13.12 STABILITY ANALYSIS BY METHOD OF SLICES FOR STEADY STATE SEEPAGE

Figure 13.24 shows a slope through which there is steady state seepage. For the nth slice, the average pore water pressure at the bottom of the slice is equal to $u_n = h_n \gamma_w$. The total force caused by the pore water pressure at the bottom of the nth slice is equal to $u_n \Delta L_n$.

Effective stress parameters are to be used when pore pressure is considered

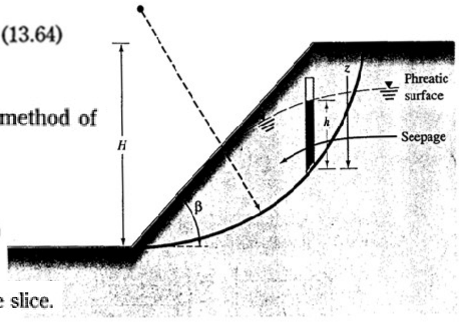
Thus, Eq. (13.56) for the ordinary method of slices will be modified to read

$$F_s = \frac{\sum_{n=1}^{n=p} [c\Delta L_n + (W_n \cos \alpha_n - u_n \Delta L_n)] \tan \phi}{\sum_{n=1}^{n=p} W_n \sin \alpha_n} \quad (13.64)$$

Similarly, Eq. (13.63) for Bishop's simplified method of slices will be modified to the form

$$F_s = \frac{\sum_{n=1}^{n=p} [cb_n + (W_n - u_n b_n) \tan \phi] \frac{1}{m_{(\alpha)n}}}{\sum_{n=1}^{n=p} W_n \sin \alpha_n} \quad (13.65)$$

W_n in Eqs. (13.64) and (13.65) is the total weight of the slice.



Note that W_n in Eqs. (13.64) and (13.65) is the total weight of the slice.

▼ FIGURE 13.24 Stability analysis of slope with steady state seepage

Using the method of slices, Bishop and Morgenstern (1960) and Spencer (1967) provided charts to determine the factor of safety of simple slopes that takes into account the effects of pore water pressure. These solutions are given in Sections 13.13 and 13.15.

13.13 BISHOP AND MORGENSTERN'S SOLUTION FOR STABILITY OF SIMPLE SLOPES WITH SEEPAGE

Using Eq. (13.65), Bishop and Morgenstern developed tables for the calculation of F_s for simple slopes. The principles of these developments can be explained as follows. In Eq. (13.65),

$$W_n = \gamma b_n z_n \quad (13.66)$$

where z_n = average height of the nth slice. Also in Eq. (13.65)

$$u_n = h_n \gamma_w$$

So, we can let

$$r_{u(n)} = \frac{u_n}{\gamma z_n} = \frac{h_n \gamma_w}{\gamma z_n} \quad (13.67)$$

Note that $r_{u(n)}$ is a nondimensional quantity. Substituting Eqs. (13.66) and (13.67) into Eq. (13.65) and simplifying, we obtain

$$F_s = \left[\frac{1}{\sum_{n=1}^{n=p} \frac{b_n}{H}\frac{z_n}{H} \sin \alpha_n}\right] \times \sum_{n=1}^{n=p} \left\{\frac{\frac{c}{\gamma H}\frac{b_n}{H} + \frac{b_n}{H}\frac{z_n}{H}[1 - r_{u(n)}] \tan \phi}{m_{\alpha(n)}}\right\} \quad (13.68)$$

For a steady state seepage condition, a weighted average value of $r_{u(n)}$ can be taken, which is a constant. Let the weighted averaged value of $r_{u(n)}$ be r_u. For most practical cases, the value of r_u may range up to 0.5. So,

Constant
↓

$$F_s = \left[\frac{1}{\sum_{n=1}^{n=p} \frac{b_n}{H}\frac{z_n}{H} \sin \alpha_n}\right] \times \sum_{n=1}^{n=p} \left\{\frac{\left[\frac{c}{\gamma H}\frac{b_n}{H} + \frac{b_n}{H}\frac{z_n}{H}(1 - r_u) \tan \phi\right]}{m_{\alpha(n)}}\right\} \quad (13.69)$$

The factor of safety based on the preceding equation can be solved and expressed in the form

$$F_s = m' - n'r_u \qquad (13.70)$$

where m' and n' = stability coefficients. Table C.1 (Appendix C) gives the values of m' and n' for various combinations of $c/\gamma H$, D, ϕ, and β.

To determine F_s from Table C.1, we must use the following step-by-step procedure:

1. Obtain ϕ, β, and $c/\gamma H$.
2. Obtain r_u (weighted average value).
3. From Table C.1, obtain the values of m' and n' for D = 1, 1.25, and 1.5 (for the required parameters ϕ, β, r_u, and $c/\gamma H$).
4. Determine F_s, using the values of m' and n' for each value of D.
5. The required value of F_s is the smallest one obtained in step 4.

▼ EXAMPLE 13.10

A slope is 46.5 ft high. Given: slopes = 2 horizontal:1 vertical, ϕ = 20°, c = 400 lb/ft², γ = 115 lb/ft³, and r_u = 0.28. Determine the factor of safety, F_s.

Solution

$$\frac{c}{\gamma H} = \frac{400}{(115)(46.5)} = 0.075$$

We are given that ϕ = 20°, slopes = 2H:1V, and r_u = 0.28. The following table can now be prepared:

	Toe circle or D	m'	n'	$F_s = m' - n'r_u$
Table C1.(g) →	Toe circle	1.593	1.158	1.269
Table C1.(h) →	1.0	1.610	1.100	1.302
Table C1.(i) →	1.25	1.688	1.285	1.328
Table C1.(h) →	1.5	1.918	1.514	1.494

So, $F_s \approx 1.269 \approx$ **1.27**

▼ TABLE C.1 Values of m' and n'

a. Stability coefficients m' and n' for $c/\gamma H = 0$

	Stability coefficients for earth slopes							
	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	0.353	0.441	0.529	0.588	0.705	0.749	0.882	0.917
12.5	0.443	0.554	0.665	0.739	0.887	0.943	1.109	1.153
15.0	0.536	0.670	0.804	0.893	1.072	1.139	1.340	1.393
17.5	0.631	0.789	0.946	1.051	1.261	1.340	1.577	1.639
20.0	0.728	0.910	1.092	1.213	1.456	1.547	1.820	1.892
22.5	0.828	1.035	1.243	1.381	1.657	1.761	2.071	2.153
25.0	0.933	1.166	1.399	1.554	1.865	1.982	2.332	2.424
27.5	1.041	1.301	1.562	1.736	2.082	2.213	2.603	2.706
30.0	1.155	1.444	1.732	1.924	2.309	2.454	2.887	3.001
32.5	1.274	1.593	1.911	2.123	2.548	2.708	3.185	3.311
35.0	1.400	1.750	2.101	2.334	2.801	2.977	3.501	3.639
37.5	1.535	1.919	2.302	2.558	3.069	3.261	3.837	3.989
40.0	1.678	2.098	2.517	2.797	3.356	3.566	4.196	4.362

b. Stability coefficients m' and n' for $c/\gamma H = 0.025$ and $D = 1.00$

	Stability coefficients for earth slopes							
	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	0.678	0.534	0.906	0.683	1.130	0.846	1.365	1.031
12.5	0.790	0.655	1.066	0.849	1.337	1.061	1.620	1.282
15.0	0.901	0.776	1.224	1.014	1.544	1.273	1.868	1.534
17.5	1.012	0.898	1.380	1.179	1.751	1.485	2.121	1.789
20.0	1.124	1.022	1.542	1.347	1.962	1.698	2.380	2.050
22.5	1.239	1.150	1.705	1.518	2.177	1.916	2.646	2.317
25.0	1.356	1.282	1.875	1.696	2.400	2.141	2.921	2.596
27.5	1.478	1.421	2.050	1.882	2.631	2.375	3.207	2.886
30.0	1.606	1.567	2.235	2.078	2.873	2.622	3.508	3.191
32.5	1.739	1.721	2.431	2.285	3.127	2.883	3.823	3.511
35.0	1.880	1.885	2.635	2.505	3.396	3.160	4.156	3.849
37.5	2.030	2.060	2.855	2.741	3.681	3.458	4.510	4.209
40.0	2.190	2.247	3.090	2.993	3.984	3.778	4.885	4.592

(continued)

▼ TABLE C.1 Continued

c. Stability coefficients m' and n' for $c/\gamma H = 0.025$ and $D = 1.25$

	Stability coefficients for earth slopes							
	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	0.737	0.614	0.901	0.726	1.085	0.867	1.285	1.014
12.5	0.878	0.759	1.076	0.908	1.299	1.098	1.543	1.278
15.0	1.019	0.907	1.253	1.093	1.515	1.311	1.803	1.545
17.5	1.162	1.059	1.433	1.282	1.736	1.541	2.065	1.814
20.0	1.309	1.216	1.618	1.478	1.961	1.775	2.334	2.090
22.5	1.461	1.379	1.808	1.680	2.194	2.017	2.610	2.373
25.0	1.619	1.547	2.007	1.891	2.437	2.269	2.879	2.669
27.5	1.783	1.728	2.213	2.111	2.689	2.531	3.196	2.976
30.0	1.956	1.915	2.431	2.342	2.953	2.806	3.511	3.299
32.5	2.139	2.112	2.659	2.686	3.231	3.095	3.841	3.638
35.0	2.331	2.321	2.901	2.841	3.524	3.400	4.191	3.998
37.5	2.536	2.541	3.158	3.112	3.835	3.723	4.563	4.379
40.0	2.753	2.775	3.431	3.399	4.164	4.064	4.958	4.784

d. Stability coefficients m' and n' for $c/\gamma H = 0.05$ and $D = 1.00$

	Stability coefficients for earth slopes							
	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	0.913	0.563	1.181	0.717	1.469	0.910	1.733	1.069
12.5	1.030	0.690	1.343	0.878	1.688	1.136	1.995	1.316
15.0	1.145	0.816	1.506	1.043	1.904	1.353	2.256	1.567
17.5	1.262	0.942	1.671	1.212	2.117	1.565	2.517	1.825
20.0	1.380	1.071	1.840	1.387	2.333	1.776	2.783	2.091
22.5	1.500	1.202	2.014	1.568	2.551	1.989	3.055	2.365
25.0	1.624	1.338	2.193	1.757	2.778	2.211	3.336	2.651
27.5	1.753	1.480	1.380	1.952	3.013	2.444	3.628	2.948
30.0	1.888	1.630	2.574	2.157	3.261	2.693	3.934	3.259
32.5	2.029	1.789	2.777	2.370	3.523	2.961	4.256	3.585
35.0	2.178	1.958	2.990	2.592	3.803	3.253	4.597	3.927
37.5	2.336	2.138	3.215	2.826	4.103	3.574	4.959	4.288
40.0	2.505	2.332	3.451	3.071	4.425	3.926	5.344	4.668

(continued)

TABLE C.1 Continued

e. Stability coefficients m' and n' for $c/\gamma H = 0.05$ and $D = 1.25$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	0.919	0.633	1.119	0.766	1.344	0.886	1.594	1.042
12.5	1.065	0.792	1.294	0.941	1.563	1.112	1.850	1.300
15.0	1.211	0.950	1.471	1.119	1.782	1.338	2.109	1.562
17.5	1.359	1.108	1.650	1.303	2.004	1.567	2.373	1.831
20.0	1.509	1.266	1.834	1.493	2.230	1.799	2.643	2.107
22.5	1.663	1.428	2.024	1.690	2.463	2.038	2.921	2.392
25.0	1.822	1.595	2.222	1.897	2.705	2.287	3.211	2.690
27.5	1.988	1.769	2.428	2.113	2.957	2.546	3.513	2.999
30.0	2.161	1.950	2.645	2.342	3.221	2.819	3.829	3.324
32.5	2.343	2.141	2.873	2.583	3.500	3.107	4.161	3.665
35.0	2.535	2.344	3.114	2.839	3.795	3.413	4.511	4.025
37.5	2.738	2.560	3.370	3.111	4.109	3.740	4.881	4.405
40.0	2.953	2.791	3.642	3.400	4.442	4.090	5.273	4.806

f. Stability coefficients m' and n' for $c/\gamma H = 0.05$ and $D = 1.50$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
10.0	1.022	0.751	1.170	0.828	1.343	0.974	1.547	1.108
12.5	1.202	0.936	1.376	1.043	1.589	1.227	1.829	1.399
15.0	1.383	1.122	1.583	1.260	1.835	1.480	2.112	1.690
17.5	1.565	1.309	1.795	1.480	2.084	1.734	2.398	1.983
20.0	1.752	1.501	2.011	1.705	2.337	1.993	2.690	2.280
22.5	1.943	1.698	2.234	1.937	2.597	2.258	2.990	2.585
25.0	2.143	1.903	2.467	2.179	2.867	2.534	3.302	2.902
27.5	2.350	2.117	2.709	2.431	3.148	2.820	3.626	3.231
30.0	2.568	2.342	2.964	2.696	3.443	3.120	3.967	3.577
32.5	2.798	2.580	3.232	2.975	3.753	3.436	4.326	3.940
35.0	3.041	2.832	3.515	3.269	4.082	3.771	4.707	4.325
37.5	3.299	3.102	3.817	3.583	4.431	4.128	5.112	4.735
40.0	3.574	3.389	4.136	3.915	4.803	4.507	5.543	5.171

(continued)

TABLE C.1 Continued

g. Stability coefficients m' and n' for $c/\gamma H = 0.075$ and toe circles

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.593	1.158	2.055	1.516	2.498	1.903	2.934	2.301
25	1.853	1.430	2.426	1.888	2.980	2.361	3.520	2.861
30	2.133	1.730	2.826	2.288	3.496	2.888	4.150	3.461
35	2.433	2.058	3.253	2.730	4.055	3.445	4.846	4.159
40	2,773	2.430	3.737	3.231	4.680	4.061	5.609	4.918

h. Stability coefficients m' and n' for $c/\gamma H = 0.075$ and $D = 1.00$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.610	1.100	2.141	1.443	2.664	1.801	3.173	2.130
25	1.872	1.386	2.502	1.815	3.126	2.259	3.742	2.715
30	2.142	1.686	2.884	2.201	3.623	2.758	4.357	3.331
35	2.443	2.030	3.306	2.659	4.177	3.331	5.024	4.001
40	2.772	2.386	3.775	3.145	4.785	3.945	5.776	4.759

i. Stability coefficients m' and n' for $c/\gamma H = 0.075$ and $D = 1.25$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.688	1.285	2.071	1.543	2.492	1.815	2.954	2.173
25	2.004	1.641	2.469	1.957	2.972	2.315	3.523	2.730
30	2.352	2.015	2.888	2.385	3.499	2.857	4.149	3.357
35	2.728	2.385	3.357	2.870	4.079	3.457	4.831	4.043
40	3.154	2.841	3.889	3.428	4.729	4.128	5.603	4.830

TABLE C.1 Continued

j. Stability coefficients m' and n' for $c/\gamma H = 0.075$ and $D = 1.50$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.918	1.514	2.199	1.728	2.548	1.985	2.931	2.272
25	2.308	1.914	2.660	2.200	3.083	2.530	3.552	2.915
30	2.735	2.355	3.158	2.714	3.659	3.128	4.128	3.585
35	3.211	2.854	3.708	3.285	4.302	3.786	4.961	4.343
40	3.742	3.397	4.332	3.926	5.026	4.527	5.788	5.185

k. Stability coefficients m' and n' for $c/\gamma H = 0.100$ and toe circles

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.804	2.101	2.286	1.588	2.748	1.974	3.190	2.361
25	2.076	1.488	2.665	1.945	3.246	2.459	3.796	2.959
30	2.362	1.786	3.076	2.359	3.770	2.961	4.442	3.576
35	2.673	2.130	3.518	2.803	4.339	3.518	5.146	4.249
40	3.012	2.486	4.008	3.303	4.984	4.173	5.923	5.019

l. Stability coefficients m' and n' for $c/\gamma H = 0.100$ and $D = 1.00$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.841	1.143	2.421	1.472	2.982	1.815	3.549	2.157
25	2.102	1.430	2.785	1.845	3.458	2.303	4.131	2.743
30	2.378	1.714	3.183	2.258	3.973	2.830	4.751	3.372
35	2.692	2.086	3.612	·2.715	4.516	3.359	5.426	4.059
40	3.025	2.445	4.103	3.230	5.144	4.001	6.187	4.831

(continued)

TABLE C.1 Continued

m. Stability coefficients m' and n' for $c/\gamma H = 0.100$ and $D = 1.25$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	1.874	1.301	2.283	1.558	2.751	1.843	3.253	2.158
25	2.197	1.642	2.681	1.972	3.233	2.330	3.833	2.758
30	2.540	2.000	3.112	2.415	3.753	2.858	4.451	3.372
35	2.922	2.415	3.588	2.914	4.333	3.458	5.141	4.072
40	3.345	2.855	4.119	3.457	4.987	4.142	5.921	4.872

n. Stability coefficients m' and n' for $c/\gamma H = 0.100$ and $D = 1.50$

Stability coefficients for earth slopes

	Slope 2:1		Slope 3:1		Slope 4:1		Slope 5:1	
ϕ	m'	n'	m'	n'	m'	n'	m'	n'
20	2.079	1.528	2.387	1.742	2.768	2.014	3.158	2.285
25	2.477	1.942	2.852	2.215	3.297	2.542	3.796	2.927
30	2.908	2.385	3.349	2.728	3.881	3.143	4.468	3.614
35	3.385	2.884	3.900	3.300	4.520	3.800	5.211	4.372
40	3.924	3.441	4.524	3.941	5.247	4.542	6.040	5.200

13.14 MORGENSTERN'S METHOD OF SLICES FOR RAPID DRAWDOWN CONDITION

Morgenstern (1963) used Bishop's method of slices to determine the factor of safety, F_s, during rapid drawdown. Morgenstern used the following notations (Figure 13.25)

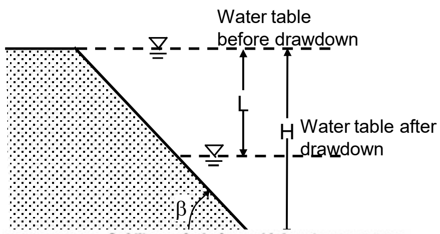


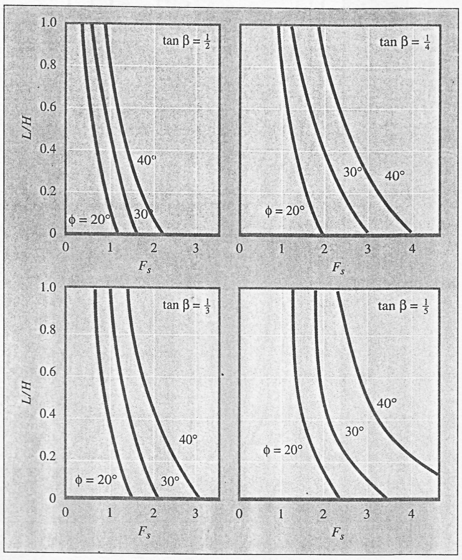
FIGURE 13.25 Stability analysis for rapid drawdown condition

1. L = height of drawdown
2. H = height of embankment
3. β = angle that the slope makes with the horizontal

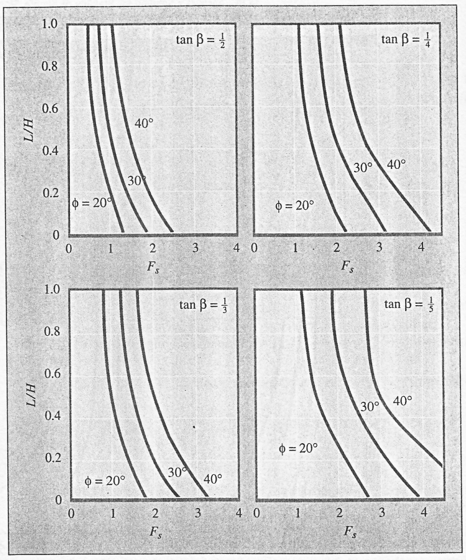
Morgenstern also assumed that

1. The embankment is made of homogeneous material and rests on an impervious base.
2. Initially the water level coincides with the top of the embankment.
3. During drawdown, pore water pressure does not dissipate.
4. The unit weight of saturated soil (γ_{sat}) = $2\gamma_w$ (γ_w = unit weight of water).

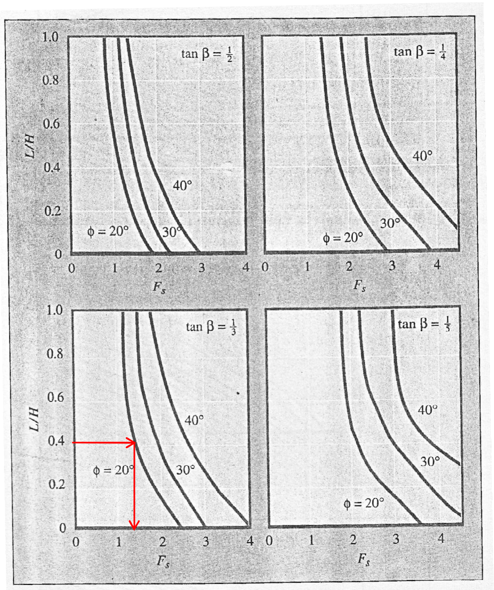
Figures 13.26 through 13.28 provide the drawdown stability charts developed by Morgenstern.



▼ **FIGURE 13.26** Morgenstern's drawdown stability chart for $c/\gamma H$ = 0.0125

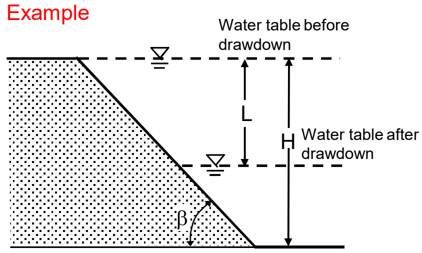


▼ **FIGURE 13.27** Morgenstern's drawdown stability chart for $c/\gamma H$ = 0.025



▼ FIGURE 13.28 Morgenstern's drawdown stability chart for $c/\gamma H = 0.05$

Example



γ = 16 kN/m^3 Slope – 3 (H) : 1 (V)

c = 20 kPa H = 25 m

ϕ = 20^0 L = 10 m

F_s = ? By Morgenstern's method

$$\frac{c}{\gamma H} = \frac{20}{16 \times 25} = 0.05 \qquad \frac{L}{H} = \frac{10}{25} = 0.4$$

Now for c/(γH)=0.05, ϕ = 20^0 and L/H =0.4 from graph,

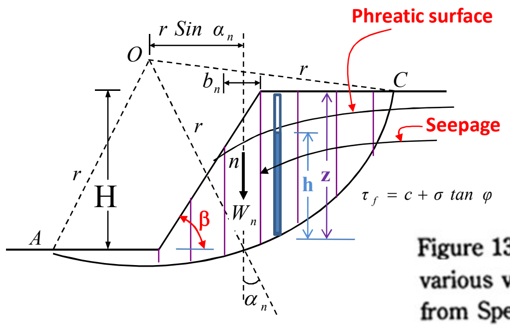
F_s = 1.4

13.15 SPENCER'S SOLUTION FOR STABILITY OF SIMPLE SLOPES WITH SEEPAGE

Takes into account the inter-slice forces

Satisfy the equations of equilibrium w.r.t both moment and forces

(Bishop's method satisfies only moment equilibrium)



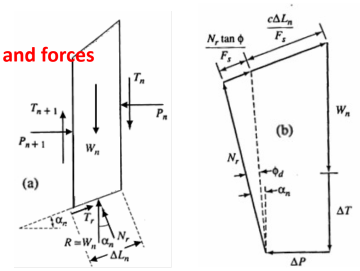


FIGURE 13.23 (a) forces acting on the *n*th slice; (b) force polygon for equilibrium

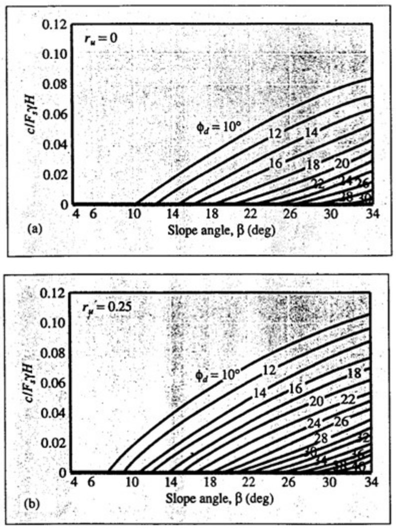
Figure 13.29 shows the variation of $c/F_s\gamma H$ for various values of the slope angle, β; ϕ_d; and r_u from Spencer's analysis.

$$\phi_d = \tan^{-1}\left(\frac{\tan\phi}{F_s}\right) \quad (13.71) \qquad r_{u(n)} = \frac{u_n}{\gamma z_n} = \frac{h_n \gamma_w}{\gamma z_n} \quad (13.67)$$

where z_n = average height of the *n*th slice.

γ, c, and ϕ, — average values of unit weight, cohesion, and friction angle respectively.

Charts for slope stability analysis of simple slopes with seepage by Spencer's method



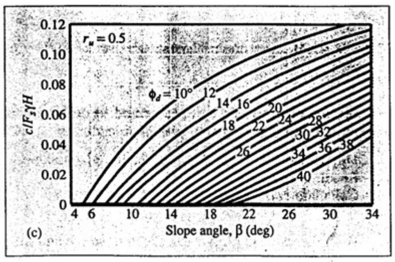


FIGURE 13.29 Plot of $c/F_s\gamma H$ against β for various values of ϕ_d (after Spencer, 1967)

Steps for Analysis

1. Determine c, γ, H, β, ϕ, and r_u
2. Assume a value of F_s.
3. Calculate $c/[F_s\gamma H]$.
4. With the value of $c/F_s\gamma H$ and the slope angle, β, enter the proper chart to obtain ϕ_d.
5. Calculate $F_s = \tan\phi/\tan\phi_d$.
6. If the value of F_s as assumed in step 2 is not the same as that calculated in step 5, repeat steps 2 through 5

The center of the circle can also be determined (App.C3/B M Das. We are not going to discuss.

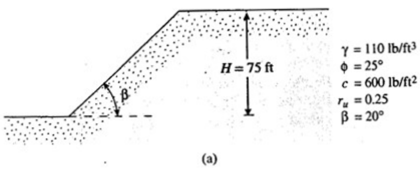
▼ **EXAMPLE 13.11**

A slope is shown in Figure 13.30a. Determine the factor of safety, F_s, of the slope, using Spencer's solution.

Solution A table can be prepared with several values of F_s

$F_{s(assumed)}$	$\frac{c^a}{F_{s(assumed)}\gamma H}$	ϕ_d^b	$F_{s(calculated)} = \frac{\tan\phi}{\tan\phi_d}$
1.0	0.0727	10	2.645
1.5	0.0485	14.5	1.803
2.0	0.0364	17	1.525

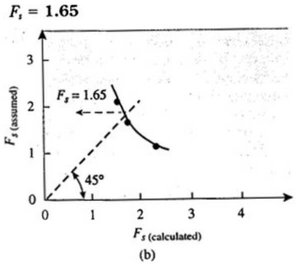
[a] c = 600 lb/ft²; γ = 110 lb/ft³; H = 75 ft
[b] From Figure 13.29b (for β = 20°)



A graph can now be plotted with $F_{s(assumed)}$ and $F_{s(calculated)}$ (Figure 13.30b). From this figure, we see that when $F_s = 1.65$, the value of $F_{s(assumed)}$ is equal to $F_{s(calculated)}$. So, for this slope,

$$F_s = 1.65$$

▲



▼ **FIGURE 13.30** Factor of safety of a slope by using Spencer's solution

13.16 FLUCTUATION OF FACTOR OF SAFETY OF SLOPES IN CLAY EMBANKMENT ON SATURATED CLAY

P – point on potential failure surface APB

At $t=0$ i.e. before construction of embankment, pore pressure at P, $u = h\gamma_w$

$t=0$ to $t=t_1$

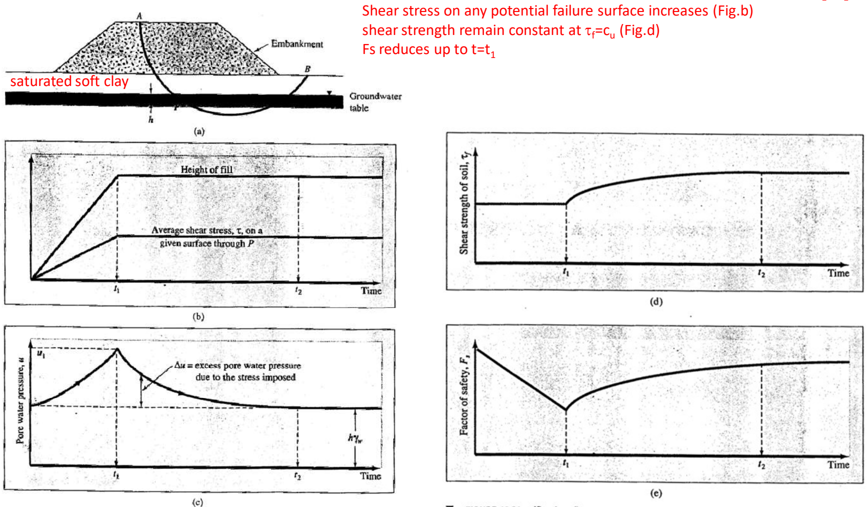
Construction of embankment, maximum ht. reaches at t=t1 (Fig.a)

Rapid construction – undrained condition; pore pressure increases to u_1; $u_1>h\gamma_w$

Shear stress on any potential failure surface increases (Fig.b)

shear strength remain constant at $\tau_f=c_u$ (Fig.d)

Fs reduces up to $t=t_1$



▼ FIGURE 13.31 Factor of safety variation with time for embankment on soft clay (redrawn after Bishop and Bjerrum, 1960)

▼ FIGURE 13.31 (Continued)