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Environmentally Sustainable, Ecologically Conservable and Economical Viable Design and Construction Solution of Ship Side Launching Wharf

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ABSTRACT

India is on development path and construction of various infrastructures work is happening at increasing pace and magnitude. The cement and reinforcement are most essential materials required for a infrastructure projects. Both cement and steel production produce large amount of carbon di oxide and also require large amount of energy for production. This is one main aspect of environmental destruction. Ship building activities are ever increasing in India and so construction of new shipyards and modernization of existing shipyards. Launching of ship is one of the most important operations in the entire ship construction process. Getting permissions for such construction involves various authorities and agencies such as concerned Industrial Development Corporation, River Navigation Department, Caption of Ports, Coastal Regulation Zone Authority, Pollution Control Board to name a few. This paper presents some important aspects of environmentally sustainable, ecologically conservable and economical solution Design and Construction Solution of Ship Side Launching Wharfby substituting conventional RCC piles by rammed stone columns to a large extent and use of gabion walls for closing the face of jetty in place of steel or RCC sheet pile making use of locally available quarry stones.

Key words: *Shipyard, Wharf, Side Launching, Rammed Stone Column, Gabion*

Introduction

Launching of ship is one of the most important operations in the entire ship construction process. Newly constructed ships are launched by various methods such as longitudinal launching systems, vertical launching system and side launching system. Due to space constraints and various other reasons and associated advantages; the use of side launching is becoming increasing popular. Such a side launching jetty coming within the Coastal Regulation Zone requires permissions from various Government authorities such as concerned Industrial Development Corporation, River Navigation Department, Caption of Ports, Coastal Regulation Zone Authority, Pollution Control Board to name a few. This paper presents some important aspects of environmentally sustainable, ecologically conservable and economical solution Design and Construction Solution of Ship Side Launching Wharfby substituting conventional RCC piles by rammed stone columns to a large extent and use of gabion walls for closing the face of jetty in place of steel or RCC sheet pile making use of locally available quarry stones.

Side Launching

The side launching is often used where the width of water available is considerably restricted. There are in fact some advantages to this method, for example the absence of keel declivity, and the relatively simple cradle and short ground ways which do not extend into the water. However, it means that a large area of waterfront is taken up by a single building berth and the ship is only reasonably accessible from one side during construction. The ground ways are arranged transversely, i.e. at right-angles to the line of keel. Sliding ways also can be placed transversely with the packing above them forming the cradle, but sometimes they are generally arranged longitudinally also. In this case where they are parallel to the keel the sliding ways are in groups covering two or three ground ways. Packing again forms the cradle with tie pieces between the groups of sliding ways.

One of the features of side launching is the drop where the ground ways are not extended into the water; consequently, large angles of heel occur when the vessel strikes the water. As a result, it is necessary to carry out careful stability calculations and close any openings before side launching a vessel. Anyway, stability calculations are also required for a conventional end launch. One of the most important aspect of side launching wharf is that face of the wharf has to be kept closed so as to keep both ship and wharf safe particularly during ship launching operation. Normally this closing is done with the help of sheet pile wall. Normally a side launching wharf is a piled foundation platform. Technically a concrete platform parallel to coast is referred as a wharf while that projecting in water is referred as jetty.

Case Study

It was proposed to build a side launching wharf (SLW) for a shipyard located on the banks of river Zuari to cater for grand assembly, ship launching and outfitting work for flat bottom ships with length ranging from 50 m to 90 mwith dead weight tonnage ranging from 500 t to 2000 t. The site of proposed side launching wharf (SLW) is indicated in Figure 1. Accordingly, a piled foundation wharf (107 m long and 25 m wide) was proposed, with the use of steel sheet piles for closing the face of wharf.

Conventional Side Launching Jetty Proposal

For designing the side launching wharf an assessment of various loading was done in a realistic manner. The various loadings considered are cross and longitudinal section shifting loads, stanchion loads, crane loading, track beam loading, wind pressure, wave pressure, and lateral pressure at the time of launching the vessel, seismic forces etc. was carried out.

On the basis of various functional requirements, loading configurations, soil conditions and tidal variationsinitially a piled foundation wharf of size 107 m long and 24 m wide was proposed (which in subsequent revision was modified to 101 m long and 19 m wide). The Figure 2 and Figure 3 presents the typical plan and cross-section of the wharf respectively. Steel sheet piles were proposed for closing the face of wharf. The quantities of various materials and the approximate cost of this modified proposal are indicated in Table 1.

Sustainable Side Launching Wharf Proposal

However due to time constraints, difficulties in construction of large number of piles and associated cost implication beside obtaining construction per-

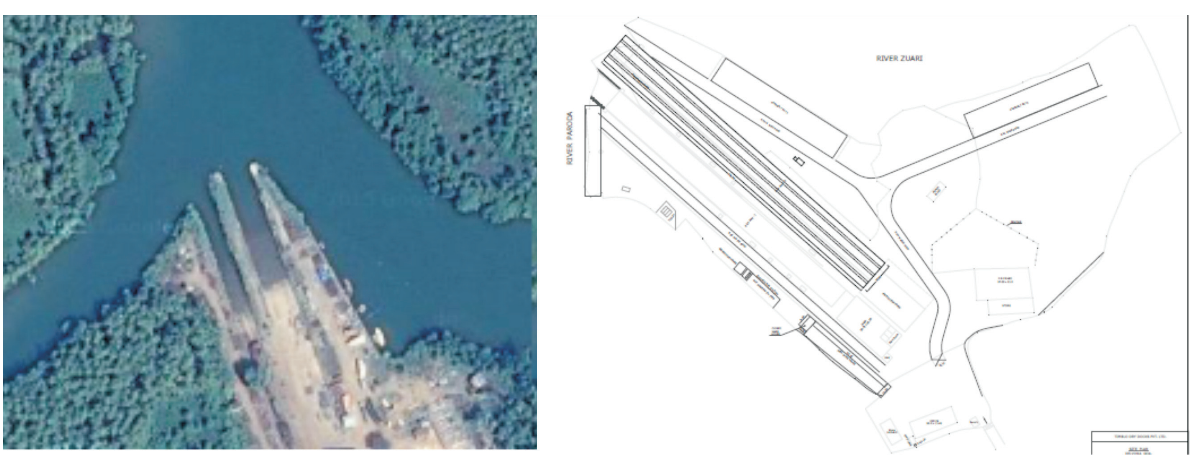


Fig. 1. Location of proposed Side Launching Wharf

Table 1. Quantities and cost of Conventional Side Launching Wharf Proposal

Item	Quantity	Unit Rate (Rs)	Approximate Cost (in Lakhs)
Excavation	2229 m^3	300	6.7
Pile Boring	1040 rm	2500	26.0
Rubble Soling	539 m^3	500	2.7
PCC	201 m^3	3500	7.1
RCC	1546 m^3	5000	77.3
Reinforcement	223 t	42000	93.7
Hardener	1919 m^2	350	6.7
Pile Casing	32.4 t	55000	17.8
Nose Angles	2.1 t	50000	1.1
Steel Inserts	8.9 t	50000	4.5
Steel Sheet Pile	75.75 t	70000	53.1
Miscellaneous		@ 5%	14.8
Total Cost (in Lakhs)			311.50

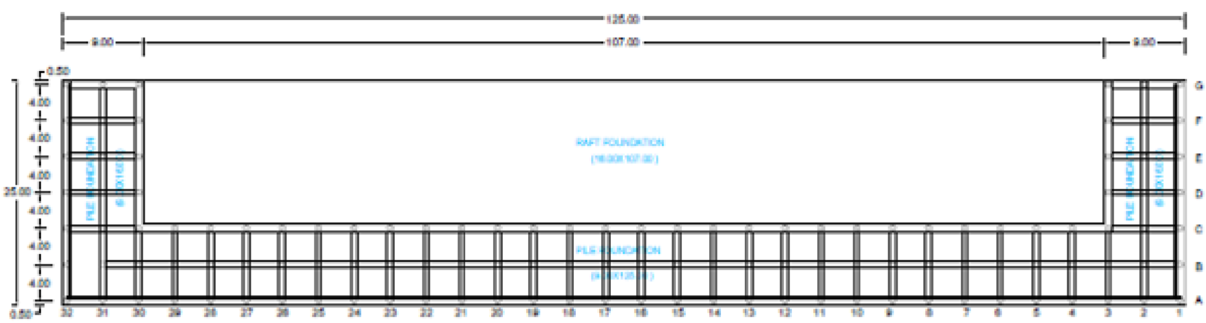
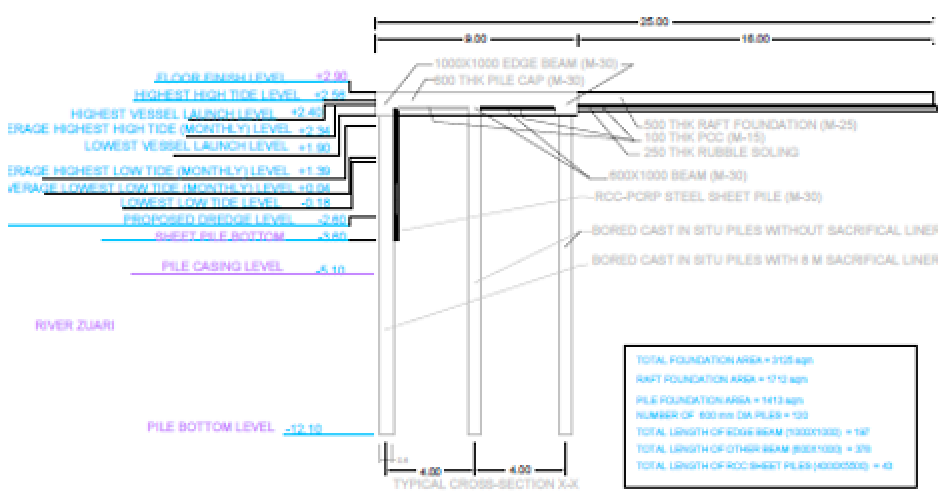


Fig. 2. Typical Planof Proposed Conventional Side Launching Wharf

missions; it was required to modify the proposal so as to complete it in time frame of 3 to 4 months, with use of a smaller number of piles and to reduce the cost and at the same time not affecting the functional requirements of the proposed SLW significantly. Accordingly, a revised proposal which was environmentally sustainable, ecologically conservable and economical solution for ship side launching wharf was proposed. It involved substituting conventional RCC piles by rammed stone columns to a large ex-



(a) Typical Cross-Section of Side Launching Jetty

Fig. 3. Typical Cross-Section of Proposed Conventional Side Launching Wharf

tent and use of gabion walls for closing the face of jetty in place of steel or RCC sheet pile. It made use of locally available quarry stone for rammed stone columns as well as gabion which also provided economic and employment opportunity to local people. Accordingly, as required for functioning of SLW stone columns, concrete beams to support track beam loading and keel loading was worked out.

The typical plan and section of the revised proposal is presented in Figure 4 and 5 respectively. The proposed SLW has overall length of 101.75 m and width of 19.0 m. It consisted of eight small pile supported rafts parallel to river side each supported on 4 piles of 600 mm dia. with pile caps of size 5.75 m x 3.75 m. These pile caps were connected by a concrete edge beam of length 107.75 m and cross section 1m x1m. As the soil profile indicated marine clay up to about 6 m followed by competent stratum; in interior portion piles were replaced by rammed stone columns. Accordingly, in place of about 100 plus RCC piles it was proposed to have 37 RCC piles towards the river face and balance 64 rammed stone columns. The quantities of various materials and the approximate cost of this innovative and sustainable proposal are indicated in Table 2.

Sustainability Aspects

The infrastructure construction involves use of significant quantum of RCC. The cement and reinforcement are essential and integral part of RCC. It is also a big concern that production of cement and reinforcement generate large amount of carbon-di-oxide (CO_2) and both consume significant amount of energy for its production which in turn again generate large number gases including Co2. Thus, reduction in use of RCC (that is cement and reinforcement) to the extent possible without compromising the basic and essential function of structure will lead to environmentally sustainable, ecologically conservable and economical solution. In view of this the alternate solution for SLW involving significant reduction in use of RCC and use of locally available quarry stone for rammed stone column (in place of RCC pile) and gabion wall (in place of steel sheet pile for closing the face of SLW was proposed, employed and successfully executed and the facility is function well without any issue or problem.

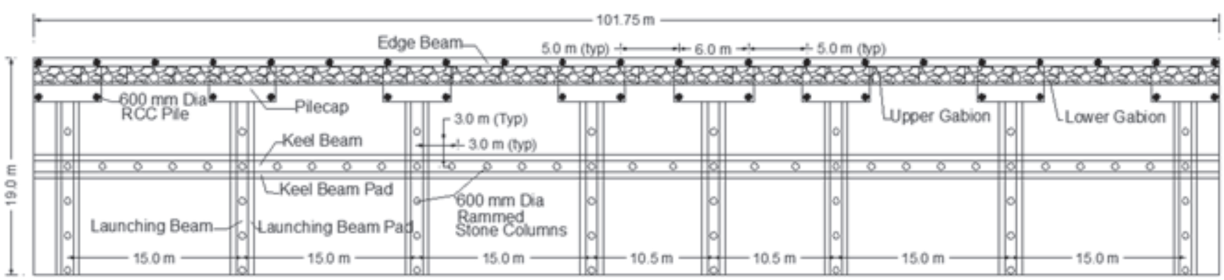


Fig. 4. Plan of Sustainable Side Launching Wharf

Table 2. Cost Estimation for Sustainable Construction of SLW

Item	Quantity	Unit Rate (Rs.)	Approximate Cost (in Lakhs)
Excavation	855 m^3	300	2.6
Pile and Stone Column Boring	690 rm	2500	17.3
Rubble Soling	408 m^3	500	2.1
PCC	194 m^3	3500	6.8
RCC	348 m^3	5000	17.4
Reinforcement	46 t	42000	19.3
Hardener	369 m^2	350	1.9
Pile Casing	9.3 t	55000	5.1
Nose Angles	3.5 t	50000	1.8
Steel Inserts	2.3 t	50000	1.2
Gabion Wall	102 rm	25000	25.5
Miscellaneous		@ 5%	5.0
Total Cost (in Lakh)			**106.0**

The quantum of amount of concrete and steel required for conventional SLW and in innovative SLW are presented in Table 6. It can be seen from Table 6 that in Innovative Side Launching Wharf (ISLW) there is 1205m^3 reductions in use of concrete and 281 t reduction in use of steel. In fact, total use of concrete in ISLW is about 31% of that of Conventional Side Launching Wharf (CSLW). Similarly, the steel used in ISLW is just about 18% of that used in CSLW.

By considering that 1 m^3 of concrete required about 400 kg of cement, the cement saved due to reduction of 1205 m^3 concrete works out to be about 482 t of cement. According to Marceau *et al.* (2008) on an average 1 t of cement production generate about 0.925 t of CO_2. Thus, CO_2 saved of account of reduction in cement in ISLW works out to be about 445 t. Further as per World steel Association's sustainability indicators 2022 report, 1 t of steel production produces about 1.93 t of CO_2. In the present case reduction in use of steel was 281.1 t which translates into 542 t reduction in CO_2. Thus, total reduction in CO2 on account of reduction in use of concrete and steel in ISLW is about 1000 t of CO_2. According to NRMCA the contribution of CO_2 in greenhouse gases is about 10-20%. The report further states that the energy required to produce 1 m^3 of concrete is about 6 GJ and that for steel is 30GJ thus clearly indicating that ISLJ is environmentally sustainable option. The total saving in energy on this account is about 15660 GJ.

Further it can be seen from data given in Table 5 that it is not only in reduction of CO_2 emission of about 1000t, it is also cost. The cost reduction on account of reduction of use of steel and concrete is about 142.7 lakh. In fact, total cost of ISLW is about 35% of that of SLW clearly indicating that it is an economical solution too.

As reported by Steven *et al.* (2020) various researchers reported that concrete has had particularly deleterious consequences on aquatic ecosystems, whether coastal marine, riverine, wetland, estuarine, or freshwater habitats, and that concrete use has contributed substantially to these systems being

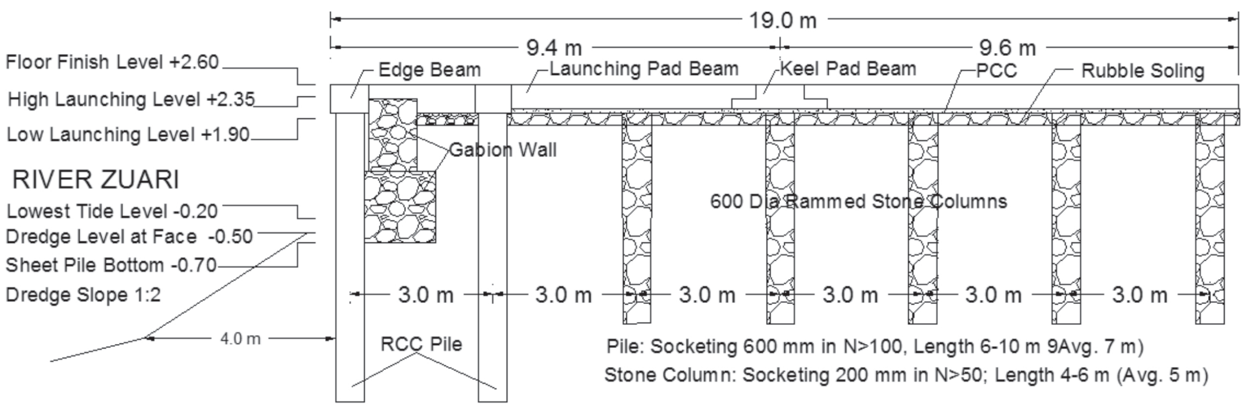


Fig. 6. Typical Cross Section of Innovative Side Launching Wharf

Table 3. Comparison CSLW and ISLW it terms of Quantity of Concrete and Steel used and its Cost Reduction in Cost

Item	Quantity of items involving cement and steel		Reduction in Quantity	Unit Rate (Rs.)	Reduction in cost (Lakh)
	CSLW	ISLW		ISLW	
PCC (M-15)	201 m^3	194 m^3	7.0 m^3	3500	0.25
RCC (M-25)	1546 m^3	348 m^3	1198 m^3	5000	59.90
Total use of Concrete	1747 m3	542 m3	1205 m^3		60.15
Reinforcement	223 t	46 t	177 t	42000	74.34
Pile Casing	32.4 t	9.3 t	23.1 t	55000	12.71
Nose Angles	2.1 t	3.5 t	-1.4 t	50000	-0.70
Steel Inserts	8.9 t	2.3 t	6.6 t	50000	3.30
Steel Sheet Pile	75.8 t	….	75.8 t	70000	53.06
Total use of Steel	342.2 t	61.1 t	281.1 t		142.71
Total Cost (in Lakh)					202.86

among the most altered, degraded, and threatened worldwide. In the present case a 105 m long steels sheet pile wall is replaced by gabion wall which is made of natural stones and porous and thus aqua culture when comes closer to it does not getalien feeling but a feeling that it is their own habitat. Thus, ISLW is ecologically sustainable too.

Conclusion

This paper presents some important aspects of environmentally sustainable, ecologically conservable and economical solution Design and Construction Solution of Ship Side Launching Wharfreferred as Innovative Side Launching Wharf (ISLW) in place of Conventional Side Launching Wharf (CSLW) by substituting conventional RCC piles by rammed stone columns to a large extent and use of gabion walls for closing the face of jetty in place of steel or RCC sheet pile making use of locally available quarry stones. The major conclusions of the study are

(i) Due to space constraints the side launching method is becoming increasingly popular. The innovative approach proposed for construction of side launching wharf makes use of composite construction consisting of RCC piles at river face, rammed stone columns to support RCC keel beam and side launching beams.

(ii) The innovative substitution of majority of RCC bored cast insitu piles and Steel sheet piles with rammed stone columns and gabion wall and replacing the whole raft with keel beam and side launching not only reduced the time of construction but also the cost significantly and use of concrete and steel reduced significantly.

(iii) The reduction in concrete is about 1025 m^3 and that in steel is about 281t. This saved the emission of about 1000 t of CO_2 and also saving of over 15000 GJ energy clearly demonstrating that the ISLW is an environmentally sustainable solution.

(iv) The reduction of cost on account of reduction in concrete and steel is of over Rs. 142 Lakh, In fact the total cost of ISLW is about 35% of that of CSLW, again clearly demonstrating that it is not only environmentally sustainable but also considerably economical solution.

(v) As the 105 m log water face does not have steel or concrete wall to close the face of wharf but porous gabion wall made of natural stone, thus protecting the habitat and ecosystem close to it clearly demonstrating that the ISLW is not only environmentally sustainable, considerably economical but also ecologically conservable.

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