

Technical Report on Design and Execution of Desalination Plants in Minicoy and Agatti, UT Lakshadweep

Sea water desalination is attaining increasing attention of present day policy makers, especially with the growing demands that urbanization, population explosion, irregular rainfall and ground water contamination on the fragile natural resources. 'Low Temperature Thermal Desalination' (LTTD) is one process that uses the availability of a temperature gradient between two water bodies, such as the Ocean Thermal Gradient that describes temperature variation across the depth of the oceans, to obtain fresh water. The available thermal gradient between warmer surface water and colder deep seawater is utilized by flash evaporating the warm water at low temperatures and condensing the resultant vapour with cold water.

Earth System Science Organization, Ministry of Earth Sciences, Government of India, Through National Institute of Ocean Technology (ESSO-NIOT), India, has successfully demonstrated the 100 m³/day capacity land based desalination plant in the remote islands of Agatti and Minicoy of UT Lakshadweep in 2011 following the initial success of similar capacity plant at Kavaratti island.

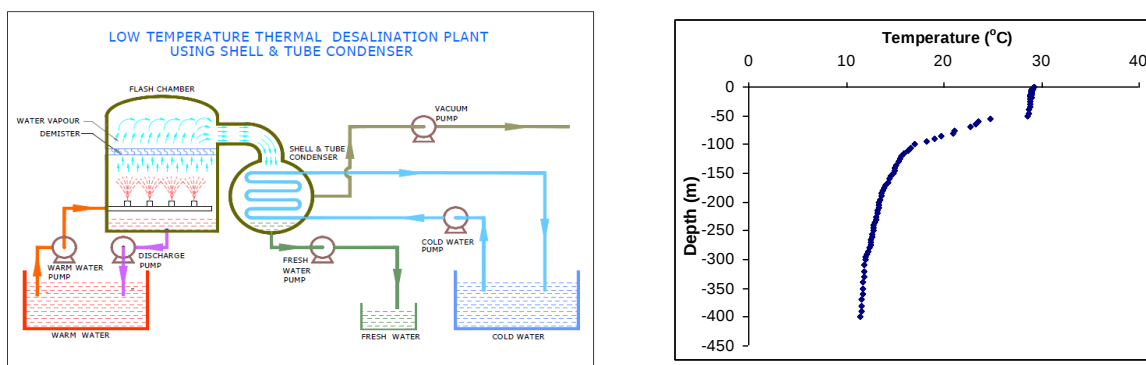


Fig. 1 Schematic Diagram of LTTD working principle (left) and the Ocean Thermal Gradient in coastal waters (NIO, Goa, 2000)

The bathymetry around the islands allows availability of 350-380m water depth within 400-1000m from the shore, for drawing water at 10-12°C. The temperature gradient of 16°C between the deep sea cold water at 12°C and the warm surface sea water at about 28°C is utilized in the LTTD process as shown Fig. 1. The plant consisted of the design and integration of three distinct components, namely, Process Equipment; Cold Water Pipeline; and, Marine Structures.

Process Equipment

The main components that are required for LTTD plant are the flash chamber, the condenser, pumps and pipelines to draw warm and cold water, a vacuum pump to maintain the plant at sub-atmospheric pressures and a control system as shown in Fig. 2. A flash chamber of 2.8m diameter and about 5.2m height made of SS 304L with vertical spouts and S-type demister pads are used for the flash evaporation. A 1.2m section of the flash chamber is used as a deaerator to separate part of the non-condensable gases and leakage air before entering the flashing area. A shell and tube condenser, made of SS 304L shell of 1.2m diameter and 1120

(Cu Ni 90/10) tubes of 0.019m outer diameter is used for the condensing the resultant vapour. The condenser was designed in HTRI with a TEMA BHM configuration. Major part of the plant piping was completed with HDPE. The vacuum system is to facilitate the evaporation in the flash chamber and liquefaction in the condenser by maintaining them at sub-atmospheric pressure.

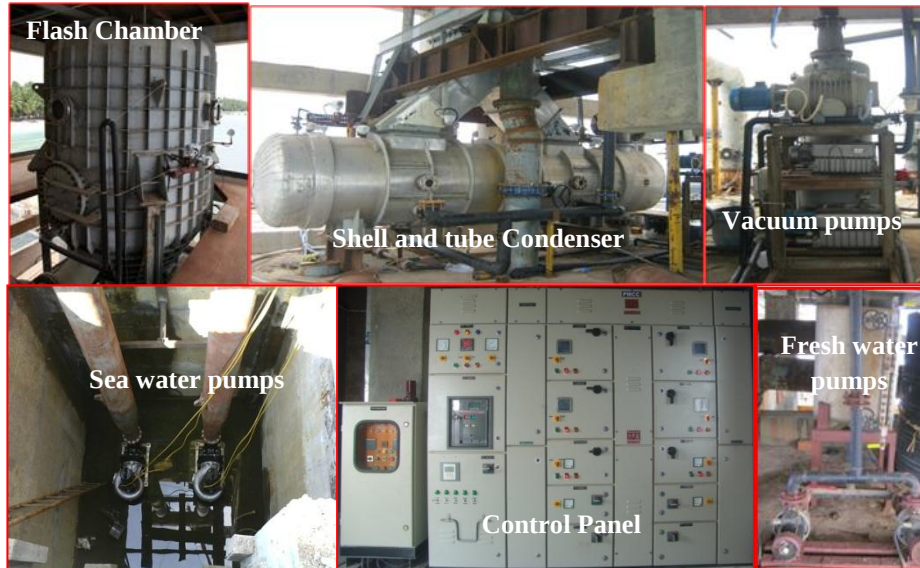


Fig. 2 Major plant components

The sea water pumps were selected based on the minimum power consumption by optimal choice of operation. The flash chamber was placed above 10m from the sea level to optimize the pumping losses for the warm water to the flash chamber. Siphon was employed to minimize the head requirement for the cold water pump. Detailed parametric analysis was performed to arrive at the operating point of the plant, with sufficient margin for the pumps to cater to the varying water levels due to the tides. Simulations on flow features inside the Flash chamber and structural analysis of the flash chamber is shown in Fig. 3.

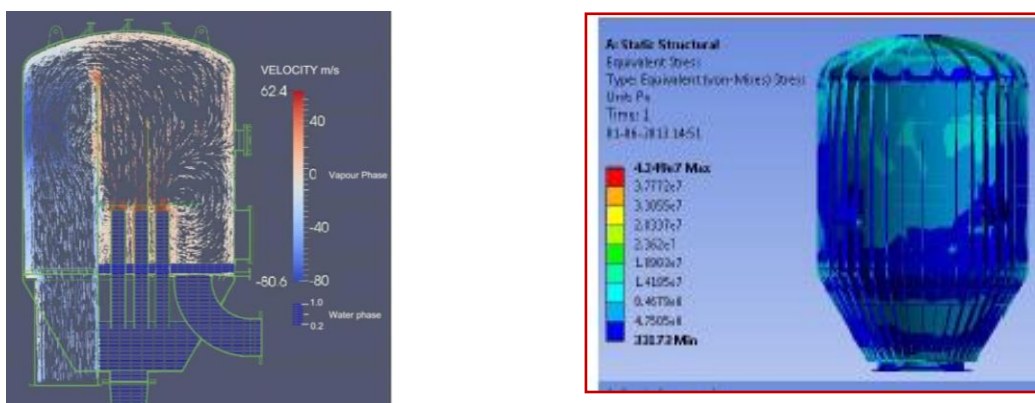


Fig. 3 A schematic of the vapour and liquid flow within the flash chamber (left) obtained from OpenFoam analysis (left) and Stress analysis of the Flash chamber in ANSYS

- The power requirement of the process was reduced to 9 kWhr / m³. The factors that contributed include optimal selection of design point for operation, designing of the equipment, selection and placement of the equipment.
- The distance of the demister pads from the spout pipes in the flash chamber was found to be one of the controlling parameters for maintaining the desired production quality. A TDS of below 50 ppm was achieved at Agatti with the modifications.
- Operational experience from the plants suggested that with the modifications in the inlet piping for Agatti, it may be possible to increase the production capacity of the plant with the same equipment. Similarly, with an optimal design of the discharge system, the production capacity at Minicoy could also be improved.

Table 1 Quality of Water Produced at Agatti and Minicoy Plants					
Sl No	Parameter	Units	Desirable Limit / (Permissible Limit) (as per IS 10500:1991)	Agatti Plant Water Quality	Minicoy Plant Water Quality
1	Colour	-	Un objectionable	OK	OK
2	Odour	-	Un objectionable	OK	OK
3	Turbidity	NTU	5 (10)	Not Detected	Not Detected
4	pH	-	6.5-8.5	8.03	8.2
5	Total Dissolved Solids	ppm	500 (2000)	30	88
6	Total Coliform	MPN	Nil	Nil	Nil
7	Faecal Coliform	MPN	Nil	Nil	Nil

The quality of water produced at Agatti and Minicoy plants as shown in Table 1, indicates that the Total Dissolved Solids of the product water could be maintained well below the desirable limits of 500 ppm.

Submarine Pipeline

The Submarine Pipeline draws the coolant water at about 12°C from 350-400m depth, it comprises rigid steel pipe in the shallow water region and High Density Poly Ethylene (HDPE) pipe in inverse catenary configuration as shown in Fig. 4. Inverse catenary pattern had the advantage of the natural buoyancy of the pipe to traverse very rugged and often very steep bottom terrain with no physical contact. This configuration was found to be more suitable for Lakshadweep coral Islands. Detailed route surveys of the sea bed were not necessary to implement the technique, except at the two ends of the catenary. The catenary mostly detached from the seafloor it was not susceptible to earthquake damage. The configuration is not suitable for shallow water applications or those with gentle slope where its topmost point approached the ocean surface. A catenary design had been successfully employed by MoES-NIOT in the island based LTTD plant at Kavaratti (Kathirolu, 2008). Plastic pipe, available in large diameters, had advantages over steel pipe such as corrosion resistance for seawater and better insulation and hence High Density Polyethylene (HDPE) pipe was employed in the Islands. For desalination plant in Agatti, HDPE combined with steel pipe was employed.

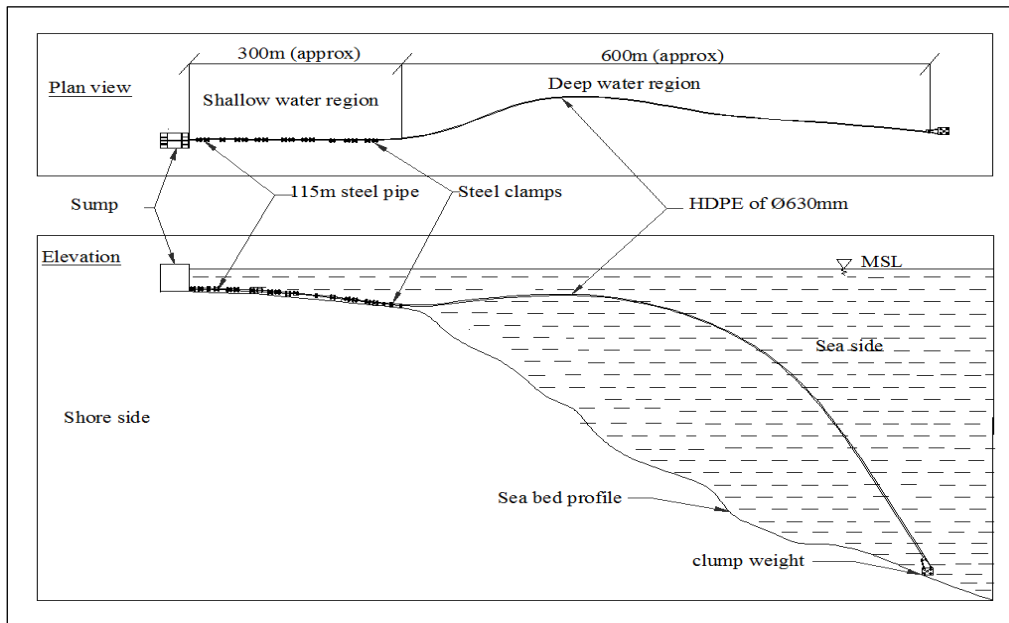


Fig. 4 A View of Deployed Configuration of HDPE pipe

The selection of site for LTTD plant is governed by the proximity from the coast to the 400m depth contour that contains about 10-12°C water, local bathymetry and wave climate at the site for the sump, and the bathymetry from the sump location to the shore. Typical bathymetry profiles for different Islands are shown in the Fig. 5 indicate that the distance from shore to the required depth of 400m was site specific.

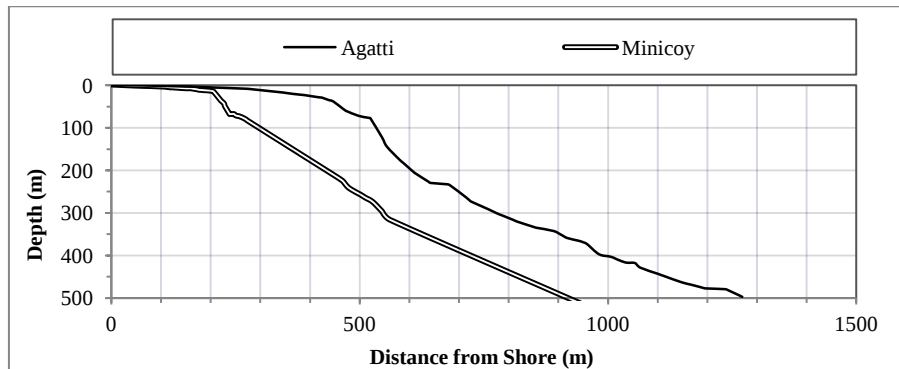


Fig. 5 Bathymetry profile for different Islands

Analysis and design of cold water pipe

Numerical simulation was carried out for operational / extreme loads using OrcaFlex to arrive at suitable mooring configuration. The pipe was analysed as a line element subjected to environmental loads. The environmental conditions required for the analysis were obtained from the long term averages of local measurements. The analysis was carried out in two stages that estimate tensile forces, bending moments, shear forces, torsion moments and finally total load acting on the CWP and its resultant profile configuration. The analysis was carried out for different wave and current combinations. It was evident from the results that the configuration was stable even at extreme environmental conditions.

Deployment of cold water pipe

The geometrical and flow characteristics of the pipe are given in Table 2 . Agatti island had a complex sea bed topography, with the sump location about 220m from shore, 30m contour about 170m from sump. The length of the cold water pipe in Agatti Island was 970m of which 220m was in shallow water and 750m in deep water (inverse catenary portion).

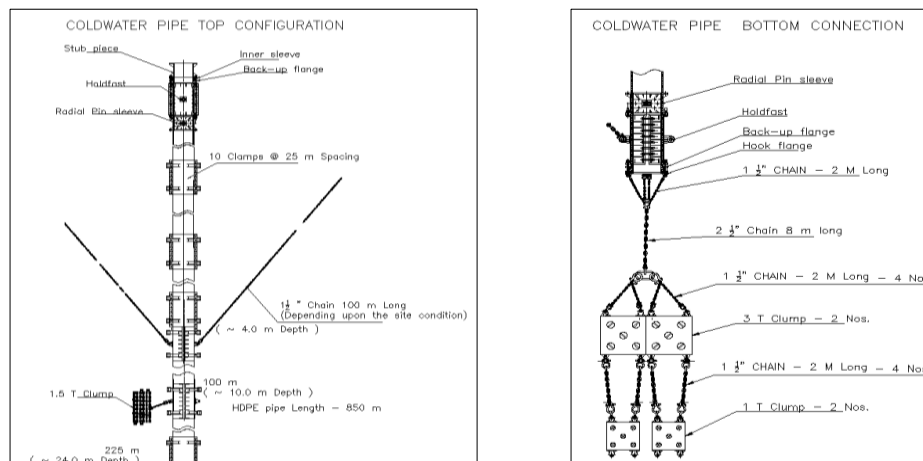


Fig. 6 Assembly and deployment of Cold water pipe

Table 2 Geometrical and flow characteristics of Cold Water Pipe	
Length	970m
Steel pipe	$L=120m, OD\Phi 570m, t=10mm$
HDPE pipe	$L=750m$ PE100, PN6, $OD\Phi 630m$, SDR21
Flow rate	150 kg/s
Flow Velocity	0.6 m/s

A flexible hose was attached in the intermediate region between the CWP and the sump. The front and rear end of the HDPE pipe were attached with friction grip components that transfer the loads from the HDPE pipe. Various dead weights, anchors, supports, chains and flexible elements such as flexible hoses, shock cells, clamps were used. Chains and redundancy ropes were used at various points of the pipeline to secure it and thus reduce the risk of loss under different scenarios. HDPE pipes were welded in 12m sections to form continuous pipe of required length and the components required as per the design were attached on the lagoon side. After pulling the pipe into lagoon water, the required buoyancy pontoons were attached

and pipe was towed from lagoon to the site using tug/barge. The front end was first connected and secured to shore and the rear end was then lowered after attaching the mooring weights as shown in Fig. 6.

Shallow Water Region

If HDPE pipe were used in shallow water, it needs to be buried in soil or weighed with concrete blocks. Since, it was not possible to bury the pipeline in coral bed without much damage to environment, the pipe needs to be weighed with concrete blocks. The pipeline can be stable only if the forces acting in place were greater than the forces that would tend to move the pipe. The shallow water pipeline that extended from 5m to 30m depth was a combination of steel pipe for 120m from the sump and HDPE pipe for the remaining length. Steel pipes were subjected to corrosion and posed problems to maintain cold water temperature. Hence protective coatings were required for steel pipes. Concrete blocks may not be required in case of steel pipe because of its self-weight that may provide resistance to wave and current loads. Since HDPE was buoyant, it will not give enough resistance to the wave and current loads, it was necessary to weigh it down to provide stability. In order to ensure stability of pipeline in shallow water, an analysis was carried out using static equilibrium between loads due to possible environmental conditions (waves and currents) and resistance offered by the concrete blocks.

Deep Water Region

After the pipe at Agatti was deployed during pre-monsoon, the catenary pipe section in the deep water region was exposed to surface due to reversal of coastal currents as shown in Fig. 7. The analysis was revised with ground conditions and additional weights were added to ensure the pipeline 50m below the water surface.



Fig. 7 Pipe surfacing

Numerical simulations were carried out with 7x200kg clamps for varied spacing and the depth of submergence of pipeline was estimated based on the final converged position. An optimal 65m depth of submergence was finally selected for implementation at site. The pipeline was inspected two seasons through under water diving and the inspection results indicated that the motions of the pipe were minimal and that the pipe configurations remained continuously below the sea-surface. The final configuration in submerged is shown in Fig. 8.

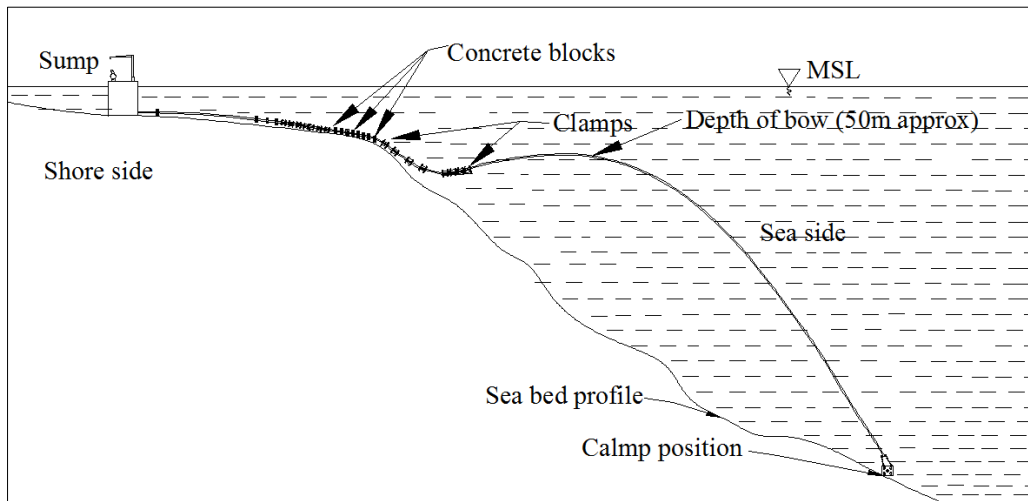


Fig. 8 Final configuration of CWP

Marine Structures

All the marine structures required for the plant were designed and executed with minimal infrastructure, and implemented in an environmentally protected area. A sump, as shown in Fig. 9, with a completed weight of 5000 kN was erected in 5m water depth to house the pumps; with dimensions of 8mx12mx8m. A 3m wide bridge connected the sump in 5m water depth with the shore. A plant building that extends up to 19m above the chart datum, was constructed in the intertidal zone, as shown in Fig. 10.



Fig. 9 Views of Sump during its Tow (left) and the towing route of Sump (right)



Fig. 10 Views of Agatti Plant showing the Plant Building, Bridge and the Sump

The selection of site, design and execution of marine structure for desalination plant is critical for the timely completion of the project. The marine structure consists of the major components, viz,

- Sump / intake structure to cold and warm water
- Approach trestle from sump to plant building/land to carry cold/warm water pipe
- Plant structure to support process equipment.

The general layout of marine structures based on hydrodynamic survey at Agatti and Minicoy Islands is shown in Figures 11 to 14. The configuration of the island indicated its North East section to be ideal for location of the plant considering the following requirements:

- Proximity of the 5m depth contour from the shore to place the intake structure; and,
- Proximity of the 400m depth contour from the shore / intake structure for deploying the cold water pipeline to draw cold water (10° to 12° C).

Lakshadweep islands experience typical climate with temperature 35°C in April/May with a humidity of 70 to 75%. The average wind speed is around 5-6m/s with maximum of 39m/s during monsoon. The eastern side of island experiences high waves of 5m height during Pre-monsoon as well as monsoon and the underwater current could be around 0.5m/s.

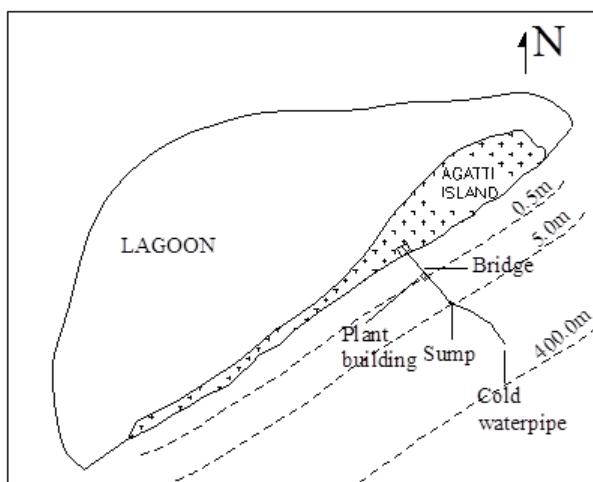


Fig. 11 Layout of marine structure: Agatti

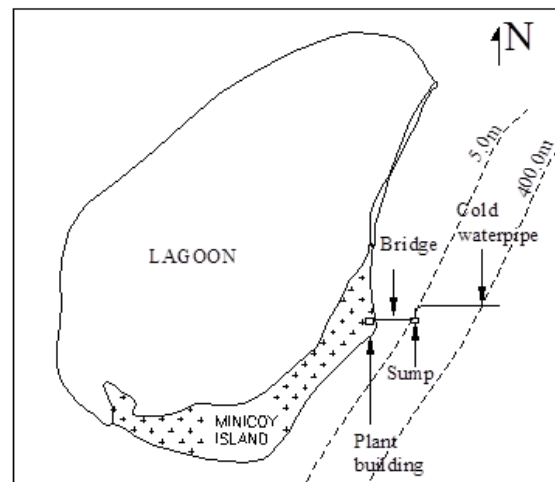


Fig. 12 Layout of marine structures Minicoy

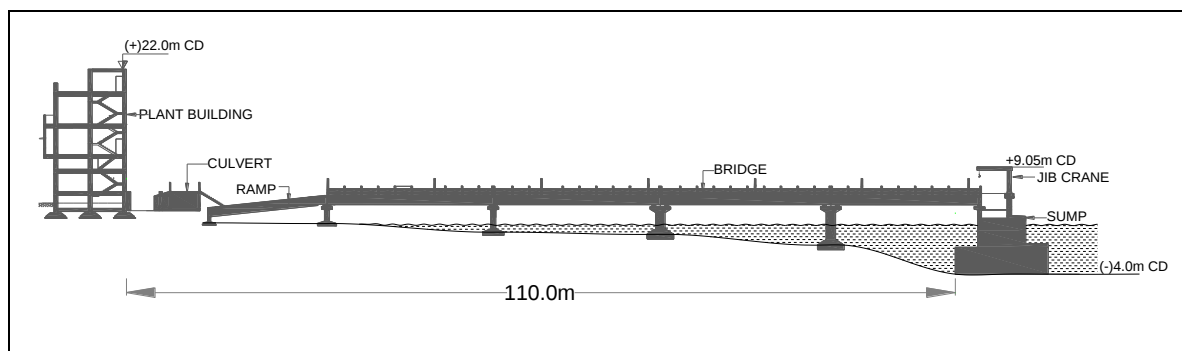


Fig. 13 Marine structures and Plant Building, Minicoy

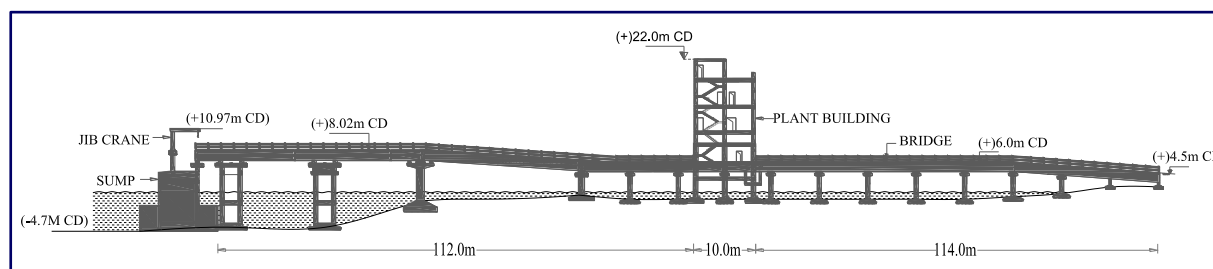


Fig. 14 Marine structures and Plant Building, Agatti

Sump

A concrete structure was installed at about 5m water depth (with respect to Chart Datum, CD) to house the sea water pumps. The dimensions of the sump were obtained considering the necessary clearances for the pumps and also the requirements for draft, towing, floating and stability at various stages of its construction and installation. The 12.17m x 8.3m x 9.1m sump accommodated two sets of pumps, two warm water and two cold water pumps along with the piping with necessary clearances. The structure was to be designed for prevailing wave, current and wind conditions. Considering the draft and freeboard required for the total as-built weight of the completed structure and the actual available depth in the lagoon, the sump was partially constructed in the lagoon, pushed in steps into lagoon to carry out 2 more stages of construction as per the draft and free board requirements for the operation and then towed about 7-10 km across the island. Two more stages of construction were carried out, one before and the other after its lowering to cater to the clearance and over topping requirements of the structure.

The warm water was drawn at the sump location from 3m below the mean sea level while the deep sea cold water pipe connected horizontally to the sump at its bottom. As the sump was located in wave breaker area, it was designed for loads as indicated in Table 3. The location for sump placement was prepared to remove the partial undulations.

Table 3 Loads considered for the design of sump at 5m water depth		
Type of load	Intensity	Remarks
Dead Load	—	Based on Density of Material

Wave Load	100 kN/m ²	Including current
Bridge Load	1250 kN	End span of bridge
Uplift Pressure	60 kN/m ²	Assumed 6m water depth
Sand Ballast Load	75 kN/m ²	Filled in the wing portion

Stability of Sump

The stability of the sump was checked against overturning and sliding. Additional gravity load, rock anchors and shear keys were provided to avoid sliding. The calculation for overturning and sliding is shown in Table 4 and the free body diagram is shown Fig. 15. The sump in Agatti was observed to experience high wave load of 100kN/m² during the pre-monsoon swells with wave height of 5m and period of 16 sec. Considering the high wave activity, a separate study has been initiated under wave structure interaction to estimate wave forces on structures.

Table 4 Caluclation for Overturning and Sliding of sump			
Description	Load (kN)	Lever arm (m)	Moment (kN.m)
<i>Overturning moments:</i>			
Wave load	7470	4.5	33615
Uplift force	5385	6.1	32769
Total	12855		66384
<i>Restoring moments:</i>			
Sump Weight	6000	6.1	36510
Sand ballast load	1302	1.5	2021
Sand ballast load	1302	10.6	13824
Water load	2678	6.1	16298
Bridge deck load	1000	3.1	3085
Rock Anchors	3000	6.1	18255
Total	15282		89993
<i>Check for Overturning:</i>			
Overturning Moment	66384 kN.m		Safe against over turning
Moment	89993 kN.m		
Restoring Factor of safety	1.43 > 1.4		
<i>Check for sliding:</i>			
Total Horizontal load (F)	6723 kN		Safe against sliding

Total Vertical load [R]	15282 kN	
Co-efficient of friction (μ)	0.3	
$\mu \times R$	4585 kN	
Shear key and rock anchors capacity	6000 kN	
Factor of safety	1.57 > 1.4	

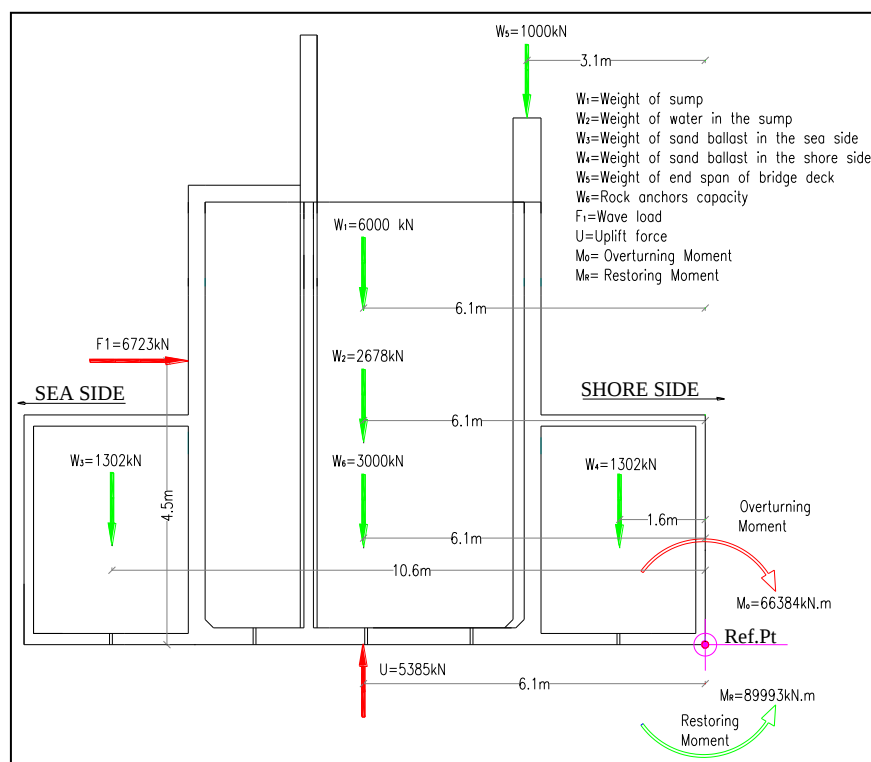


Fig. 15 Free body diagram of sump for stability check

Statics and Dynamics of Floating Sump

Statics and dynamics of sump were calculated for floating and towing the sump from lagoon to the site in 5m water depth. The isometric view of partly constructed sump considered for towing is shown in Fig. 16 and overall isometric view of sump is shown in Fig. 17.

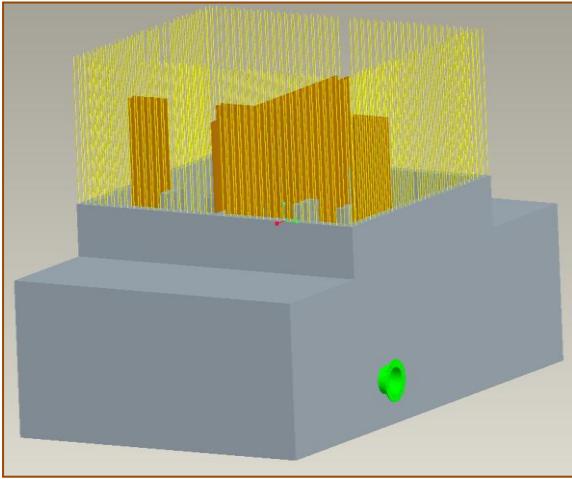


Fig. 16 Isometric view of Partially Constructed Sump

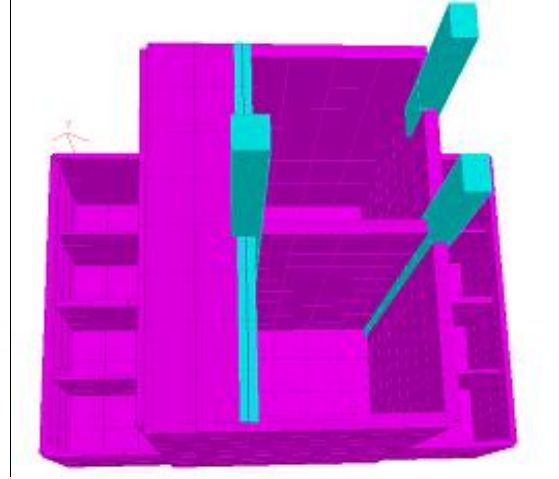


Fig. 17 Isometric view of the Completed Sump

Analytical for rectangular sump

The analytical calculation for floating stability of sump during towing is given in Table 5. Considering the draft and freeboard requirements during the tow and erection, a built up height of 4.4m was considered.

Table 5 Metacentric Height of the Sump	
Weight of sump, m	2839.4 kN
Water plane Area, A_{wp}	101.01m ²
Draft, D	2.742 m
Center of Buoyancy KB (=D/2)	1.371m
Center of Gravity KG	1.878m
BG (=KG-KB)	0.507m
Transverse Second Moment of Area I_T	579.89 m ⁴
Longitudinal Second Moment of Area I_L	1246.71 m ⁴
$BM_T (=I_T / V)$	2.093 m
$BM_L (=I_L / V)$	4.500 m
Transverse Metacentric Height $GM_T (=BM_T - BG)$	1.587 m
Longitudinal Metacentric Height $GM_L (=BM_L - BG)$	3.994 m

Frequency Vs RAO Plots

Numerical studies were conducted to estimate the hydrostatic and dynamic behavior of the sump for surge, sway, heave, roll, pitch, and yaw. The responses were plotted in Fig. 18 Damping and added mass coefficients were shown in Fig. 19. It was observed that natural periods for Roll, Pitch and Heave motions analytically estimated were comparable with numerical results obtained from Boundary Element Analysis (BEM) based Ansys AQWA

software. The typical periods for heave, pitch, roll were 1.18 rad/s, 1.37 rad/s, and 1.07 rad/s respectively.

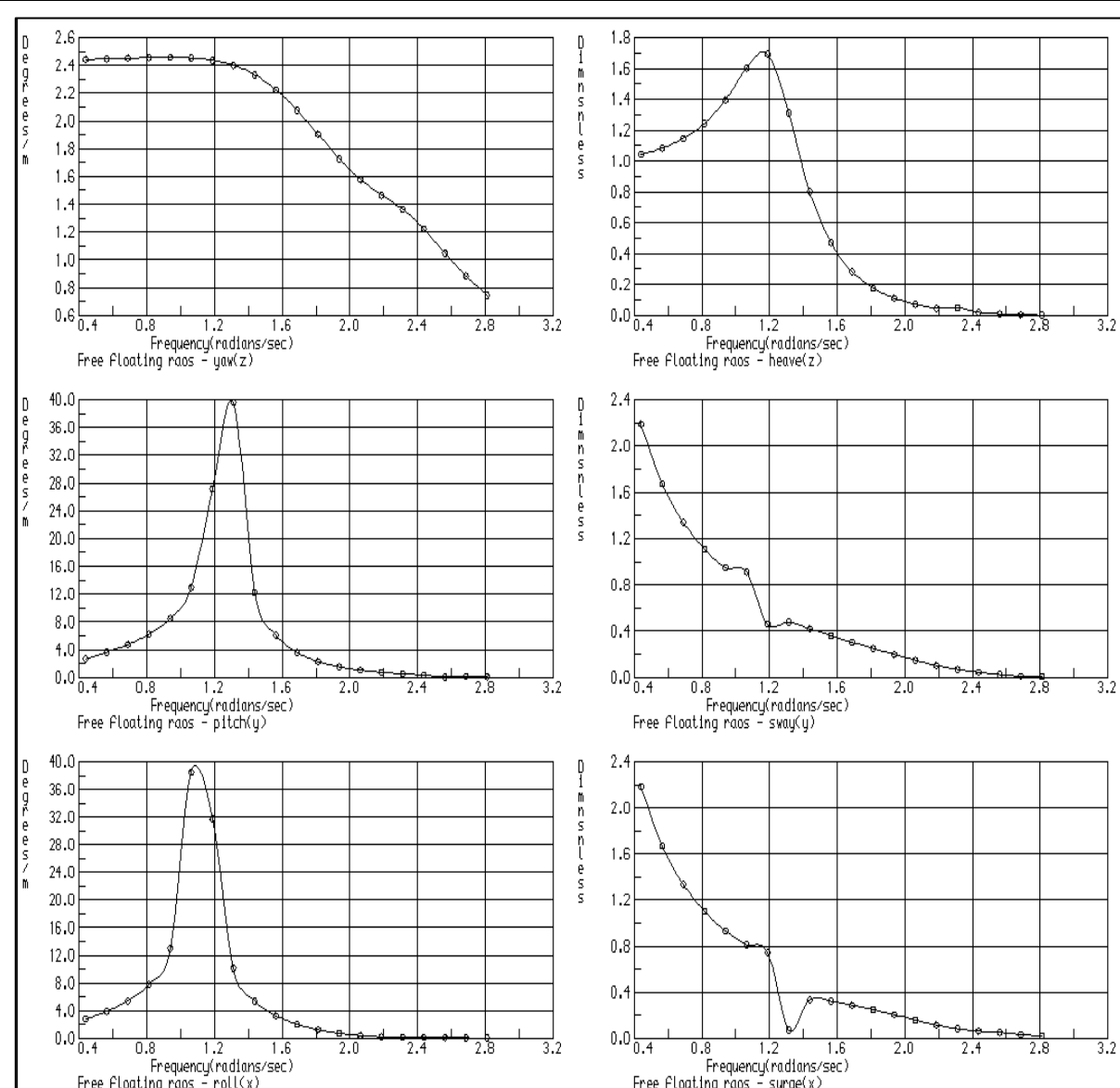


Fig. 18 Frequency Vs RAO Plots of sump

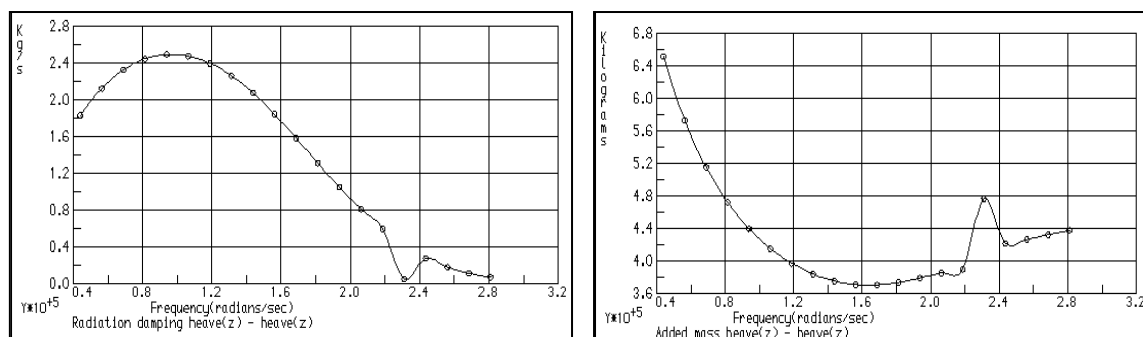


Fig. 19 Damping and Added mass Plots of sump

Casting, Towing and Installation of Sump

Considering the requirement to draw cold and warm water separately, 2 water tight compartments each with 4m x 8m cross section were provided. Two RCC sections of 8m x 3m were also built on either sides of sump in order to increase the stability during towing and for filling additional weight to increase the gravity load after positioning at site as indicated in Figures 20 and 21. RCC sump was constructed initially in the lagoon shore with bed preparations such as sand bags, levelling for base slab concreting as shown in Fig. 22.

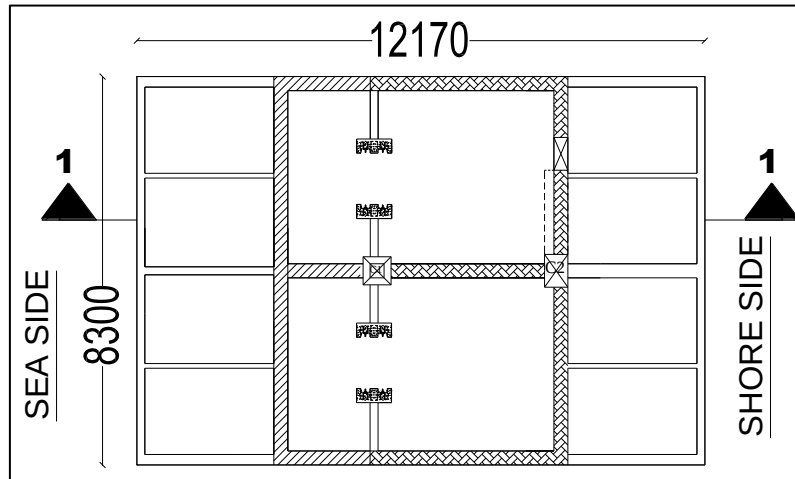


Fig. 20 Plan of sump

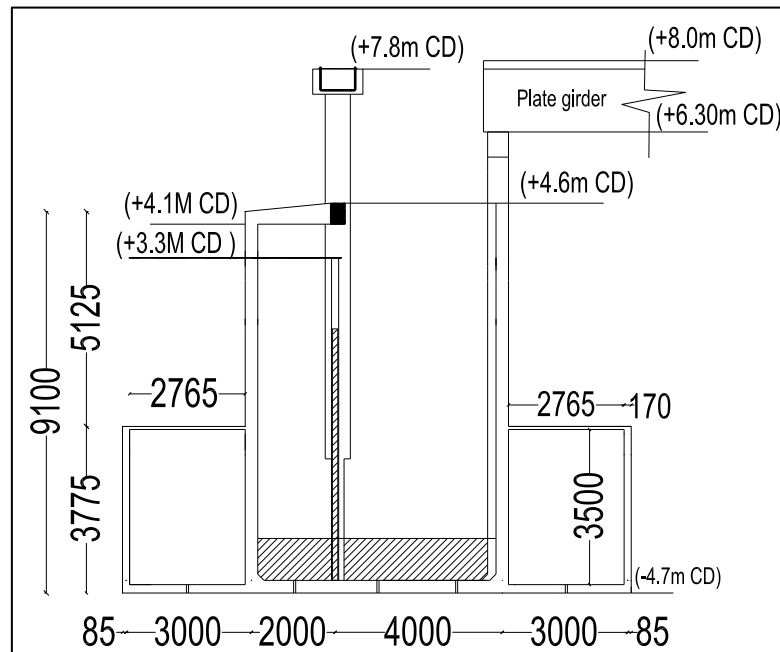


Fig. 21 Cross Section of sump (1-1)

Sump weight was limited to 1900kN to facilitate its launch from shore into the lagoon. Steel sections were used with rollers below the sump for sliding the sump. Two 1000kN Hydraulic jacks were used to launch the sump as shown in Fig. 23. Considering the minimal

infrastructure available in the island such as manual winches, boats and hydraulic jacks, the sump was launched within just 15 days as shown in Fig. 24.

After launching, the sump was further cast in lagoon in floating condition up to a draft of 1.8m considering the available depth to cross the lagoon channel. It was then towed out of lagoon for about 10 km to the eastern side of the island as indicated in Fig. 25 for its final installation at the site. The towing route was selected based on draft of the sump, available water depth in lagoon and location of coral boulders within the channel. The sump was towed in open sea and brought to final location as shown in Figures 26 and 27. It was then ballasted, lowered and positioned at the required location in about 5m water depth. The whole operation could be achieved through careful assessment of draft catering to the site requirements at various stages of construction, towing, lowering and positioning.



Fig. 22 Bed preparations for sump at lagoon beach



Fig. 23 Hydraulic jack for pushing sump



Fig. 24 Sump after pushing in to lagoon

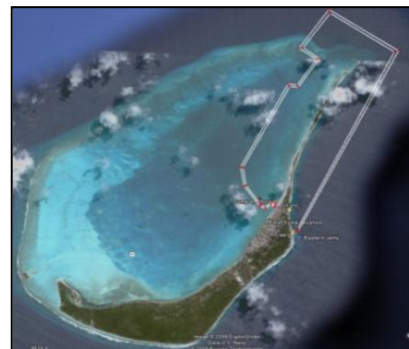


Fig. 25 Towing route of the sump



Fig. 26 Towing of Sump in open ocean at Agatti



Fig. 27 Towing of Sump in open ocean at Minicoy

Bridge

Bridge was constructed to carry cold and warm water pipelines from sump located at 5m depth to the shore and also to facilitate the necessary maintenance, connecting the sump to shore and plant building. It was supported by gravity based concrete piers. The length of the bridge may vary from 100m to 250m depending on island. The total length of the bridge at Minicoy was about 110m with four major spans of 22m each, as shown in Fig. 28.

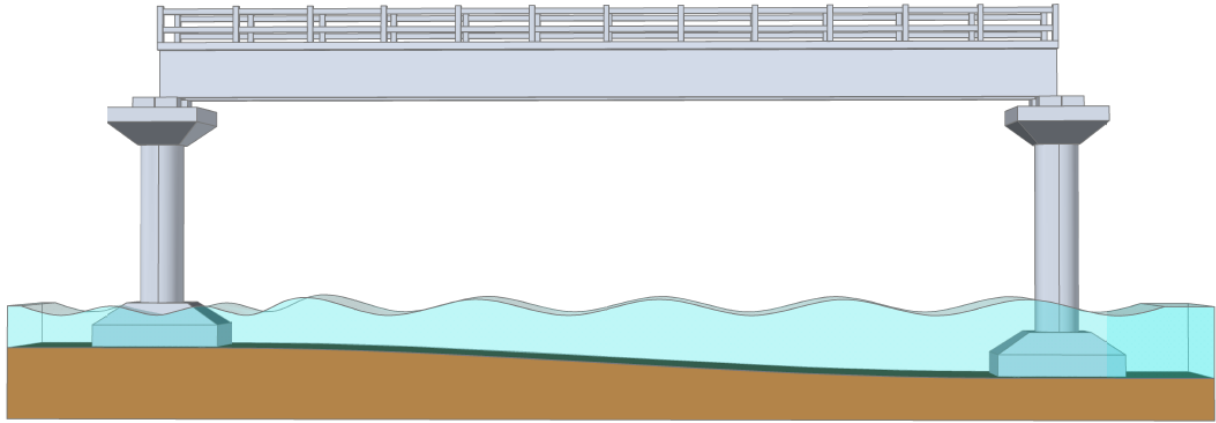


Fig. 28 Elevation of approach trestle (one span)

Bridge at Agatti

The 240m long Agatti bridge consisted 15 spans, each of 15m in the intertidal region and of 25m within and beyond the breaker region. About 130m span was in the intertidal region and 110m span was in active breaker region.

Out of 14 piers that were cast for the bridge, the 11 piers in intertidal region were partially cast on steel staging until they clear the local water depth on lowering. They were then lowered with chain pulleys of 100 kN capacity. The piers beyond the breaker region were cast in the lagoon, encased in water tight pontoons to be floated to the site and lowered at appropriate position, secured by suitable anchors. The bridge deck in intertidal area was of concrete cast-in-situ and in breaker area was of steel plate girder deck encased in a coating. The loads considered for the design of bridge are shown in Table 6.

Table 6 Loads considered for the design of the bridge		
Type of load	Intensity	Remarks
Dead Load	–	Based on Density of Material
Live Load	Live load = 3 kN/m ² Pipe Load = 3.21 KN/m	–
Wind Load	1.6 kN/m ²	Basic wind speed is 39 m/sec
Wave Load	30 kN/m	At 3m depth in breaker zone and it will vary based on water depth, wave period and height
Earthquake Load	Zone III Importance factor :1.5 Response Reduction factor :5	As per IS:1893-2002

Construction and installation of bridge piers beyond breaker zone (P13, P14)

The construction of piers in and beyond the breaker zone was a challenging task. These piers witnessed 3 m to 4 m high waves with periods ranging from 10-16 seconds. The marine structure at Agatti had to be redesigned to withstand extreme waves. Accordingly, the construction methodology was modified to suit local conditions. The sump in 5m water depth was located 90m away from the breaker zone. Hence the spans of the bridge to the sump were adjusted to limit only one pier in the breaker zone and two piers beyond breaker zone with a span of 25m. The dimensions of the pier are shown in Figures 29 and 30. The pier footing was cast in a steel caisson in the lagoon area as shown in Figures 31 and 32 and then floated using buoyancy of the caisson, towed and installed in its final location as per bridge alignment. The total weight of the partially cast RCC footing with steel pontoon was limited to around 200kN during its floating and towing. One more stage of construction was carried out up to the pier cap level after its lowering at the required location.

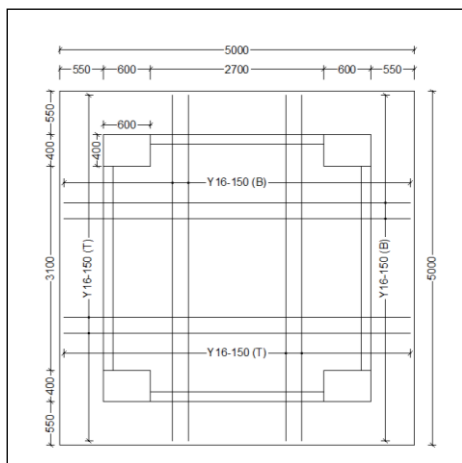


Fig. 29 Dimensions of P13 and P14 footing.

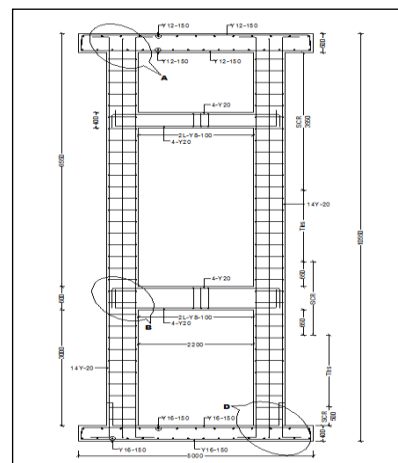


Fig. 30 Side elevation of P13 and P14 column

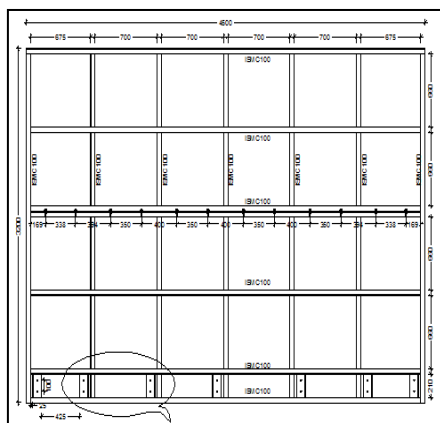


Fig. 31 Elevation details of caisson for P12 and P13.



Fig. 32 Assembled steel caisson for P12 and 13

Construction and installation of bridge pier (P12) in the breaker zone

The pier in breaker zone (P12) was initially installed in the same manner as the piers P13 and P14 beyond the breaker zone. However, high breaking waves were prevalent in the region as shown in Fig. 33. Due to high wave action P12 was damaged during its partial construction

stage as shown in Fig. 34. Detailed analysis with revised design in the wave breaking zone was carried out. A circular pier with rectangular footing and provisions for rock anchoring was designed for P12. In order to cast and lower the P12, a steel frame stage was designed, fabricated and erected at the required location as shown in Fig. 35.



Fig. 33 Breaking waves in P12



Fig. 34 Damaged pier 12 due to high waves

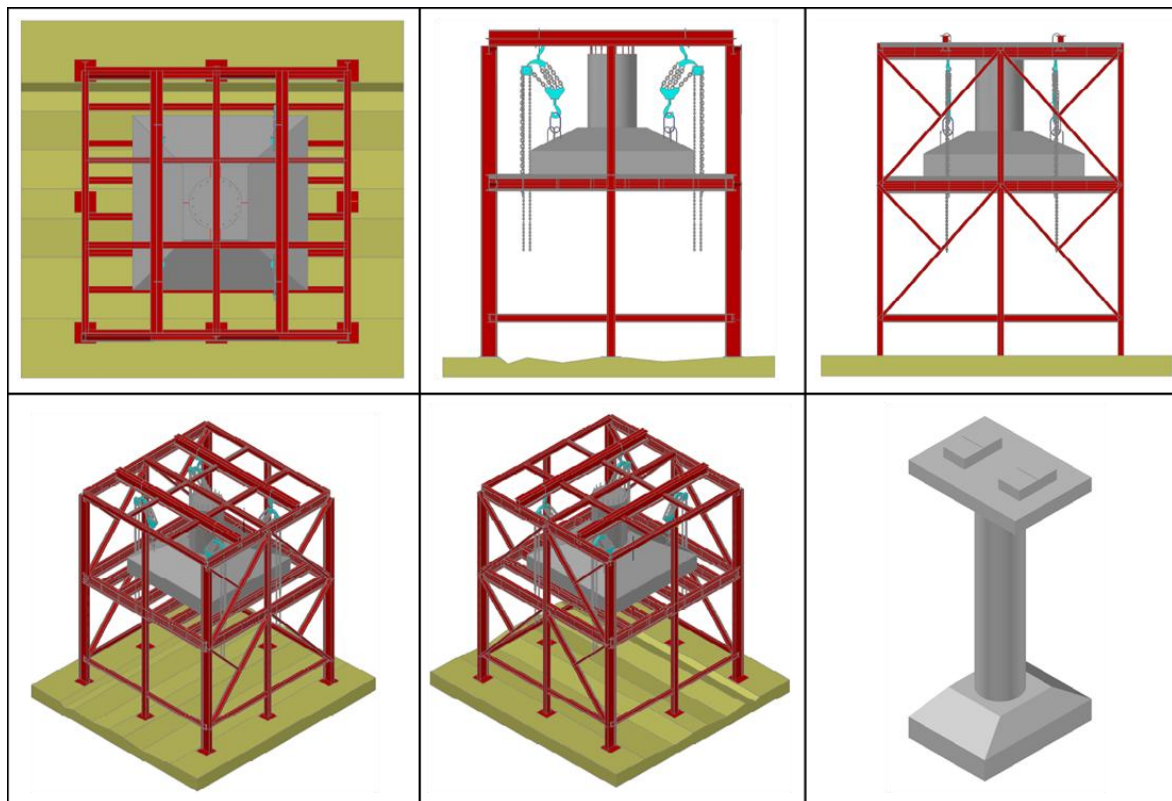


Fig. 35 Revised Pier 12 with steel frame stage

Reinforcement and concreting work for P12 on steel staging is shown in Figures 36 and 37. The footing and column weighing of about 1000 kN was lowered into the water using chain pulley blocks. A view of P12 after it was lowered is shown in Fig. 38. Fully concreted P12 till pier cap level is shown in Fig. 39. The construction of Agatti plant was delayed due to rough weather conditions and lack of equipment to install the foundation. A major achievement of the project was pier (P12) in the wave breaking area and installation at site, where wave height was 2m.



Fig. 36 Reinforcement work for P12 footing on stage



Fig. 37 Concreting work of P12 on steel stage



Fig. 38 Footing of P12 lowered in water



Fig. 39 Completed Section of P12 with pier cap

Launching and erection of plate girder bridge at Agatti

To avoid construction difficulties in the erection of the deck beyond the breaker at Agatti plant, 60m long structural steel plate girder bridge was designed for the section between the sump and P12. The structural steel for the plate girder was fabricated at main land to form 16 sections, each about 7m long with necessary splice plates, bolts etc., and transported to Agatti island. After completing the final in-situ stage of the construction of piers beyond the breaker, the I sections were assembled, bolted, welded and placed on the deck of RCC bridge as shown in Fig. 40. Rollers were kept at about 20m intervals on the bridge and were locked to bridge. A derrick system was erected on the pier 12 to hold the front end of plate girder during launching as shown in Fig. 41. The plate girder during its launch is shown in Fig. 42. After launching the plate girder, it was lowered on the RCC bearing blocks cast on the pier caps, bolted and welded through the plates inserted on the bearing blocks as shown in Fig. 43. In-situ concreting was carried out between piers P11 and P12 and then a coat of micro concreting was applied to the exposed steel of the plate girder as shown in Fig. 44. The final view of the completed plate girder is shown in Fig. 45.



Fig. 40 Assembled plate girder on the bridge



Fig. 41 Derrick for plate girder launching



Fig. 42 Launching of plate girder



Fig. 43 Plate girder welded with bearing blocks



Fig. 44 Micro concreting work



Fig. 45 View of the plate girder after completion

Plant Building

The plant building housed the plant equipment such as Flash chamber (dry weight: 80 kN, approx.) and the condenser (dry weight: 120 kN, approx.) along with the associated ducting, piping, vacuum system, electrical control panel, a store room for spares, control room and miscellaneous. The flash chamber and the condenser were designed for an internal pressure of 2.7 kPa. The plant building at Agatti is shown in Fig. 46.

In order to utilize the gravimetric ceiling, the floor of the flash chamber with warm water opening was placed at a height of about 10.8 (C.D). The shell and tube condenser that also

operated at 2.7 kPa was placed at approximately the same level as bridge to optimize the support structure necessary for condenser on one hand and ducting losses for vapour that flows in vacuum conditions on the other hand. The fresh water generated in the condenser was pumped with centrifugal pumps.

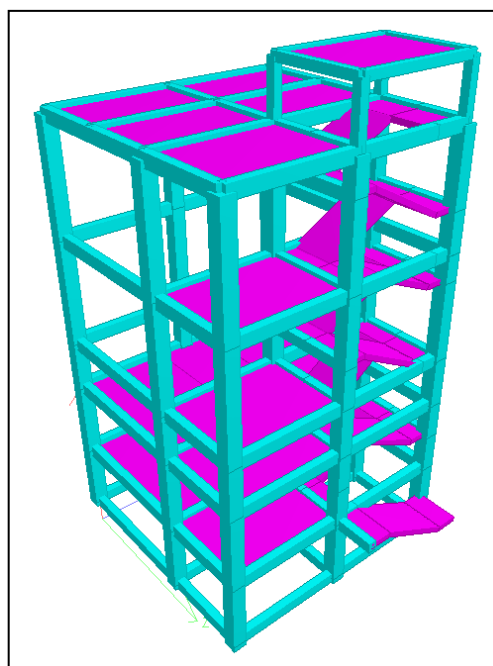


Fig. 46 Plant Building at intertidal zone in Agatti

Project Team

Dr.M.A.Atmanand, Director, NIOT
Dr.M.V.Ramana Murthy, Project Director
Dr. S.V.S Phani Kumar, Scientist E
Civil/ Structural Team Mr. R. Saravanan, Mr. K. Mullaivendhan, Mrs. Sareena, Mr. Irsad, Mr. A.S. Kiran, Mr. Ramesh Mr. Malik P.M.C, Mr. Antony Johnson, Mrs. V.Gajalakshmi
Mechanical, Electrical and Instrumentation Team Mr. D. Balaji, Mr. Srinivasulu Reddy Pilli, Dr. G. Dhinesh, Mr. K. Jayaraj, Mr. A. Jyothi Prakash, Mr. G. Chandrashekar, Mr. A. Naveen, Mr. Lawerance, Mr. R Elavarasan, Mr. R Kumaradevan
Dr. Purnima Jalihal, Head EFW group and Team Dr. K.M.Sivakholundu, Head CE group and Team