Use of Stabilized Blended Calcium Sulfate (BCS) in Pavements

Mingjiang Tao, Ph.D.

Zhongjie “Doc” Zhang, Ph.D., P.E.

Louisiana Transportation Research Center

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Outline of Presentation

- Background
- Result summaries of laboratory & field testing programs
- Recommendations for using stabilized BCS

Background

- Fluorogypsum (FG) :
- FG+Lime/Limestone → Blended Calcium Sulfate (BCS)
- Problems with the utilization of BCS

Problems with non-stabilized BCS

Construction difficulties

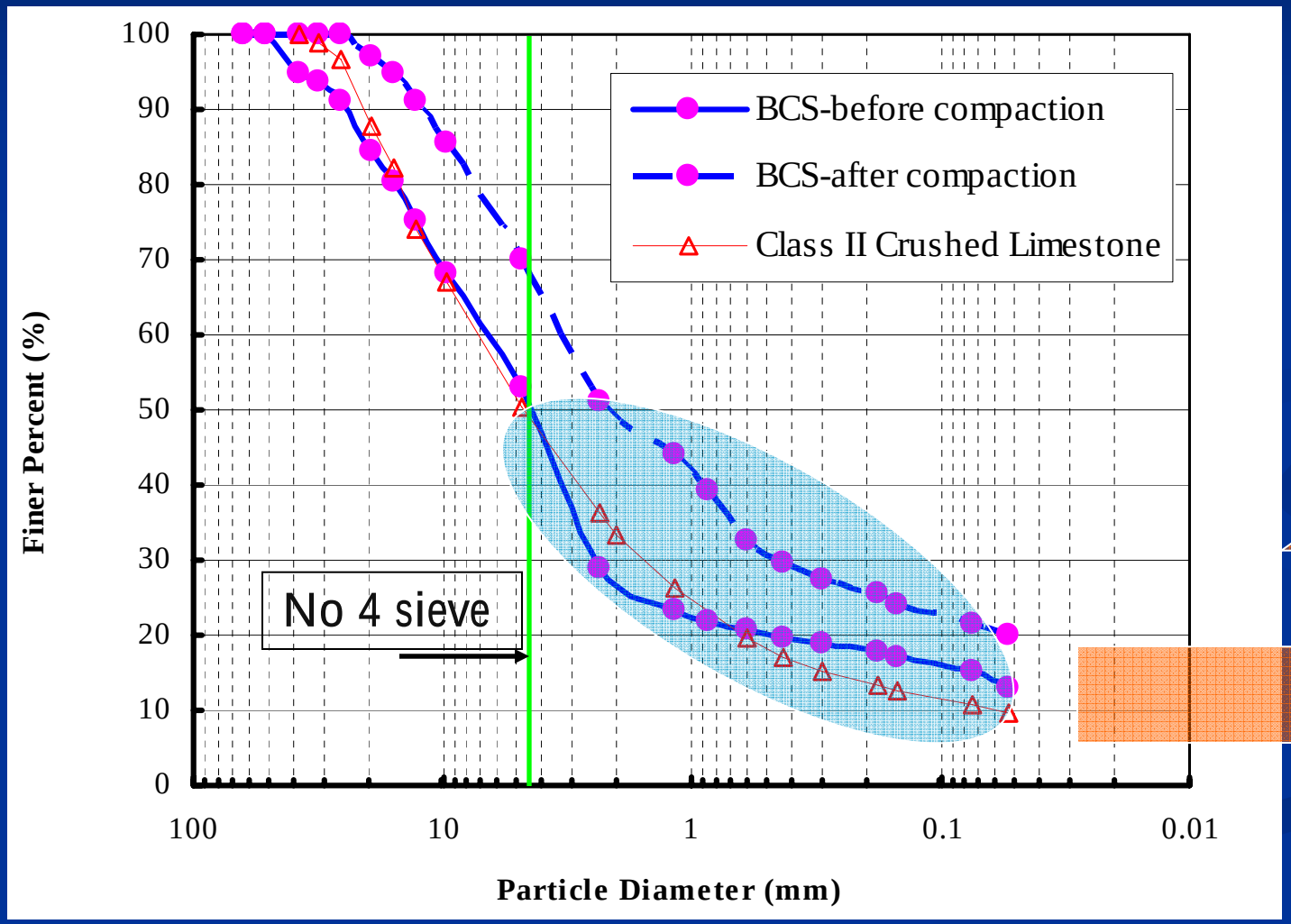
Dramatic deterioration of strength

Stage I
Laboratory Testing Program

Laboratory Testing Program

- To determine basic physical properties of BCS
- To determine significant factors affecting strength of BCS
- To seek an appropriate stabilization recipe to ameliorate water susceptibility of BCS

Basic Properties of BCS



C_u=150
C_z=24

GM/A-1-a

Basic Properties of BCS

Modified Proctor Compaction:

- γ_d=109 pcf, w_{opt}=12%

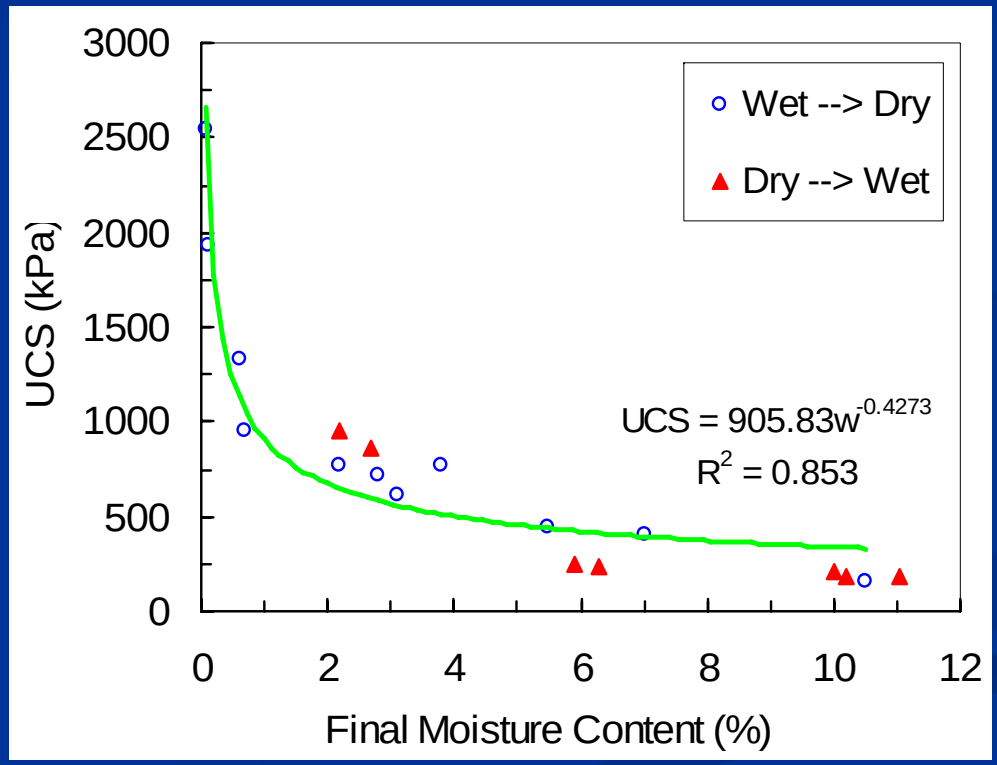
Drying Condition:

- In a 40^{o}C oven for 24 hours
- A CoreDry Machine for 100 minutes

Basic Properties of BCS-Con.

Factors affecting BCS's Strength

- Density
- Curing conditions
- Free water content



Stabilized BCS

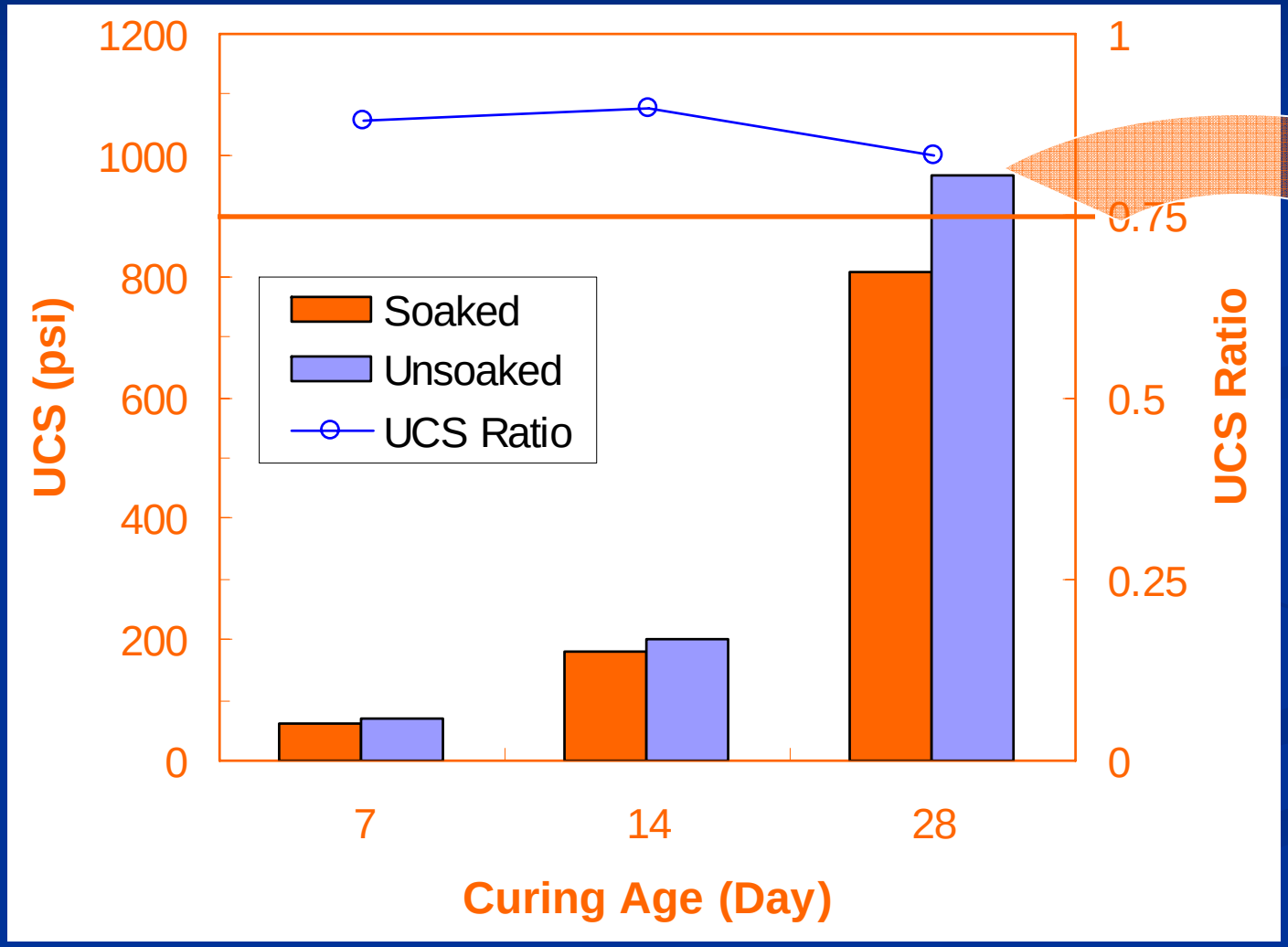
- BCS stabilized with grade 120 ground granulated blast furnace slag (GGBFS) @10% by weight;
- Curing Conditions: wrapped in plastic bags and put in a 100% RH room (70^{o}F)
- Significant factors: density, moisture content (curing)

Stabilized BCS

Non-stabilized BCS

GGBFS-stabilized BCS

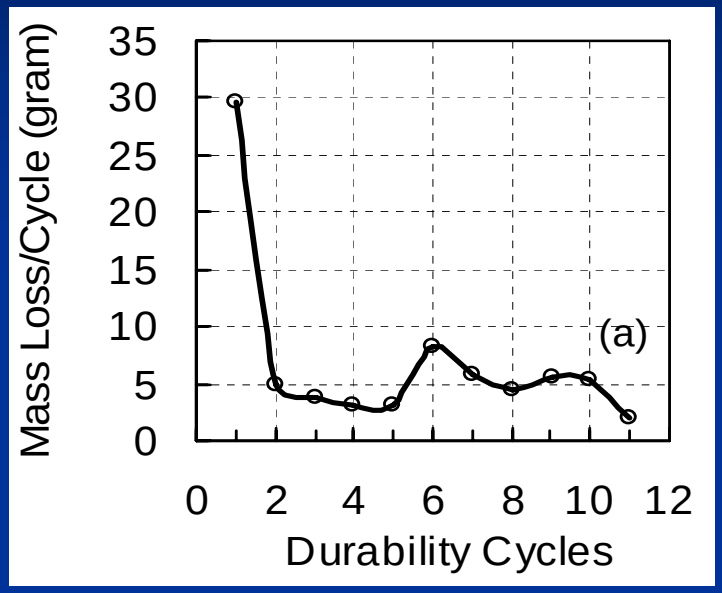
Stabilized BCS (-4) (10% GGBFS by weight)

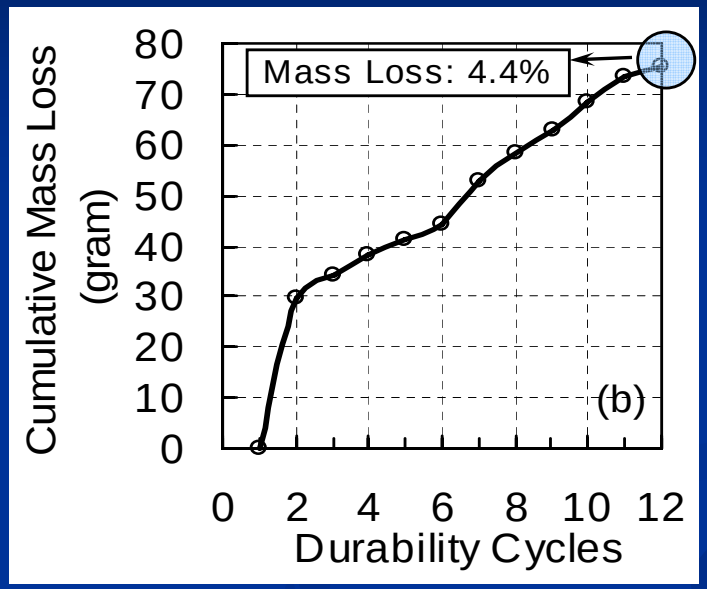


Water Resistance

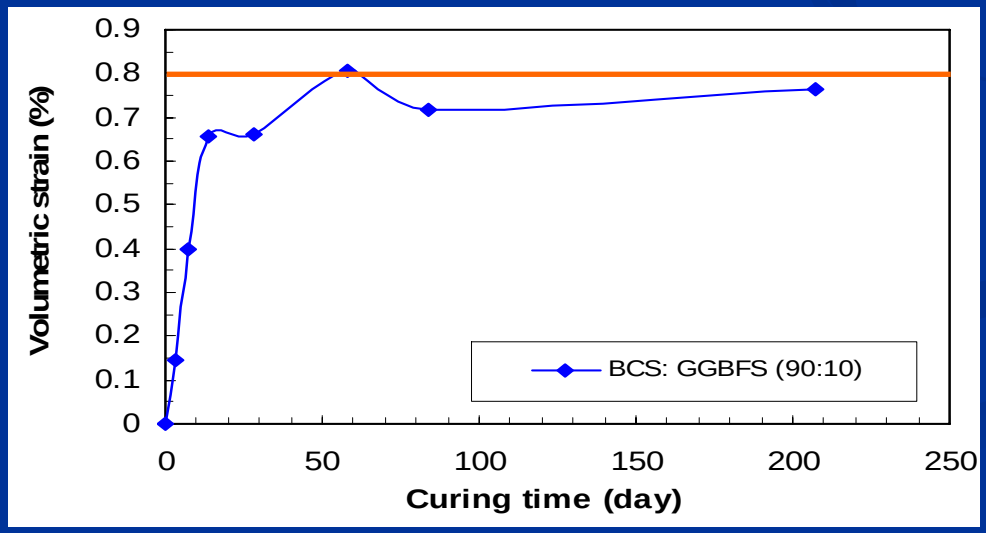
UCS_w/UCS_d

Durability and Expansion of GGBFS-Stabilized BCS





Durability



Expansion

Conclusions from Laboratory Studies

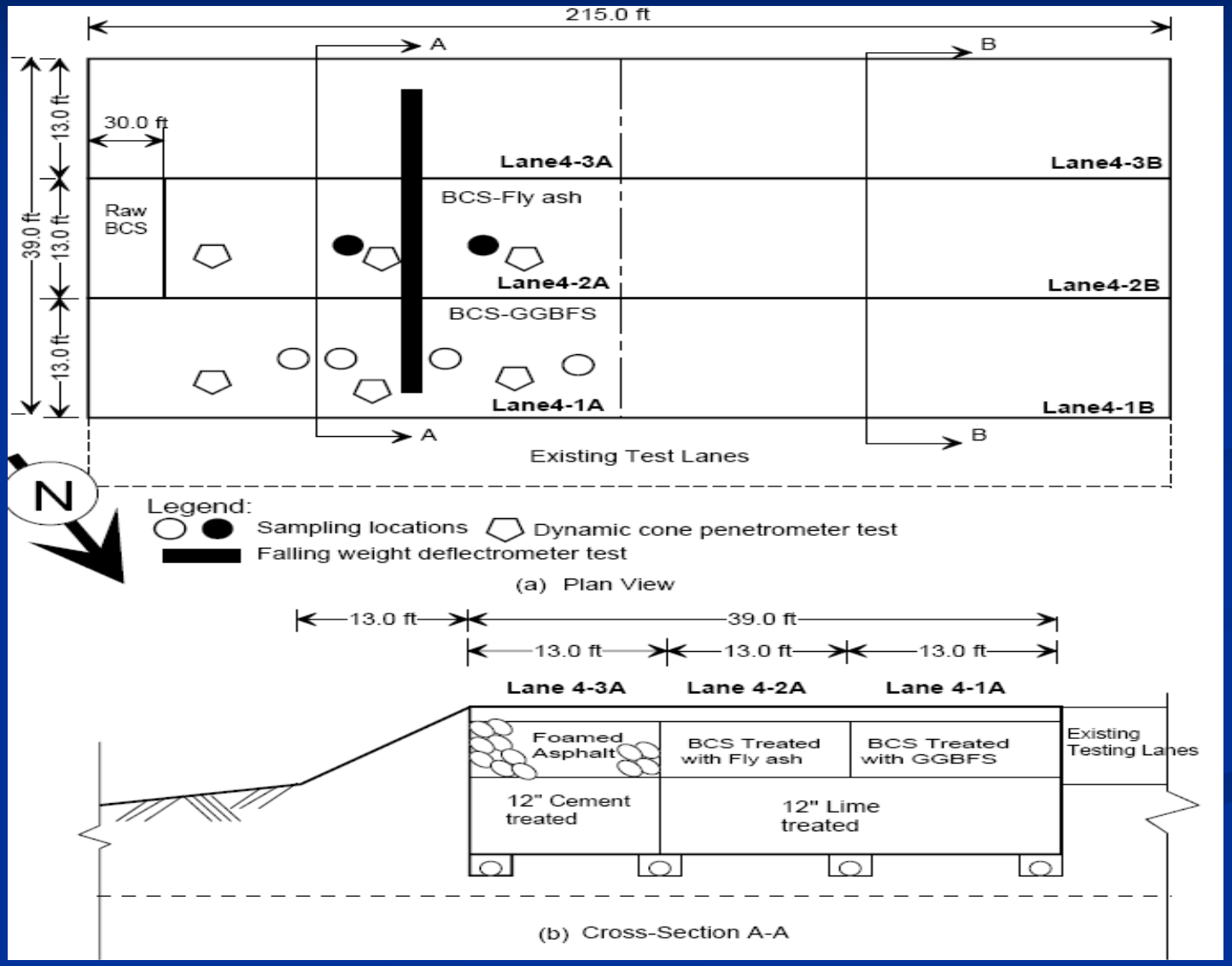
- Non-stabilized BCS:
  - high strength at dry conditions;
  - high water sensitivity;
- It is inappropriate to use non-stabilized BCS as a base course material with wet environments.
- BCS can be successfully stabilized by GGBFS or GGBFS and some secondary stabilizers.

Stage II
Field Testing Program

Full-scale field Testing Program

- Construct a full-scale field testing section;
- Determine Unconfined compression strength (UCS), Resilient modulus, permanent deformation of stabilized BCS in the laboratory
- Characterize stabilized BCS by using Dynamic Cone Penetration (DCP), Falling Weight Deflectometer (FWD), and DYNAFLECT tests

Layout and Profiles of Testing Sections



Construction of Field Testing Sections

Laboratory Testing Program

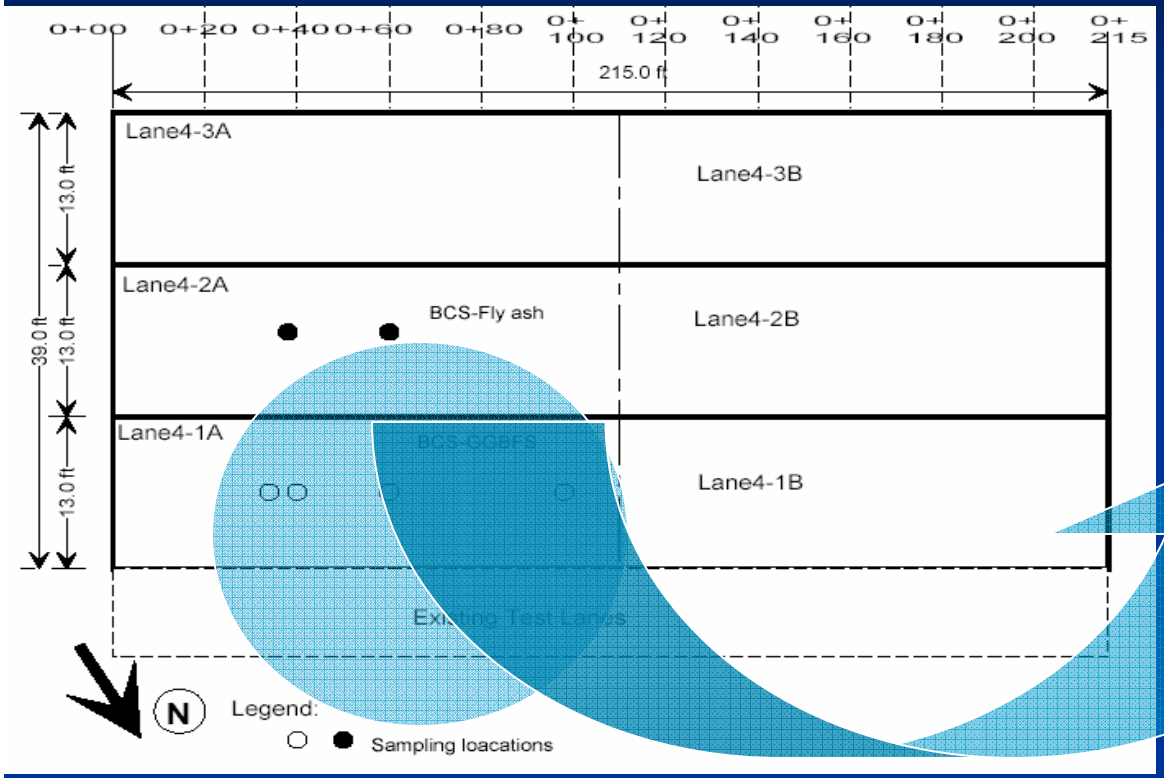
- Unconfined compression strength (UCS) test
- Repeated Loading Triaxial tests-Resilient modulus and permanent deformation

Laboratory Testing Program

Tested Samples:

- Collected at the ALF testing site and molded in the laboratory;
- Cored directly from the testing section

Tested Materials



Samples molded at the laboratory

Tested Materials-Cond.

In-Situ Tests

- Dynamic Cone Penetration (DCP); Falling Weight Deflectometer (FWD); DYNAFLECT

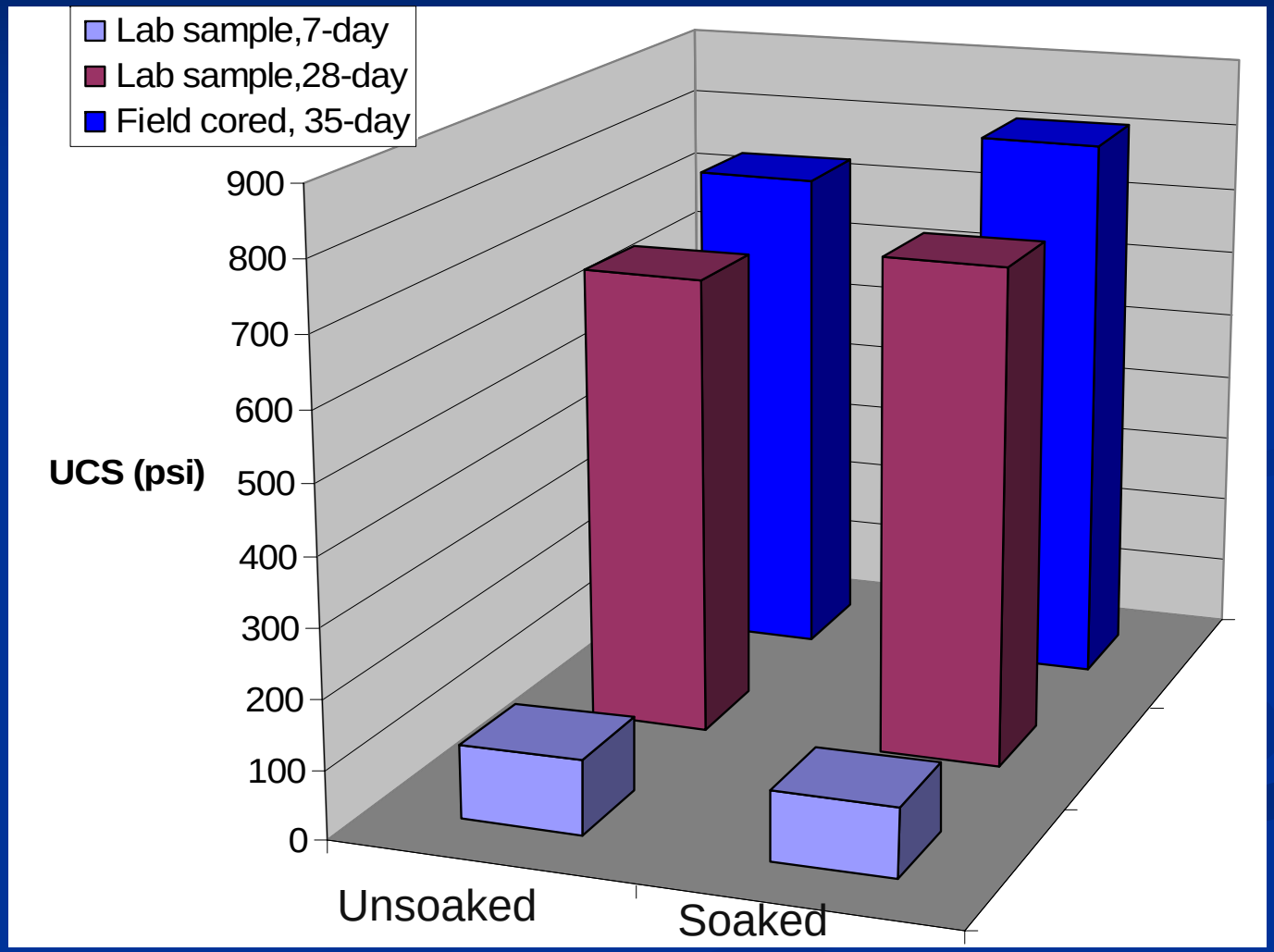
DCP

FWD

DYNAFLECT

Testing Results-UCS

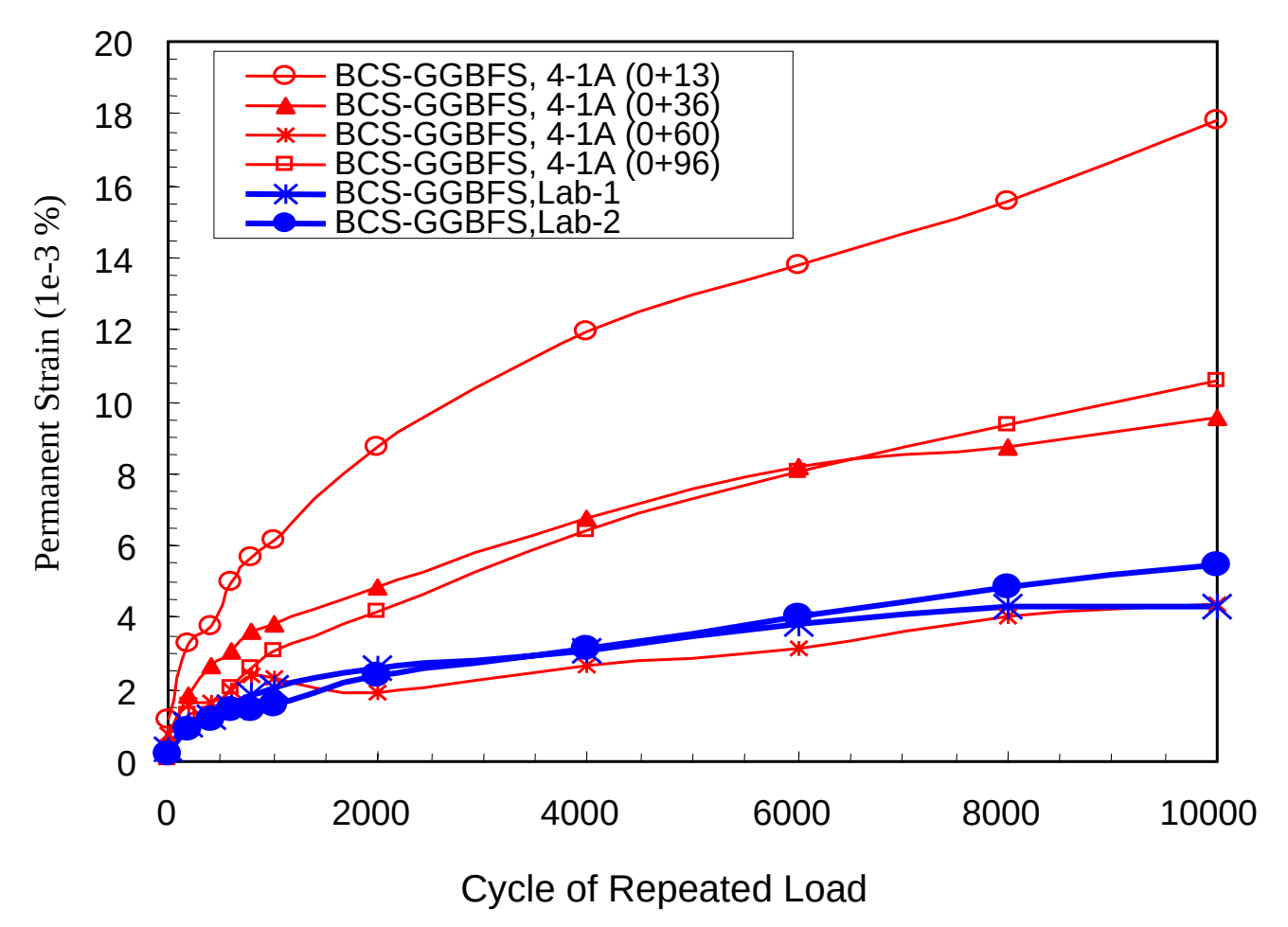
GGBFS-BCS



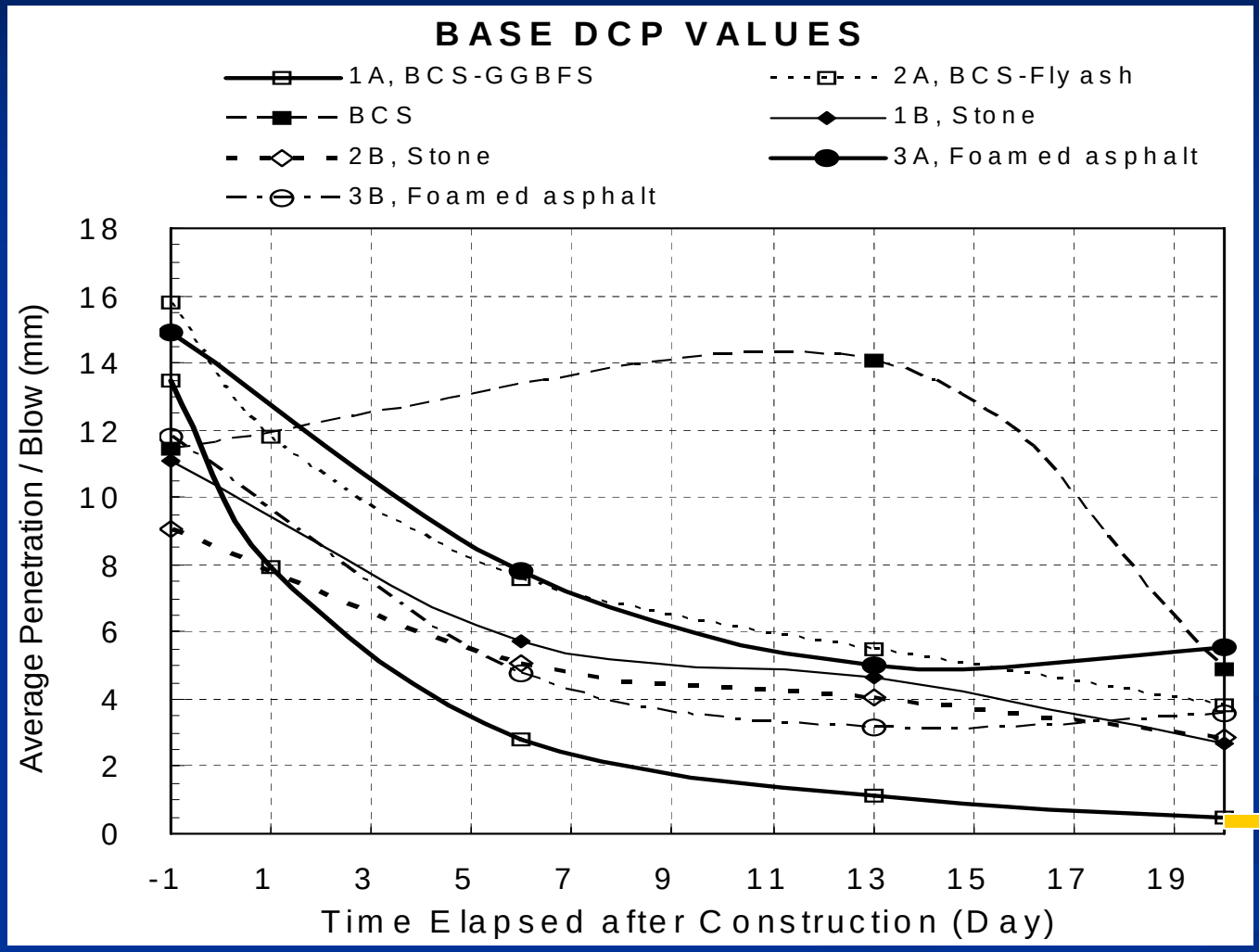
Lab Test Results-UCS

Samples	UCS (psi) Unsoaked	UCS (psi) Soaked	UCS ratio	Curing ages (days)
Lab molded	108.3	99.9	0.92	7
lab molded	672.6	725.4	1.08	28
Field cored	732.7	815.2	1.11	35

Permanent Deformation Characteristics



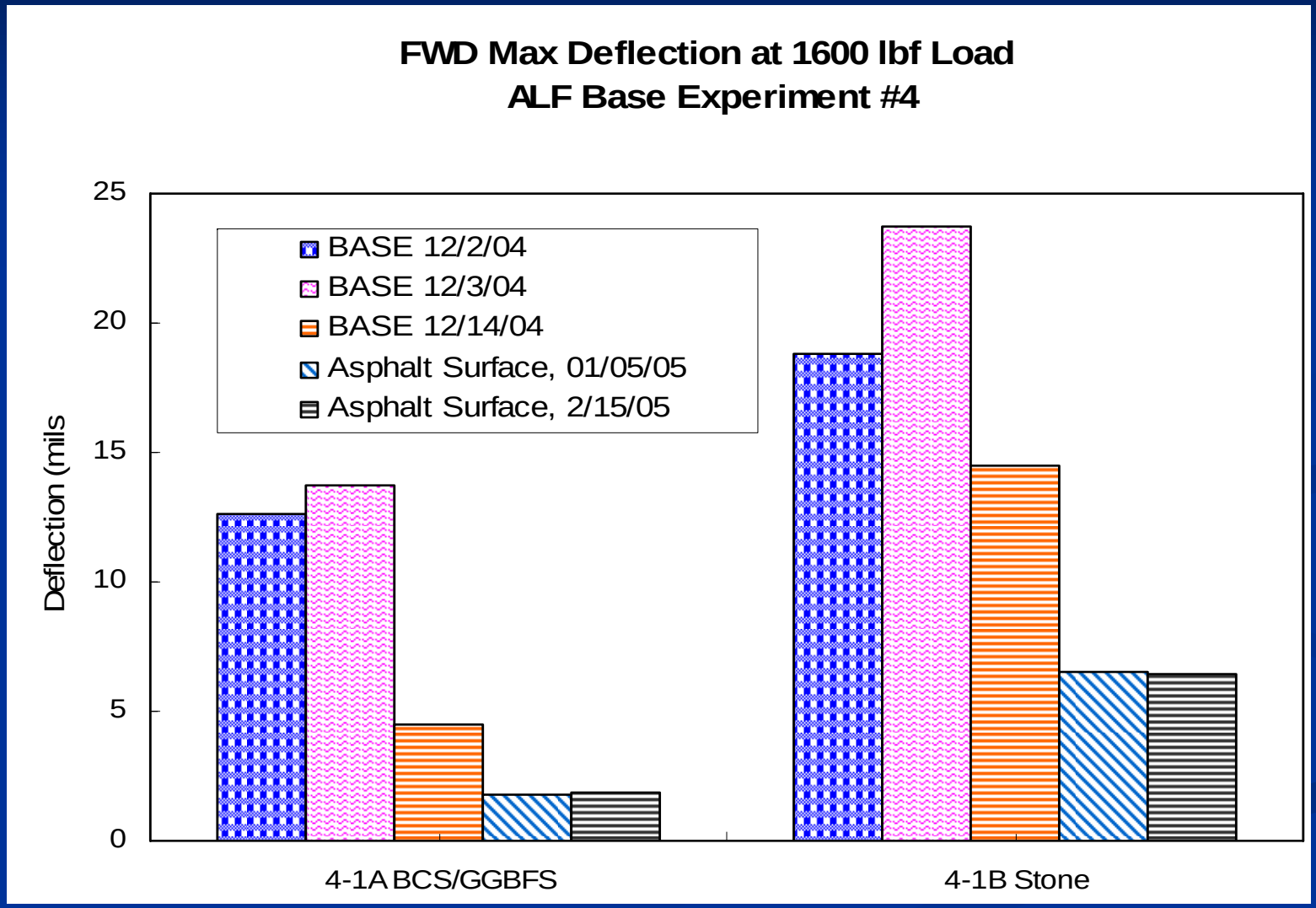
DCP Results



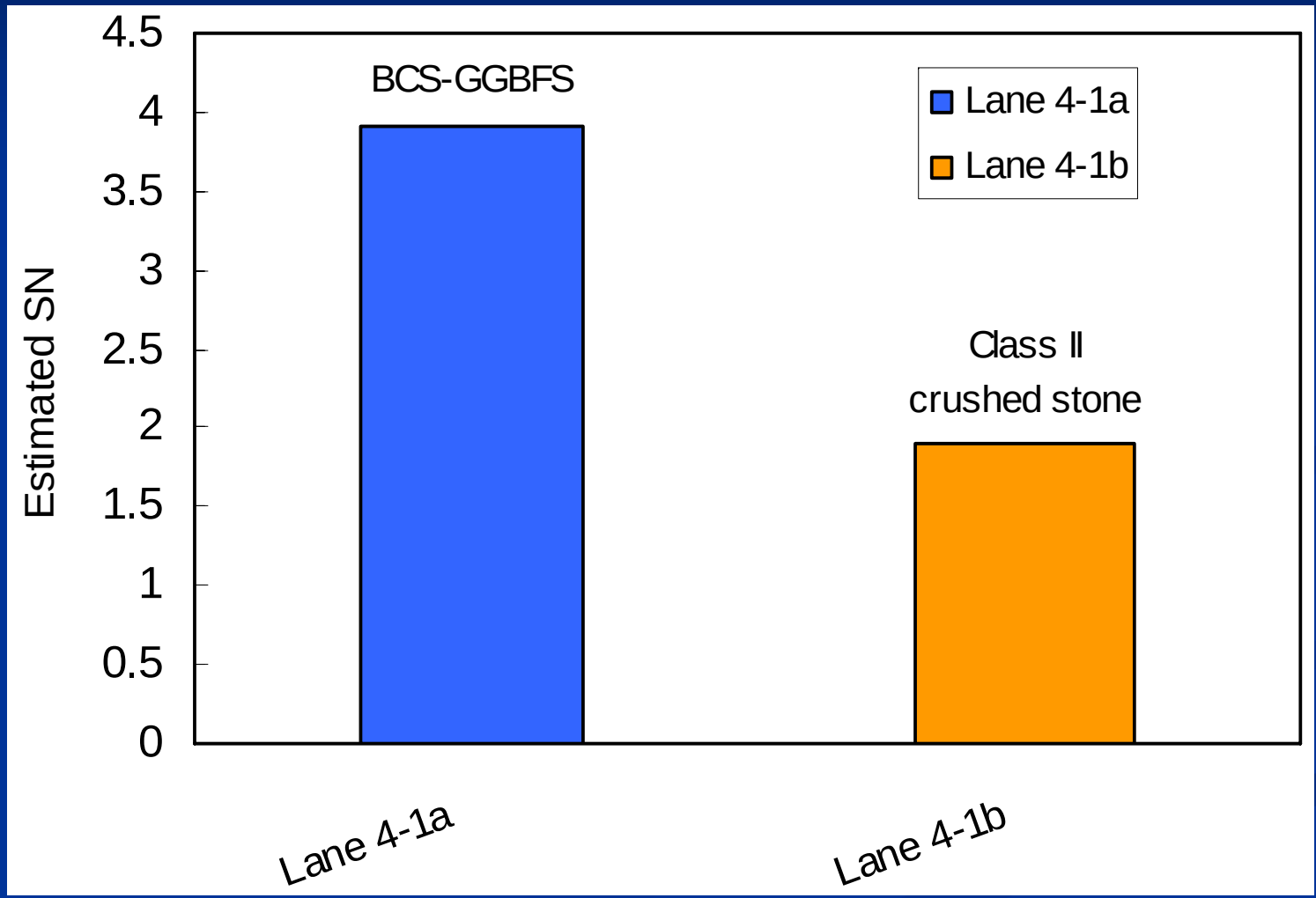
0.5mm/blow;

Good base: <=3mm/blow

FWD Results


FWD Max Deflection at 1600 lbf Load
ALF Base Experiment #4
Deflection (mils
25
20
15
10
5
0
BASE 12/2/04
BASE 12/3/04
BASE 12/14/04
Asphalt Surface, 01/05/05
Asphalt Surface, 2/15/05
4-1A BCS/GGBFS
4-1B Stone

DYNAFLECT Results



Summary of In-Situ Test Results

Source of data	a_2	Curing ages (days)	Con. Pressure (psi)	σ_d (psi)	Modulus, ksi
Lab molded samples	0.287-0.293	28	3	5.4	119.6-126.5
Field cored samples	0.174-0.219	35	3	5.4	42.1-63.7
FWD tests	0.403	121			349.3
DYNAFLECT tests	0.356	121			

Conclusions of Field Testing Program

- The GGBFS-stabilized BCS achieved higher strength and stiffness than those of the Class II crushed limestone base material.
- The construction procedure at the ALF testing section is successful for the slag-BCS stabilization.

Recommendations

- Design Parameters of GGBFS-stabilized BCS in pavements

UCS (psi) (7/28)	Mr (ksi)	a_2	w (%)	γ_d (pcf)
100/700	50.0	0.25	18.0	109.0

Recommendations

- A construction specification for BCS stabilization

  Material selection:

  - Particle size distribution meets LA DOTD class II aggregate specifications and a pH value of 7.0;
  - GGBFS: the 120 grade at 10% by volume;
  - Water: potable without any deleterious materials;

Recommendations

- Moisture Content: 6 percent over optimum value (12%);
- Field placement, mixing, and compaction;
- Construction quality control;
- Curing in the field.

Questions ?