CHAPTER ELEVEN

COMPUTATIONS

QUANTITY CALCULATIONS

The Calculation of Quantities Worksheets, for most of the major pay items encountered in finalizing projects, can be found on the computer website: "http://www.ncdot.org/doh/preconstruct/ps/contracts/standards/quantities/default.html".

These work sheets contain information (formulas, sketches, etc.) to explain the Method of Calculating Quantities. Additional information is available in this chapter and can be discussed with the Plan Review Engineer.

Proof rolling is recommended by the Geotechnical Engineering Unit. When the pavement design recommendations are submitted to the Project Engineer, proof rolling recommendations will be included. The recommendations shall also be discussed on the field inspection.

Proof rolling is to be performed to a width of 2′ (feet) outside the proposed top edges of full depth pavement. Proof rolling is computed at the rate of three hours per 24′ width of full depth pavement per mile. Full depth pavement widths other than 24′ shall be prorated to correspond with this unit measurement. Final payment will be in accordance with Section 260 of the "Standard Specifications for Roads and Structures".

Example Methods Of Computing Hours Per Mile Of Proof Rolling For Various Width Pavements.:

Example 1. 22′ Width Roadway, With No Paved Shoulders.
22′ (two 11′ Lanes) + 4′ (2′ outside lt. & rt. Full Depth Pavement) = 26′ width.
26′ width x (3 hrs. per mile\ per 24′ roadway width) = 3.25 hrs. per mile.

Example 2. 24′ Width Roadway, With 2′ Full Depth Paved Shoulders.
24′ (two 12′ Lanes) + 4′ (2′ Full Depth Paved Shoulders lt. & rt.) + 4′ (2′ outside lt. & rt. Full Depth Pavement) = 32′ width.
32′ width x (3 hrs. per mile\ per 24′ roadway width) = 4.00 hrs. per mile.

Example 3. 60′ Width Roadway, With 4′ Full Depth Paved Shoulders.
60′ (five 12′ Lanes) + 8′ (4′ Full Depth Paved Shoulders lt. & rt.) + 4′ (2′ outside Full Depth Pavement lt. & rt.) = 72′ width.
72′ width x (3 hrs. per mile\ per 24′ roadway width) = 9.00 hrs. per mile.

AGGREGATE BASE COURSE (ABC) 11-1B

When all calculations are completed and totaled, the following procedures shall be used in the computation of ABC quantities.

0 TO 1000 TONS OF ABC – ADD 10%
1001 TO 5000 TONS OF ABC – ADD 5%
5001 TONS OF ABC AND ABOVE – ROUND OFF TO NEXT 100 TONS

PRIME COAT 11-C

Section 600 of the Standard Specifications For Roads and Structures states that prime coat will not be required unless called for on the plans and in the estimate.

Areas where prime coat should be included on a project are as follows:

1. On mainline and/or -Y- line paving areas when requested by Division Engineer, if approved by the Pavement Management Unit.

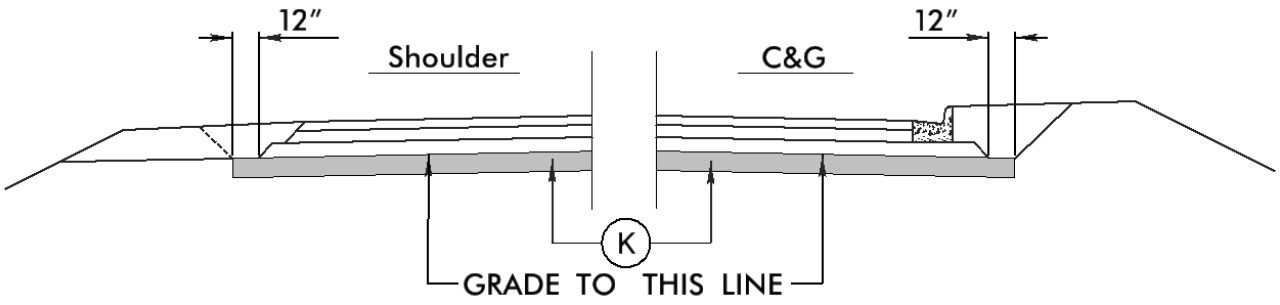
2. On any paving project (including detours and paved shoulders) when the bituminous concrete thickness is less than 2″.

3. In conjunction with 10′ paved shoulders, if the remainder of the shoulder is all ABC, this area should be primed at a rate of 0.5 gallons per Sq. Yd.

Areas to be primed are shown on the typical sections.

SUBGRADE STABILIZATION 11-1D

- When stabilized Subgrade is specified in the Geotechnical Recommendations for Pavement Design, it shall be included in the Pavement Schedule and shall be shown on the applicable typical sections. (See Pavement Schedule in this manual, Part II, 6-lD.) The stabilized subgrade shall extend 12″ outside the bottom of the subgrade.
- Do not use stabilization on pavement widths less than six feet.



The most commonly recommended subgrade stabilization's are as follows:

1. Lime Stabilization requires the pay item "Lime Treated Soil (Slurry Method)," "Lime Treated Soil (Quicklime)," or "Lime Treated Soil (Hydrated Lime)." Lime Stabilization also requires pay items "Lime for Lime Treated Soil," "Asphalt Curing Seal," and "Blotting Sand." The blotting sand quantity is shown in the Geotechnical Recommendations for Pavement Design.
2. Cement Stabilization requires the pay items "Soil Cement Base," "Portland Cement for Soil Cement Base," "Asphalt Curing Seal" and "Blotting Sand." The blotting sand quantity is shown in the Geotechnical Recommendations for Pavement Design.
3. Aggregate Base Course for the Cement Area requires the pay item "Aggregate for Soil Cement Base." This pay item is only used when it is specified that a percentage of the cement stabilized area also requires aggregate base course.
4. Aggregate for Aggregate Stabilization recommendations requires the pay item "Stabilizer Aggregate."

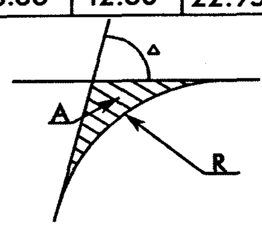
Deviations from the Geotechnical Recommendations for Pavement Design shall be documented by the Pavement Design Engineer in the Pavement Management Unit.

TABLE 1 11 - 1 / T - 1

TABLE 1

AREA OF TURNOUTS (IN S.Y.)

R \ Δ / F	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°
F	.00614	.01489	.02996	.05373	.08934	.14094	.21457	.3191	.4681	.6849	1.0100	1.5257	2.4231
10	0.07	0.16	0.33	0.60	0.99	1.57	2.38	3.55	5.20	7.61	11.22	16.95	26.92
12	0.10	0.24	0.48	0.86	1.43	2.26	3.43	5.11	7.49	10.96	16.16	24.41	38.77
15	0.15	0.37	0.75	1.34	2.23	3.52	5.37	7.98	11.70	17.12	25.25	38.14	60.58
17	0.20	0.48	0.96	1.73	2.87	4.53	6.89	10.25	15.03	21.99	32.43	48.99	77.81
20	0.27	0.66	1.33	2.39	3.97	6.26	9.54	14.18	20.80	30.44	44.89	66.81	107.69
22	0.33	0.80	1.61	2.89	4.80	7.58	11.54	17.16	25.17	36.83	54.32	82.05	130.31
25	0.43	1.03	2.08	3.73	6.20	9.79	14.90	22.16	32.51	47.56	70.14	105.95	168.27
27	0.50	1.21	2.43	4.35	7.24	11.42	17.38	25.85	37.92	55.48	81.81	123.58	196.27
30	0.61	1.49	3.00	5.37	8.93	14.09	21.46	31.91	46.81	68.49	101.00	152.57	242.31
32	0.70	1.69	3.41	6.11	10.17	16.04	24.41	36.31	53.26	77.93	114.92	173.59	275.70
35	0.84	2.03	4.08	7.31	12.16	19.18	29.21	43.43	63.71	93.22	137.47	207.66	329.81
37	0.93	2.27	4.56	8.17	13.59	21.44	32.64	48.54	71.20	104.18	153.63	232.07	368.58
40	1.09	2.65	5.33	9.55	15.88	25.05	38.15	56.73	83.21	121.75	179.55	271.22	430.75
42	1.20	2.92	5.87	10.53	17.51	27.62	42.06	62.54	91.75	134.24	197.96	299.04	474.93
45	1.38	3.35	6.74	12.09	20.10	31.71	48.28	71.79	105.32	154.10	227.25	343.28	545.20
47	1.51	3.65	7.35	13.19	21.93	34.59	52.66	78.32	114.89	168.10	247.89	374.47	594.73
50	1.71	4.14	8.32	14.92	24.82	39.15	59.60	88.64	130.02	190.24	280.55	423.79	673.06
52	1.84	4.47	9.00	16.14	26.84	42.35	64.47	95.87	140.64	205.78	303.45	458.40	728.02
55	2.06	5.00	10.07	18.06	30.03	47.37	72.12	107.25	157.33	230.20	339.47	512.80	814.43
57	2.22	5.37	10.82	19.40	32.25	50.88	77.46	115.20	168.98	247.25	364.61	550.78	874.74
60	2.46	5.96	11.98	21.49	35.74	56.38	85.83	127.64	187.24	273.96	404.00	610.28	969.24
62	2.62	6.36	12.80	22.95	38.16	60.20	91.64	136.29	199.93	292.53	431.38	651.54	1034.93



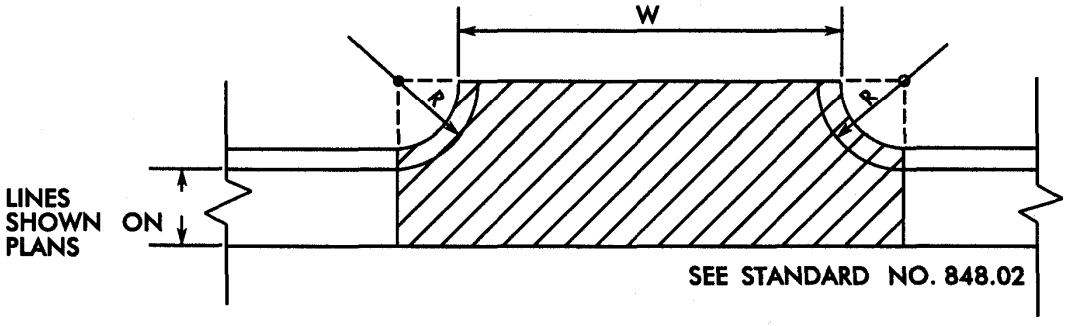
$A = \frac{R^2}{9}\left(\tan\frac{1}{2}\Delta - \frac{\Delta\pi}{360}\right)$ (IN SQ.YDS.)

$\left(\tan\frac{1}{2}\Delta - \frac{\Delta\pi}{360}\right)$ = "F" IN TABLE ABOVE

TABLE 2 **11 - 1**
T - 2

RADIUS TYPE

DRIVEWAY PAVEMENT AREAS
IN SQUARE YARDS

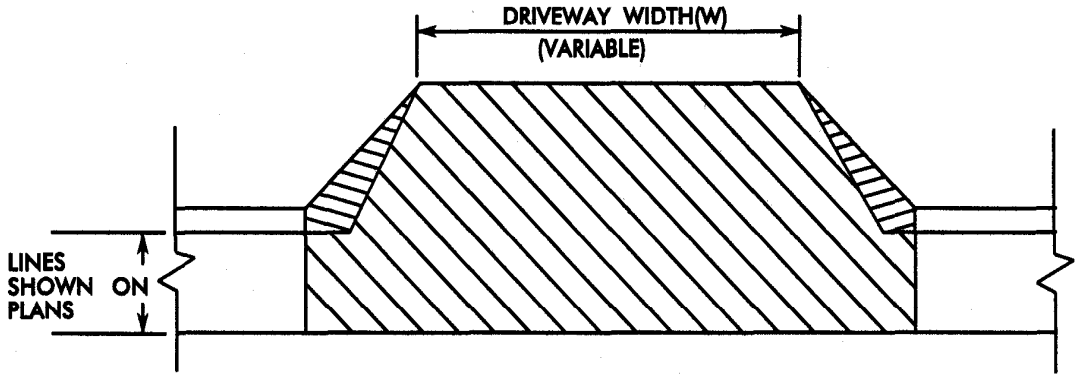


WIDTH (W)	RADIUS (R)						
	2	2.5	3*	3.5	4	4.5	5
8	4.496	5.302	6.131	6.984	7.862	8.763	9.688
10	5.385	6.302	7.243	8.207	9.195	10.207	11.243
12	6.274	7.302	8.354	9.429	10.529	11.652	12.799
14	7.163	8.302	9.465	10.651	11.862	13.096	14.355
15	7.607	8.802	10.020	11.263	12.529	13.819	15.132
16	8.052	9.302	10.576	11.874	13.195	14.541	15.910
18	8.941	10.302	11.687	13.096	14.529	15.985	17.466
20	9.830	11.302	12.798	14.318	15.862	17.430	19.021
22	10.718	12.302	13.909	15.540	17.195	18.874	20.577
24	11.607	13.302	15.020	16.763	18.529	20.319	22.132
25	12.052	13.802	15.576	17.374	19.195	21.041	22.910
26	12.496	14.302	16.131	17.985	19.862	21.763	23.688
28	13.385	15.302	17.243	19.207	21.195	23.207	25.243
30	14.274	16.302	18.354	20.429	22.529	24.652	26.799
32	15.163	17.302	19.465	21.651	23.862	26.096	28.355
34	16.052	18.302	20.576	22.874	25.195	27.541	29.910
35	16.496	18.802	21.131	23.485	25.862	28.263	30.688
36	16.941	19.302	21.687	24.096	26.529	28.985	31.466
38	17.830	20.302	22.798	25.318	27.862	30.430	33.021
40	18.718	21.302	23.909	26.540	29.195	31.874	34.577
45	20.941	23.802	26.687	29.596	32.529	35.485	38.466
50	23.163	26.301	29.465	32.651	35.862	39.096	42.355

* Cell in Roadway's libraries are based on 3' radius and the DDB use these pavement values when computing automated quantities.

TABLE 3 **11 - 1**
T - 3

DROP TYPE
DRIVEWAY PAVEMENT AREAS
IN SQUARE YARDS



SEE STANDARD NO. 848.03

W	SQ.YD.	W	SQ.YD.	W	SQ.YD.	W	SQ.YD.
8	6.528	19	12.639	30	18.750	41	24.861
9	7.083	20	13.194	31	19.306	42	25.417
10	7.639	21	13.750	32	19.861	43	25.972
11	8.194	22	14.306	33	20.417	44	26.528
12	8.750	23	14.861	34	20.972	45	27.083
13	9.306	24	15.417	35	21.528	46	27.639
14	9.861	25	15.972	36	22.083	47	28.194
15	10.417	26	16.528	37	22.639	48	28.750
16	10.972	27	17.083	38	23.194	49	29.306
17	11.528	28	17.639	39	23.750	50	29.861
18	12.083	29	18.194	40	24.306	51	30.417

FOUNDATION CONDITIONING MATERIAL 11-2A

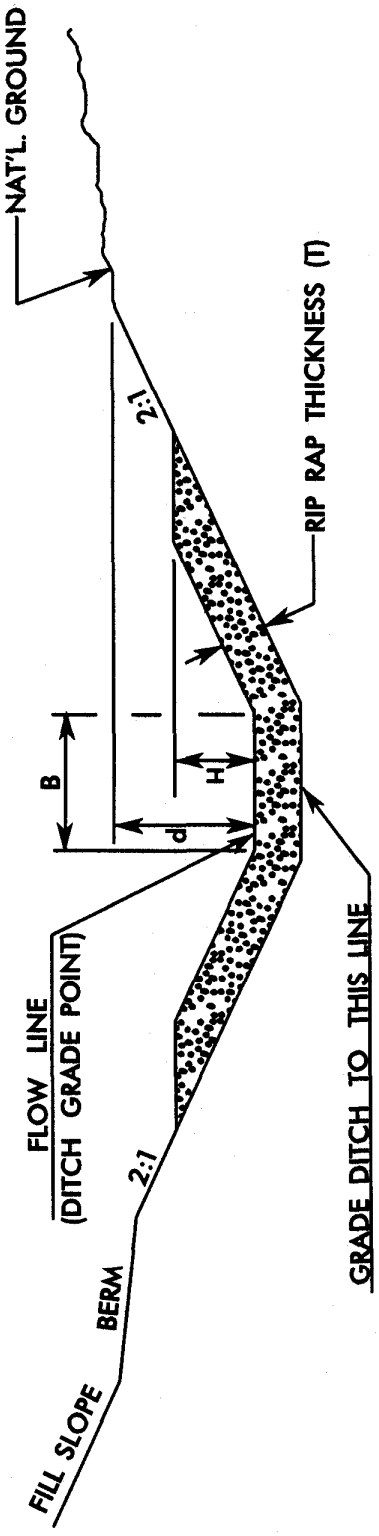
The actual quantity of foundation conditioning material needed for each pipe installation will depend on the soil conditions. For computing the Engineer's estimate, it is assumed that 20% of the pipe on every project will require foundation conditioning material. To determine the tonnage required, multiply the total length of the pipe, disregarding size and type, by 0.106.

INSTALLATION OF RIP RAP IN DITCHES 11-2B

For computing Rip Rap in ditches refer to Figures 1 thru 3 of this section.

FIGURE 1 **11 - 2B**
F - 1

RIP RAP APPLICATION IN DITCHES



B = BASE WIDTH (SHOW "O" IF V-DITCH)
H = DEPTH OF DITCH TO BE PROTECTED WITH RIP RAP
d = MINIMUM DEPTH OF DITCH REQUIRED (TO FLOW LINE)
T = THICKNESS OF RIP RAP APPLICATION

FIGURE 2 **11 - 2B**
F - 2

FORMULAS FOR COMPUTING RIP RAP

DISCRIPTION	THICHNESS (T)	RATE	FORMULAS
CLASS 'B' RIP RAP (W/FILTER FABRIC)	12" (1.0')	100#/CF	L(0.124 + 0.05B + 0.224H) = TONS
CLASS 'B' RIP RAP (W/OUT FILTER FABRIC)	15" (1.25')	100#/CF	L(0.193 + 0.063B + 0.280H) = TONS
CLASS 'A' RIP RAP (NO FILTER FABRIC)	8" (0.667')	100#/CF	L(0.055 + 0.033B + 0.149H) = TONS
CLASS I RIP RAP (CHANNNELS AND DITCHES)	18" (1.5')	105#/CF	L(0.292 + 0.079B + 0.352H) = TONS
CLASS I RIP RAP (PIPE OUTLETS)	15" (1.25')	105#/CF	L(0.203 + 0.066B + 0.294H) = TONS
CLASS II RIP RAP	24" (2.0')	105#/CF	L(0.519 + 0.105B + 0.470H) = TONS

FILTER FABRIC FORMULA : $\frac{L * (4.944T + 4.472H + B)}{9}$ SQ. YDS. FILTER FABRIC

NOTE: FORMULAS BASED ON 2:1 SIDE SLOPES (REVISED 9/14/93 RDH)

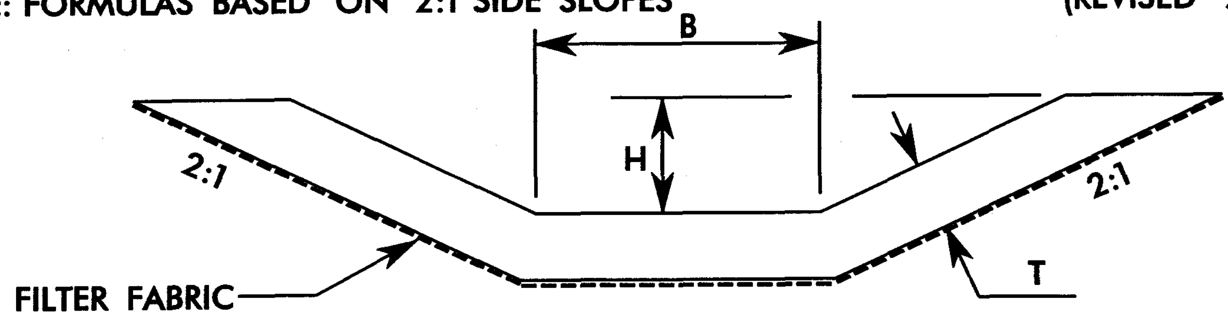
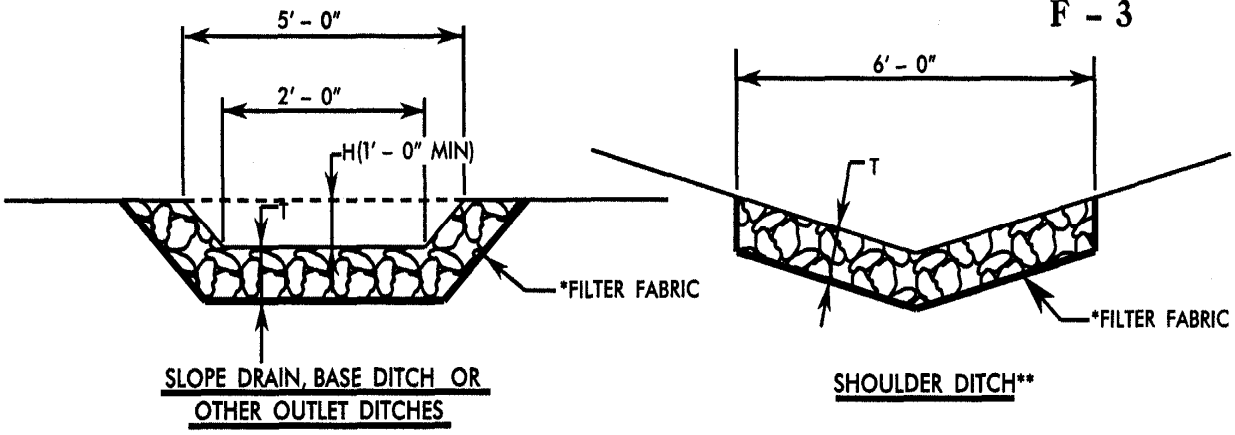


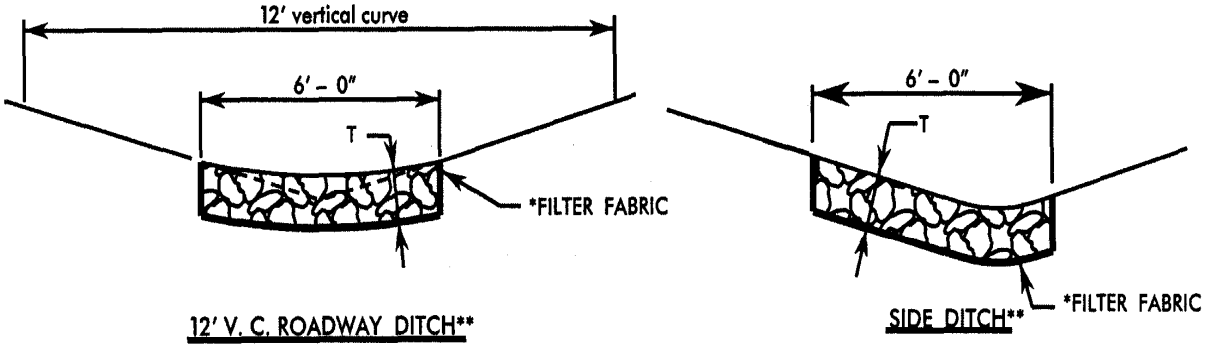
FIGURE 3 INSTALLATION OF RIP RAP

11 -2B
F - 3



TYPE OF DITCH	SLOPE	CLASS "A" RIP RAP		CLASS "B" RIP RAP	
		TONS PER LIN. FT.	THICKNESS(T)	TONS PER LIN. FT.	THICKNESS(T)
2' BASE	1 1/2 : 1	0.195	8"	0.332	12"
3' BASE	1 1/2 : 1	0.228	8"	0.382	12"
4' BASE	1 1/2 : 1	0.262	8"	0.432	12"
2' BASE H=1.5'	1 1/2 : 1	0.308	8"		
2' BASE H=2.0'	1 1/2 : 1	0.369	8"		
2' BASE H=1.5'	2 : 1	0.354	8"		
2' BASE H=2.0'	2 : 1	0.428	8"		
2' V		0.067	8"		
4' V		0.133	8"	0.200	12"
6' V		0.200	8"	0.300	12"

GENERAL NOTES:
CLASS OF RIP RAP USED AS STATED IN PLANS.
PAYMENT FOR RIP RAP WILL BE MADE AT THE CONTRACT UNIT PRICE PER TON FOR RIP RAP.
WIDTH AND SHAPE OF DITCHES SHALL BE AS SHOWN OR AS DIRECTED BY THE ENGINEER.



*NOTE: USE FILTER FABRIC LINER FOR ALL CLASS "B" RIP RAP INSTALLATIONS.
USE FILTER FABRIC LINER ONLY WHEN SPECIFIED FOR CLASS "A" RIP RAP INSTALLATIONS

**NOTE: EXCAVATION FOR PLACEMENT OF RIP RAP IN THESE 3 APPLICATIONS IS CONSIDERED INCIDENTAL TO THE COST OF THE RIP RAP.
EXCAVATION OF BASE DITCHES ARE TO BE PAID FOR AS DRAINAGE DITCH EXCAVATION.

FORCE ACCOUNT ESTIMATES 11-3

Force Account Estimates are only applicable to Federal Aid Projects.

Estimates for force account items will be submitted to the Roadway Design Unit by the Design Review Engineer in Traffic Engineering and Safety Systems. (See The Policy and Procedure Manual, 6/7)

Generally, the following items are covered by force account estimates: signalization, permanent signing, detour signing, and paint striping items.

The Policy and Procedure Manual 18/1, provides information related to Railroad Force Account Items.

COMPUTER ESTIMATES 11-4

All estimates will be entered into Trns*port Estimate Computer Program by the design group responsible for the plans.

FENCE 11-5

CHAIN LINK FENCE 11-5A

(See Roadway Standard Drawing, STD. No. 866.01)

End Brace	- 1 - Terminal Post	1 @ 8′ Panels
Line Brace	- 1 - Terminal Post	2 @ 8′ Panels
Corner Brace	- 1 - Terminal Post	2 @ 8′ Panels

Use end brace on both ends of each section of fence.

Use line brace at 700′ intervals on tangents, at 350′ intervals on curves, and at breaks less than 30 degrees.

Use corner brace at breaks greater than 30 degrees.

WOVEN WIRE FENCE 11-5B

(See Roadway Standard Drawings, STD. No's. 866.02 and 866.03)

End Brace -	2 @ Posts
	1 @ 8′ Panels
Line Brace -	3 @ Posts
	2 @ 8′ Panels
Corner Brace -	3 @ Posts
	2 @ 8′ Panels

Use end brace on physical ends of fence only.

WOVEN WIRE FENCE (Continued) 11-5B

Use line brace at 300′ intervals and at 200′ intervals on curves greater than 3 degrees.

Use corner brace at breaks of 15 degrees and greater.

LUMP SUM GRADING 11-6

The following guidelines will be used by the Project Engineer or private engineering firms, to decide whether or not a project will be let on an individual item basis or lump sum grading basis.

Quantities will be prepared in the traditional manner. Once these quantities are known, the following procedures will be used to decide the basis of letting the project:

1. Estimate the quantities for the items and extend prices as follows:

ITEM	QUANTITY PER UNIT		UNIT PRICE	EXTENDED PRICE
CLEARING AND GRUBBING	_____	ACRES	$ 10,000	$ _____
UNCLASSIFIED EXCAVATION	_____	YD ^{3}	6.00	_____
BORROW EXCAVATION	_____	YD ^{3}	6.25	_____
SHOULDER BORROW	_____	YD ^{3}	6.25	_____
FINE GRADING	_____	YD ^{2}	2.50	_____
REMOVAL OF EXISTING ASPHALT PAVEMENT	_____	YD ^{2}	2.50	_____
REMOVAL OF EXISTING CONCRETE PAVEMENT	_____	YD ^{2}	10.00	_____
BREAKING OF EXISTING ASPHALT PAVEMENT	_____	YD ^{2}	2.00	_____
BREAKING OF EXISTING CONCRETE PAVEMENT	_____	YD ^{2}	5.00	_____
		TOTAL	$	_____

2. If the summation of the item amounts is $1,000,000.00 or less, then the grading may be let on a "lump sum" basis with concurrence of the Division Engineer. If the cost of any one of the items, excluding clearing and grubbing and fine grading, is 50% or more of the total cost calculated, then that item shall be included as an individual item with the other items being done on a “Lump Sum Grading” basis. A special provision will be needed in this case and the pay item “Grading” should be indicated as a “sp” in the estimate. If the sum of the item amounts exceeds $1,000,000.00 or is 25% or more of the total cost of the project, the project shall contain the individual items in accordance with the Standard Specifications.

3. Other considerations for lump sum grading may utilize a dollar limit. For example, 3R Projects with "Trenching & Widening" and minor grading should be considered when use of cross-sections for earthwork by the Resident Engineer is not practical. When applying lump sum grading to these special applications, approval by the Assistant State Roadway Design Engineer and Proposals and Contracts Section Engineer is required on a project-by-project basis.

The net result of this method of letting the grading should result in less construction engineering manpower for the applicable projects.

See Part II, Chapter 19, Section 19-5 for the “Lump Sum Grading Note”.