Development of Premium Pavement Designs

Field Investigation of High Performance Pavements in Virginia

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Project Objective

- To develop a premium pavement design with a life span of 40 years or more
- Phase I:
  - ✓ Field evaluations and analysis of existing pavements (18 section in high-traffic areas)
  - ✓ Laboratory testing and analysis of the hot-mix asphalt (HMA) and concrete layers

Scope of Work

- Work initiated in January 2004
  - ✓ Site Selection
  - ✓ Field Investigation
  - ✓ Data Analysis
  - ✓ Findings, Conclusions and Recommendations

Site Selection

- Four Pavement Types:
  - ✓ Flexible
  - ✓ Jointed Plain Concrete
  - ✓ Continuously Reinforced Concrete
  - ✓ Composite (AC on CRCP and AC on CPCP)
- Target Age Ranges
  - ✓ Less than 5 years
  - ✓ 10 to 15 years
  - ✓ Greater than 20 years
- 18 Total Sites (0.5-mile in length)

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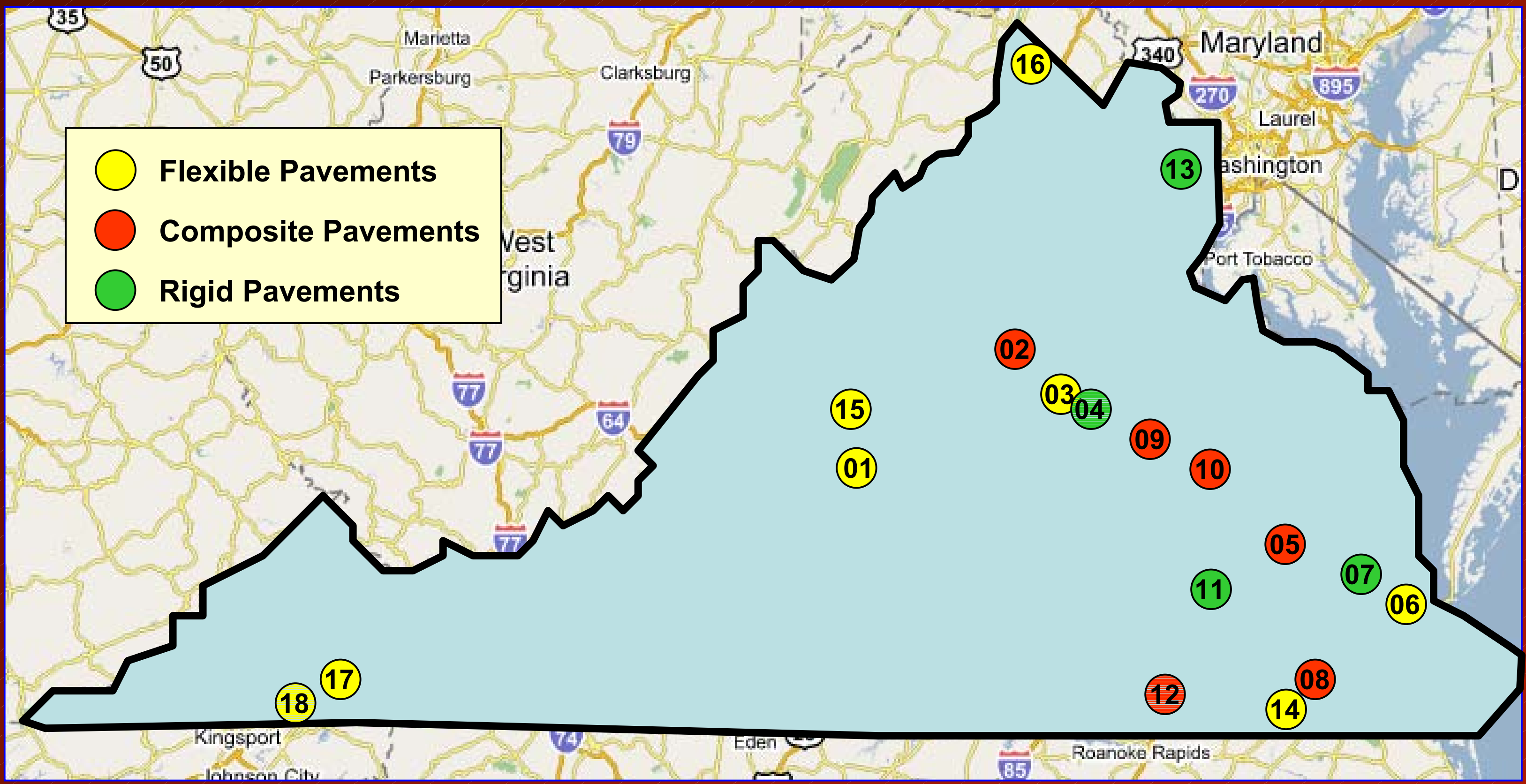
Selected Sites



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Site	County	Route	Direction	Milepost*	Pavement Type^	Pavement Age/ Surface Age (yrs)
01	Amherst	US-29	South	7.80-7.30	Flexible	34 / 11
02	Albemarle	I-64	East	12.99-13.37	Comp. CRCP (rehab)	34 / 12
03	Louisa	I-64	West	9.91-9.41	Flexible	34 / 9
04	Louisa	I-64	West	2.28-1.78	CRCP	17 / 17
05	New Kent	I-64	East	14.69-15.19	Comp. CRCP (rehab)	32 / 13
06	York	I-64	West	2.62-2.12	Flexible	25 / 7
07	York	I-64	West	22.23-24.71	JPCP	7 / 7
08	Suffolk	US-58	East	25.50-26.00	Comp. JRCP (rehab)	72 / 1
09	Henrico	I-295	South	5.29-5.79	Comp. CRCP (rehab)	23 / 6
10	Hanover	I-295	South	9.52-10.02	Comp. CRCP (rehab)	24 / 9
11	Prince George	I-295	South	8.37-8.87	CRCP	12 / 12
12	Greensville	I-295	North	5.50-6.00	Comp. JPCP (rehab)	14 / 6
13	Fairfax	I-66	West	8.20-7.82	JPCP	8 / 8
14	Russell	I-19	North	8.68-9.18	Flexible	6 / 6
15	Rockbridge	I-81	South	22.92-22.42	Flexible	37 / 17
16	Frederick	I-81	North	21.31-21.87	Flexible	39 / 13
17	Washington	I-81	South	12.50-12,00	Flexible	42 / 11
18	Washington	I-81	South	1.50-1.00	Flexible	5 / 3

Field Investigation

- Joint effort between VDOT, VTRC and Virginia Tech
- Tests
  - ✓ FWD Testing ▪
  - ✓ GPR
  - ✓ Coring and Subgrade Boring
  - ✓ Visual Condition Survey
  - ✓ Ride Quality/ Friction Survey

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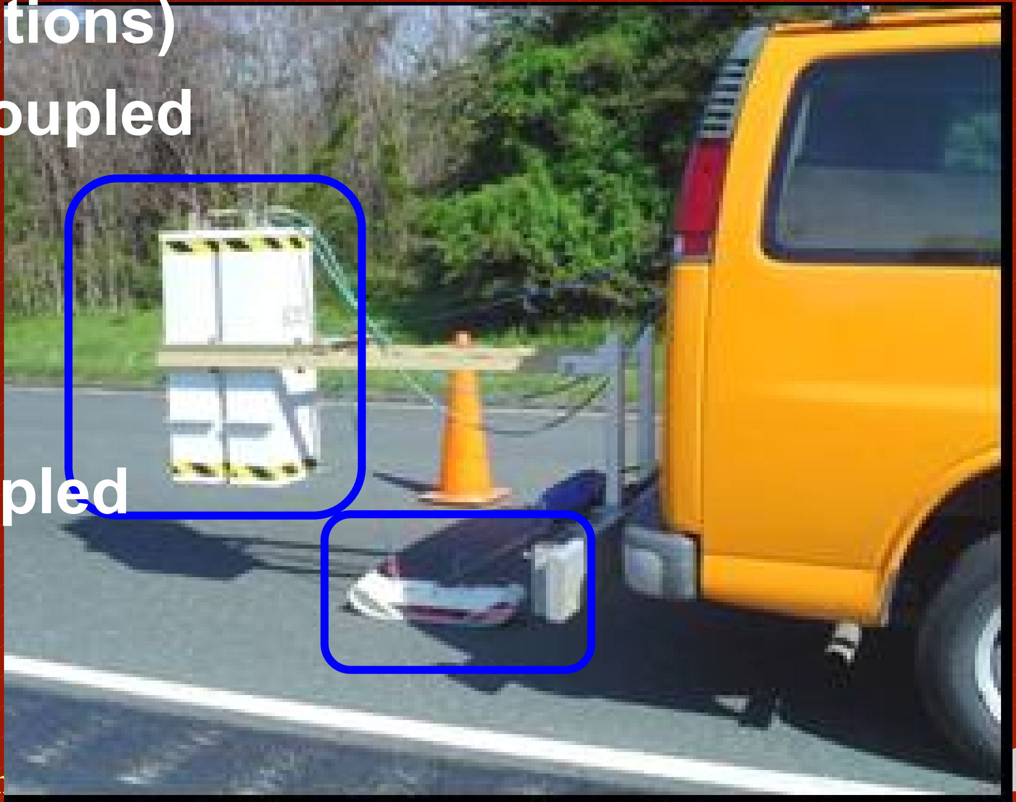
FWD Testing

- Test pattern dependent on pavement structure
- Basin Testing
  - ✓ 4 load levels and 3 drops per load level
  - ✓ 50 foot intervals in OWP (AC surface)
  - ✓ Every fourth slab for JPCP
- Joint Testing
  - ✓ Same load package at Basin
  - ✓ Every fourth slab
  - ✓ Approach testing of joints / OWP

GPR Testing

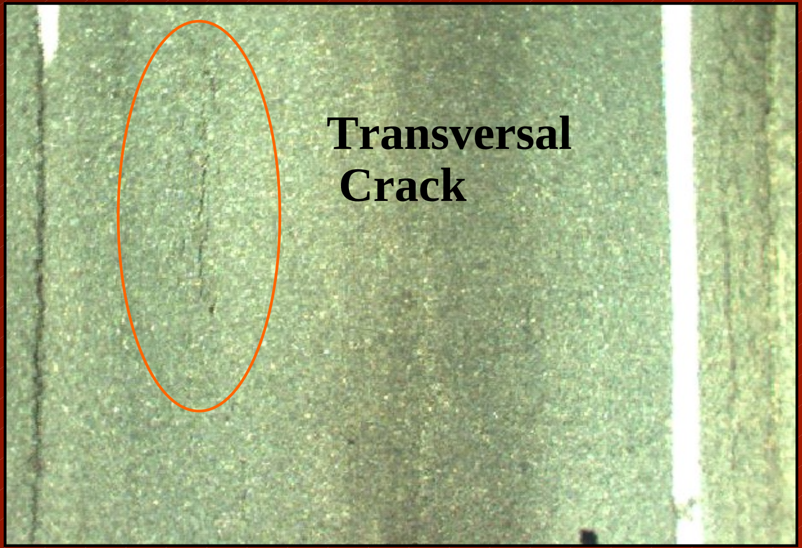
- Test set-up dependent on pavement
- Flexible
  - ✓ Three passes (center lane, wheel path, and stationary at core locations)
  - ✓ High-Frequency Air-Coupled Antenna @ 50 mph
- Rigid and Composite
  - ✓ Three Passes
  - ✓ Two antennas: air coupled + ground coupled @ Less than 10 mph

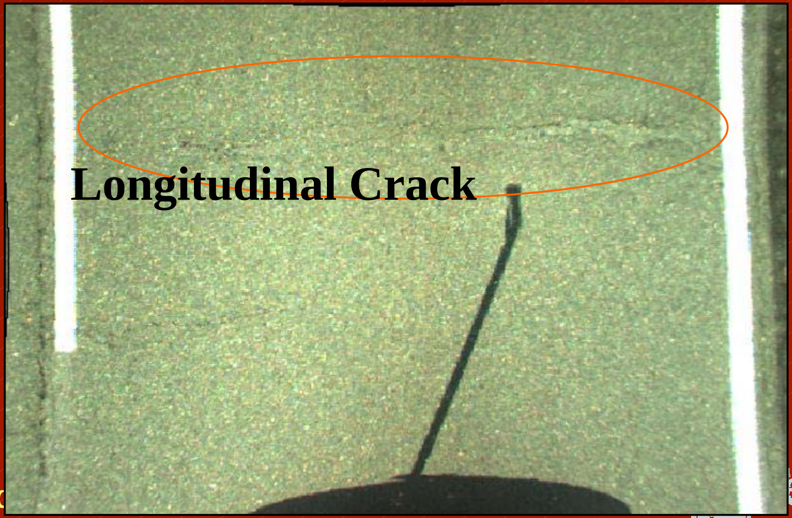


Coring and Boring

- Retrieve pavement materials samples for laboratory testing
- Number of tests varied based on pavement type
- Controlling factor was amount of lane closure time

Distress Survey

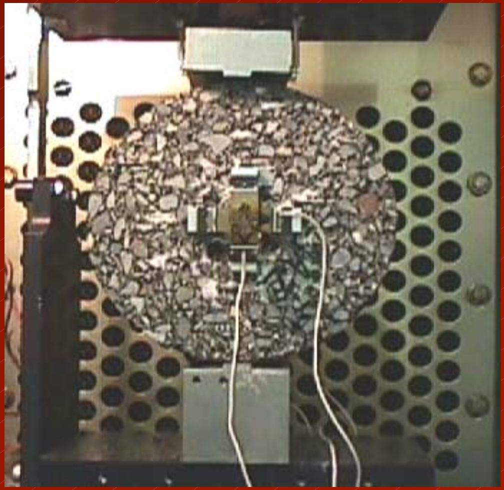




VT Digital Camera System

Laboratory Moduli Determination

- Hot Mix Asphalt
  - ✓ Resilient Modulus (ASTM D4123)
  - ✓ Creep
- Portland Cement Concrete
  - ✓ Compressive strength
  - ✓ E(psi) = 57,000 (f'c)1/2

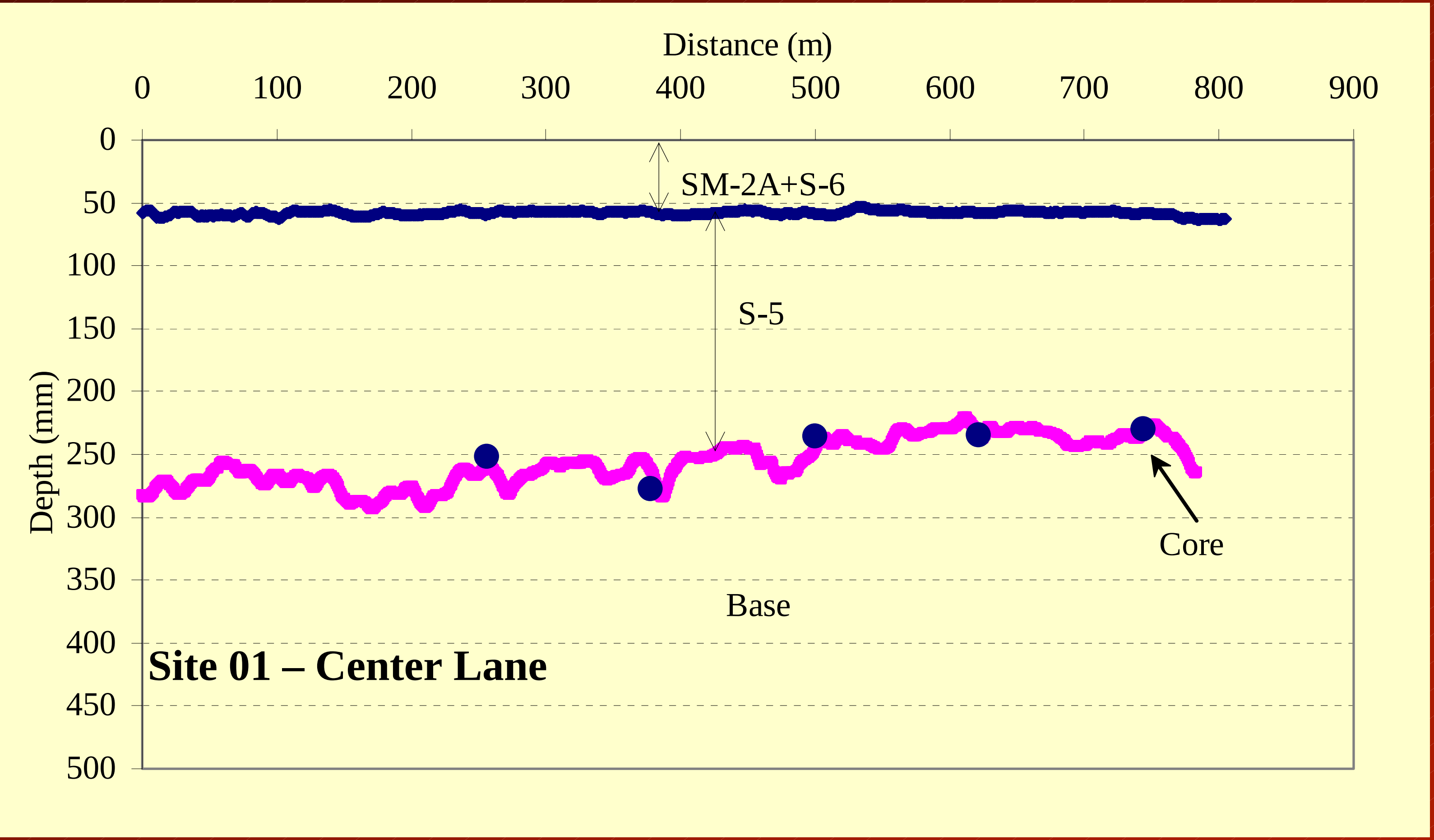


Functional Performance

Task 3 - Data Analysis

- GPR Analysis: Thicknesses
- FWD Data Analysis:
  - ✓ Backcalculations (Elmod)
  - ✓ Variability
- Visual Distresses
- Laboratory Material Characterization
- Functional Performance

GPR Thicknesses



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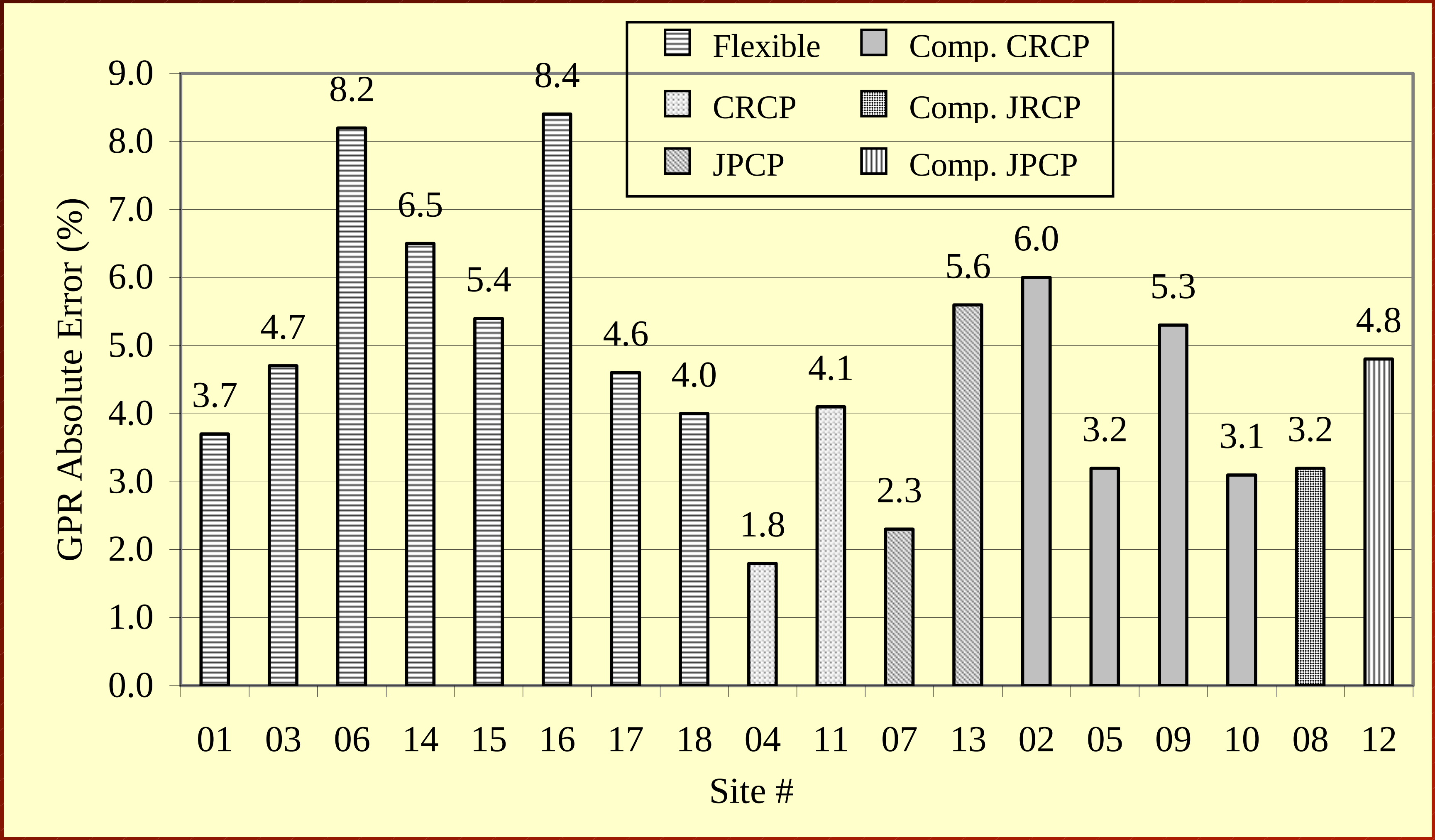
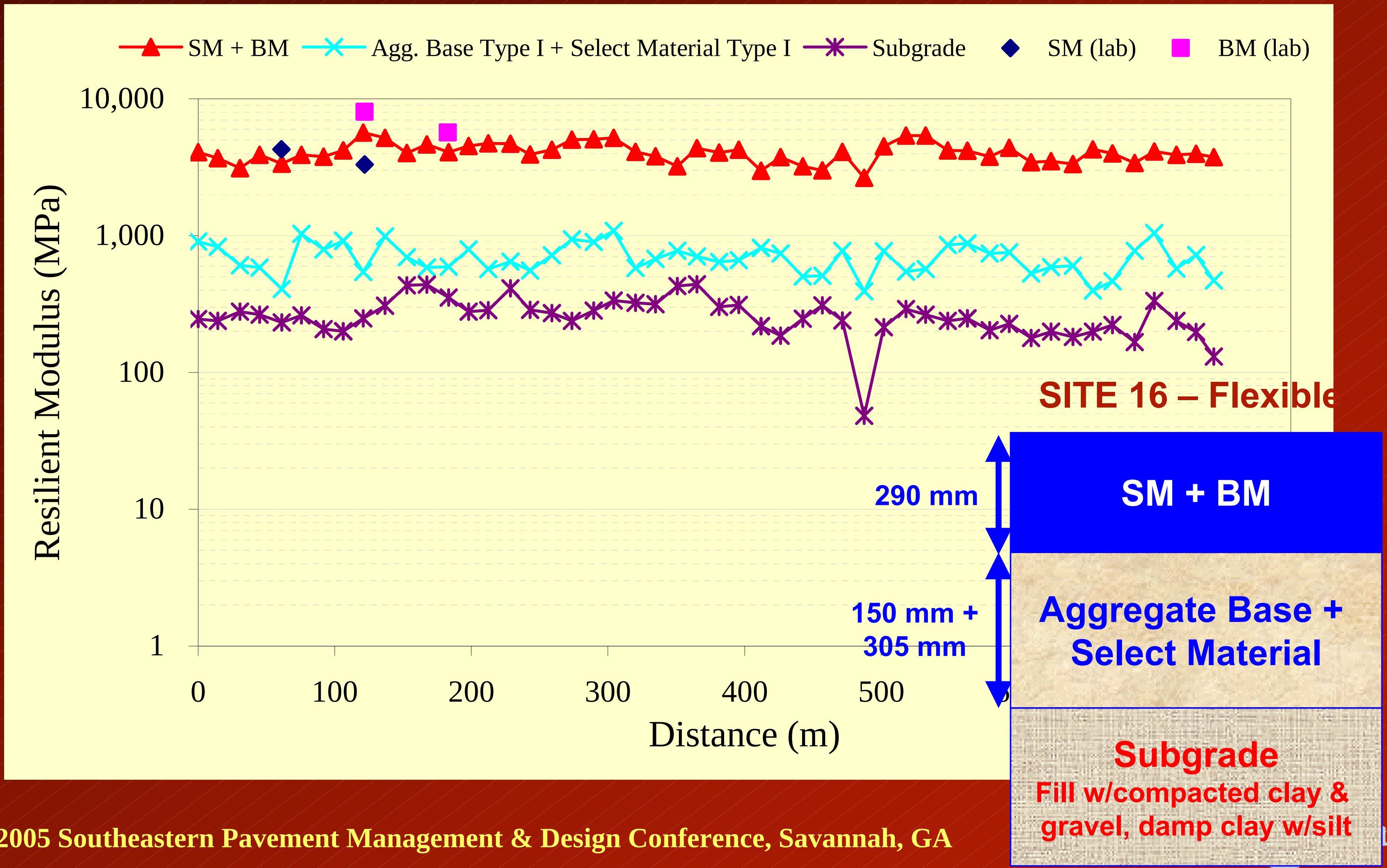
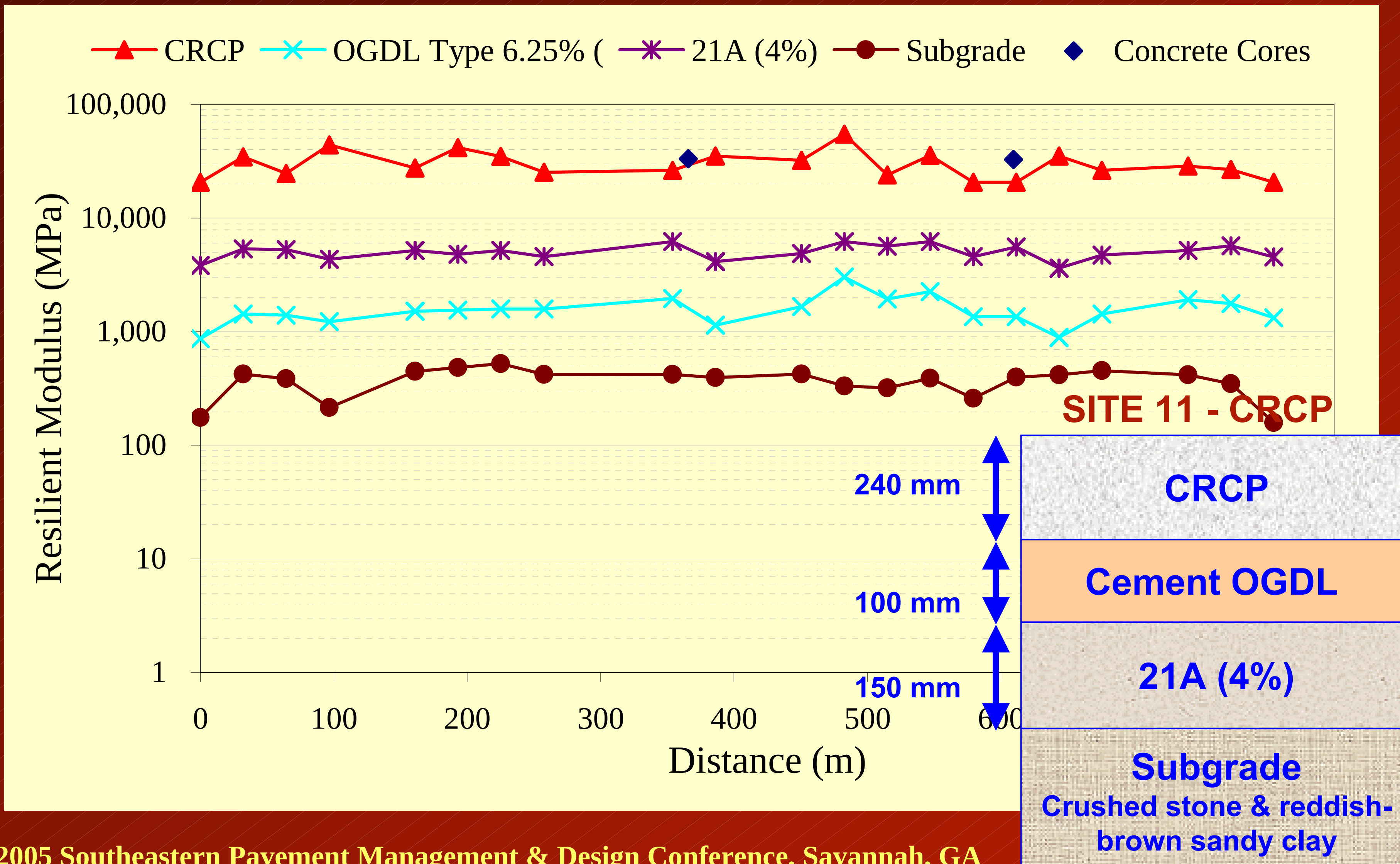
Average GPR Thickness Error



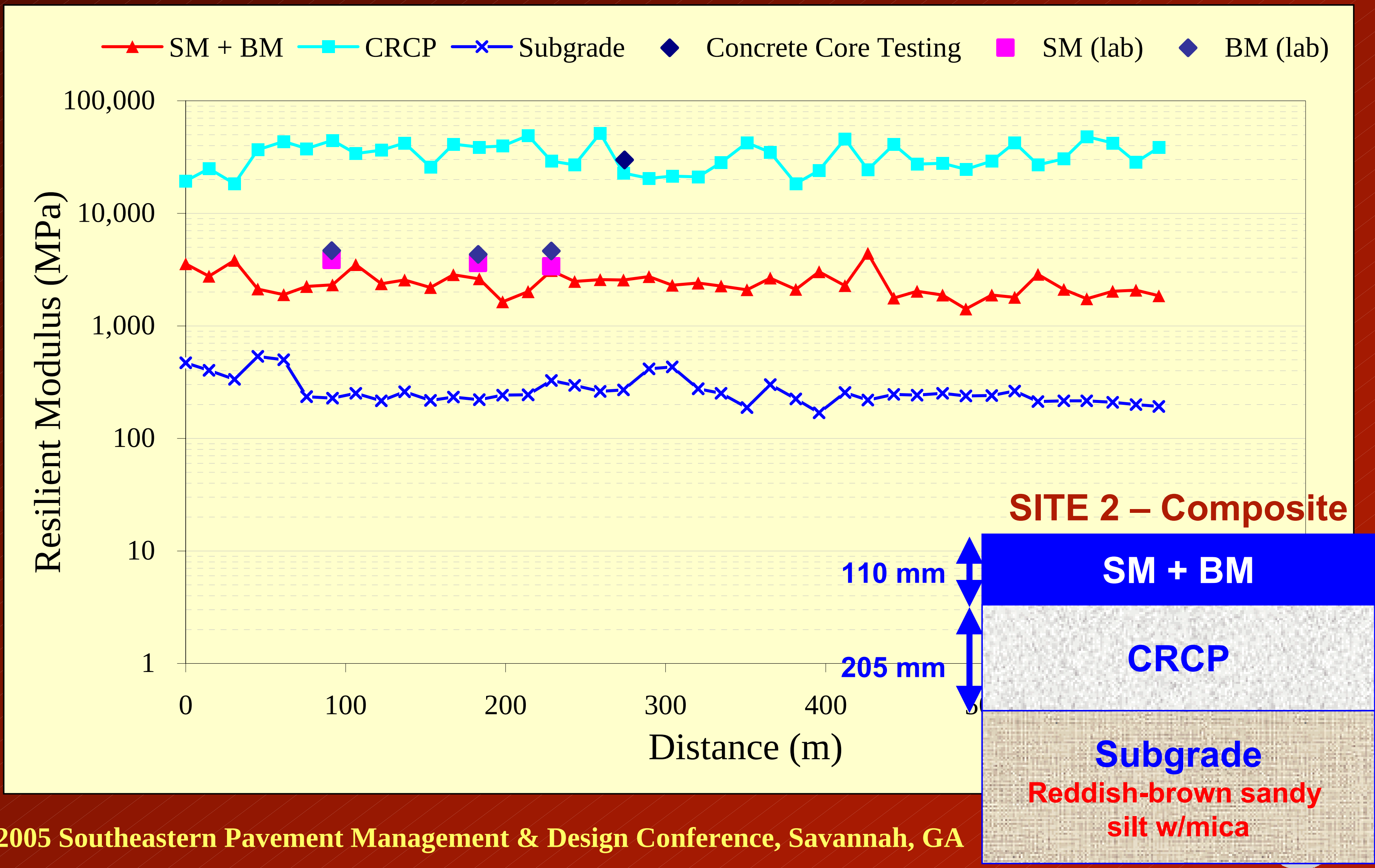
FWD Analysis: Flexible Site 16



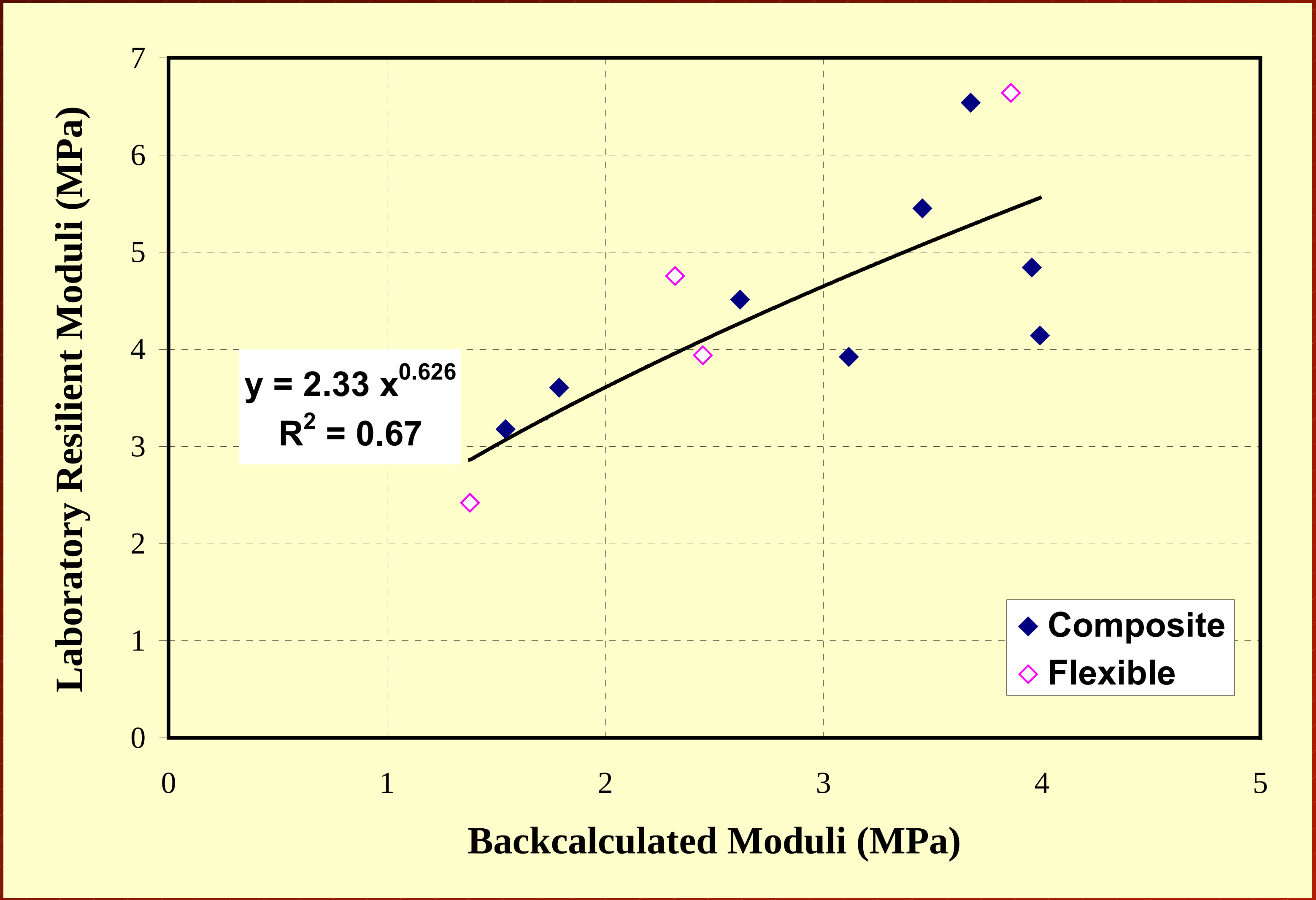
FWD Data Analysis: Rigid Site 11



FWD Data Analysis: Composite Site 2



Laboratory vs. Backcalculated HMA Moduli



Surface Distress Interpretation

Site #	Adequacy level for each type of distress											
	Long. Crk.			Trans. Crk.			Fatigue Crk.			Rutting		
	I	M	A	I	M	A	I	M	A	I	M	A
FLEXIBLE PAVEMENTS												
01	-	-	X	-	-	X	-	-	X	-	-	X
16	-	-	X	-	-	X	-	-	X	-	-	X
18	-	-	X	-	-	X	-	-	X	-	-	X
COMPOSITE PAVEMENTS												
02	-	-	X	-	-	X	-	-	X	-	-	X
05	-	X	-	-	-	X	-	-	X	-	-	X
09	-	-	X	-	-	X	-	-	X	-	-	X
10	-	-	X	-	-	X	-	-	X	-	-	X

I = Inadequate; M = Marginal; A = Adequate (M-E Design Guide)

Functional Performance Assessment

Site #	Type	Roughness, IRI mm/km (in/mi)	IRI COV (%)	Skid Number SN40	SN40 COV (%)
01	Flexible	1529.4 (96.9)	33.1	37.9	9.1
02	Comp.	1374.7 (87.1)	17.7	32.7	7.0
03	Flexible	1202.7 (76.2)	28.7	39.9	3.5
04	CRCP	1537.2 (97.4)	27.9	37.5	10.1
05	Comp.	1188.4 (75.3)	30.2	45.9	4.6
06	Flexible	1005.4 (63.7)	28.7	44.4	4.3
07	JPCP	888.6 (56.3)	39.4	35.1	33.1
08	Comp.	1139.5 (72.2)	38.5	45.2	4.2
09	Comp.	1306.8 (82.8)	29.0	37.0	4.1
10	Comp.	1041.7 (66.0)	21.6	41.0	4.9
11	CRCP	980.1 (62.1)	23.4	44.4	10.6
12	Comp.	634.5 (40.2)	20.6	35.5	9.8
13	JPCP	1521.5 (96.4)	22.4	45.5	26.2
14	Flexible	1257.9 (79.7)	26.8	40.3	4.6
15	Flexible	847.5 (53.7)	14.4	36.0	11.3
16	Flexible	637.6 (40.4)	23.6	35.6	6.2
17	Flexible	1336.8 (84.7)	30.6	44.9	3.6
18	Flexible	1149.0 (72.8)	25.8	32.4	10.6

Findings

- All the sites are performing satisfactorily and show very low structural distresses.
  - ✓ This was expected because the research team aimed at selecting the "best performing" pavement sections in the Commonwealth.
- Most of the fatigue cracks observed are longitudinal cracks in the wheelpath
  - ✓ Probably top-down cracks.

Findings

- GPR can determine the total thickness of the surface layers (HMA or PCC) with a high degree of accuracy
  - ✓ Especially if calibrated with a minimum number of cores.
  - ✓ Average absolute thickness error = 4.7% (1.8% - 8.4%)
  - ✓ The concrete thickness may not be determined from the GPR data in the case of composite pavements.

Findings

- The historical records available in VDOT databases are not complete
  - ✓ Several thickness differences were observed in the cores and GPR measurements.
- Observation of the cores showed some indication of HMA deterioration
  - ✓ Probably stripping (in some of the sections).

Findings

- SMA mixes performed better than standard SuperPave mixes when overlaying rigid pavements.
  - ✓ Sites 09 and 10 have similar designs but Site 10 (SMA) seems to be performing better although it has higher truck traffic.
  - ✓ In this case, material characteristics of the pavement system have more effect on the performance than the traffic loading.

Recommendation

- The selection of the most appropriate premium pavement design should be based on a detailed **Life-cycle Cost Analysis**.
  - ✓ **Mechanistic-empirical** modeling of the best performing section within each category to predict future pavement performance

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Other Recommendations

- Field evaluation of sites thought to have average and poor performance need to be conducted.
- Characterize the pavement materials in accordance with NCHRP 1-37 on M-E Design.
- Test the most promising designs using an Accelerated Pavement Testing (APT) facility for major distresses.

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Other Recommendations

- Continue periodic monitoring of these sites
  - ✓ Especially at the time of rehabilitation.
- Consider the use of FWD and GPR for quality control and assurance

Conclusions

- The analysis of the collected data suggests that premium pavement designs can be obtained.
  -
- It was confirmed that FWD, GPR, and digital imaging are useful tools to assess the condition of existing pavements.

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Another Application of the Data…

- **Use the results for the field evaluation of the high performance pavement to verify the applicability of the M-E models to conditions in the Commonwealth of Virginia**
- **Utilize the M-E Design Software to predict the performance of selected structures and compare the results to the current condition determined from visual survey**

Follow-up Study…

- Dynamic modulus (E*)tests in the lab on the composite HMA cores
  - ✓ 5 temperatures and 4 loading rates → master curve. ▪
- Volumetric properties → predicted E* master curve
- Resilient modulus
- Comparisons

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Questions?