5.8 Bishop method:

Bishop (1955) gave a simplified method of analysis which considers the forces on the sides of each slice. The requirement of equilibrium is applied to the slices. The factor of safety is defined as the ratio of the maximum shear strength (s) possessed by soil on the trial surface to the shearing resistance mobilized (Cm)·

$$\text{Thus } F_s = \frac{S}{\tau_m} ------ (1)$$

The forces acting on the slices are given below [Fig.5.28a]

1. Weight of slice, W=γhb, where h is the average height
2. Normal force on the base, N'=N-ul, where u is the pore pressure, and l is the length of the base (=bsecα).
3. Shear force on the base, T=τ m l.
4. Normal forces on the sides E1 and E2
5. Shear forces on the sides X1andX2.
6. Any external force acting on the slice.
7. The problem is statically indeterminate. To solve the problem, a number of simplifying assumptions are made regarding the interslice forces X1, X2, E1andE2.

Fig.5.28 (b)shows a slope. Taking moment's about o.

$$\sum \text{Tr} = \sum \text{Wrsin}\alpha$$

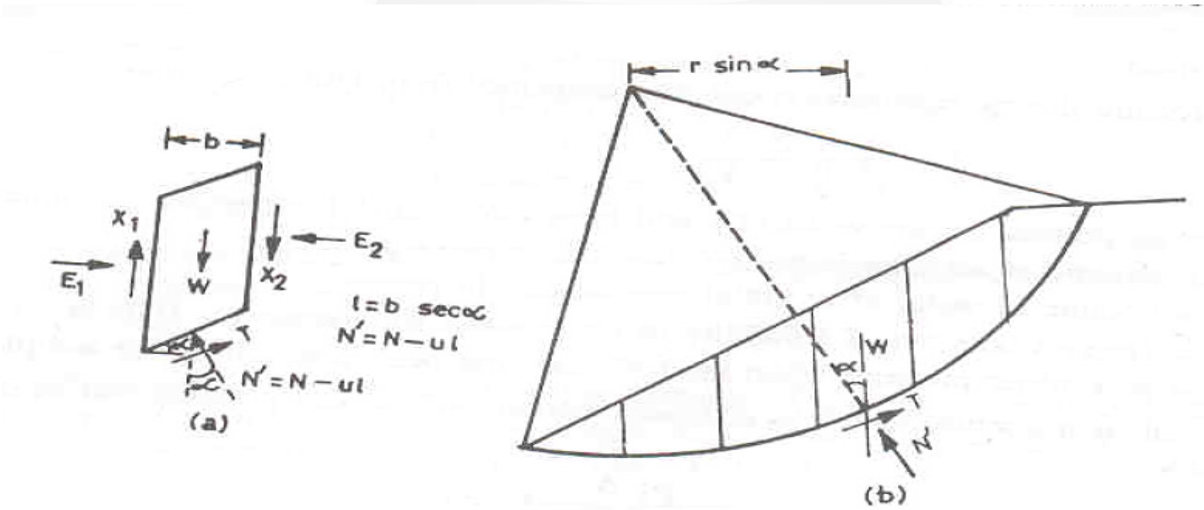

Fig 5.28 Bishop failure plane

$$T = \tau_m l = \frac{S}{F_s} xl$$

Therefore,$\sum \frac{S}{F_s} xl\, xr = \sum Wxrxsin\alpha$

$$F_s = \frac{\sum sxl}{\sum Wsin\alpha} = \frac{\sum(C' + \bar{\sigma}tan\varphi')l}{\sum Wsin\alpha}$$

$F_s = \frac{\sum sxl}{\sum Wsin\alpha} = \frac{\sum Cl + tan\varphi' \sum N}{\sum Wsin\alpha}$

where $N' = \bar{\sigma}\, l - - - - - - (2)$

In the conventional Swedish circle method, the resultant of interslice forces is taken as zero.

$$N' = Wcos\alpha - ul$$

$$F_s = \frac{C'L_a + tan\varphi' \sum(Wcos\alpha - ul)}{\sum Wsin\alpha}$$

$$F_s = \frac{C'L_a + tan\varphi' \sum(N - U)}{\sum T} - - - - - - (2)$$

In bishop simplified method ,it is assumed that the resultant forces on the sides of the slice are horizontali.e,X_1- X_2=0

Resolving the forces in the vertical direction,

$$W = N'cos\alpha + ulcos\alpha + Tsin\alpha + X_1 - X_2$$

$$\text{Substituting } T = \frac{S}{F_s} xl \text{ and } X_1 - X_2 = 0$$

$$W = N'cos\alpha + ulcos\alpha + \frac{(C'l + N'tan\varphi')}{F_s} sin\alpha$$

$$W = N'cos\alpha + ulcos\alpha + \frac{C'l}{F_s} + \frac{N'tan\varphi'}{F_s} sin\alpha$$

$$N'\left(cos\alpha + \frac{tan\varphi'}{F_s} sin\alpha\right) = W - ulcos\alpha - \frac{C'lsin\alpha}{F_s}$$

$$N' = \frac{W - ulcos\alpha - \frac{C'lsin\alpha}{F_s}}{\left(cos\alpha + \frac{tan\varphi'}{F_s} sin\alpha\right)} - - - - - - (3)$$

$Substitute\ N'$ in equation(2)

$$F_s = \frac{\sum c'l + tan\varphi'\left(\frac{W - ulcos\alpha - \frac{C'lsin\alpha}{F_s}}{\left(cos\alpha + \frac{tan\varphi'}{F_s}sin\alpha\right)}\right)}{\sum Wsin\alpha}$$

$$F_s = \frac{1}{\sum Wsin\alpha}\left\{\sum c'l + tan\varphi'\left(\frac{W - ulcos\alpha - \frac{C'lsin\alpha}{F_s}}{\left(cos\alpha + \frac{tan\varphi'}{F_s}sin\alpha\right)}\right)\right\}$$

$$F_s = \frac{1}{\sum Wsin\alpha}\sum\left[c'bsec\alpha + \frac{tan\varphi'\left(Wsec\alpha - ul - \frac{C'ltan\alpha}{F_s}\right)}{1 + \frac{tan\varphi'}{F_s}tan\alpha}\right]$$

$$F_s = \frac{1}{\sum Wsin\alpha}\sum\left[c'bsec\alpha - \frac{C'l\frac{tan\varphi'}{F_s}}{1 + \frac{tan\varphi'}{F_s}tan\alpha} + \frac{tan\varphi'(Wsec\alpha - ul)}{1 + \frac{tan\varphi'}{F_s}tan\alpha}\right]$$

$$F_s = \frac{1}{\sum Wsin\alpha}\sum\left[\frac{c'bsec\alpha(1 + tan\alpha\frac{tan\varphi'}{F_s}) - c'bsec\alpha tan\alpha\frac{tan\varphi'}{F_s}}{1 + \frac{tan\varphi'}{F_s}tan\alpha} + \frac{tan\varphi'(Wsec\alpha - ubsec\alpha)}{1 + \frac{tan\varphi'}{F_s}tan\alpha}\right]$$

$$F_s = \frac{1}{\sum Wsin\alpha}\sum\left[\frac{c'bsec\alpha}{1 + \frac{tan\varphi'}{F_s}tan\alpha} + \frac{tan\varphi'(Wsec\alpha - ubsec\alpha)}{1 + \frac{tan\varphi'}{F_s}tan\alpha}\right]$$

$$F_s = \frac{1}{\sum Wsin\alpha}\sum\left[c'b + (W - ub)\frac{tan\varphi' sec\alpha}{1 + \frac{tan\varphi'}{F_s}tan\alpha}\right]$$

$$F_s = \frac{\sum\frac{1}{m_a}[c'b + (W - ub)tan\varphi']}{\sum Wsin\alpha} ------(5)$$

Where $m_a = \left(1 + \frac{tan\varphi'}{F_s}tan\alpha\right)cos\alpha ------(6)$

Sometimes the pore pressure u is expressed in terms of pore pressure ratio r_u.In that case,

$$u = r_u \gamma h = r_u \left(\frac{W}{b}\right)$$

Equation 5 gives the factor of safety of the assumed failure surface. As the factor of safety (F,) appears on both the sides, a process of successive approximation is required. A value of F_s, is assumed and the analysis done. The value computed from Eq.5 is compared with the assumed value .If the two values differ, the process is repeated till convergence. As the convergence is rapid ,only 34 trials are required. A computer may also be used.

The effective stress analysis is generally done, but the total stress analysis is also possible. The factor of safety determined by Bishop's simplified method is an under estimate and, therefore, it errs on the safe side. The error is generally less than 2% and not more than 7% even in an extreme case.

5.9 SLOPE PROTECTION MEASURES:

The slopes which are susceptible to failure by sliding can be improved and made usable and safe, various methods are used to stabilise the slopes.

- Slope flattening reduces the weight of the mass tending to slide
- Providing a beam below the toe of the slope increases the resistance to movement
- Drainage helps in reducing the seepage forces
- Densification (on compaction increases the shear strength of soils)
- Consolidation by external load, increases the stability
- Grouting and injection of cement help in increasing the stability
- Retaining wall can be provided for lateral support, this method is costlier.
- Stabilization of the soil (removing the weak soils) improves the stability of slopes.