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Memo

To: Tom Barnitz, ODOT D9
From: Doug Voegele, HDR
Project: SCI-823-6.81; PID 19415
CC: Brad Hyre, HDR
Date: May 1, 2008
Job No: 45878

RE: SCI-823-0.00/6.81
PID No. 19415
Portsmouth Bypass Phase 1
Earthwork Factors

The following shrink/swell factors are recommended for the sedimentary rock types encountered within Phase I.

Common Soil	10% Shrink
Shale/Siltstone/Thinly-Bedded Sandstone	10% Swell
Thickly-Bedded Sandstone/Limestone	20% Swell

These values were derived from Table 6-12 of the "*Federal Lands Highway Project Development and Design Manual*" (FHWA, 1988) and "*Design Directive 406 – Earthwork Factors*" (West Virginia DOH, 1998), both of which are attached for reference. These earthwork factors have been used successfully by HDR on large-scale earthwork projects with PennDOT, the Pennsylvania Turnpike Commission, and the WVDOH, states with geology similar to that encountered at the project site.

Also attached is the determination of the composite shrink/swell factor for Phase I. Relative percentages of soil, shale and sandstone were ascertained for each cross-section provided in DLZ's revised soil profile sheets dated March 6, 2008. A composite shrink/swell factor of **15%** is recommended.

Shrink/Swell Factors

FHWA
WVDOH

Table 6-12
Shrink/Swell Factors for Common Materials*

Material	Measured				
	In Situ	Loose		Embankment	
	Weight[1]	Weight[2]	% Swell[3]	Weight[2]	% Swell/Shrink[3]
Andesite	4,950	2,970	67	3,460	43
Basalt	4,950	3,020	64	3,640	36
Bentonite	2,700	2,000	35	–	–
Breccia	4,050	3,040	33	3,190	27
Calcite-Calcium	4,500	2,700	67		
Caliche	2,430	2,100	16	3,200	-25
Chalk	4,060	2,170	50	3,050	33
~~Charcoal~~	~~–~~	~~1,030~~	~~–~~	~~–~~	~~–~~
Cinders	1,280	960	33	1,420	-10
* Clay					
Dry	3,220	2,150	50	3,570	-10 AVG = -10%
Damp	3,350	2,010	67	3,720	-10
Conglomerate	3,720	2,800	33		
+ Decomposed rock					
75% R. 25% E.	4,120	3,140	31	3,680	12
50% R. 50% E.	3,750	2,710	38	4,000	-6 AVG = -1% USE 0%
25% R. 75% E.	3,380	2,370	43	3,720	-9
Diorite	5,220	3,130	67	3,650	43
Diotomaceous earth	1,470	910	62		
Dolomite	4,870	2,910	67	3,400	43
* Earth, loam					
Dry	3,030	2,070	50	3,520	-12 AVG = -12%
Damp	3,370	2,360	43	3,520	-4
Wet, mud	2,940	2,940	0	3,520	-20
Feldspar	4,410	2,640	67	3,080	43
Gabbro	5,220	3,130	67	3,650	43
Gneiss	4,550	2,720	67	3,180	43
* Gravel					
Dry—					
Uniformly Graded	2,980	2,700	10	3,150	-5
Average Gradation	3,280	2,730	20	3,570	-8
Well Graded	3,680	2,770	33	4,130	-11
Wet—					AVG = -5 %
Uniformly Graded	3,310	3,150	5	3,150	-5
Average Gradation	3,640	3,290	10	3,570	-2
Well Graded	4,090	3,520	16	4,130	-1
Granite	4,540	2,640	72	3,170	43
* Gumbo					
Dry	3,230	2,150	50	3,570	-10 AVG = -10%
Wet	3,350	2,020	67	3,720	-10
Gypsum	4,080	2,380	72		
Igneous rocks	4,710	2,820	67	3,300	43

* Soil = Avg 10% shrink
+ WTHRD ROCK = 0%
SHALE = 10% SWELL

SANDSTONE/LIMESTONE = 20% SWELL

Table 6-12 (continued)
Shrink/Swell Factors for Common Materials*

Material	Measured				
	In Situ	Loose		Embankment	
	Weight[1]	Weight[2]	% Swell[3]	Weight[2]	% Swell/Shrink[3]
Kaolinite					
Dry	3,230	2,150	50		
Wet	3,350	2,010	67		
Limestone	4,380	2,690	63	3,220	36 ←
* Loess					
Dry	3,220	2,150	50	3,570	-10 } AVG = -10 %
Wet	3,350	2,010	67	3,720	-10
Marble	4,520	2,700	67	3,160	43
Marl	3,740	2,240	67	2,620	43
Masonry, rubble	3,920	2,350	67	2,750	43
Mica	4,860	2,910	67		
Pavement					
Asphalt	3,240	1,940	50	3,240	0
Brick	4,050	2,430	67	2,840	43
Concrete	3,960	2,370	67	2,770	43
Macadam	2,840	1,700	67	2,840	0
Peat	1,180	890	33		
Pumice	1,080	650	67		
Quartz	4,360	2,610	67	3,000	43
Quartzite	4,520	2,710	67	3,160	43
Rhyolite	4,050	2,420	67	2,870	43
Riprap rock	4,500	2,610	72	3,150	43
*Sand					
Dry	2,880	2,590	11	3,240	-11 ← } AVG = -11 %
Wet	3,090	3,230	5	3,460	-11 ←
Sandstone	4,070	2,520	61	3,030	34 ←
Schist	4,530	2,710	67	3,170	43
Shale	4,450	2,480	79	2,990	49 ←
*Silt	3,240	2,380	36	3,890	-17 ←
Siltstone	4,070	2,520	61	4,560	-11 ←
Slate	4,500	2,600	77	3,150	43
Talc	4,640	2,780	67	3,250	43
Topsoil	2,430	1,620	56	3,280	-26
Tuff	4,050	2,700	50	3,050	33

***Western Construction, November 1958.**

Note:
[1] Pounds per cubic yard. Subject to average ±5% variation.
[2] Pounds per cubic yard. Weights subjects to adjustments in accordance with modified swell and shrinkage factors.
[3] Based on average in situ densities. A negative number represents a shrinkage. Factors subject to ±33% variation.

• Source: Chapter 6, FHWA (Sept 88) - Federal Lands Highway Project Development and Design Manual

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
DESIGN DIRECTIVE

406
EARTHWORK FACTORS
February 26, 1998

The following values are to be used as a guide in computing earthwork volumes for a project:

Soil	15% shrinkage
Shale	5% swell
Limestone or Sandstone	15% swell

The Designer shall use his judgment on intermediate values other than those listed above.

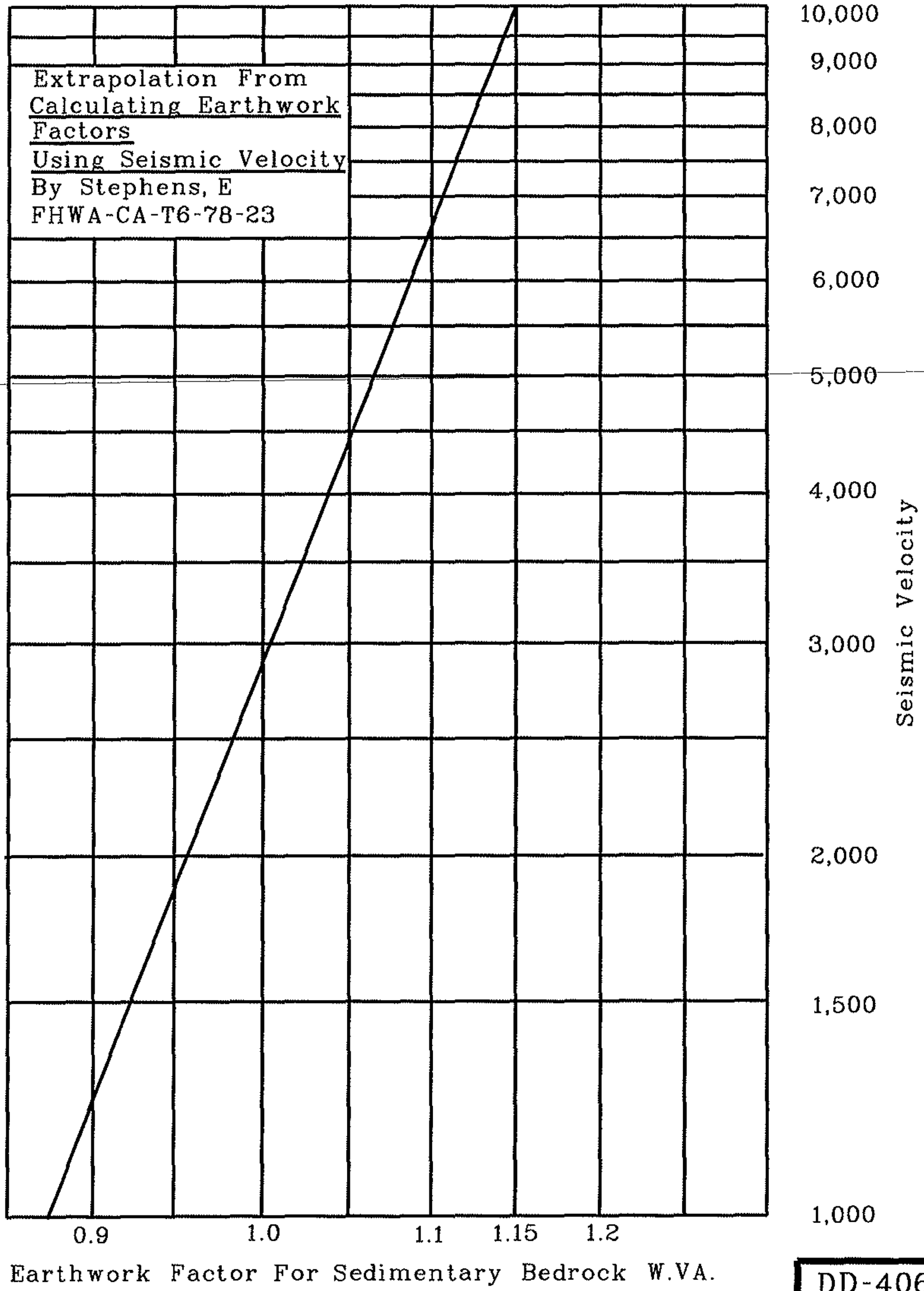
For example, where hard shale is found, possibly 10% swell could be used.

When it is necessary to compute a more accurate earthwork volume and the cost can be justified, the earthwork factors could be determined for soil and bedrock as follows:

1. Soil - Density tests of the soils could be taken in the field and these results compared to AASHTO T99 test results obtained from laboratory testing.
2. Bedrock - Refractory seismic wave velocities of the bedrock could be obtained and these values used to estimate an earthwork factor from the attached graph.
3. Individual factors for each cut shall be used in lieu of an average value for the entire project if data is available indicating such.

Volumes of the materials with different earthwork factors will be calculated and then adjusted earthwork volumes computed. These adjusted volumes will then be summed to obtain a total earthwork volume for the project.

Attachment



Extrapolation From Calculating Earthwork Factors Using Seismic Velocity
By Stephens, E
FHWA-CA-T6-78-23

DD-406

Determination of
Composite Shrink/Swell Factor

Job No. 000000000045878 PID No. 19415

HDR Computation

Project SCI-823-0.00/6.81 Portsmouth Bypass Phase I
Computed JSA
Date 4/29/2008

Subject Earthwork Factors
Checked DMV
Date 5/1/2008

Task Determine Composite Shrink/Swell Factor
Sheet 1
Of 3

Station		Location	Subsurface Material	Percent of Cross Section	Cut End Area (sf)	Total Cut End Area (sf)
SR 823	357+50	-	Soil	100%	5,087	5,087
			Shale	0%	0	
			Sandstone	0%	0	
SR 823	416+50	Rock Cut # 11	Soil	3%	235	7,826
			Shale	0%	0	
			Sandstone	97%	7,591	
SR 823	420+50	Rock Cut # 11	Soil	27%	6,580	24,371
			Shale	30%	7,311	
			Sandstone	43%	10,480	
SR 823	424+00	Rock Cut # 11	Soil	63%	4,421	7,017
			Shale	0%	0	
			Sandstone	37%	2,596	
SR 823	428+00	Rock Cut # 11	Soil	3%	1,003	33,445
			Shale	11%	3,679	
			Sandstone	86%	28,763	
SR 823	432+00	Rock Cut # 11	Soil	3%	508	16,940
			Shale	23%	3,896	
			Sandstone	74%	12,536	
SR 823	434+00	Rock Cut # 11	Soil	79%	1,515	1,918
			Shale	0%	0	
			Sandstone	21%	403	
SR 823	438+00	-	Soil	5%	121	2,416
			Shale	0%	0	
			Sandstone	95%	2,295	
SR 823	448+00	Rock Cut # 12	Soil	0%	0	1,773
			Shale	0%	0	
			Sandstone	100%	1,773	
SR 823	452+00	Rock Cut # 12	Soil	4%	551	13,778
			Shale	0%	0	
			Sandstone	96%	13,227	
SR 823	455+50	Rock Cut # 12	Soil	0%	0	8,873
			Shale	0%	0	
			Sandstone	100%	8,873	
SR 823	459+00	Rock Cut # 12	Soil	0%	0	950
			Shale	0%	0	
			Sandstone	100%	950	

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HDR Computation

Project SCI-823-0.00/6.81 Portsmouth Bypass Phase I

Computed JSA

Date 4/29/2008

Subject Earthwork Factors

Checked DMV

Date 5/1/2008

Task Determine Composite Shrink/Swell Factor

Sheet 2

Of 3

Station		Location	Subsurface Material	Percent of Cross Section	Cut End Area (sf)	Total Cut End Area (sf)
SR 823	481+00	Rock Cut # 13	Soil	10%	905	9,047
			Shale	0%	0	
			Sandstone	90%	8,142	
SR 823	498+00	Rock Cut # 14	Soil	38%	1,057	2,781
			Shale	0%	0	
			Sandstone	62%	1,724	
SR 823	501+50	Rock Cut # 14	Soil	1%	185	18,531
			Shale	0%	0	
			Sandstone	99%	18,346	
SR 823	508+50	Rock Cut # 15	Soil	15%	959	6,394
			Shale	14%	895	
			Sandstone	71%	4,540	
SR 823	512+00	Rock Cut # 15	Soil	1%	296	29,576
			Shale	7%	2,070	
			Sandstone	92%	27,210	
SR 823	516+00	Rock Cut # 15	Soil	9%	2,792	31,025
			Shale	11%	3,413	
			Sandstone	80%	24,820	
SR 823	520+00	Rock Cut # 15	Soil	6%	1,450	25,370
			Shale	0%	0	
			Sandstone	94%	23,848	
SR 823	524+00	Rock Cut # 15	Soil	10%	3,474	34,743
			Shale	0%	0	
			Sandstone	90%	31,269	
SR 823	529+00	Rock Cut # 15	Soil	100%	1,698	1,698
			Shale	0%	0	
			Sandstone	0%	0	
SR 823	535+50	-	Soil	100%	2,010	2,010
			Shale	0%	0	
			Sandstone	0%	0	
TR 234	12+00	Shumway Hollow Road	Soil	0%	0	1,432
			Shale	0%	0	
			Sandstone	100%	1,432	
TR 234	15+00	Shumway Hollow Road	Soil	43%	1,348	3,135
			Shale	0%	0	
			Sandstone	57%	1,787	

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HDR Computation

Project SCI-823-0.00/6.81 Portsmouth Bypass Phase I

Computed JSA

Date 4/29/2008

Subject Earthwork Factors

Checked DMV

Date 5/1/2008

Task Determine Composite Shrink/Swell Factor

Sheet 3

Of 3

Station		Location	Subsurface Material	Percent of Cross Section	Cut End Area (sf)	Total Cut End Area (sf)
TR 234	26+00	Shumway Hollow Road	Soil	33%	1,848	5,601
			Shale	0%	0	
			Sandstone	67%	3,753	
TR 234	27+00	Shumway Hollow Road	Soil	100%	3,581	3,581
			Shale	0%	0	
			Sandstone	0%	0	
TR 234 Ramp D	386+00	Ramp T234D	Soil	50%	3,379	6,757
			Shale	0%	0	
			Sandstone	50%	3,379	
TR 234 Ramp D	390+00	Ramp T234D	Soil	100%	8,172	8,172
			Shale	0%	0	
			Sandstone	0%	0	
TR 234 Ramp D	394+00	Ramp T234D	Soil	100%	2,193	2,193
			Shale	0%	0	
			Sandstone	0%	0	
CR 28 Ramp A	525+00	Rock Cut # 15	Soil	7%	1,560	21,334
			Shale	0%	0	
			Sandstone	93%	19,774	
CR 28 Ramp D	525+00	Rock Cut # 15	Soil	23%	4,043	17,580
			Shale	0%	0	
			Sandstone	77%	13,537	

Determine Composite Shrink/Swell Factor for Entire Project Based on Subsurface Profile:

	Soil	Shale	Sandstone	Total
Total (ft^2)	60,972	21,265	273,045	355,282
Percent of Total	17%	6%	77%	100%
Shrink/Swell Factor	-10%	10%	20%	-
Weighted Shrink/Swell Factor	-1.7%	0.6%	15.4%	**14.3%**

<u>Use Composite Shrink/Swell Factor = 15%</u>