CE 585

Construction Site Erosion Control

The University of Alabama

Tuscaloosa, AL

New Chevrolet and Cadillac Dealership

Jasper, AL

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Homework #5

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1.0 Introduction

This exercise is for the purpose of practicing channel and slope stability analysis on construction sites. The author has chosen the new Chevrolet and Cadillac dealership in Jasper, AL was chosen by the author to use for a class project in Construction Site Erosion, CE 585. The site is located in the southwest corner of the I-22 exit onto Industrial Blvd in Jasper, AL. This document contains a brief description of the drainage channels onto the site, across the site, and below the site. There are three such drainage channels (see Figure 1a). On the eastern side of the project a channel crosses a portion of the project, continues through a box culvert for a distance then into a short segment of stream which will flow into a drainage pond before leaving the site (Outlet A). In the middle portion of the site a road culvert empties an up-slope drainage area from the North into a very short segment of stream which will pick up some runoff from the East and some from the West before passing into a pipe culvert which will flow underneath the site emptying into a sediment pond and then exiting the site to the South (Outlet B). On the westernmost edge of the project stream passes nearby in which the western portion of the site will drain into (Outlet C). For this exercise only the drainage area flowing to the eastern most outlet is analyzed.

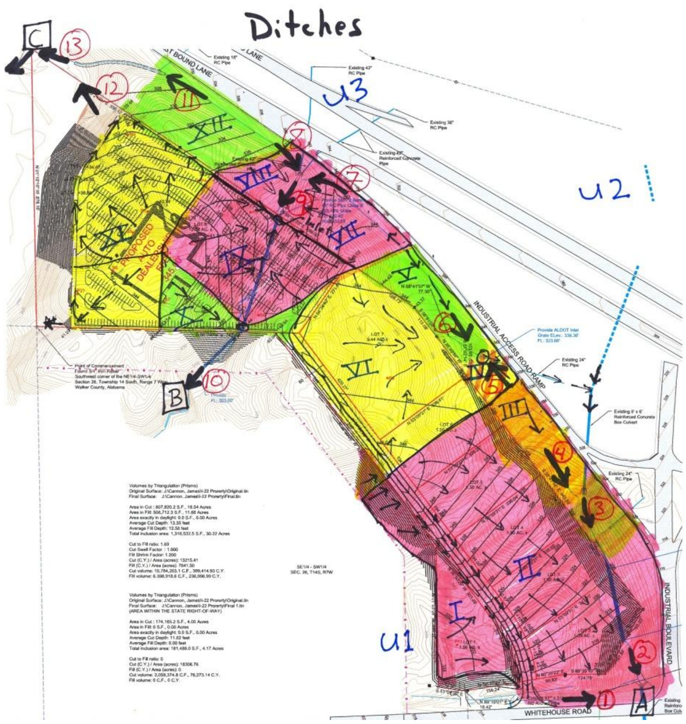

Figure 1a: Drainage Areas for Ditches

2.0 The Assignment

For assignment #5 we were asked to:

1. design an appropriate diversion swale, or main drainage swale for our site using the previously calculated flow rates.
    a. Select a suitable channel lining, including the consideration of check dams
    b. Justify selections with appropriate calculations
2. Identify several different slope categories on our site
    a. Propose suitable control practices for each type
    b. Justify selections with appropriate calculations

In both cases we are allowed to use North America Greens software program (Erosion Control Materials Design Software) to assist in the selection of liner and slope protection materials. However, the basic calculations for at least one example drainage swale and slope should be conducted manually.

3.0 Drainage Swale Design

The site design does not include channels within the site. There are several channels which the site drains into however these channels lay in undisturbed areas. These channels have established vegetation (lining). The locations of the channels are shown in figure 1a. For this exercise the author checks the stability of six drainage channels. As found in an earlier exercise, the design storm for drainage swales is for a five-year event. The method for analyzing the drainage channels is given below:

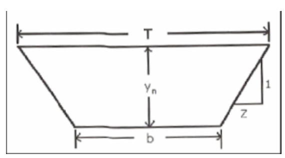

Figure 3a: Channel Dimensions

The predominant soil for the entire site (and surrounding area) is stiff, sandy clay. The following parameters apply:

Maximum permissible velocity (V_o) = 5.0 ft/sec
Allowable shear stress (τ_o) = 0.46 lb/ft^2
Roughness of channel lining soil, n = 0.025

The Manning's roughness coefficient is used to calculate the hydraulic radius as shown below:

$$R = \left[\frac{Vn}{1.49\, S^{0.5}} \right]^{1.5}$$

Calculations for analyzing the existing channels are shown in table 3a.

Initial Channel Condition	Cover Factor, C_f Table 5.5	Existing Cover Manning, n table 3.16	5 yr Q (cfs)	S_o (ft/ft)	$Qn/S_o^{1/2}$	y *use goalseek to set* $Qn/So^{1/2}=AR^{2/3}$	b (ft)	z (ft/ft)	A (ft^2)	P (ft)	R (ft)	$AR^{2/3}$	V (fps)	effective τ_e on soil (psf)	need additional lining (yes/no)
grass	0.75	0.035	51.16	0.135	13.26	1.85	3.00	2	12.43	11.29	1.10	13.26	4.11	1.18	yes
grass	0.75	0.035	200.93	0.025	281.30	4.81	10.00	4	140.56	49.65	2.83	281.30	1.43	0.56	yes
grass	0.75	0.035	188.62	0.025	264.07	4.67	10.00	4	134.11	48.54	2.76	264.07	1.41	0.55	yes
grass	0.75	0.06	6.8	0.11	3.71	0.86	3.00	4	5.54	10.09	0.55	3.71	1.23	0.16	no
grass	0.75	0.06	1.3	0.44	0.18	0.18	3.00	4	0.65	4.44	0.15	0.18	2.01	0.17	no
grass	0.75	0.06	4.24	0.44	0.58	0.29	3.00	4	1.20	5.38	0.22	0.44	3.54	0.27	no

Table 3a: Channel Analysis

It appears from the calculations above that three of the channels have inadequate lining while the remaining three channels appear to be stable. For those channels which require stronger lining table 3b shows the chosen lining option:

Synthetic Lining Option						
Channel Name	Chosen Lining		lining coeff., n	Allowable V_{max} (fps)	Allowable τ_o (psf)	Longevity (months)
1	NAG P300	unvegetated	0.02	9.00	2.00	permanent
		vegetated	0.049	16.00	8.00	permanent
2	NAG P300	unvegetated	0.02	9.00	2.00	permanent
		vegetated	0.049	16.00	8.00	permanent
3	NAG P300	unvegetated	0.02	9.00	2.00	permanent
		vegetated	0.049	16.00	8.00	permanent

Table 3b: Chosen Ditch Linings

4.0 Slope Stability

The modified Manning's formula is used to calculate the flow depth for the sheetflow condition used for slope stability analysis. Previously calculated peak flow rates are used in the calculations. The maximum allowable shear stress on the soil is 0.46 psf.

$$y = \left(\frac{qn}{1.49 s^{0.5}} \right)^{\frac{3}{5}}$$

Modified Manning's formula

Where:
y = the flow depth (in feet),
q = the unit width flow rate (Q/W)
n = the sheet flow roughness coefficient for the slope surface
s = the slope (as a fraction)

The corresponding maximum shear stress is calculated using the following equation:

$\tau_o = \gamma y S$

where:
γ = specific weight of water (62.4 lbs/ft3)
y = flow depth (ft)
S = slope (ft/ft)

To determine the maximum shear stress felt by the underlying soil after protective measures are taken is calculated using the following equation:

$$\tau_e = \tau_o (1 - C_f) \left(\frac{n_s}{n} \right)^2$$

Where,
τ_e = effective shear stress exerted on soil beneath mat on slope
τ_o = maximum shear stress from the flowing water = 1.02 lbs/ft2
C_f = cover factor = 0 for unvegetated slope
n_s = roughness coefficient of underlying soil = 0.020
n = roughness coefficient of mat = assume 0.055 for unvegetated mat on slope

The slopes are defined in figure 4a.

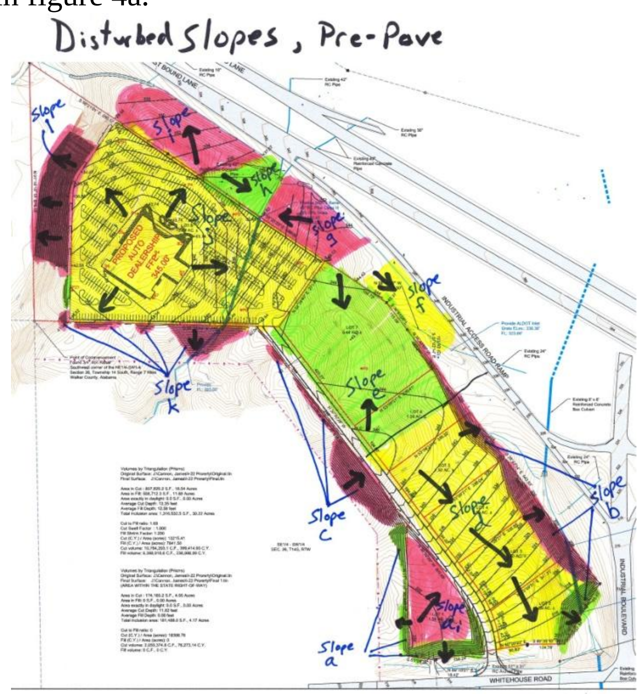

Figure 4a: disturbed slopes

As determined in a previous exercise the five-year rain event is used in analyzing slope stability. The results of the calculations for slopes a through g are shown in table 4a:

Sub-Area	Area (acre)	Slope (ft/ft)	Width of slope, W (ft)	Q_5, 5 yr event (cfs)	q, Q/W	n, bare soil	y (ft)	Bare Soil τ_0 (psf)	need for additional protection (yes/no)	Seeding and Mulching Cover Factor, C_f (table 5.22)	Seeded & Mulched τ_e (psf)
Slope a	1.1	0.25	1,000	4.52	0.0045	0.025	0.005	0.0797	no	0.14	1.42E-02
Slope a1	1.23	0.02	280	4.83	0.0173	0.025	0.024	0.0304	no	0.06	5.90E-03
Slope b	1.32	0.33	970	5.42	0.0056	0.025	0.005	0.11	no	0.17	1.89E-02
Slope c	0.2	0.33	78	0.82	0.0105	0.025	0.008	0.1607	no	0.17	2.76E-02
Slope d	5.61	0.05	273	23.07	0.0845	0.025	0.048	0.1498	no	0.06	2.91E-02
Slope e	4.83	0.04	500	19.86	0.0397	0.025	0.033	0.0814	no	0.06	1.58E-02
Slope f	1.35	0.05	113	5.37	0.0475	0.025	0.034	0.106	no	0.06	2.06E-02

Table 4a: Slope stability analysis

From the analysis it appears the slopes are stable with only seeding and the use of straw as mulch. However slopes a1, d, and e are each more than 200 ft long and therefore will require additional considerations for shortening the effective slope length while vegetation is establishing. Slope a should have a filter fabric fence installed across the slope, extending from the SE corner of the slope to approximately the midpoint of the West edge of the slope. Slope d should have multiple diversion ditches placed. Since each of the lot lines are spaced approximately 200 ft apart on this slope, it will be sensible to construct diversion channels along each East-West lot line with temporary drainage pipes located at the eastern slope (slope b) draining the diversion channels into ditches 3 and 4 as shown in figure 1a.

5.0 Conclusion:

For this project there are not any additional channels being created. The existing channels were analyzed and it was determined that three of the channels are adequately lined and three of the channels need to have stronger linings installed. The slopes on this project are predominantly mild. Due to the mildness of the slopes and properties of the soils the slopes are easily protected against erosion. For the slopes seeding and mulching is adequate except for the longer slopes which require the consideration of installing features which will decrease the effective slope length. Such a consideration is the installation of diversion ditches along the longer slopes.