ELEMENTS OF ENGINEERING I (ENGG 111)

BUILDING MATERIALS, COMPONENTS AND STRUCTURE

Lecture 2

FOUNDATION

Phases of building construction

Component/stages of RCC residential building construction (photos)

FOUNDATION BRICK SOLING (FOLLOWED BY E/W Excavation)

Laying of footing bar (followed by PCC above brick soling)

RCC residential building construction phase photos

Isolated footing with column

Combined footing with column before concreting

RCC residential building construction phase photos

Continuous footing with column layout before concreting

Pouring of concrete in continues footing

RCC residential building construction phase photos

Concreting of isolated footing

Finished concrete in combined footing

RCC residential building construction phase photos

Construction of external wall above footing

Construction of plinth portion

RCC residential building construction phase photos

Substructure Up to plinth

Plinth beam rebar detailing

RCC residential building construction phase photos

Plinth beam rebar detailing

Construction of Superstructure

RCC residential building construction phase photos

Rebar detailing of super structure (staircase)

Rebar detailing of super structure (beam slab and lift core)

RCC and Steel composite structure construction phase phots

RCC with steel truss (Multipurpose hall of KU, Construction photos)

Different structures (Building Civil Construction)

https://www.dudbc.gov.np/uploads/default/files/a1efdb9058f9151775d9a2bae473ac0b.pdf

FOUNDATION

The lowest part of the structure which provides a base to transmit load from the building to sub-soil.

Foundations are provided to:

- Distribute **the load of building over a large area**.
- Limit **the magnitude and unequal settlements**
- Provide **a level surface**
- Take the structure **deep into ground to ensure stability and prevent overturn**

Kind of Loads in Building Foundation

1. DEAD LOAD	2.	LIVE LOAD
3. WIND LOAD	4.	SEISMIC LOAD

Load transfer must be in following ways

1. Settlement are within **permissible limits**
2. Soil doesn't fail in shear (**soil bearing capacity**)
3. Proper load transfer (load path proper to subsoil)

REQUIREMENT OF GOOD FOUNDATION

i. Shall sustain Dead Load + Live Load, and transmit to the subsoil in such a way that no settlement and no soil failure occurs
ii. Foundation base should be rigid so that differential settlement are limited when unequal load distribution occurs
iii. No distress due to swelling or shrinkage of the sub soil, (so deepen must be founded)
iv. Should be so located that its performance may not be affected due to any unexpected future influences
v. Should be stable and safe against overturning

BEARING CAPACTIY OF SOIL (kN/m^2)

- *the capacity of soil to support the loads applied to the ground*

- Measure of maximum average contact pressure between foundation and soil where by it doesn't produce shear failure
- Minimum depth of Footing(By Rankine)

$$H=P/w*((1-\sin\Phi)/(1+\sin\Phi))^2$$

P= Safe bearing capacity of soil

w=Unit wt. of Soil

Φ=Angle of response of soil

Always Should be greater than 0.90 m

- Width of wall foundation (B) =Design load per unit length of wall/Soil Bearing Capacity
- Area of Column Footing=Load Carried by column/B.C of Soil

NBC:205, Foundation soil and foundation safe bearing classification

S.N.	Safe Bearing Capacity (kN/m2)	Foundation type	Soil /foundation material
1	>200	Hard	Rock, Gravel
2	150-200	Medium	Sand
3	100-150	Soft	Clay
4	50-100	Week	Loose Clay

NBC: National Nepal Building Code 205:1994

TYPES OF FOUNDATION

1. Shallow foundation, Depth (D) <=Breadth (B)
2. Deep foundation, Depth (D) > Breadth (B)

1. Shallow foundations
    i. Spread foundation
    ii. Combined foundation
    iii. Strap foundation
    iv. Mat foundation
2. Deep foundation
    i. Pile foundation
    ii. Pier foundation/ Drilled Cassion foundation
    iii. Well foundation/ Cassion foundation

SHALLOW FOUNDATION

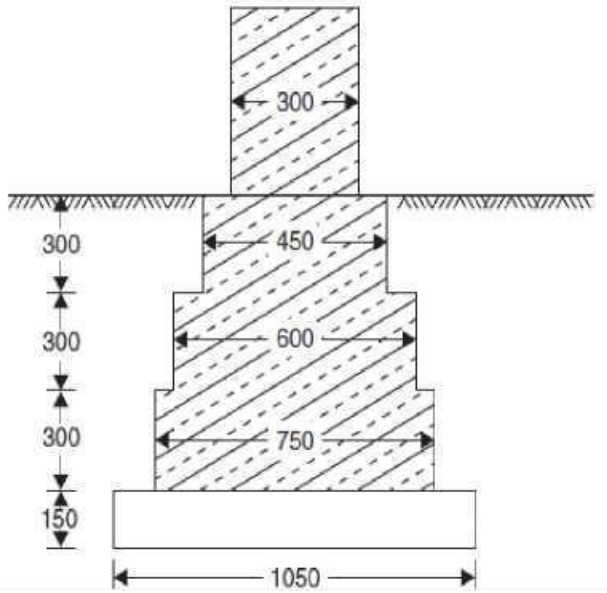
1. SPREAD FOUNDATION

TYPES

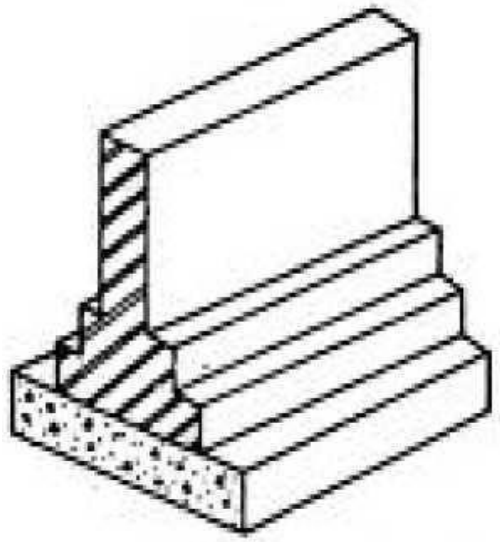
i. CONVENTIONAL SPREAD FOOTING/WALL FOOTING
ii. RCC SPREAD FOOTING
iii. GRILLAGE FOUNDATION

a. CONVENTIONAL SPREAD FOOTINGS

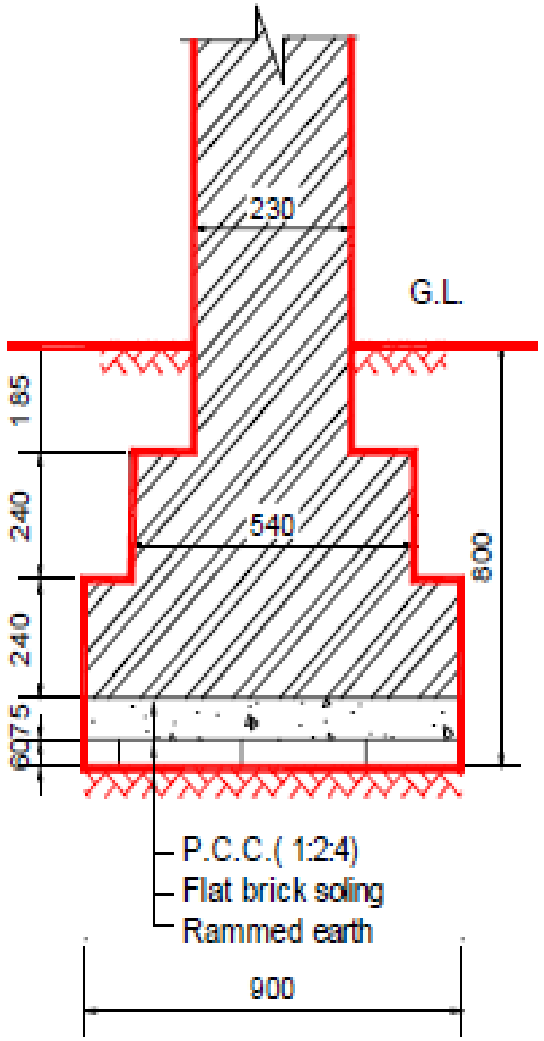
- This type of foundations are commonly used for walls and masonry columns
- These foundations are built after digging the trenches to required depth.
- Such footings are economical up to a maximum depth of 3 m.
- Also called shallow foundations.
- Plain Cement concrete 1:4:8
- Concrete Thickness:150 to 200 mm
- Built in course such that each course project 50 to 75 mm from the course lying above it.



3 stepped wall footing

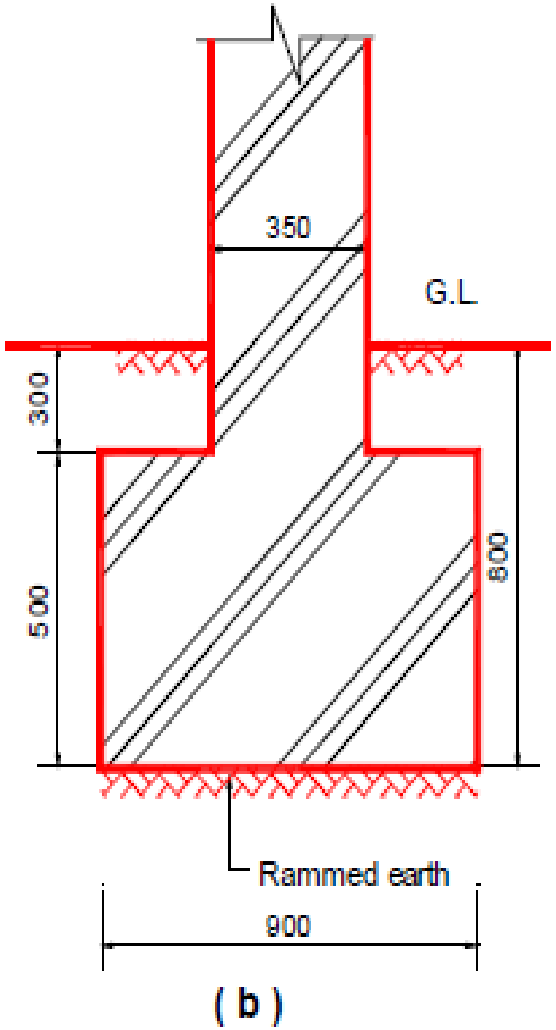


2 stepped wall footing



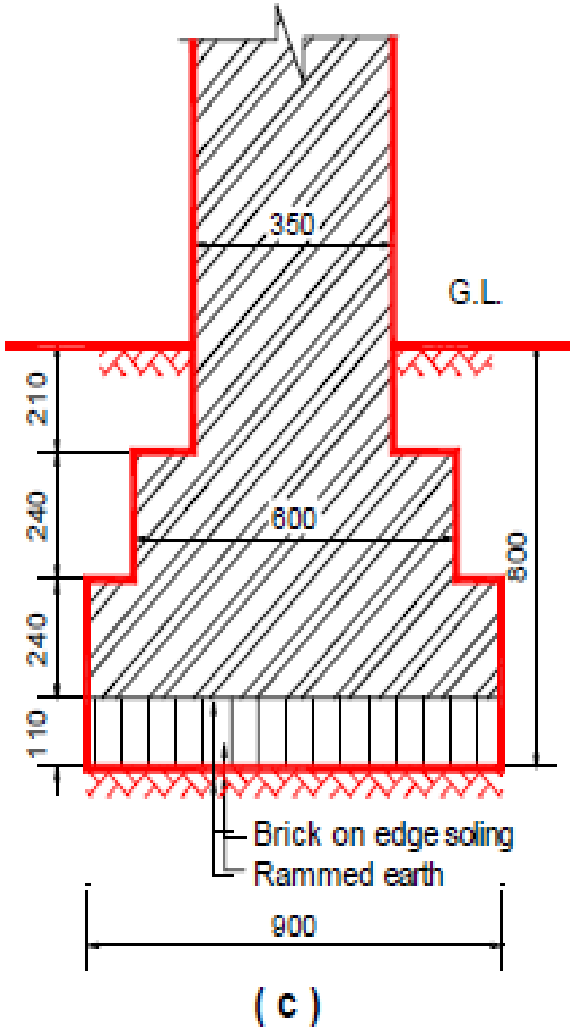
(a)

Brick masonry cement mortar (1:6)



(b)

Stone Masonry cement mortar (1:6)



(c)

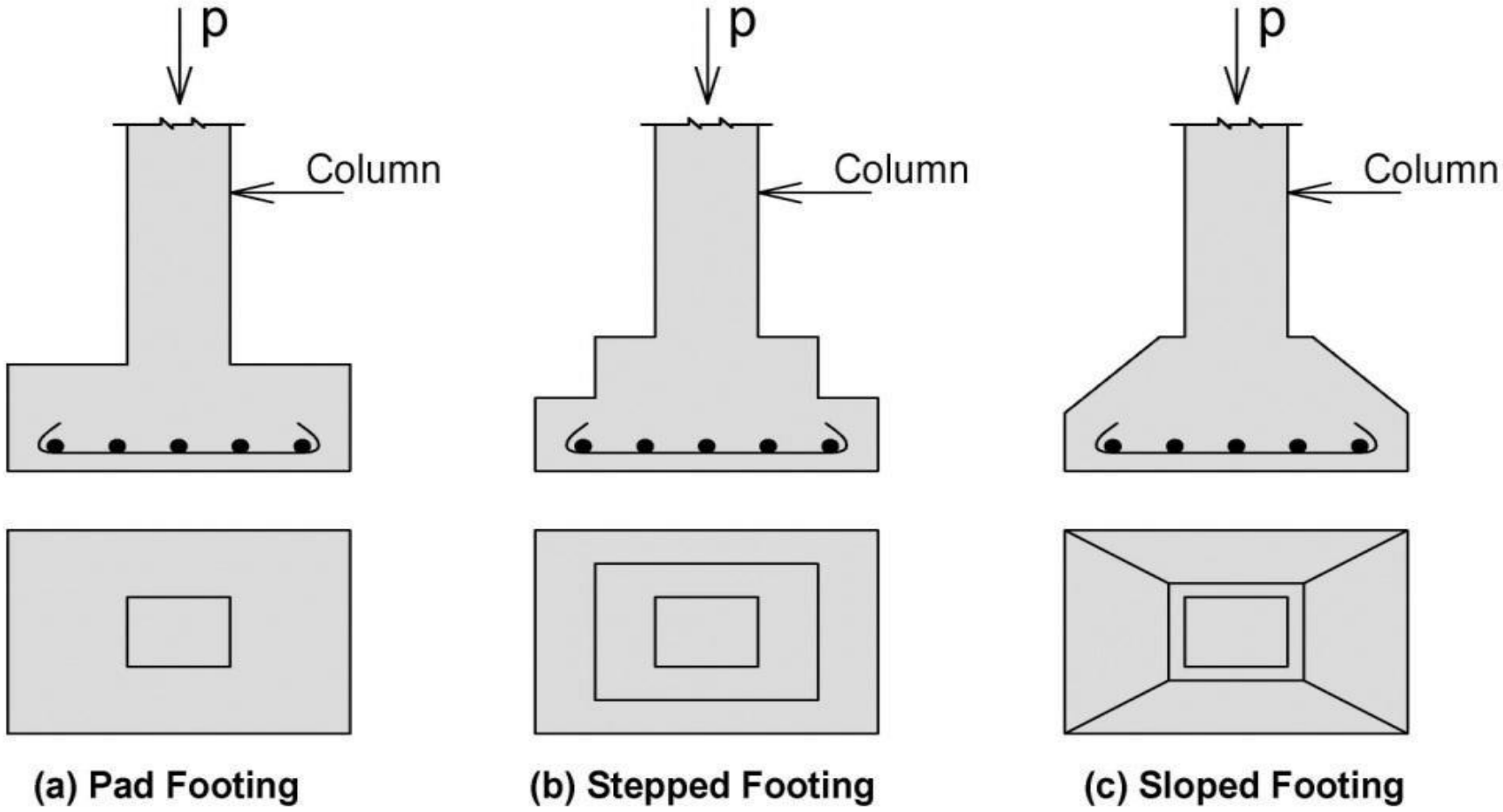
Brick Masonry Mud mortar

Fig: NBC 202, typical footing for one story load bearing wall

SHALLOW FOUNDATION

b. RCC SPREAD FOOTING/ ISOLATED FOOTING (for smaller load on column)

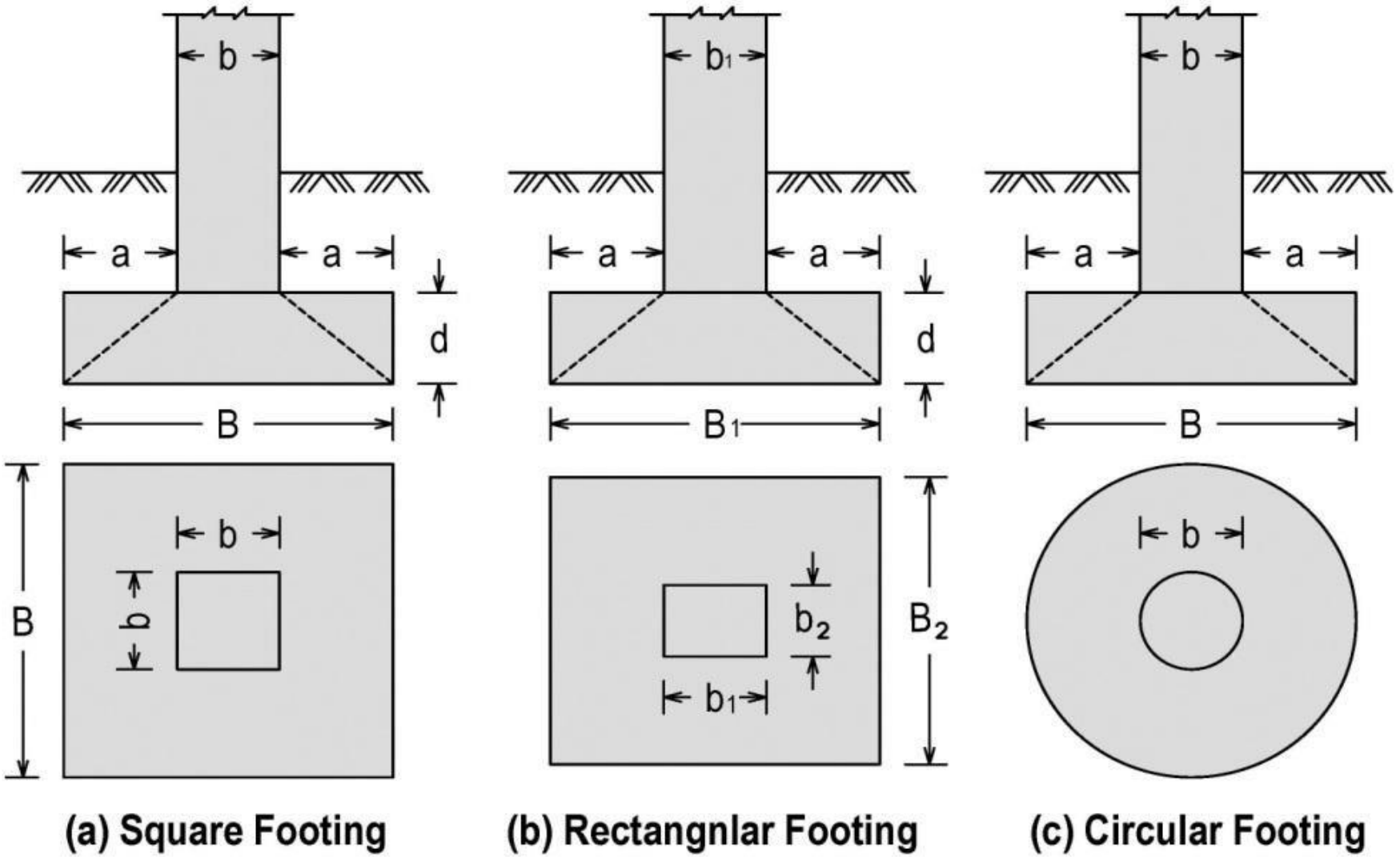
- may be sloped or not sloped
- May be square, rectangular or circular in plan



(a) Pad Footing (b) Stepped Footing (c) Sloped Footing

SHALLOW FOUNDATION

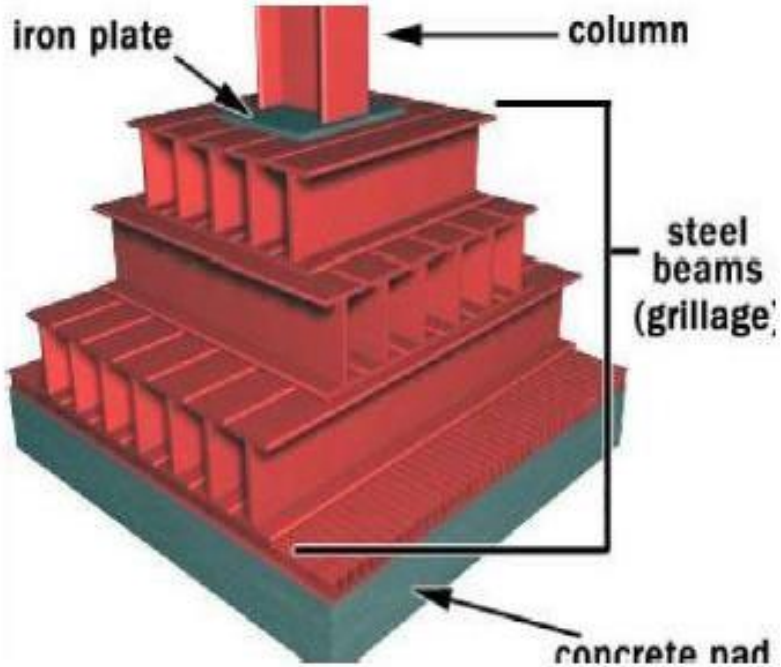
RCC SPREAD FOOTING/ ISOLATED FOOTING



(a) Square Footing (b) Rectangnlar Footing (c) Circular Footing

c. Grillage Foundation

- Used when **load on foundation is too heavy and the bearing capacity of soil is low**.
- It consists of one tier or more tiers of I-sections steel beams.
- Top tier consists of less number but large size steel section while lower tier consists of larger number but smaller size steel sections.
- Column load is transferred to the top tier through a base plate.

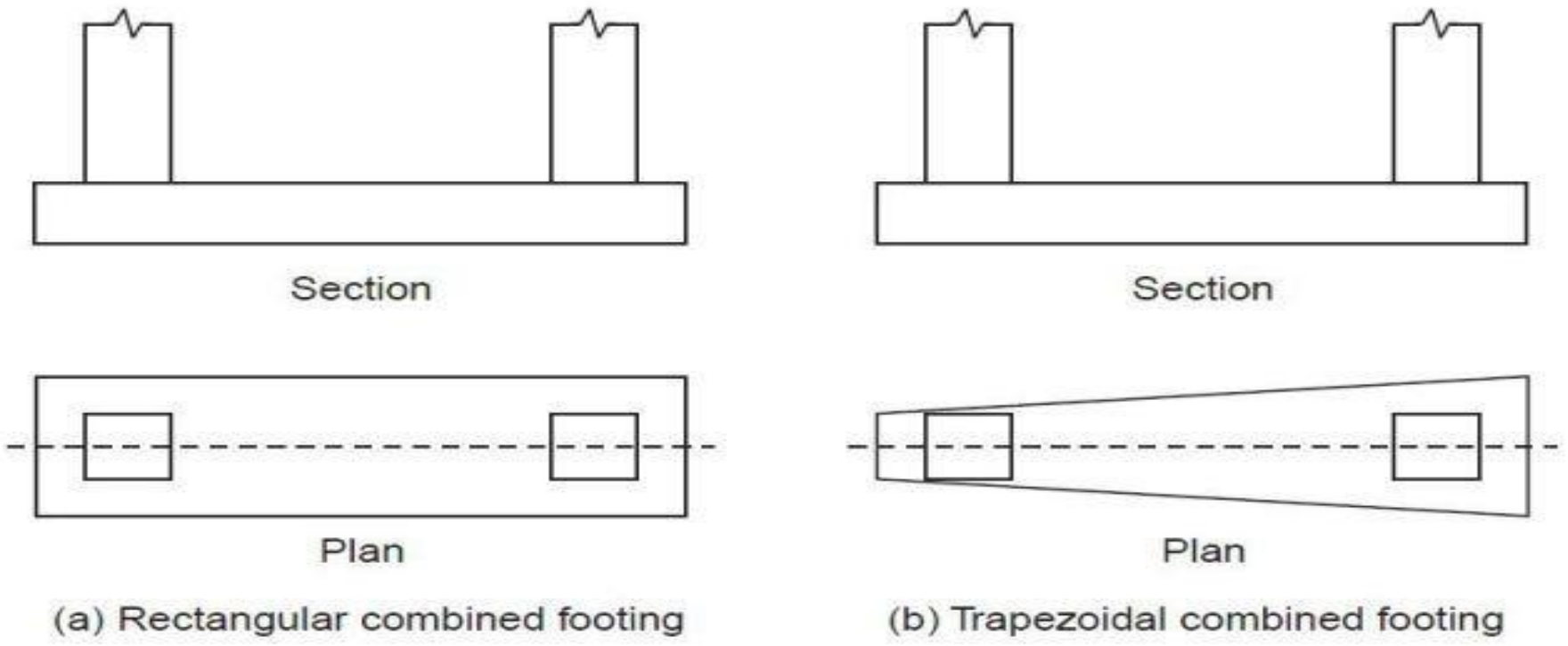


Steel Grillage

SHALLOW FOUNDATION

2. COMBINED FOUNDATION

- When two or more columns are close to each other their foundation may overlap in such case combined footing is provided
- These may be rectangular or trapezoidal shape in plan
- These may be for wall and column footings
- Continuous footing , if more then two column are in combined footing



(a) Rectangular combined footing

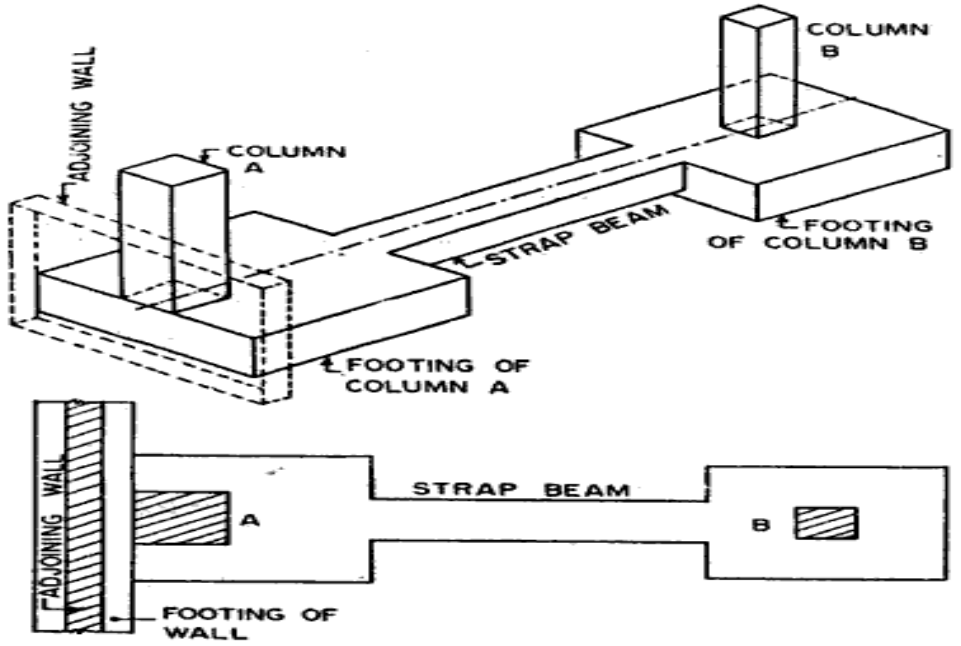
(b) Trapezoidal combined footing

Combined Footing on site

SHALLOW FOUNDATION

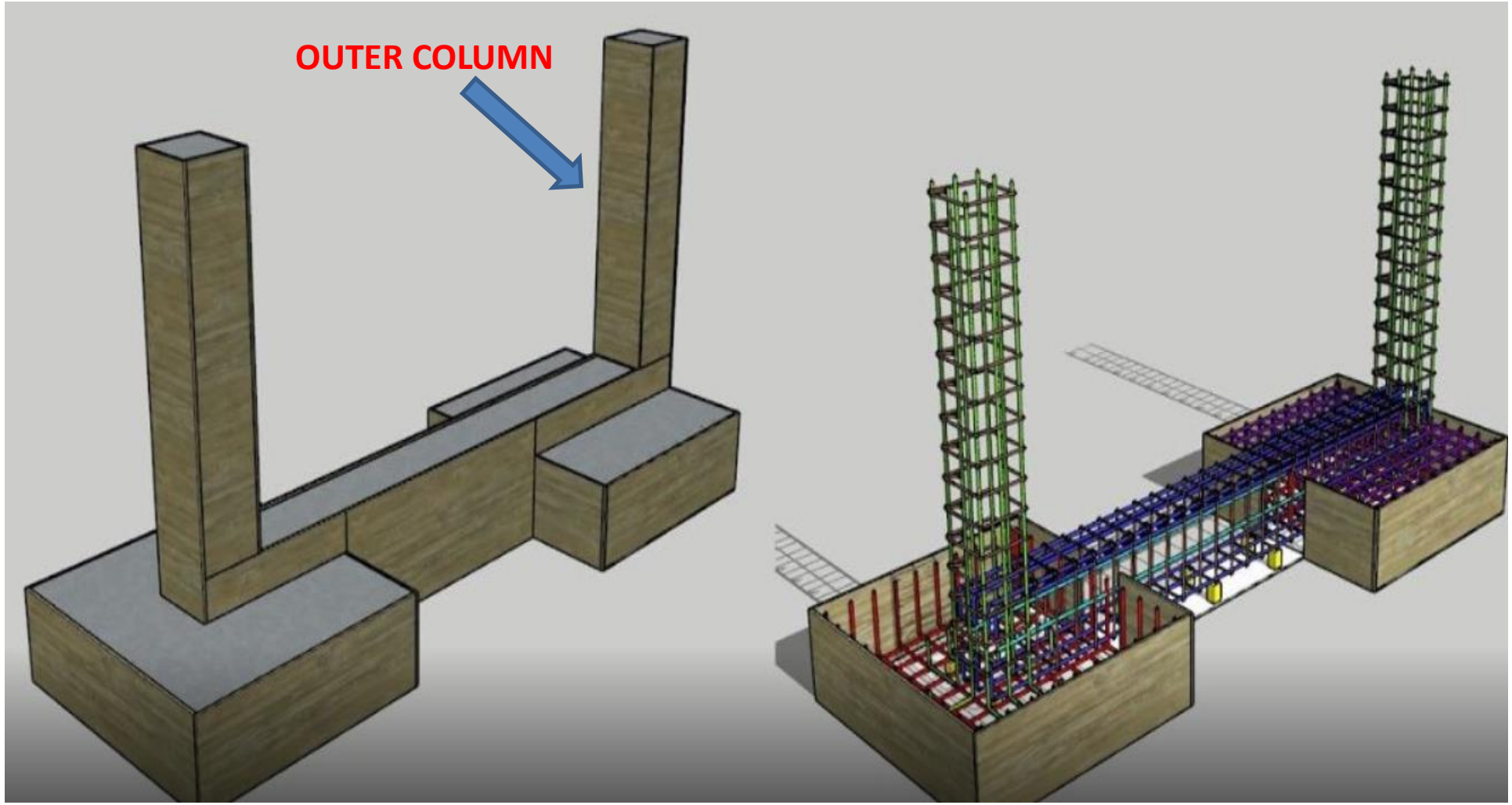
3. STRAP FOUNDATION

- If two isolated footings are **joined by beam called strap beam**, such footing is known as strap footing
- The beam joining **is called strap footing**
- If there is lack of land in corner , corner line of column are joined with interior line of columns for load transfer with strap beam



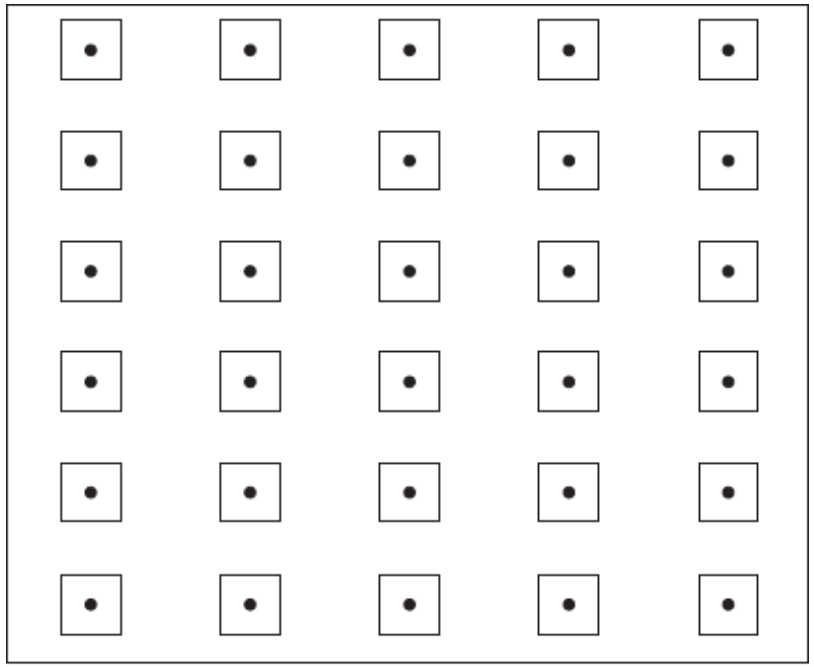
SHALLOW FOUNDATION

3. STRAP FOUNDATION



https://structville.com/2021/04/design-of-strap-footing-cantilever-footing.html

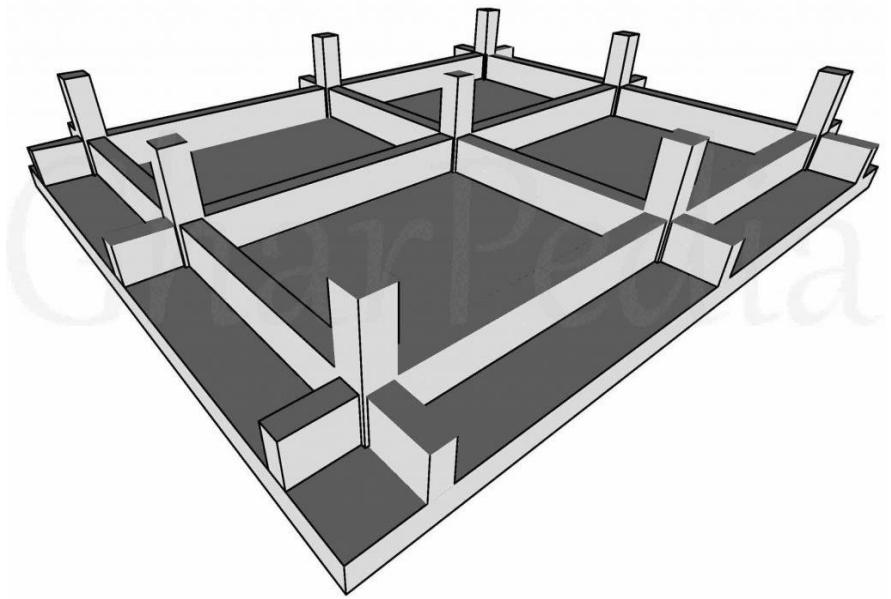
4. Mat Footing/Raft Footing



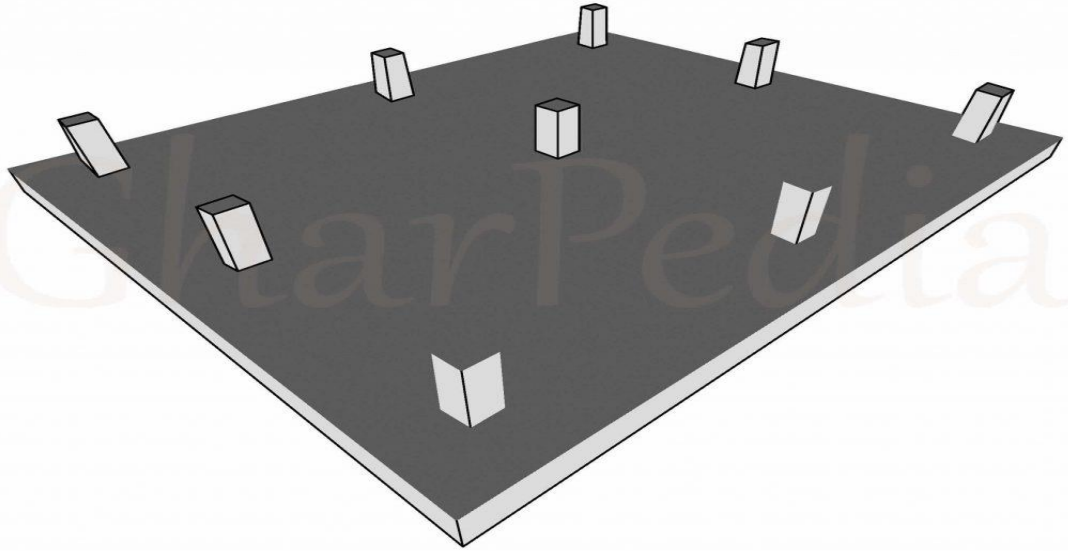
- If the load on the column is quite high (Multistory columns), isolated columns overlap with each other, in such situation a common footing may be provided to several columns also known as raft footings.

- When beams are provided in both directions over the footing slab for connecting columns, the raft foundations may be called as grid foundation

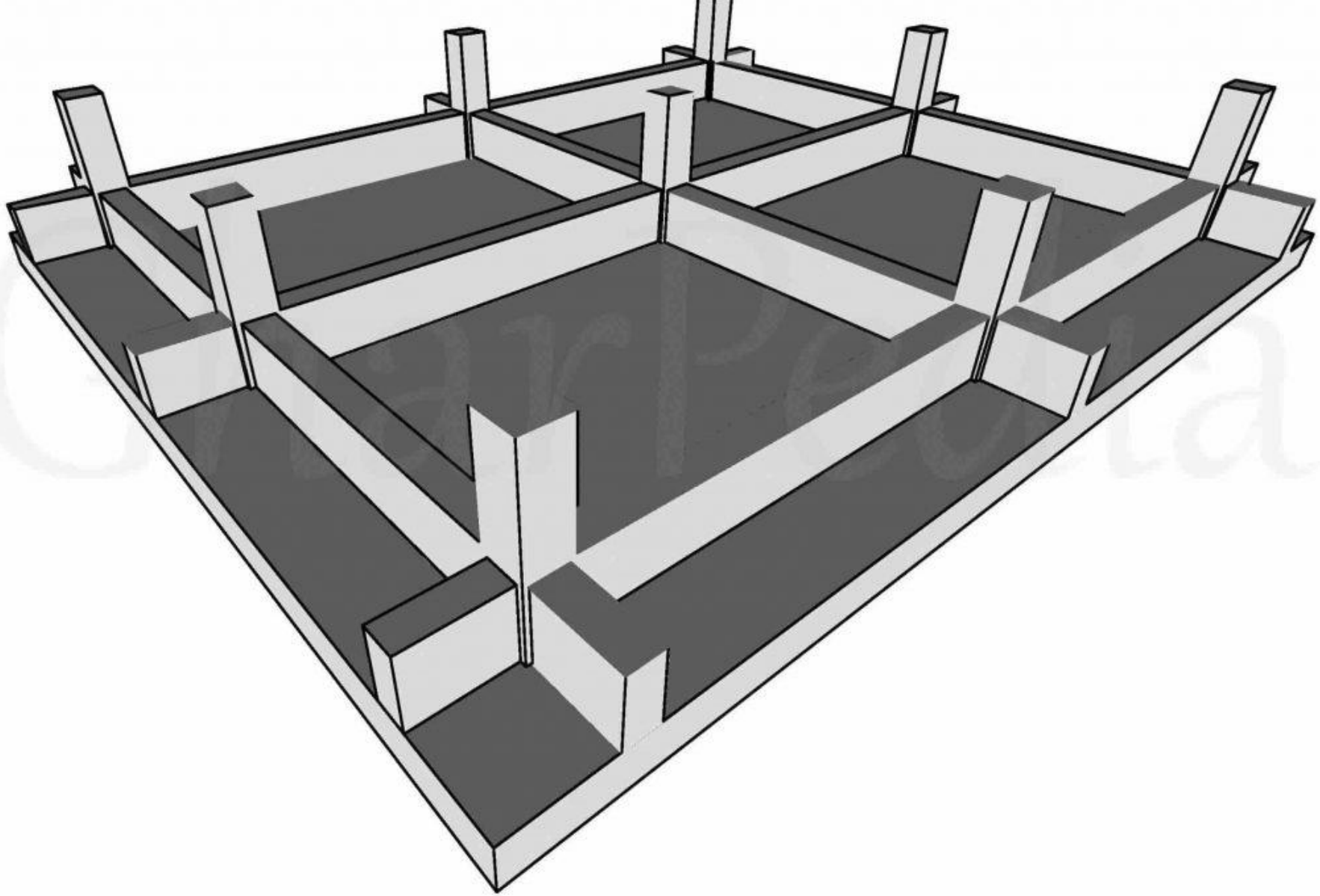
- Advantage of such footing is settlement is uniform.



Slab-beam type raft foundation



Flat slab type raft foundation



Slab-beam type raft foundation

DEEP FOUNDATION

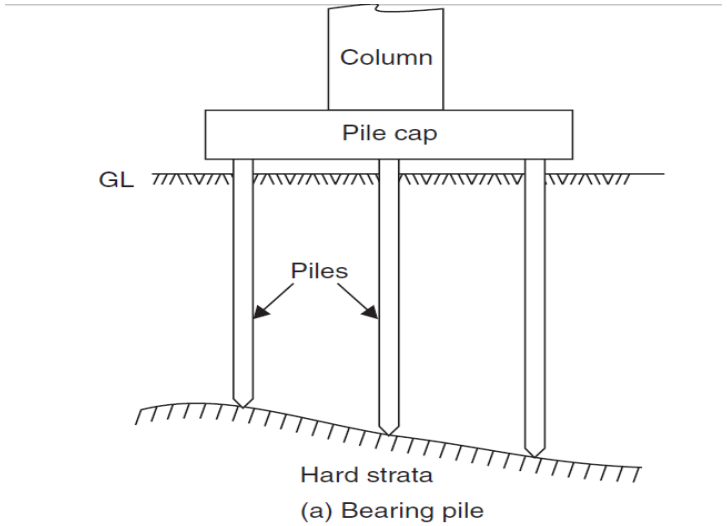
1. PILE FOUNDATION

- A **pile** is basically **a long cylinder of a strong material such as concrete that is pushed into the ground** to act as a steady support for structures built on top of it.

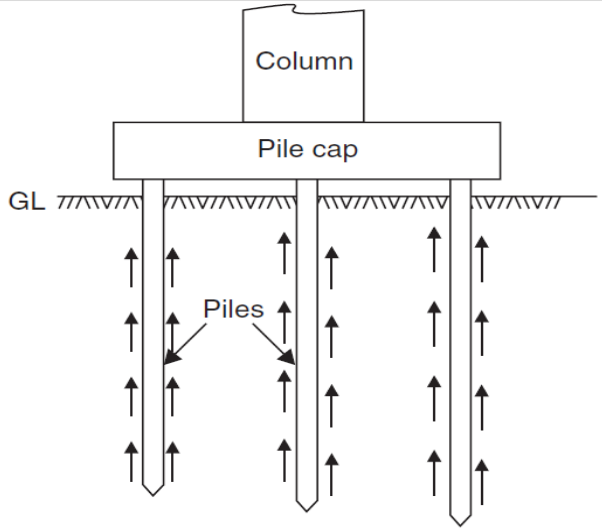
Pile foundations are used in the following situations:

(a) When there is a layer of weak soil at the surface. This layer cannot support the weight of the building, so the loads of the building have to bypass this layer and be transferred to the layer of stronger soil or rock that is below the weak layer.

(b) When a building has **very heavy concentrated loads and its distribution is uneven**, such as in a high rise structure, bridge, or water tank



(a) Bearing pile



(b) Friction pile

DEEP FOUNDATION

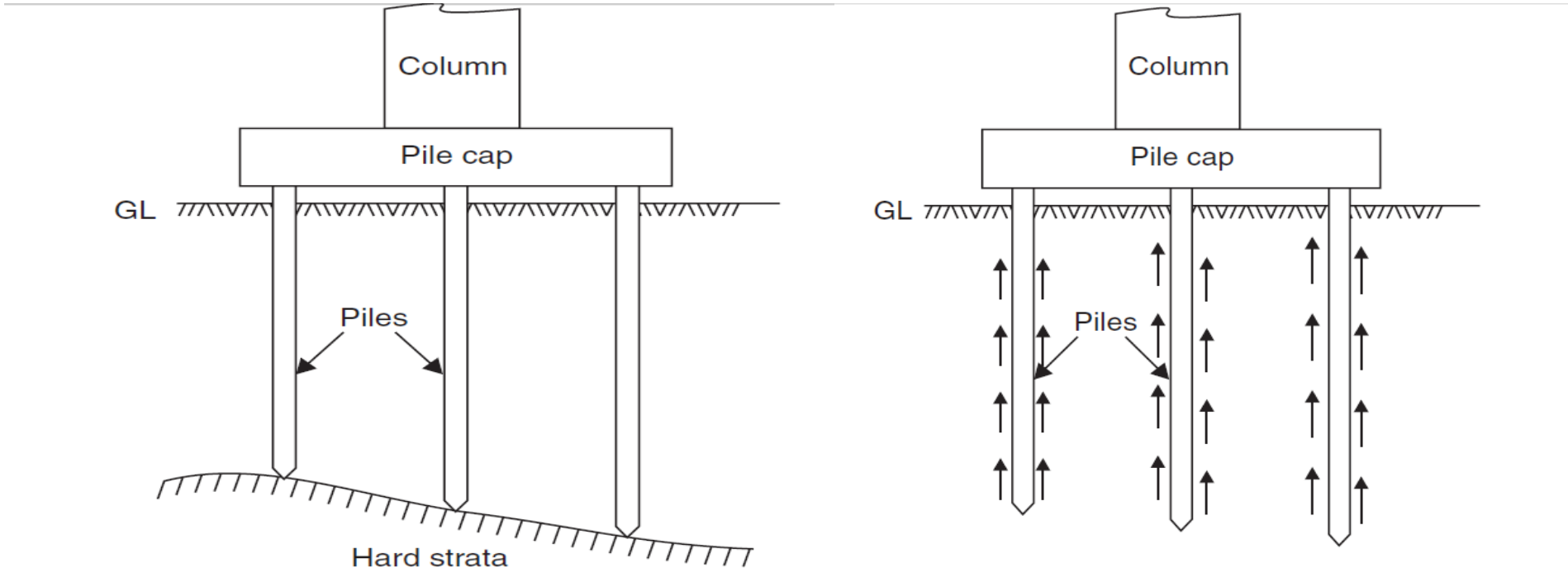
1. PILE FOUNDATION

Types:

(1) bearing pile (driven into ground until hard ground stratum reached)

(2) friction pile (transfer load by friction between surrounding soil and pile surface area)

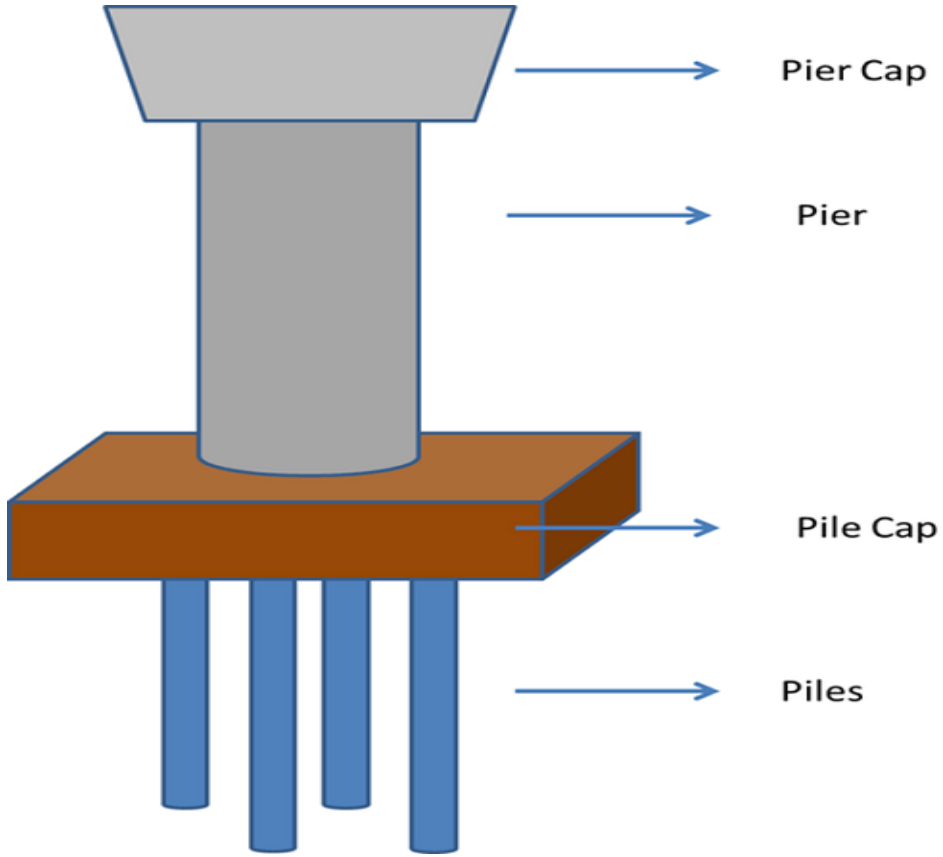
(3) both bearing and friction pile (both friction and bearing load transfer**)**



DEEP FOUNDATION

2. PIER FOUNDATION

- ✓ A *pier foundation* is a collection of **large diameter cylindrical columns to support the superstructure** and transfer large super-imposed loads to the firm strata below.
- ✓ It stood several feet above the ground. It is also known as **"post foundation"**



DEEP FOUNDATION

3. WELL FOUNDATION

- **Well foundation** is a type of deep **foundation** which is generally provided **below the water level for bridges.**
- Cassions or **well** have been in use for **foundations** of bridges and other structures since Roman and Mughal periods.

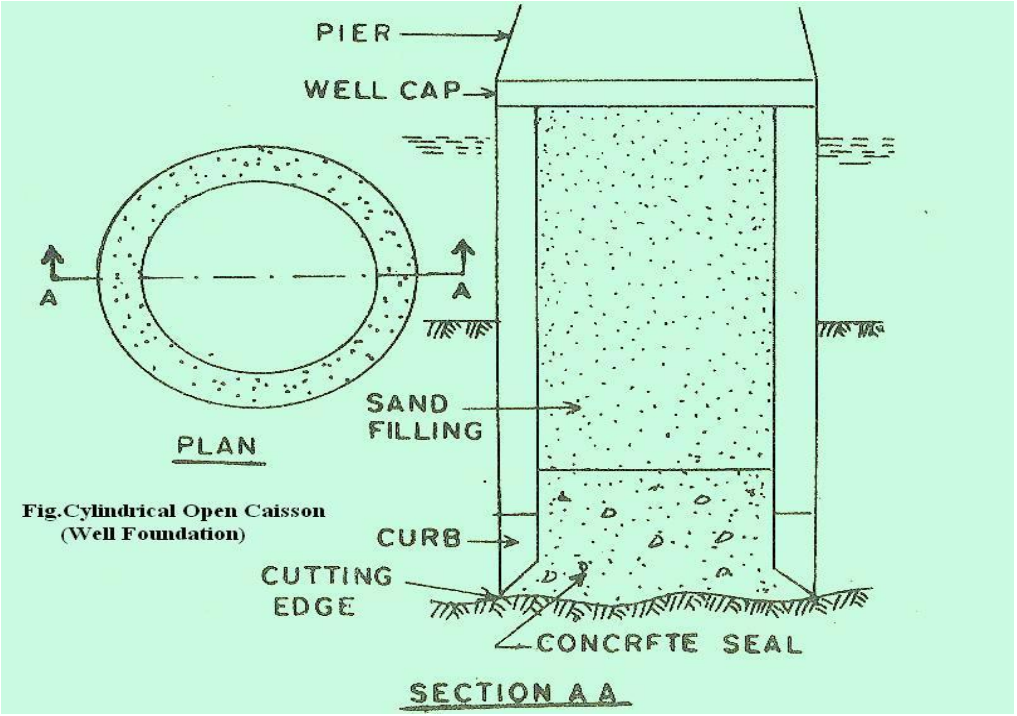


Fig.Cylindrical Open Caisson (Well Foundation)

Note 1:
RCC footing can also be classified as c

1. One way reinforced footings.
2. Two way reinforced footings.

One Way Reinforced Footing: These footings are **for the walls.** In these footings **main reinforcements are in the transverse direction of wall**. Used for Walls

Two Way Reinforced Footings: For columns two way reinforced footings are provided. Adopted for Columns (isolated, combined, strap, raft are two way RCC foundations)

Note 2

Arch F ooting

- Inverted arch foundations are provided in the places where the SBC of the soil is very poor and the load of the structure is through walls.
- End walls should be sufficiently thick and strong to withstand the outward horizontal thrust. (Arch Effect)

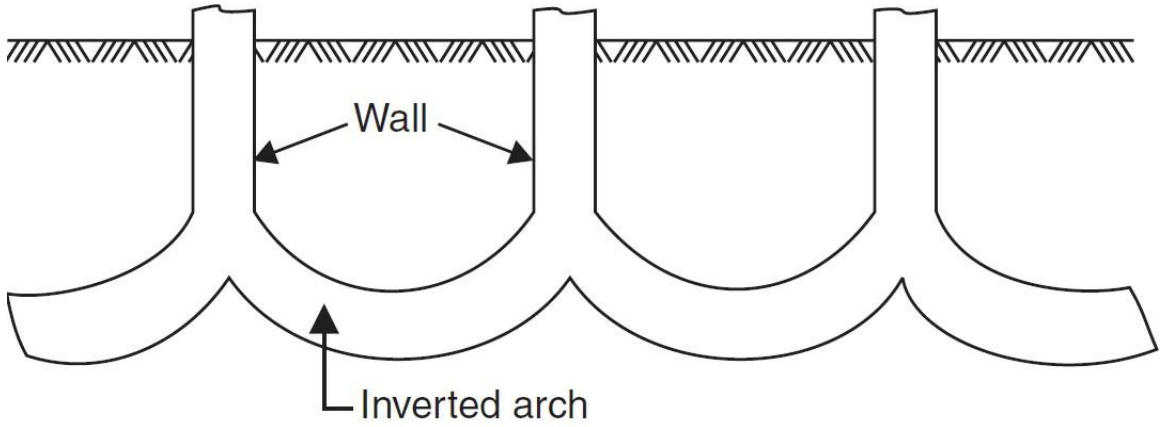


Fig. 7.8. Inverted arch footing

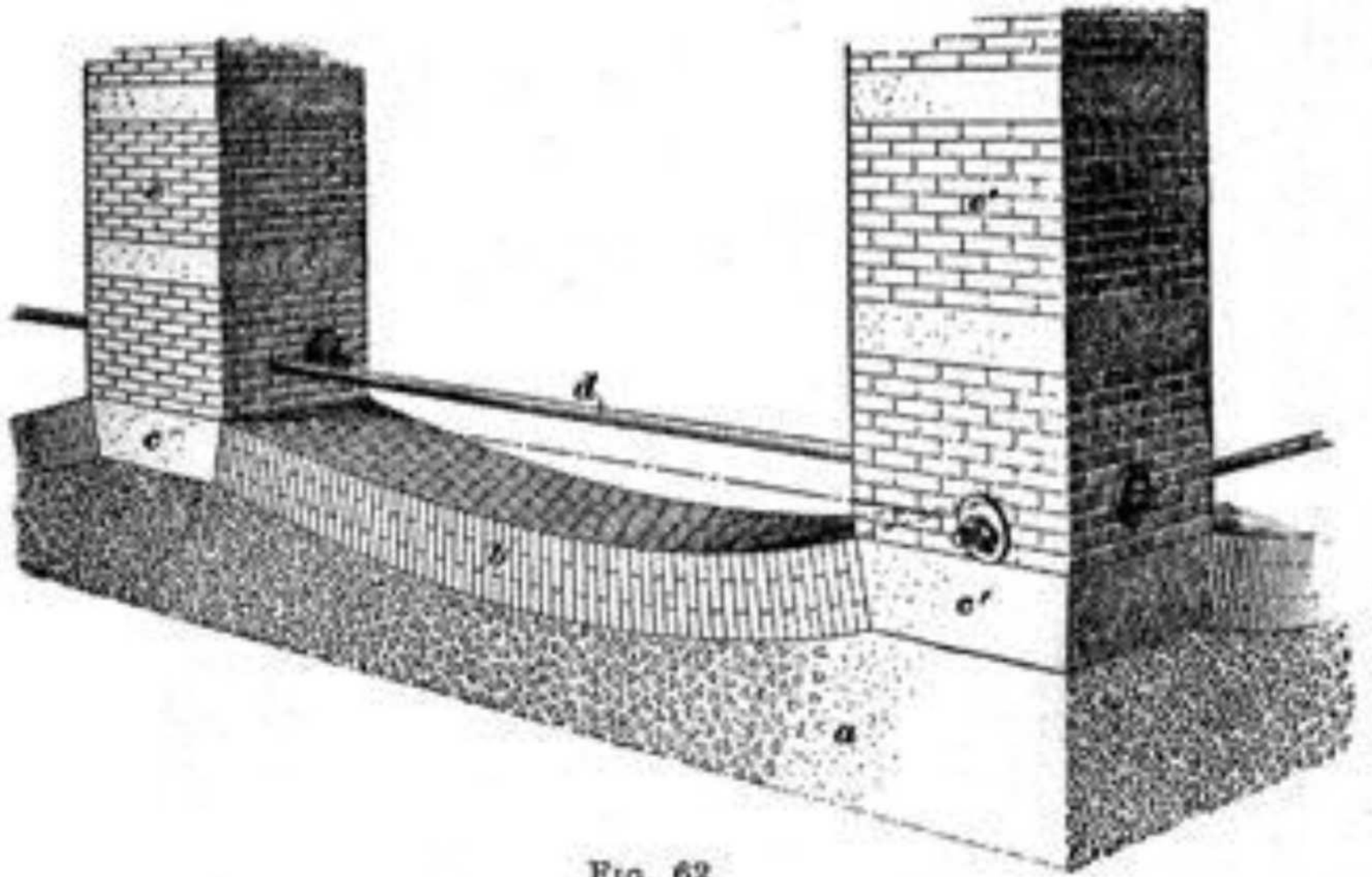


Fig. 62

Summary of foundation

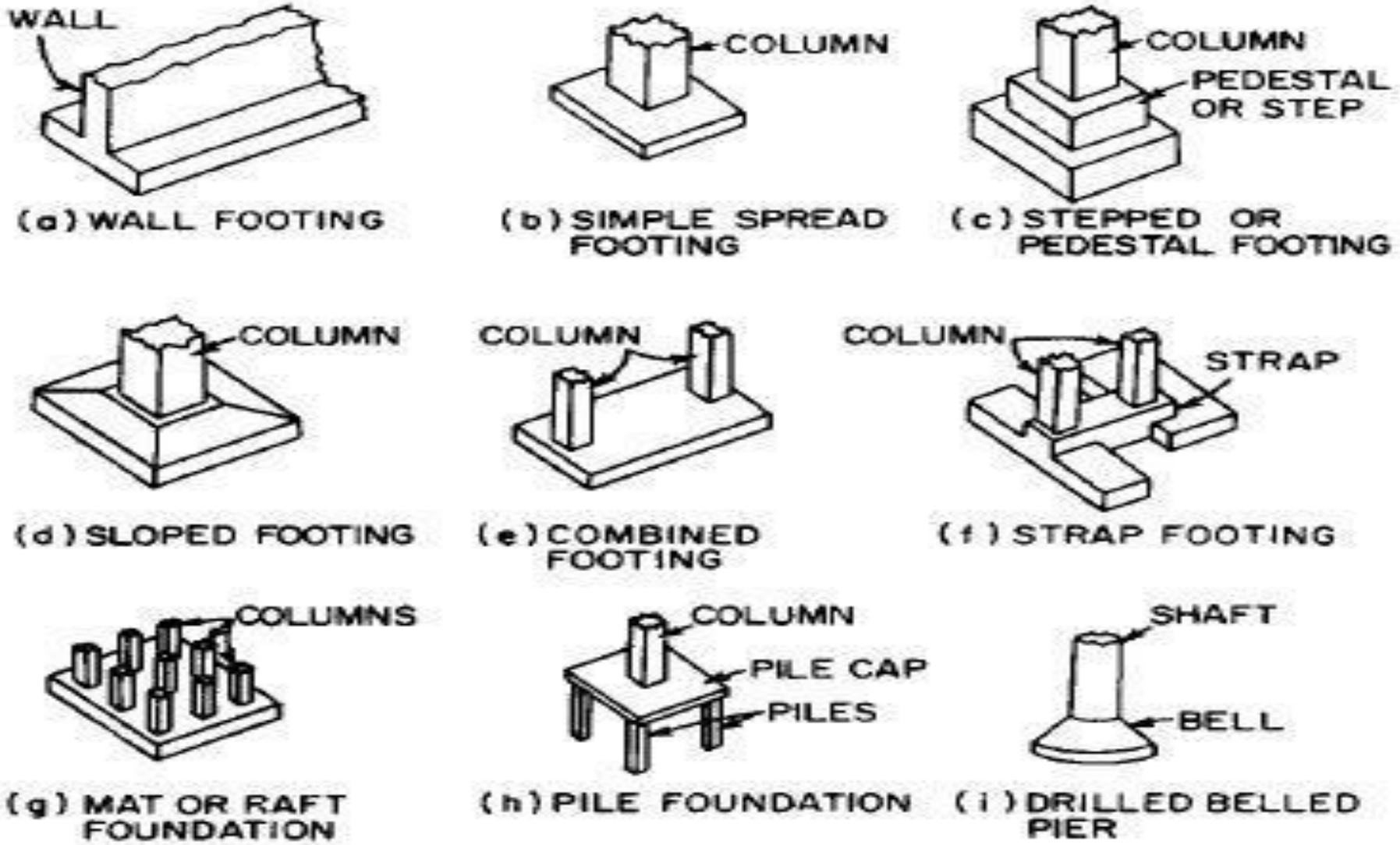


FIGURE 9.41 Common types of foundations for buildings.

Causes of Failure of Foundation

- *Lateral Pressure tending to overturn the structure*
- *Roots and Vegetation*
- *Atm. Effects (Rain, heat, temperature)*
- *Sub-soil moisture movement*
- *Unequal settlement of sub-soil*
- *Poor Building Site & Ground Preparation*

Factors to be considered while choosing the type of foundation

i. Soil strata
ii. Bearing capacity of soil
iii. Type of structure
iv. Type and amount of loading
v. Economy
vi. Permissible differential settlement