CHAPTER 11

Bearing capacity of foundations

FAILURE OF FOUNDATIONS

11.1 Forms of failure: The purpose of a structural foundation is to transfer the structural loads safely to the ground below. Failure of a foundation may take one of two forms [11.9]:

(a) Catastrophic collapse of the soil beneath the foundation, if the shear strength is inadequate to support the applied load. Failures of this type are not very common, but, where they do occur, they may lead to large movements and distortion of the superimposed structures, and they may take place very rapidly.

(b) Excessive settlement of the structure, due in part to distortion of the soil mass as a result of the applied shear stresses, and in part to consolidation of the soil as a result of the increased normal stresses.

Both the settlement and the resistance to shear failure depend on the size and shape of the foundation, and on its depth below the surface, in addition to the properties of the soil. In designing a foundation, it is generally necessary to examine the possibility of both forms of failure. The ultimate resistance to catastrophic failure is considered in this chapter. Settlement problems will be examined in Chapter 12.

11.2 Types of foundation: The type of foundation selected depends on the type and magnitude of the loads to be supported, and on the properties of the soil below. Where a stratum having a high shear strength and adequate thickness exists near the surface, the structural loads may be supported on small separate pad or strip footings. The structure offers little resistance to relative movement of such foundations, and considerable distortion of the structure can result if individual footings settle differentially. This form of foundation is therefore not generally satisfactory unless the compressibility of the soil is low or the structural loads are small.
Where the total area of the footings would exceed about half the plan area of the structure, the possibility of using a raft foundation should be examined. The principal purpose of such a foundation is to spread the load over the largest possible area, so as to increase the load carrying capacity and to reduce the settlement. A raft, by restricting the relative movements of column bases, also limits the differential movements in the structure. However, a raft is itself generally much more rigid, and therefore much more susceptible to damage by differential settlement, than the structure above it. The need to strengthen the raft to resist such distortion usually makes this form of foundation unduly expensive if the differential settlements are likely to be large.

Where large settlements are likely, or where no stratum of sufficient bearing capacity exists close to the surface, it may be necessary to construct a piled foundation. The purpose of this is to carry the structural loads down to a lower stratum which is capable of supporting them. The design of piled foundations is discussed in Chapter 13.

Both shear stresses and settlements depend on the net increase in the load applied to the ground—that is, the difference between the load imposed by the structure and the weight of any excavated soil. The net load may be reduced by increasing the amount of excavation. In extreme cases, where large basements are incorporated in the structure, the imposed loads may be made equal to the weight of the excavated soil, so that there is no net increase in the load on the ground. There should then be negligible ground movements and no possibility of a catastrophic failure, regardless of the shear strength or compressibility of the soil.

11.3 Slip-line fields in the soil beneath a foundation: Fig. 11.1 shows a typical pattern of slip-lines in the soil beneath a foundation on the point of collapse. The regions $ACD$ and $A'C'D'$ are zones of passive Rankine failure, as described in Section 8.24 above. In each of these zones, there are two families of slip-lines inclined to each other at an angle $(\pi/2 + \varphi)$. The

![Fig. 11.1 Typical rupture surfaces beneath a foundation at failure.](image-url)