Rehabilitation of Colonial National Historic Park Using Chemical Stabilization

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Schnabel ENGINEERING

Build Better. Together.

Owner

Federal Highway Administration (FHWA)
Eastern Federal Lands (EFL)

Design Build Team

Contractor: Wagman Heavy Civil
Designer: Johnson, Mirmiran & Thompson (JMT)

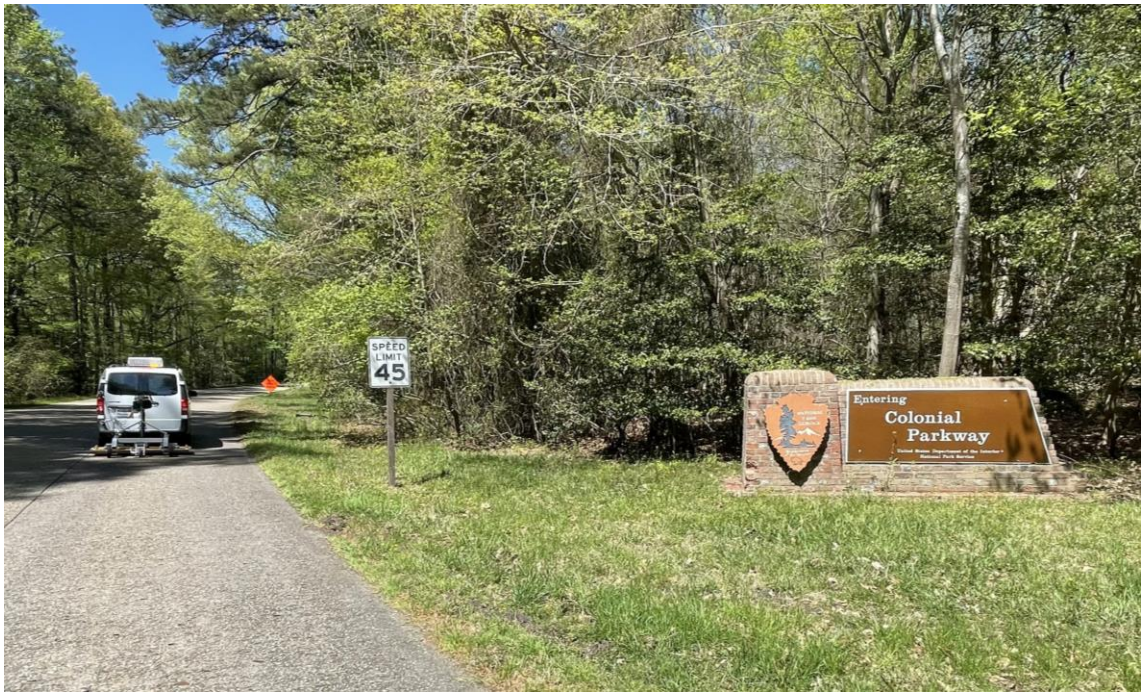
Location


60
INTERSTATE
64
199
Green
Spring
Plantation
5
Colonial
Parkway
York River
17
Gloucester
Williamsburg
238
Yorktown
Jamestown
Ferry
143
Jamestown
James River
105
173
17
60
Newport
News

Background

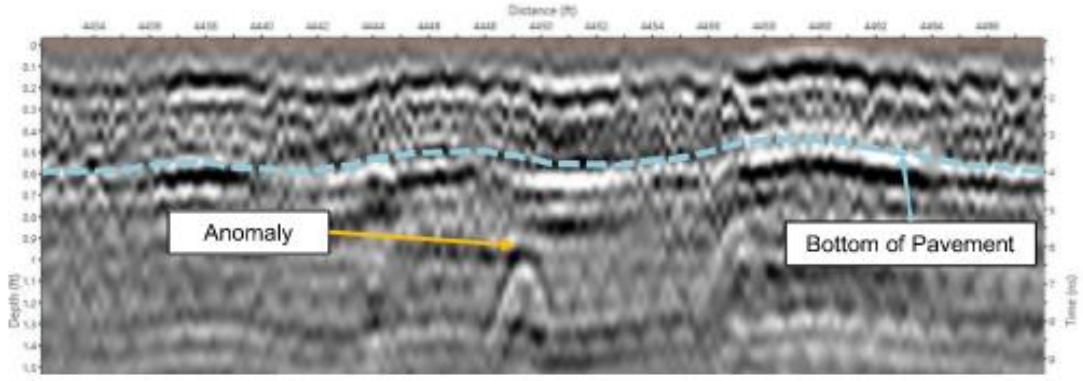
Existing pavement originally constructed in the 1930's and 1950's with a rehabilitation in the 80s.

- Typically consists of 5 to 9 inches of reinforced concrete pavement
- Up to 16.5 inches of "topping" or subbase
- Field exploration observed about 5 to 10 ¼ inches of concrete with reinforcement located 2 to 4 inches below the surface

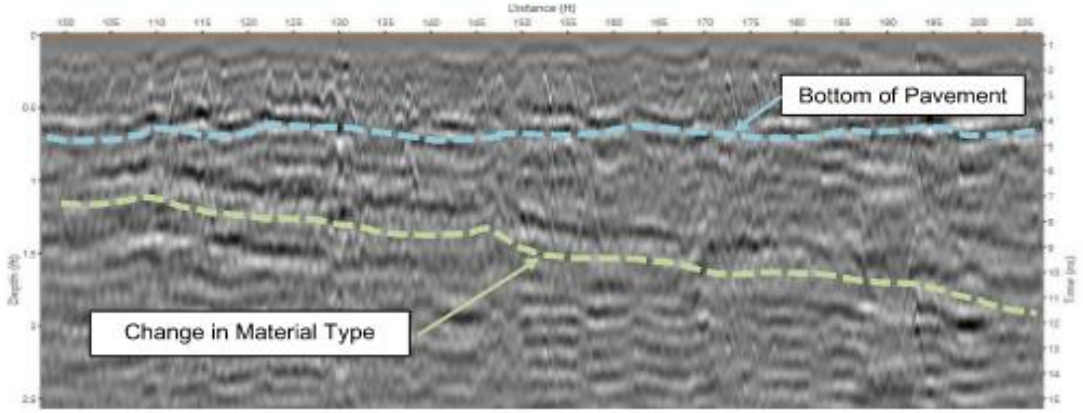


- 10.3 Miles (31.1 lane miles)
- 5 Segments
- 41 Environmentally Sensitive Areas

GPR Results



- Anomaly caused by high moisture or void



- Anomaly caused by change in material type

Data Collected on Existing Subgrade

FWD Data

- Design methodology in AASHTO 98 supplement
- Average k-value of 88 to 139 pci
- Data collected in spring

SPT N-values

- N-value: 1 to 28 in first two SPT samples
- Average 9 bpf
- 18 percent had N value < 5

Data Collected on Existing Subgrade

Dynamic Cone Penetrometer (DCP)

- Kessler DCP
- Subgrade k-values varied from 79 to 141 pci

CBR Values

- Lab testing CBR values from 3 to 44
  - 1998 supplement correlates k-value based on CBR tests for soils classifying as A-2 or coarser and degree of saturation for A-4 or finer

Data Collected on Existing Subgrade

Location	Boring No.	Strata	USCS	AASHTO	Natural Moisture (%)	LL	PI	% Gravel	% Fines	Max. Dry Density (pcf)	Opt. Moisture (%)	CBR Value	% Swell	k-Value *Note 1 (psi)	k-Value *Note 2 (psi)	k-Value *Note 3 (psi)
A	PV19-01*	-	SC	A-2-4	12.9	24	9	13	20	116.2	10.8	3*	0.5*	-	80	300-400
101+00	BH-101	C	SC	A-6	15.2	36	19	1	40	118.1	12.8	5.7	0.8	65-215	-	25-255
155+88	BH-111	F	SC	A-7-6	17.2	46	27	0	42	113.3	15.8	6.7	0.7	95-180	-	300-400
D	PV19-06*	-	SC	A-2-4	19.4	31	16	20	23	113.3	13.6	4*	0.1*	-	110	300-400
538+10	BH-206	E	CL	A-6	23.1	36	17	3	63	114.4	15.4	7.3	0.9	65-215	-	25-255
583+92	BH-303	E	SP-SC	A-2-7	8.6	56	36	0	8	111.3	12.8	26.7	0.0	-	315	150-350
585+00	PV19-11		SM	A-2-4	5.8	NP	NP	3	15	124.1	10.4	9*	0.0*	-	190	300-400
613+19	BH-309	F/B	SC	A-6	15.0	40	23	0	46	117.6	13.3	9.5	0.4	65-215	-	25-255
623+50	BH-311	F/B	CL	A-7-6	20.5	44	24	0	55	114.2	15.0	8.5	0.7	95-180	-	40-220
657+87	BH-404	F/W	CL	A-4	12.8	22	9	0	63	120.7	11.5	5.1	0.4	95-180	-	40-220
679+18	BH-407	B	SC	A-7-6	22.1	47	25	0	46	112.1	15.7	13.1	0.4	95-180	-	40-220
733+15	PV19-31	-	SC	A-2-4	12.6	27	10	2	18	117.1	11.3	4*	0.4*	-	110	300-400
738+37	BH-416	W	SM	A-1-b	10.1	NP	NP	0	16	117.4	11.8	35.4	0.0	-	360	200-400
746+72	BH-418	B	SC	A-6	19.9	37	20	0	45	115.9	13.8	9.2	0.9	65-215	-	25-255
765+20	BH-422	F	CL	A-7-6	19.6	42	23	0	51	113.1	15.8	10.1	0.5	95-180	-	40-220
801+43	BH-429	F	CH	A-7-6	22.6	50	25	0	54	109.5	16.9	7.8	1.4	95-180	-	40-220
107+25	RW-01	F	SM	A-4	16.9	NP	NP	0	50	124.4	11.1	6.2	0.0	95-180	-	40-220
109+10	RW-02	W	SC	A-7-6	23.9	44	27	0	41	116.6	15.2	10.5	0.9	95-180	-	40-220
119+90	BH-504	F	CL	A-6	16.8	33	17	0	63	117.6	13.8	5.4	0.5	65-215	-	25-255
128+21	BH-506	F	SC	A-6	20.8	38	18	4	42	115.2	13.9	10.7	0.2	65-215	-	25-255
137+71	BH-508	W	CL	A-6	14.8	30	16	0	57	118.7	12.9	6.9	0.3	65-215	-	25-255
1351+05	RW-03	F	CL	A-6	30.9	38	23	2	60	109.4	15.7	4.1	0.3	65-215	-	25-255
1252+50	RW-04	F	CL	A-6	26.8	33	19	0	82	116.5	13.7	44.0	0.2	65-215	-	25-255
1353+00	RW-07	F	SC	A-2-6	21.1	27	11	0	30	124.6	11.0	17.0	0.1	-	265	150-350
162+40	RW-05	B	SC	A-6	36.6	37	13	0	46	104.1	20.3	3.5	1.3	65-215	-	25-255
165+49	BH-521	Y	CH	A-7-6	36.5	51	29	1	56	111.0	15.2	4.2	1.9	95-180	-	40-220
179+18	BH-525	B/Y	SC	A-2-6	27.0	33	13	5	26	118.0	13.6	19.6	0.1	-	275	150-350
198+19	BH-532	F	SC	A-7-6	23.1	46	23	2	47	112.5	15.3	6.3	1.0	95-180	-	40-220
202+75	RW-06	F	CL-ML	A-4	23.3	23	7	0	53	113.9	14.4	10.7	0.7	95-180	-	40-220
227+15	BH-538	F	CL	A-7-6	20.4	42	24	0	52	112.2	15.9	4.1	1.3	95-180	-	40-220
237+03	BH-540	F	SC	A-2-6	21.1	34	18	2	34	120.9	11.8	10.9	0.4	-	200	150-350
257+13	BH-545	F	CL	A-6	15.7	27	13	0	54	120.8	11.6	6.7	0.3	65-215	-	25-255

[1]The k-value range considers a degree of saturation of 50 to 90 percent, typical for soils above the groundwater table, as indicated in Table 40 in the *1998 Supplement*, which provides the approximate relationship of k-value range based on the degree of saturation for soils classifying as A-4 or finer.

[2]The k-value considers Figure 41 in the *1998 Supplement*, which provides the approximate relationship of k-value range based on the CBR value for soils classifying as A-2 or coarser.

[3]The k-value considers Table 11 in the *1998 Supplement*, which provides the approximate relationship of k-value range based on the USCS and AASHTO claffication.

*Compaction and CBR tests performed on composite sample and CBR value provided without documentation in the RFP.

Cement Stabilized Subbase

Project specific specification for process and incorporating hydraulic cement was developed for this project

- FP-14 Section 213 – Subgrade Stabilization
- FP-14 Section 305 – Full Depth Reclamation with Cement
- VDOT Specification Section 307 – Hydraulic Cement Stabilization

Bulk samples were collected and combined to form 11 composite samples

- Typically, poorer quality soils were selected for testing
- Two to three specimens were prepared, Atterberg Limits and strength testing were performed.
- Durability Testing

Cement Stabilized Subbase

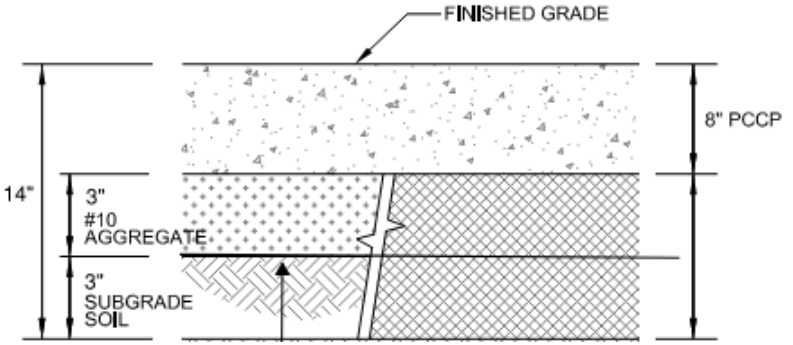
- Average unconfined compressive strength requirement = 200 psi
- Mixture with 5% cement met this requirement
- Recommended 8% in segment G and 6% with 50/50 blend of #10 screenings in other segments where higher plasticity soils exist

Composite ID (USCS: AASHTO)	% Cement Added	AASHTO	USC (psi)			Average UCS (psi)
Comp-01 (SC: A-2-6)	+3%	A-2-4	129.5	110.4		120
	+5%	A-2-4	228.3	211		220
	+7%	A-2-4	317.9	234.6		276
	+9%	A-2-6	369.7	367.5		369
	+12%	A-2-4	432.4	469		451
Comp-03 (SC: A-2-4)	+4%	A-2-4	159.9	97.5		129
	+5%	A-2-4	194.1	202.3	200.9	199
	+6%	A-2-4	203.8	164.1	212.2	193
Comp-04 (SC: A-2-6)	+6%	A-2-4	383.9	356.1	363.7	368
	+8%	A-2-4	355.5	411.7	409.4	392
Comp-06 (CL: A-6)	+4%	A-4	211.4	189.1	190.6	197
	+6%	A-4	232.4	258.6	253.6	248
	+8%	A-4	256.9	264.7	290.3	271
Comp-10 (CL: A-6)	+6%	A-6	142.8	292.6	323.8	253
	+8%	A-6	318	324.2	297.3	313
	+10%	A-6	301.9	398.7	378.9	360
Comp-11 + #10 Screenings (SC: A-7-6)	50/50 +4%	A-2-6	274.9	353.4	349.8	326
	50/50 +6%	A-2-6	459.2	456.4	391.5	436
	50/50 +8%	A-2-6	597.4	589.3	507.5	565

Rigid Pavement Design

Design

Pavement Material	Thickness
Joint Reinforced Concrete Pavement (JRCP)	8.0 Inches
Bond Breaker and Curing Compound	
Cement Stabilized Subbase	6.0 Inches



Alternatives

Pavement Material	Option 1	Option 2	Option 3	Option 4
Jointed Reinforced Concrete Pavement (JRCP)	8.0 inches		8.5 inches	
Bond Breaker	Yes	Required	No	Yes
Cement Stabilized Subbase	4.5 inches			
Cement Treated Aggregate (CTA)		4.0 inches		
Soil-Aggregate Subbase (AASHTO M147)			4.0 inches	
Modified Subbase (AASHTO M147) + Cement*				4.0 inches

*Cement considered for constructability, not as a stabilized subbase for additional pavement support.

Sampling and Testing Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production									
Cement Stabilized Subbase (CSS) Before Adding Cement	Measured and tested for conformance (106.04)	Gradation	–	AASHTO T27 and T11	Minimum 1 per 2000 yd^2	Existing Subbase or Existing subbase with added Aggregate	If requested	24-Hours	
		Liquid Limit	-	AASHTO T89					
		Plastic Limit	-	AASHTO T90					
		USCS and AASHTO Soil Classification	-	ASTM D2487					
		Moisture-density (max density)	–	AASHTO T134	As directed by the CO		If requested	3 days	Add Cement at Lab Prior to Test
	Process control (153.03)	Gradation	–	AASHTO T27 (undried condition)	As directed by the CO	Behind Reclaimer	No	Upon Completion of test	Minus 2-inch sieve only
		Moisture Content (in-place)	–	AASHTO T217 (speedy moisture meter)	"	"	"	"	
CSS with cement material	Measured and tested for conformance (106.04)	Cement Addition Rate	–	Subsection 316.05(b)	As directed by CO	Behind Cement Distributer	"	"	
CSS with cement after Mixing		Unconfined compression strength (7-day)	–	Table 316-2	1 set per 3500 yd^2 or a Minimum 1 set per Day	After Mixing Before Compaction	If requested	7 Days	Test location may be selected by CO.
	Process control (153.03)	Gradation	–	Subsection 316.10	As directed by CO		"	"	Minus 1-½ -inch and No. 4 sieve only

Sampling and Testing Requirements

Material or Product (Subsection)	Type of Acceptance (Subsection)	Characteristic	Category	Test Methods Specifications	Sampling Frequency	Point of Sampling	Split Sample	Reporting Time	Remarks
Production (continued)									
CSS with cement after Compaction	Measured and tested for conformance (106.04)	Density	–	AASHTO T 310 or other Approved methods	1 per 500 yd^2 or as directed by the CO	In-place after compaction	No	End of Day	Test locations selected by CO.
		Cement Treated Lift Thickness	–	Subsection 316.11	1 minimum daily or as directed by the CO	Within construction joints where feasible.	No	"	
Finished Product									
Cement Stabilized Subbase	Measured and tested for conformance (106.04)	Surface tolerance & grade	–	Subsection 301.06	Determined by the CO	Completed CSS surface	No	Before placement of next layer or as requested	
		CSS Thickness		Coring maximum 4-inch diameter core or other approved method.	3 per 3500 yd^2	Minimum 3 days after completion		End of Day	Test locations selected by CO.

Construction

Coring Soil Cement

Coring cont’d

- ALDOT-462
  - 3 test in triangular pattern
  - 4 inches total penetration
  - MCS = $1220e^{-0.559*DCP}$

MCS = Mold Cylinder Strength (psi)

DCP = Average DCP slope (mm/blow)

Unsuitable Soils

Unsuitable Soils

Problems During Construction

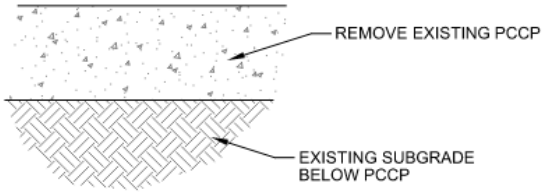
- Weather
- Real Estate
  - Construction Traffic

Problems During Construction

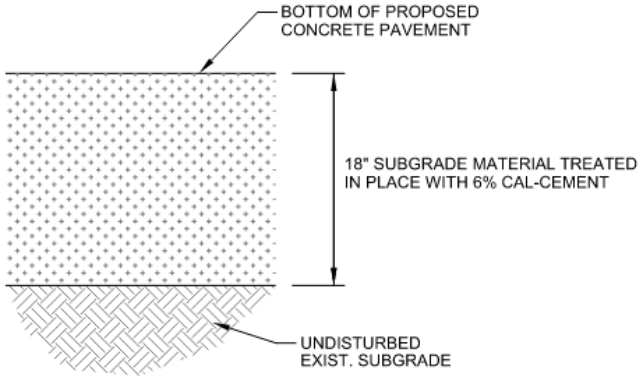
- Variations in lab results vs field conditions
  - Use of one-point proctors

Deeper Soil Mixing

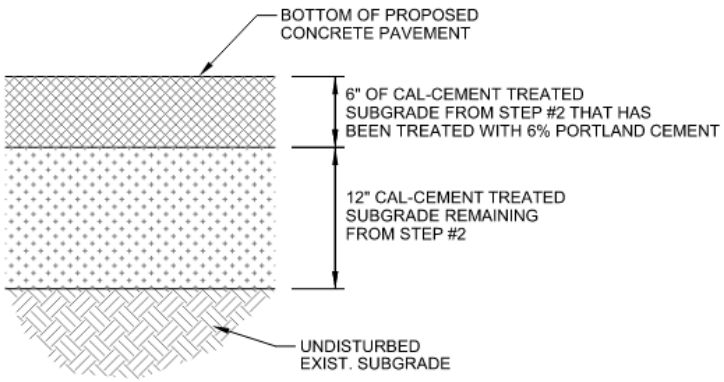
Deeper Soil Mixing



PCCP CONSTRUCTION STEP #1
(NTS)



PCCP CONSTRUCTION STEP #2
(NTS)



PCCP CONSTRUCTION STEP #3
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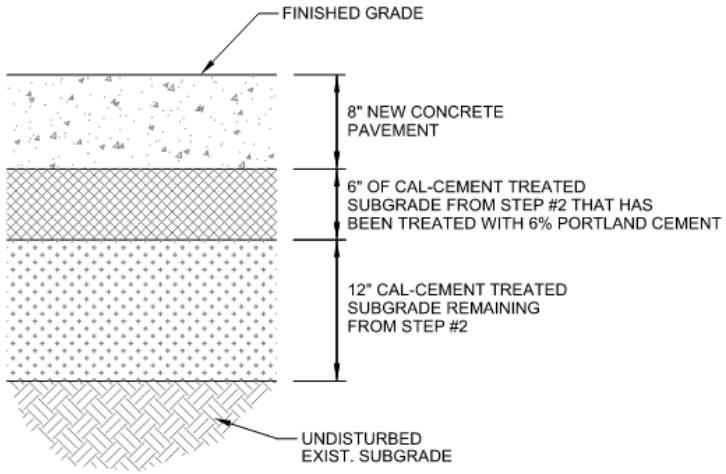

PCCP CONSTRUCTION STEP #4
(NTS)


WIRTGEN
W 380 CRi
ORM-C

Questions?

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