

**Pipeline crossing across Manori Creek, Bombay; Advantages of
Marine Acoustic Techniques in route selection**

K. H. Vora

Cesar Moraes

Geological Oceanography Division
National Institute of Oceanography,
Dona Paula, Goa 403 004

SYNOPSIS

(The utility of offshore pipelines is increasing in transportation of bulk liquid material, not only for oil industry but also for waste disposal and intake structure for cooling.) Designing and planning submarine pipeline needs careful consideration as they are placed in a hostile environment on unprepared foundation. The need for assessing seabed conditions for potential hazards cannot be over emphasized. The multi-sensored, high-resolution acoustic methods are the tools essential for obtaining such informations. The National Institute of Oceanography (NIO) had carried out such survey in Bombay for obtaining geological informations in order to plan and design a pipeline route crossing Manori creek to transport fresh water. The survey comprising of echosounding, side scan sonar and subbottom profiler followed by soil sampling and accompanied by an accurate positioning system was carried out using a small boat. The survey revealed that the original proposed route,

although was shortest, had to pass through rugged bed with a steep gradient and had practically no unconsolidated sediment cover, beside the same was passing through an existing ferry route and was in the midst of small fishing harbour. On the other hand, the seabed along the route suggested as per present survey, about 400 - 500 m north, was generally even and covered by 2 -3 m unconsolidated sediments and away from ferry route and fishing harbour. The thickness of the sediments prevailing in the large part of the route is sufficient to ensure necessary burial of pipelines to prevent damages by anchoring of the vessels or by some other way. The survey, therefore, has helped in identifying potential hazards and likely difficulties in laying and maintaining pipeline as also selecting proper alignment.

INTRODUCTION

Pipelines are essential component of network in transportation of bulk liquid material. In the recent years, the size, numbers and the applications of offshore pipelines have been steadily increasing. The major need being bulk transportation of oil and gas from offshore platform to shore through submerged pipelines. Another widespread application of pipelines is in the disposal of municipal and industrial wastes in rivers, lakes and ocean. A marine pipeline is a highly unusual structure as they are placed on unprepared foundation (PALMER and BROWN, 1980). The design criteria and planning aspects of a submarine pipeline depend on many factors such as the type of pipeline, (i.e., steel or HDPE), diameter, nature of surface coating to provide weight and protection from corrosion, scouring of foundation, internal and external stresses developed likely cause of damages etc. All such factors may vary from place to place and case to case and therefore no general guidelines can be drawn up. Various investigations, like deciphering hydrodynamic regime, (i.e., prevailing currents and waves); environment and geological conditions (i.e. topographic and bathymetric variations), type, thickness and geotechnical properties of sediments are required for planning and designing pipelines

and selecting its route. Integrated, high-resolution marine geological and geophysical surveys are required to obtain necessary data on prevailing geological environment and seabed characteristics. Such surveys are also needed to identify probable hazards/difficulties likely to occur while laying. The cost of site survey is negligible in comparison with overall cost of the project and correct planning of the survey at this stage can save vast sum of money at a later date (Davies 1980).

The present paper highlights the methods, equipments and significance of geological and geophysical surveys in selecting submarine route by discussing a case history from Manori creek, Bombay.

The Municipal Corporation of Greater Bombay (MCGB) considered laying a pipeline for drinking water supply from Malad side to Manori village, about 500 m length of which was required to cross Manori creek (Fig 1). Marve is a good fishing harbour with infrastructure facilities like road, public transport etc. with the creek entrance providing an excellent shelter for boats and also there exists a good jetty with a regular ferry service for Manori.

Previous Work HERBICH, (1981) has discussed in detail the forces effecting offshore pipelines, scour protection and related environment factors. Various aspects such as installation, trenching, connection, positioning and repair of submarine pipelines with emphasize on design criteria and pipe selection and need of marine survey have been discussed by MOUSELLI (1981).

PAULOS (1988) has discussed foundation requirement in relation to various types of offshore structures, effects of soil behavior and seafloor stability. The extent of scour that can take place around a submarine pipeline and possibility of natural self burial are discussed by LEEUWESTEIN (1985).

SIDDIQUIE et al (1985) and BHATTACHARYA et al (1981) have reported the implications of high resolution marine geophysical surveys with special reference to selecting route for submarine pipeline from Bombay High oil fields to Hazira in Gujarat and to Bombay Harbour. RAJU and VORA (1987) have discussed the techniques to inspect the exposed pipeline on the seafloor.

METHODS

Position fixing at sea is of vital importance. It is extremely necessary that an accurate and reliable position fixing system with a good repeatability be deployed while collecting data. Accordingly, a Motorola Miniranger III system was installed temporarily on a 15 m long survey boat.

Echosounding provides continuous depth profile of the seabed. An Atlas deso - 10 echosounder was used for survey having basic scale of 0 - 20 m and maximum range of 280 m. A downward facing transducer, controlled by a recorder onboard, transmits the sound pulses at 30 and 210 KHz frequencies which get reflected and refracted at water-sediment interphase and are received and recorded by the recorder. A tide pole was set up at Marve jetty to observe tidal height during the survey period for applying tidal corrections. Side-scan sonar essentially provides a plan view of seafloor. The topographical and lithological variations on the seafloor are represented on sonographs in the form of tonal variations. The transducers are fixed on either side of the tow-fish which can scan from 25 to 500 m on both sides of the survey track. The microprocessor controlled system corrects automatically for speed and slant range. The image so produced provides much needed supplementary information on a geomorphic feature for the echosounding data which provides variation in vertical direction.

An ORE shallow seismic profiling system was also used at Manori creek which is similar to echosounding, the major difference being operating frequency which is 3.5 KHz in this case for better

penetration. The sound waves at this frequency penetrate subbottom and provide information on type and thickness of the sediments. There are various other technical improvements like signal processing and time varied gain for better resolution.

The surficial soil samples were collected using a van veen grab (area 0.04 m^2) from selected locations, after careful scrutiny of the data collected. The sediment samples are 'truths' necessary for proper analysis and interpretation of indirect underway data. They are also useful in preparation of sediment distribution map of the area.

RESULTS

20 tracks parallel to the creek and 6 tracks across the creek were surveyed concurrently with echosounding, side-scan sonar and sub-bottom profiling. The depth in the survey area varied from 0.8 m above chart datum to 6.6 m below the chart datum. Most part of the survey area, however, lies within 0 - 2 m. As the survey timings were generally coincided with flood tide timing, it was possible to survey very shallow area lying above the chart datum. General gradient observed in the area is 1:90 towards south where the creek joins the sea and water depth increases.

The geomorphological features observed in the area are 2 - 4 m deep channel on western side, occurrence of a shoal associated with channel and an escarpment near Manori jetty where water depth decreases from $>6 \text{ m}$ to $<2 \text{ m}$ (fig. 2).

Sonograph from the area indicate that the floor is generally carpeted by sand. From the other type of acoustic reflectance on sonographs (mostly from the axial part), it was inferred that the creek bed may be comprising of consolidated sediments or rocks in patches.

The isopach map (fig. 3), based on the shallow seismic profiles from the area, indicate that the penetration observed in the survey

area was generally in the range of 1 - 3 m. No sedimentation is noticed along the creek axis as the large part is anyway rocky. The western part of the survey area, however, shows more than 3 m of sediment deposition. On the other hands, the section along the eastern side clearly shows about 2 - 3 m penetration. Mostly, a reflector at about 1 m depth was consistent while second reflector which in most part represented acoustic basement, was at 2 to 3 m. The lensoid deposits were marked frequently in the profiles. In the axial area, perhaps sediment gets eroded away because of high energy flow of water due to narrowing of the creek. The area where no penetration was observed could be rocky or covered with coarse grained or hard consolidated sediments.

The collection of surface sediment samples was difficult due to strong currents prevailing in the area. Total 9 grab samples were collected which comprised of coarse sand with shells or fine sand except at one location where rock piece was collected.

DISCUSSION

The study clearly depicted the geological conditions The prevailing in the area. Though the original route suggested (AB in fig. 2) is shortest, after scrutiny of bathymetric and isopach maps (fig 2 and 3) it is evident that this route had to pass through large variations of depths and steep gradient over the area which is practically devoid of sediment cover. Pipeline along this alignment will also be affected by fishing activity and ferry route, and likely to be damaged by anchors.

In view of the above it was necessary to find an alternative alignment based on the data collected during survey in the vicinity. About 400 to 500 m northward of the proposed route (i.e. along CD in fig. 2 & 3), the area has only about 1 m variation in depth except a small part at western end, and the isopach map indicates generally more than 3 m of sediments along the alignment. This sediment cover would be sufficient to bury the pipeline to prevent

any accidental damages. Also no indication of rock outcrop has been observed here and the area is also quite upstream to be disturbed by ferry or fishing activity, information which is critical in planning and designing pipeline.

CONCLUSIONS

The high resolution marine geological and geophysical data collected from the Manori creek has clearly helped in selecting a suitable route for laying a submarine pipeline route as also pointing out the likely hazards or difficulty in pipeline laying and stability besides providing general environmental information.

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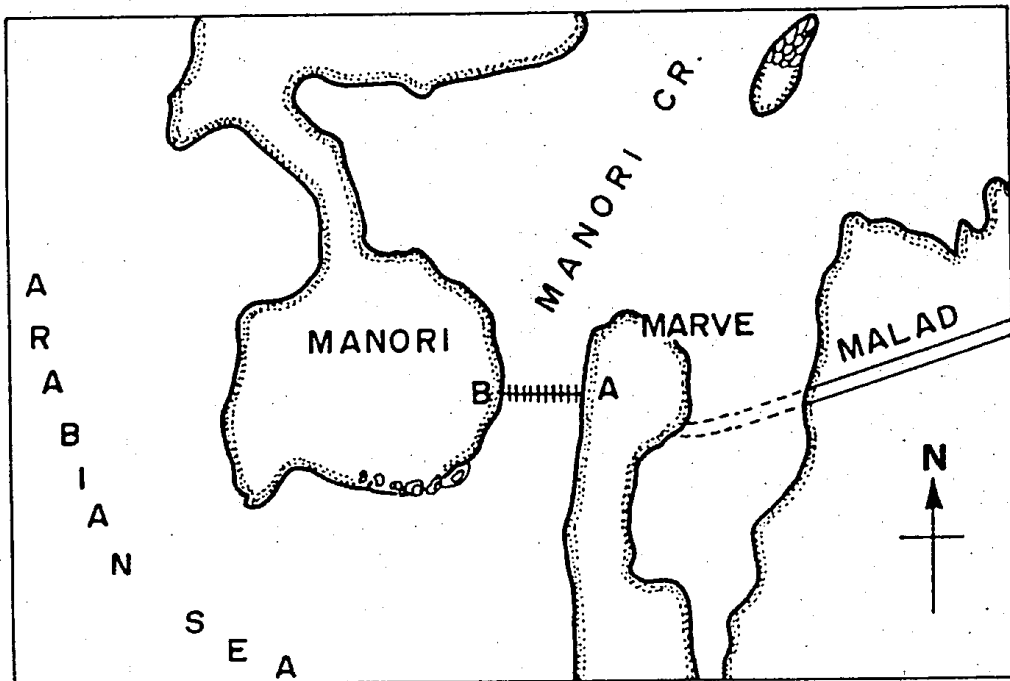


Fig.1 Location map showing the alignment of originally proposed route (AB)

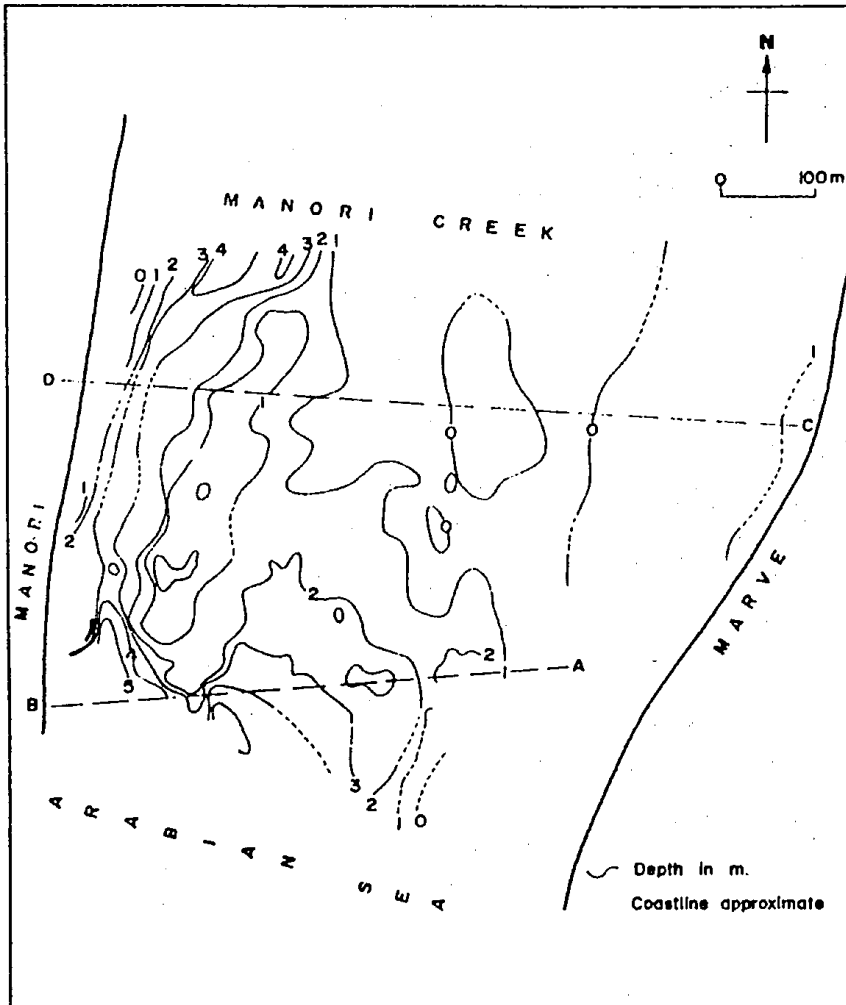


Fig.2 Map showing Bathymetry of the area (contour interval 1m.).
 Alignment AB is originally proposed while CD is proposed after
 this study.

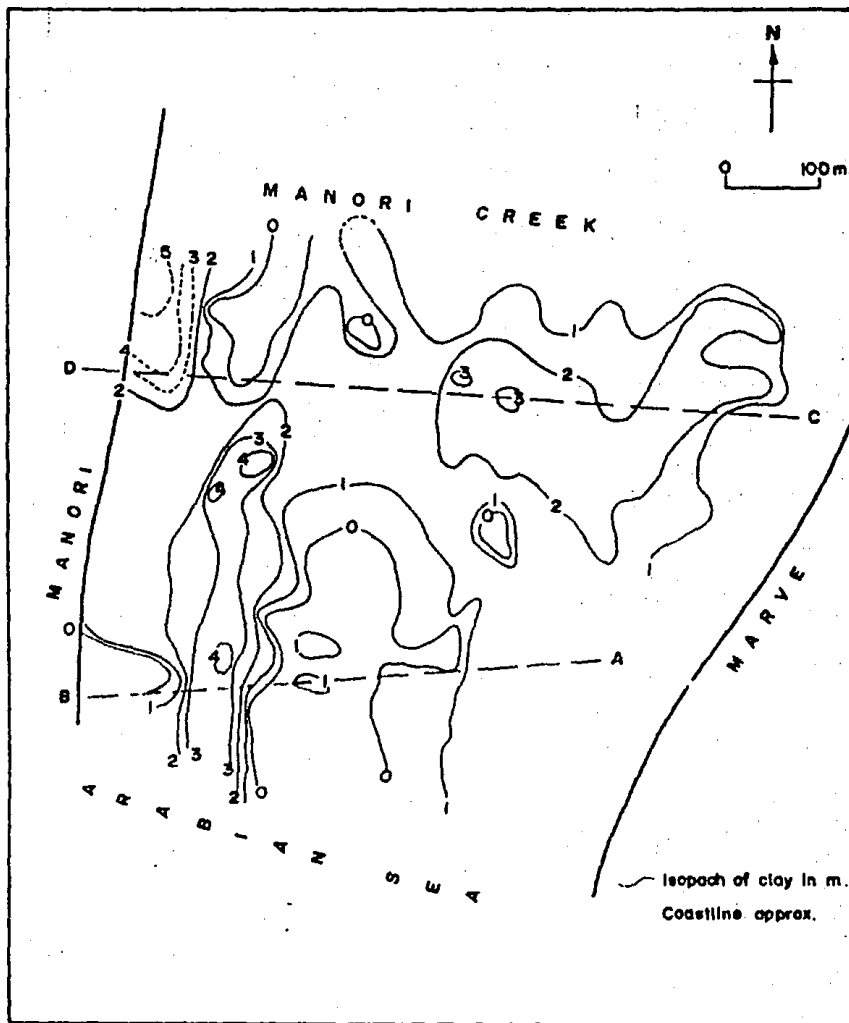


Fig.3 Isopach map showing thickness of soft sediments / clay in m.

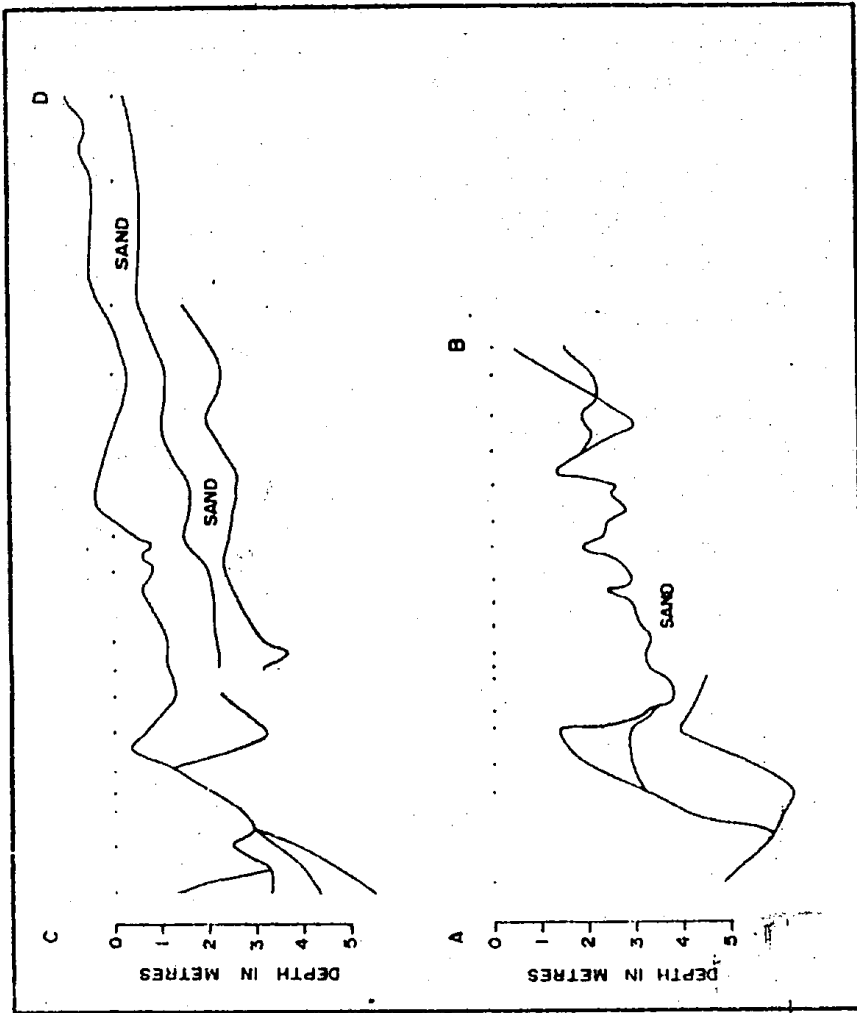


Fig. 4 Shallow seismic sections along the originally proposed alignment (AB) and suggested alignment (CD).