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Temporary Grain Storages for Commercial Applications

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Zwischenspeicherung von Getreide
Stockage temporaire de céréales pour applications commerciales
Almacenamiento provisional de cereales para aplicaciones comerciales

商業用の一時穀物貯蔵
商用短期谷物存贮
مستودعات التخزين المؤقت للحبوب للاستخدامات التجارية

Summary

For some years the Grain Elevators Board N.S.W. has been conducting extensive trials and economic analysis to determine the optimum type of temporary bulk grain storage structure for N.S.W. conditions. This paper presents some of the results of these investigations. Four types of storage structures are discussed: (a) traditional 'A' frame type, (b) PVC covered type, (c) earth covered type and (d) commercial butyl rubber type. Comparisons are made of the capital and operating costs per tonne, construction details, grain handling procedures and special features of each type of storage.

The initial results of the investigations indicate that the butyl rubber storage is uneconomic for the storage of large commercial quantities of grain and the 'A' frame storage is too vulnerable to storm damage and is unfavourable from a pest control point of view. Both the PVC and earth covered storages are currently favoured by the Board but the PVC storage has generally lower operating costs and offers less risk of grain contamination by the earth covering.

1. Introduction

Most of Australia's bulk grain handling authorities have been forced to use temporary grain storages at one time or other. Although highly unsatisfactory for many reasons, the need to use temporary facilities is caused by the wide fluctuations in grain production and varying amounts of carryover grain in the system. This is compounded by the desire of management to avoid over capitalisation in permanent storages to handle the peaks in the demands on the system. Since the 1960s the Grain Elevators Board of N.S.W. (Board) has stored in excess of six million tonnes of wheat in temporary storage, but there have been seasons when the system was only partially utilised.

The economics of temporary storage usage has often been questioned and this led to an investigation of alternative structures and handling techniques. Only commercial quantities of grain (i.e. in excess of 10,000 tonne lots) have been considered and a detailed report of these investigations has been prepared [5].

Four types of temporary storage structures were considered most suitable and have been investigated closely. These are:

1. 'A' frame type — this is the traditional type of storage used by the Board and has galvanised iron roof and sloping walls supported on steel 'A' frames (Fig. 1).

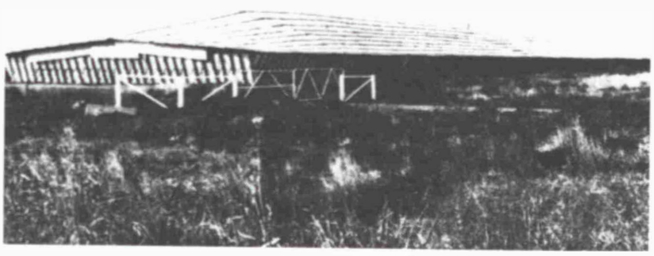

Fig. 1: 'A' frame storage

2. PVC above-ground type — with inclined earth load-bearing walls and covered with PVC sheeting (Fig. 2).

Fig. 2: PVC above-ground storage

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3. Earth covered type (in either an underground pit or above-ground with earth bank walls) with polyethylene lining and covered with a layer of earth (Fig. 3).

Fig. 3: Underground storage

4. Butyl rubber type — a commercial storage with rubber sheeting inside a wire meshed bin (with either an air inflated rubber roof or a loose rubber roof covering) (Fig. 4).

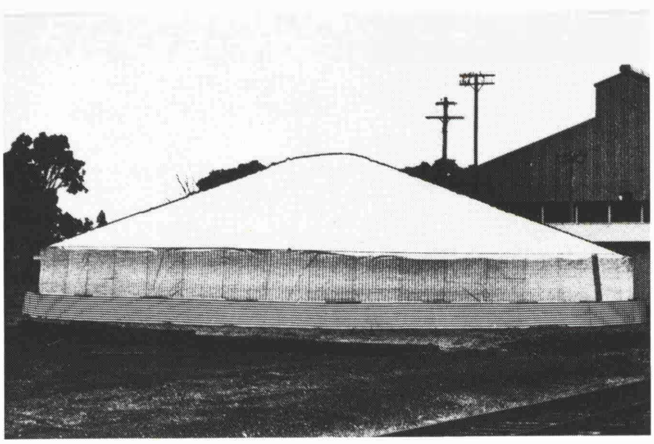


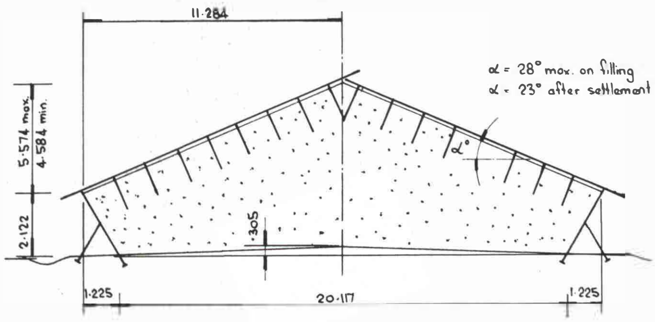
Fig. 4: Butyl rubber storage

Other types of temporary storage such as field bins or converted aircraft hangers have been used by the Board but are not considered here.

2. Construction

The 'A' frame storage is approximately 25 m wide and may be any length — usually 300 to 1000 m. Storage capacities range from 10,000 to 40,000 tonnes in a single strip. After the site has been cleared of all vegetation, the earth floor is formed into a profile with a cross-section as shown in Fig. 5. Corrugated iron wall sheeting is supported on the steel RSJ 'A' frames which are spaced at regular intervals down the length of the storage — the feet of the 'A' frames are buried in the soil.

After Sisalkraft sheeting has been placed on the earth floor, the grain is loaded into the storage by portable elevators and grain throwers, leaving a peaked mass of grain. Roofing takes place at the end of the day and proceeds by driving timber pegs into the grain. Timber purlins sit on these pegs and run longitudinally down the storage. The roofing iron is

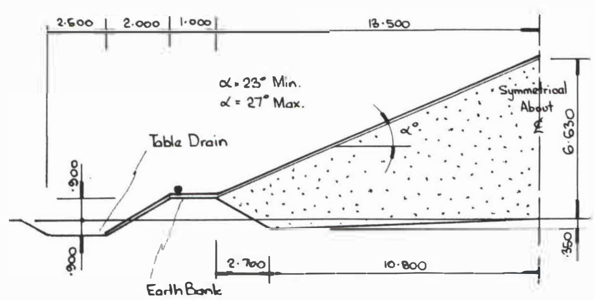


CROSS SECTION

Fig. 5: Details of an 'A' frame storage

placed on and a set of top purlins is installed. All the purlins are wired to the pegs using soft black wire that passes through gaps left in every second sheet of iron. At regular intervals down the length of the storage, storm protection wires are anchored to the walls and pass over the roof.

The above-ground PVC covered storage was developed by the Board some three years ago. A strip of land 30 m wide and any length is formed into a profile as shown on Fig. 6. Earth banks are used to support the wall pressures imposed by the grain.



HALF CROSS SECTION

Fig. 6: Details of PVC above-ground storage

Like the 'A' frame type, Sisalkraft sheeting is used for the floor — the sheeting passes up the banks and down the outside. Grain is then fed into the storage using portable elevators and grain throwers and a peaked grain mass is formed. The PVC roof sheeting is placed on the grain stack as the filling takes place. Special techniques have been developed to handle the heavy rolls of sheeting, which are made in strips approximately 4 m wide and are bonded together on site using a PVC solvent welding adhesive. The sheets are taken down over the bank and are held in place with weights, which are PVC tubes filled with earth. Wind restraints made from seat-belt webbing pass over the roof at regular intervals.

The earth covered storage was designed by the CSIRO Division of Entomology who are carrying out trials with the

Board [7]. Two types of earth covered storages are being tested — one is an underground pit with a cross-section as shown in Fig. 7 and the other with a cross-section similar to that shown on Fig. 6. After the pit (or earth banks) have been formed, light-weight (150 microns thick) polyethylene sheeting is placed on the floor and the grain is placed into the storage using the same machinery as for the two previous storage types. A layer of polyethylene is placed on the peaked grain surface. And a layer of sand covers the polyethylene before a soil cover one metre thick is put on top. The sand prevents large lumps of soil from puncturing the roof sheeting. Extreme care must be taken in placing the soil cover and when emptying the storage otherwise soil will be mixed with the grain.

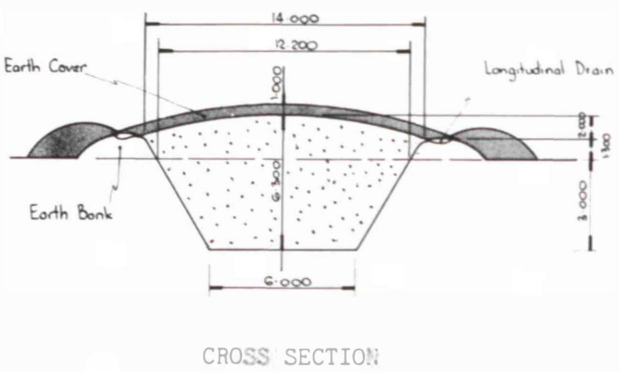


Fig. 7: Details of underground storage

Butyl rubber storages are manufactured by Cherwell Valley Company, Germany and are distributed in Australia by Neuero Francis Pty. Ltd. — storage capacities currently range from 1,000 to 5,000 tonnes. The storages are erected on a circular area of level ground covered with fine granular material. A steel mesh surround bin is stood on the ground and bolted together, the rubber side walls and bottom are spread evenly and the wall material is clamped to the mesh bin. Two types of roof arrangements are available. One is an air inflated rubber roof and the other is a loose rubber sheeting called a sack/bulk type and is simply placed on the grain surface.

Either pneumatic conveyors or augers can be used to fill the storage. For the inflatable roof type, the air supply is simply turned off after filling the storage and the roof collapses onto the grain. Fig. 8 shows a typical air inflated type.

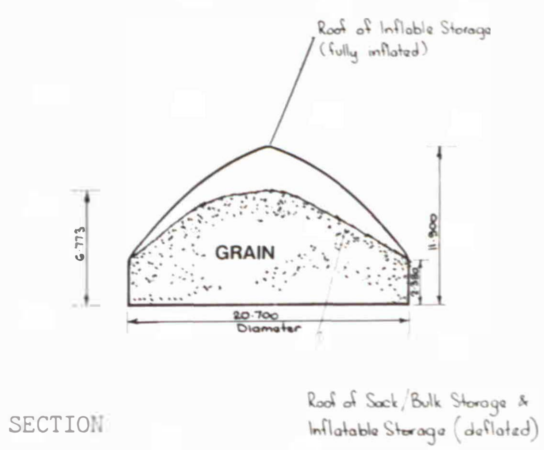


Fig. 8: Details of inflatable butyl rubber storage

3. Experiments and Trials

'A' frame temporary storages have been used by the Board since 1964 — during this time approximately 4 million tonnes of wheat have been stored in this type of storage. From December 1977 to September 1978, 3,890 tonnes of wheat were placed in the first PVC above-ground storage at Narrabri, N.S.W. During the 1978/79 and 1979/80 seasons about 1.5 million tonnes were stored in PVC storages. Although assessments of its economics and operational applications are still being formed it appears likely that this type of temporary storage will be used extensively by the Board in the future.

From December 1975 to May 1976 the CSIRO and the Board in a joint project, stored 1,826 tonnes of wheat at Narrabri, N.S.W. in an earth covered underground storage. A further 2,014 tonnes were installed in underground storage at Boggabri in December 1977 for long term trials. The grain was outloaded during July 1979.

The Board purchased both types of butyl rubber storages during 1976 for trial purposes and 1,005 tonnes of wheat was put in storage at Ballimore N.S.W. These trials were to assess in-loading and out-loading procedures but later trials were made to assess the ability to fumigate the grain.

4. Estimates of Costs

In the original study [5] all cost estimates were made as at the end of December 1978. But the estimates given here have been adjusted (in accordance with movements in the 'consumer price index') to the end of December 1979 and all costs have been rounded to the nearest ten cents. Table 1 gives the estimated average capital and annual operating costs for each type of storage.

Table 1: Estimated average capital and annual operating costs ($/tonnes)

Storage Type	Capital Costs 1) 2)		Operating Costs 2) 3)	
	NEW SITES	EXT. SITES	1ST YEAR	2ND YEAR
'A'Frame	7.10	6.20	6.10	2.30
PVC Aboveground	4.50	3.80	4.30	1.30
Earth Covered	1.90	1.30	4.90³)	0.70³)
Butyl Rubber	28.40	27.40	9.10	5.60

(1) all estimates are as at December 1979
(2) estimates made on the basis of a 20,000 tonnes storage (for 'A' frame, above-ground and earth covered) and 5,000 tonnes (for butyl rubber).
(3) operating costs for the earth covered storage may be inaccurate due to a lack of experience by the Board in large scale trials.

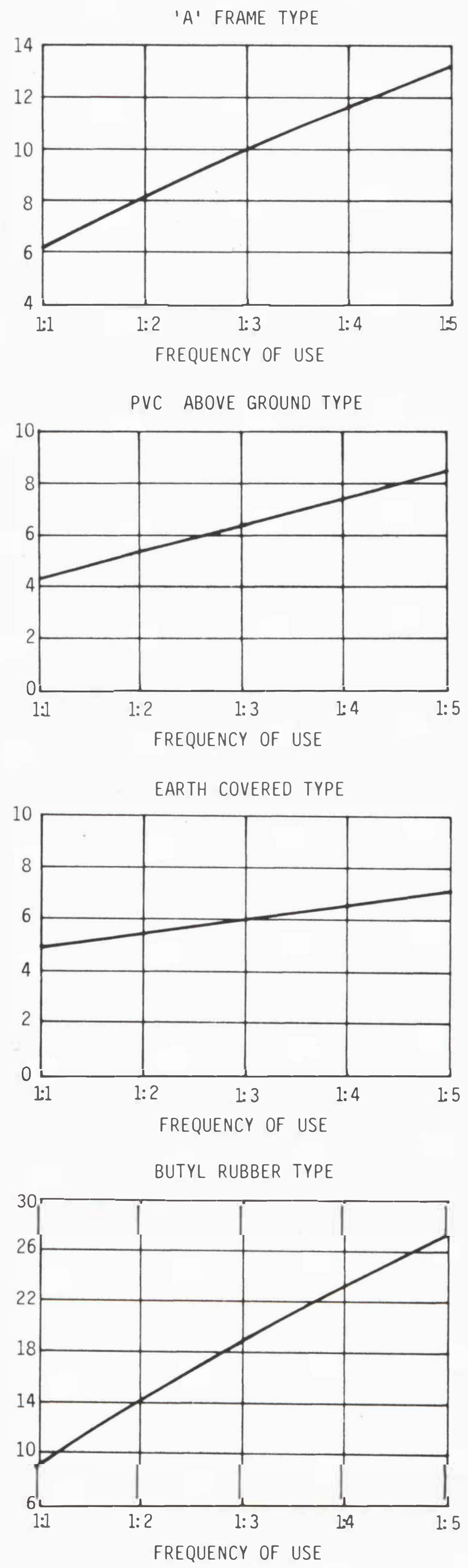
Capital costs include: structural material, portable in-loading machinery and storm covers, but do not include land purchase (or leasing) costs. Operating costs include: costs of consumables, such as bolts, etc., site preparation, cost of freight of the materials, roofing contracts, opportunity costs on capital investment, depreciation, labour costs, repairs and maintenance and cost of grain cartage into and out of the storage. Not included are costs that are normally incurred by a grain handling authority, e.g., pest or rodent control and administrative overheads.

The actual costs incurred at any site will depend very much on factors such as: the amount of earthworks required, the remoteness of the site, delays in construction or filling the storage (due to bad weather) and the distance the grain has to be carted from the growers' receival point. All figures quoted are the expected average costs.

Two estimates are given for capital costs. The costs incurred at new sites include site preparation and contracts for standing the wall frames (for 'A' frame storages). These costs are substantially reduced when rebuilding at an existing site.

Two estimates are also given for operating costs. The costs for the first year of using a storage include the items listed above but also include costs of demolition and stacking of materials. But the annual operating costs for storing the grain beyond the first year include only certain of the cost components for the first year. These are opportunity costs, depreciation and energy costs. When temporary storage materials are not used they attract certain 'costs of owning' (i.e. opportunity costs and depreciation) which mean that the storage cost per tonne is higher when the storages are used. This factor discourages bulk handling authorities from carrying excessive temporary storage materials. A sensitivity analysis was conducted to examine the cost effects of infrequent use and Fig. 9 summarises the results. The minimum frequency of use of 1:5 was chosen (i.e., use the materials only one year in five). The results seem to indicate that the PVC and earth covered storage costs are less sensitive to infrequent use and this is an important factor in the choice of storage.

Fig. 9: Sensitivity of operating costs to frequency of use



The sheeting costs for the PVC storage are a significant part of operating costs. However, it was difficult to estimate the life of the sheeting, an assumed life of 5 years was used in the above analysis — although the manufacturers claimed 10 years life. To gauge the possible importance of sheeting life on operating costs a sensitivity analysis was conducted and Table 2 shows the results. It can seen that for sheeting life beyond 3 years the operating costs are relatively insensitive to sheeting life and the original choice of 5 years life gives realistic results.

Table 2: Sensitivity of operating costs to sheeting life. PVC storages

Sheeting Life (Years)	Cost ($/tonne)
1	6.20
3	4.60
5	4.30
7	4.20
9	4.10
11	4.00

5. Features of Each Storage

One of the most important features of all grain storages is the ability to protect the grain in all conditions. In this respect the 'A' frame storage has proved poor because rainwater can enter to the grain through the cracks in the roof sheeting and occasional wall collapses have been experienced, see Fig. 10. The PVC storage and earth covered storage have proved very good in protecting the grain in heavy rain and even in flood conditions. 'A' frame storages also offer very poor resistance to rodent attack and are difficult to fumigate.

Fig. 10: Collapsed walls of 'A' frame storage

To date the PVC storage is most promising because it gives excellent grain protection against rainwater, insect attack, grain spillage and there is little chance of admixtures with soil. Some problems have been encountered though. One heavy hailstorm punched many holes in the PVC roof but the grain showed very little water damage and a second roof sheet was placed on the first sheet. Another problem was encountered when a flock of Galahs ate holes in the PVC sheeting and caused extensive damage although no damage was caused to the grain. This problem was overcome by placing coloured bunting over the stack and this kept the birds away. The PVC sheeting has proved extremely tough — we have evidence that one temporary storage stack is often used as an unauthorised trail bike track.

It was believed that earth covered storages should offer good protection against rodent attack, but tests at Boggabri proved this not to be the case. Earth covering could also extend the life of the PVC sheeting against ultraviolet degradation but the sheeting would then be vulnerable to tearing by the earthmoving machinery. To avoid contamination of the grain by the soil covering, particular care must be taken in placing and removing the soil and handling techniques are still being developed. There are good reasons why soil covering might be contemplated for long term storage — say more than one year — but the Board has been most reluctant to do this because of the higher handling costs, possible grain losses due to soil contamination, the short periods in storage and the need for quick outloading rate. The underground pit type of earth covered storage has proved to be uncomfortably hot for the men and machinery in summer conditions. Any further trials of the earth covered storage will be with the above ground earth bank type.

Butyl rubber storages are too expensive for large scale storage of grain but they are useful for storage of small segregated parcels or for fumigation. Working conditions inside an air inflated storage can be very hot and dark — lighting is not possible due to the risk of a dust explosion. Care must be taken to empty the storages from the centre to maintain uniform wall pressure otherwise the bin may collapse.

6. Conclusions

The search for a better and more economic temporary storage continues to be sought by the Board — improvements will always be possible. And similar investigatory work is being conducted in other states. The need for temporary storage is established because the rate of growth in Australia's grain industry is very high and construction costs for permanent storage are soaring.

It now seems certain that in N.S.W. at least, the traditional 'A' frame storage will be phased out due to its poor protection against storm and rain damage and its vulnerability to insect and rodent attack. PVC storages are currently being used as an alternative because of its economic operation, excellent grain protection and the possibility to fumigate the grain in storage. If storage beyond two years is expected then earth covering on a PVC storage may be contemplated — this has not been practiced (other than for experimental trials) because of the increased operating costs and the possible grain losses due to soil contamination of the grain.

Earth covered polyethylene storages offer advantages for long term storage but labour costs push up the operating costs. Removal of the soil reduces outloading rates and presents a great threat of soil contamination.

Total costs are a major deciding factor in the choice of a temporary storage design. Because of its recurrent nature annual operating costs are most important. Analysis reveals that these costs are rather sensitive to storage utilisation and further trials and economic analysis are required.

What of the future? Hybrid temporary storage designs with, say, earth floor and banks (probably sealed with asphalt) but with a permanent self supported iron roof are currently under investigation. In the long term these may prove more economic even though they are not portable and will have higher capital costs. Temporary storage design is still in a stage of evolution but more efficient designs result with each iteration of the design process.

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