Storing fly ash the 'green' way

why a dome was the optimum solution for Carmelo

View of the San Juan skyline, showing the new fly ash dome for Ecológica Carmelo.

Carmelo, a major producer and manufacturer of concrete products in Puerto Rico, is about to finish the construction of a 50,000-ton-capacity dome to store fly ash. This dome is for use by Carmelo's new subsidiary Ecológica Carmelo.

The dome is built on Pier 16 at the San Juan Bay, and has a small footprint of only 2,000m^2. It is the first of its kind on the island, built for industrial purposes, and has certainly changed the skyline of San Juan.

The decision to opt for a dome over other potential storage solutions was taken because of its rapid construction, structural integrity, and cost and space efficiency. The construction of the dome (56 metres diameter, 26 metres high, storage capacity of 34,000m^3) took only 42 working days from inflation stage to finished shell. A further advantage of the dome is its ability to withstand hurricane force winds.

Ecológica Carmelo's commitment to the environment is reflected in its decision to choose a dome. The facility is equipped with the most advanced technology, and automated controls for providing a hermetic, emissions-free structure for bulk handling operations in environmentally sensitive areas. The unobtrusive shape of the dome also enhances the aesthetic value of the future development of the port area.

Automated mechanical dome reclaiming system

The following advantages are offered by marrying the concepts of dome storage with an efficient mechanical reclaim system:

- superior protection of stored materials;
- major capital cost savings compared with other storage and reclaim systems;
- maximum utilization of the storage space inside the dome;
- virtually 100% reclaim of the stored materials;
- high reclaim rates;
- reduced operating and maintenance costs;
- no personnel working inside the dome, a major safety feature; and
- excellent environmental control.

The fly ash handling and reclaiming equipment installed in the Ecológica Carmelo dome comprise:

- a centre column support base;
- a rotating column located at the centre of the dome;
- a support bridge and rotating screw reclaimer;
- a cable hoist for raising and lowering the bridge;
- observation and maintenance platform;
- an equipment mounting platform;
- head house column drive equipment;
- controlled discharge and enclosed pneumatic air slide discharge conveyor; and
- emergency discharge aeration pads.

During phase one of the reclaim cycle, without the use of the reclaim screw, the stored fly ash 'ratholes' by activating a doughnut-shaped side discharge pile aeration system installed at the base of the rotating centre column.

During phase two, the fly ash is reclaimed using a combination of gravity and screw reclaim. Finally, during phase three, the mechanical screw pulls the remaining fly ash to the centre doughnut-shaped side discharge ring without the use of aeration. The fly ash is then conveyed to the bucket elevator pit outside the storage dome, by means of an enclosed air slide discharge conveyor, and elevated to truck load-out bins. Three flow control gates control the flow of fly ash to the discharge air slide conveyor.

Redundant discharge capability

The reclaim system has a companion provision for 'emergency discharge' which allows for the continuation of reclaim operations while preparations for repairs are being made. The emergency discharge system will discharge significant quantities of fly ash from that sector of the pile between the dome's centre and the entry door, thus providing means of allowing large front end loader access under much improved conditions.

Tunnel-less reclaiming system

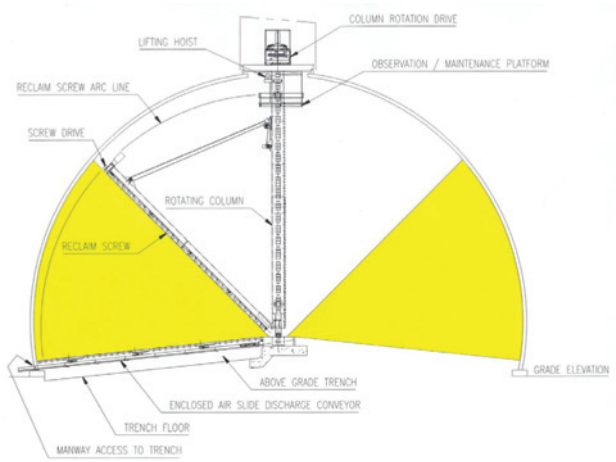
Ecológica Carmelo selected the tunnel-less reclaiming retrieval system for the dome because of the following advantages of this modified design.

❖ elimination of the normal 'below grade' tunnel reduced potential problems associated with the high water table. The site selected by Ecológica Carmelo for its new import terminal has a water table very near the ground surface and the modified design helped minimize construction and operational concerns;

❖ reduced 'live loads' into the soils. Redesign of the reclaiming auger support structure allowed for a reduction in vertical loads by 40%-45%. Further redesign of the column bottom support allowed the vertical 'live loads' to be transferred directly into the soils without having to first go through a structural support which traditionally would 'free span' over a 'below grade' tunnel;

❖ the changes in the overall configuration allowed for the elimination of the traditional reclaimer support base and other manufacturing-related expenses, thus reducing the cost of the equipment. Significant site-related construction savings were also achieved due to the elimination of the traditional 'below grade' tunnel; and

❖ increased dome storage capacity in a dome with the same site footprint. Utilizing a 166ft-diameter storage dome, Ecológica Carmelo is able to store 50,000 tons of imported fly ash.



Each dome discharge cycle is predictably the same as the previous one. The reclaimer's operation is not affected by the tendency of stored fly ash to compact into a cohesive mass as a reaction to pile pressures, humidity and time. Non-moving storage subjected to moisture-laden air and high pressure over time can harden and gain significant strength. The reclaim system has been designed to reclaim stored fly ash at a minimum rate of 250 tph.

Dome control systems

The Ecológica Carmelo plant comprises the standard TSI base system, modified to meet its special requirements. This includes an Allen-Bradley Control Logix PLC, two Wonderware HMIs, additional I/O and screens to include operation of the truck loadout, ship to dome storage and ticketing system.

Two identical computers were used, allowing the operators to monitor the control system from one and load trucks from the other. The advantage of this system; both computers are identical and function as a completely integrated HMI for control of the process and ticketing system.

The TSI base system includes as a minimum one Wonderware HMI, one PLC and one Communications network.

a. HMI – This provides the operator with clean, clear, and precise information to operate and control the reclaiming process. The screens are ergonomically designed for the operators. Consideration has been given to making the colours both meaningful and easy to use. All data is trended in real time, however historical trending is also made available. Alarming is accurate and well defined.
b. PLC – safely controls the operation of the reclaiming process. The PLC system comprises a main processor, power supply and associated I/O modules. The programming logic is well structured, organized and annotated.
c. Communications network – CAT5 Ethernet runs from the main CPU to the control room HMI. A hub is provided to allow the process control engineers to plug in additional computers and/or development tools.

In addition to the base system, custom features can be added, to meet the unique requirements of our clients. Additional screens and I/O are added, to tie other areas of the plant into the same control system as the mechanical reclaimer. Some of these features include:

a. Overview screen of the entire process.
b. Truck and rail load-out screens.
c. Ship loading and ship unloading screens.
d. Maintenance and other diagnostics and troubleshooting screens.
e. Ticketing, printing and database features.
f. Additional computers for redundancy as well as operational use.
g. Redundant PLC for backup purposes.
h. P& ID, loop, electrical schematics and other drawings.
i. Customized HMI or PLC to match the existing plant standardization requirements.
j. Dial-up, ISDN, DSL support service contracts.

Added high-speed capability allows the system to be monitored over the internet.

The Ecológica Carmelo plant will include pop-up screens for each mechanical component. These screens provide information to the operators, depicting interlock status, run status and fault status as well as PLC programming information for plant maintenance. Starting and stopping of devices is from these pop-up screens.

The ship unloader

Initially, the fly ash will be supplied to the dome by 18,000dwt ships. When the project is fully on line, it will be supplied by 40,000dwt ships.

An important consideration for choosing this particular ship unloader was to keep the dockside free for other activities when the fly ash was not being handled. Therefore, a rail mounted ship unloader was not allowed. A mechanical unloader that requires a lot of dock-mounted equipment to transfer the fly ash to the dome was also out of the question.

Pneumatic unloaders require only a pipeline between the unloader and the dome. Together with Ecológica Carmelo, a pipeline has been developed that can be put in position on the dockside to unload the ships, then removed after the ship is unloaded. From the edge of the dockside to the dome storage, the pipeline is buried and does not obstruct any other activities in the harbour.

The ship unloader is sized to unload 40,000dwt ships and has an unloading capacity of 400tph. The weight of this mobile unit is about 200 tons. Pulling such a weight through the dock area is difficult. The solution was to make the unit self-propelled by using hydraulic motors to drive the set of wheels under the platform. To move the ship unloader, the hydraulic oil which operates the suction arm is directed to the drive motors. The unit is guided by a hydraulic steering cylinder that steers the front set of wheels. One man with a remote control can drive the unit from its parking position in the harbour to the dockside where the ships have to be unloaded.

The unloader equipment is driven by diesel motors and operates independently from any port facility. There is no need for electrical power supply, cooling water or auxiliary air.

The ship unloading process and the transport of the fly ash to the dome storage is almost a fully automated procedure and controlled by a PLC (programmable logic controller). The manual tasks of the operator are limited to the starting and stopping of the unloader and the operation of the suction arm controls. All equipment needed to unload the ship and to convey the fly ash to the dome is built on the same mobile platform.

Special attention has been given during the design of the unloader to maintenance requirements.

Maintenance costs — and downtime — have been kept to a minimum, thanks to:

- a separate filter vessel. By using a separate filter vessel instead of the installation of filter elements in both transfer vessels, the number of filter elements is reduced. The reduced number of filter elements in the filter vessel is not exposed to overpressure like the filter elements in transfer vessels. In addition, these filter elements will last longer.
- walk in air plenum. The filter vessel has been made higher than needed for the process. This extra height is used to ease maintenance. Via a ladder and entrance door at the side of the filter vessel, one can enter the filter vessel and inspect or replace the filter elements. No crane is needed to lift the complete top of the vessel, and the inspection work can be done during all weather conditions.
- special pinch valves. The valves that are fitted in the air piping conveyor are exposed to high wear. This is caused by the cement and transport air passing these valves at high speed. The valves on the ship unloader for Ecológica Carmelo are executed as pinch valves instead of butterfly valves. These can be guaranteed for more than 100,000 tons of fly ash handled. When the valves are worn out, only the rubber inner sleeve of the valves must be exchanged. This can be done in a simple way and reduces the costs of maintenance and downtime of the ship-unloader.

The ship unloader is further equipped with the standard Van Aalst Bulk Handling BV features like:

RECENT FLY ASH DOMES FROM DOME TECHNOLOGY

Domes are well known in the cement industry. Since 1994, Dome Technology has constructed eight fly ash storage domes totaling more than 320,000 ton (290,000 metric tonnes [mt]).

Year	Location	Dimensions	Capacity	Method of Reclaim
1994	Lafarge Corp, Alpena, MI	55 m x 28.2 m	52,000 mt	Mechanical
1995	Alsein Breitenburg, Germany	59 m x 31.7 m	52,000 mt	Mechanical
1997	Below Creek Power Plant, NC	50 m x 25.1 m	36,000 mt	Fluidized floor
1998	Boral Material Tech, Fontana, CA	29 m x 16.2 m	8,800 mt	Fluidized floor
1999	Undisclosed client, SC	38 m x 22.6 m	14,600 mt	Fluidized floor
2002	Winyah Power, Georgetown, SC	38 m x 22.6 m	14,600 mt	Fluidized floor
2002	Great River Energy, ND	67 m x 24.4 m	68,200 mt	Mechanical/fluidized floor
2003	Ecologica Carmelo, San Juan, PR	56 m x 26 m	50,000 mt	Mechanical

❖ radio remote control which allows the operator to take any position from where he has the best view of the suction arm;
❖ rotating fluidization nozzle which loosens up the packed material before it is sucked out of the ship. Loosening the fly ash in the ship's hold before it is picked up reduces the stresses in the arm and greatly increases the lifespan of the arm; and
❖ hurricane aeration system increases the amount of fly ash that can be transported with the transport air volume. This reduces the power consumption of the ship-unloader.

Summary

Efrain Carreras, vice-president of operations and COO of Grupo Carmelo headed the construction team as Grupo Carmelo acted as their own general contractor. Cast-in-place pilings were used to shore up the area where the dome was to be located. Because of the high water table, the option to go with the dome and the tunnel-less reclaim system was made. As mentioned earlier, the tunnel-less system works especially well in areas such as ports where the water table is high.

A note of interest to the reader is that this particular combination of the dome/tunnel-less mechanical reclaim system is the second of its kind. The first system was built for California Portland Cement (CPC) at the Port of Stockton, Stockton, CA, for 65,000 mt of cement.

Once the cast-in-place piles were in place, construction of the ringbeam foundation began. Upon completion of the ringbeam, fill was placed in a mound inside the ringbeam to form the concrete floor. Once the mound of fill was in place and properly shaped, the trough and floor was poured.

The steps in construction for this dome were in a different order from the steps in the CPC project. At CPC, once the ringbeam foundation was completed, the air form was attached to the ringbeam, inflated and the dome constructed. After construction of the CPC dome, the trough and sloped floor was constructed inside the dome shell. At Ecológica Carmelo, it was easier to construct the sloped floor and trough before the dome was constructed.

Contributions for this paper are Melba Figueroa, President of Grupo Carmelo; Hans van Est, Van Aalst Bulkhandling; Rex Wood, VP Sales for Cambelt International; Wayne Caballero of Trimax Systems International.

COMPANIES INVOLVED IN THE CARMELO FLY ASH DOME PROJECT

Suppliers	Scope	Location
Dome Technology	Dome Shell	Idaho Falls, Idaho
Van Aalst Bulk Handling	Ship unloader	The Netherlands
Cambelt International	Mechanical reclaim system	Salt Lake City, Utah
Trimax Systems	PLC System	Brea, California