

Design and Construction of a Large Shiplift Facility in India

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Abstract: To meet the growing shipbuilding needs in Indian subcontinent, L&T Shipbuilding has set-up a modern shipyard facility at Kattupalli near Chennai, India. As part of shipyard infrastructure, a state-of the art Shiplift and Transfer System has been implemented. With facility to handle ships of beam up to 43m and lifting capacity of 21000 MT (expandable to 26000 MT), this is one of the largest shiplifts in the world. To optimize the project cost and develop technology capability, entire planning, design, development and construction of Shiplift system including equipment and control system were handled indigenously. This along with stringent time schedule posed numerous challenges to the project team. Innovative solutions were adopted to overcome challenges and to maintain the project cost within budget. This paper covers the design and construction aspects of Shiplift system with focus on civil works. Challenges faced and solutions adopted are provided. The conclusion of the paper is that world class solutions can be developed and implemented successfully by pooling the available expertise and integrating it with specialist support.

Keywords: Drydock, Marine Structure, Shiplift, Shipyard.

1. Introduction

This paper describes the shiplift and transfer system constructed as part of L&T Shipyard at Kattupalli near Chennai, India with focus on civil works. This is one of largest shiplifts in Asia with a lifting capacity of 21000 MT (expandable to 26000 MT).

2. Project background

L&T Shipyard is located on the east coast of India, at Kattupalli near Chennai. It is part of an integrated marine complex consisting of Container Port, Shipyard and Modular Fabrication Facility. The facility was set-up to cater to the growing needs of modern shipbuilding and repair facility in Indian subcontinent. At present most of the new build / repair works are carried out in East Asian or Middle East yards.

Location and Overall Layout the facility are shown in Figure 1 & 2.

3. Shiplift concept and technology

During planning phases of Shipyard, two alternate dry docking concepts were evaluated, one is conventional dry dock and other being modern shiplift technology. Considering the need to cater to new build and repair business as well as other

operational considerations, it was decided to adopt shiplift system for dry docking needs of the yard.

At a basic level, shiplift is a large marine elevator which can be lowered into water for lifting the ship to the yard level or lower the ship from yard level into water.

A shiplift consists of a steel lifting platform suspended by wire ropes, raised and lowered vertically by a series of hoists. The hoists are distributed in equal numbers on either side of the platform and located on piers or foundations. By synchronising all the hoists, the platform is raised or lowered uniformly and in a horizontal plane. Fine level adjustment is also available in the system.

Shiplift platform is the largest component in the system and is built with high tensile steel. Both rigid and articulated designs have been implemented in existing shiplifts with each having its own distinct advantages. The shiplift platform's vertical lifting speed is generally in the order of 150mm - 200mm per minute, but lifting speed never being a critical design requirement [1].

Transfer system is used to move the ship from yard to shiplift platform or from platform to its intended dry berth in the yard. It consists of series of heavy duty steel beams (Cradles) supported by a pair of

hydraulic trolleys. The trolley system moves on a pair of rails and has hydraulic jack to support cradle beam and electric motor drive with fine control mechanism. This is used to move and position the ship accurately in its position.

The shiplift is controlled and operated from a control system and operating console. The control system has a number of in-built safety mechanisms to prevent incidents like overloading.

4. Shiplift system

After the selection of shiplift, available technology options were reviewed. As procurement of total system from a technology provider was much costlier, it was decided to develop the system in-house. As the company had sufficient expertise in such complex heavy engineering systems, this was considered feasible. A cross functional expert team was formed covering different disciplines to plan and develop the system. Independent experts with shiplift functional and implementation background were recruited to provide guidance and carry out independent reviews.

After numerous design trials and value engineering exercises, design configuration shown in Table 1 was adopted.

Table 1: Design Parameters

Parameter	Value
Length of shiplift platform	200 m
Width of platform	46 m
Available Vertical Travel	18 m
Hoists – 590 MT capacity	68 Nos.
Spacing of Hoists	4.8 m / 7.3 m
Articulated Steel Platform (with timber decking)	8500 MT
Design life of Platform	50 years
Classification / Certification	Lloyd's Register

5. Project structure

Due to the criticality of project, the project was managed by a task force team headed by senior management team. All the stack holders were represented in the team. Major decisions were discussed and decided by the task force. This helped in resolving issues quickly. This task force approach to managing the project was one the key success factor.

6. Design

6.1 General

The design of shiplift system was carried out by an interdisciplinary team of specialists drawn from different engineering units of the company. Civil works team included marine structures, Pavements and Utilities design specialists. Platform and Lifting / Transfer system was handled by two teams, one for mechanical / structural works and another covering electrical, Instrumentation and Control Systems. These specialist teams were guided by the independent shiplift expert.

6.2 Layout and structural systems

Different layouts options like wet basin, finger type piers and hybrid systems were evaluated. After functional and preliminary cost comparisons, it was decided to adopt a finger type layout with platform located beyond shoreline in basin area. Two outfitting jetties are integrated on either side of the shiplift structure. Transfer areas and Dry berths used for positioning of ships are located behind the jetty area within shoreline. Cross section of shiplift is shown in Figure 3. Layout of shiplift facility is shown in Figure 4.

The shiplift main piers and end transfer areas were designed as piled deck structure with appropriate combination of marine / structural loads. Reclamation area behind Shiplift was retained with a combination of Sheet pile wall and rock bund structure. Reclamation area adjacent to shiplift was provided with rock revetment protection.

The onshore structures consisting of transfer / dry berths, crane foundations and pavements were designed as ground supported structures using beam on elastic foundation approach.

6.3 Marine structures

During preliminary design, different types of pile systems viz., Steel / Precast / Hybrid were compared from both design and construction aspects. Due to local expertise and its inherent cost advantage, bored cast-in situ pile system was chosen as preferred system. All the marine structures were designed with large diameter (1300mm / 1200mm) vertical bored cast-in situ piles with permanent casing. No raker piles were used in the system, mainly to improve constructability. Initial Pile loads were specified to verify the design parameters used in geotechnical design.

Superstructure was designed with a combination of Precast and In-situ elements. This helped in

achieving the right balance between design requirements and ease of construction. Maximum precast element weight was kept below 20 MT.

Considering durability requirements, following requirements were specified for concrete works:

- Concrete Grade: M40 (Splash Zone), M30 (above Splash Zone)
- Cement content : 400 kg/cum (Min.)
- Water cement ratio of 0.40 by weight (Max.)
- Minimum cover to reinforcement: 75mm (Splash Zone), 65mm (above Splash Zone)
- Chloride penetration in 30 years < 5mm

7. Construction

Materials for the works were sourced locally except for specialist items like Jetty furniture. Plant and Machinery for the works were also used from existing pool or sourced locally.

Major materials required for the work were Concrete and Reinforcement. Concrete was produced in batching plants established at site. Aggregate for concrete was sourced from quarries located 100km away. Reinforcement was procured from primary producers. Reinforcement was processed in central rebar yard for various works.

7.1 Marine piles

Large diameter piles were installed using Hydraulic Piling rigs mounted on temporary steel platforms and Jack-up barge. Piling operation was assisted by crane, primarily to install casing and reinforcement cage. Casing was installed by vibro hammer. After casing driving, piling rig completed the boring operation to required depth. Bentonite slurry was used to stabilise the bore. Concreting was done by tremie method. Capacity of regular piles was verified with High Strain Dynamic tests conducted on randomly selected sample piles.

Pile bore collapse due to presence of very loose sand layer ($N < 10$) below dense layer of sand posed a serious problem during piling operation. This was overcome by extending the permanent casing below this loose sand layer.

Position of piles was very critical, especially for piles at winch location, as large deviation will create eccentric loading and affect the capacity /

design parameters. Stringent control procedures were adopted to ensure pile installation tolerance (± 75 mm).

7.2 Superstructure

Superstructure elements were precast in a central casting yard set-up at site. Installation was done by crane from completed deck. In-situ portion of deck was taken-up sequentially. Installation of jetty furniture (Fenders, Bollards, and Stairs, Mooring rings) was done subsequently. More than 50% of superstructure works were precast, greatly enhancing the quality and speed of construction.

7.3 Shiplift platform

Shiplift Platform fabrication was carried out at project site itself. Assembly and installation was taken-up after substantial portion of civil works were completed. Winches were erected and integrated with Platform subsequently. After completion of electro-mechanical works, testing and commissioning was taken-up and completed.

7.4 Commissioning

Entire shiplift system was commissioned and certified by Lloyd's Register in Jan 2012. Since then the shiplift system has successfully performed many dry docking operations to date meeting or exceeding the performance requirements set out during design.

Figure 6 shows the shiplift facility in operation.

8. Conclusions

Shiplift and transfer system, one of the largest in the world at present was successfully completed as per plan within the budget. Design and construction of such large capacity complex shiplift system within short schedule was not achieved elsewhere without the active involvement / support from a technology provider. This was made possible by innovative solutions using the expertise available in the company with specialist support and focussing on the functional requirements through value engineering.

References

- [1]. Gregory P. Tsinker, Marine Structures Engineering Specialised Applications, Chapman & Hall, New York, 1995, pp. 245-259.



Figure 1: Location of the Project

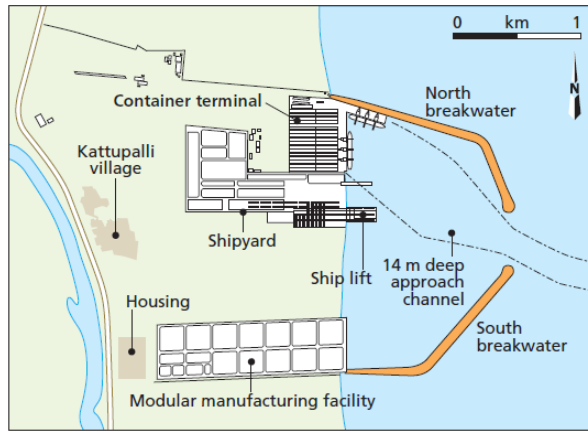


Figure 2: Overall layout of the facility

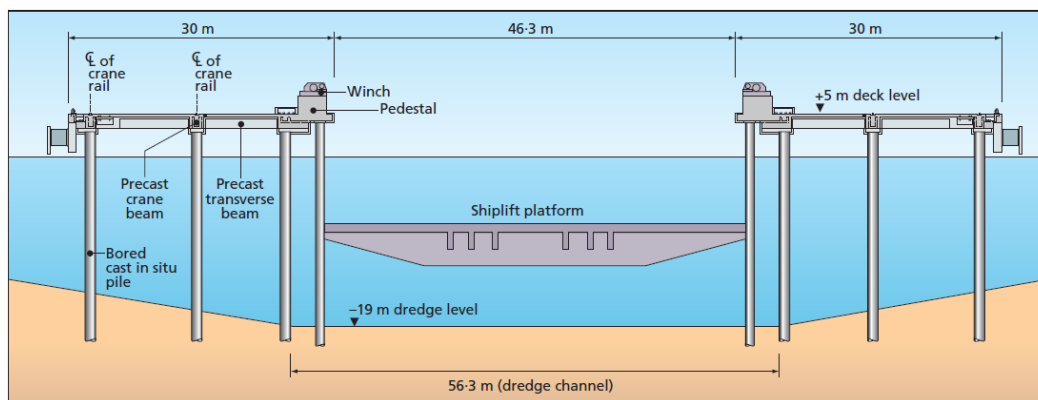


Figure 3: Cross section of Shiplift



Figure 4: Layout of Shiplift facility



Figure 5: Shiplift under construction



Figure 6: Shiplift facility in Operation