



Scott Blevins, PE

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

July 17, 2003

MEMORANDUM TO: Mr. Jay Bennett, PE, State Roadway Design Engineer
Mr. Scott Blevins, PE, Engineering Coordinator
Division Engineers

FROM: Victor Barbour, PE *Victor Barbour*
State Design Services Engineer

SUBJECT: Pavement Structure Volume

Highway construction plan's final quantities for Unclassified Excavation are based on excavating to the subgrade. Frequently, the project is paved prior to the time final field measurements are made for the Unclassified Excavation quantity. The pavement structure volume (pavement and shoulder construction above the subgrade in unclassified excavation areas) must be added to the field measurements taken after paving and shoulder work are completed. In an effort to hopefully reduce the amount of time it requires to compute final quantities and process final estimates, it has been determined that the earthwork summary in the plans should show the volume of pavement and shoulder construction in cuts. This volume should be calculated for the -L- line and any -Y- lines that have a significant amount of unclassified excavation.

Roadway Design has developed a procedure to calculate this volume utilizing microstation and geopak. Please see the attached procedure. In addition, please see the attached examples of how the volume should be shown on the earthwork summary sheet.

This information will be implemented with the November 2003 letting.

By copy of this memorandum, I am requesting that Mr. Frankie Draper investigate and make any necessary revision to the Roadway Design Manual.

If you have any comments or questions concerning the procedure of how to calculate the pavement structure volume, please contact Mr. Ted Walls at (919) 250-4016. If you have any comments or questions concerning pavement structure volume, please contact Ms. Cynthia Perry, PE, at (919) 250-4128.

JVB/cbp

Attachments

Cc: Ms. Deborah Barbour, PE
Mr. Azam Azimi, Phd., PE
Mr. Frankie Draper
Mr. Randy Garris, PE

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CALCULATION OF PAVEMENT STRUCTURE VOLUME

Calculation of the Pavement Structure Volume requires running the earthwork quantities calculations twice. Once with the Finished grade definition reflecting the top of pavement and the second run reflecting the top of subgrade. The Pavement Structure Volume is computed as the difference in Excavation Unadjusted Volumes from the Grand Summary Totals for these two earthwork outputs.

The Pavement Structure Volume should be calculated for the -L- line and any -Y- lines that are a significant part of the overall Earthwork quantity.

The following procedure is based on using the standardized level and color symbology as defined in the NCDOT Level/Symbology Chart and utilizing the default parameters in the NCDOT Roadway Design Criteria files.

Step 1: Compute the Top of Pavement Earthwork Quantity

Step 2: Compute the Subgrade Earthwork Quantity

Step 3: Computing the Pavement Structure Volume

Step 4: Summary of Earthwork

Step 1: Compute the Top of Pavement Earthwork Quantity

Edit the Earthwork Input file to reflect the top of pavement definition. A level & color definition is required.

XSECTION

/* Top of Pavement calculations */

earthwork

Tolerance = 0.003

xs dgn = 1.xsc

proposed finish grade

soil type = a2

fill multiplication factor = 1.15

type = line

lv = 2,10 ←

co = 0-2 ←

existing ground line

soil type = a2

type = line

lv = 60

write earthwork shapes

plot parameters

lv = 16

co = 16

stratify shape color

Computed values for Top of Surfacing:

G R A N D	S U M M A R Y	T O T A L S		Mult Factor
		Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	

A2				
	➔ Excavation	41666	41666	1.00
	Fill	65821	75694	1.15

Step 2: Compute the Top of Subgrade Earthwork Quantity

Edit the Earthwork Input file to reflect the top of Subgrade definition. A level & color definition is required. Note: Before proceeding with this step delete, the earthwork shapes created in step one.

XSECTION

/* Top of Subgrade calculations */

earthwork

Tolerance = 0.003

xs dgn = 1.xsc

proposed finish grade

soil type = a2

fill multiplication factor = 1.15

type = line

lv = 10

co = 2,10

existing ground line

soil type = a2

type = line

lv = 60

write earthwork shapes

plot parameters

lv = 16

co = 16

stratify shape color

Computed values for the Subgrade:

GRAND SUMMARY	Material Name	TOTALS		Mult Factor
		Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	

A2	→ Excavation	45620	45620	1.00
	Fill	60700	69805	1.15

Step 3: Computing the Pavement Structure Volume

Excavation 45620 cu yd (Grand Summary Totals- Subgrade Quantities- Step 2)
 Excavation 41666 cu yd (Grand Summary Totals- Top of Pavement Quantities- Step 1)
 3954 cu yd (Pavement & Shoulder Material Quantity in the Exc. areas)

Step 4: Summary of Earthwork

The computed quantity should be shown at the bottom of the Summary of Earthwork stating which alignments were included in the computation.

Example of note used for -L- line comps only:

SUBTOTALS	45620	50881	7969
EST. 5% TO REPLACE TOPSOIL ON BORROW PITS			398
PROJECT TOTAL	45620	50881	8367
GRAND TOTAL	45620		8367
SAY	46000		8400

ESTIMATED UNDERCUT EXCAVATION = 1900 CY

-L- PAVEMENT STRUCTURE VOLUME = 3954 CY

Example of note used when -Y- line excavation quantities are a significant part of the total excavation:

SUBTOTALS	45620	50881	7969
EST. 5% TO REPLACE TOPSOIL ON BORROW PITS			398
PROJECT TOTAL	45620	50881	8367
GRAND TOTAL	45620		8367
SAY	46000		8400

ESTIMATED UNDERCUT EXCAVATION = 1900 CY

-L- & -Y3- PAVEMENT STRUCTURE VOLUME = 4767 CY

FIGURE 4

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PROJECT: _____ COUNTY: _____ Volumes in Cubic _____ SHEET _____ OF _____ SHEETS
 DATE: _____ COMPILED BY: _____

STATION	EXCAVATION				EMBANKMENT				BORROW			WASTE			TOTAL
	TOTAL UNCLASS.	ROCK	UNDERCUT	UNCL. UNCL. UNCL.	TOTAL	ROCK	EARTH	EMBANK. (+) 20%	BORROW	ROCK	SUITABLE	UNCL.	TOTAL		
L 220+00	75,000	10,000	5,000	1,000	60,000	10,000	50,000	70,000				10,000	4,000	6,000	10,000
Y10 15+00	8,000			8,000	10,000		10,000	12,000	4,000						
SUBTOTAL	83,000	10,000	5,000	1,000	70,000	10,000	60,000	82,000	4,000			4,000	4,000	6,000	10,000
L 250+00	14,000	2,000			20,000	2,000	18,000	23,600	9,600						
SUBTOTAL	14,000	2,000			20,000	2,000	18,000	23,600	9,600						
L 280+00	80,000			12,000	40,000		40,000	48,000				20,000	20,000	12,000	32,000
Y11 27+00	20,000	1,000	7,000	19,000	3,000	1,000	2,000	3,400				16,600	16,600	7,000	23,600
SUBTOTAL	100,000	1,000	7,000	12,000	43,000	1,000	42,000	51,400				36,600	36,600	19,000	55,600
TOTAL	197,000	13,000	12,000	13,000	133,000	13,000	120,000	157,000	13,600			40,600	40,600	25,000	65,600
Loss due to clear. & grub.	-5,000														-5,000
Adjust undercut			5,000		5,000		5,000	6,000	6,000						5,000
Waste to repl. Borrow									-19,600						-19,600
GRAND TOTALS	192,000	13,000	17,000	13,000	138,000	13,000	125,000	163,000				16,000	16,000	30,000	46,000
SAY	192,500														
PAVEMENT: SURFACE VOLUME = 5000															

PROJECT _____ COUNTY _____ Volumes in Cubic _____ SHEET _____ OF _____ SHEETS
 DATE _____ COMPILED BY: _____

STATION	STATION	EXCAVATION					EMBANKMENT			BORROW	ROCK	WASTE				
		TOTAL UNCLASS.	ROCK	UNDERCUT	UNCLASS. UNSUIT.	SUITABLE UNCLASS.	TOTAL	ROCK	EARTH			EMBANK. (+) 20 %	SUITABLE	UNSUIT.	TOTAL	
L 120+00	150+00	60,000	5,000	3,000	7,000	48,000	75,000	5,000	70,000	89,000					10,000	10,000
Y1 10+00	20+00	10,000				10,000	8,000		8,000	9,600				400		400
	SUBTOTAL	70,000	5,000	3,000	7,000	58,000	83,000	5,000	78,000	98,600	36,000			400	10,000	10,400
L 150+00	180+00	50,000	10,000			40,000	7,000	7,000	7,000	7,000				40,000		43,000
	SUBTOTAL	50,000	10,000			40,000	7,000	7,000	7,000	7,000				40,000		43,000
L 180+00	210+00	40,000			8,000	32,000	80,000		80,000	96,000	64,000				8,000	8,000
Y2 20+00	30+00	20,000		7,000		20,000	25,000		25,000	30,000	10,000				7,000	7,000
	SUBTOTAL	60,000		7,000	8,000	52,000	105,000		105,000	126,000	74,000				15,000	15,000
	TOTAL	180,000	15,000	10,000	15,000	150,000	195,000	12,000	183,000	231,600	110,000			40,400	25,000	68,400
		-5,000				-5,000		3,000	-3,000	-600	5,000					
	Less due to clear. & grub.															
	Rock waste to repl. bor.															
	Adjust for rock waste															
	Earth waste to repl. bor.															
	Est. Shoulder Material															
	Additional Undercut			5,000			12,000		12,000	14,400	14,400			-40,400		-40,400
	PROJECT TOTALS	175,000	15,000	15,000	15,000	145,000	212,000	15,000	197,000	251,400	91,400			5,000	30,000	30,000
	Est. for repl. Topsoil on borrow pits										6,570					
	GRAND TOTALS	175,000									95,970					
	SAY	175,500									96,500					
	FINEMENT STRUCTURE VOLUME = 5,000															

-L- & -Y-2

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F-4

FIGURE 4

PROJECT COUNTY Volumes in Cubic SHEET OF SHEETS
 DATE COMPILED BY:

STATION	STATION	EXCAVATION					EMBANKMENT			BORROW	WASTE			TOTAL
		TOTAL UNCLASS.	ROCK	UNDERCUT	UNCLAS.	SUITABLE UNCLAS.	TOTAL	ROCK	EARTH		EMBANK. (%)	ROCK	SUITABLE	
L 220+00	250+00	75,000	10,000	5,000	1,000	64,000	60,000	10,000	50,000	70,000	4,000	6,000	10,000	10,000
Y10 15+00	25+00	8,000				8,000	10,000		10,000	12,000				4,000
	SUBTOTAL	83,000	10,000	5,000	1,000	72,000	70,000	10,000	60,000	82,000	4,000	6,000	10,000	10,000
L 250+00	280+00	14,000	2,000			12,000	20,000	2,000	18,000	23,600	9,600			
	SUBTOTAL	14,000	2,000			12,000	20,000	2,000	18,000	23,600	9,600			
L 280+00	310+00	80,000			12,000	68,000	40,000		40,000	48,000			12,000	32,000
Y11 27+00	39+00	20,000	1,000	7,000		19,000	3,000	1,000	2,000	3,400			7,000	23,600
	SUBTOTAL	100,000	1,000	7,000	12,000	87,000	43,000	1,000	42,000	51,400			19,000	55,600
	TOTAL	197,000	13,000	12,000	13,000	171,000	133,000	13,000	120,000	157,000	13,600		25,000	65,600
	Loss due to clear. & grub. Additional undercut Waste to repl. Borrow	-5,000		5,000		-5,000	5,000		5,000	6,000	6,000		5,000	5,000
	GRAND TOTALS	192,000	13,000	17,000	13,000	166,000	138,000	13,000	125,000	163,000			30,000	46,000
	SAY	192,500												

REV. DATE: Draft

FIGURE 3

19-3
F-3

PROJECT _____ COUNTY _____ Volumes in Cubic _____ SHEET _____ OF _____ SHEETS _____
 DATE _____ COMPILED BY: _____

STATION	STATION	EXCAVATION				EMBANKMENT				BORROW	ROCK	WASTE		TOTAL	
		TOTAL UNCLASS.	ROCK	UNDERCUT	UNCLAS. UNSUIT.	SUITABLE UNCLAS.	TOTAL	ROCK	EARTH			EMBANK. (+) %	SUITABLE		UNSUIT.
L 120+00	150+00	60,000	5,000	3,000	7,000	48,000	75,000	5,000	70,000	89,000	36,000			10,000	10,000
Y1 10+00	20+00	10,000				10,000	8,000		8,000	9,600			400		400
	SUBTOTAL	70,000	5,000	3,000	7,000	58,000	83,000	5,000	78,000	98,600	36,000		400	10,000	10,400
L 150+00	180+00	50,000	10,000			40,000	7,000	7,000	7,000	7,000					43,000
	SUBTOTAL	50,000	10,000			40,000	7,000	7,000	7,000	7,000		3,000	40,000		43,000
L 180+00	210+00	40,000			8,000	32,000	80,000		80,000	96,000	64,000			8,000	8,000
Y2 20+00	30+00	20,000		7,000		20,000	25,000		25,000	30,000	10,000			7,000	7,000
	SUBTOTAL	60,000		7,000	8,000	52,000	105,000		105,000	126,000	74,000			15,000	15,000
	TOTAL	180,000	15,000	10,000	15,000	150,000	195,000	12,000	183,000	231,600	110,000		40,400	25,000	68,400
	Loss due to clear. & grub.										5,000				
	Rock waste to repl. bor.							3,000	-3,000		-3,000				-3,000
	Adjust for rock waste														
	Earth waste to repl. bor.														
	Est. Shoulder Material														
	Additional Undercut			5,000			12,000		12,000	14,400	14,400				-40,400
	PROJECT TOTALS	175,000	15,000	15,000	15,000	145,000	212,000	15,000	197,000	251,400	91,400		5,000	30,000	30,000
	Est. for repl. Topsoil on borrow pits										4,570				
	GRAND TOTALS	175,000									95,970				
	SAY	175,500													
	Pavement Structure Volume = 5000														