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CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

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SMALL CAPACITY GRAIN STORAGE BINS FOR RURAL AREAS

Introduction

With increase in the production of food grains, imporfance of its safe and scientific storage has also increased in present day context. Although, the problem of bulk storage of foodgrains and minimising losses there in is being looked after by various government agencies, it is equally important to evolve ways and means for safe storage of grain and seed retained by the villagers for their domestic consumptien and crops. About one and a half decade back, a survey was undertaken in the villages of western U.P. and Karimnagar district of Andhra Pradesh, to ascertain the method of construction, design and capacity of traditional bins used for domestic storage and to assess the factor and quantum of loss of foodgrains.

It was found that spoilage is substantial. Storage capacity per unit ranges between one quintal and three tonnes. However, majority of them are of one tonne capacity. The spoilage is mainly due to rodent attack, insect and pest attack, moisture and heat. The last two reduce their nutrition vaiue, too.

Existing Structures

Common storage structures or containers are either made underground or above-ground. Underground bins are called 'Khatties' or 'banda' and are in use where level of subsoil water is low. The pits are not completely airtight and waterproof. but they are lined with straw or other absorbent material which by becoming moist and mouldy, depletes the intergranular air or oxygen, so that insects, if present, are killed. The grain in underground storage is more free from seasonal fluctuations of temperature and humidity, provided adequate precautions are taken against seepage etc. Moreover the underground storage pits are nearer to airtight storage with its consequent advantage mentioned above.

Bins above the ground are called 'Kothi', Bukhary, Kuthar, Kuthla, Kanaja, Thekka, Morai, Puri, etc. Materials, used for construction, are clay wood, bamboo, straw, sarkanda and bricks etc. The above ground structures can be maintained in more hygienic condition and are more convenient for inspection and for operations like turning of grains.

Ideal Condition of Storage

The storage of foodgrains, which is a living material that respires and carries on biological processes, is quite different from the storage of inert materials. This is a complex phenomenon and needs considerable study of parameters, causing spoilage. Foodgrain is subjected to qualitative and quantitative losses due to four major destructive agents, namely, (1) large vermins i.e. rodents, birds etc., (2) insects and micro organisms, (3) moisture and (4) heat. The first cause i.e., vermlns are external threats and can be prevented by incorporation of measures impenetrable by them. The last three causes are, in fact, interdependent and attacks of insects and micro organisms can be considerably controlled by creation of suitable conditions of temperature and moisture in the interior of the bin. Ideal condition for this is to maintain the interior temperature of the bin at 21°C and the moisture content of grains at around 9%. Moisture and air ingress, from outside, must be prevented.

Research and Development Work

Many research organisations are working simultaneously, for development of designs for such structures. A few designs have already been prepared,

using materials like soil, bamboo, cement, plywood and light gauge metal sheets.

"Pusa bins" and modified clay bins made of soil were developed by fhe Indian Council of Agricultural Reaearch (ICAR) and Central Building Research Institute (CBRI) respectively and are suitable for self-help construction in villages.

Structural Eogineering Research Centre (SERC) developed a prefabricated technique for construction of ferro-cement bins having capacities between 1 and 3 tonnes. Components for such bins may be prefabricated at urban centres and transported to the villages and assembled there. Similarly, Indian Plywood Industries Research Institute (IPIRI) Bangalore, has developed prefabricated plywood grain bins of capacities ranging between 1 and 10 tonnes.

Indian Grain Storage Research & Training Institute, Hapur, conducts research on storage bins, storage conditions and grain handling and processing equipment and also holds training courses on the above subjects. Among many kinds of bins developed by them, the metal bins, particularly, are highly commendable. Capacity of their bins varies from 1 to 15 tonnes.

Work done at CBRI

This institute has been engaged in the work of developing small capacity bins for about a decade and has evolved quite a few designs. The technique has been simplified to bring it within the reach of technical skill available in rural areas. Four designs finalised, so far, are discussed below along with their costs and different tests conducted on their performance.

Underground concrete bin (capacity 1 tonne)

The bin is cylindrical and consists of 38 mm thick precast R.C.C. rings, fabricated with the help of steel or wooden moulds. These rings form the inner fabric of the structure while the outer one is 114 mm thick burnt brick wall in cement mortar. A sandwiched layer of bitumen felt, pasted with hot bitumen, on the outer surface of the precast concrete rings, after sealing their joints with cement mortar and bitumen, acts as vapour barrier.

The foundation for the structure is constructed in brick masonry over a concrete base. The floor is finished with cement mortar after laying a bitumen felt, which is sandwicaed between the base concrete and floor finish. Precast concrete cover for the manhole is fabricated on the ground with the help of earthen formwork and provided with locking arrangements. A rubber gasket is also provided under the manhole cover to make it airtight and to prevent any moisture migration. A prototype was constructed at CFTRI, Mysore where its behaviour and performance were found sarisfactory. The details of the structure are shown is Fig. 1. The cost of structure for one tonne capacity comes to about Rs. 1250.00 (material and labour) at local (Roorkee) market rates in 1986.

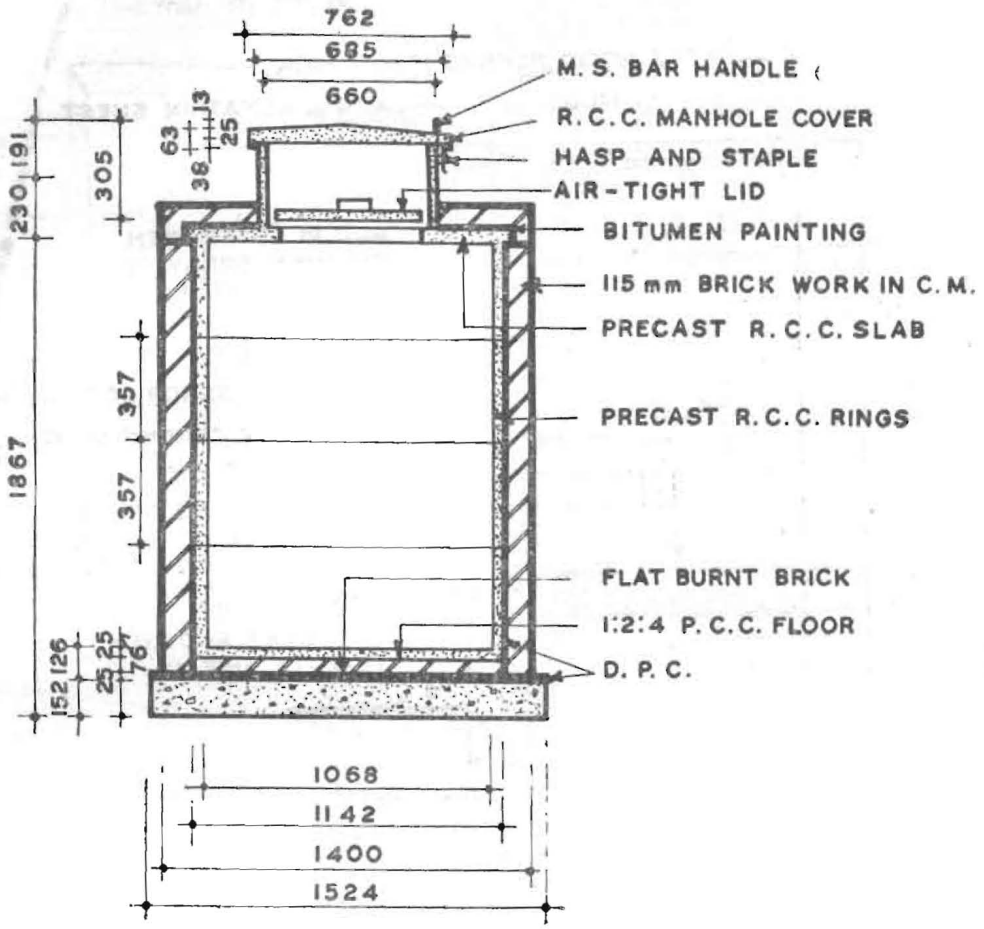
1. Modified domestic clay bins (for use under cover-capacity 1 tonne)

The structure is cylindrical in shape and consists of 230 mm thick burnt brick work in mud mortar upto plinth. The floor filling consists of a bottom layer 100 mm thick, and then a 50 mm layer of sand impregnated with creosote oil, a layer 150 mm thick of broken glass and properly compacted brick bats. A layer of 25 mm thick cement concrete (1 : 3 : 6) with waterproof membrane of 400 gauge alkathene sheet laid with a coat of bitumen and 12 mm thick cement plaster is provided to act as a floor. A tin sheet (from old empty, oil or bitumen drum) is cut in a round shape and provided in the brickwork at plinth level below the flooring. This sheet is partly projecting outside the wall, and has downward slope to act as barrier against rodents and termite.

The superstructure consists of 230 mm thick wall made of sundried bricks laid in mud mortar and reinforced by placing split bamboo at every 230 mm spacing. The vertical bamboos are tied with circular ring of split bamboo provided at 230 mm spacing. G.I. wires are used for tying these splits together. Outer surface is finished with 12 mm thick non-erodable mud plaster. Ordinary mud plaster is applied on the inner face.

The bin is closed by placing on its top, wooden lid made of 12 mm thick waste wood planks. This lid is wrapped in a polythene sheet (400 gauge). The bin is now sealed by using 75 mm thick layer of mud on top and mud mortar at all joints to make it airtight. An opening of about 250 mm dia. is provided in the centre of the lid which is closed with

a metal cover with handle. This helps in periodic fumigation and checking of the grains from the top. The outlet pipe provided at floor level is also closed with a wooden piece and gunny bag or a metal cover with locking arrangement. A polythene sheet is also wrapped at the mouth of the pipe to make it airtight.



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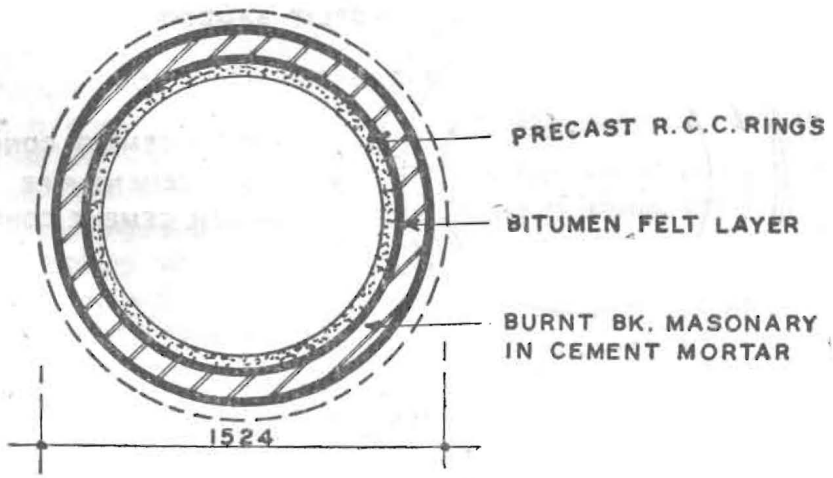
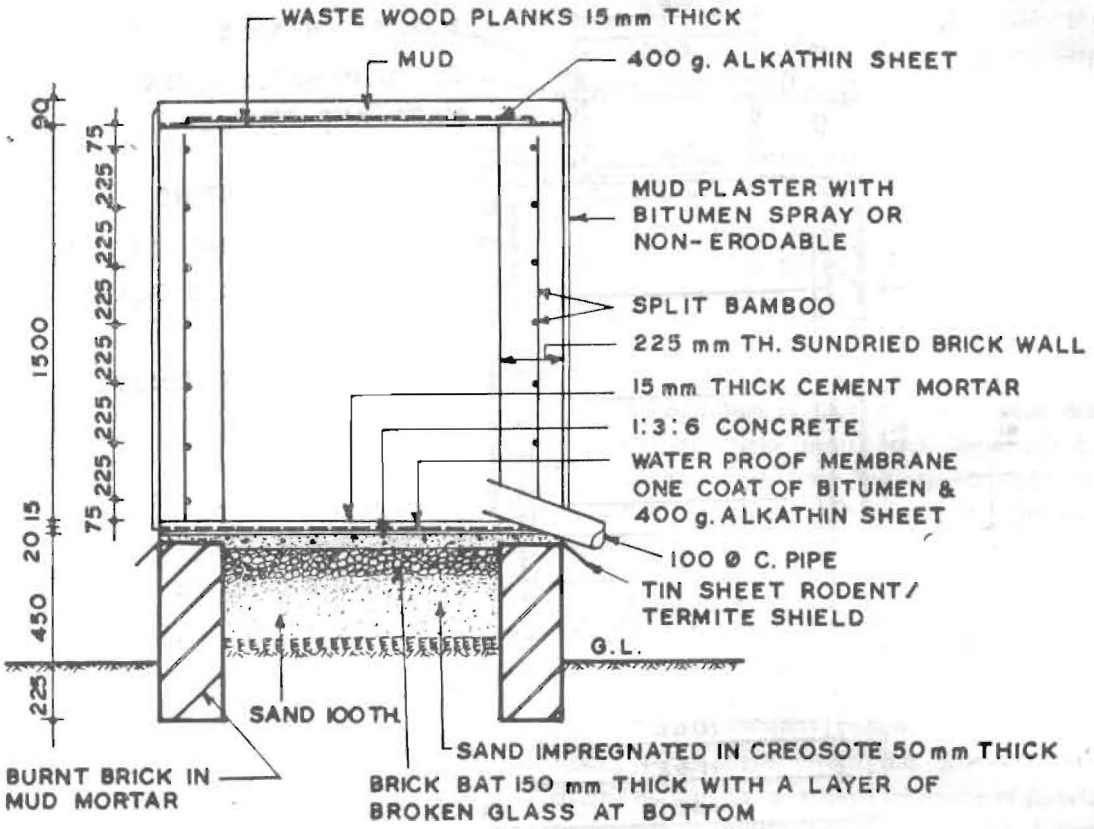


Fig. 1. Underground Concrete Bin Capacity 1 Tonne

The dimensions have been so chosen that the bin is marginally shallow. It has been designed for hoop stresses only. The behaviour has been confirmed by actual test carried out at this institute, The details are shown in Figs. 2 & 3. Overall cost of labour and material is Rs. 700.00 at local market



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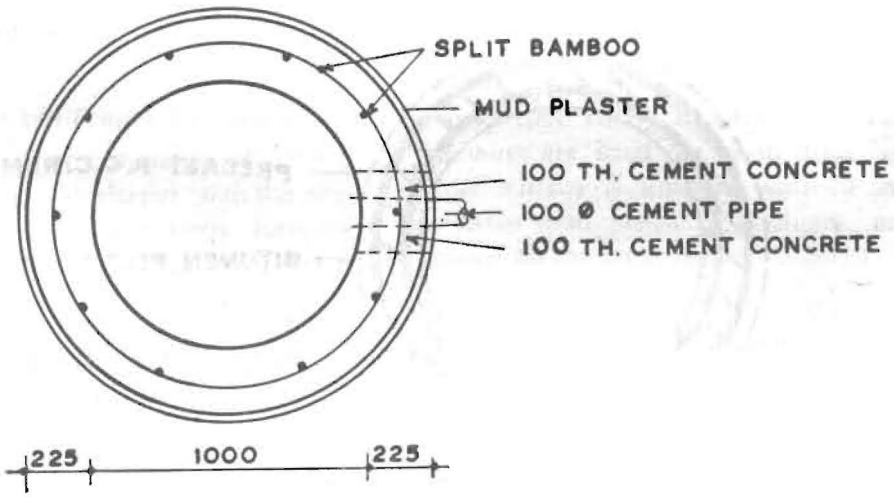

Fig. 2 Moeified Clay Grain Bin Capacity 1 Tonne

(Roorkee) rates in 1986. If materials like bamboo, waste wood and sundried bricks etc. are arranged by the owner free of cost and he provides his own labour, the bin should cost less than Rs. 250.00.

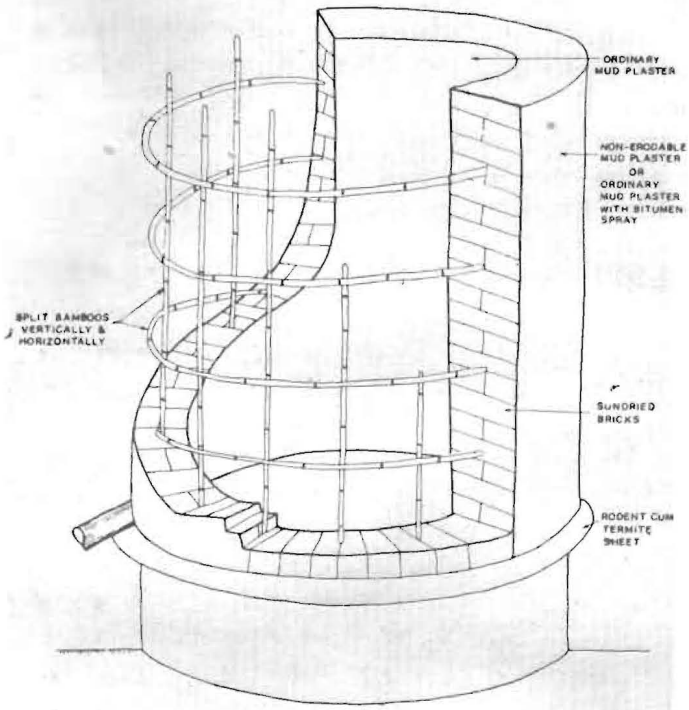

Fig. 3 Dissected View of Modifed Clay Bin

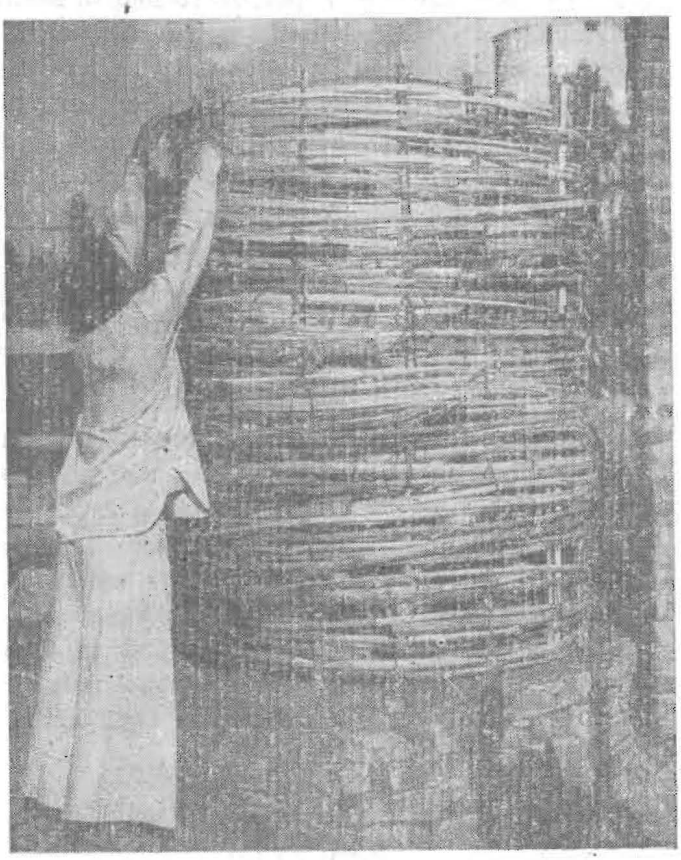

Fig. 4 Alternative Design of Modifed Domesic Clay Bin

Alternative Design

The above design may be made by using split bamboo mesh of cylindricai shape and plastered with mud on both the faces instead of using sundried brick wall as described earlier (Fig. 4). This type of construction often proves cheaper than the one with sundried bricks.

Procedure of construction upto plinth is similar to the domestic clay bin described earlier, except that the bamboo knitted mesh is placed from above the ground level and sandwiched in the burnt brick work in the centre of the wall upto plinth, to have sufficient anchorage at the bottom. The rings and the vertical bamboos are tied with binding wire. Another difference is that due to reduced wall thickness, the outer dimension is less than that of domestic clay bin.

Prototypes of the above two designs have been made in the laboratory and structural test carried out successfully. The cost of 1 tonne capacity bin at 1986 Roorkee market rates is about Rs. 550.00 (Rs. 350/- for material and Rs. 200/- for labour). In case this silo is constructed on the basis of self help and the material such as bamboo, mud, etc. is arranged by the villager free of cost, it may be constructed in less than Rs. 150.00. Prototypes of the above described clay silos were constructed at IGSI, Hapur for testing their behaviour and performance.

3. Modified brick bin (above ground and outdoor–capacity 1 to 3 tonne)

The brick silo of 3-ton capacity (above ground) is square in shape, having burnt brick walls upto plinth in cement mortar, over lime concrete base. The superstructure consists of two walls, 115 mm thick of burnt brick in cement mortar. The inner wall is constructed first and plastered with cement mortar on the outer face. Another layer of 2 coats of hot bitumen or 1 coat of hot bitumen and 400 gauge alkathene sheet is applied over it to act as vapour barrier. External wall is constructed around

the inner one keeping a gap of 15 mm, in which mud mortar is filled, while the wall is being made. The flooring is made with two layers of flat bricks with either 2 coats of bitumen or 1 coat of bitumen and 400 gauge polythene sheet sandwiched between these two layers. The upper layer of flooring is finished with cement plaster. A 100 mm (4") dia. S.W. pipe at 45° slope is provided above plinth and embedded in floor to work as outlet for grain. This pipe is provided with an adjustable cover and clamp fixed on its collar.

The grain is filled from the top for which an opening is provided in the roof. Three small brick panels resting on a wooden beam and the 4th one square serving as an opening for a manhole makes the roof cover. The manhole is covered with wooden plank, bhusa in gunny bags and finally with polythene sheet and G.I. sheet cover with locking arrangement. The brick panel roof cover is finished with cement plaster, giving it adequate slope to drain off rainwater. The details are shown in Fig. 5 and a

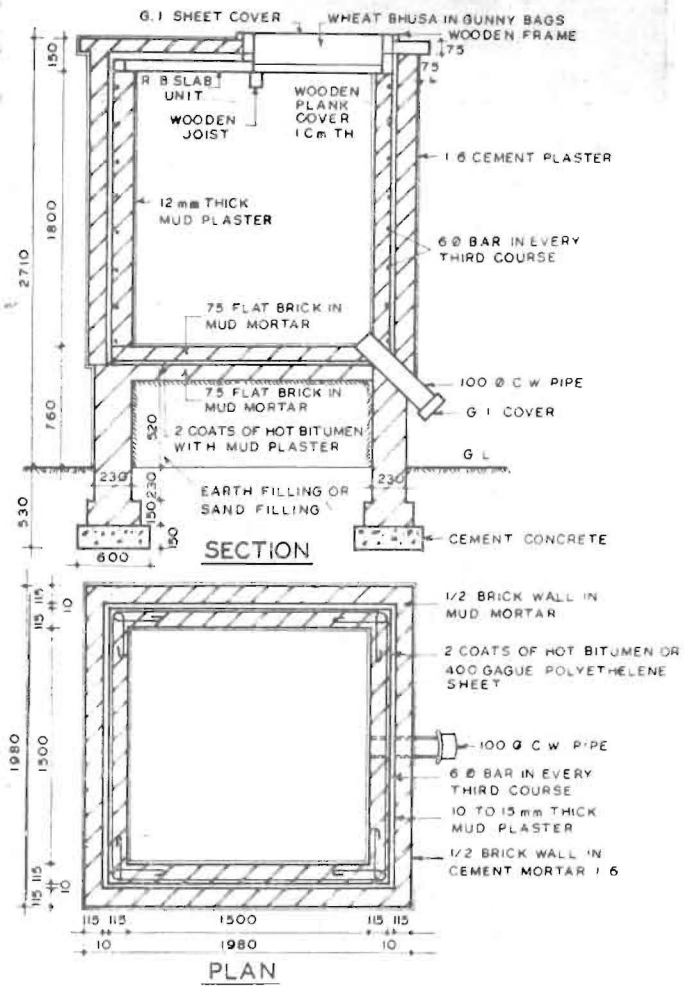

Fig. 5 Brick Silo Capacity 3 Tonne

view of the completed grain bin constructed at IGSI Hapur is shown in Fig. 6.

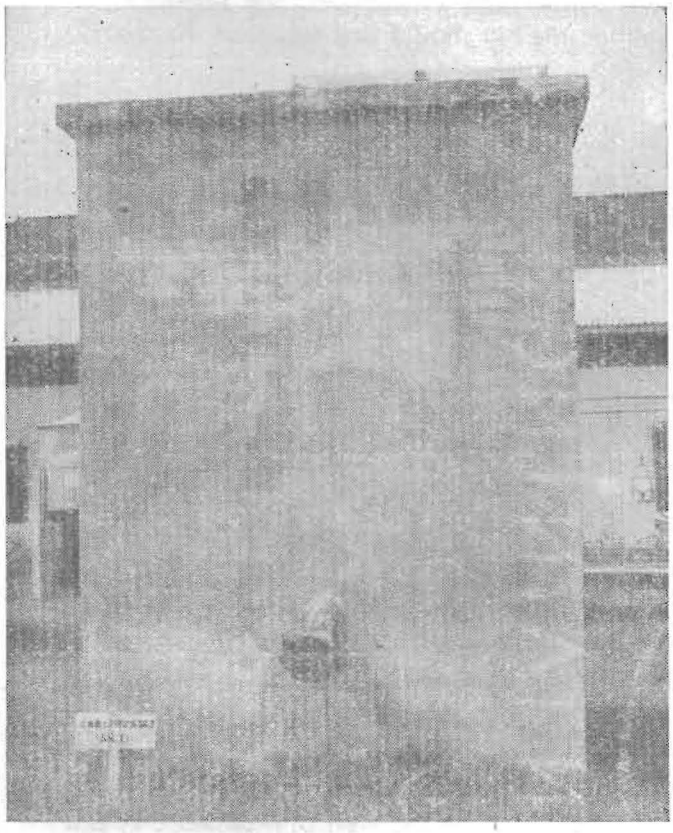

Fig. 6 Msdified Brick Bin Capcity 3 Tonne

The structure is square and has been designed to reduce the skill required to construct a circular one. The wall with reinforced brick masonry is designed to take the stresses arising out of grain loading. This conforms to IS : 4995–1968. The cost of 1 tonne capacity bin is Rs. 1200.00 and that of 3 tonne capacity is Rs. 2050.00 approximately at local (Roorkee) market rates in 1986.

4. Semi underground cement bin (capacity 1 tonne)

The shape of this bin is semi-spherical below ground level and frustrum of a cone above the ground level. The basic idea of choosing such a shape and design is that the semi-spherical portion is below ground level and has adequate support of the ground and the height of the frustrum of cone chosen is so low, that traditional type of cot (charpai) can be placed over the bin with the advantage that the bin which is a "cast-in-situ" structure does not require any additional floor space in the room.

Dimensions of the bin are shown in Fig. 7. For starting construction, a semi-circular pit of

required dimension is dug, and the shape is corrected with a template. After finishing this surface with trowel, a layer, 20 mm thick, of cement mortar (1:8) is laid in the semi-spherical shape in one operation upto G.L. with the help of the same template. Then a waterproofing layer of 2 coats of bitumen is provided over this layer. Next 16 gauge chicken wire mesh is spread over the entire surface. Over this 1 : 3 cement mortar is applied in uniform thickness of 10 mm. One more layer of same chicken mesh is spread over this, over which is again applied the same 10 mm thickness of the same mortar. Thus this operation is done in two identical layers.

For construction of conical portion above the ground, the bottom semi spherical portion is filled with dry sand which is continued upto the top, where a profile of the same shape and of internal dimensions as that of the frustrum of a cone, is made with dry compacted sand. Chicken wire mesh, which is continued from the bottom, is taken to the top and a layer of 20 mm thick cement mortar 1 : 3 is laid with 2 layers of chicken mesh and finished to shape as shown in the drawing. Extra precaution is to be taken at the junction of semi-spherical and conical portions, to see that chicken mesh and fabrication continues. There should be no joint at the junction, (Figs. 7 & 8).

Lid is also precast, using cement concrete and chicken mesh reinforcement and fixed with airtight rubber gasket.

Bottom surface of this bin is well supported on firm ground and is able to resist all the stresses. Above ground portion is conical whose walls are at a slope of 35° to the base, which is more than the angle of repose of wheat. Hence no stresses on account of loading of grain are transmitted to the walls. A prototype has been made at this Institute and found satisfactory in its structural behaviour. The cost of 1 tonne capacity bin comes to Rs. 900.00 at 1986 Roorkee market rates.

The bins mentioned above are those whose performance has been found satisfactory. Hence they are recommended for adoption.

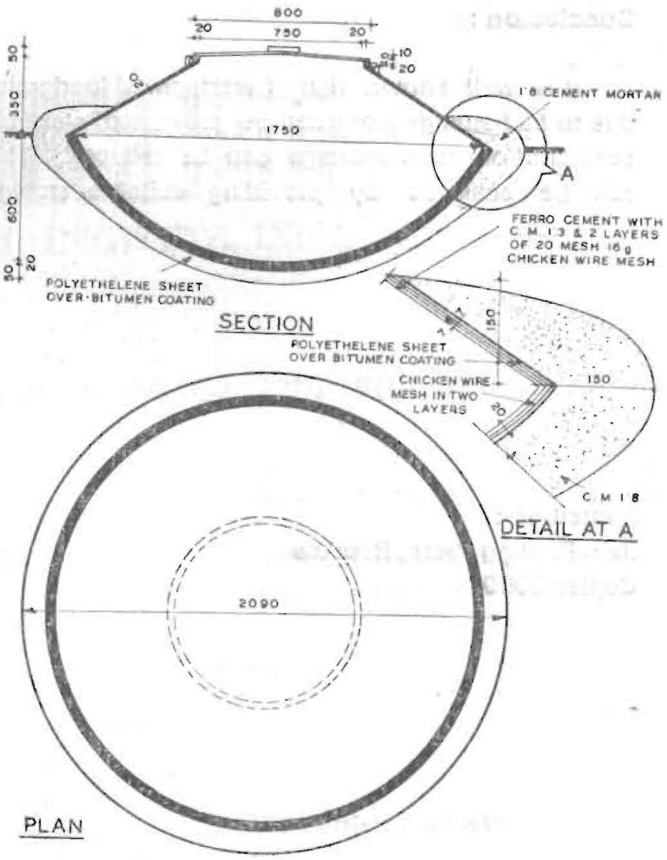

Fig. 7 Semi Undergound Cement Bin Capacity 1 Tonne

Fig. 8 Semi Underground Cement Bin Capacity 1 Tonne

Conclusion :

It is well known that if wastage of foodgrains due to bad storage alone can be prevented, a sizable portion of our food shortage can be reduced. This can be achieved by providing suitable storage conditions and structures for storing the quantity, which has to be stored at farm level. Use of small capacity and low cost storage bins can go a long way in preventing the spoilage and contamination of grains, which is retained and consumed in the village.

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