Chapter 8. Stability of Earth Slopes

8.2 Slopes of Limited Height

○ Method of slope stability analysis considering equilibrium of free body as a whole : Friction circle method (Fig. 1)

○ Method of slices : (Fig. 2)

- Basic assumption : the normal stress acting at a pt. of the failure are should be influenced mainly by the cut of soil lying above that point ; thus, can be sliced

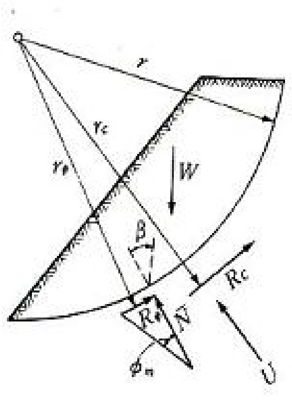


Fig. 1. Equilibrium in a Friction Circle Method

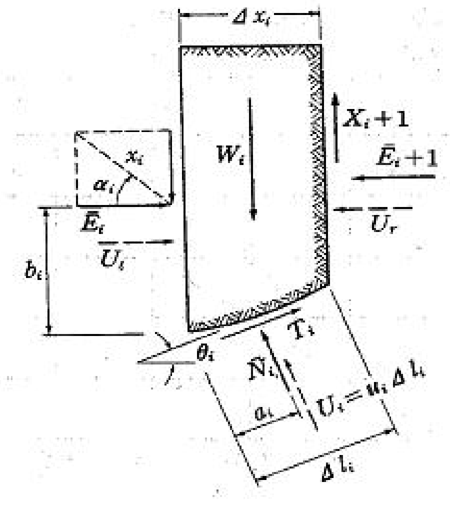


Fig. 2. Equilibrium in a Method of Slices

- Unknowns vs. equations (Table 8.1, p. 241)

  Unknowns : 5n-2, n : number of slices
  Equations : 3n
  ] if n=1 knowns = unknowns

  if slice very thin, n unknowns saved i.e., 4n-2 vs 3n (still n-2 unknowns more) α_i (Fig. 2) becomes known

- Many different assumptions are made :

· Ordinary method (Swedish circle or Fellenius) Eq. (8-31), p. 242~243
· Simplified Bishop method Eq. (8-33) (8-34), p. 243~244

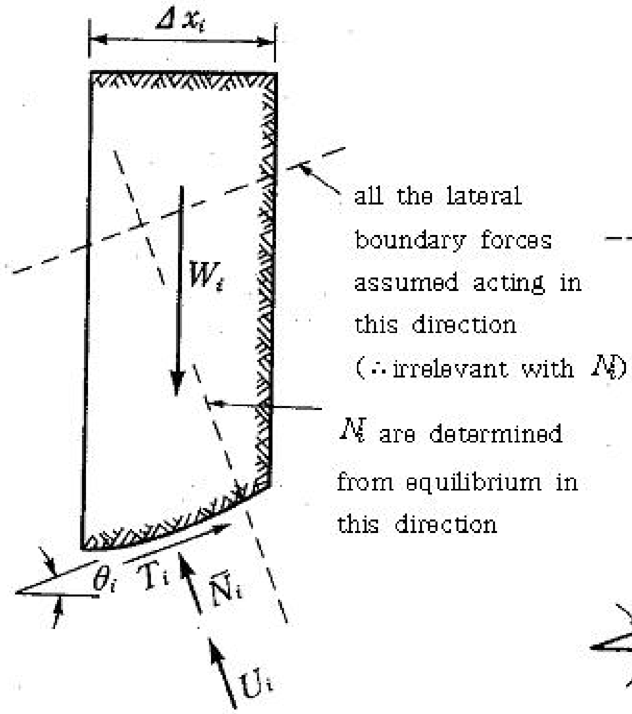


Fig. 3. Ordinary method

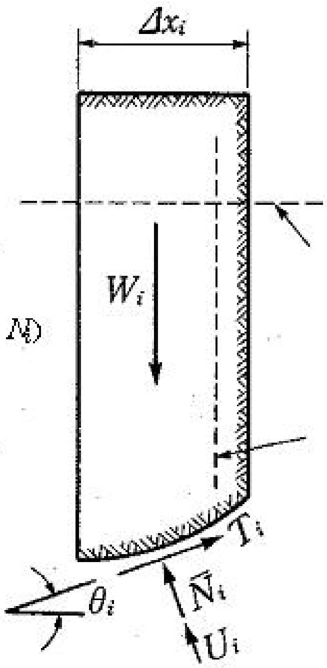


Fig. 4. Simplified Bishop method

- Factor of safety

$$FS = \frac{M_R}{M_D} = \frac{\text{Moment of Shear Strength along Failure Arc}}{\text{Moment of Failure Mass}}$$

$$M_D = \sum W_i \cdot r\, sin\theta_i = r \sum W_i sin\theta_i$$

$$M_R = r \sum (\bar{c} + \bar{\sigma} \tan\bar{\phi})\Delta l_i = r(\bar{c}L + \tan\bar{\phi} \sum N_i)$$

$$\therefore\ FS = \frac{\bar{c}L + \tan\bar{\phi} \sum N_i}{\sum W_i \sin\theta_i}$$

- Ordinary method

$$\overline{N_i} + U_i = W_i \cos\theta_i$$

$$\overline{N_i} = W_i \cos\theta_i - U_i = W_i \cos\theta_i - u_i \Delta l_i$$

$$FS = \frac{\bar{c}L + \tan\bar{\phi} \sum (W_i \cos\theta_i - u_i \Delta l_i)}{\sum W_i \sin\theta_i}$$

- Simplified Bishop method

$$\overline{N_i} = \frac{W_i - u_i \Delta x_i (1/FS)\bar{c}\Delta x_i \tan\theta_i}{\cos\theta_i [1 + (\tan\overline{\theta_i} \tan\bar{\phi})/FS]}$$

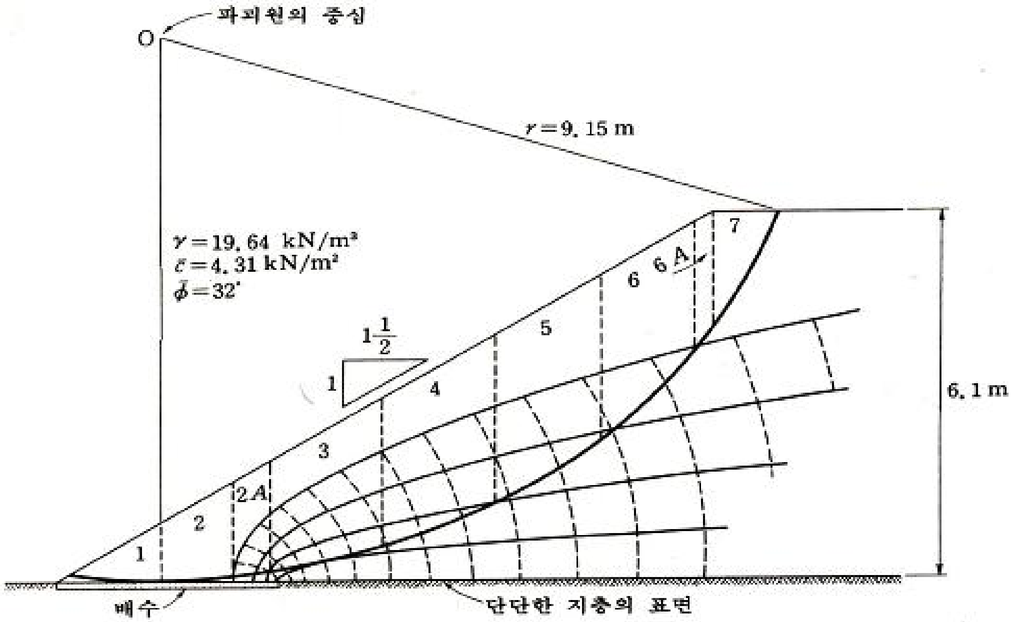
$$FS = \frac{\sum [\bar{c}\Delta x_i + (W_i - u_i \Delta x_i)\tan\bar{\phi}][1/M_i(\theta)]}{\sum W_i \sin\theta_i}$$

$$M_i(\theta) = \cos\theta_i [1 + (\tan\theta_i \cdot \tan\bar{\phi})/FS]$$

예제 8.5 예제 8.4의 사면에 대하여 일반적인 절편법을 사용하여 안전율을 계산하라.

풀이 표 예 8.5에 안전율을 구하는 과정이 나타나 있다.

$$F=\frac{4.31(12.76)+251.2\tan 32°}{181.9}=\frac{55.00+156.97}{181.9}=\frac{211.97}{181.9}=1.17$$



(표 예 8.5)

절편	W_i (kN)	$\sin\theta_i$	$W_i \sin\theta_i$ (kN)	$\cos\theta_i$	$W_i \cos\theta_i$ (kN)	u_i (kN/m)	Δl_i (m)	U_i (kN)	N_i (kN)
1	13.2	−0.03	−0.4	1.00	13.2	0	1.34	0	13.2
2	24.6	0.15	1.2	1.00	24.6	0	0.98	0	24.6
2A	19.1	0.14	2.7	0.99	18.9	1.4	0.58	0.8	18.1
3	67.5	0.25	19.6	0.97	65.5	10.0	1.62	16.2	49.3
4	81.8	0.42	34.4	0.91	74.4	13.9	1.71	23.8	50.6
5	84.8	0.58	49.2	0.81	68.7	12.0	1.89	22.7	46.0
6	67.4	0.74	49.9	0.67	45.2	5.3	2.04	10.8	34.4
6A	7.2	0.82	5.9	0.57	4.1	0	0.37	0	4.1
7	22.3	0.87	19.4	0.49	10.9	0	2.23	0	10.9
			181.9				12.76		251.2

〈참고〉 $r\sum W_i \sin\theta_i=9.15(181.8)=1664.4$ kNm는 표 예 8.4의 마지막 항의 모멘트값과 일치해야 한다. 약간의 차이는 반올림 오차에서 비롯된 것이다.

예제 8.6 예제 8.4의 사면에 대하여 Bishop의 간편법을 사용하여 안전율을 계산하라.

풀이 표 예 8.6에 안전율을 구하는 과정이 나타나 있다.

(표 예 8.6)

(1) 절편	(2) Δx_i (m)	(3) $c\Delta x_i$ (kN)	(4) $u_i\Delta x_i$ (kN)	(5) $W_i-u_i\Delta x_i$ (kN)	(6) (5)tan $\bar{\phi}$ (kN)	(7) (3)+(6) (kN)	(8) M_i		(9) (7)÷(8)	
							$F=1.25$	$F=1.35$	$F=1.25$	$F=1.35$
1	1.37	5.8	0	13.2	8.3	14.2	0.97	0.97	14.6	14.6
2	0.98	4.2	0	24.6	11.4	13.8	1.06	1.05	13.0	13.1
2 A	0.55	2.4	0.8	18.3	11.4	13.8	1.06	1.05	13.0	13.1
3	1.52	6.6	15.2	52.3	32.7	39.3	1.09	1.08	36.1	36.4
4	1.52	6.6	21.1	60.7	37.9	44.5	1.12	1.10	39.7	40.5
5	1.52	6.6	18.2	66.6	41.6	48.2	1.10	1.08	43.8	44.6
6	1.34	5.8	7.1	60.3	37.7	43.5	1.05	1.02	5.4	5.6
6 A	0.18	0.8	0	7.2	4.5	5.3	0.98	0.95	5.4	5.6
7	0.98	4.2	0	22.3	13.9	18.1	0.93	0.92	19.5	19.7
									232.7	236.4

각 가정에 대하여

$$F=1.25, \quad F=\frac{232.7}{181.9}=1.28$$

$$F=1.35, \quad F=\frac{236.4}{181.9}=1.30$$

$F=1.29$로 가정하여 계산하면 $F=1.29$를 얻는다.