# The Keys to Successful Terminal Design

Javier Martinez Goytre, GlobBULK Consulting, outlines the key points to consider in cement terminal design.

## Introduction

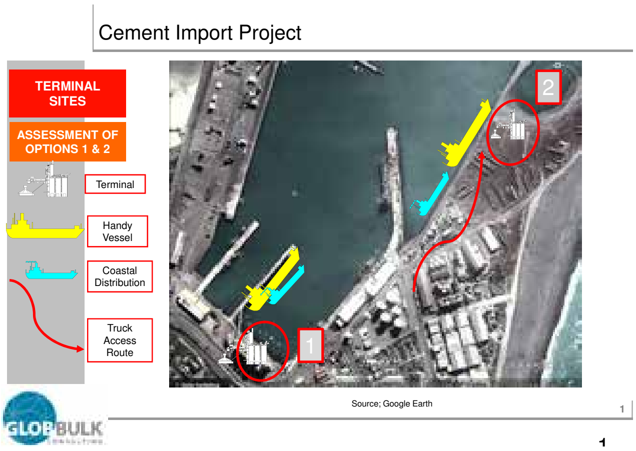
The cement industry witnessed an uprising trend in the optimisation of existing cement production assets in recent years. With existing production imbalances in many regions of the world, and limited access to capital markets to finance new CAPEX investments, the industry refocused its strategies seaborne distribution (exports and imports) and light assets strategies (low CAPEX, phased projects, modularisation). Export and import terminals are a flexible solution, allowing business-capture opportunities quickly and with limited financial exposure .

This article outlines key factors to be considered when designing cement terminals: i.e.: terminal size, storage capacity, dispatch facilities, the environment, and health and safety. However, it has to be considered that there is not such a matrix that, provided with the input factors, will produce the optimum terminal layout or the best arrangement of ship's operation.

Underscoring the risks of proper design of terminals may result in operational constrains and cost overruns, hampering the operational efficiency and financial performance of the project.

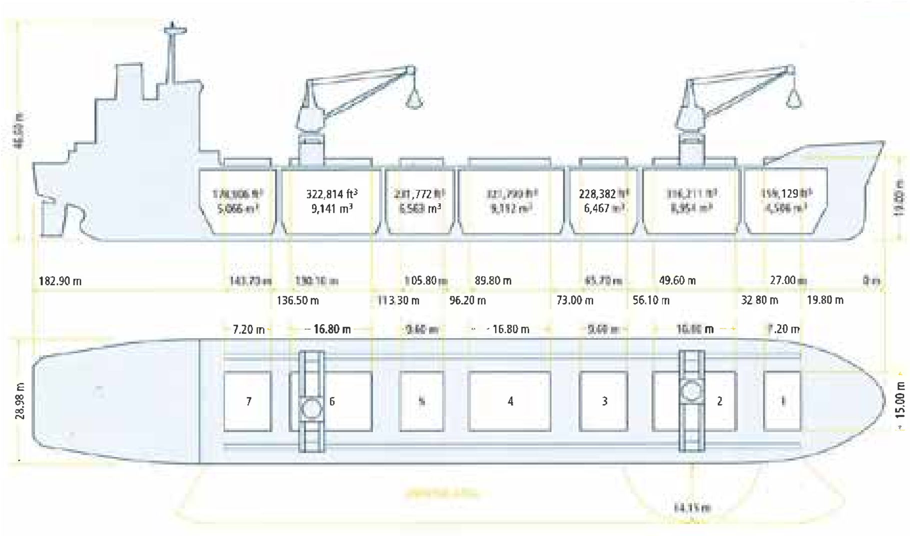
## Infrastructure: port characteristics

The following factors have to be considered in order to estimate the optimum size of incoming vessels into port facilities.




Assessment of potential sites for cement terminal, both with direct access to berths.

Cement terminal and dedicated berthing facilities, including railway mounted shipunloader.




Typical cross section of a conventional geared bulkcarrier.

### Berthing facilities

Cement terminals are typically allocated by port authorities into bulk products and minerals sectors. Once the terminal site has been defined, the following operational berth specifications have to be gathered:

- LOA (length overall) of the jetty: defining the length of the incoming vessel.
- Draft and tidal variations: allowing the determination of the size of the vessel.
- Under keel clearance (UKC), as a safety provision for incoming vessels.
- Tidal variations: required to adequately design shore-based unloading equipment of bulk carriers, which has to reach cargo holds both in high and low tides.
- Berth occupancy rate (BOR): allows the prediction of whether the jetty has enough availability to accommodate additional number of vessels servicing the operation. BORs above 70% imply high occupancy and thus imply that vessels will be waiting at anchorage, having a significant impact in operating costs

### Design vessel

The 'design vessel' concept is commonly used in engineering calculations. It could be a real vessel, or several actual vessels, taken as examples, with dimensions selected from a database in order to cover the expected variability of vessels calling the port facility.

The design vessels are assumed to have the most significant effects on the facilities under design, and they are not necessarily the largest expected vessels to be received. Having defined the design vessel, 'average vessels' will fit into the facilities.

Capacity of the design vessel is critical when defining the storage capacity of the terminal, to accommodate the incoming cargo, but also when designing the shore-based shipunloading equipment. The outreach of the shipunloader's reclaim arm, its height, and the possibility of travelling alongside the vessel in order to access the different hatches: it is all influenced by the vessel's characteristics

## Terminal design

The design of terminals should be driven by the total cost of ownership (a balanced combination between CAPEX and OPEX). In recent years, emphasis has been put on low CAPEX. In general, a sound cement terminal designshould comprise the following:

### Soil conditions and utilities

Appropriate soil investigations are recommended in all cases. The type of soil investigations should be defined to consider the following:

- The geotechnical information available.
- The project phase: depending on whether the project is at conceptual, feasibility study, or detailed-engineering phase, soils investigations will have different scope.
- The type of project: soil requirements are different when building a flat storage terminal in a consolidated port area, a massive concrete silo in a swampy area, or a dome silo in a reclaimed area.
- The type and conditions of ground materials: soil investigations differ substantially from solid rocks to soft materials. Regarding conditions, it should consider whether the site could be affected by geological faults or by karstic phenomenon (in limestones) with cavities prone to potential collapse; sands could be subject to liquefaction in case of seismic activity, etc

The integrity of the terminal structures to be built should not be compromised by cost savings on the geotechnical surveys, as accurate geotechnical surveys guarantee – to the maximum extent possible – safe design and construction.

The availability of water needed during construction for concrete production at site, and for water consumption for offices, showers, etc., should be considered, while the power supply infrastructure has to be thoroughly investigated to check the high-voltage lines in the area and the location and/or availability of transformers to step down to the medium and low voltages required for the terminal.

### Environmental conditions

Bulk materials generate dust when they are manipulated. The amount of dust generated depend on a number of factors:

- Finer products tend to be suspended in the air and remain there for long time.
- The higher the drop, the more and larger impacts among particles and air turbulences, which are at the source of the dust generation.
- Wind acting on spilled products can generate dust.

Stringent environmental conditions for dust and effluent emissions apply in public or private ports, where bulk products have to be handled. Unloading operations of bulk carriers with open hatches are more exposed to dust emissions than any other terminal activity. For this reason, the design of adequate shipunloaders has to be made with care. Sometimes, the sole method of unloading cement is

Dust emissions during unloading operations at a terminal on the West Coast of Africa.

using pneumatic self-unloading vessels (PSUVs), where bulk cement handling from vessel to terminal is made on a totally enclosed pipeline system with no dust emissions.

### Terminal type and size

Three different terminal types can be widely considered when designing a cement import operation.

#### Vertical silos

These are vertical cylinders, made of concrete or steel. The reclaim system that can feed trucks, railway wagons, or belt conveyors is located at the bottom of the silo. When used for storage of cement, this is typically loaded by a combination of bucket elevator and airslide/belt conveyor system.

Reclaiming systems for cement can be either inverted cone silos (with several material outlets around the bottom and collected to a central bin) or fluidised bottoms, where compressed air is injected into canvas, divided into several aeration pads

The advantages of vertical silos include the following:

- Closed storage: material is protected from exposure to the weather.

- It is an efficient storage system, when there is a scarcity of available space (a common factor in many public ports).
- Storage management is often made following a first-in first-out (FIFO) sequence.
- Allows for storage of different types of bulk products (granulated ground blastfurance slags, bulk cement, flyash) and different cement types.
- Easy management of feeding and reclaim operations, and good control of stocks.
- Steel silos are typically used for storage capacities below 5000 t, whereas concrete silos are used for storage capacities over 6000 t.

The disadvantages of vertical silos include the following;

- Large soil loads, which may require deep foundations or soil improvement.
- Large CAPEX requirements.
- Reclaiming galleries may have to be excavated below water level (inside port areas).
- Visual impact: construction height limitations may apply.
- Steel silos are specifically exposed to marine corrosion in a marine environment.

### Storage domes

Domes have a hemispherical shape, placing the bulk materials directly over the floor, covered by the curved roof of the dome.

Vertical concrete silos at the Port of Umm Al Quwain, UAE.

Bulk cement is fed into the dome by means of pipeline system or airslides. Reclaiming is typically made by means of a tilting and rotating screw conveyor that reclaims material from all areas of the dome into a central spot in the centre of the dome floor. From the centre of the dome, cement is dropped into an underground gallery, where it is conveyed by means of belt conveyors, screw conveyors, or a pneumatic system.

The advantages of storage domes include the following:

- Closed storage: material is protected from exposure to the weather.
- Storage management is often made following a FIFO sequence.
- Loads are spread over a larger area than in vertical silos.
- Easy management of feeding operation; good control of stocks.
- High structural rigidity (particularly positive in earthquake zones).

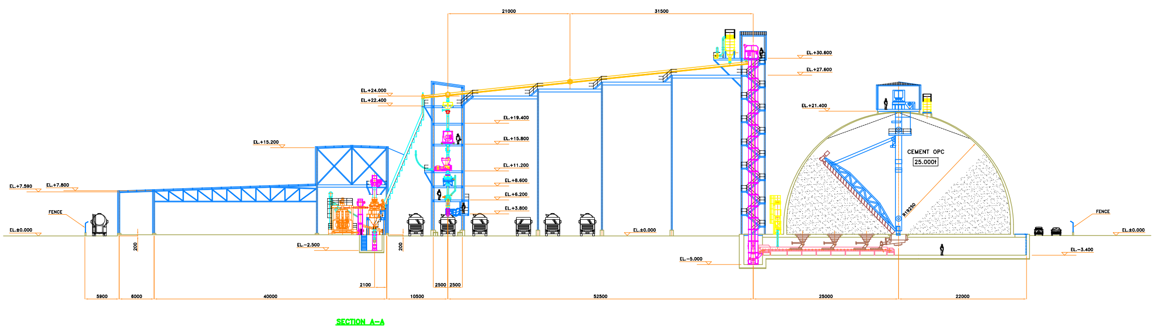
The disadvantages of storage domes include the following:

- Larger footprint than vertical silos.
- Can only store one product.
- Higher CAPEX required, but less than vertical silos for same capacities.
- Potential reclaim problems derived from dead stock.
- Reclaim galleries may have to be excavated below water level in port areas.
- Mechanical reclaimers are subject to wear and tear.

### Flat storage

These are covered sheds to store all type of bulks materials or bagged products, with different shapes and loading or unloading systems.

When used for cement, it is stored inside the warehouse by means of pipeline network system using pneumatic conveying the vessel. Reclaim of cement is typically made with front-end loaders into a hopper.



Terminal cross section with dome silo (Barbados).

The advantages of flat storage include the following:

- In many cases, it entails the lowest possible CAPEX of all the alternatives considered.
- Closed storage: material is protected from exposure to the weather.
- Can be used for all kind of bulk materials.
- Products can be separated, with intermediate walls for multiproduct storage.
- Low soil pressures imply that heavy foundations (piling, etc) are very seldom required.

The disadvantages of flat storage include the following:

- Larger footprint than silos or domes.
- More labour intensive than silos or domes.
- Access to the warehouse can be limited during filling and reclaiming due to dust creation.
- Environmental conditions for the front-end loader operator may pose hazards, due to low visibility and dust generation.

### Storage capacity estimates

Calculations for terminal storage capacity estimates range from 1.3 – 1.5 times the size of average incoming vessels for safety reasons. Large distances between the source of cement and the terminal location may require storage capacity of 1.5 times (beyond in certain cases) the bulk carrier capacity, in order to prevent stock breakdowns, due to contingencies happening during a vessel's trip. Short distance from cement sources to terminals allow for a smaller terminal storage capacity estimate of about 1.3 times the bulk carrier capacity.

The following factors should be considered when calculating a vessel's trip duration:

- Queuing/anchorage at loading port, including idle time.
- Loading port loading rates.
- Distance between loading port and port of destination (nautical miles).
- Vessel's average speed (knots).
- Special navigation conditions (hurricanes seasons, piracy, etc).
- Queuing/anchorage at port of destination, including idle time.

Dispatch facilities of the terminal should be designed considering the following:

- Yearly throughput (in thousand tpy) of dispatch.
- Dispatch seasonality on a monthly basis, in order to design peak dispatch rates, according to peak estimated sales.
- Bulk/bag ratio deliveries to design bulk, bagged, and palletised cement dispatch facilities.
- Product portfolio: different qualities of products to be sold.

Typical layout of a flat storage terminal.

Lately, manufacturers of packing machines for cement have developed flat bottom packers in an effort to decrease the packing plant buildings height and, therefore, the quantities of structural steel, cladding and CAPEX involved.

## Health and safety

Increasing consciousness in occupational health and safety (OH&S) has led to more importance being placed on safety, when designing terminals, as well as during construction and operational phases.

In many cases, a company's OH&S directives have to co-exist with those applying in public ports: traditional OH&S cardinal rules related with personnel identification, walkways for pedestrians, traffic flow, fall from heights, falling objects, noise, personal protective equipment (PPE), isolation and lockout procedures, working under the influence of alcohol and drugs, etc., overlap with specific safety provisions in port areas. Addition OH&S factors to conside include the following:

- Not allowing access to unauthorised staff near vessel's unloading area. Fence the area, where possible, in coordination with port authorities.
- Provide specific PPEs for staff boarding vessels.
- Lifting operations with port cranes or vessel cranes shall follow specific safety rules, such as verification of all lifting equipment and ancillary devices. Operations are to be under the management of an appointed rigger.
- Clearing the areas under suspended loads.
- Special care with railway traffic inside port facilities, as well as moving equipment, such as port cranes, mobile lifting cranes for containers, and truck traffic, etc.

## About the author

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