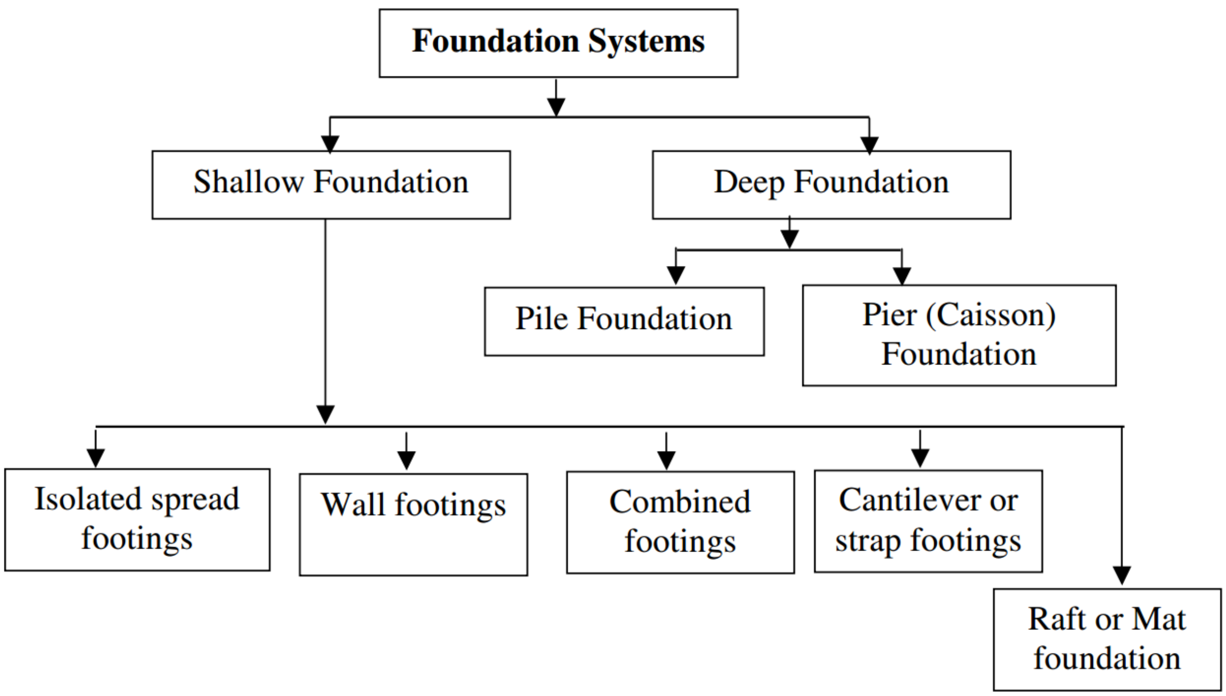
Foundation or Footing Design: Part 1

Foundation or Footing

"Footings are structural elements that transmit column or wall loads to the underlying soil below the structure. Footings are designed to transmit these loads to the soil without exceeding its safe bearing capacity, to prevent excessive settlement of the structure to a tolerable limit, to minimize differential settlement, and to prevent sliding and overturning. The settlement depends upon the intensity of the load, type of soil, and foundation level. Where possibility of differential settlement occurs, the different footings should be designed in such away to settle independently of each other. Foundation design involves a soil study to establish the most appropriate type of foundation and a structural design to determine footing dimensions and required amount of reinforcement."

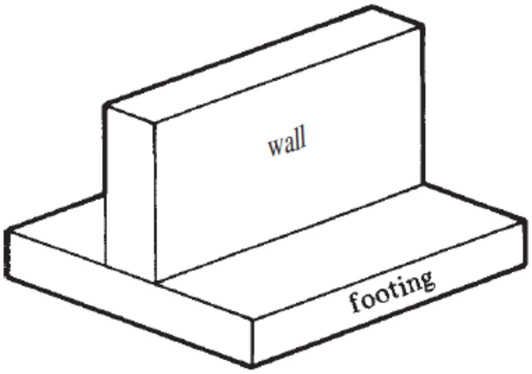
Footings may be classified as **deep or shallow**. If depth of the footing is equal to or greaterthan its width, it is called deep footing, otherwise it is called shallow footing.
Shallow Foundations – are usually located no more than 6 ft below the lowest finished floor.



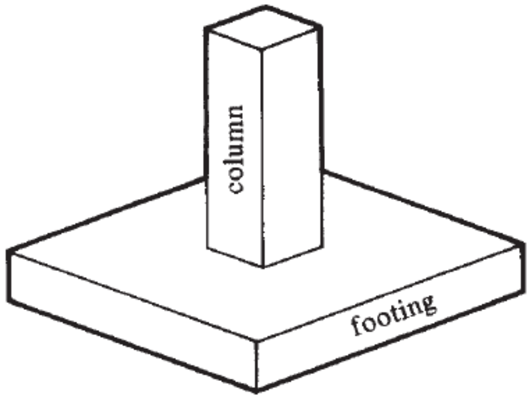
A wall footing, as shown in Figure (a), is simply an enlargement of the bottom of a wall that will sufficiently distribute the load to the foundation soil. Wall footings are normally used around the perimeter of a building and perhaps for some of the interior walls.

An isolated or single-column footing, as shown in Figure (b), is used to support the load of a single column. These are the most commonly used footings, particularly where the loads are relatively light and the columns are not closely spaced.
Combined footings are used to support two or more column loads, Figure (c). A combined footing might be economical where two or more heavily loaded columns are so spaced that

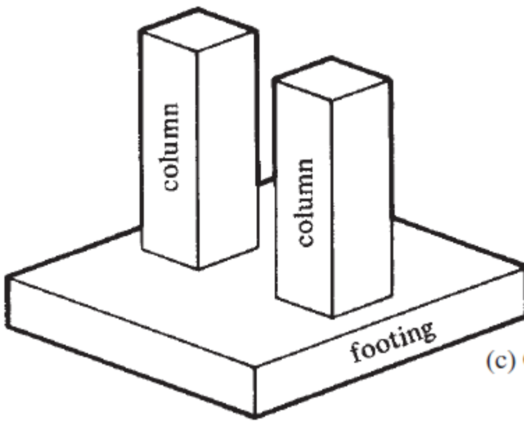
normally designed single-column footings would run into each other. Single-column footings are usually square or rectangular and, when used for columns located right at property lines, extend across those lines. A footing for such a column combined with one for an interior column can be designed to fit within the property lines.



(a) Wall footing



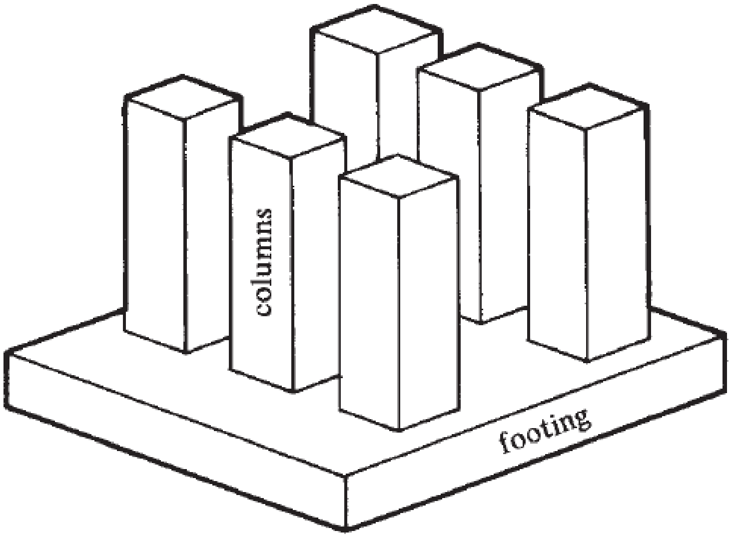
(b) Isolated or single-column footing



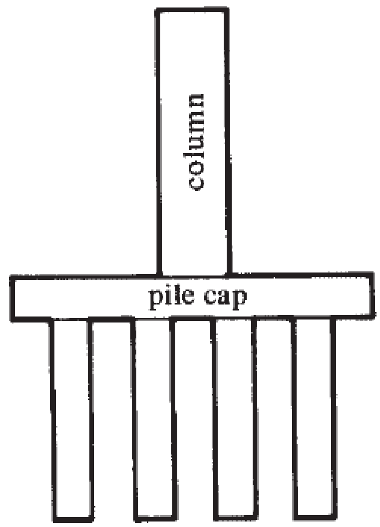
(c) Combined footing

A mat or raft or floating foundation, Figure (d), is a continuous reinforced concrete slab over a large area used to support many columns and walls. This kind of foundation is used where soil strength is low or where column loads are large but where piles or caissons are not used. For such cases, isolated footings would be so large that it is more economical to use a continuous raft or mat under the entire area. The cost of the formwork for a mat footing is far less than is the cost of the forms for a large number of isolated footings. If individual footings are designed for each column and if their combined area is greater than half of the area contained within the perimeter of the building, it is usually more economical to use one large footing or mat. The raft or mat foundation is particularly useful in reducing differential settlements between columns—the reduction being 50% or more. For these types of footings, the excavations are often rather deep. The goal is to remove an amount of earth approximately equal to the building weight. If this is done, the net soil pressure after the building is constructed will theoretically equal what it was before the excavation was made. Thus, the building will float on the raft foundation.

Pile caps, Figure (e), are slabs of reinforced concrete used to distribute column loads to groups of piles.



(d) Mat or raft or floating foundation



(e) Pile cap

Figure: Types of footing

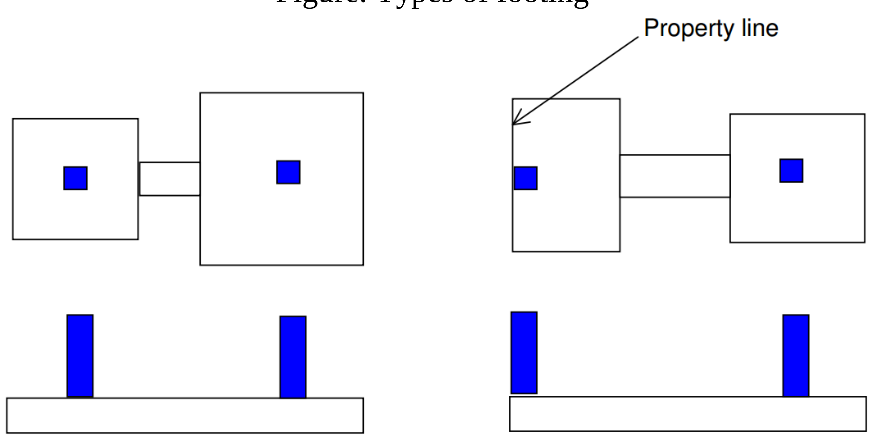


Figure: Cantilever or strap footings

Cantilever or strap footings: These are similar to combined footings, except that the footings under columns are built independently, and are joined by strap beam.

Pressure Distribution below Footings

The soil pressure at the surface of contact between a footing and the soil is assumed to be uniformly distributed as long as the load above is applied at the center of gravity of the footing. This assumption is made even though many tests have shown that soil pressures are unevenly distributed due to variations in soil properties, footing rigidity, and other factors.

When a rigid footing is resting on sandy soil, the sand near the edges of the footing tends to displace laterally when the footing is loaded. This tends to decrease in soil pressure near the edges, whereas soil away from the edges of footing is relatively confined. On the other hand, the pressure distribution under a footing on clay is similar to Figure below. As the footing is loaded, the soil under the footing deflects in a bowl-shaped depression, relieving the pressure under the middle of the footing. For design purposes, it is common to assume the soil pressures are linearly distributed.

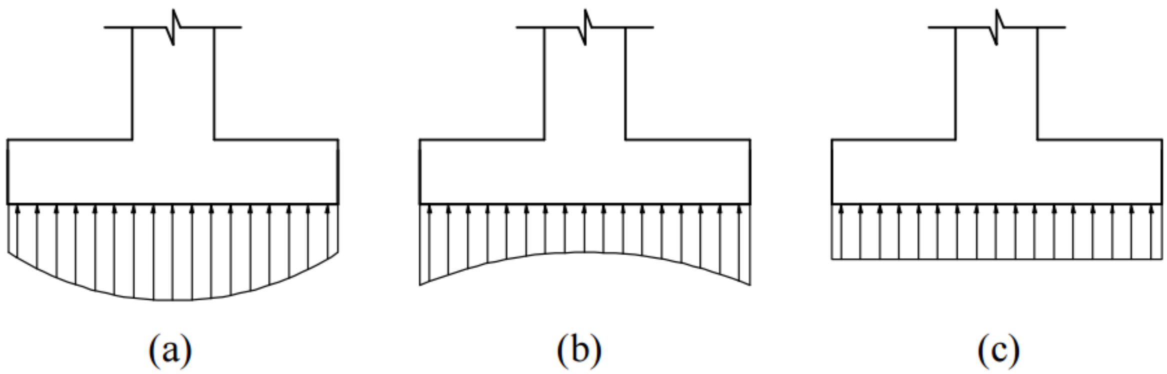
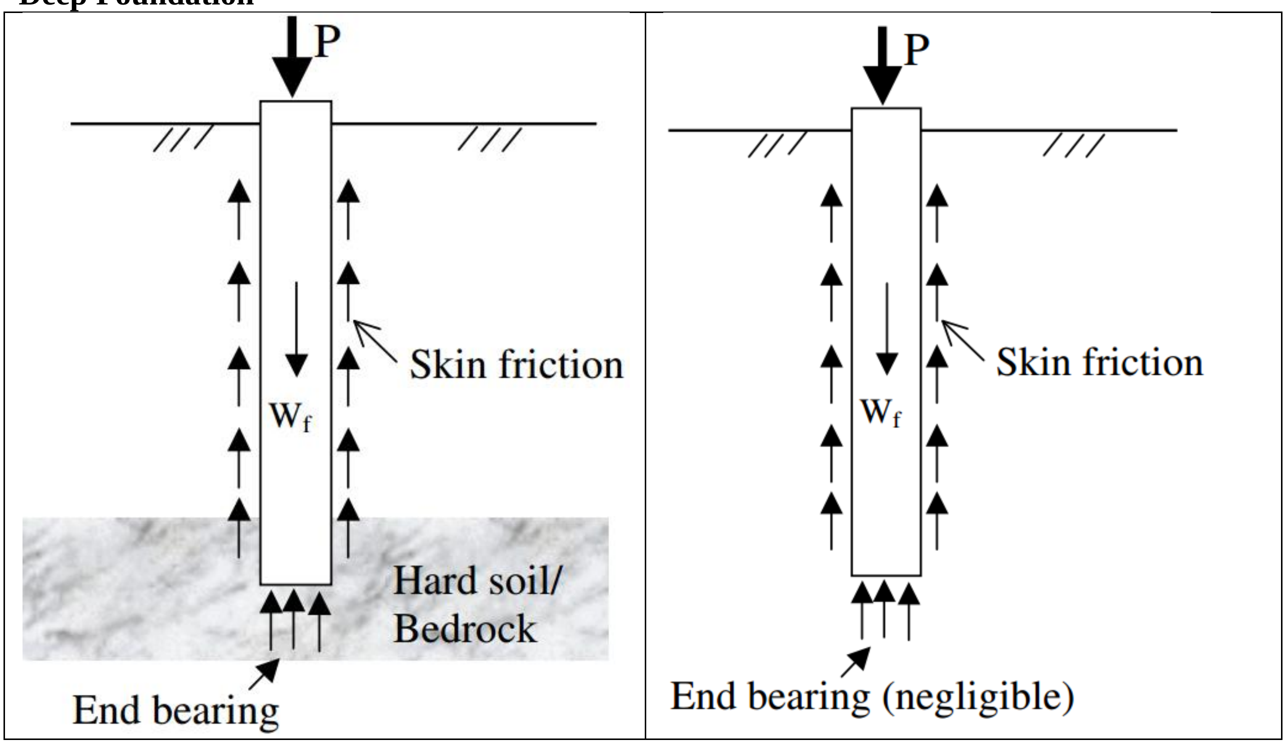


Figure: Pressure distribution under footing; (a) footing on sand; (b) footing on clay; (c) equivalent uniform distribution

Deep Foundation



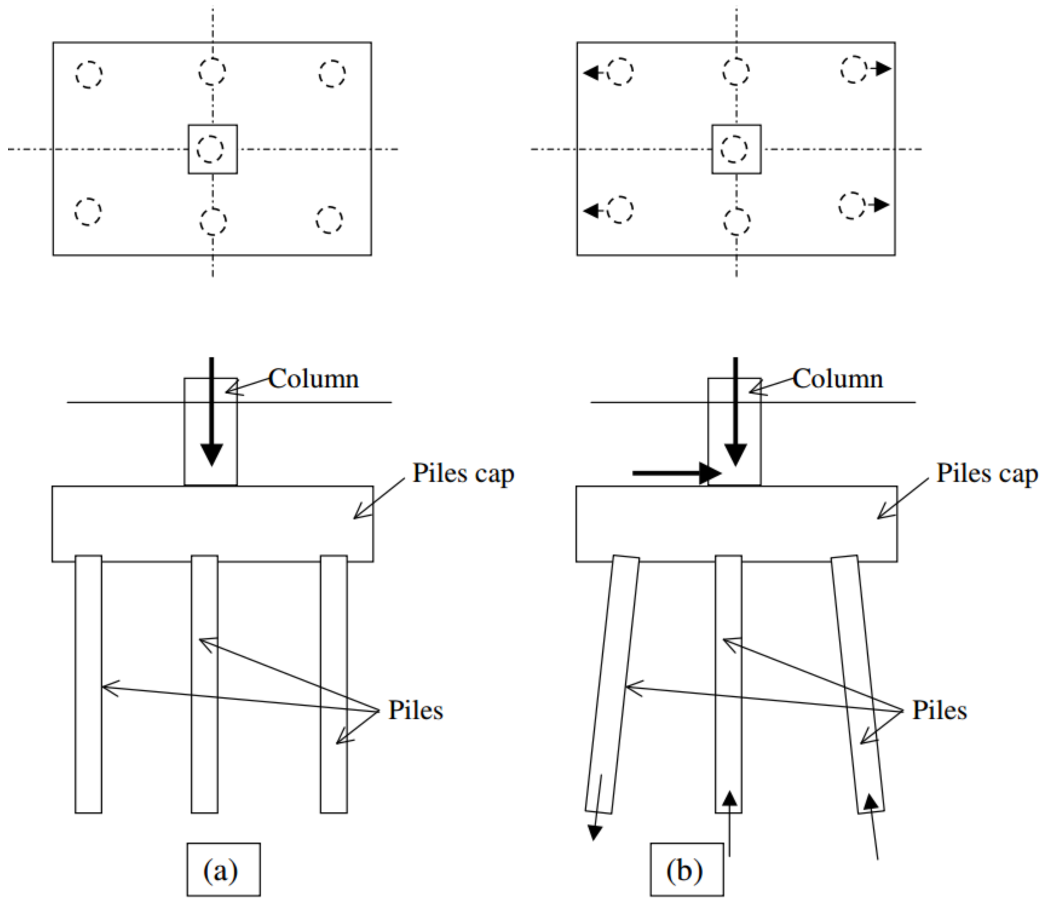
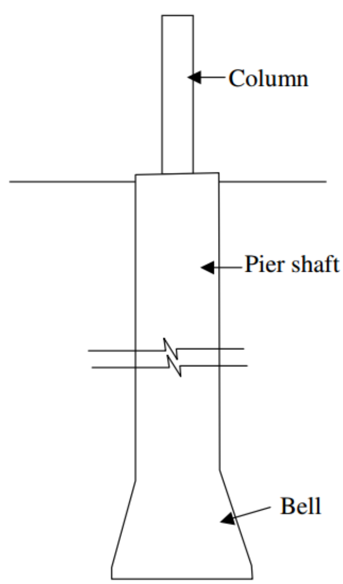


Fig. Pile Foundation- (a) Vertical Piles; (b) Battered Piles



Pier Foundation (Caisson)

TABLE: Maximum Allowable Soil Pressure

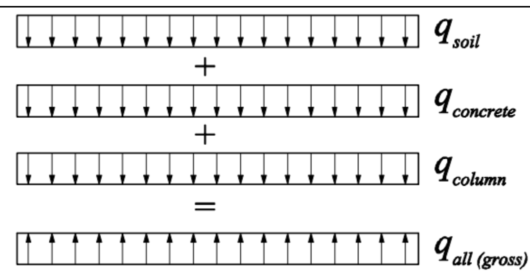
Class of Material	Maximum Allowable Soil Pressure: U.S. Customary Units (kips/ft^2)	Maximum Allowable Soil Pressure: SI Units (kN/m^2)
Rock	20% of ultimate crushing strength	20% of ultimate crushing strength
Compact coarse sand, compact fine sand, hard clay, or sand clay	8	385
Medium stiff clay or sandy clay	6	290
Compact inorganic sand and silt mixtures	4	190
Loose sand	3	145
Soft sand clay or clay	2	95
Loose inorganic sand–silt mixtures	1	50
Loose organic sand–silt mixtures, muck, or bay mud	0	0

The allowable soil pressure for soil may be either gross or net pressure permitted on the soil directly under the base of the footing. The gross pressure represents the total stress in the soil created by all the loads above the base of the footing. These loads include: (a) column service loads; (b) the weight of the footing; and (c) the weight of the soil on the top of the footing, or

$$q_{gross} = q_{soil} + q_{footing} + q_{column}$$

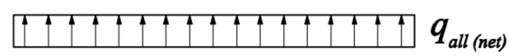
For moment and shear calculations, the upward and downward pressures of the footing mass and the soil mass get cancelled. Thus, a net soil pressure is used instead of the gross pressure value, or

$$q_{net} = q_{gross} - q_{footing} - q_{soil}$$



$$q_{all\,(gross)} = q_{soil} + q_{concrete} + q_{column}$$

(a)



$$q_{all\,(net)} = q_{all\,(gross)} - q_{soil} - q_{concrete}$$