Objectives

In this section you will learn the following

- Introduction

LIMIT EQUILIBRIUM

The so-called limit equilibrium method has traditionally being used to obtain approximate solutions for the stability problems in soil mechanics. The method entails a assumed failure surface of various simple shapes—plane, circular, log spiral. With this assumption, each of the stability problems is reduced to one of finding the most dangerous position of the failure or slip surface of the shape chosen which may not be particularly well founded, but quite often gives acceptable results. In this method it is also necessary to make certain assumptions regarding the stress distribution along the failure surface such that the overall equation of equilibrium, in terms of stress resultants, may be written for a given problem. Therefore, this simplified method is used to solve various problems by simple statics.

Although the limit equilibrium technique utilizes the basic concept of upper-bound rules.

Of Limit Analysis, that is, a failure surface is assumed and a least answer is sought, it does not meet the precise requirements of upper bound rules, so it is not a upper bound. The method basically gives no consideration to soil kinematics, and equilibrium conditions are satisfied in a limited sense. It is clear then that a solution obtained using limit equilibrium method is not necessarily upper or lower bound. However, any upper-bound limit analysis solution will be obviously limit equilibrium solution.

Module 3 : Method of Analyses

Lecture 12 : Limit Equilibrium [Section 12.1 : Introduction]

Recap

In this section you have learnt the following

- Introduction

Objectives

In this section you will learn the following

- Problems

Problem

Obtain the ultimate load carrying capacity of the shallow footing

Trial I

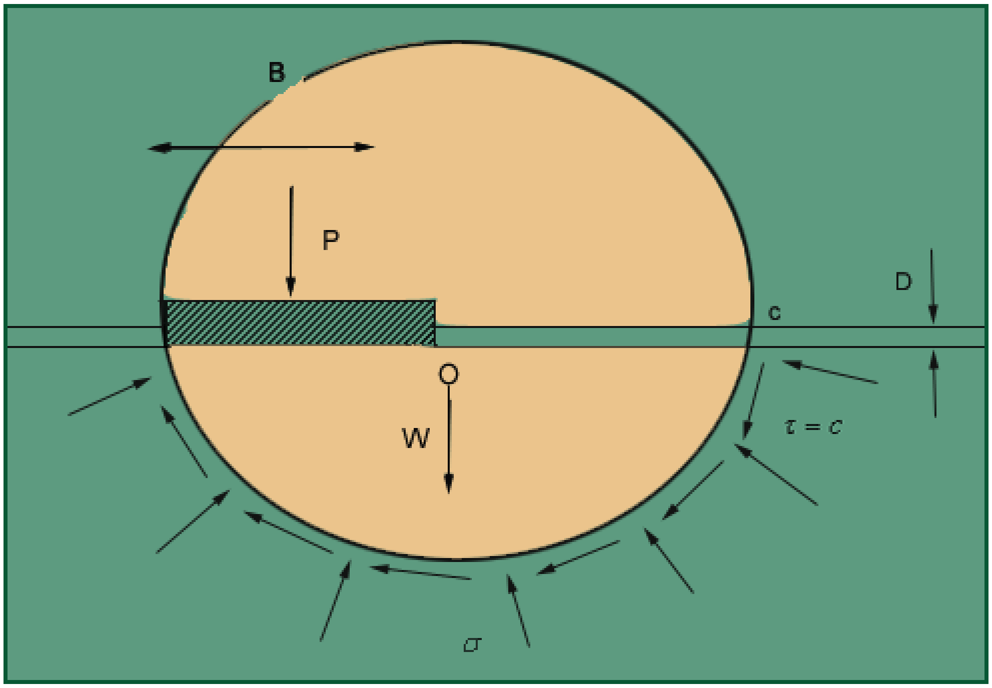

Fig. 3.1 Semicircular failure surface below footing

Consider the footing as shown in the figure 3.1 and consider the bearing capacity of the surcharged cohesive soil in which the angle of internal friction is zero. It will be assumed that there is no contact between the footing and the surcharge. The limit equilibrium solution takes as its failure mode a rotation of a semicircular section about its own center, O, located at the center of the footing. The distribution of normal stresses along the semicircular surface is unknown, but the shear stresses is assumed to be equal to the cohesion component, c.

The summation of moments about the center of rotation, O, is taken:

$$-P*0.5B+\pi B_c B+BD\gamma*0.5B+D_c B=0$$

where, the term D_cB is due to the shearing of the surcharge material. The resultant of the weight of the rotating soil, as well as the normal stresses along the circumference, pass through the center, O, and produce no moments. The ultimate bearing capacity of the footing by limit equilibrium is given by:

$$q_o=P/B=6.28_c(1+0.32D/B+0.16\gamma D/c)$$

when the footing is a surface footing, D=0 which gives ,
q_o = 6.28c , or N_c = 6.28

Trial II

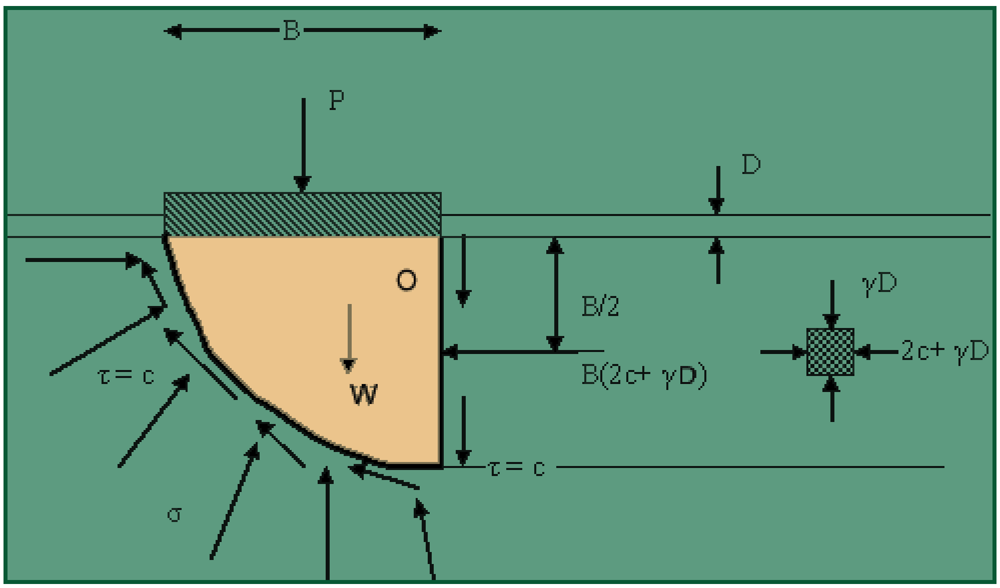

Fig. 3.2 Quarter circular failure surface below footing

Consider the quarter circular failure surface as shown in the fig. 3.2 with remaining assumptions and properties remaining same. A commonly accepted method in limit equilibrium analysis is to assume the quarter circle rotation produces uniaxial compression of the soil it bears against, as shown in the figure. The maximum compression that the soil element can sustain is $(2_c + \gamma D)$ since 2_c is the greatest allowable difference between the principle stresses and γD corresponds to a hydrostatic pressure which is in equilibrium with the surcharge at the top surface. (The pressure due to the weight of the soil in the region is neglected).

Summing up all moments about O of all the forces, we get,

$$-P*0.5B + \pi*(0.5B)cB + B(2_c + \gamma D)(0.5B) = 0$$

The ultimate bearing capacity of the footing by limit equilibrium is given by:

$$q_o = P / B = c(\pi + 2)\gamma D = 5.14c + \gamma D$$

When the footing is a surface footing, D=0 which gives ,

q_o = 5.14c , or N_c = 5.14

Therefore by assuming different failure surfaces the Limit Equilibrium method yields different results.

Recap

In this section you have learnt the following

- Problems

Congratulations, you have finished Lecture12. To view the next lecture select it from the left hand side menu of the page