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9. Grain Terminal, Trafaria (Portugal)

Owner:	*Silopor*
Engineers:	*Silo – V. Coias e Silva* *Maritime structures – Somec SA; ENARCO Lda*
Contractors:	*Engil SA; Somec SA; Simon-Carves*
Works duration:	*3 years*
Service date:	*1986*

General

The construction of the Grain Terminal of Trafaria is the greatest achievment ever in the field of grain handling in Portugal, and one of the greatest in Europe. The silo itself, with its 2 000 000 kN storage capacity is currently the largest in Europe and one of the largest in the world.

The construction of the Terminal entrusted Portuguese and British companies in joint venture. The Terminal was set out near Trafaria and concerns a land area of about 140 000 m^2 which received over 900 000 m^3 of sand dredged from the river bottom in the manoeuvring and docking areas (Fig. 1).

The terminal comprises the following works:

a) Works on the land area:

- the silo itself, consisting of four blocks of bins 72 to 76 m high, designed to the storage of grain and related products
- the main intake tower, 82 m high, housing eight elevators
- the weighing center, 39 m high, where the automatic weighers are installed
- the outloading tower, 48 m high, adjoining the weighing center, where the outloading and recirculating elevators are located
- the control building, 25 m high, accommodating the control system of the whole Terminal
- the road outloading silo, 42 to 49 m high, consisting of outloading bins, weighers and loading tunnels, for bulk loading of lorries.

b) Maritime works:

- the formation of the large land embankment platform
- the quay for importation purpose to be used by ships up to 120 000 dwt on the north side (bottom at -18 m) and ships up to 60 000 dwt on the south side (bottoms -14 m).
- the transhipment quay for ships up to 40 000 dwt (bottoms at -12 m)
- the quay for exportation to be used by coasters and barges up to 10 000 dwt (bottoms at -7 m).

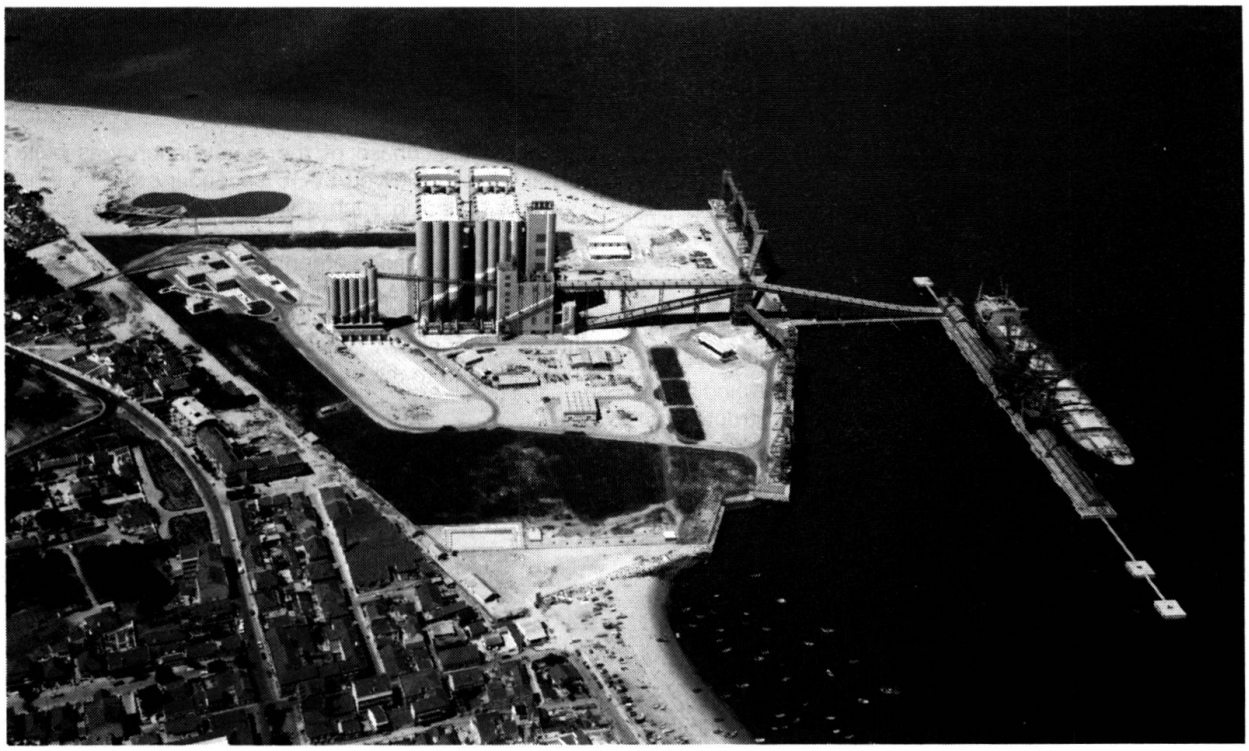

Fig. 1 Grain Terminal of Trafaria

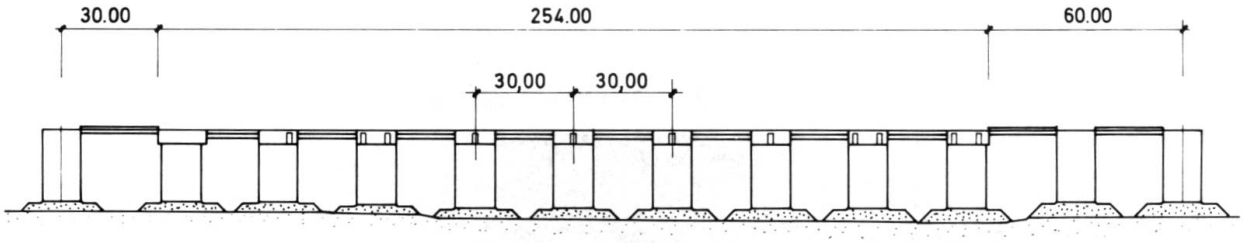

Fig. 3 Importation Quay – Longitudinal side view

Silo

The silo is in reinforced concrete and consists of circular bins tangent along four orthogonal generatrices called main beams, the «ace of diamonds» or interspace bins also being used for storage. The silo is made up of monolithic batteries or blocks of bins, in patterns of 3 × 3 or 4 × 4 structurally independent from each other. Altogether there are six of this silo blocks, comprising two basic sizes of circular bins: 10.1 m and 7.55 m in diameter. The typical organization of the silo along its height is shown in Fig. 2.

The foundations of the silo blocks consist of rectangular cast in situ reinforced concrete piles, transfering the vertical loads to the miocenic substratum.

Importation quay

The importation quay consists of a set of multicelular reinforced concrete caissons connected with a deck,

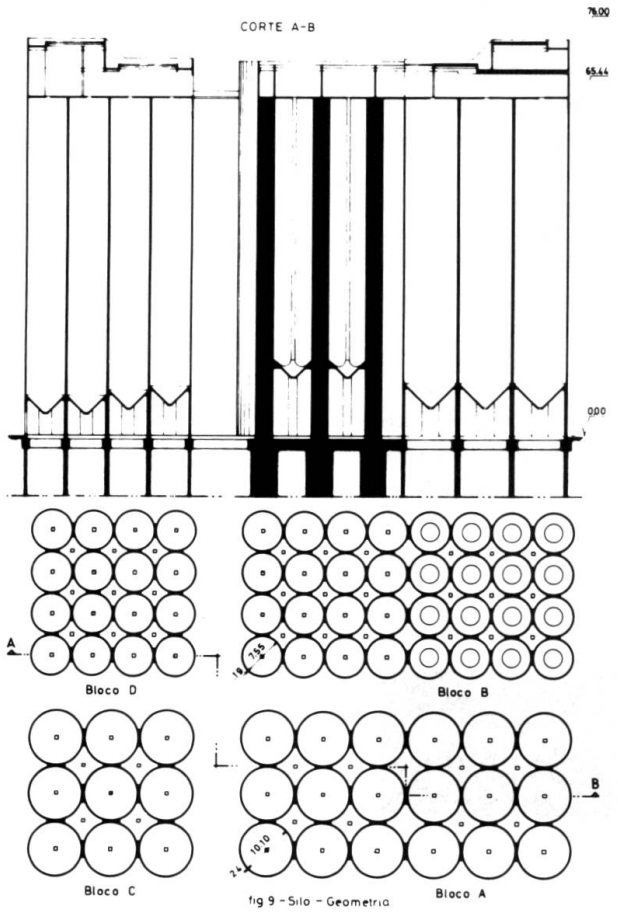

Fig. 2 Silos Geometry

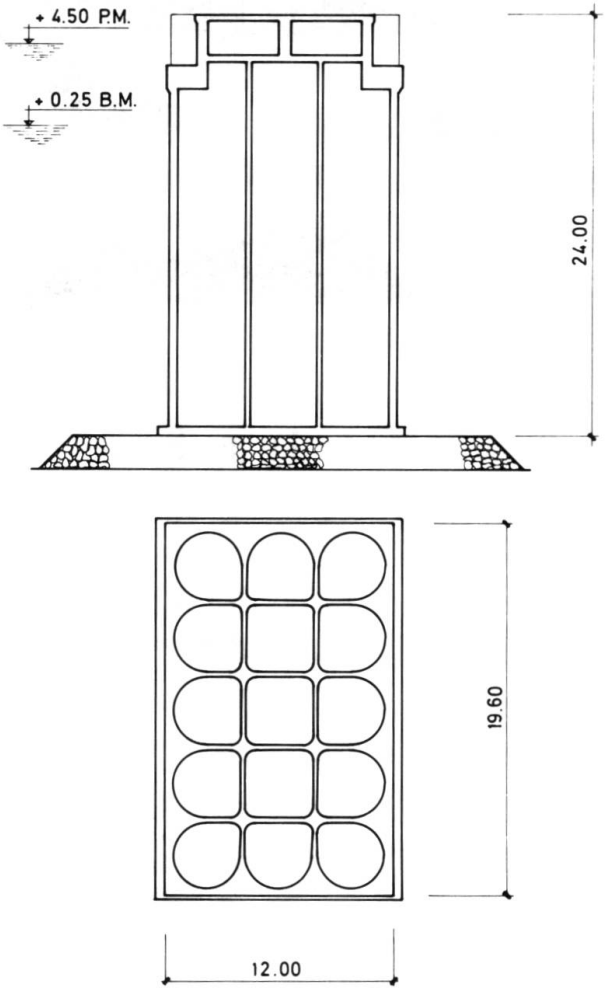

Fig. 4 Multicelular reinforced concrete caissons

with dimensions in plan of 20.7 × 19.0 m^2. This deck consists of a system of longitudinal and transversal girders linked with a slab with 0.30 m thickness. Over them run two steel cranes weighing 6500 kN each (Fig. 3).

The caissons have dimensions in plan of 12.0 × 19.6 m^2 and about 24 m high, and have their cells filled with sand. The caisson bottom slab was cast in site, then removed to the dry dock where the walls were slip-formed, and then the caisson was put into the water and went floating until it reached its position where it was sunk by filling the cells with sand (Fig. 4).

The caissons have their foundation rockfill embankments with thickness variable from 1.5 to 5.0 m, which stand on the sand aluvial deposits.

(V. Coias e Silva, V. Monteiro, A. Vale e Azevedo)