

Providing Infrastructure To Facilitate Ro-Ro Services And Construction Of Breakwater At Mandawa

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Abstract— Alibaug is located about 120 km south of Mumbai. The distance from Mumbai to Alibaug is 10 Nautical miles which is about an hour ferry ride from where catamaran/ferry services are available to Mumbai, whereas road takes about 3 1/2 hour to 5 hours to travel. Ferry service from 6AM to 6PM is available thought the year, except during monsoon. Speedboats from the Gateway of India to Mandwa Jetty take roughly 20–25 minutes depending on the weather and can be hired at the Gateway of India. The new jetty installed in 2014 at Mandwa ensures safety of passengers traveling by speedboat. So the Mumbai Maritime Board has decided to construct the RollOn - RollOff (RO-RO) services to reduce the travel time and that too in half the price. This will help people to reach Alibaug in very less time and so this will increase the reach of Mumbai to Alibaug. This will help in increasing the wharf area and keeping the tourist locations alive, as it will become easy to reach, it will attract more and more people and so will the government will generate revenue out of it due to tourism. The present work thus discusses the practical aspects of the construction stages of a breakwater and a jetty and also the practical executional challenges related to it.

Keywords— catamaran, ferry, jetty, roll on - roll off, speedboats, wharf.

1 INTRODUCTION

Mumbai as the capital city of the state of Maharashtra is one of the most important cities in western India. It has its own culture, traditions and festivals and is an important tourist destination. This erstwhile port city has now developed to become one of the foremost metropolises of the world having monuments of historical importance which are prime tourist attractions & leisure spots and frequented by a number of residents of Mumbai and tourists all year round. Across the Mumbai Harbour, lie the seventh-century rock-cut temples of Elephanta. Once known as Gharapuri, or the Fortress City, the Caves are now designated as a World Heritage Site and visited by hundreds of tourists both for their art, historical and scenic value. Mandwa is about a 45 minute ferry ride from Mumbai and very easily accessible for residents of Mumbai. It is popular because of its green surroundings and cottages. All these locations are visited frequently by public and foreign tourist and in addition by citizens who own their own leisure crafts. There is presently no docking facility in Mumbai Harbour area and the Radio Club location already has a number of passenger's boats, harbour ferry boats, pleasure yachts and boats anchored off the gateway of India. These crafts require adequate berthing facilities. The existing temporary jetty at the Gateway of India is used for water transport to areas like Elephanta and Mandwa, but it is inefficient to handle passenger traffic and provide proper berthing to ferries and yachts. Due to high-end touristic traffic from the region around Gateway of India and lack of proper facilities for berthing of the passenger ferries, boats and yachts there is

huge potential for developing a passenger Terminal for safely & efficiently embarking and disembarking passengers and other public. The Maharashtra Maritime Board (MMB) have short-listed the site at Apollo Bunder, Mumbai where potential exist for developing a Passenger Terminal.

1.1 Mumbai to Alibaug

Figure 1 Alibaug is located about 120 km south of Mumbai, at 18°38'29"N 72°52'20"E. The average elevation is 0 metres. The District Government offices are located along the sea coast road. Alibaug is the center place of Raigad District.

Alibaug is a coastal town and municipal council in Raigarh district of Maharashtra, India. It is the headquarters of the Raigarh district. Revdanda, Chaul, Nagaon, Akshi, Varsoli, Thal, Navgaon, Kihim and Aawas villages were known as "Ashtagare".

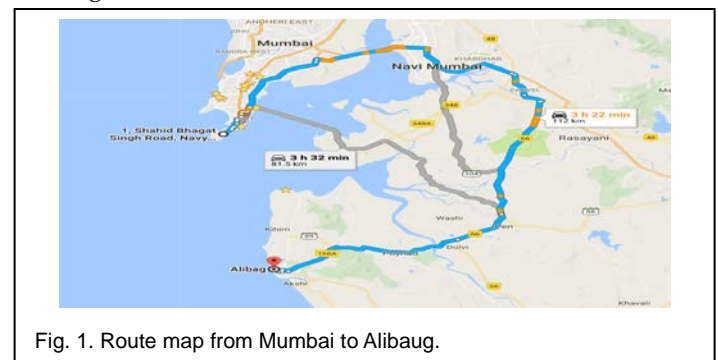


Fig. 1. Route map from Mumbai to Alibaug.

• ROAD: One can reach Alibaug via Pen (30 km), which is on the Mumbai (78 km) – Goa road. From Mumbai, one can reach Alibaug by traveling on the Mumbai-Goa highway (NH-17) till Wadkhal (or Vadkhal) and taking the right fork from Wadkhal – the left fork being the road to Goa. It is approximately 108 km from Mumbai. You can go to Alibaug by S.T. bus from Mumbai. From Mumbai to Alibaug having daily 35–40 S.T. buses. Borivali, Thane, Kalyan, Pune, Kolhapur, Miraj,

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Nashik have buses to Alibaug.

- **RAILWAY:** The nearest rail railway station is at Pen. Through Pen, it is connected to Panvel and onwards to Mumbai and the Indian Railways network.

- **AIR:** The nearest airport is Chhatrapati Shivaji International Airport | Mumbai, 140 km.

- **WATERWAYS:** The nearest jetty is Mandwa from where catamaran/ferry services are available to Mumbai. Another port in the vicinity is Rewas, from where a ferry service is available to Ferry Wharf (Bhau cha Dhakka) (Dockyard Road) is available. There is a jetty at Custom Bandar from where fishermen in Alibaug set sail. Ferry service between Mandwa and Gateway of India, Mumbai. They run at a frequency of an hour throughout the year from morning 6 to evening 6, except during monsoon. The trip takes 40 to 55 minutes depending on the type of boat. From Mandwa operators carry passengers to Alibaug in their own chartered buses. The bus journey time is 30 minutes. Alibaug beach is walking distance from the bus-stop.

Another option is to take a ferry from "Bhaucha Dhakka" to Rewas. Timings are the same but schedule may change depending on the tide. From Rewas take state transport bus or rickshaw to Alibaug. Bus Journey time: 1 hour to reach Alibaug. One benefit of using the Bhaucha Dhakka - Rewas route by ferry is that you can take a two-wheeler along on the ferry on this route for a nominal charge. Speedboats from the Gateway of India to Mandwa Jetty take roughly 20–25 minutes depending on the weather and can be hired at the Gateway of India.

TABLE 1
COST OF BOAT TICKET FROM MUMBAI TO ALIBAUG

| MUMBAI – ALIBAUG BOAT OPERATOR | TICKET PRICE FOR TRAVEL BETWEEN MUMBAI AND ALIBAUG | | |
|--------------------------------|--|------------|-----------------|
| | MAIN DECK | UPPER DECK | AIR-CONDITIONED |
| Ajanta | 85 | - | - |
| PNP Maritime Service | - | - | 150 |
| Maldar Catamarans | 110 | 135 | 150 |
| Apollo Catamaran | 110 | 135 | 150 |

1.2 Tourism

The following are the main tourist attractions in and around Alibaug:

- Alibaug beach
- Siddheshwar Mandir near Khandale
- Alibaug Fort
- Khanderi and Underi Islands
- Magen Avot Synagogue
- Varsoli Beach
- Akshi Beach
- Nagaon Beach
- Kihim-Navgaon Beach
- Rewas

- Chaul Revdanda
- Kanakeshwar Mandir
- Mandawa
- Kashid Beach
- Korlai Beach

2 NEED OF PROJECT

As discussed earlier the distance from Mumbai to Alibaug is around 120km approximately, but the distance by sea is just 10 nautical miles (18.52 Km) which takes only one hour to travel whereas road takes about 3 1/2 hour to 5 hours to travel to Alibaug and vice versa. So the MMB has decided to construct the RO-RO services to reduce the travel time and that to in half the price.

This will help people to reach Alibaug in very less time and so this will increase the reach of Mumbai to Alibaug. This will help in keeping the tourist locations alive, as it will become easy to reach it will attract more and more people and so will the government will generate revenue out of it due to tourism.

2.1 Project intended objectives

- **Creating tourism enhancing infrastructure:** Addressing the high tourism demand is one of the primary objectives of the proposed infrastructure. There are nearly 100 launches and catamarans that operate using jetties 2, 3 and 5 of Gateway of India (Apollo Bunder) every-day. Every 20 minutes there is a vessel that leaves Apollo Bunder carrying approximately 100 passengers. Launches from Apollo Bunder travel to Elephanta Island, Mandwa and JNPT. Well planned infrastructure is expected to create increased demand from tourists/customers. This is also likely to create the necessary conditions for the increasing connectivity to other destinations nearby.

- **Creating easy access to the vessels at sea and enhancing safety for passengers:** Currently, passengers are required to pass through more than 2 vessels each time they intend to board their departing vessel. This not only makes it cumbersome, but also makes jumping over boats a scary proposition for passengers. This is especially the case for women and children. A well planned facility is proposed that will address this lacuna thereby enhancing safety. This facility will also ensure that embarkation and disembarkation into a ferry will take place in an orderly way.

- **Creating an additional revenue sources:** It is forecasted that the revenues from advertisement, passenger levy, shop / restaurant operation fee, battery charging, diesel, water, and sewerage will lead to cash collection of nearly Rs 5 crores annually. Additional revenue of Rs 0.5 crores can be generated from parking fees collected (two wheeler and four wheeler parking).

- **Addressing the needs of discerning yacht owners:** Yacht owners have expressed their difficulty in accessing their personal crafts. The jetty is a step towards ameliorating their troubles. A jetty access fee of Rs 1,000 can be collected for berthing at the jetty. This is likely to earn revenues for Rs 0.36 crore per annum.

- **Development of the leisure boating industry in Maharashtra and Mumbai.** The Yachting Association of India has

made several attempts to request the authorities to developed infrastructure for developing leisure boating activities. This jetty is a positive step towards achieving this goal.

3 RO-RO SERVICES

To reduce the burden of over 10,000 Goa and Konkan bound vehicles on city roads of Mumbai to Goa, the Mumbai Port Trust (MbPT) has awarded the work order for the Ro-Ro (Roll On & Roll Off) water transport services terminal at Ferry Wharf, even as similar development is underway at Mandwa in Alibaug by the Maharashtra Maritime Board (MMB).

"PROVIDING INFRASTRUCTURE TO FACILITATE RO-RO SERVICES AND CONSTRUCTION OF BREAKWATER AT MANDAWA" a project worth Rs 135,00,00,000, in which it covers the entire construction of the jetty, ferry wharf, breakwater, so that the RO-RO service vessels can carry vehicles as well as passengers from one end to another. The construction was divided in to two major phases;

- a) Phase I - Construction of Breakwater
- b) Phase II - Construction of Approach Jetty

"One Ro-Ro service will be able to carry over 300 passenger cars or about 100 trucks. It will not only help save almost 3-4 hour of travel time as well as fuel, but also control vehicular pollution," said MbPT.

According to MbPT, the fare per car or SUV would be Rs 400-Rs 500 and for trucks, Rs 700-Rs 800.

3.1 Infrastructure details and berthing of vessels

1. The length of the berth for RO - PAX vessel, planned to be constructed at Mandwa, is 100 mtrs and ramp width is 30 mtrs. Minimum water depth to be maintained by MMB, in the approaches to Mandwa terminal would be 3.0 mtrs chart datum. Minimum depth at approaches to Nerul terminal would be also 3.0 mtrs.

2 The selected operator shall procure suitable vessels for the terminal at Ferry wharf, Mandwa and Nerul.

3. The vessels and operations shall comply with all appropriate applicable acts, rules and regulations of the competent authority and the operator shall demonstrate how he proposes to achieve this in the detailed concept plan.

B. Criteria for ro-ro pax vessels

1. Ro-Ro Pax vessel should be preferably with forward and aft ramp for fast turnaround.

2. The vessels should be such that the vehicles in the vessel are discharged on "First in First out basis".

3. Carrying Capacity Requirement: The vessel should preferably carry minimum 40 PCUs (Passenger Car Unit) and 300 passengers.

4. The width of the ramp, being constructed at Mandwa, is 30 mtrs. Therefore, the vessel should be appropriate dimensions.

5. The operator shall provide at least 3 vessels from each terminal to maintain the frequency of every 30 minutes from either terminal. The turnaround time at any of the terminal should not exceed about 30 minutes.

6. The operator should operate and manage the services for 24x7.

7. The services should be capable of all-weather operations

with exception of very occasional extreme conditions as per data of Indian Metrological Department (IMD).

8. The vessel should be capable of all tidal range operation considering current speed.

9. Vessel should be highly manoeuvrable, capable of berthing and unberthing without Tug Assistants.

10. Vessel should have twin screw and stern and bow thrusters or any other propulsion system which can undertake such type of manoeuvrings.

11. Lashing arrangement is to be provided for vehicles in the vessel to prevent shifting enroute.

12. The vessel should have Navigation equipment's such as LSA, FFA, navigation requirements as per classification society.

13. Mooring men are to be provided at Ferry Wharf, Mandwa to handle vessels mooring lines while berthing and unbreathing.

14. Quick and efficient mode of mooring and unmooring.

15. The vessel to be registered under Inland Vessels Act, 1917 or a foreign vessel under Bare Boat Charter cum Demise (BBCD) or under Merchant Shipping Act, GOI, for operations. The vessel to be insured as per statutory requirements.

16. The operator should ensure suitable insurance for the passengers.

17. The operator should have provision of refreshment facilities in the vessel like drinking water, snacks etc.

18. The operator shall co-ordinate with MMB and MbPT for the operation and scheduling of RO-RO PAX services.

4 CONSTRUCTION PHASE

The construction of various phases related to execucional practices are discussed under:

PHASE I - CONSTRUCTION OF BREAKWATER

Breakwater Detailing

A. Detailing of cross-section of trunk portion of breakwater

1. Crest Height: 15m. (From Bed)

2. Sea Side: 8t Tetrapod's

3. Trunk Portion (slope 1:2)

a) Primary Layer: 8t Tetrapod's

b) Secondary Layer: 1.0t - 1.5t stones

c) Core Layer: 20 - 100 kg stones

4. Toe Armour: 1.5t - 2.5t stones (slope 1:3 with 2m thickness)

5. Bedding Layer: 10kg stones (0.3m thick)

B. Detailing of cross-section of round head portion of breakwater

1. Crest Height: 15m. (From Bed)

2. Trunk Portion (slope 1:2)

a) Primary Layer: 10t Tetrapod's

b) Secondary Layer: 1.0t - 1.5t stones

c) Core Layer: 20 - 100 kg stones

3. Toe Armour: 1.5t - 2.5t stones (slope 1:3 with 2m thickness)

4. Bedding Layer: 10kg stones (0.3m thick)



The First step in execution of offshore breakwater is to set a point outside the water. First there is an arrangement made to setup the Total Station on the existing Mandwa jetty, from there the first co-ordinates of the breakwater were given.

Figure 3 the boulders were brought in the barges on that location and dropping of boulders started. Boulders varying from 20 to 100 kg as per specifications, the arrangement for the boulders were made from a quarry site 70Km of radius within the site location.

Figure 4 A Grab Crane arrangement was done by placing it on Spud type Pontoon. The quarry barge takes nearly 2 hours to travel from Belapur to Mandwa Jetty. So accordingly arrangements were done for the barges that if once the work start we have continuous supply of quarry thought the work without much breaks.

In the above Figure 6 there is a 3 Spud type Pontoon used on which a 80t capacity Grab type crawler crane is fixed and it is lifting the stones from the barge and placing it in the sea. The position is fixed by the total station that is stationed on the existing mandawa jetty. This work is continued till the stones are seen above the sea.

Figure 4 one can see that how the quarry is dropped for the first time just by the help of total station marking system. This is how the work of a break water start for the first time in sea with no fixed reference mark to make one reference point first on the breakwater location.

This initial placement of boulder is the toughest part as it is done like a blind person, with no reference point. But when we see the boulders coming out of the sea that's the MSL we are able to set the exact co-ordinates and proceed the work further.

Figure 6 and 8 the front hoe crawler is placed on the break water to give its respective shape as assigned by the authorities.

Figure 7 the ranging rods are fixed on the center line of the breakwater and ranging is done to fix the alignment.

Figure 9 in which it is seen that 85% of the placing of the rubble mound is been placed and almost ready for the tetrapod's to be placed on it.

Breakwater was further covered from sea side by tetrapod units and there were 2 types of tetrapod were used depending upon the side and location where it has to be placed,

- 8 Tons (3.1m high) for the trunk portion
- 10 Tons (3.4m high) for round head portion

The 8 Ton tetrapod was placed on the straight line of the breakwater, because the waves will have less displacement whereas on turning point of breakwater 10 Ton tetrapod is

being placed. As more displacement is expected and even diffraction also occurs at that point which leads to increase in the wave energy. The tetrapods were constructed within 20Km radius within the site, from there they were loaded on the barge and brought to the site directly for the final placement due to lack of storage area. In all there were 4 Barges for all king of material procurement work.

Figure 10 and 11 it is seen that the tetrapods are brought from the casting site that is 20km of radius within the site. The tetrapod's are the lifted with the crane and then placed on the breakwater.

Figure 12 and 13 are the completed work of the breakwater. Finalized with all the placing and arrangements of the armor stones and the tetrapod's.

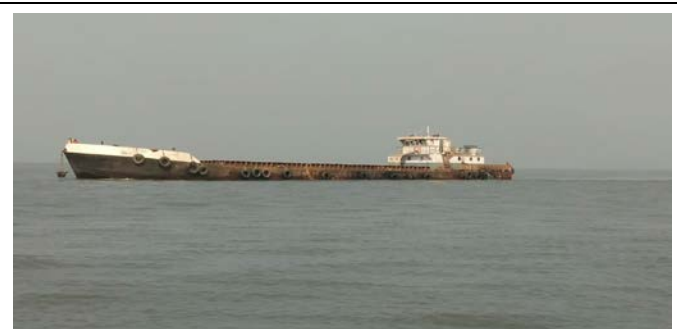


Fig. 3. Barge carrying quarry



Fig. 4. Grab crane lifting boulders for placement



Fig. 5. First projection of breakwater above MSL

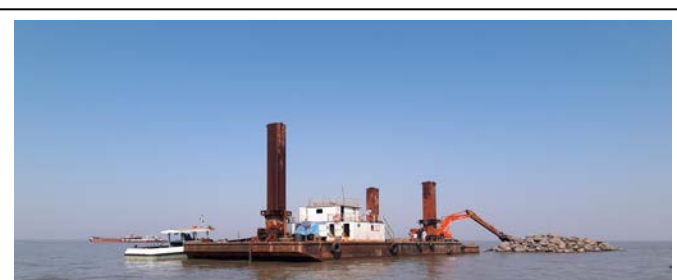




Fig. 7. Fixing of alignment with ranging rods



Fig. 11. Excavator shaping the breakwater



Fig. 8. Front hoe crawler excavator arranging the boulders

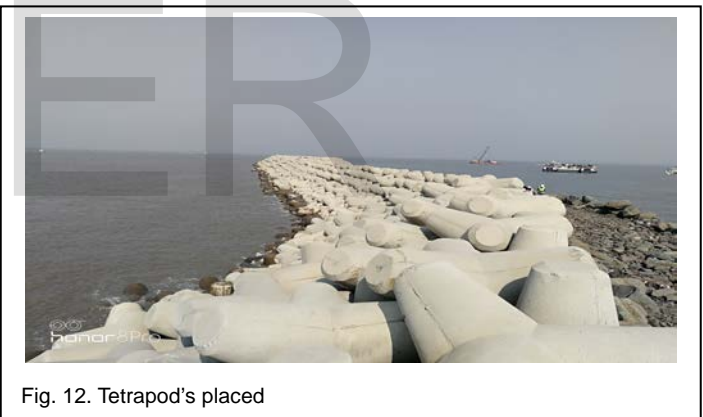


Fig. 12. Tetrapod's placed



Fig. 9. 85% completion of boulder placement



Fig. 13. Tetrapod Completion of breakwater construction



5 CONSTRUCTION OF APPROACH JETTY

A jetty is a structure that projects from the land out into water. Often, "jetty" refers to a walkway accessing the center of an

enclosed water body. The term is derived from the French word *jetée*, "thrown", and signifies something thrown out.

Another form of jetties, wing dams are extended out, opposite one another, from each bank of a river, at intervals, to contract a wide channel, and by concentration of the current to produce a deepening. Where docks are given sloping sides, openwork timber jetties are generally carried across the slope, at the ends of which vessels can lie in deep water or more solid structures are erected over the slope for supporting coal-tips.

Pile work jetties are also constructed in the water outside the entrances to docks on each side, so as to form an enlarging trumpet-shaped channel between the entrance, lock or tidal basin and the approach channel, in order to guide vessels in entering or leaving the docks. Solid jetties, moreover, lined with quay walls, are sometimes carried out into a wide dock, at right angles to the line of quays at the side, to enlarge the accommodation; and they also serve, when extended on a large scale from the coast of a tide less sea under shelter of an outlying breakwater, to form the basins in which vessels lie when discharging and taking in cargoes in such a port.

Figure 14 and 15 the pile liners are driven in sea bed and then the gantry crane is placed over it. Placing of gantry crane in short means constructing it on site on the pile liners. At Mandwa the jetty constructed is a pile type jetty consisting of 85 number of piles and a floating pontoon for connecting the jetty with the ship that arrives at the jetty. This will help the easy access for the vehicular movement from ship to jetty and vice versa.

Area Statement

- Reclamation Area/Parking: 159.00X100.00= 15900 m²
- Terminal Building: 40.00 X 20.00 = 800.00 m²
- Approach Jetty: 10.00 X 214.00 = 2140.00 m²
- Turning Platform: 30.00 X 30.00 = 900.00 m²
- Link Span : 40.00 X 7.50 = 300.00 m²
- Pontoon : 20.00 X 22.00 = 440.00 m²
- Berthing Dolphin: 7.00 X 8.00 = 56.00 m²

Figure 16 states that molder is used to mold the metal sheets in to circular piles. This is a slow process and takes time once the sheets are molded then they are welded with 6 numbered welding rod. Then there are ties attached to the piles at joints. These ties are 3*3 inches in size, at multiple points specially specified. The metal sheets were 6mm thick and 3m*1.5* in size. They were specially approved by SAIL, for its use for this project.

Figure 18 the winch is an ISO certified one, it is manufactured by Kirloskers Engineering PVT. Ltd. The winch consist of 6 cylinders engine and having an 1800 rpm. The winch requires 50-60 liters of diesel approximately every 6 hours. The Chisel is a Sharp Edge Chisel Type, it weigh 3.5T.

Figure 19 bailer is an equipment used to remove muck out of a pile specially. This bailers opens inside way it is dropped in the pile due to muck pressure the gate opens and the muck fills in then the gate is automatically closed due to the weight of the muck.

It can be see that the pile casing is fixed then the metal pile cap is placed over it after the chiseling and bailing work is done then cavity helps the pile to drive in, but this is not so

easy. So the pile cap is placed over the pile and with the help of Monkey load is applied over the pile cap and the pile is driven in to it. The driving operation depends upon the soil condition.

The pile is driven up till the hard strata is obtained, once the pile touches the hard strata it is stopped there further driving is not done. The once the hard strata is obtained still 2.5m depth is further excavated in to the hard strata for rigid support.

The further driving in to the hard strata could have been prohibited but it cross checks that the strata is uniform till its required depth, as the rocks found there is igneous so it's a solid base or a fragmented on is checked properly.

Figure 20 the concreting was done by M40 grade of concrete, Tremix type of concreting method was adopted for it. In this method the concreting pipe is placed at the bottom of the pile then in the hopper of 1cubic meter of concrete is placed in it and then the stopper is release. Due to pressure the concrete flows with great velocity and pressure, this helps in concrete to spread at the bottom floor and pushes the water upwards. While concreting, when the pile is filled with concrete it is made to over flow around 1.5 cubic meter of concrete. Then after drying each row is connected by concreting each row in a box structure.



Fig. 14. Arrangement of actual and temporary pile liners



Fig. 15. Constructing and placing the gantry crane on the pile liners





Fig. 17. Sharp edge chisel 3.5ton capacity



Fig. 18. Winch arrangement on the gantry crane



Fig. 19. Bailer, one way opening 0.5m3 capacity



Fig. 21. Pre-caste of structure units

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