A Unique Cement Terminal

Ad Ligthart, Cement Distributions Consultants, the Netherlands, describes the construction of a 30 000 t storage dome equipped with a fluidised floor, as an expansion of the Silvi terminal in Pennsylvania.

Introduction

The number of cement domes equipped with fluidised floors is is on the rise. There are some good reasons for this. Capital costs can be quite favourable compared with other systems, operational costs are quite low, the reliability of the system is very high and fluidised floors allow for greater flexibility in the design of the storage facility. Although the fluidised floor is relatively simple in concept, the design does require experience and knowledge on cement behaviour during storage. Setpack of cement is the largest enemy of silo and dome storage. Fluidised floors can be highly effective against setpack but only if they meet certain conditions.

Riverside Construction Materials, Ltd, one of the Silvi Group companies, recently commissioned a new 33 000 st storage dome as an expansion to its import terminal in Bristol, Pennsylvania, USA. This storage dome is equipped with a fluidised floor. The combined dome and floor design for this terminal are a prime example of how the characteristics of fluidised floors can be used to their best advantage.

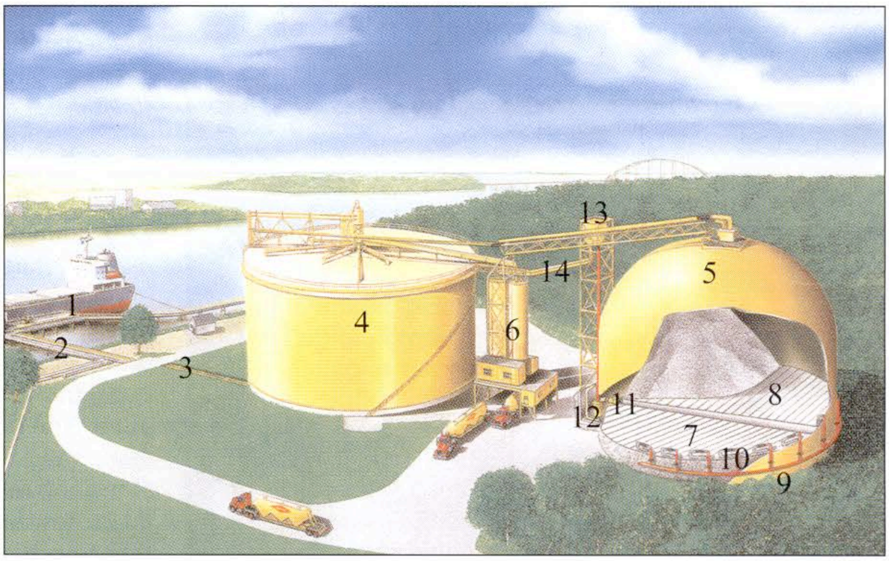

Figure 1. Operational concept of the Silvi Terminal. Cement is supplied to the terminals by bulkcarriers (1) of approx. 30 000 dwt. A shipunloading system (2) including two pneumatic screwpumps conveys the cement through pipelines (3) to the terminal. The cement is conveyed to either the existing storage tank (4), the new storage dome (5) or directly to the truck loading silos (6). The cement in the dome can be reclaimed by means of a fluidised floor that consists of a longitudinal fluidised trench (7) and transverse fluidisation section (8). Each fluidising section is supplied with air from a ringline (90 and individually controlled by means of a valve and flexible connection (10). Cement is extracted from the dome through a side outlet (11) equipped with lumpcatcher and flow control valve. An airlift (12) vertically conveys the cement up to a receiver (13). From the receiver the cement is then conveyed to the truckloading silos using an aeroslide (14).

Cement import terminal

The Riverside Construction Materials terminal, located on the Delaware River, just north of Philadelphia, has been in operation since the mid 1980s. The storage facility at the terminal consisted of a single large steel silo with a capacity of 32 500 t. The extraction facility for this silo consisted of a concrete bottom sloped towards the middle of the silo, on top of which a large number of aeration panels were fitted. This made the cement flow to the centre of the tank and then into an airlift located in a cellar beneath the floor. The airlift conveyed the material vertically up through a pipeline into a cyclone on top of the tank. From this cyclone the cement was conveyed to two truckloading silos beside the storage tank, by means of an aeroslide. Cement was delivered by selfdischarging ships with a capacity of 15 000 – 40 000 dwt. These selfdischarging ships conveyed the cement pneumatically via pipelines into the cyclone on top of the storage tank. The cement was distributed over the tank or to the truckloading silos from the cyclone by means of a star shaped set of aeroslides. This system is still operating well.

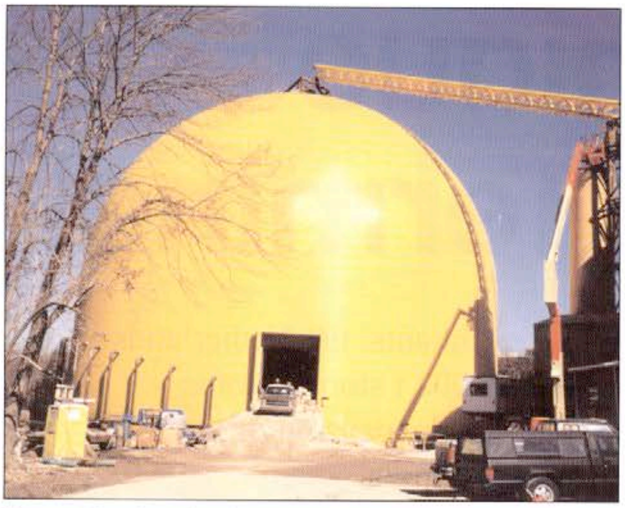

Figure 2. The dome (supplied by Domtec International) has a diameter of 120' and a height of 102'. On the inside the installation of the fluidised floor is taking place. On the left side of the dome the ring pipeline can be seen with the air supply pipes that enter the dome above floor level.

Figure 3. A transversal view on the fluidised floor system (Supplied by Van Aalst Bulk Handling). The trench toward the outlet in the rear is clearly visible. The fluidising fabric has been installed on the transverse sections but not yet on the trench.

Figure 4. The fluidising fabric is installed on the concrete bottom. On the right side the work is completed. On the left side the concrete floor with embedded air channels is still visible.

The terminal is now receiving cement in general type bulkcarriers of 40 000 dwt, and the Delaware River is suitable to receive ships of that size. Riverside Construction Materials installed a simple but effective shipunloading system to receive cement from these bulkcarriers. The system uses two pneumatic screw pumps of 300 tph each to convey the cement to the terminal. Using Handysize bulkcarriers not only required a shipunloading system but also an enlargement of the storage facility. Riverside Construction Materials set out to evaluate various types of storage facilities and reclaim systems, and select suitable suppliers. As a result of this process it ordered a high rise dome with a storage volume of 33 000 st and a reclaim system consisting of a full fluidised floor with a 250 tph airlift system. The dome was ordered from Domtec International, USA. The fluidised floor and airlift system were contracted from Van Aalst Bulk Handling, The Netherlands, with Cement Distribution Consultants, The Netherlands, taking care of general project engineering. Silvi acted as its main contractor with a substantial amount of the work arranged locally.

Full fluidised floor concept

The principle of the fluidised floor is based on the well known fluidisation principle. When cement rests on fluidising fabric and compressed air is fed underneath it, the air will penetrate through the fabric and enter the cement. The cement/air mixture becomes fluid. By putting the fabric on a slope the fluidised cement will flow to the lowest point. The new dome for Silvi has a side outlet. To make the cement flow to this outlet a trench runs along the centreline of the dome at an angle of 8° down towards the outlet. To feed the cement to the trench, the concrete bottom of the dome slopes downward transversely at an angle of 8° towards it. This configuration can clearly be seen in the artist impression of the project (Figure 1) and Figures 3 and 4 which depicts. The concrete floor is completely covered with fluidisation fabric.

The layout of the floor looks relatively simple. However, to design such a floor requires knowledge and experience. The fluidised floor is the only means of extracting cement from the dome. When it is incorrectly designed, the worst outcome could be that part of the contents of the dome cannot be extracted. When designing a dome floor, one has to understand the possibilities, but even more, the limitations, of fluidisation. The largest limitation is that it has no affect when the cement height on top of the fluidisation fabric is greater than 20-24 ft. This is because the material pressure is higher than the air pressure which is used to fluidise the cement. When a dome is fully loaded with cement, the material height above the floor is substantially higher than 20-24 ft. The floor therefore has no effect at all in the early phase of the extraction process. Figure 5 shows the sequence in which the cement is extracted from a dome with fluidised floor and side outlet. Initially only a vertical flow down to the outlet will occur (1). This will soon expand into a funnel flow (2). For cement, the sides of the funnel from which it flows downward have an angle of approximately 50° with the horizontal. At a certain point the funnel will expand so far that the material height above the trench at the outlet is less than 20 ft (3). At this moment fluidising the trench starts to take effect. By fluidising the lower half of the trench (for which only very little air is required) a large volume of the cement in the dome can be reclaimed using little energy (4). By further fluidisation of the combined lower and upper halves of the trench, the dome is further emptyed (5). Now only a large triangle of cement remains on the left (6) and right (7) sides of the trench.

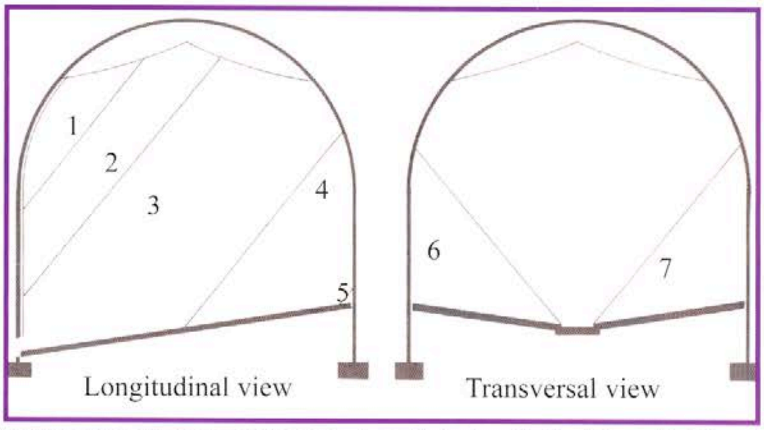

Figure 5. The sequence in which a dome is emptied using a fluidised floor with side outlet. A large part of the cement can be reclaimed fluidising only the lower half of the centre trench (4) using very little energy.

The large floor areas on each side of the trench are divided into a large number of fluidising sections, with each section being fluidised separately. By alternatively fluidising one section in combination with fluidising the trench, a controlled massflow is achieved from the sides of the dome to the trench and then to the outlet.

The largest danger to cement stored in domes and silos is setpack of cement. This problem occurs when cement is stored over a longer period of time under large material pressure. When setpack occurs, the cement solidifies into hardpacked lumps that are extremely difficult to reclaim. The only way to prevent this is to completely clean out the silo or dome on a regular basis. At the Silvi terminal this is possible because there are now two storage facilities, the existing storage tank and the new dome. By alternating the emptying of each storage facility, a good rotation of stock can be achieved thus preventing setpack of the cement.

A unique feature of a fluidised floor is that it has the capability to create a good ration of stock within one storage facility. To a large extent, the dome for the Silvi terminal already had this capability.

By only fluidising the centre trench, over 60% of the dome volume can be extracted. This leaves approximately 20% of the dome volume on each side of the trench. The fluidised floor can be controlled in such a way that only one side of the dome is fluidised, or even only one quadrant. Even when the dome is never completely empty, at least half the floor can be cleaned, and by rotating this, setpack can be prevented.

The experience gained with the Riverside Construction Materials project will make it possible to develop large cement terminals with only one storage dome. For these large terminals the cost savings of using one very large dome, instead of two domes with half the storage capacity, are substantial. However large cement import terminals can sometimes still be 33% full when the next ship arrives. To achieve a good rotation of stock it is necessary for cement to be stored on one side of the floor while the other half is completely emptied. Figure 6 shows how this can be carried out using a separation wall approximately 10-15 ft high in the centre of the trench. This effectively divides the fluidised floor into two individual extraction systems that can be operated independently. Each half of the dome floor can be regularly emptied completely. Cement terminals can now be built using a single dome as a storage facility, without the risk of setpack. The divided floor provides the same redundancy as two separate reclaim systems, and the reliability that goes with it.

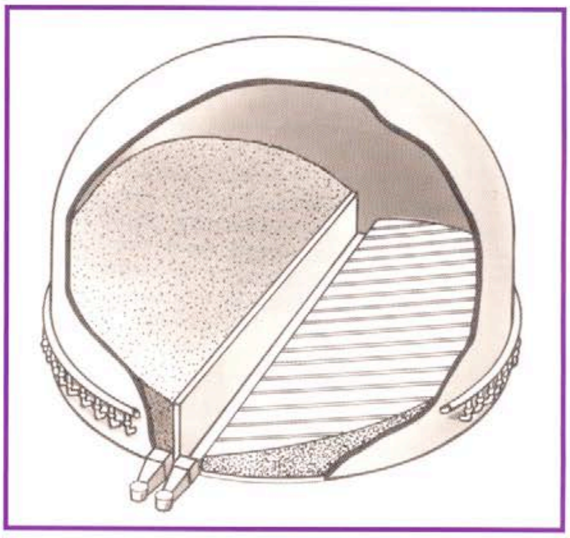

Figure 6. A dome with fluidised floor and separation wall dividing the floor system into two individual systems. This allows for full stock rotation within a single dome.

A 'floating' floor

Fluidised floors by themselves are already quite competitive compared to other reclaim systems. However, their key advantage lies in the savings in civil construction that can be realised. Using a fluidised floor with a side outlet, for example, requires no tunnels under the dome. The dome at Riverside Construction Materials highlights another possibility that fluidised floors can offer: the construction of a dome and floor without piling! The dome structure itself is relatively light and in most cases a ringbeam foundation will be sufficient to support it. A cement load of 30 000 st on a floor with a diameter of only 120 ft is an entirely different issue however. Although some soil stabilisation was necessary (a layer of 15 ft of clay was replaced by sand), the omission of piling underneath the floor meant that the floor would settle. An estimation of the settlement was made and found to be acceptable. The floor has been designed without any rigid connection to the dome itself. It is actually 'floating'. This required the fluidisation system of the floor to be specially designed. The floor consists of large number of sections that each have an individual air supply. Instead of feeding the sections with rigid piping from the underside, through a concrete floor, a different design was made. From the ringline, for each section a pipe runs up and enters the dome above floor level. This pipe is then connected to the fluidising section by means of a flexible connection that allows for a maximum settlement of 8 in. and is strong enough to withstand the pressure of a material height of 100 ft. Also at the outlet of the dome provisions were made to cope with settlement of the floor.

Conclusion

The new dome at the Riverside Construction Materials terminal received its first load of cement in April of this year. At that time only the work inside the dome had been completed. The ringline and feeding pipes outside the dome were still under construction, as well as the airlift tower. The complete system was ready in June and the terminal has been extracting cement from the dome successfully since. Settlement of the floor has only been minor and has posed no problems for the operation of the fluidised floor system. Because the new fluidised floor has an air supply consisting of a large number of small blowers from the existing silo aeration systems as well as two new blowers, it is possible to carry out research on the minimal air requirements to fluidise the cement for each phase of the extraction from the dome. The control system, which already allows for several modes of automatic as well as manual reclaim, has the future capability to automatically select the optimal combination of fluidised area and supply during each phase of extraction, minimising energy costs.

This new dome combines a number of features that are unique for a cement terminal. It is a prime example of how a large storage facility with a fully automatic reclaim system can be built at a very low capital cost per ton of storage. The experience gained with this project will make it possible to make the next big step. This is the construction of a large cement terminal, which will only have a single dome as a storage facility. This single dome however, will have the same capabilities in respect to stock rotation, redundancy and reliability as exisiting multiple facilities, but at a substantially lower capital cost.

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