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RESEARCH ARTICLE

RECENT DEVELOPMENT IN FOOD GRAIN STORAGE STRUCTURE FOR KOHLAN AREA JHARKHAND

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ABSTRACT

Recent Innovative, cost efficient and sustainable farm structure of 1 tonne capacity from locally available late rite stone with cement as binder and R.C. Cas roof was designed. Engineering properties of the food grain(variety paddy, wheat etc) were determined. The engineering properties of the late rite stone were recorded as compressive strength (510 N/cm2) and water absorption. Traditional theory was used to design the height and diameter of the bin. Safe height of the bin was 1.6 m and the diameter was 1.2 m. Maximum lateral pressure exerted by the paddy and other grain grains on the wall of the bin of the designed dimensions was 248.78 kg m-2. Design wall thickness, depth of foundation and total load supported by the foundation was 150 mm, 750 mm and 7935.93 kg m-2, respectively. Roof of the bin was designed as a circular R. C. C. slab with its Design thickness of 100 mm and design diameter of the reinforcement was 6 mm with 140 mm c/c spacing. Total span of the roof is 2 m with 0.2 m overhangs. Laterite bin was constructed according to the dimensions determined by calculations. The total cost of the structure is7275 INR. Assumptions considered are as follows average paddy temperature remains nearly constant throughout the day. Axial temperature was greater than the peripheral because of heat added by the respiration of the paddy grains. Average moisture content of the paddy in to player was greater than that in the bottom layer. Moisture gradient due to difference in relative humidity has might have resulted in wetting upper paddy to become wet. Relative humidity inside the bin was greater than the outside because of vapour addition by the respiration of the stored paddy.

Key words: Design, Development, Paddy Storage Structure, Low Cost, Moisture Content.

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INTRODUCTION

Although in India certain crops can be produced throughout the year, the major food crops such as cereal grains and tubers, including potatoes etc are normally seasonal crops. Consequently the food produced in one harvest period, which may last for only a few weeks, must be stored for gradual consumption until the next harvest, and seed must be held for the next season's crop. In addition, in a market that is not controlled and unpredictable, the market value of any surplus crop tends to rise during the off-seasonperiod, provided that it is in a marketable condition. Therefore the principal aim of any storage system mustbe to maintain the crop in prime condition for as long as possible. The storage and handling methods should minimize losses, but must also be appropriate in relation to other factors, such as economies of scale, labour cost and availability, building costs and machinery cost.

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Grain drying

The handling and storage of grains will be discussed inan orderly sequence. First we discuss the requirements for safe storage, including the principle involved in both natural and artificial drying, followed by drying methods suitable for the small grower, as well as for the larger scale operations of cooperatives and commercial farms.

Requirements for safe storage

Crops left standing un-harvested tend to show diminishing quantitative and qualitative returns through shatter losses and attacks by insects, mould, birds and rodents. One of the most critical physiological factors in successful grain storage is regulating moisture content of the crop. High moisture content leads to storage problems because it encourages fungal and insect problems, respiration and germination. However, moisture content in the growing crop is naturally high and only starts to decrease as the crop reaches maturity and the grains are drying. In their natural state, the seeds would have a period of dormancy and then germinate either when re-wetted by rain or as a result of the naturally adequate moisture content. Another major factor influencing spoilage is temperature. Grains are biologically active and respire during storage. Another major temperature effect is on the activity of insect and fungal problems. With lower temperatures, the metabolic rate of insects and fungi decreases and consequently so does the activity causing spoilage. A damp or warm spot in grain will increase the rate of respiration. In addition to heat, another cause of respiration is moisture. The heat and moisture from such a 'hot spot' can spread by convection, encouraging moulds and bacteria, which in turn respire and give off more heat and moisture. It therefore becomes a self-generating process. Insect activity also increases with arise in temperature. These spoilage mechanisms can also affect the viability of grain required for seed or malting, where the inability to germinate would render it unmarketable. We will study the relationship between moisture content and temperature affects the storability of crops. It can be seen that the moisture content of grain must be reduced at higher temperatures.

Moisture content

The moisture content of a crop is normally given on a'wet basis' (wb) and is calculated as follows (%mcwb)

$$\text{Moisture content} = \frac{\text{Weight of moisture}}{\text{Weight of wet sample}} \times 100$$

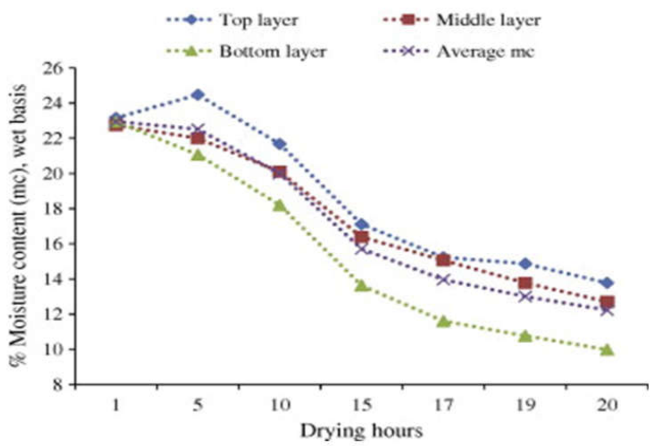
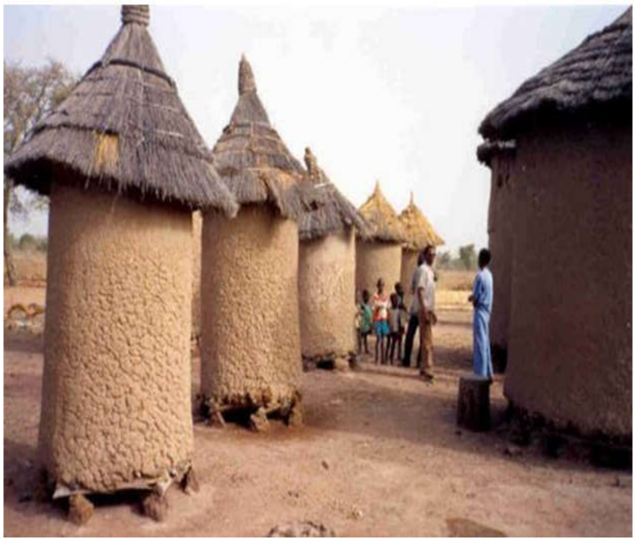


Figure show the moisture content of grains in storage

So in order to overcome the above said obstacles we need to design the equipment used in seedling, harvesting, transportation, storage and processing of dried paddy beans there is a need to know various physical and mechanical properties as a function of moisture content .The physical and mechanical properties of dry bean grains are to be known for the design and improvement of storage structures, relevant machines and facilities for harvesting, storing, handling and processing. The dimensions, size and mechanical behaviour of dry bean are important for designing of separating, harvesting, sizing and grinding machines. Bulk density, angle of internal friction, porosity and pressure ratio affects the structures loads (vertical and horizontal loads acting by product on silo wall) The most important in designing of drying and aeration (natural and mechanical), store systems (silos and warehouses) and transporting structures. The coefficient of friction (static and dynamic) of the grain against the various surfaces is also necessary in designing of conveying, grain flow (mass and hopper) and storage structures. The objective of this research was to design a dry bean storage system at irrigation land (non-irrigation, drip irrigation) on physical properties (length, width, thickness, surface area, volume, bulk density and porosity) and mechanical properties (angle of internal friction, static coefficient of friction, Poisson ratio and pressure ratio).Farmers store the paddy, wheat in locallymade structures in their houses. The traditional structures prevailing in kohlan are kananj or sathi, mudi, kangee, matkae, tatti, hadpa. But there is loss of time as well as money for transporting the grain to the place of storage. Therefore, it is necessary to develop the on farm storage facility for storing rough paddy, hence the study is aimed to arriveat a cost effective practical solution for this problem faced by the farmers by using locally available material.



MATERIALS AND METHODS

Theoretical Design of Paddy Storage Structure of 1 Tonne Capacity: Paddy storage structure of 1 tonne capacity is theoretical designed considering following criteria.

Diameter and Height of the Bin

- Weight of paddy to be stored = 1000 kg
- Bulk density of paddy (580kg/m^3)

It varies from 550 kg/m^3 to 610 kg/m^3 (Kachru,1999). The minimum value was selected for design. Thus we would consider average design bulk density of paddy is 580 kg/m^3

$$\text{Volume of paddy} = \frac{\text{Weight of paddy to be stored} = 1000/580 = 1.724 m^3}{\text{Bulk density of paddy}}$$

Natural angle of repose of paddy = 36.5^0 (Kunze *et al.* (2004)

Coefficients of friction: The angle of repose is relevant whenever grain is put in a pile, or put inside a bin or a receiving hopper or a drying chamber. A pile remains stable as long as its angle is equal to or smaller than the angle of repose, but the grains slide down whenever more grain is put on top tending to increase the angle beyond. The pile is formed because of internal grain-to-grain friction. The tangent to the angle of repose is the coefficient of internal friction

$\psi = \tan\theta$

Angle of repose varied somewhat among 14 varieties of paddy and milled rice with a mean of approximately 36.5° in both cases. The value determined by as quoted by Kunze et al. (2004), is 36°.By Rankine's theory, height and diameter of the bin was taken as 1.6 and 1.2 m

Design of Roof

- The roof is designed as a circular R. C. C. slab with overhang of 200 mm.

Design load = 5.25 × 1.5 = 7.875 kN/m2 ≈ 8 kN/m2.

Let the bending moment and shear force for circular slab could be calculated as follows (Shah, 2001).

M_r = Bending moment in radial direction. M_r at edge = 0+

M_r at center is given by = $\frac{3 \text{ X WX } a^2}{16}$ = $3x8x1^2/16$

M_r =1.5 K N-m

M_Θ = Bending moment in circumferential direction

M_Θ at edge is given by = $\frac{2\text{X WX } a^2}{16}$ = $2x8x1^2/16$ =1k N-m

M_Θ at center is given by = $\frac{3 \text{ X WX } a^2}{16}$ = $3x8x1^2/16$ =1.5 k N-m

Vr = Shear force in radial direction

V_r at Center = 0.5 × w × a = 0.5 × 8 × 1 = 4 kN

Maximum bending moment at center (Mrmax) = 1.5 kN-m

Maximum bending moment at edge (Mθmax) = 1 kN-m

Design of Wall

- Lateral pressure exerted by paddy on wall is given by

$P_h = K_a \gamma h$

Where, K_a = coefficient of active pressure determined by

$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}$$

$K_a = \frac{1 - \sin(36.5^0)}{1 + \sin(36.5^0)} = 0.254$

γ = Bulk density of paddy = 580 kg m^{-3}
P_h= 0.254 × 580 × 1.6 =235.712 kg m^{-2}Permissible tensile stress of cement mortar (F_s) = 3200 kg m^{-2}

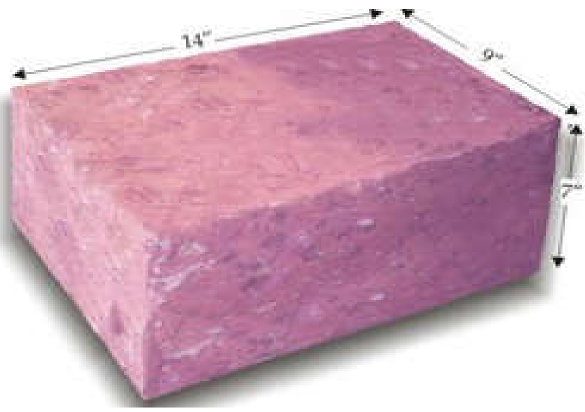
The tensile strength of cement mortar was considered in the design because the stone masonry will fail along the joint of cement mortar, which is the weakest section of the structure.

Thickness of wall (t) = $\frac{P_h \text{ x } D}{2 \text{ x } F_s}$ = (235.712x1.2)/(2x3200)=0.044

Factor of safety assumed to be 3

Design thickness of wall = 0.044 x 3 =0.132m=132mm

But the standard size of laterite stone available in the market was 455.6mm×228.6mm×150 mm. Thus, the minimum thickness of wall provided was 150 mm.



Images of standard Laterite stones available in local market

Volume of stone masonry = Volume of the masonry × Total height

= (Outside cross-sectional area – Inside cross-sectional area) × height

$=\pi$ x$(1.5^2-1.2^2)$x$(1.6+1.0)/4=1.654m^3$.

Number of laterite stones = $\frac{\text{Total volume of masonry}}{\text{Volume of laterite stone}}$

Volume of laterite stone= 0.45x0.22x0.15=0.01485
=1.654/0.01485 =111.

Taking into account the size reduction of stones while cutting and giving curvature total 140 stones were used.

Design of foundation

Load per unit area to be supported by the foundation
Load of paddy= 212.21 kg m-1
Load of stone masonry=2456.14kg m-3
Total load of laterite stone masonry of wall = 2500 kg i.e. 530.52 kg m^{-1}

Load of Roof= $\frac{10}{\pi \times (1.5^2-1.2^2)/4}$.

Total Load of Roof per Unit Cross-Sectional area = 816.33 + 15.71 = 832.04Kg-m^{-2}
Load of roof per unit perimeter = 112.32 kg m-1
Load of floor = 126.75 kg/m
Total load on foundation (Pf) = 5984.05 kg m-2

Depth of foundation

Depth of foundation (d) = $\frac{P_f \times K_r^2}{w}$=0.2852m

Factor of safety = 3
Design depth of foundation = 285 × 3 = 855 mm

Width of foundation

Total load on foundation per unit length =212.21 + 530.52 + 112.32 + 126.75 = 981.8 kg m-1

Width of foundation = $\frac{\text{Load on foundation per unit length}}{\text{Safe bearing capacity of soil}}$ =981.5/15000 =0.065m.

Factor of safety = 2

Design width of foundation = 0.065 × 2 = 0.13 m = 130 mm
Check against failure of wall.

The horizontal section of wall must be checked for the stresses produced due to weight of paddy transferred, weight of masonry, weight of roof transferred and due to wind pressure.

Thus total stress on the wall = 165.786 + 3929.82 + 832.04 + 981.48 = 5909.13 kg m-2 = 5.791 N/cm2.

Compressive strength of late rite stone = 510 N cm-2

As total stress on wall is very less than the compressive strength of laterite stone, hence the wall is very safe. As total stress on wall is very less than the compressive strength of laterite stone, hence the wall is very safe. Materials required and the cost of construction of laterite bin are presented in the table. Bin was loaded with paddy of variety R-117. Initial moisture content was 11.7 %.

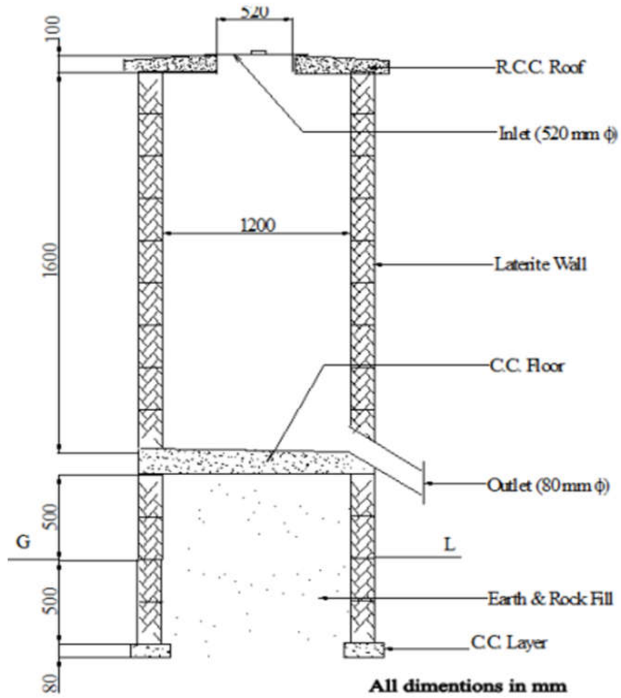


Plate 1. Elevation of laterite bin

The mass of paddy stored was375 kg. It occupied height up to 45 cm from bottom. Moisture content of paddy samples at top and bottom of the paddy grain bulk was recorded with the help of Universal Moisture Meter.

RESULTS AND DISCUSSION

Survey of the local paddy storage structures revealed that the most popularly Hadpa and Kanang are used for storing the paddy by the farmers, but these structures cannot withstand the wind as well as rainwater impact hence cannot be used outdoors. To overcome these drawbacks, a structure was constructed in laterite stone which is plenty available in Kohlan region.

Cost Analysis

S.No	Material/item	Cost	Quantity	Amount (INR)
1	Laterite Stone (40cm×25cm×15cm)	Rs.10 per piece	145	1450
2	Cement	Rs.145 per bag	10 bags	1450
3	Sand	Rs.2000 per brass	0.25 brass	500
4	Stone Chips	Rs.8 per pot	50 pots	400
5	M. S. Bars	Rs.17 per kg	25 kg	425
6	Binding Wire	Rs.25 per kg	1 kg	25
7	Nails (2")	Rs.25 per kg	1 kg	25
8	Labour			3000
Total				7275

Plan of structure was decided to be circular rather than square since there are no corners, the cleaning becomes easier and there are no wet pockets. The design capacity of bin was decided 1 tonne since the marginal farmers require small storage structure of about same capacity for paddy. The decrease in the international prices of food grains may pose a threat to the traditional storage practices if a relevant economical model is not created that pours food grains at competitive prices into the market. The increase in prices of production inputs like plant protection, fumigants etc. presents another constraint in developing a remunerative system of traditional storage. Besides, the growing trend of alternate use of grain, e.g. bio fuels, reduces the grain supply for consumption purposes thereby threatening the importance of traditional storage methods. The decrease in consumer demand for products of processed grain is another concern that would need. The easy availability of raw material from agricultural by-products, low-priced labour traditional knowledge and limited access to improved warehousing drive rural farmers towards traditional storage practices. Nevertheless, given the massive gap between production and modern storage capacity, it is imperative to encourage and improve the traditional storage practices. It offers many opportunities given the infrastructural constraints with public as well as private stakeholders. The need of the hour is to bolster traditional storage methods with modern inputs and to provide cost-effective storage structures to farmers, so as prevent enormous storage losses on one hand and strengthen national food security on the other.

Conclusion

Improved one tonne low cost paddy storage structure made out of laterite stone with R. C. C. roof and concrete floor is beneficial for marginal farmers.

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