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16.1) Types and Functions

- Footings are the last structural elements through which loads pass, and are almost always made from reinforced concrete.

- Footings support columns and walls and transmit and distribute their loads to the underlying soil. Since soil is much weaker than the concrete columns and walls that must be supported, contact area between soil and footing is much larger than the supported member.
16.2) Spread Footings

- Spread footings can be classified as wall and column footings.

- A wall footing is simply a strip of reinforced concrete, wider than the wall, that distributes its pressure.

- Single column footing is usually a square, sometimes rectangular, representing the simplest and most economical type.

- The use of single column footings is met with difficulty of property rights that prevents the use of footings projecting beyond the exterior walls.

- Combined footings or strap footings are used to enable one to design footings under two or more columns that will no extend beyond property lines. This type of footings can also be used under closely spread, heavily loaded, columns.

- Spread footings are the most commonly used types of footings. If the soil is weak and/or column loads are great, a mat or raft foundation that extends under the full area of the building is required, unless a deep foundation is called for by soil conditions.
16.3) Design Factors

- In ordinary construction, the load on a wall or column is transmitted vertically to the footing, which in turn is supported by the upward pressure of the soil.

- If the load is symmetrical with respect to the bearing area, the bearing pressure is assumed to be uniformly distributed, which is only approximately true.

- Under footings resting on coarse-grained soils, the pressure is larger at the center of the footing and decreases toward the perimeter. This is so because the individual grains in such soils are somewhat mobile, so that the soil located close to the perimeter can shift slightly outward in the direction of the lower soil stresses.

- In clay soils, pressure are higher near the edge than at the center of the footing, since in such soils the load produces a shear resistance around the perimeter that adds to the upward pressure.

- It is customary to ignore the aforementioned non-uniformities and assume constant pressure under the footing.
16.4) Loads, Bearing Pressures,

- Unlike to the strength design of other structural members which uses factored loads and factored nominal strengths, footing design is determined for *unfactored service loads* and *allowable soil bearing pressure* \( q_a \). This is because, for footing design, safety is provided by overall safety factors.

- Allowable bearing pressures are established from principles of soil mechanics, and are usually based on a safety factors of 2.5 to 3.0 against exceeding the bearing capacity of the soil.

- For concentrically loaded footings, the required area is determined from:

  \[ A_{req} = \frac{D+L}{q_a} \]  
  \( (16.1) \)

- For eccentrically loaded footings, the following flexural formula

  \[ q_{\text{max,min}} = \frac{P \pm Mc}{A} \]  
  \( (16.3) \)

  Permits the determination of the bearing pressure at the two extreme edges. The footing area is found by trial and error from the condition \( q_{\text{max}} \leq q_a \).
If the eccentricity falls outside the kern, Eq. (16.3) gives a negative value (tension) for $q$ along one edge of the footing. Since no tension can be transmitted from the soil, Eq. (16.3) is no longer valid and the maximum pressure can be found from:

$$\rightarrow q_{max} = \frac{2P}{3bm} \quad (16.4)$$

Which must not be larger than the allowable pressure $q_a$.

Once the required footing area has been determined, the footing must be designed to resist all moments, shears, and other internal actions caused by the applied loads.

The final footing design is based on the regular factored load:

$$\rightarrow U = 1.2D + 1.6L$$

The bearing pressures are recalculated for the factored loads for the purpose of strength computations. These fictitious pressures that are needed only to determine the factored loads for use in design. To distinguish them from the actual pressures $q$ under service loads, the soil pressures that equilibrate the factored loads $U$ are designated as $q_u$. 