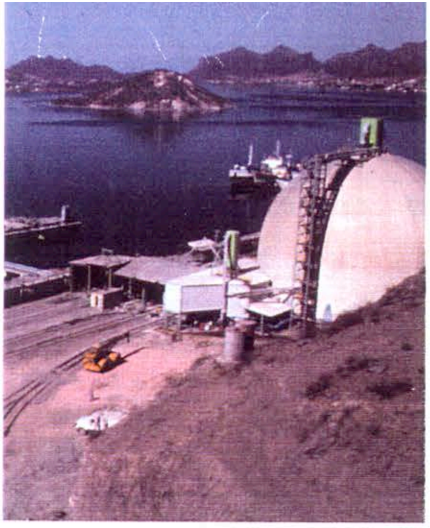


Go with the flow

by Ad Ligthart, Cement Distribution Consultants

The difference between a good cement terminal design and a bad cement terminal design is the designer's ability to identify how cement would best flow through the terminal. Terminals which are designed with optimal flow in mind will be laid out to meet this objective, which can result in lower capital and operational costs. In this article, Ad Ligthart looks at how cement moves through a terminal and looks at new design developments intended to optimise this flow.

Although cement terminals have been built for over 30 years, cement terminal design is still not a very mature science. This is most obvious at large cement terminals, where the capital cost of terminals with similar capabilities can range between US$12-35m. How can these very large capital cost differences be explained?

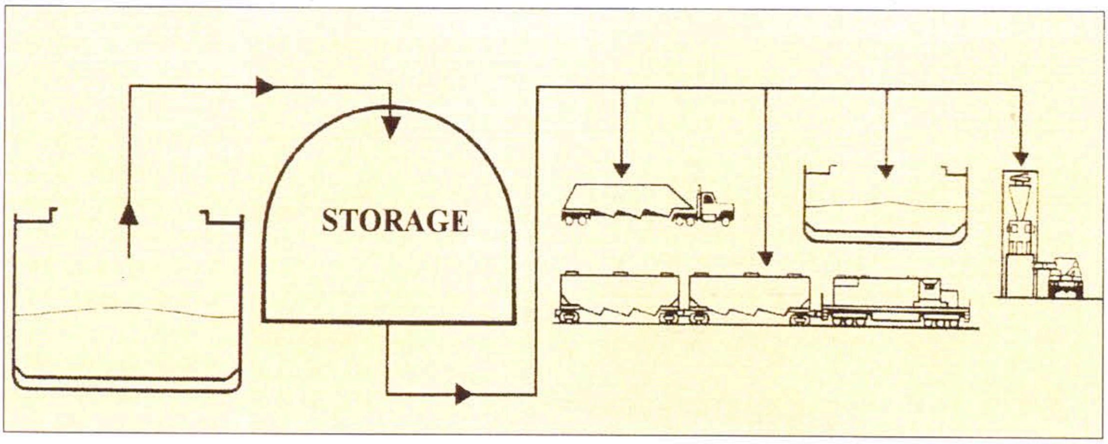
The difference between a 60,000t flat storage warehouse and dome storage of an equal size is approximately US$2.5-3m. At worst, the difference between various shipunloading systems can be as much as US$1m, but in most cases it is much less.

There can, of course, be restrictions on a specific terminal site that have to be overcome, for example a poor dock situation that has to be improved. Terminals also have different applications. One terminal might distribute cement using only bulk trucks, whilst others might also distribute cement onwards in river barges, in railway wagons or in bags. Even when all these factors are added up, there is still a large gap. This gap is caused by differences in terminal design concepts.

Cement terminals with a high capital cost are often designed by people used to designing cement plants. At a cement plant the material flow is adapted to meet production requirements. When the same design philosophy is used for a cement terminal, the main components of the terminal will be allocated a position first and then the conveying equipment is added to connect these locations. This can result in very expensive terminal solutions. A cement terminal is a distribution facility, it is not an extension of a cement plant. Of course storage facilities and equipment have to be capable of handling cement but the design of the terminal must be governed by the logistics and economics of distribution and not the production requirements of manufacturing. The distribution logistics of a terminal are very similar whether the material flow consists of containers, cars, oranges or bulk cement. On one side of the facility large quantities are coming in on a somewhat irregular basis, and on the other side many small quantities are leaving the facility on a frequent and regular basis (which might be subject to seasonal and other influences). The distribution facility has to be able to receive the incoming flow and disperse the outgoing flow with the minimum of storage, handling and effort (and their associated costs) in between.

Good cement terminal design focuses on the flow of cement through the terminal. The layout of the terminal and the storage facility and distribution outlet points are designed to meet the optimal flow. When this is done properly it not only brings about substantial reductions in capital cost but also in operational costs.

Figure 1: a typical flow sheet of a traditional cement import terminal. All cement goes through the storage facility before it is distributed onward and therefore all cement is double handled



Basic design considerations

Figure 1 shows a traditional flow diagram of a cement terminal. All cement is conveyed from the incoming ship into the storage facility, from where it is conveyed to the bulk truck loading station or (where applicable) bagging plant, railcar loading facility or barge loading system. The

Annual throughput	tpa	200,000	400,000	600,000	800,000	1,000,000
Shipunloader capacity	tpd	6000	6000	6000	6000	6000
Shipunloading time per year	days	33	67	100	133	167
Shipunloading time per year	%	9	18	27	37	46
Quantity of cement that can be directly transferred to distribution outlets	tpa	18,000	72,000	162,000	296,000	460,000
Quantity of cement that has to be stored and double handled	tpa	182,000	328,000	438,000	504,000	540,000

Figure 2: potential to move cement through a terminal without using the storage facility

terminal design usually reflects this, with the shipunloading operation on one side of the storage facility and the onward distribution operations on the other. In this configuration all cement is double handled.

Considerable savings can be achieved when cement is conveyed directly from the incoming ship to the bulk truck loading station and other outlet points. Figure 2 shows an example of how much of a saving this can be. For a large terminal, 10-40 per cent of the throughput can be transferred directly without the need for intermediate storage and double handling. The operational savings that can be made are quite substantial.

Figure 3 shows a flow diagram of the ideal situation, whereby it is possible to convey cement from the storage facility, as well as from the incoming ship, to the distribution outlet points. This requires a special design that is able to cope with both of the difficulties listed below.

- A shipunloading system unloads and conveys cement at a high capacity and on a continuous basis. Bulk truck loading, bagging, etc is done at a much lower capacity and on an intermittent basis.
- The terminal has to be designed along the flow of the cement. When this is not done, separate conveying systems are required to feed the distribution outlet points.

Quite often terminals are not designed along the cement flow. In such a design, all the major components are first given a location and only afterwards are the conveying systems added to connect them. This results in many individual and sometimes very long and elaborate conveying systems.

To overcome the difference between the high capacity, continuous conveying of the shipunloader or storage reclaim system, and the slower, intermittent output of the terminal outlets, intermediate buffer storage is created. Examples of this are large truck loading silos or a large buffersilo before a barge loading system. Such intermediate buffer storage is usually very high, necessitating the installation of vertical conveyors as well. The cost of all these conveyors and intermediate buffer storage can be quite significant.

A terminal designer that looks at a terminal from a distribution perspective will focus on the cement flow first and design the terminal around that. For example, the bulk truck loading station can be located on the waterside of the storage facility, below the conveying system, between the shipunloader and the storage facility. The ability to load truck loading silos and the main storage facility has been achieved with the same conveying system and the shortest possible conveying distances. This design is very cost effective .

Intermediate buffer storage is a costly nuisance in a cement terminal. Sometimes this can be reduced or avoided by equalising the flow on both sides. For example, the intermittent character of loading river barges (caused by opening and closing hatchcovers and moving the barges) can be resolved by adding a second barge loading point. When one barge is loaded, a second barge is put into position and the hatch opened. A complete barge convoy can be loaded without interruption or delays and with little or no buffer storage at the loading system.

When a terminal is built with the aim of minimising cement flows and intermediate buffer storage, a number of design improvements are possible. Flat storage and dome storage have different characteristics and require different solutions.

Flat storage

The expensive parts of a cement terminal are the intermediate buffersilo(s) above the bulk truck loading station. For large terminals, as much as 400-600t of overhead storage is required. The height of such overhead storage can be as much as 20-30m, which requires substantial vertical conveying equipment. Several small, flat storage facilities already operate without overhead truck loading silos. The most

Figure 3: the 'ideal' flow sheet of a cement terminal where cement can be conveyed from the ship directly to the distribution outlets as well as the storage facility, minimising double handling

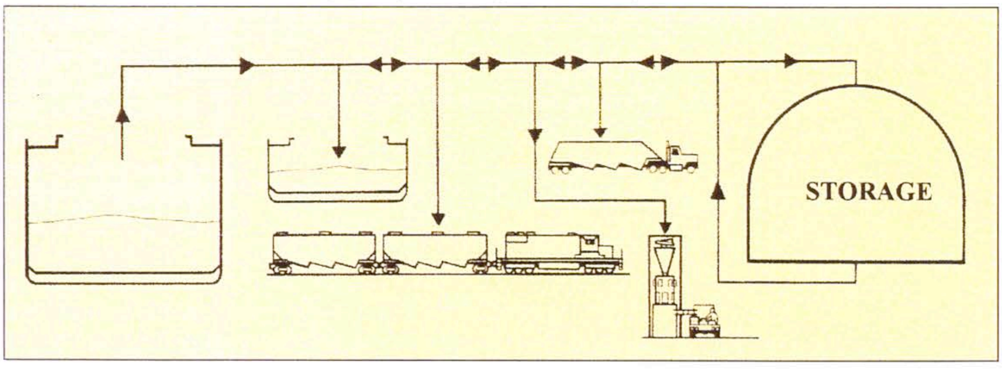


Figure 4a: a simple flat storage reclaim system. Cement is loaded by a front-end loader into a hopper and by means of an inclined screw conveyor and loading bellows conveyed into the bulk truck

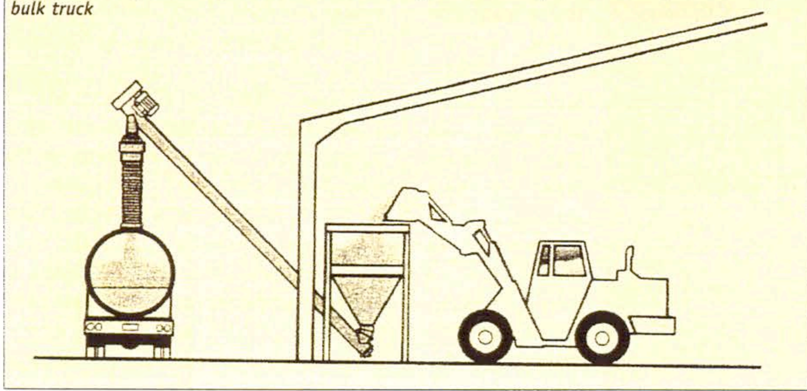


Figure 4b: a flat storage reclaim system with recessed hopper and vertical screw conveyor. This allows for higher truck loading capacity and a more effective use of the front-end loader

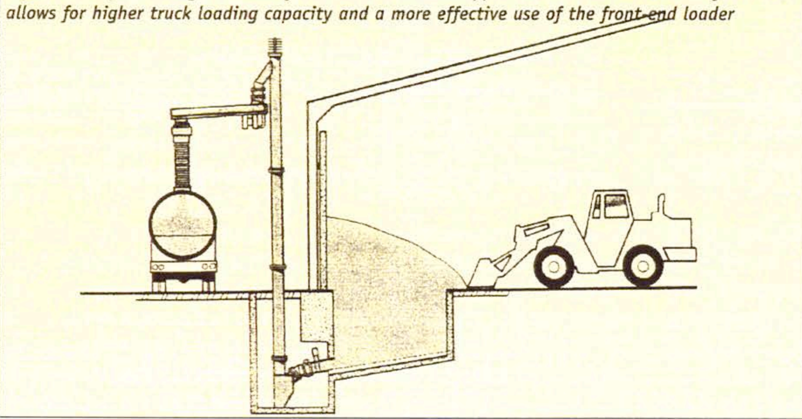
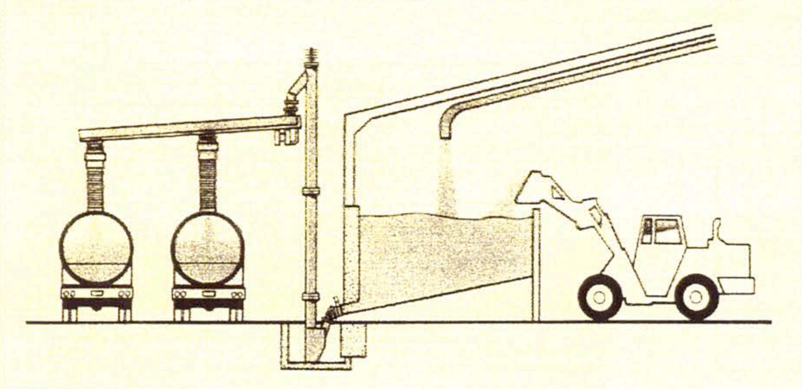


Figure 4c: a flat storage reclaim system using a reclaim bunker with fluidised floor. This provides very large buffer storage and can be filled directly from the ship as well as the warehouse



simple system in this respect is shown in Figure 4a. A front-end loader reclaims cement and puts it into a hopper. The bulk truck is loaded directly from the hopper via an inclined screw conveyor and loading bellows. The system is very simple and has a very low cost but also has substantial disadvantages from a flow perspective as it is not possible to load trucks directly from the shipunloader and loading bulk trucks is relatively slow.

An improved version is shown in Figure 4b. Here, the reclaim hopper is recessed into the floor and increased in size. It is possible to put some buffer cement capacity on top of this recessed hopper. Also, the front-end loader can have a higher capacity as it only has to push cement. Bulk trucks can be loaded quickly. It is still not possible to load trucks directly from the shipunloader and front-end loaders are still required every time a bulk truck arrives.

These systems are not very suitable for terminals with a high throughput. Even now, large flat storage terminals still use large overhead truck loading silos. At this moment however, the first large storage terminal, with an internal buffer storage integrated into the flat storage facility, is under construction. The concept is shown in Figure 4c. By means of concrete walls, an internal bunker is created with a volume of approximately 500t of cement. The reclaim bunker is filled by means of a front-end loader. An inclined fluidised floor ensures a cement flow to the outlets of the reclaim bunker. At each outlet a high capacity screw conveyor is located which feeds the truck loading system. The cement flowing to the trucks is controlled by a flow control valve at each outlet. From a flow perspective, this is a very good solution. The reclaim bunker can be filled directly from the shipunloader by the conveying system that also loads the warehouse. By omitting the overhead truck loading storage the overall cement flow is reduced. The reclaim bunker has a significantly lower cost than the overhead truck loading silos and related conveying equipment. The buffer storage is sufficient for efficient front-end loader use.

The next step in flat storage reclaim is presently under design at Cement Distribution Consultants. This is a reclaim system suitable for flat storage terminals with an annual throughput of 600,000tpa or more. An artists impression of this system is shown in Figure 5.

The reclaim bunker is loaded from recessed hoppers. This makes it possible to increase the height of the walls of the reclaim bunker to between 6-8m, increasing the buffer storage volume to over 1000t. This makes it possible to limit the use of the front-end loader to one shift per day. For the remainder of the day, trucks can be loaded automatically from the reclaim bunkers. The vertical screw conveyors have a maximum capacity of 500tph, although the actual capacity is controlled by the flow control valves feeding the vertical screw conveyors. In this way, it is possible to automatically load trucks to their maximum possible payload.

Dome terminals

Dome terminals have, over the past 10 years, become increasingly popular, especially in the US. The typical dome terminal design that has been developed in the US, for large cement terminals, consists of two

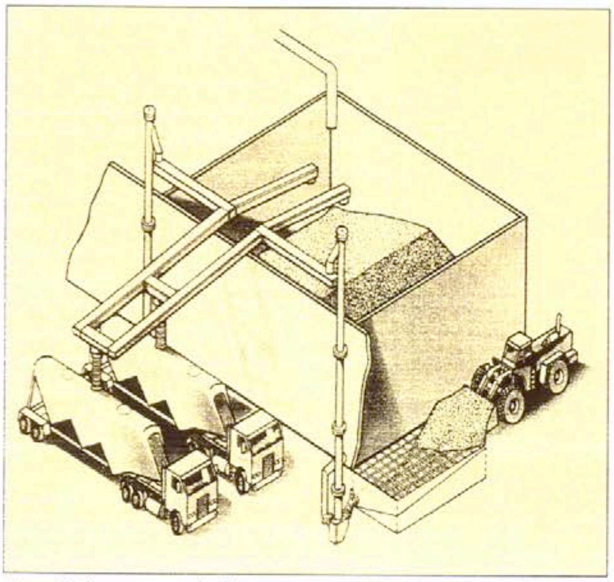


Figure 5: the next stage in flat storage reclaim systems combines a recessed hopper with a large reclaim bunker and high capacity truck loading

domes of 25,000-30,000t each with mechanical reclaimers. The reclaimers feed conveying systems located in a tunnel under each dome. From these tunnels the cement is then conveyed to truck loading silos and other outlet points. The reasons given for using two domes instead of one large one are that this guarantees a good rotation of stock and provides sufficient redundancy in case of equipment breakdowns. These reasons are quite valid.

Setpack of cement can be a substantial problem in cement storage. Setpack of cement occurs when cement is stored under pressure for a long time. The cement can compact to such a degree that it can no longer be extracted by the reclaim system of the storage facility. The only method to prevent setpack of cement is to fully empty a storage facility at regular intervals. With two domes that are emptied alternately, setpack of cement is effectively prevented.

The two dome concept makes it difficult, however, to get a terminal layout that meets an optimal cement flow. Almost all these terminals are incapable of feeding the truck loading station directly from the shipunloader. All cement is double handled. A number of conveying systems are required to get the cement through the terminal.

For an optimal flow of cement through a dome terminal, single dome storage is preferable over multiple domes. However, what really has to be resolved is the setpack problem. The solution for this can be found in the fluidised floor system. During the last two years, fluidised floors have emerged as an alternative to mechanical reclaim systems. At present, four domes with fluidised floors are under construction. The fluidised floor by itself is not sufficient to prevent setpack. The cement volume in a cement terminal varies between approximately 15-100 per cent of the storage volume. Cement terminals are never fully emptied as this implies a "no sales" situation. Therefore, how can it be guaranteed that all cement is regularly reclaimed from a single storage facility?

The solution that Cement Distribution Consultants has developed, in co-operation with Dome Technology, is very simple. The concept is shown in Figure 6. In a large single dome a full fluidised floor is combined with a low dividing wall in the middle. The fluidised floor is effectively divided into two systems. Only one half is operational at any given time, allowing only cement from that side to be reclaimed. The height of the central dividing wall is such that approximately 30 per cent of the storage volume stays on the side of the floor that is not operational. This makes it possible to clean out each half of the dome alternately.

A single dome storage facility such as this can represent a capital cost saving of several million US dollars, as well as a reduction in operational costs when compared to a two dome facility of the same size.

The fluidised floor with side outlets also makes it possible to use the truck loading system without overhead silos, as discussed earlier in this article. The vertical screw conveyors can then be located directly behind the flow control valves at the dome outlets. Depending on the required number of truck loading positions and redundancy, the number of dome outlets and screw conveyors can be selected.

Conclusion

There is still room for a lot of improvement in cement terminal design. The key to these improvements is to design a terminal based on the best possible cement flow and design the terminal layout and storage facility to meet this. Compared to the conventional design method, whereby the conveying systems are adapted to meet the terminal layout and the storage facility, very substantial savings in capital cost and operational cost are possible.

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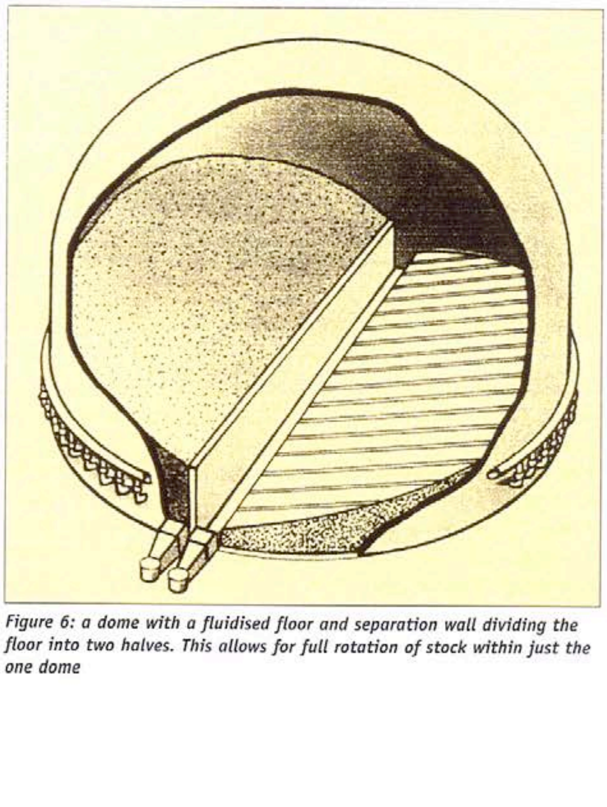

Figure 6: a dome with a fluidised floor and separation wall dividing the floor into two halves. This allows for full rotation of stock within just the one dome