CONCEPTUAL DESIGN OF LARGE DRYDOCKS. RECENT IMPROVEMENTS

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INTRODUCTION

During the 70's and the early 80's in the 20th century some repair yards sprang up in the Mediterranean area (Spain, France, Italy and Malta) and in the Arabian Gulf (Bahrain, Saudi Arabia, Iran and Dubai) chiefly to take advantage of their location at the end of ships' return journey with ballast from all those routes that pass by the main source of the world oil supply. Similar initiatives were implemented in other regions, to wit Latin America (Ecuador, Venezuela and Brazil) and in Africa.

Portuguese engineering[1] played a major role in the carrying out of basic studies, projects and the supervision of the construction of the largest shipyards undertaken in the world at that time, with the following being worthy of special mention: Lisnave at Margueira, in Almada (fig. 1), Setenave at Mitrena, in Setúbal (fig. 2); Astilleros Españoles in Cadiz, Spain (fig. 3); ASRY, Arab Shipbuilding and Repair Yard in Bahrain (fig. 4); and JSRY, Jeddah Shipbuilding and Repair Yard in Saudi Arabia (fig. 5).

A shipyard built from scratch is undoubtedly a venture in which marine works are preponderant and may account for 65% of the total cost of the venture, thereby justifying the need for sound experience in the design of these works in order to achieve their better adaptation to natural – generally extremely adverse – physical conditions. In a shipyard we can find virtually all types of marine works (protection and sheltering works, dredging and landfills, drydocks, quays, jetties and dolphins) and complex geotechnical works (soil treatment and consolidation, cofferdams and lowering the

Figure 1. Margueira Shipyard, in Almada, Portugal.

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Figure 2. Mitrena Shipyard (1st phase 1975-1998 in Setúbal, Portugal).

Figure 3. Cádiz Shipyard, Spain.

water table). The launch of a venture of this kind is thus always a great challenge for the creativity of the designer in his quest for construction solutions that not only meet demanding operational, environmental and safety requirements but also afford the optimization of construction costs and terms for completion.

This situation came about in Portugal when in early 2001 Lisnave concentrated its activity at the Mitrena shipyard on the River Sado estuary, Setúbal, owing to the closure of the Margueira shipyard. Studies on the world ship repair market revealed that the decommissioning of the aforementioned shipyard would entail the construction of further two or three docks for Panamax type ships (80.000dwt) at Mitrena. Taking due account of all the aforementioned operational, environmental and safety requirements and also local geotechnical conditions, PROMAN designed an unconventional system for docking ships called the "Hydrolift". This system basically consists of three docking platforms with slabs situated close to the made ground surface, and of a frontal lock whose function it is to raise the ship in relation to the tidal level outside, and also to lower the ship after repairs have been made (fig. 6).

More recently, from 2005 until now, as a result of the enormous increase of offshore oil-fields exploration in Brazil, some shipyards are under design and construction conceived for building ships and offshore units. PROMAN had the opportunity to partici-

Figure 4. ASRY, in Bahrain.

Figure 5. JSRY, in Jeddah, Saudi Arabia.

pate in different phases of design of ERG, Estaleiro Rio Grande (fig. 7) and EAS, Estaleiro Atlântico Sul, Suape (fig. 8), operating in 2010.

On ground shipbuilding and repairing of big ships and offshore platforms is, undoubtedly, an interesting and up-to-date tendency in order to avoid work constraints in a confined conventional drydock. The kind of solutions used for this purpose is briefly described in the following.

Figure 6. Hydrolift in the Mitrena shipyard.

Figure 7. ERG - Río Grande, RS, Brasil.

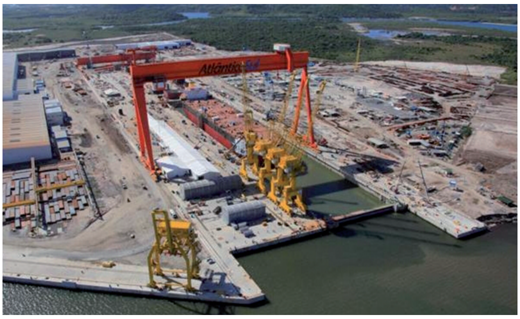

Figure 8. EAS - Suape, PE, Brasil.

ON GROUND SHIPBUILDING AND TRANSFER TO A BARGE

On ground building of big ships and large offshore units, such as FPSO (Floating, Production, Storage and Off-loading), FSO (Floating, Storage and Off-loading), SSP (Semi-Sub Platform) and TLP (Tension-Leg Platform), is mainly interesting for mass-production.

Figure 9 shows FPSO being built on the ground and to be transferred to special barge for transportation to drydock for completion.

Figure 9. FPSO unit built on ground.

Figure 10. SSP built on ground and transferred to special barge.

Figure 10 shows SSP built on the ground to be transferred afterwards to special barge. This solution of shipbuilding requires special equipment and technology and delicate operations of skid launching and load out.

ON GROUND SHIPBUILDING AND TRANSFER THROUGH A LOCK

In the first phase of Mitrena Shipyard, built in 1972-1975 (fig. 2), was adopted one innovative solution, named "platform solution", for on ground shipbuilding of VLCC up to 600.000tdw [Sardinha, J.M. (1967) and Menezes, J.C. and Cerejeira, J.M. (1974)]. As shown in Figure 11, the shipbuilding dock 20, or platform, 420 m x 75 m, has its walls projecting upwards about 6m from the ground level and the bottom slab some 2m below. This arrangement allows easy access to the interior of the platform for both people and vehicles. Between the platform and the estuary of the river Sado there is the ship repairing dock 21,450 m x75 m. When the hull is completed it is transferred to the out-fitting quay through this repair dock, which acts as a lock. To make this operating possible the copings of docks 20 and 21 are at the same level.

The entrance of dock 21 is fitted with a flap gate to enable to be emptied for ship repair to be carried out. To reach the level that allows the transfer of the new hulls, two additional gates are required, one at the front of the repair dock 21 (fig. 12) and another at the rear end of dock 20.

From 2001 until now the activity of Mitrena Shipyard is mainly dedicated to ship repairing and dock 20 is being mostly utilised for longer ship repair works (fig. 13).

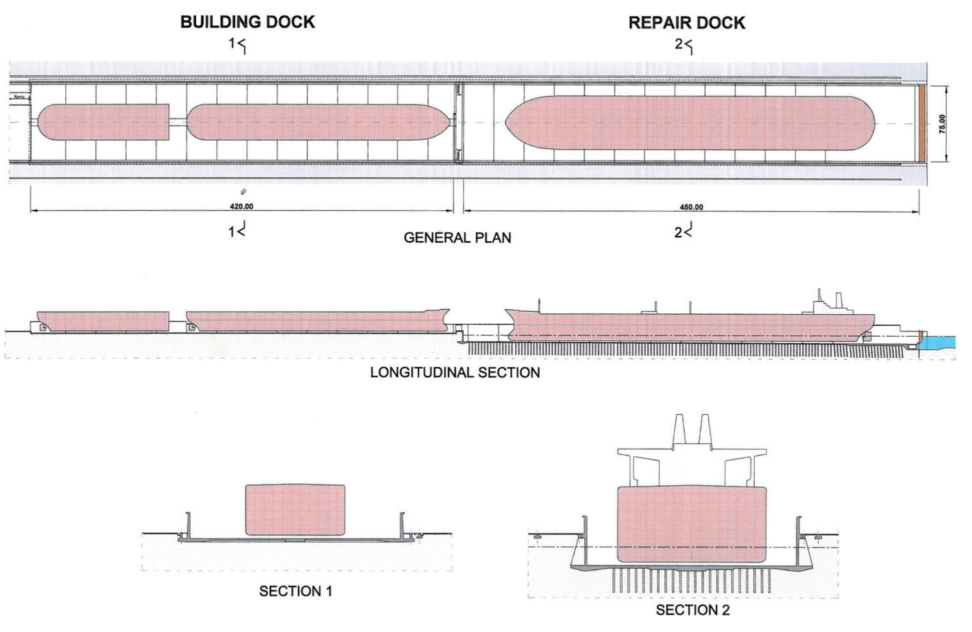

Figure 11. Mitrena shipyard - Platform solution for on ground shipbuilding.


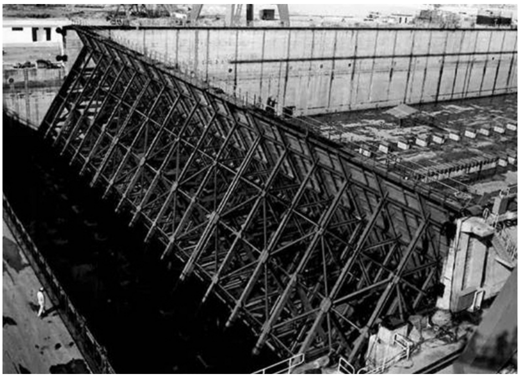

Figure 12. Mitrena shipyard - Gates in the entrance of dock 21.

Figure 13. Mitrena shipyard - Docks 20 and 21.

ON GROUND SHIPREPAIRING AND TRANSFER THROUGH A LOCK

The same "platform solution" was adopted in the expansion of Mitrena Shipyard carried out in 1998-2000 for ship repairing, named Hydrolift (fig. 6). [Sardinha, J.M. and Cerejeira, J.M. (2001)].

This new system, with 3 platforms and a front lock, was compared with two conventional drydocks solution at the conceptual phase of design and it was considered advantageous because of the main the following reasons:

- The total cost (€50 000 000) and time for construction (24 months) of both solutions were equivalent.
- The Hydrolift solution presented comparatively the following main operational advantages:
  - 50% larger docking capacity (3 platforms instead of 2 drydocks);
  - increase of the productivity of repairing works at the ground level, with easy access to the platforms bottom slabs for both people and vehicles;
  - better environment protection with facilities to segregate waters and solid detritus for treatment.
- The conceptual design of the Hydrolift proved to be well adapted to the local soil conditions:
  - the sandy alluvial formation, with more than 40 m of thickness, contains clean medium to coarse sands, with very high permeability (k=3x10-3m/s);
  - the foundation level of the platforms slabs is placed near the ground level avoiding the hydrostatic under pressure;

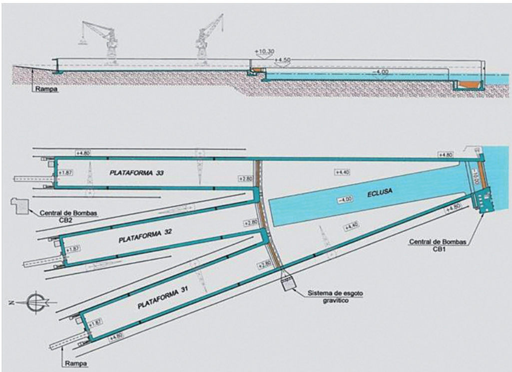

Figure 14. Hydrolift general plan.

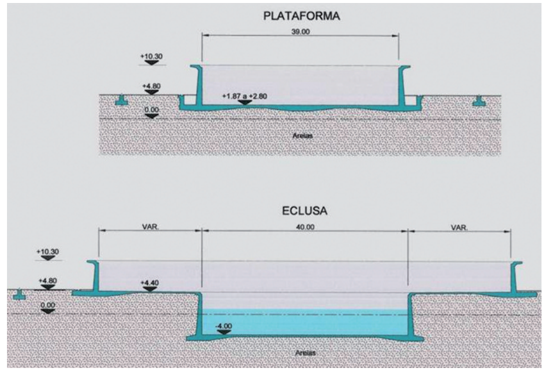

Figure 15. Hydrolift typical cross sections.

- the front lock is not to be emptied and so no anchoring is needed;
- the sandy soils, densified by means of vibroflotation, are adequate for direct foundation of the structures.

Figure 14 shows the general plan of the system and figure 15 the typical cross section of the platform and the lock.

Figure 16 shows the ship haulage system for docking operations

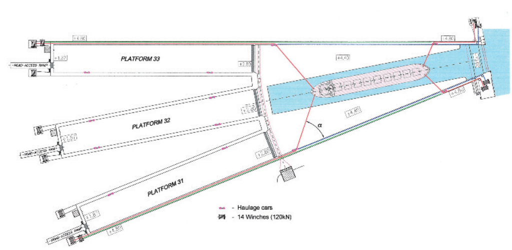

Figure 16. Hydrolift ship haulage system.

The dock filling is made by means of the main pump house CB1, located in the front of the lock. The pumping capacity is 4 x 46 500 m^3/h, with 4 main pumps of 1400 HP, which makes it possible to fill the lock and one platform in one and an half hour. Figure 17 shows pump house typical cross sections.

The dock emptying is made mainly by gravity in the discharging channel as shown in figure 18.

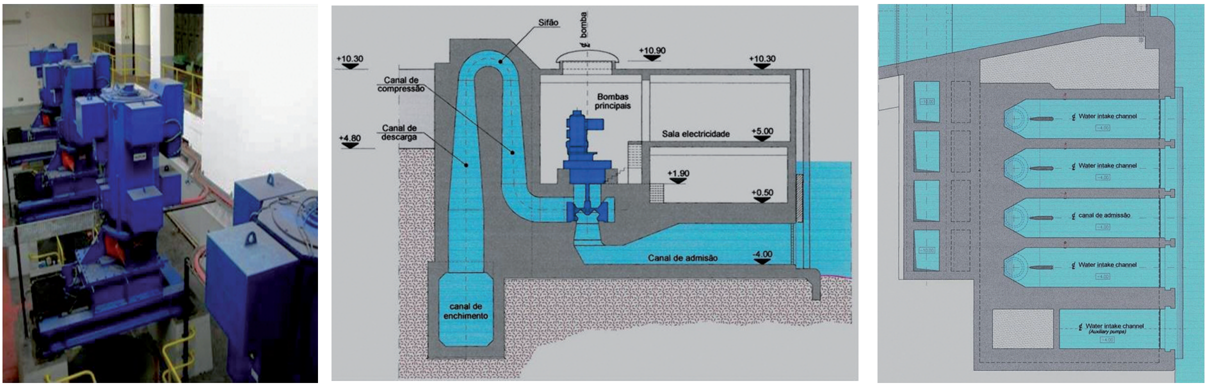

Figure 17. Hydrolift pumphouse (CB1) cross sections.

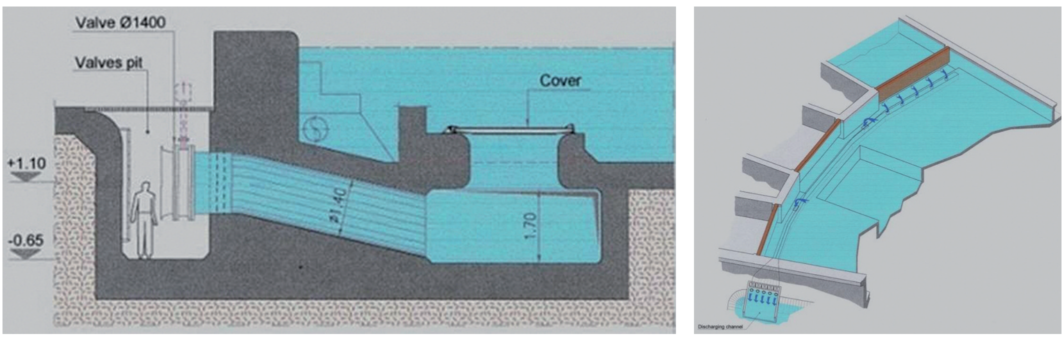

Figure 18. Hydrolift discharging channel.

The more polluted water that remains on the platform slab after the main emptying is pumped by means of another pumphouse (CB2), located in the platforms rear area, to the shipyard treatment station.

Figures 19 and 20 show views and the cross sections of the front lock and platform flap gates, respectively.

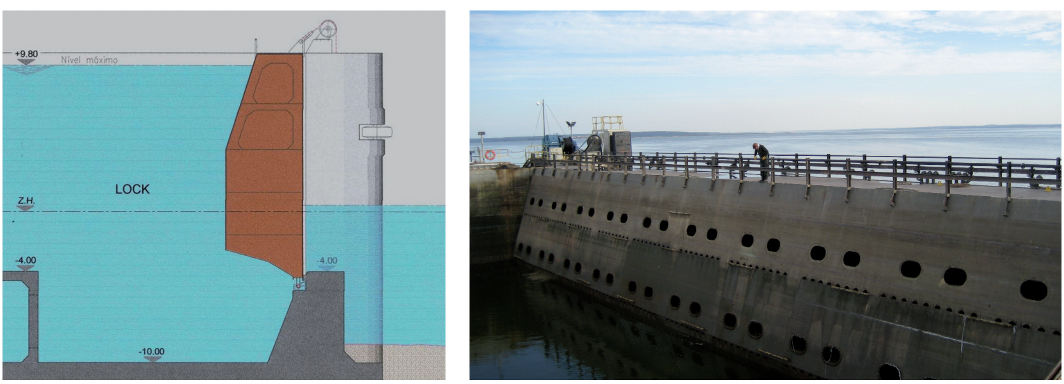

Figure 19. Hydrolift front lock flap gate.

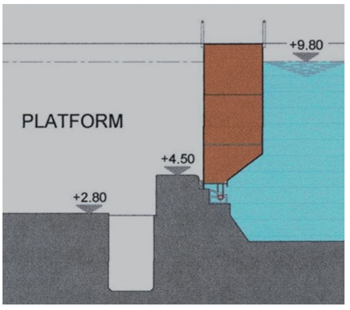

Figure 20. Hydrolift platform flap gates.

Figure 21 shows the view of the construction. The lock was built in dry conditions by means of one front sand cofferdam and a dewatering system with 86 deep wells and well point lines at the deeper part for pumphouse and dock gate pit. The volume of water pumped was about 2,6m^3/s.

The reclaimed area of the platforms, with 70 000 m^2, was densified with vibroflotation.

Figure 21. Hydrolift during the construction.

Other main work quantities:

- 110.000 m^3 of reinforced concrete;
- 610.000 m^3 of sand fills;
- 45.000 m^3 of rock fills;
- 50.000 m^2 of pavements.

The present cost of the *Hydrolift* per square meter of the useful area of the three docks (32.760m^2) is about €2700, including gates, out fittings and mechanical and electrical services, which is a very low unit price.

CONCLUSION

The conceptual design of a shipyard, as a whole, and particularly its main infrastructures, the dry docks, is the most important phase of the studies, demanding the advice of a multidisciplinary engineering task force, in order to reach the main objectives of the project, which are: to minimize the initial investments and the operational costs and maximize the productivity.

On ground shipbuilding and repairing of big ships and offshore platforms is an interesting and up-to-date tendency in order to avoid constraints in a confined conventional drydock.
This paper was focused on the description of the solutions conceived and built with success forty years ago at Mitrena Shipyard for on ground building of ships up to 600.000tdw and in the expansion of the same shipyard with the said Hydrolift ten years ago for on ground repairing of ships up to 80.000tdw.

Depending on the operational requirements and local conditions, this kind of solutions must be considered in the conceptual design phase of the project of a new shipyard in view of technical and economical comparison with other solutions.

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