasion and water resistance, and the current **ISSA TB 109 (Loaded Wheel Test)** for deformation resistance.

Proposed Mix Design Flowchart

1. Materials selection
2. Create mix matrix and determine mix constructability
3. Determine short-term constructability properties
4. Determine optimum binder content
5. Evaluate cohesion properties at various curing conditions
6. Evaluate long-term properties of mixture





Strawman Specification

Set Time	Test or field Condition	Units	Traffic			Temperature			Humidity	
			Hi	Med	Low	Hi 35 C	Med 25 C	Low 10 C	Hi 90%	Normal 50%
Rapid	PFS-1 (Mixing)									
	Mixing Torque - maximum	kg-cm	9	9	9	9	9	9	9	9
	Mixing time - minimum	sec.	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120 sec.	kg-cm	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	-	clear water	clear water	N/A	clear water	clear water	clear water	clear water	clear water
	Coating	-	100%	100%	95%	95%	95%	100%	100%	95%
	PFS-2 (Wet Cohesion)									
	30 min. cohesion - minimum	kg-cm	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	kg-cm	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	kg-cm	25	25	25	25	25	25	25	25
12 hr. cohesion - minimum	kg-cm	28	28	28	28	28	28	28	28	
PFS-3 (Abrasion Loss)										
30 min. loss - maximum	g/m ²	200	200	400	300	300	300	300	300	
1hr. loss - maximum	g/m ²	100	100	300	100	200	100	100	200	
3 hr. loss - maximum	g/m ²	100	100	200	100	100	100	100	100	
Slow	PFS-1 (Mixing)									
	Mixing Torque - maximum	kg-cm	9	9	9	9	9	9	9	9
	Mixing time - minimum	sec.	120	120	120	120	120	120	120	120
	Spread index - maximum @ 120 sec.	kg-cm	12	12	12	12	12	12	12	12
	Blot test - 30 sec.	-	clear water	clear water	N/A	clear water	clear water	clear water	clear water	clear water
	Coating	-	100%	100%	95%	95%	95%	100%	100%	95%
	PFS-2 (Wet Cohesion)									
	30 min. cohesion - minimum	kg-cm	12	12	12	12	12	12	12	12
	60 min. cohesion - minimum	kg-cm	23	20	20	20	20	20	20	20
	90 min. cohesion - minimum	kg-cm	25	25	25	25	25	25	25	25
12 hr. cohesion - minimum	kg-cm	28	28	28	28	28	28	28	28	
PFS-3 (Abrasion Loss)										
30 min. loss - maximum	g/m ²	200	200	400	300	300	300	300	300	
1hr. loss - maximum	g/m ²	100	100	300	100	200	100	100	200	
3 hr. loss - maximum	g/m ²	100	100	200	100	100	100	100	100	



Asphalt Emulsion Requirements

PROPERTY	Test Method	Minimum	Maximum
Viscosity, Saybolt Furol @ 77° F, Seconds	AASHTO T 59	20	100
Storage Stability test, one day, %	AASHTO T 59	-	1
Particle Charge test	AASHTO T 59	Positive	
Sieve Test, %	AASHTO T 59	-	0.1
Tests on Distillation			
Oil distillate, by volume or emulsion, % residue	AASHTO T 59	60	-
Tests on Residue			
Penetration, 77° F, 100g, 5 sec	AASHTO T 49	55	90
Ductility, 77° F 5 cm/min, cm	AASHTO T 51	70	-
Solubility in trichlorethylene, %	AASHTO T 44	97.5	
Softening Point, minimum	AASHTO T 53	135 °F	



Aggregate Quality Requirements

Test	Test Method	Requirement
Sand Equivalent, min	AASHTO T 176	65
Los Angeles Abrasion, loss at 500 rev., max [†]	AASHTO T 96	35
Percentage of Crushed Particles, minimum	AASHTO T	100
Magnesium sulfate soundness, max. loss, %, 4 cycles	AASHTO T 104	20
Micro-Duval, loss, %**	AASHTO	Report



Aggregate Gradations

Grade	US Sieve Size	Passing by Weight, %	Job Mix Formula Tolerance Limits, % + -
A	? 9.5 mm	100	5
	#4 4.75 mm	70-90	5
	#8 2.36 mm	45-70	5
	#16 1.16 mm	28-50	5
	#30 600 μ m	19-34	3
	#50 330 μ m	12-25	3
	#200 75 μ m	5-15	2
B	? 9.5 mm	100	5
	#4 4.75 mm	94-100	5
	#8 2.36 mm	65-90	5
	#16 1.18 mm	40-70	5
	#30 600 μ m	25-50	3
	#50 330 μ m	18-30	3
	#200 75 μ m	5-15	2
C	? 9.5 mm	100	
	#4 4.75 mm	100	5
	#8 2.36 mm	90-100	5
	#16 1.16 mm	65-90	5
	#30 600 μ m	40-65	5
	#50 330 μ m	25-42	4
	#200 75 μ m	10-20	2



Where Are We?

Really Good Question!



Work Plan and Study Approach

- Phase III Activities



Phase III – Training

- ❑ **Training – Complete 1.5-day Training Course materials and Pre-Job Module**





Training Course

- Instructor's Guide
 - Basic Information
 - General introduction
 - Set-up and wrap-up procedures
 - Annotated outline by session



Pre-Job Training Module

- “Tailgate” presentation
 - Targeted at agency and contractor personnel on the job
 - Share “must know” information
 - Pocket-size guide book for field use



Work Plan- Phase III

- Construct Pilot Projects
 - Identify Test Sections
 - Site Selection guidelines
 - Test Section Layout
 - Construction Guidelines
 - Pre-construction
 - Construction
 - Post-Construction



Work Plan- Phase III

- **Identify Test Sections**

Traffic	Surface Type	Climatic Region			
		Wet-Freeze	Wet-No Freeze	Dry-Freeze	Dry-No Freeze
High	HMAC	*(1,2)	*(1,2)	*(1,2)	*(1,2)
	PCC				
Moderate	HMAC	*(1,2)	*(1,2)	*(1,2)	*(1,2)
	PCC				

Work Plan- Phase III

- Construction Guidelines
 - Insure proper placement
 - Observe and evaluate constructability
 - Coordinated effort between
 - Agency
 - Research Team
 - Contractor
 - Material Supplier
 - Use Guidelines developed in study
 - Document activities





Acceptance of Mixture

- Need for field control test
- Need for sampling and testing of completed mixture
- Automated sampling device from equipment manufactures?



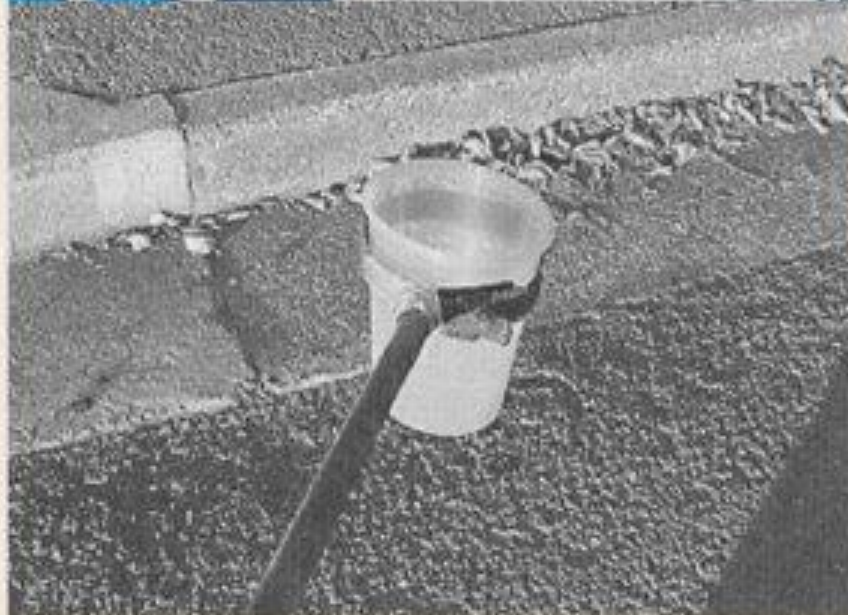
GeoGauge

- Non-destructive, quick measurements of stiffness
- Can be used to measure the rate of cure in cement-treated base materials
- Produced by Humboldt





Sampling





Q and A

Questions?

Thanks!