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“ Construction of Grain Storage Bins in the Punjab ”

By

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Introduction.—Provision of food for the masses of a country has always been a matter of great concern to the state. India has always been largely an agricultural country and in times of normal crops both in this country as well as in the neighbouring ones adjustments to meet the demands of the population could easily be made. Large stocks of rice used to be imported from Burma and Indonesia while considerable quantities of wheat were exported from Punjab both to the deficit areas in this country as well as to other countries. The ravages of war however brought about a considerable food shortage all over the world and the experience gained actually during the war years which entailed heavy restriction on transport arrangements led Government to seriously consider ways and means of providing some positive means of amelioration in case of necessity. The terrible famine in Bengal which occurred some years ago and was responsible for the loss of so many lives helped considerably in bringing this question to the fore front. In 1944 therefore the Central Government formed a Directorate of Storage in the Food Department which took this question of providing proper storage with active interest. A survey of the prevailing position in the country with regard to storage was taken and on investigation it was found that the accommodation available was very appalling and far from satisfactory. The primitive methods of storage which will be discussed later on were found to have provided no effective check against losses by weevils, pests, rats and other rodents, losses on account of which were estimated to be very considerable. It was pretty obvious that if millions were to be saved from starvation, something must immediately be done to reduce this loss to the minimum. In Punjab alone where the production of wheat is estimated to be $3\frac{1}{2}$ million tons, the quantity lost annually on account of these pests is at a very modest estimate reckoned to be over a lakh of tons. At the prevailing price of wheat at about Rs.9 a maund the cost of this amount is over rupees 25 millions. Besides the loss in money, what is more important is the loss in quantity which if properly conserved would help to save so many people from starvation in other parts of the country. On the same basis the total figures of loss for the food-grains for the whole of the country would certainly amount to be very stupendous. It would therefore be seen, that the need for proper storage and efficient conservation has always been in existence and it is really a great pity, that it has not been seriously taken up in the past.

Primitive Methods of Storage.—As indicated above it is only very recently that the question of adequate storage has been taken into consideration. Prior to this the storage accommodation provided was of a very inadequate nature. The average farmer used to store wheat which he retained on his own holding in receptacles or granaries made either of mud or of matting prepared either from straw or bamboo reeds or some similar suitable material. In some places this small storage by the farmers was also done in cylindrical containers made of closely woven hemp cloth. They were suspended from the roof in order to save them from damp and weevils. When the stocks to be dealt with were larger in quantities they were put in for storage in rooms set apart in a portion of the house itself. Where the houses had more than one storey the rooms on the ground floor were generally used for this purpose. These Kothas are usually made of burnt brick in mud and the grain is stored there in bulk. When the losses in such a form of storage became apparent, greater attention was paid to the quality of brick work and the floors of these Kothas and cement concrete in floors as well as cement plaster in walls was tried in several places by the more advanced type of Zamindars. At its very best however this type of storage was far from ideal.

In the mandies where the quantities to be handled are quite considerable, wheat has invariably been stored in big Kothas containing about one thousand maunds or so. Generally this kind of storage is provided in the lower floors of houses which are not being used as living quarters. This arrangement protects the storage from the ravages of weather but in most of the godowns there is no provision against damp or against infestation of weevils and other pests.

Ever since the question of losses became to be realized in seriousness, attempts have been made to improve the condition of these godowns by providing either cement concrete in floors or by cement plastering the walls or treating them with some insecticide before wheat is actually stored in them. Both types of storage, *i.e.*, in bulk and bags has been adopted in the past. Bulk storage appears to find more favour than the other one. Not only does it save the cost of bags and the deterioration thereof but it is generally experienced that wheat stored in bulk is less liable to deterioration than that in bags.

This type of storage has had its limitations but when the grains were available in plenty and no serious consideration was given to the losses, the practice hitherto adopted was allowed to be carried on without any serious interest being taken in effecting improvements. But when the prices of grain rose very high due to general scarcity and consequent demands, the necessity of conserving all possible grain became really very apparent. Steps were therefore taken to improve the existing godowns as as best as possible and also to devise better means of storage. As a beginning, reinforced cement concrete Khaties were adopted in Muzaffarnagar District. They were very cheap to construct and were a considerable improvement on the old type of pit method of

conservation and storage. These Khatties were constructed close to the mandies and were mostly under ground. The filling was done from the top and the wheat was taken out of these Khatties also from the top man-hole by means of baskets. The experience gained on them was that the losses on account of weevils were reduced considerably but the trouble on account of dampness especially in the wheat that came in contact with the walls could not be solved satisfactorily. Each Khatti measured $10' \times 10' \times 8'$ and was capable of holding about 450 maunds of grain. For a certain time the wheat stored in the concrete Khatties could be sold at a premium of about -/1/- per maund over that stored in katcha pits. It was however found that it was difficult and comparatively expensive to take out grain from these Khatties. It was therefore felt that storage above ground would perhaps be better and more economical in the long run. In consultation with trade, the Food Department of the Government of India evolved a design which has been adopted in Sind: This consist of series of rectangular rooms raised about 3' above the ground level with a sloping floor. Wheat is carried to the top by means of staircase and filled into these godown through the man-holes, located on the top. For discharging the godowns wheat would be taken out from a trap door in the side. This design was also considered by the Punjab Government but on account of certain difficulties involved in its use was not adopted. After a great deal of discussion and consideration the Punjab Government adopted another design which was regarded as a considerable improvement on that put up by the Government of India. The exact design used is described in the succeeding paragraphs.

Design.—The design adopted for storage is on the same lines as is usually adopted all over the world for silo construction. It consists of a series of hexagonal bins which are carried over pillars raised about 10' above ground. The walls of the bins are brick in cement (1 : 3 mortar) suitably reinforced with hoop iron while the hopper is of reinforced concrete and supported from peripheral beams also of reinforced concrete that span the various pillars supporting the superstructure. The top slab is also of reinforced concrete and is suitably designed to withstand any supper loads that may come thereon. The pillars were originally intended to be done in plain cement concrete but on account of difficulties of transport required for the collection of materials for this type of work it was considered more expedient to make them in brick. All the pillars are inter-connected at the foundations so that the chances of unequal settlements in any of the bins are reduced to the minimum. The peripheral beams at the hopper have been designed as Monolithic in construction. The slopes of the sides of the hopper has been kept at 35° to the horizontal which permits a very easy flow of grain and facilitates easy clearance of the siloes. The capacity of each silo is reckoned to be about 1,000 maunds. This size was adopted because the trade generally favoured godowns of this size for business transactions. The sides of the silos are 6.5' in length and the height of the bins is about 15' above the top of the hopper.

Siting of the godowns.—Opinions have differed whether the godowns to be constructed for storage should be built close to the mandies or close to the railway stations. In several places however mandies and railway stations are very close to each other and therefore what is good from one point of view would be equally good from the other aspect as well. But there are several other places where mandies are located at some distance from the railway stations and choice had therefore to be made whether the proposed godowns should be located close to the mandi or close to the railway station. It is however pointed out that sites round about the mandies are mostly so cramped and built upon already that it is not conveniently possible to obtain any land for storage construction of the new type in most of the mandies. The old type godowns which have been allowed in the past to cluster round mandies have utilized all available sites for building construction in their proximity and have therefore rendered the new construction extremely difficult if not impossible in several places. Moreover the success of any proper storage scheme will depend considerably on the amount of facilities that could be provided at the time of despatch. Any system of storage has to be looked at from various angles of view and one of the most important ones is that it should provide a balance of reserve which could be drawn on in case of urgent necessity at a very short notice and the quantities could be readily transported to the places where they are required. In other countries most of the elevators are considered to be a liability of the railway authorities and have been constructed on the railway premises. While no step in this direction has so far been taken in this country it is not too much to expect that before very long opinions may change and the railway department may decide to help the Agriculturists by offering special facilities for the despatch of the agricultural produce. Therefore with this object in view, attempts were made to secure land required for the storage construction from the North Western Railway authorities in as many places as possible.

It was only in cases where the North Western Railway found it impossible to lease out land that some other sites were actually considered but these ones too were located as close as possible to the railway station. The main object governing the choice of these sites was that at the time of despatch, loading should be as convenient as could possibly be managed and the present loading facilities available on the railway system should be utilized to the maximum degree.

To take over huge strips of land from the railway authorities was not an easy matter and as questions of broad policy were involved in the proposals, it took some amount of time before any decision thereon could be arrived at. Originally it was intended that the land required for this construction should be purchased outright from the railway administration but later on it was thought more expedient to try to lease out the same on the usual terms. Most of the godowns have therefore been constructed on the railway land as close to the railway station and the Goods Platform as could conveniently be managed and is only at very

few sites where the lease of railway land was not possible, that godowns have been located on non-railway land. In such places also attempts were made to secure land as close to the railway station as possible so that the cost of subsequent handling at the time of despatch is reduced to the minimum.

Size of the Godowns—Previous experience of storage in ordinary godowns has been of a mixed nature. In some of the godowns which were inspected in several mandies it was found that bulk storage had been adopted to a height of 14' or 15' without any serious difficulty and the size of the rooms where such storage was provided varied considerably according to requirements. The general opinion of the trade however was, that the larger the godown the less is the chance of loss on account of weevils. Naturally the over head charges are also reduced in proportion as the size of storage increases. However as already indicated above, the size of each silo unit was kept as about 1,000 maunds which could permit a transaction to be carried on quite conveniently later on. The actual capacities of the various bins were worked out by the Civil Supplies Department and vary from 500 tons to 3500 tons. A full detail of the accommodation provided at each place is given below :—

1.	Renala Khurd	...	...	500 tons
2.	Okara	...	...	3000 tons
3.	Montgomery	.....	...	2000 tons
4.	Chichawatni	...	...	2000 tons
5.	Pakptatan	...	...	1000 tons
6.	Arifwala	...	...	3000 tons
7.	Burewala	...	...	1500 tons
8.	Vehari	...	...	1500 tons
9.	Kahrora Paca	...	...	2000 tons
10.	Mian Channu	...	...	2000 tons
11.	Khanewal	...	...	1500 tons
12.	Jahanian	...	...	1500 tons
13.	Sheikhupura	...	...	1500 tons
14.	Chuharkana	...	...	1500 tons
15.	Gujranwala	...	...	1000 tons
16.	Kamoke	...	...	1000 tons
17.	Hafizabad	...	...	1000 tons
18.	Nankana Sahib	...	...	1500 tons
19.	Warburton	...	...	500 tons
20.	Sangla Hill	...	...	1500 tons
21.	Jaranwala	...	...	3000 tons
22.	Chak Jhumra	...	...	1500 tons
23.	Tandlianwala	...	...	2000 tons
24.	Gojra	...	...	3500 tons
25.	Toba Tek Singh	...	...	2500 tons
26.	Pir Mahal	...	...	1500 tons
27.	Kamalia	...	...	1000 tons
28.	Sargodha	...	...	3000 tons
29.	Sillanwali	...	...	2000 tons
30.	Bhalwal	...	...	1000 tons
31.	Phullarwan	...	...	1000 tons
32.	Lyallpur	...	...	4000 tons
33.	Jagraon	...	...	2000 tons
34.	Moga	...	...	2500 tons
35.	Talwandi	...	...	500 tons

36.	Kasur	...	...	2000 tons
37.	Guruharsahai	...	...	500 tons
38.	Mukhsar	...	...	300 tons
39.	Fazilka	...	...	1000 tons
40.	Abohar	...	...	1500 tons
41.	Malout	...	...	500 tons

These sizes have been fixed with due regard to the quantities likely to be available for storage in each mandi after the purchases separately made for immediate despatch have been accounted for. The storage provided is in most places a very little fraction of the total quantities of grain that come into the market at the time of the harvest. It is however anticipated that once a beginning on proper storage has been made in these places a great incentive will be afforded to the public as well for improving the condition of their own storage and in the course of time something substantial would have been done to achieve the target.

From the economic point of view it would appear that a small size storage would require practically the same amount of expense in organization and control as a big sized one and therefore it would appear desirable to have bigger storage provided nearly at all the mandis. This is of course an ideal proposition but in order that a proper beginning may be made straightway it was considered necessary to keep the sizes restricted to meet the immediate requirements. The possibilities of these godowns being subsequently let out to the trade or transferred to the control of the Co-operative Department at some later date for being used by their co-operative societies was also kept in view when the sizes of the godowns were fixed by the Civil Supplies Department.

Bins

Details of Design.—As stated above the capacity of each bin is only about a 1000 maunds and the required size of storage at each place has been provided by multiplying the number of such units. The grouping of these units has however been arranged in the form of bee live cluster so that the maximum amount of saving on material may be obtained. For a 500 tons storage the number of bins is 14 while that for a 3000 tons is 84. The numbers of the bins vary in proportion to the size actually required at each place.

Foundation.—Reference to the design (Drawing No. 1, will show that the load of the bins is transmitted to the pillars through the foundations. Originally it was intended that each pillar should be provided with separate foundation. Later on it was considered more appropriate to connect up the pillars at the foundation level, so that the concentrated loads under them might be more uniformly distributed all over the surface and a lateral support to the foundations of each pillar might also be possible. The foundations have all been done in cement concrete 1 : 6 : 12 and the brick work in foundations has also been done in cement. In very many places difficulties on account of dampness and water logging in the area had to be surmounted and wider foundations had to be provided to reduce the bearing pressure on the soil to a safe limit. Generally

speaking however a foundation pressure of nearly one ton per sq. ft. has been aimed at.

A 6" thick damp proof course of 1 : 2 : 4 cement concrete has been provided under the pillars at the plinth level.

Pillars.—Originally it was intended to use plain cement concrete in pillars so that the same could be moulded at site to any forms that were necessary on account of intricate construction. As however adequate supplies of shingle and sand, etc., could not be readily arranged it was decided to use brick pillars for the purpose. The design of these pillars however had to be simplified, so that unnecessary cutting of bricks was avoided and easy construction could be possible. Bonding of bricks for the pillars presented another serious problem and had to be overcome by providing beds of cement concrete 1 : 2 : 4 at various levels in the height. On the top of the pillars a cap of 6" thick cement concrete 1 : 2 : 4 has been provided to serve as a bed plate for the peripheral beams supporting the hoppers.

Hoppers.—A detailed design of the hopper and the peripheral beam is enclosed at the end of the paper (Drawing No. 2). Calculations for the hopper have been omitted as it would make the paper unnecessarily cumbersome, but it is simply stated that the hoppers in the bin walls were designed on the Janssens formula, which deals with the pressure exerted by grain in silos. The angle of slope for wheat is usually about 22° and in order that no difficulty might be experienced in the flow of the grain through the bottom of the hopper, the side of the hoppers has been kept at an angle of 35° to the horizontal. The reinforcement in the hoppers runs both circumferentially and radially so that both the types of stresses that may come on the hopper slab have been provided for.

The peripheral beams that support the hopper were designed as ordinary beams to take all the weight of the walls as well as of the hopper and necessary provision of adequate quantities of steel has been made therein for hanging the hopper from them.

As work on the hoppers as well as beams could not be completed in one operation, joints had to be left as a matter of necessity and after a good deal of consideration it was considered best that these joints be left in a vertical plane at the middle of the beams.

Shuttering.—The shuttering for the hoppers and beams presented some considerable amount of difficulty. Timber shuttering was originally intended to be provided and arrangement were made through the Timber Supply Directorate for the procurement of about 40,000 cu. ft. of timber required for this work. This quantity was the utmost that could be got released at a time when timber was entirely controlled and supplies were extremely scanty. As however the works were required to be completed very quickly and the timber made available could not suffice for the entire shuttering in one lot, this type of shuttering had to be replenished with something rigged up by use of bricks and jungle wood which was

universally, extensive trials have still to be arranged to get at a reasonable figure of average outturn that could be expected from its use. Attempts are also being made to get the bins filled by manual labour which has been employed in one case to carry wheat in bags right from the ground level to the top. The cost of filling is definitely greater than what could be obtained by the use of machinery. If however manual labour had to be employed to fill the bins a very easy staircase was necessary for this purpose and the same has been provided.

Subsidiary Buildings.—Besides the main bins a small office and Chaukidar's quarters have been provided at each site. In addition to this a platform has also being provided whereon the grain could be unloaded from the bullock carts before it is taken up to the top for filling into the bins. Originally it was intended that drying platforms should be provided at each site whereon the grain could be dried before it is put in for storage. After discussion with the Entomologist the requirements of platforms for this type of work were calculated and it was found that the cost of providing such platforms would be really considerable. It was therefore suggested by trade representatives that just immediately after the harvest season, the grain is usually dry and could be put in for storage without any risk of serious trouble arising on that account. Therefore it has been decided by the Civil Supplies Department the provision of drying platforms may be omitted altogether but that suitable platforms to cope with the unloading and inspection of supplies as received from the mandis may be provided at each site.

Lyallpur Elevator.—A properly designed elevator was constructed by the Punjab Government at Lyallpur in 1920. It contained 32 bins with a total storage capacity of about 4,000 tons. This elevator was equipped with a fairly modern machinery driven by electricity and provided an adequate means of cleaning, grading and storing the wheat as well as afforded an economical handling of the grain due to the use of the mechanical means as against manual labour. The elevator was leased out to private firms and attempts were made to make it an economical proposition but somehow or the other it did not find much favour with the trade and it was finally decided to close it down in 1926. During the war when storage became an immediate necessity, the question of reviving this elevator was again given some consideration but no final decision was taken thereon. Now again an attempt has been made to make the bins in the elevator fit for storage. All the defects in the plaster and on the roof have been remedied. The roof which was leaking badly has been gunnited with cement mortar and it is anticipated that there will be no trouble on account of leakage. The old machinery which was proposed to be employed for cleaning and grading the wheat has been cut out for the present and as the electric motors had in the course of time become extremely inefficient on account of loss of various parts a new electric connection from the main power supply has been secured and electric drive provided to lift the wheat up to the top of the bins. All other minor alterations that were necessary have also been

carried out and it is expected that in its present form, the elevator will provide proper storage for about 4,000 tons of wheat.

The total storage provided under this scheme is 63,000 tons exclusive of the Lyallpur elevator. If the capacity available at that place is also included the total accommodation available would be 67,000 tons. The total cost of the project as estimated is Rs.54,16,970. This figure includes not only the cost of the storage bins themselves but also the cost of other subsidiary structures such as quarters, approach roads, platforms and compound walls where required. The overall cost of storage per maund is estimated to be Rs.3-2-7 only. These godowns will be operated by the Civil Supplies Department and the cost of establishment for using them is not likely to be anything considerable.

Economics of Storage.—The average trader is so used to his primitive methods of storing wheat in ordinary godowns, that he is inclined to look with a certain amount of concern on any improved method that may be adopted for this purpose. In this country as well as in any other one, conservatism of ideas is always difficult to get over and it is only by a good deal of propaganda and example that the old ideas can be changed. As already indicated in the commencement of this paper, loss on account of defective system of storage amounts to about Rs.20,00,00,000 for the whole country. This figure is too tremendous to be foregone without any action being taken to reduce the same. There is no doubt that the methods adopted by the trade provide for storage at a very cheap cost but their figures only include the immediate expense incurred by the traders and do not take into consideration the accumulative effect that is brought about by the wastage which occurs in such a system. Nor does it take into any account the necessity from national point of view providing proper storage which is really so urgent.

Many of the agricultural countries in other parts of the world have adopted proper storage for their produce and during the last 20 or 30 years a very large number of silos have been put up not only in Canada but in Argentine and Australia as well. Of course these silos are very big units and deal with large quantities of grain but the principle on which they have been provided should apply equally well to this country as well. This project was also conceived as only a small beginning in the proper direction and although it does not claim to fall in line with the up to date methods of storage and turn over provided in other countries, it is stated, that in the course of time and with proper encouragement from the trade it might be possible to build up a truly national system of grain storage particularly suited to this country.

The appalling shortages of food all over the world to which India is no exception have brought the question of large scale storage again to the forefront. All sorts of ideas for providing reserves are under discussion. It has been suggested that an emergency reserve of about 1½ million tons should be provided in this country which could be utilized in the case of food shortage. If this reserve has to be found

from the produce available in the country itself, it is natural that at least a good deal of storage will need to be provided at the producing centres while some provision may also be necessary in the deficit areas as well to prevent losses on account of vagaries of weather etc. It is very difficult to foresee that under the conditions prevailing at present any other country would be prepared to let us have large quantities of food-grains to be utilized as a reserve in this country. Therefore the question of providing accommodation for such storage which will naturally be at the ports is a very uncertain one. Quite lately a great amount of effort has been made to step up production of food-grains in this country in order to cope with the shortage as well as to ensure adequate supplies for the population. There is no doubt that these schemes will bear fruit in due course and therefore it would appear that in provinces where agriculture is the main occupation of the people, storage will be matter of considerable importance.

Having accepted the necessity for storage it has still to be seen, what would be the best form in which this has to be provided. The general holdings of the cultivator are in most cases too small to permit of any extensive storage schemes being tried by him. Perhaps some of these stores could be run on co-operative methods and it is expected that this system of dealing with the storage will be given good consideration in due course. In mandis however where the quantities of arrivals of grain at the harvest season are in normal times fairly considerable, proper storage must be given immediate consideration. So long as the prevailing food shortage continues and Monopoly procurements as well as rationing continue to be adopted it would appear that storage has to be the concern of Government alone. But when things come back to normal and the trader finds that he has large stocks of grain on his hand to deal with, naturally he would like to take advantage of the experience gained by Government in these hard years and would certainly be in a mood to adopt the improved methods of storage which are being evolved now.

For a storage to be economical, it has to be tackled on a very large scale. The main success of any scheme depends upon the reduction in the cost of handling as well as the security from infestation that it can afford. The researches carried out by the Agriculture Department on saving the grain from pests show, that godowns which can give practically complete immunity from loss can be constructed. Having obtained these godowns the cost of handling the grain in them is also an important matter. For this purpose it would appear that properly designed elevators with adequate machinery for handling, cleaning, grading and turning over in case of necessity would be most important. Unfortunately the experience gained on the Lyallpur elevator from the years 1920 to 1926 has not been very happy but there appears to be no reason why if the problem is tackled once again on proper lines, we may not be able to achieve a good measure of success as has obviously been done in other countries of the world and thus save the colossal amount of wastage that is otherwise bound to occur.

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