

# Modern storage structures

Lecture 14

# Modern storage structures

- The modern facilities for storing grains in bulk is 'silo'.
- Silos are constructed from **steel** or **reinforced concrete**.
- There are a cluster of adjoining silos in any modern large capacity processing plant.
- These silos are generally **circular with conical** bottom.
- Bulk storage bins for storing grains can be made from reinforced concrete, plain or corrugated galvanised sheet, mild steel black sheet, aluminium sheet, fibre glass, brick, ferro cement, asbestos sheet etc.
- But in India **mild steel bins** and **R.C.C. bins** are quite common.

# Advantages of modern storage bins

- less expensive and easier handling and quality control
- Lesser space requirement
- Elimination of cost of bags
- Provision of automation and mechanisation for quicker handling and maintaining quality of stored product
- Protection from losses due to birds and rodents.

# Angle of rupture

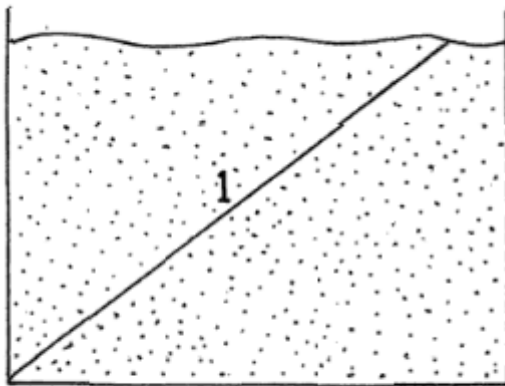
If  $\Phi$  is the angle of repose of material, then the angle of rupture may be taken as with the horizontal.

$$\text{Angle of rupture} = (90 + \phi) / 2$$

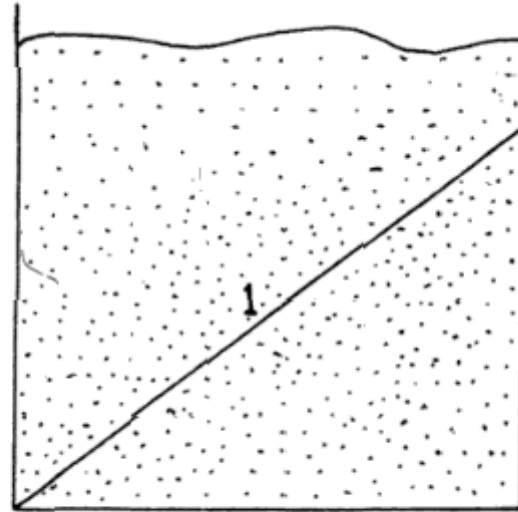
- **Plane of rupture**
- The plane of rupture is that surface down which a wedge of material bounded by one wall face, the free surface, and the plane of rupture would start sliding if bounding wall were to move.

# Criteria for shallow/ deep bin

The silo are classified as,  
(1) shallow bins and (2) deep bins.



**Fig. 4.9 : Shallow bin**  
1. plane of rupture



**Fig. 4.10 :Deep bin**  
1. plane of rupture

# Criteria for shallow/ deep bin

- A grain bin referred to as a shallow bin when the depth of grain is less or equal to the equivalent diameter.
- The equivalent diameter is taken as four times the hydraulic radius of the bin.
- $H_d < 4R$  , Where  $H_d$  is depth of grain.

# Criteria for shallow/ deep bin

$$R = \text{hydraulic radius} = \frac{\text{area of cross section of bin}}{\text{perimeter of bin}}$$

As per the definition given by Issacson and Boyd for deep bin

$$\frac{H_d}{D} \geq 0.75 \left( \frac{1}{\mu k} \right)$$

for shallow bin  $\frac{H_d}{D} < 0.75 \left( \frac{1}{\mu k} \right)$

where,  $D$  = diameter of circular bin  
 $\mu$  = coefficient of friction

$$k = \text{pressure ratio, } \frac{\sigma_3}{\sigma_1} \left( \frac{\text{lateral}}{\text{vertical}} \right)$$

$$= \frac{1 - \sin \phi_t}{1 + \sin \phi_t}$$

$\phi_t$  = angle of internal friction

# Criteria for shallow/ deep bin

$$h < L \tan \left( \frac{90 + \phi}{2} \right)$$

The Structure is deep if

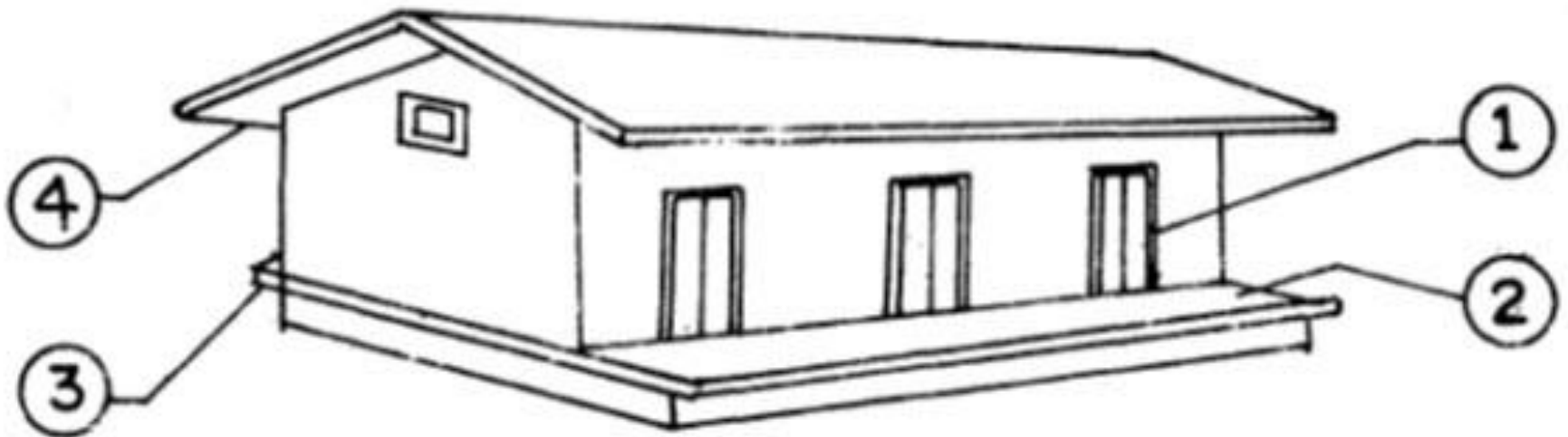
$$h > L \tan \left( \frac{90 + \phi}{2} \right)$$



# Shed (Warehouses)

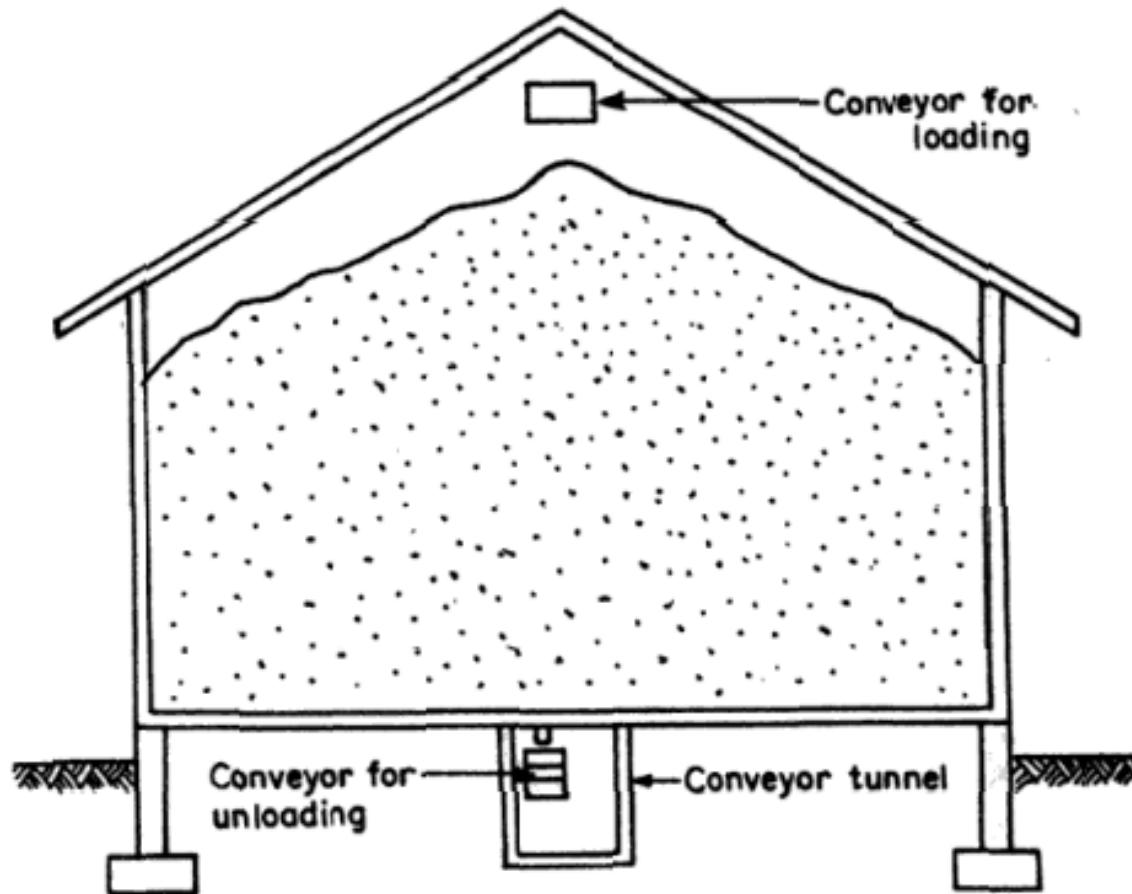
- A horizontal sheds have been used to provide **low- cost, large volume storage**.
- Very large volume sheds have also been constructed by **Food Corporation of India (FCI)** for storing grains and other products.
- Sheds are usually made of **steel or corrugated sheet construction with flat concrete floors**.

# Shed (Warehouses)



1. Sealed doors
2. Floor
3. Rat proof slab
4. Air proof roof

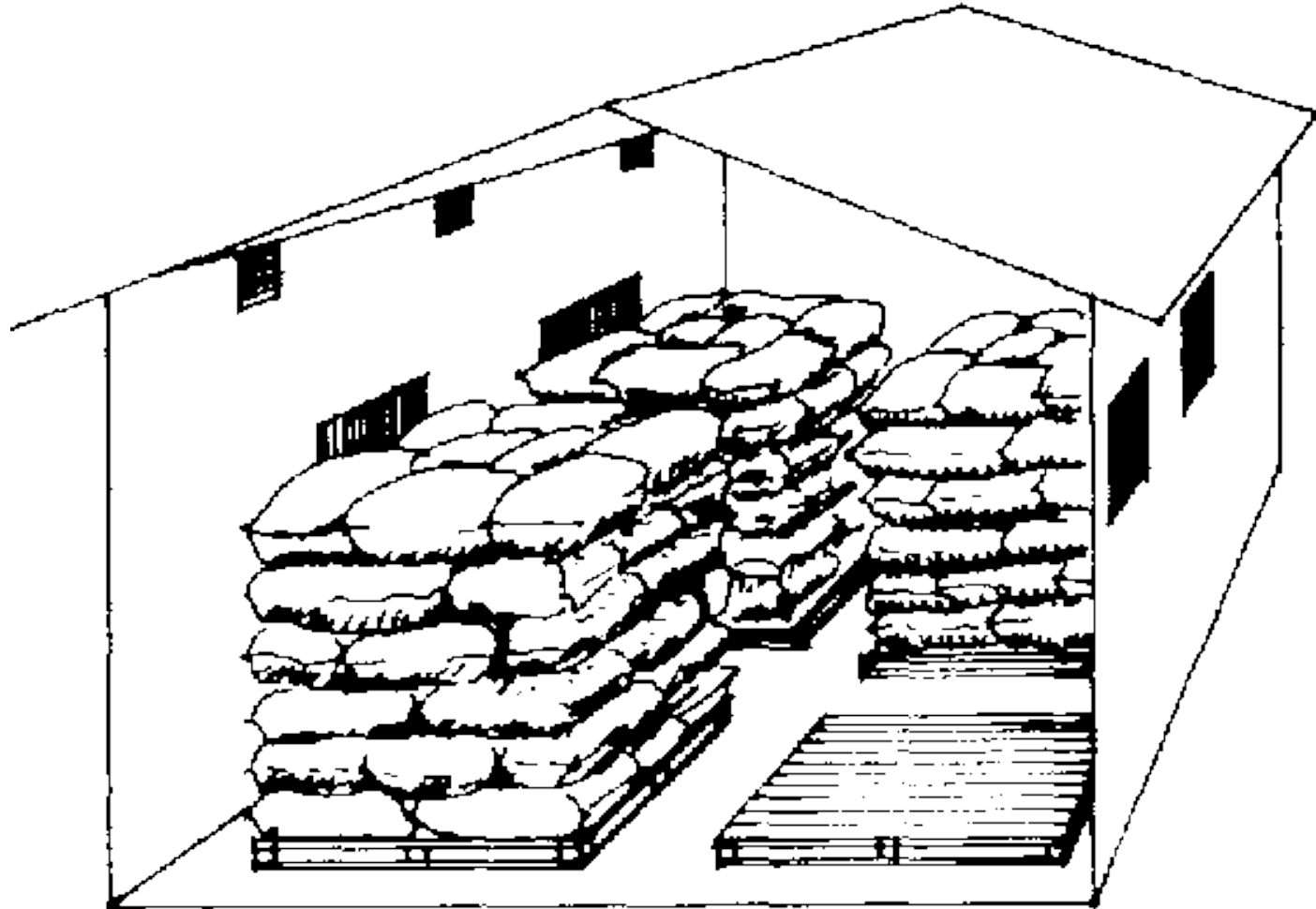
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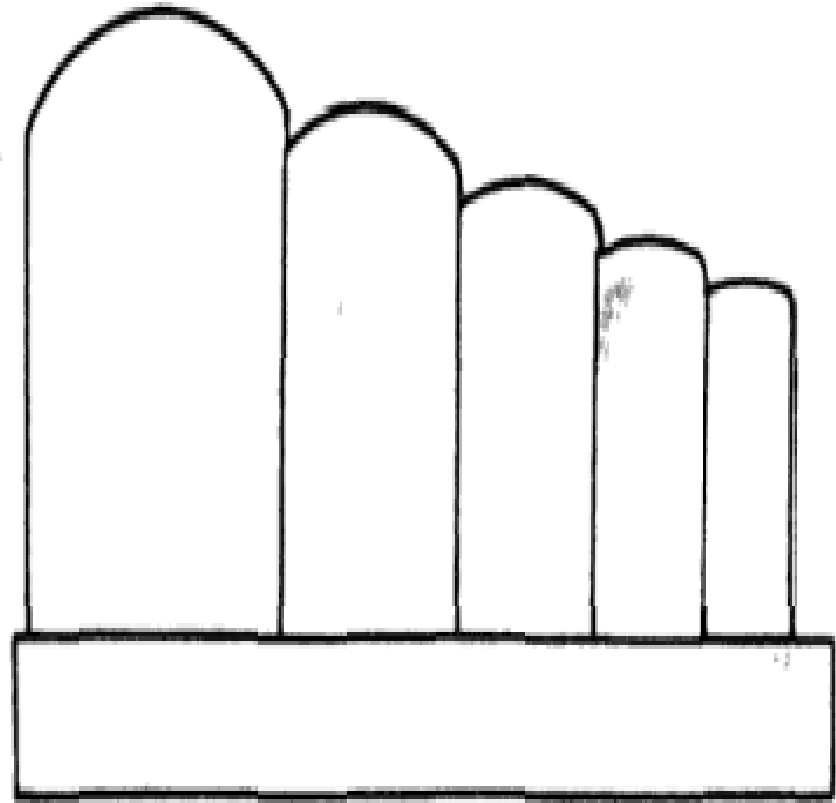
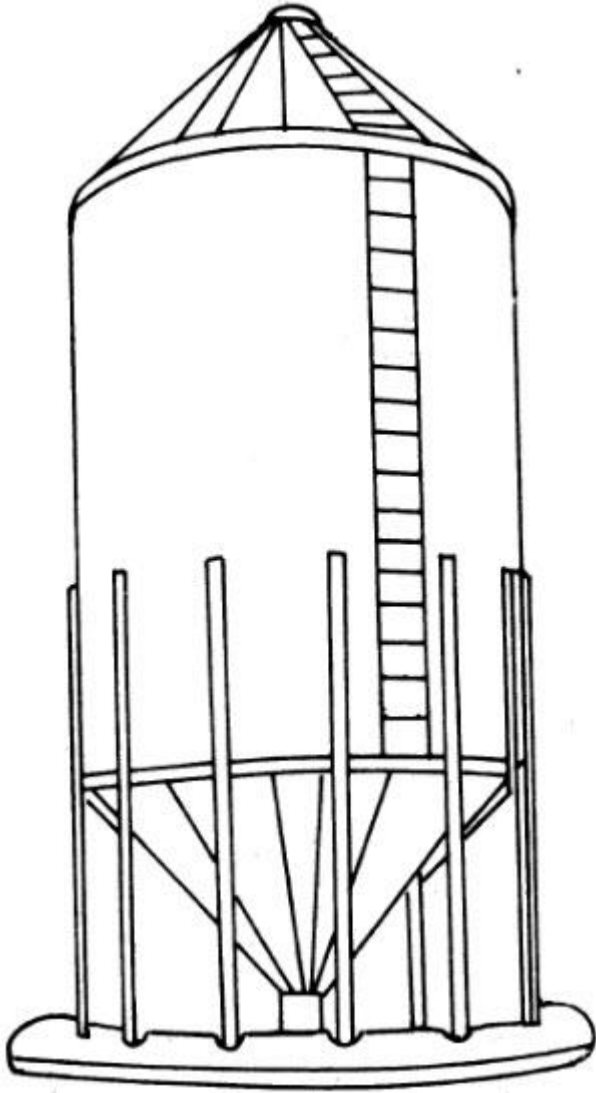
- Grain loads on the walls have to be supported by girts and heavy vertical buttersesses designed to resist their loads in bending. Roofs have to be supported on a network of purlins and rafters.
- A typical bulk warehouse would be **15 m** Wide, **60 m long** and **6 m high** at the edges.
- A building of this size would have a storage capacity of **2,840 tonnes**.
- The same size building for bag storage has only **1440 tonnes** storage capacity.

# Shed (Warehouses)

- A 5000 tonnes conventional godown will go up about 5750 tonnes capacity by storing grains in bag and bulk combine. there is increase **17% over rated capacity**. (1500 tonnes in form of bag and 4250 tonnes in bulk)
- Belt conveyors are often used in bulk sheds for loading and unloading grains.
- For larger sheds having 50,000-60,000 tonnes capacity a suspended drag-chain conveyor is used.



# Vertical silos



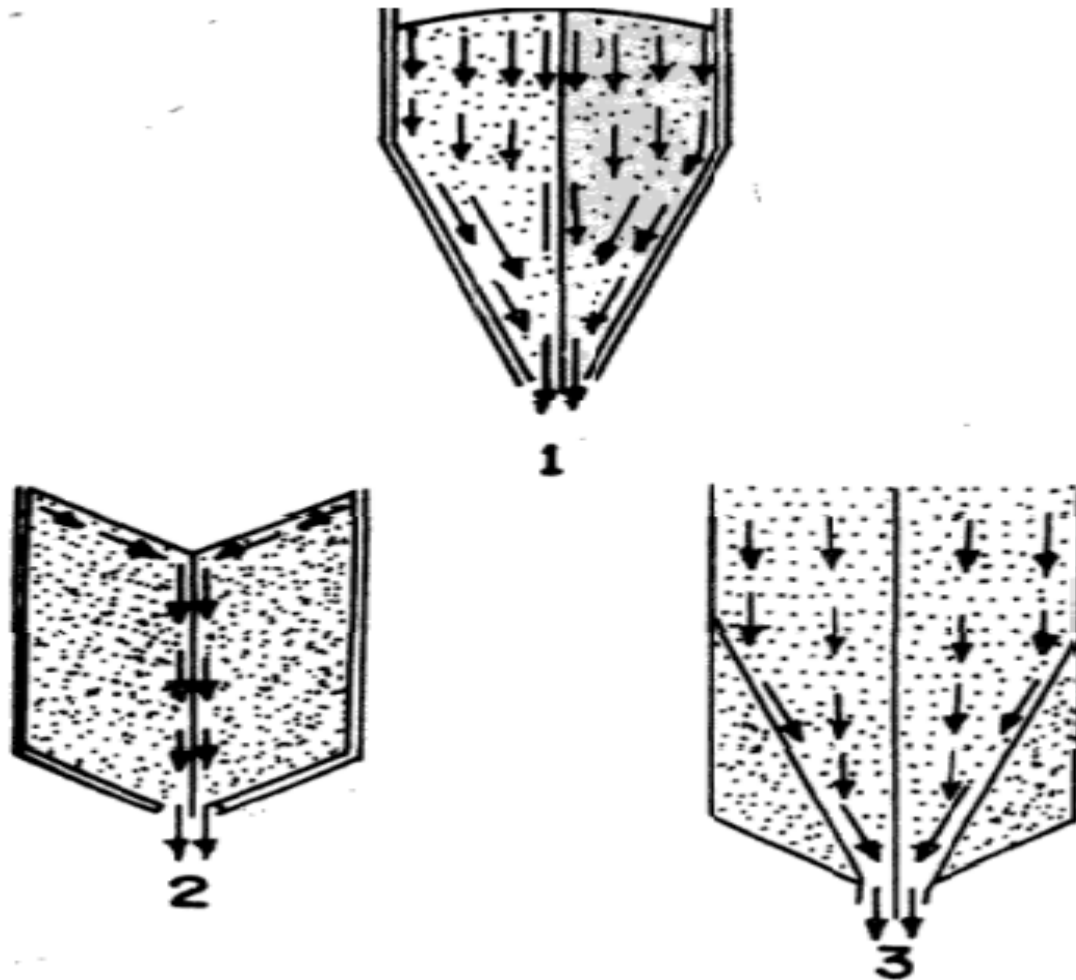
# Vertical silos



# Vertical silos

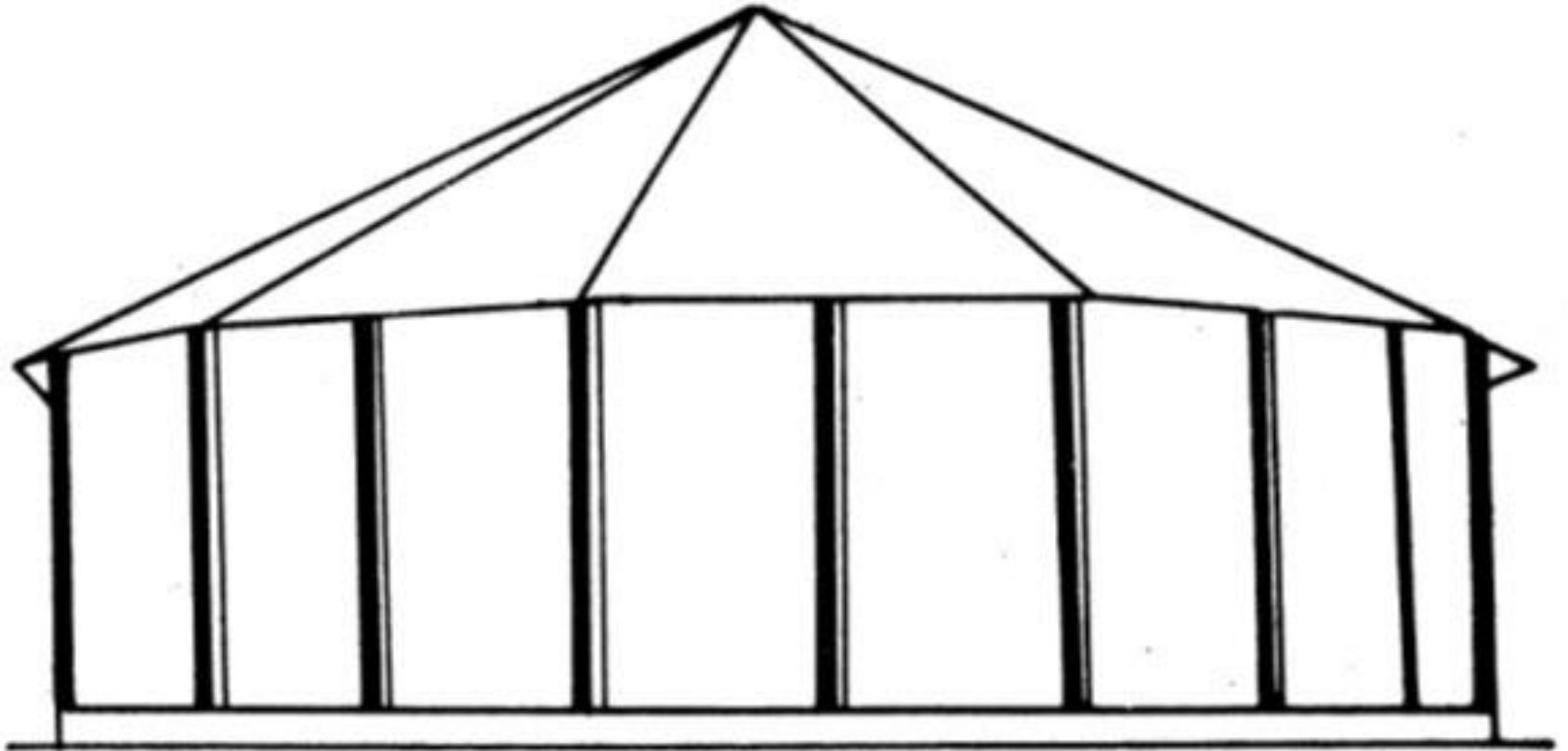
- A vertical silo is example of **deep bin**.
- Vertical silos can be circular, hexagonal, or rectangular.
- They tend to be **more expensive** than sheds.
- In case of space limitation vertical silos can be used because it requires **lesser space**.
- There are two types of vertical silos used
  - Flat bottom
  - Hopper bottom vertical silos.
- **Prefabricated galvanized metal silos** are available in many sizes.
- These may be fabricated by metal sheets, galvanized metal or reinforced.
- Hopper slope angles of **60° - 70°** are necessary to achieve reliable mass flow.

# Flow pattern in vertical silos



**Fig. 4.15 :** Flow patterns when emptying a vertical silo  
1. Product in motion throughout 2. pipe flow  
3. flow with static zone at the bottom

# Squat silo



# Squat silo

- A Squat silos are the example of **shallow bin**.
- A squat silo has a wall height to **diameter ratio 0.5** or even less.
- Squat silo can compete with sheds for low-cost quality storage.
- Squat silos are **structurally efficient**, thus can be built from lighter materials and costs are generally lower for a given storage volume.
- Squat silos as large as having **48 m diameter, 10.5 m** high walls and **25 m** high at roof apex are being built.

