

BOTTOM MOUNTED SEABED MOORING FRAME FOR HIGH CURRENT FIELD

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Abstract

Longterm current measurements for a period of 14 months were taken up by National Institute of oceanography at high current regime in Gulf of Khambhat. The measurement was intended at seabed for obtaining vector averaged current speed and direction on the sea surface and at a fixed five layers. The company supplied frame was not suitable to use at the proposed measurement location, owing to random oscillation in the seabed, strong currents and high concentration of sediments in the water column. The authors have designed a special frame to withstand for above problems and the measurements were carried out successfully for such harsh environment, first time in India. The details of the design and the measurement techniques are described in the paper.

1.0. INTRODUCTION

National Institute of Oceanography, Goa undertakes various data collection programme on physical processes of the costal waters through different research and sponsored programmes . Extensive data have been collected on waves, currents, tides and sediment transport along the Indian coast. The long term data collections are often focused at open sea and river mouths where the ocean currents exist less than 4 knots. First time, a programme was initiated to take up longterm current measurement at Gulf of Khambhat, where the tidal variation reaches upto 8 m and the maximum current exceeds 7 knots. The bed morphology and tidal bore posed challenge in devising a suitable mooring, safety over the extended period and the data quality. A site specific mooring method was devised and most suitable instrument was selected. The current measurement was successfully carried out at different layers for a period of 14 months from October 2002 to November 2003.

2.0. MORPHOLOGY OF GULF OF KHAMBHAT

The Gulf of Khambhat forms on the northern part of the Arabian sea and it exhibits a second largest Gulf system in India (Fig. 1). It has a width of 80 km at mouth and funnels down to 25 km over the longitudinal reach of 140 km. The entire banks surrounding the Gulf are bordered with large tidal flats nested into numerous tidal creeks. The rivers viz., Ambika, Purna, Kim, Tapti, Narmada, Mahe, Sabarmati and Dhadar together form a complex estuarine system in

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the Gulf. Mal Bank is a prominent sand shoal present at northern part of the Gulf. The middle part of the Gulf is deeper with depth ranging upto 30 m. The seabed remains in quasi steady state and it moves as sand bars with tides. The Bhavnagar port is located on the western part of the Gulf. Many offshore oil, gas and chemical terminals have come between Hazira and Dahej. On the otherhand, the tides in the Gulf remain the largest of the Indian coast. The typical variation of the spring and neap tidal ranges remain around 9 m and 5 m respectively. The sea remain very rough during monsoon with high waves ($H_s > 3$ m) and strong wind ($v > 50$ km/hr) from June to September. Due to strong flood and ebb tidal currents, the water remains always turbid with huge bed and suspended sediment loads.

3.0. OPERATIONAL PROBLEMS IN GULF OF KHAMBHAT

while the measurement programme on current was conceived, the hindrances associated with the Gulf environment were evaluated. The problems were concentrated on three major factors, viz. strong currents, movable bed and turbid water. The reasons for failures during earlier attempts by other organizations were reviewed. In all attempts, the instruments were lost within 15 days due to the burial of bottom mounted instrument with mooring frame. In case of deployment of vertical array, the instrument were dragged away with currents. Due to large tilting of wire angle, the instrument recorded erroneous data. In some cases, the mooring was disturbed by local boats fishing in this region. Large floating debris like plants and tree branches, which often washed away by inland discharges entangled with instrument and resulted in permanent loss. Sailing inside the Gulf and carrying out any mooring operation are also much limited with available time of few hours during slack tide.

4.0. ENVIRONMENTAL DATA

The available information at NIO on the characteristics of the study region were collected. The geophysical records on the seafloor available with NIO indicate a vertical change upto 2 to 3 m over a lunar cycle. The deposition or scouring on the seafloor in one tidal cycle is estimated around 0.15 to 0.30 m. The results of modeling study on tidal currents by NIO indicated maximum current speed to reach 2.5 to 3.5 m/s. The seabed sediment at proposed measurement location was collected and identified to consist as silty sand. The water samples were collected and the suspended load were estimated as 100 mg/litre.

5.0 SELECTION OF INSTRUMENT

The current measurement was proposed at a water depth of 24m w.r.t. Chart datum, which will have around 32m during the highest tide. Further the measurement was stipulated at different layers across the vertical. Various instruments available for the current measurement were reviewed and tested at site. The rotor current meters had the limitation of measuring the maximum current upto 2 m/s. The electromagnetic current meters posed deflection of signals

due to heavy sediment load in the water column. Some of the ADCP current meters showed erroneous result particularly at higher elevations due to turbid environment and large sediment load. The problems were discussed with M/S Aanderaa Instruments, Norway and the combination of DCM12 current meter and RCM9 current meter were selected. The DCM12 has the blank region for 2 m distance above the instrument, for which it was decided to keep one RCM9 at bottom. The RCM9 was modified at factory to measure upto 5 m/s. The preliminary data quality was checked by Aanderaa Instrument and suggestions were made to suitably power the instrument and position at suitable height. Based on various trials, it was finally decided to use one set of DCM12 and RCM9 for the measurements.

6.0. DESIGN OF MOORING FRAME

The main factors considered in the design of bottom mounted mooring frame were: i) vertically stable from the action of current and wave forces, ii) optimum weight, i.e. heavy enough to offer vertical stability and light enough to avoid sinking into the seabed, iii) offer resistance against burial into the sea floor, iv) optimum height to keep the instrument above any fluctuation in seafloor elevation and v) convenient to handle manually using small boats for frequent retrievals and redeployments. Accordingly different type of mooring frames were tested at site and the performances were evaluated. On repeated trials, the configuration shown in Fig.2 was found to be more optimum and suit the requirements. The frame fabricated in SS316L has been selected for the marine environment to withstand from marine corrosion. The size have been designed with a base width of 2 m X 2 m and a height of 2 m. The entire frame weighed 150kg in air and 130kg in water.

Frame design:

The frame size was selected after considering the strong currents, seabed sediment density, and the sediment movement. Vertical rods were kept at 24 mm dia. and the horizontal supports were given with 12 mm dia. at 3 levels. Also a mesh of 20 cm apart was constructed with rods of 12 mm dia. at the bottom. The mesh rods at the ends were bent at 45° which offered resistance for burial. These arrangements helped to reduce sinking of the frame leading to the burials beneath the seabed. At the top, a gimbal assembly supplied by the manufacturer was used to mount DCM12 in order to align at vertical. Due to high currents, the instrument started tilting more than permissible limit of 20°. Then it was modified with a cylindrical casing made of 3 mm SS sheet and fabricated around the instrument. Small holes were driven around the cylinder to have a free water flow and to avoid sediment deposition. The mounting frame with details are shown in plate 1.

Total weight:

Weight equation for a cylindrical rod = $\pi \times r^2 \times l \times \rho_{ss}$

Where: $\rho = 3.143$, $r = \text{radius}$, $l = \text{length}$ and $\rho_{ss} = \text{density}$

Vertical rods = 8nos. x π x 0.0125 x 2.2 x 7850	= 68
Horizontal support rods = 12 nos. x π x 0.00625 x 8 x 7850	= 12
Bottom mesh rods = 20nos. x π x 0.00625 x 8 x 7850	= 38
Casing cylinder of 0.5 m h, 0.25 d, 0.03 m thickness	= 12
Other attachments	= 20

Total frame weight = 150kg

7.0. SPECIAL CHARACTERISTICS OF THE FRAME

The frame was having optimum weight to offer stability for the overturning moment to horizontal forces caused by waves and currents. At the same time, the weight remained not excess to avoid sinking into the sea floor. The horizontal meshes designed at the bottom caused soil resistance against sinking and avoided burial into the seafloor. The inclination of the protruded part of the meshes kept at 45° offers further resistance for overturning. The instrument mounted 2 m above the seafloor helped to avoid siltation on the current meter sensor. The hook arrangement helped for easy handling during installation and retrieval.

8.0. TRIAL MOORING AND DATA QUALITY

The locally available boat of 15 m length with A- frame having a winch capacity of 2 ton with a derrick boom was chosen for deployment and retrieval operations. Initially the frame along with the instrument was transported on board. The DCM12 instrument was attached at gimbal assembly of the frame. The frame was connected with 50 m long and 18 mm dia. polypropylene rope. A surface marker float was attached at top for identification of the mooring line. Another rope was attached as U mooring arrangement with 100 m spacing. Using the winch and derrick boom, the frame along with the instrument was lowered and placed at bottom where the water depth was 24 m w.r.t. CD. The trial deployment was done on 5.10.02. the deployment is shown in plate 1. After 2 days, the retrieval was done using the same boat with the help of winch and derrick boom. No problem was faced during retrieval and the instrument was found without any damage. The data quality was found to be normal. Excessive deposition of sediment was found inside the cylinder housing the DCM12. Then additional holes were drilled at the bottom of the cylinder for immediate flushing.

9.0. DATA PRESENTATION

Actual data collection was then commenced on 6.10.02. The retrieval was planned at every 7 days to avoid excessive burial. During the days of spring tidal days, when the currents are strong, the frame was just lifted and lowered for every 3 days to avoid burial due to movement of seafloor. The boat was tied with a moored buoy at 500 m away and 24 hours watch keeping was arranged to avoid any vandalism by local boats. The data collection was continued till November 2003. the sample data collected during 30.12.02 to 9.01.03 are shown in Fig.3. During the period of measurement the current speed reached the maximum of 3.51 m on 18.2.03 largest tide of around 10.0 m was recorded during the measurement period.

10.0. PROBLEMS ENCOUNTERED WITH MOORING AND DATA QUALITY

Mooring : Occasionally the mooring frame got embedded more in the seafloor and it had become difficult to remove the frame. Additional winch was used to pull the frame out of the floor. Hence the mooring line was changed to 20 mm dia. nylon rope to withstand for the pulling stress. Often the mooring frame was entangled with wooden logs and got anchored to the seafloor. Additional winch had become necessary to pull the frame out of the floor. Occasionally the mooring frame was seen tilted and it was assumed due to uneven seafloor associated with improper deployment.

Data Quality : The data at lower most level remained often disturbed particularly during the maximum current phase over a tidal cycle. At times the data at surface level also got affected. The higher concentration of sediment load was observed to be the main reason of this data distortion.

11.0 CONCLUSIONS

1. The specially designed frame served well for the harsh environment of the Gulf of Khambhat.
2. It was found safe to retrieve the current meter every week to avoid the burial of the frame.
3. An optimum boat size of 2 ton winch capacity with A frame was found ideal for this type of operation.
4. Since the operational window for deployment and retrieval was about half an hour, it had become essential to plan the work and carryout operations

12.0 ACKNOWLEDGEMENT

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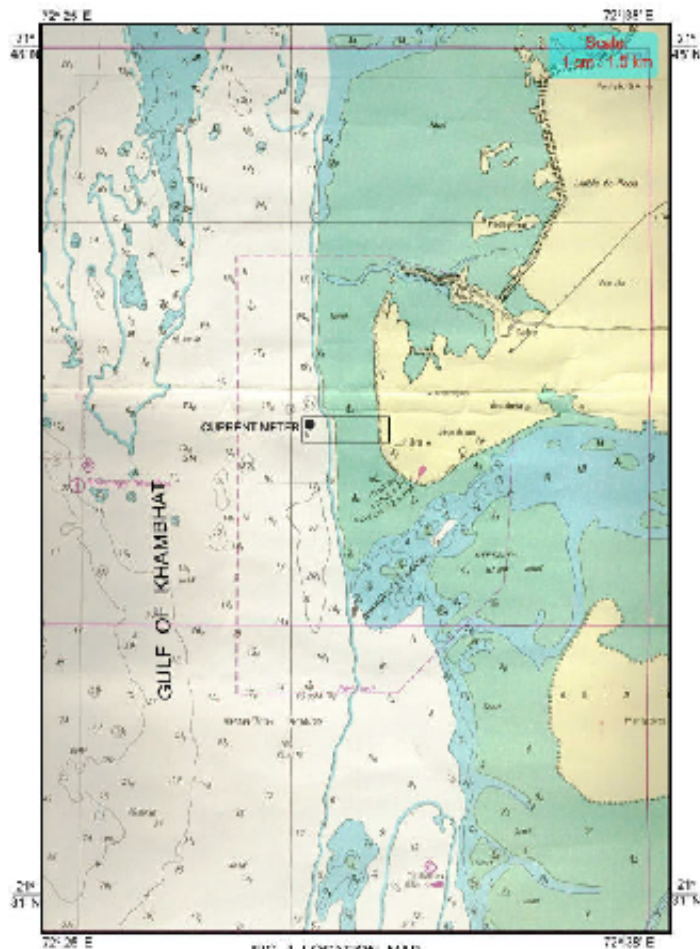


FIG. 1. LOCATION MAP

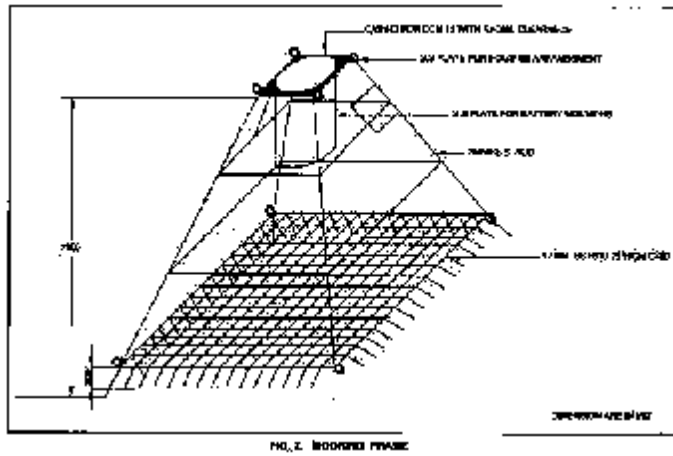


Fig. 2. Moring Frame

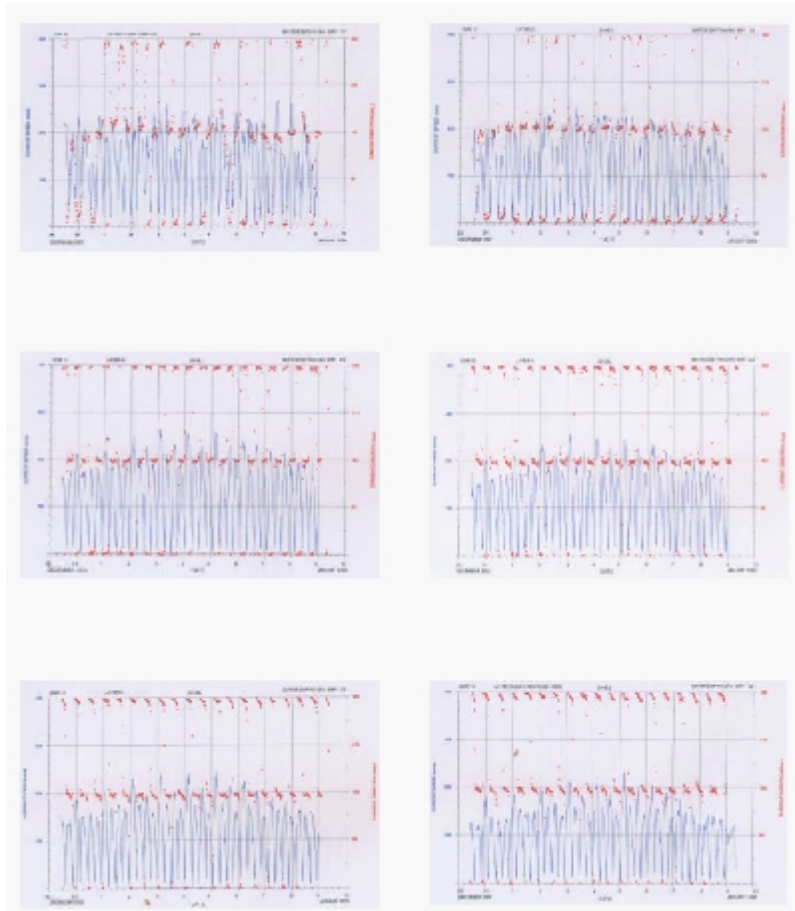


Fig. 3. Variation of Current during 30.12.02 to 9.01.03



Plate showing the Mooring Frame