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# Design of Poultry House and Steel Bin Storage Structure

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**ABSTRACT:** Poultry house design plays a vital role in the determination of the internal climatic conditions of the poultry house for optimum health of the birds and maximum production. A proper poultry house design provides adequate accommodation and an adequate supply of fresh air and light. Therefore, to store the food grain for long period and reduce grain losses during storage, the farmer needs a proper storage structure of different capacity to store grains. The deep litter poultry house was designed for 500 birds of heavy breed of age 13 to 20 weeks. The whole poultry house was divided into small compartments with a central passage. A shallow bin having an internal diameter of 1. The results showed that the dimensions of deep litter poultry houses for a particular number of birds would vary according to the floor space specified per bird. According to the capacity of each compartment number of feeders and waterers should be provided. From this experimental investigation, the results showed that the pressure distribution is influenced by the size and shape of the bin and moisture of the material to be stored, bulk density and angle of repose which in turn is affected by storage and flow characteristics.

## I. INTRODUCTION

Nowadays a large number of birds are kept in commercial poultry houses. The objectives of poultry house is to keep the birds comfortable, so as to promote good health, get maximum production and conserve feed and energy generated by birds. Poultry house design plays a vital role in the determination of the internal climatic conditions of the poultry house for optimum health of the birds and maximum production. In India, post-harvest losses are estimated to be around 10 percent, of which the losses during storage alone are estimated to be 6. To meet the current and future demand of the increasing population for food grains, it is emphasized to reduce the loss of seeds during and after harvest. But, with improved agricultural engineering, the farmers can afford to store the seeds for longer periods with minimum loss. With the above view, the project on “ Design of poultry house and steel bin storage structure “ was undertaken with the following objectives:

1. To design a deep litter poultry house for 500 birds.
2. To design a steel bin storage structure to store paddy..

The paper is organized as follows. Section II describes the review materials used for the project. The steps in designing the agricultural structures are given in Section III. Section IV presents experimental results showing results of calculations done for finding the dimensions of the designed structures and the conclusions are shown in Section V, Finally, Section VI presents references used in this project.

## II. RELATED WORK

Nardone et al. 2010 studied the effects of climate change on poultry production and the sustainability of livestock systems and it was concluded that the hot environment impairs production and reproduction performance. Longinus et al 2019 described the procedure of designing and implementing a smart embedded poultry farm. The system when tested was able to sense environmental parameter status and respond accordingly to regulate and maintain an optimum condition for improved health condition for the chicks. Enriko et al 2021 conducted an investigation to develop a chicken coop prototype that focused on temperature control systems on smart poultry

farms via the PID control approach. The PID response was found to be satisfactory for the system with  $K_p= 10$ ,  $K_i = 0$ , and  $K_D= 0.1$  Blight 1992 concluded that steel silo wall sheets expand due to the increase of temperature. As a result, the silo bin experienced a reduction in internal pressure. Xie 2015 studied the structural behavior of silo structure and lateral displacement of the corrugated sheet under grain load. All strains of the side wall were much less than the yield strain even when the silo was completely filled. Bharathi et al 2019 studied the grain temperature, moisture contents, and germination inside a corrugated steel bin filled with paddy. Germinability of the grain near the walls dropped later than those near the surface and inside the grain bulk in the presence of insect infestation. Zurovec et al 2019 studied the experimental verification of a mathematical derivation of Janssen's theory. It was concluded that the DEM method is a very suitable means for verifying the design of transport and storage facilities.

Anonymous IS 2732-1958 deals with the guidelines for location, space requirements, and the methods of construction of different classes and types of poultry houses including the necessary fixtures and equipment. Anonymous IS 9178- I, II, III 1979 described the criteria for the design of steel bins for the storage of bulk materials.

### III. METHODOLOGY

The design of the poultry house was carried out by using IS 2732-1958 code for practice for poultry designing. The steel bin structure was designed according to acceptable standards such as IS 9178 (Part I) 1979 code for criteria for the design of steel bins for storage of bulk materials and other related IS codes.

#### Design of poultry house

1. Determine the space requirement of following:
  - Floor space requirement
  - Feeder space requirement
  - Watering space requirement
2. Determine capacity and dimensions poultry house.
3. Determine the required values of following parameters:
  - a. Floor
  - b. Walls
  - c. Roof
  - d. Doors

#### Design of steel bin storage structure

##### Rankine's theory to determine pressure in shallow bin

For a shallow bin the lateral pressure can be determined by Rankine's theory,

$$P = w \cdot h \cdot \cos\alpha \frac{\cos\alpha - \sqrt{\cos^2\alpha - \cos^2\phi}}{\cos\alpha + \sqrt{\cos^2\alpha - \cos^2\phi}}$$

Where, P = lateral pressure intensity

w = unit weight or bulk density of material

$\alpha$  = angle of rupture

P acts in a direction parallel to the free sloping surface of the material stored i.e. at an angle equal to the angle of rupture,  $\alpha$ . The greatest rupture angle is  $\phi$ , the above equation reduces to

$$P = w \cdot h \cdot \cos\phi$$

The horizontal component of P is given by

$$P = w \cdot h \cdot \cos^2\phi$$

##### Steps of bin design

The design of steel or reinforced concrete bin can be divided into four parts:

1. The design of cover over the bin
2. The design of bin wall
3. The design of hopper
4. The design of supporting structure



**Top cover**

The top cover of the bin has been designed as a circular slab simply supported over the bin wall at its circumference. A central opening has to be provided for facilitating loading of the grain into the bin.

**Bin wall**

The bin wall of the shallow bin has been designed for the lateral pressure exerted by the grain. Rankine’s formula has been used for calculating the pressure. To take into account the dynamic pressure of 4 times over the static pressure has been suggested. The thickness of the wall should be such that it can withstand against any loads.

**Conical hopper**

The horizontal and vertical pressures in the hopper are calculated with the same formula that is used for the wall design. The meridional reinforcement shall extend sufficiently into the vertical wall to secure adequate bond. Thickness of the hopper has been provided equal to that of the wall.

**Ring beam**

The conical hopper is supported on a ring beam provided at the junction of the wall and the hopper. The ring beam has been designed to resist the hoop tension.

**Supporting structure**

The structure is supported over 4 nos. symmetrically placed columns. Each column is designed to carry ¼ of the total load as axial load transmitted through the ring beam. Footing can be designed for specific site requirements knowing the bearing capacity of the silo.

**IV. EXPERIMENTAL RESULTS**

The deep litter poultry house is designed for 500 birds of heavy breed and all the values are determined for the birds of age 13 to 20 weeks.

**4.1.1 Space requirements**

**a. Floor space requirement**

A floor area of 0.225 sq. m is provided for per bird of heavy breed. Therefore, the total area of deep litter poultry house for 500 birds is 112.5 sq. m. As the poultry house is divided into 10 compartments a floor area of 11.25 sq. m. is provided to accommodate 50 birds in each compartments.

**b. Feeder space requirement**

Two circular feeder of 0.5 m diameter are provided for 50 birds in each compartment of the deep litter poultry house. The feeders are kept in equidistant rows keeping a minimum distance of 1 m between two feeders.

**c. Watering space requirement**

For watering, two channel type of troughs of running length 0.625 m are provided for 50 birds in each compartments. The waterers are fixed in equidistant rows keeping a minimum distance of 1 m between two waterers in a row alternating with the feeders’ rows.

**4.1.2 Capacity and Dimensions**

The overall capacity of deep litter poultry house for 500 birds is shown in Table 4.1.

**Table 4.1 Dimensions of deep litter poultry house**

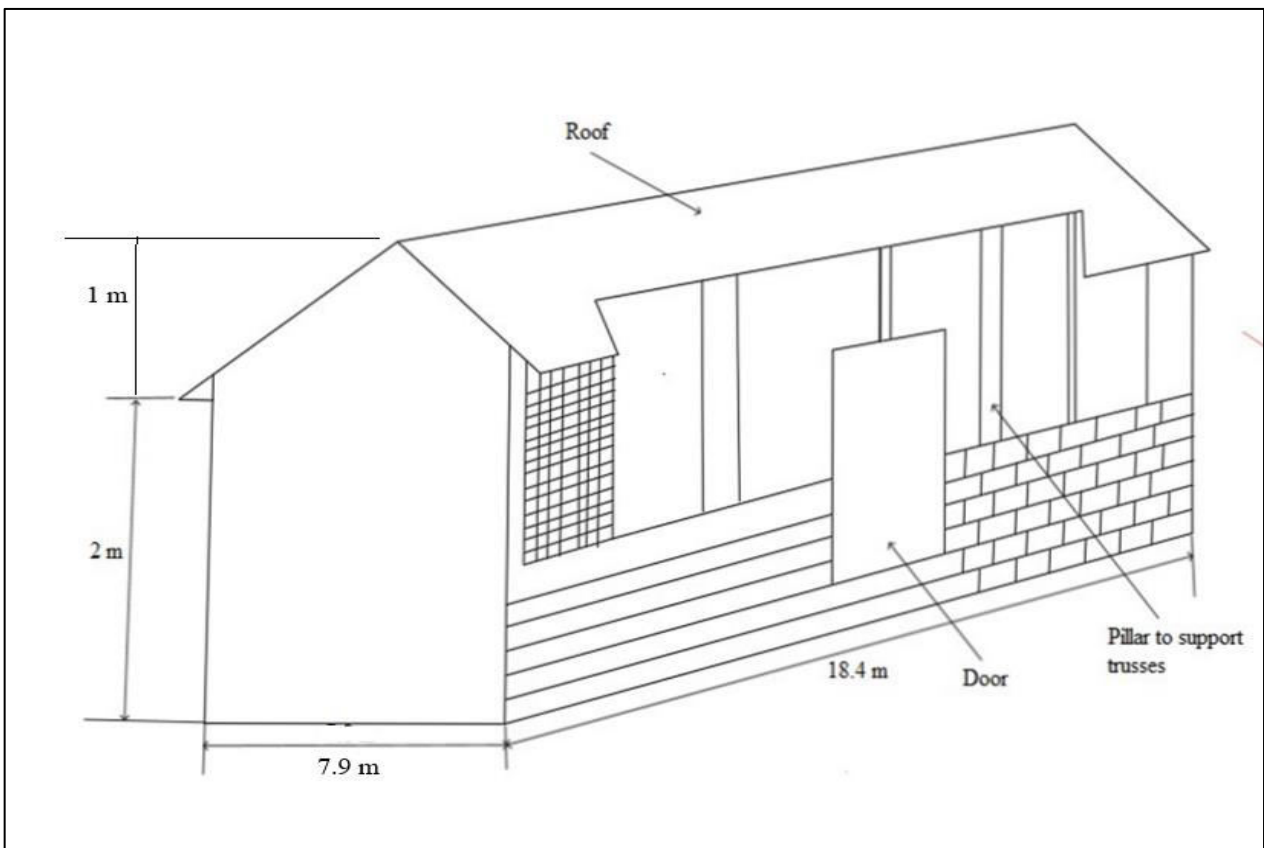
Length of poultry house (Including wall thickness)	18.4 m
Width of poultry house (Including wall thickness)	7.9 m
Length of poultry house (Excluding wall thickness)	18 m
Width of poultry house (Excluding wall thickness)	7.5 m
Minimum height of poultry house	2m
Central ridge height of poultry house	3 m

The overall dimensions of deep litter poultry house are shown in Fig. 4.1.

The capacity and dimensions of smaller compartments with a central passage are as followed in Table 4.2 and are shown in Fig. 4.2.

**Table 4.2 Dimensions of compartments of poultry house**

Total number of compartments	10
Number of birds in each compartments	50 birds
Length of each compartment	3.6 m
Width of each compartment	3.125 m
Length of central passage	18.4 m
Width of central passage	1.25 m



**Fig 4.1 Dimensions of Poultry House**

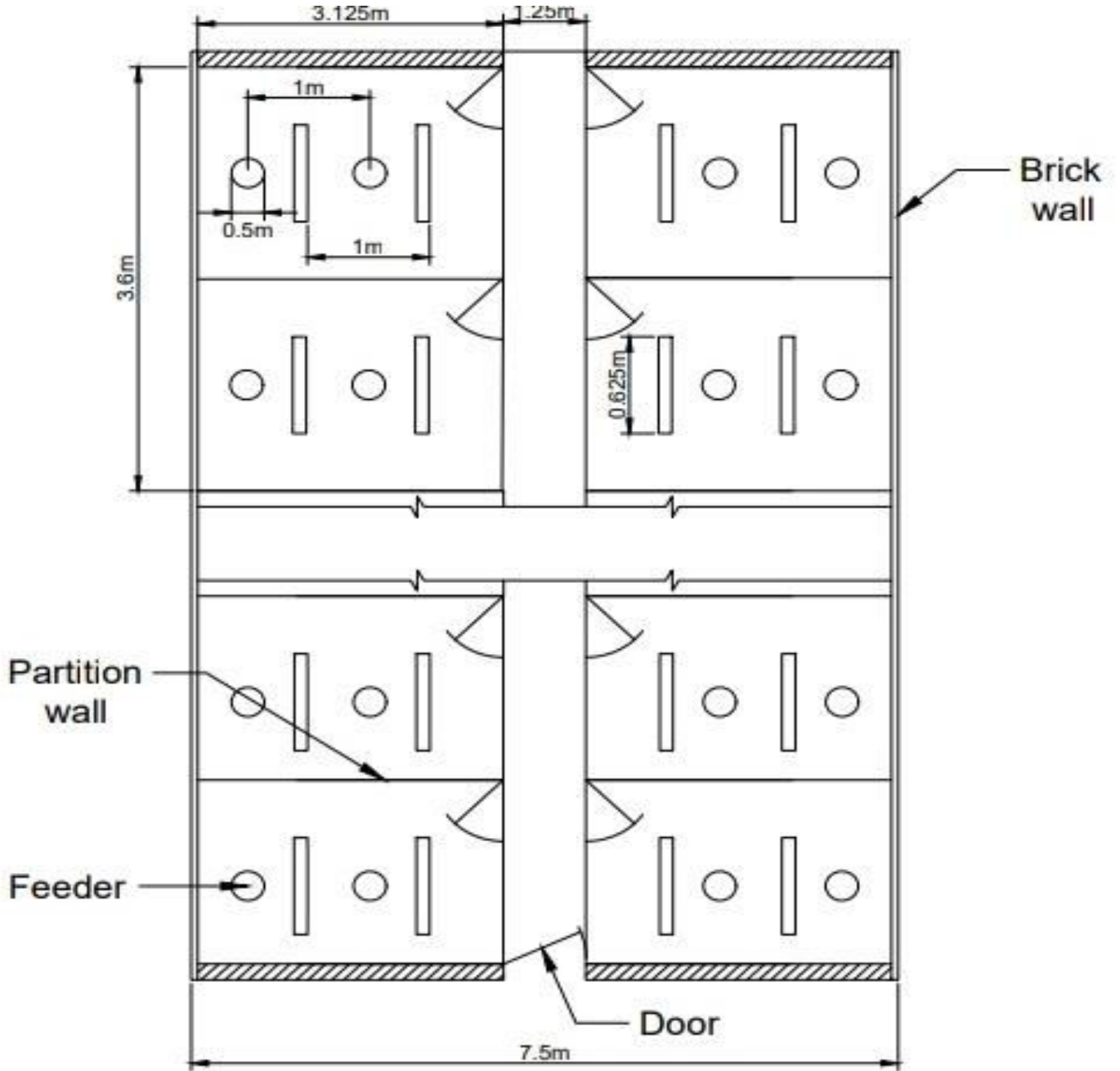


Fig. 4.2 Compartment View of Poultry House

**4.1.3 Constructional details**

The details of constructional components of deep litter poultry house are given below:

**a. Floor**

Cement concrete or brick-cement floor with a level at least 25 cm above the ground level is provided. The floor is covered with a suitable litter of about 15 to 20 cm deep. Litter material usually consist of chopped paddy straw, rice husk or dry leaves. Material like wheat or barley straw, dry grass or dry stalks of maize and bajara also make good litter.

**b. Walls**

The lower portion of the wall on the long side of the house up to 0.66 m height from the floor and it is made of 20 cm thick brick masonry in cement mortar.

The upper 1.33 m portion of the wall is made of galvanized mild steel-wire netting of about 1 mm in diameter having holes of size 12 x 12 mm supported by brick masonry pillars.

**c. Roof**

The width of the deep litter poultry is 18 m, therefore gabled type of roof with ridge ventilation is provided. The roof made up of galvanized steel sheets with a slope which depends on the rainfall and other climatic conditions of the region. In Konkan region, the summer is quite hot, the roof is made up of galvanized steel sheets with a layer of thatch to keep the house cool.

**d. Doors**

In the houses with central passage, two are doors are provided on the walls. The doors are 1.2 m wide and 2 m high and doors in the individual pens (compartments) are 0.6 m and 1.8 m high. The bottom of the doors is 30 cm above the floor at the top of the passage.

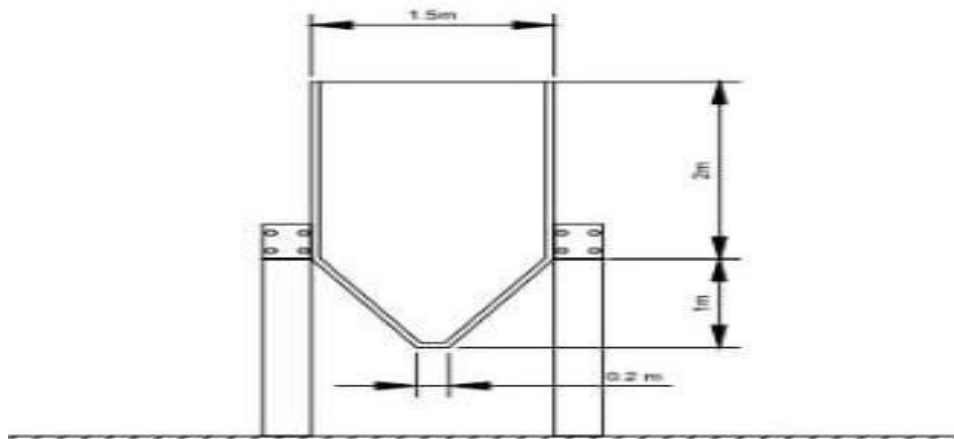
**4.2 Design of steel bin**

The steel bin of capacity 2.3 tonnes is designed to store paddy. The Table 4.3 shows the assumed data for design of steel bin.

**Table 4.3 Assumed data for design of steel bin**

Diameter of the bin (D)	1.5 m
Depth of bin above ring beam (H)	2 m
Depth of hopper below ring beam (h)	1 m
Bulk density of paddy (w)	575 kg/m <sup>2</sup>
Angle of repose (Ø)	36 <sup>0</sup>
Hopper bottom slope (θ)	45 <sup>0</sup>
Hopper bottom opening (d)	0.20 m

The dimensions of the steel bin are shown in Fig. 4.3.



**Fig. 4.3 Steel Bin**

**4.2.1 Design of bin wall**

Maximum lateral pressure occurs at the bottom of the cylindrical portion. According to section 3.2.3, the lateral pressure acting on bin wall was determined as  $750 \text{ kg/m}^3$ .

During loading and unloading of paddy dynamic pressure is exerted on the bin wall. It has been experimentally found by research workers that the magnitude of this additional pressure varies between 2-4 times that of the static load. To be on the safe side an increase of 4 times over the static pressure is being considered in the present design.

Hence, maximum dynamic pressure  
 $= 750 \times 4 = 3000 \text{ kg/m}^2$

Therefore, maximum lateral pressure expected  
 $= 750 + 3000 = 3750 \text{ kg/m}^2$

The walls are designed for the hoop tension caused by lateral pressure based on the theory of thin cylinder. At any depth  $h$ , the lateral pressure intensity was assumed as  $P_h$ , the hoop tension per unit weight was determined as  $2812 \text{ kg/m}^2$ . By using hoop tension the thickness of bin wall was determined as 10 mm i.e. 1 cm.

**4.2.2 Design of top cover slab**

The top cover slab is monolithic construction over the bin wall and have a central opening of about 30 cm diameter. But for simplicity of design, the slab is considered to be freely supported without hole, however to take care of stress concentration additional reinforcement is provided along the periphery of the hole.

According to section 3.2.4(b) for a simply supported case, the maximum radial and circumferential moments at the centre was determined as 9.5 kg-m.

**4.2.3 Design of hopper bottom**

Total volume of bin will be equal to the sum of the volume of the main bin and volume of the frustrum of the right angle cone at the bottom. Thus, the total volume of steel bin comes to the tune of  $3.97 \text{ m}^3$  i.e.  $4 \text{ m}^3$  to store 2300 kg or 2.3 tonnes of paddy.

According to section 3.2.4(c), the tension  $T$  acting on sloping wall of hopper bottom was determined as 3252 kg and the thickness of the hopper was determined as 0.019 cm.

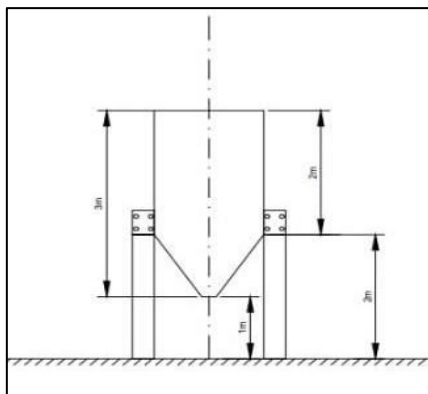
It would be advisable to use sheet of the same thickness 1.0 cm for bin wall as well as for the hopper.

**4.2.4 Design of columns**

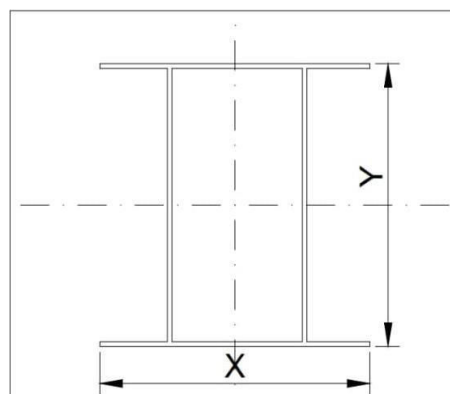
Total load on the column will be sum of weight of paddy and steel. Weight of paddy as calculated earlier = 2300 kg.

According to section 3.2.4(d), the total load acting on the columns was determined as 2844 kg.

As shown in Fig.4.4 the resultant wind load will act at a height of 2.5 m from the foot of the column. The column is subjected to load eccentric to both the axes due to the weight of bin and its contents and to the lateral thrust of the wind



**Fig. 4.4 Design of columns**



**Fig. 4.5 Supporting Column**

Neglecting the column thickness eccentricity due to the weight of bin and paddy= 1.25 m from both the axes as shown in Fig.4.5

According to section 3.2.4(d), the maximum compressive stress acting on supporting structure was determined as  $560 \text{ kg/cm}^2$ . The factor of safety for steel bin was determined as 2.67. Hence, the steel bin is safe.



#### V. CONCLUSION

1. The structural dimensions and space requirements are depends on the breed and age of the birds.
2. The designed thickness of bin wall should be such that it withstands against lateral pressure and hoop tension acting on the bin wall.
3. It was found that to use sheet of the same thickness for bin as well as for the hopper.

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