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AGRICULTURAL STRUCTURES AND ENVIRONMENTAL CONTROL BTAP3105

FOOD GRAIN STORAGE STRUCTURES

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INTRODUCTION

It is estimated that in tropical countries approximately 25-40 % of the food grains produced is lost because of inadequate storage facilities.

In the field and during storage the products are threatened by insects, rodents, birds and other pests. Also the products may be spoiled by infections due to fungi, yeasts or bacteria.

Losses during storage may be either qualitative or quantitative. Losses in weight due to feeding of rodents, spillage during loading and unloading may be attributed to quantitative losses and loss in aroma, during milling, in cooking quality, or due to fungal infections may be attributed to qualitative loss.



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Storing of seeds and grains require a combination of different temperature and RH conditions so accordingly their relative storage environment is modified to enhance a longer shelf life of the products.

Storage of grains can be defined as a batch of grain or crop kept relatively in an isolated conditions artificially created be man.

Government has constructed different food grains storage structures capable to store approx. 87 million tons against 247 million tons food grain production in the country.

There are three agencies engaged mainly in large scale storage/warehousing capacity, namely FCI, CWCs and SWCs.

Over a period of time scientific storage/ warehousing capacity is being developed by these public agencies and they are planning to increase it further.



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Produce	Safe moisture content	Produce	Safe moisture content
maize	13%	cowpeas, beans	15%
wheat	13%	groundnuts	7%
millet	13%	cocoa	7%
sorghum	13%	copra	7%
paddy	14%	palm kernels	5%
rice	13%	coffee	13%

Activate Windows
Go to Settings to activate Windows.



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REQUIREMENTS OF STORAGE :-

Provide adequate protection from rodents, birds and insects.

Provide aeration and fumigation when required.

Prevent losses due to moisture and temperature.

Permit easy inspection.

Facilitate proper cleaning and should be self cleaning in case of silo.

Economical on unit storage cost basis.

Capable to protect the grains from weather, fire and theft.



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The basic requirements to safeguard food grains from the enemies responsible for losses are :-

1. Modification of the food grains (cooling or drying)
2. modification of atmospheric conditions of the storage system

Advantages of storage :-

1. Ensures against fluctuation in production.
2. Stabilizes price.
3. Saves from distress sale
4. Strengthen public distribution system.
5. Replenishes the depleted stock.



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Bacteria can also cause spoilage of cereals but yeast cause few spoilage problems.

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Causes of spoilage

The major factors involved in the spoilage of grains by molds are moisture level, physical damage & temperature .



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WATER ACTIVITY FOR LOW & HIGH MOISTURE FOOD

Low-moisture foods are those with water activity (a_w) levels lower than 0.70 (Blessington et al., 2012).

Such foods include products which have undergone a lethality step, those that are not subjected to an inactivated step, and those in which ingredients are added after an inactivation step.

Low-acid canned foods can be preserved by controlling water activity at levels above 0.85.

The minimum a_w level for the growth of *C. botulinum* is approximately 0.93.

Water activity is usually controlled by the use of salt or sugar.

The water activity isotherm is a curve of the equilibrium moisture content versus the water activity.



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ITS LIMITS FOR STORAGE

The main limit is it often leads to loss nutrients and changes the organoleptic properties of food that is flavour or taste or colour .

Dried food does not taste the same as fresh food does.

Moisture can cause dried foods left in the food in the drying process or allowed in during storage can cause mold on food.

Overly dried fruits, vegetables and meats can be exceptionally hard, often to the point where they do not soften.



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MOISTURE AND TEMPERATURES CHANGES IN GRAIN BINS

Moisture & temperature changes in stored grains air movement inside the storage.

The migration of moisture in stored grain takes place due to change in temperature as per season i.e. winter & summer.

One of the most important factors influencing storage life of the grain is moisture content.

Also load due to any accessories like air ducts, temperature cables etc, should be considered.



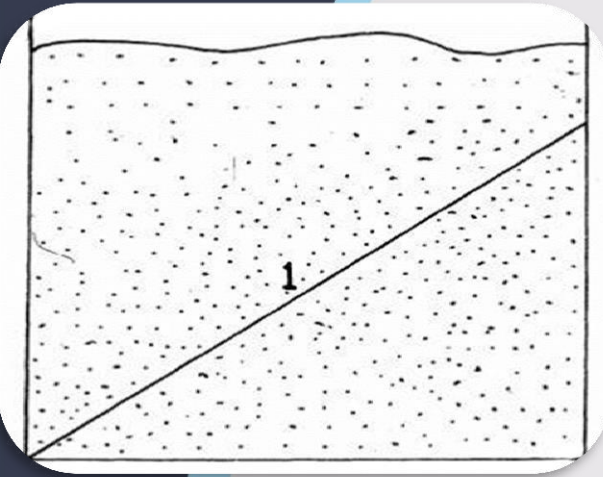
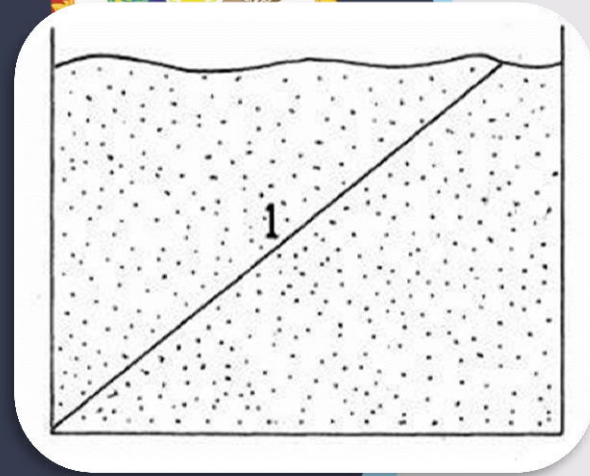
The silos or bins are considered of two types: shallow and deep bin.

A shallow bin is one in which the plane of rupture meets the grain surface at the top of the filling before it strikes the opposite wall.

Also a bin where the depth is smaller than 4 times of its hydraulic radius can be considered as shallow bin.

A deep is the one in which the plane of rupture meets the opposite side of the wall before it strikes the grain surface.

Also a bin is considered deep if its depth is greater than 4 times its hydraulic radius.





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DESIGN OF GRAIN STORAGE STRUCTURES

Proper design of the storage is not only to restrain and properly hold the material but also to minimize the damage to the grain due to moisture condensation or excess temperatures.

The storage unit must be so designed as to withstand the change in pressures during loading and unloading.

The several aspects to be considered in a storage design are types and quantities of grain to be stored, location, size and number of bins, handling equipment and methods, structural requirements, conditioning methods and requirements and plans for future use and expansion.



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CONVENTIONAL OR TRADITIONAL STORAGE STRUCTURES

Underground storage

Straw storage

Bamboo storage

Wooden storage

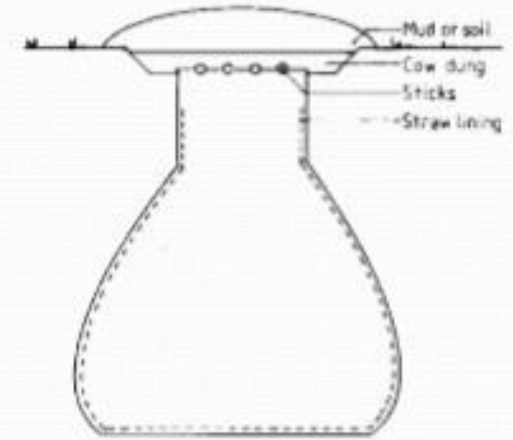
Mud Storage

Gunny storage

Metal bin storage



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Straw bin

Underground storage



bamboo baskets



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(Earthen bin)



Earthen pot-pile



(Bamboo bin),



Mud house



Wooden bin





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Gunny bags



Paper bags



Gunny bags



Metal bin storage



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Advantage:-

- It is cheap and economical.
- Storages are well known to farmers/agricultural laborers/village artisans.
- Storage keeps cooking qualities of the grains.

Disadvantages:-

- Most of the structures are not rat proof, insect proof & moisture proof.
- Straw roped structures, bamboo/reed storage, wooden structures & bags are not fire proof.
- Bags need frequent replacement.



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CONVENTIONAL STRUCTURES

Bukhari type storage structure

Morai type storage structure

Kothar type storage structure

Metal or plastic drums



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BUKHARI STORAGE

It is cylindrical in shape.

Its capacity ranges from 3.5 to 18 tonnes.

It is elevated on a wood or masonry platform.

The structure is held with timber posts which are fixed in the ground, extending up to full height of the wall.

Its floor is either made of timber planks or bamboo planks plastered with mud mixed with cow dung and paddy straw.

Its walls are timber or bamboo framework and bamboo matting, over which mud straw plaster is applied on both the surfaces.

Roof is cone type generally made of bamboo or timber framework to protect the grains from sun and rain.



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These structures are elevated up to 1.5 m above the ground by four timber or masonry pillars.

Opening for filling is provided 15 cm below the top edge of the wall and emptying opening is provided at the floor level.

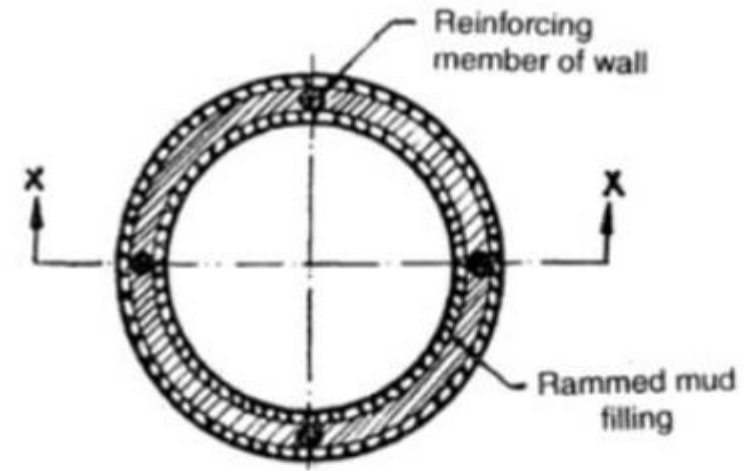
These openings are closed and mud plastered after filling the structures.

Rat proofing cones are provided at four pillars to avoid damage by rats.

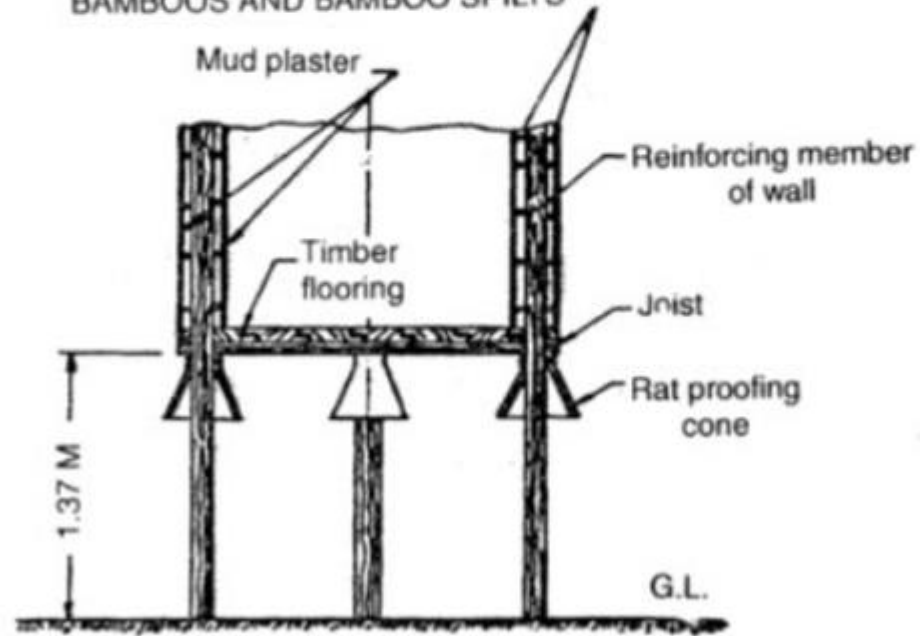
This type of structure are used for storage of paddy, wheat, gram, maize and sorghum.



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INNER AND OUTER FRAMEWORKS OF
BAMBOOS AND BAMBOO SPILTS



SECTION AT XX

Courtesy : Indian Standards Institution



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MORAI STORAGE

This structure is widely used in eastern and southern parts of the country.

Paddy, maize and sorghum are generally stored.

The shape of the structure is like an inverted truncated cone elevated by wooden or masonry pillars.

The floor is made by wooden planks and surrounded by 22 gauge corrugated metal cylinder of 90cm height with nailing on floor timber. The edge of the cylinder is flushed with the bottom end of the floor.

75 mm dia ropes made up of paddy straw or similar materials are placed inside the cylinder starting from the floor level to full height of 90cm.



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The bamboo splits are placed vertically along the inner surface without leaving any gap between them.

The height of the bamboo split is equal to the height of the structure to store the desired amount of grain.

Keeping the bamboo splits in position the grains are filled upto the cylinder height and then the bamboo splits are held straight and continuous filling of grain and winding of the rope goes on simultaneously.

To provide a smooth surface about 1 cm thick layer of mud plaster is applied over the rope.

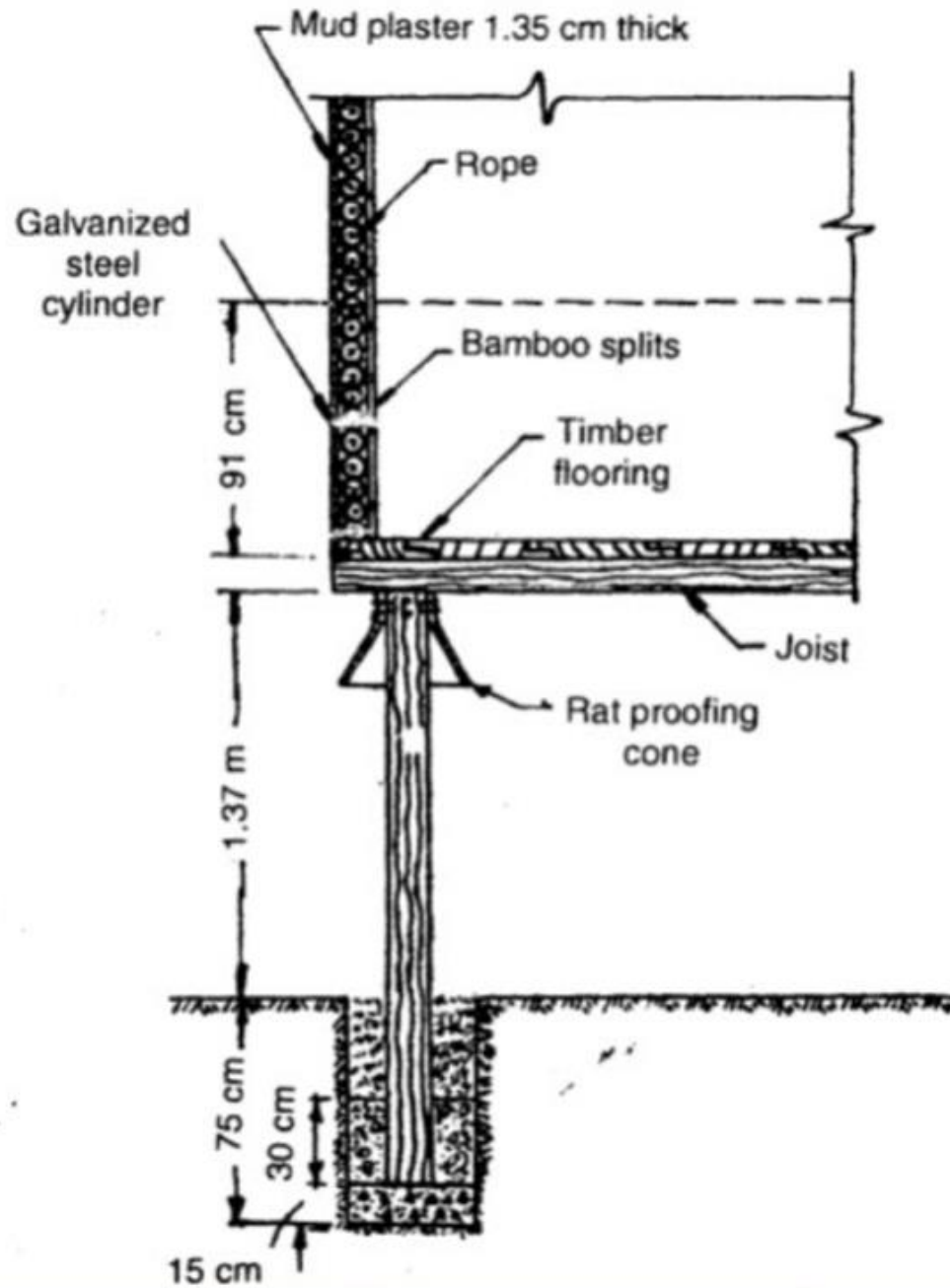
A conical roof with an ample overhang is placed.

Rat proofing cones are also provided 1.5 m above on all the four pillars to avoid damage by rats.



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KOTHAR STORAGE

It is common in northern part of the country and is used to store paddy, maize, sorghum, wheat and barley.

The capacity ranges from 9 to 35 tonnes.

It is a wooden box type structure elevated from the ground by pillars.

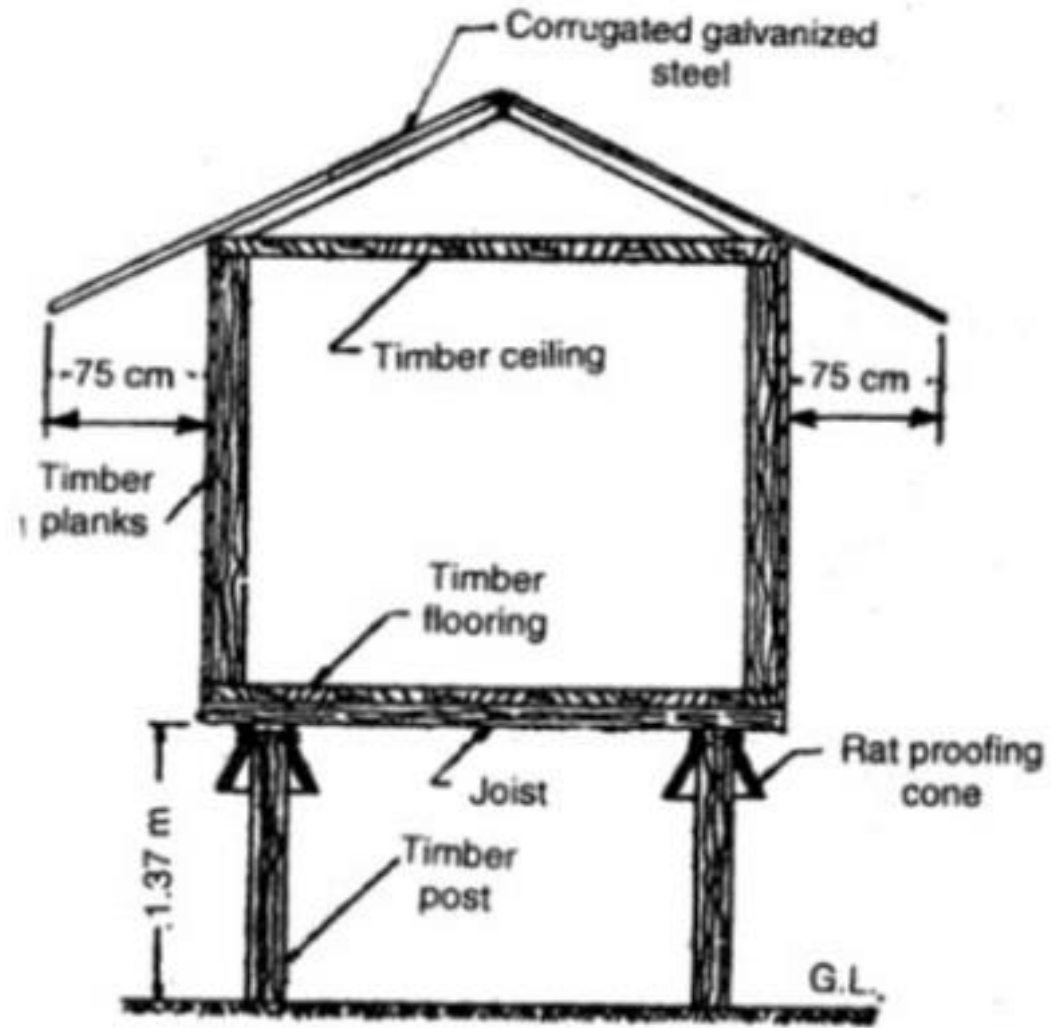
The roof is tilted and can be made of planks or corrugated metal sheets with sufficient overhang on all sides.

The structure is raised on timber pillars 1.5 cm above the ground level with rat proofing cones.



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Courtesy : Indian Standards Institute



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IMPROVED STRUCTURES

Pusa bin

Metal silos

Cover and plith storage

Pucca kothi

Hollow brick storage structure

Reinforced brick masonry bin

Partly underground and partly above ground bin



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PUSA BIN

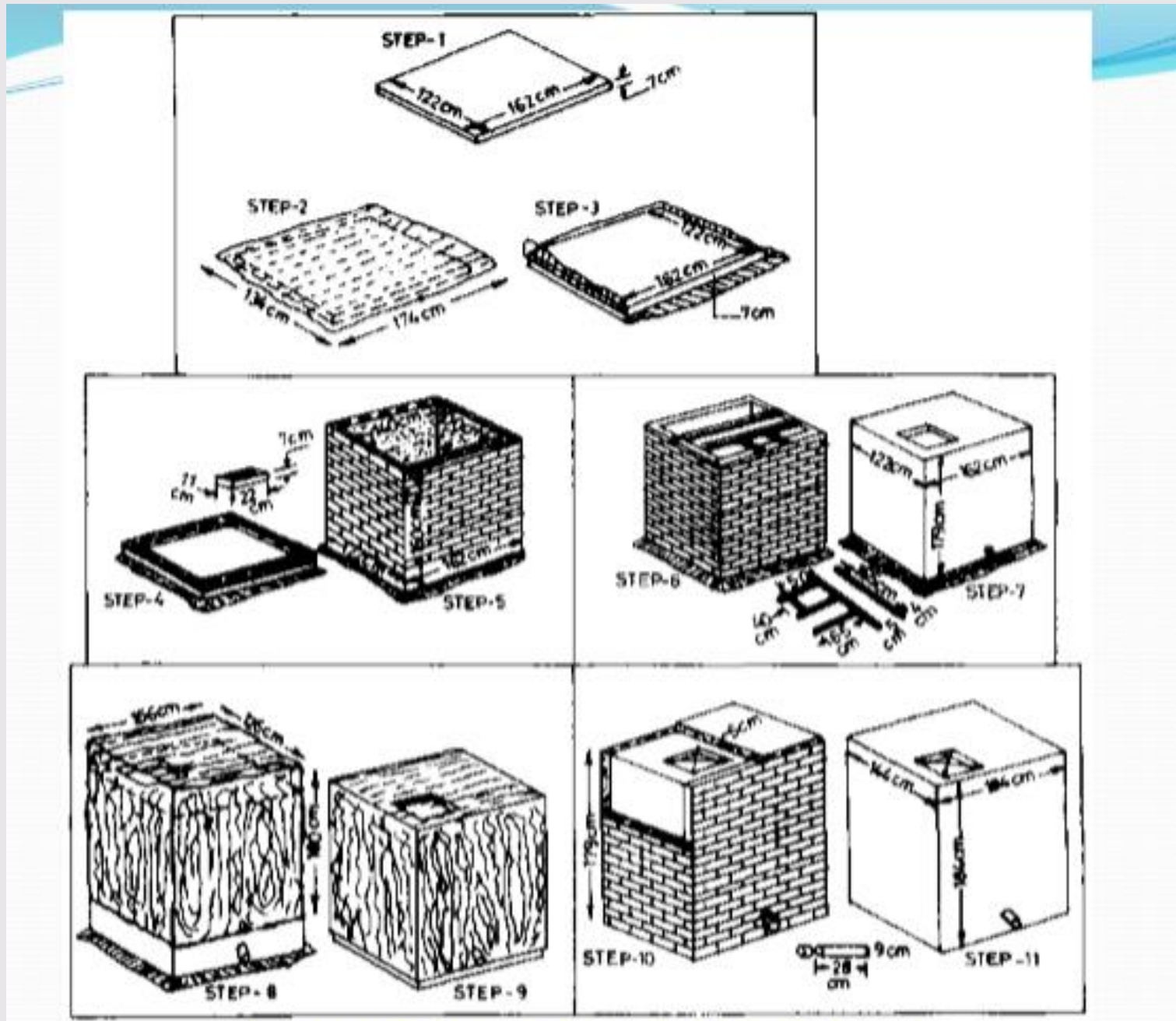
It is developed by IARI.

It is rectangular in shape and has a capacity of 1 to 3 tonnes.

The bin is constructed on a hard surface to prevent rodent attack. If the surface is not hard, a platform of burnt bricks is built. The black LDPE film (700 gauge) is spread over the platform, extending 60 mm from all four sides. Another platform of unburnt bricks is constructed over the LDPE layer. The inside wall is built to the required height, depending on the capacity of the structure. The surface of the wall is plastered with mud. A wooden frame with two poles is prepared and is placed at the top of the inner wall to support the roof. A small hole, 90 mm in diameter, is cut at the bottom in the middle of the front wall for delivery of the grain. A mud slab, 50 mm thick, is placed over the raised inner wall to serve as a roof, leaving a manhole of dimensions 500 x 500 mm at one corner. The structure is then plastered with mud on top and on all four sides, and is left to dry well. An LDPE film cover of 700 gauge black sheet made in the form of a mosquito net is then placed over the dried structure.



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Method of Constructing Pusa Bins



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At this stage, a pouch made out of galvanised iron or plastic pipe 90 mm in diameter with a cap, is fitted into the delivery hole. The LDPE cover is pulled down to meet the extending portion of the earlier layer on the platform. The edges of both the films are heat sealed. A small hole is cut in the LDPE cover to accommodate the exit pouch and the pouch is pulled out through this hole. A little soft wax is applied around the pouch touching the LDPE film to make the portion completely airtight. The LDPE film covering the manhole is cut diagonally.

The outer wall of the structure is erected using burnt bricks up to 450 mm and unburnt bricks for the rest of the portion. Alternatively, a band of metal is provided at 450 mm to make it rodent proof. The whole structure is again plastered with mud on top as well as on all four sides and allowed to dry before use.

After filling the structure with grain, the diagonal cut on the film covering the manhole is sealed with adhesive tape and the manhole is plugged with mud. For efficient performance, the Pusa bin is used only after it is completely dried and filled completely so that minimum free space is left.



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COVER AND PLINTH(CAP) STORAGE

This is an improvised arrangement for storing food grains in the open, generally on a plinth which is damp- and rat-proof. The grain bags are stacked in a standard size on wooden dunnage.

The stacks are covered with 250 micron LDPE sheets from the top and all four sides.

Food grains such as wheat, maize, gram, paddy, and sorghum are generally stored in CAP (cover and plinth) storage for 6-12 month periods.

It is the most economical storage structure and is being widely used by the FCI for bagged grains.

This has been developed by the Food Corporation of India. It involves the construction of brick pillars to a height of 14" from the ground with grooves into which wooden crates are fixed and embedded with a polythene sheet.

The structure can be fabricated in less than 3 weeks.

It is an economical way of storage on a large scale.



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METAL SILOS

It can store over 25 tonnes.

It is economically valid for large scale storage and not preferred for small scale storage.

Such silos are made of smooth or corrugated galvanized metal and are cylindrical in shape with flat top.

It is placed on platforms or plinths, to facilitate emptying.

In large storage structures bitumen layer or cement mortar layer is plastered to prevent penetration by water and pests.



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HERMETIC STORAGE

(Hermetic means there is no contact with the outside air)

Hermetically, or sealed, storage systems put grain in an airtight container such as a drum or a plastic bag. This stops air and water getting in to the stored grain from outside.

Once the container is hermetically sealed,

The moisture content of the grain will be controlled. So it reduces pest damage without using pesticides. □

Depending on the number of insects, and type and size of the system, oxygen levels will be reduced from 21% to less than 10% within a short period of time. At oxygen levels below 10%, insects are curtailed and the viability of seed ensured. Since it minimizes biological activity inside the storage, container hermetic storage also helps maintain grain quality and seed viability.

Popular in tropical regions these systems vary in size from 3 kilograms to 300 tons.



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Super grain Bags



Plastic containers



Cocoon storage



Silo bags



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TEMPERATURE AND MOISTURE CHANGES DURING STORAGE

The grains should be examine in 2 weeks

By pushing our hand into the surface as deeply as possible to feel for warm

This can be done by intersecting a long metal rod deeply into the grain to taste for warmth and crushing at various path



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MOISTURE CHANGES

At the time grain is first store grain moisture content is fairly uniform throughout the bin with time localized high moisture zones may develop due to changes in outdoor air temperature

The low outside temperature cools the grain near the wall which results in downward air flow to the grain and upward towards the centre of the bin

As the air moves throughout the grain it becomes warmer and begins to pick up moisture from grain.

Condensation occur when the warm moist air hits the cool surface of the grain near the centre of the beam thus leading to grain spoilage

Warming action from the sun on the outside of the bin causes moisture current to move up and into the bin through the centre of the bin

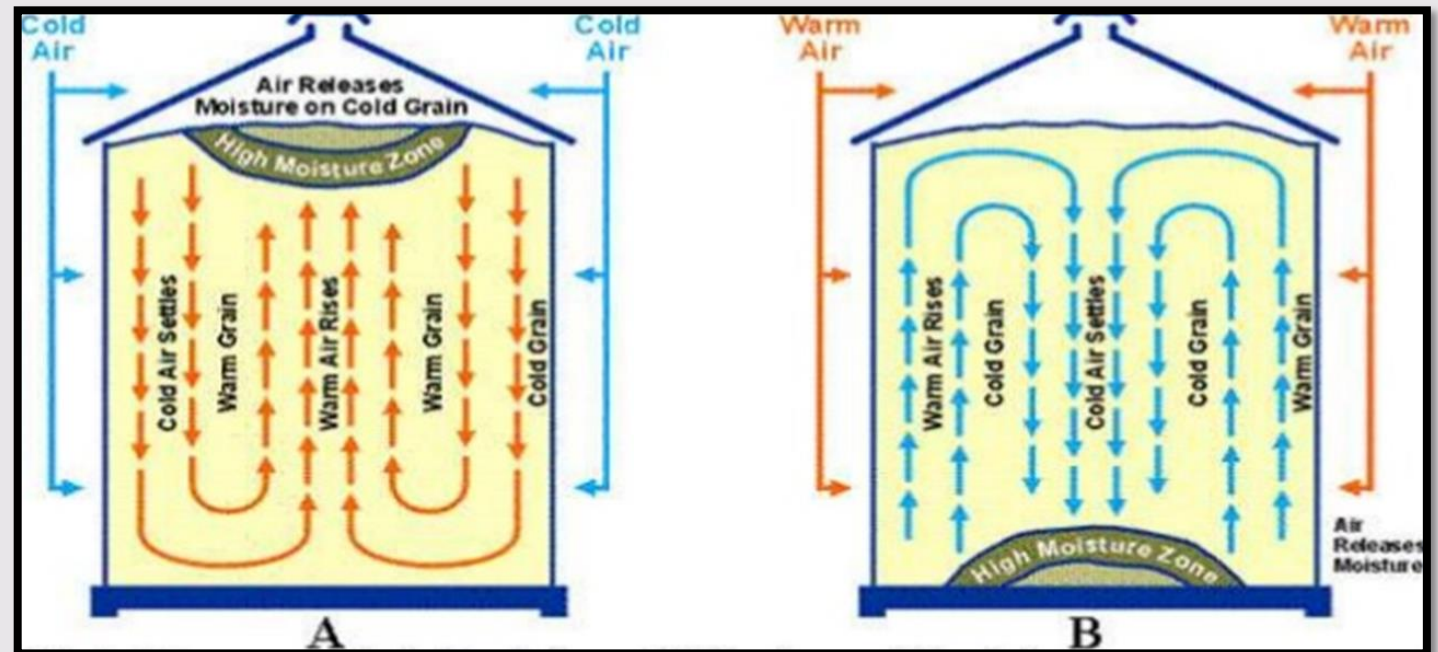
High moisture due to condensation therefore occur at the bottom of the bin



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MOISTURE MIGRATION

Air movement in the bin during cold (A) and warm (B) periods.





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GRAIN PRESSURE THEORIES

Grain storage structures are primarily designed to maintain the quality of the grains.

The grain storage bins or grain storage structures must be designed such that it can withstand two types of load:-

Load by the grain (static at times of no loading and unloading and dynamic at time of loading and unloading)

Load due to wind

The forces of the grains are exerted in the walls, floors and other structural components.

The silo walls are subjected to tension due to lateral stresses(P_L) and compression due to load transfer by friction of grain on the bin wall.

The floor is in compression all the times.

Also load due to any accessories like air ducts, temperature cables etc, should be considered.



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The silos or bins are considered of two types : shallow and deep bin.

A shallow bin is one in which the plane of rupture meets the grain surface at the top of the filling before it strikes the opposite wall.

Also a bin where the depth is smaller than 4 times of its hydraulic radius can be considered as shallow bin.

A deep is the one in which the plane of rupture meets the opposite side of the wall before it strikes the grain surface.

Also a bin is considered deep if its depth is greater than 4 times its hydraulic radius.

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 to slide if the bounding wall were to move.



LATERAL PRESSURE CALCULATIONS

1. Rankine's Equation
2. Janssen's Equation
3. Airy's Equation

Rankine's Equation for shallow bin:

$$P_1 = Kwh$$

Janssen's Equation for Deep bin:

$$P_1 = \left(\frac{wR}{\mu} \right) \left[1 - e^{-\frac{k\mu h}{R}} \right]$$

Where,

P_1 = lateral pressure

R = hydraulic radius

w = grain bulk density (unit weight of grain)

μ = coefficient of friction of the grain on the wall
= $\tan \Phi$

h = depth of grain from top

$$K = \left(\frac{1 - \sin \Phi}{1 + \sin \Phi} \right)$$



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Airy's Equation for shallow bin

$$P_1 = wh \left[\frac{1}{\sqrt{\mu(\mu + \mu')} + \sqrt{1 + \mu^2}} \right]^2$$

Where,

w = grain bulk density

h = depth of grain to point under consideration

μ = coefficient of friction of grain on grain

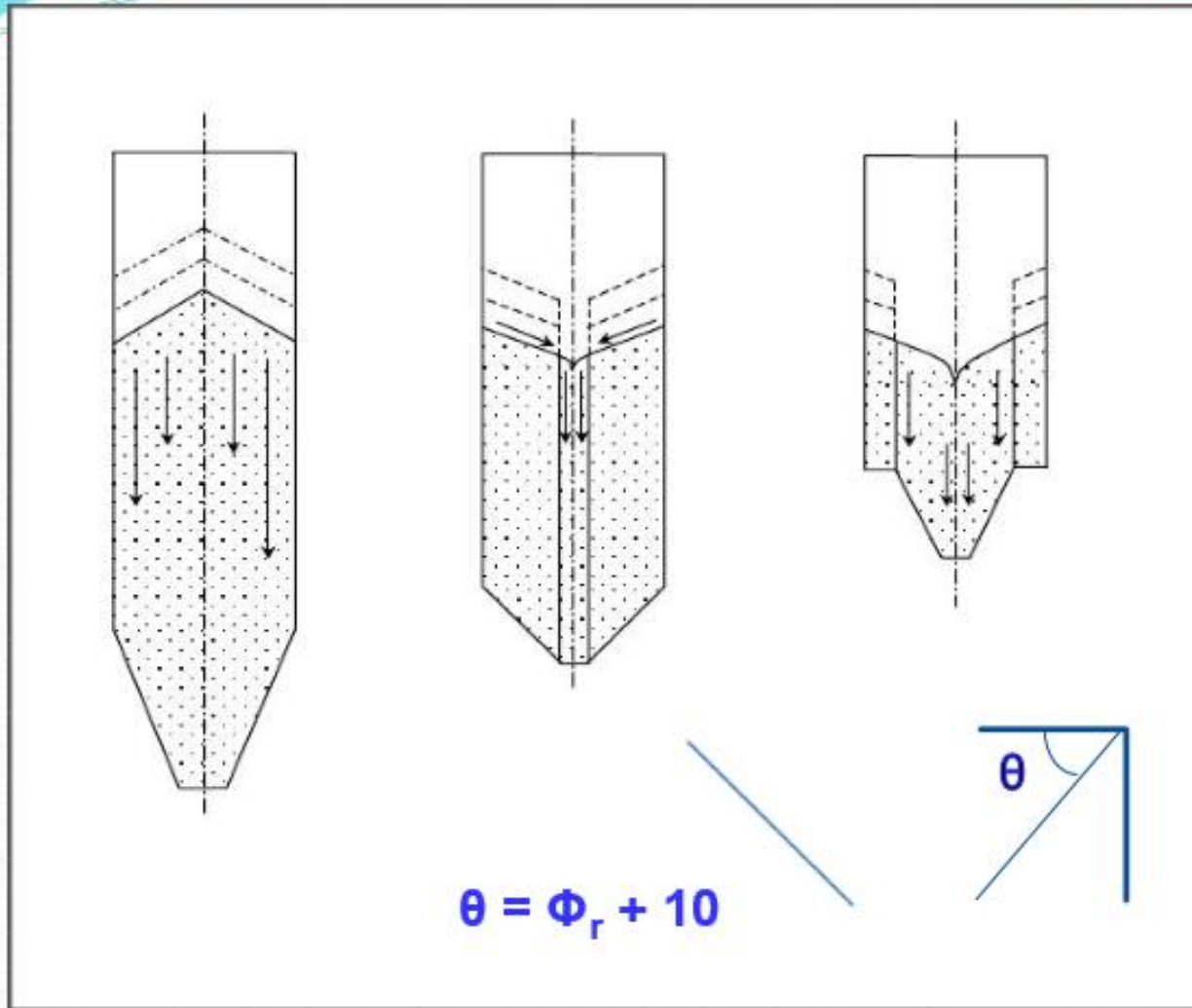
= $\tan \Phi$, Φ is angle of internal friction

μ' = $\tan \Phi'$, Φ' is the angle of wall friction.



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Types: 1 Mass Flow; 2 Funnel Flow; 3 Expanded Flow

Mass flow bins are bins in which all of the stored material is in motion during discharge. (First-in –first –out)

A funnel flow bin is a bin in which part of the stored material is in motion during discharge while the rest is stagnant. (First-in –last –out)

An expanded flow bin is a combination of a mass flow and a funnel flow bin.

Φ_r = Angle of repose

θ = Flow angle



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INTRODUCTION OF SEED STORAGE:

- The ability of seed to tolerate moisture loss allows the seed to maintain the viability in dry state. Storage starts in the mother plant itself when it attains physiological maturity. After harvesting the seeds are either stored in ware houses or in transit or in retail shops. During the old age days , the farmers were used farm saved seeds, in little quantity, but introduction of high yielding varieties and hybrids and modernization of agriculture necessitated the development of storage techniques to preserve the seeds.



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Objective of seed storage:

- ❑ To maintain initial seed quality viz., germination, physical purity, vigour etc., all along the storage period by providing suitable or even better conditions.
- ❑ Since the main objective of seed storage is maintenance of an acceptable capacity for germination and emergence, it can only be accomplished by reducing the rate of deterioration to the degree required to maintain an acceptable level of quality for the desired period.



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Stages of Seed Storage:

- ❑ The seeds are considered to be in storage from the moment they reach physiological maturity until they germinate or until they are thrown away because they are dead or otherwise worthless.
- ❑ The entire storage period can be conveniently divided into following stages.
 - ❑ Storage on plants (physiological maturity until harvest).
 - ❑ Harvest, until processed and stored in a warehouse.
 - ❑ In - storage (warehouses)
 - ❑ In transit (Railway wagons, trucks, carts, railway sheds etc.).
 - ❑ In retail stores.
 - ❑ On the user's farm.



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Purpose of seed storage;

- The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. Seeds have to be stored, of course, because there is usually a period of time between harvest and planting. During this period, the seed have to be kept somewhere. While the time interval between harvest and planting is the basic reason for storing seed, there are other considerations, especially in the case of extended storage of seed.



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- ❑ Seeds are also deliberately stored for extended periods so as to eliminate the need to produce the seed every season. Foundation seed units and others have found this to be an economical, efficient procedure for seed of varieties for which there is limited demand. Some kinds of seed are stored for extended periods to improve the percentage and rapidity of germination by providing enough time for a “natural” release from dormancy.
- ❑ Regardless of the specific reasons for storage of seed, the purpose remains the same maintenance of a satisfactory capacity for germination and emergence. The facilities and procedures used in storage, therefore, have to be directed towards the accomplishment of this purpose.