Chapter 3
3. DATA COLLECTION AND ANALYSES

The present investigation essentially involved the collection and analysis of nearshore wave data for a period of four years, synchronised recording of offshore and nearshore waves during mudbank and non-mudbank periods, collection and analysis of water and sediment samples, measurement of water temperature and currents and many laboratory measurements. This chapter presents the details of the instrumentation, field measurements, data analysis and the laboratory analytical techniques.

3.1 Location of Field Measurements

The location selected for the present study is off Alleppey (Fig.3.1), where mudbank is formed almost every year. The Coastal Laboratory established here monitors data on waves, breakers, currents, beach changes, sediments and meteorological parameters like wind, temperature and barometric pressure at regular intervals (Fig.3.2). The pier available here serves as a platform for the measurement of waves with direction, breaker parameters, currents, etc.

3.2 Wave Recording

The recording of waves in the nearshore is made using a pressure-type wave and tide telemetering system. The wave measurements in the offshore are made using a waverider buoy.

3.2.1 Nearshore wave recording system

The nearshore wave recording system (Fig.3.3) consists of a wave and tide telemeter (Sivadas, 1981), a wave recorder and other accessory units. The wave and tide telemeter in turn comprises of an underwater transducer, cable
Fig 3.1 Area of Study
Fig 3.2 General lay-out of the Alleppey Coastal Laboratory indicating the scheme of measurements.
Fig 3.3 Nearshore wave recording system
and monitoring units. The transducer has a stainless steel pressure-responsive bellow with a plunger core at one end (Fig.3.4). The core moves inside an electrical coil producing changes in inductance of the coil proportional to the water level variations. The coil is connected to the monitoring unit by a 2-core cable. The bellow and coil are kept in a protective casing. The incoming signal is passed through a wave and tide separator, which separates out the low frequency tidal fluctuations using a low pass filter. The wave output is recorded on a paper chart recorder. The frequency response of the system (Fig.3.5) has been checked for a wide range of conditions and it is found that this is greater than 95% for wave periods > 3 s. The response is nearly 100% for periods above 5 s.

In the present case, the transducer of the recording system was installed 3.5 m below water level at the end of the pier, where the depth is 5.5 m. The cable was laid over the pier. Typical nearshore wave records collected using this system during pre-mudbank and mudbank periods are presented in Fig.(3.6).

3.2.2 Waverider system

The Datawell waverider system (Fig.3.7) consists of a moored buoy which transmits wave data and a WAREP receiver, which receives and records the data on paper charts. The signals sensed by an accelerometer housed in the buoy (Fig.3.8) is double integrated to obtain vertical displacement and the wave profile information is sent through a WHIP antenna in 27-28 MHz frequency band. The waverider gives 100% response for wave periods between 2 and 10 s and it is above 95% up to 18 s (Fig.3.9). Thereafter the response decreases.
Fig. 3.4 Transducer of wave and tide recorder (Cross section)

Fig. 3.5 Frequency response diagram of wave recorder
Fig. 3.6 Typical nearshore wave records: (a) before mudbank (b) during mudbank
Fig. 3.7 Waverider buoy
A transmission range of 50 km is obtained over sea if the man-made noise level at the receiving site is low and the wave height is less than 10 m. These signals are received by WAREP and recorded in the manual or automatic mode. In the automatic mode there is facility to record data for durations of 5, 10, 20 and 40 min at intervals of 1, 2, 3, etc. hrs. as per requirement. The waverider buoy is being deployed at an offshore location well beyond the mudbank area. This location normally had a depth of about 7m (Fig.3.10).

3.3 Other Field Samplings and Measurements

To facilitate measurements and collection of samples from within the mudbank, a temporary self-supporting platform of length about 3m is erected at the pier end. Collection of water and sediment samples and measurement of current are done from this fixed station during different stages of mudbank. Here the average station depth is 5.5 m. Water samples are collected from surface and 1, 2, 3 and 4 m depths using a Nansen reversing bottle or Van Dorn water sampler depending on the current velocity and suspended sediment concentration. The temperature measurements of the water samples from the above depths are also made. Suspended sediment concentration and salinity are determined for each sample in the laboratory on the same day of sample collection. The water samples for analysis are stored in polythene bottles, previously rinsed with 5% HCl and then with distilled water. Surface sediment samples are collected using a Van-Veen grab. Measurements of coastal currents are done using a direct reading current meter (model SEA) from different depths. Measurements of longshore current are done using neutrally buoyant floats in the breaker zone by measuring the alongshore distance travelled by the floats in specific time intervals. The fluid mud samples are collected using Nansen reversing bottle or Van Dorn water sampler, depending on the current...
Fig. 3.8 Cross-section of the waverider buoy

Fig. 3.9 Frequency response of waverider
Fig. 3.10 Wave recording sites and sampling stations
conditions, during mudbank period for viscosity, bulk density, and water content determination and for textural and mineralogical studies.

In addition to the daily collection and measurements from the platform, all the samplings and measurements described above are made once at different stations inside and outside the mudbank. The sampling stations are shown in Fig.(3.10).

3.4 Analyses

3.4.1 Analysis of wave records

The wave records collected are subject to two types of analysis - Tucker and spectral methods.

3.4.1.1 Tucker analysis: The simple, fast and reliable wave record analysis procedure recommended by Tucker (1963) and modified by Silvester (1974) consists of the selection of 12 min record strips followed by measurement of the highest (A) as well as the second highest (B) crests and lowest (C) as well as second lowest (D) troughs with respect to a mean line (Fig.3.11). Then the total number of crests \(N_c\) and zero-up-crossing waves \(N_z\) in this record are counted. The zero-up-crossing period \(T_z\) is derived from this. The different wave height parameters like \(H_s\), \(H\), \(H_{1/10}\), \(H_{rms}\) which depend on \(H_1\) ( = A+C), \(H_2\) ( = B+D), \(N_z\) and are derived as recommended in Silvester (1974).

3.4.1.2 Spectral analysis: Two different methods available for the spectral analysis of wave records are the auto-covariance method (Blackman and Tukey, 1958) and the Fast Fourier Transform (FFT) method. The faster FFT method is used in the present case. A Hanning window is used for smoothing.
Fig. 3.11 Scheme of Tucker analysis of wave records

Zero up-crossings

Crests
Since the chart paper speed could not be maintained uniform for both types of records, the digitization interval varied slightly in view of the convenience of digitization, which had to be carried out manually. While the digitization interval is 0.6 s for the pressure records, it is 0.5 s for waverider records. The waverider records collected from outside the mudbank and the corresponding nearshore pressure records are digitized for 2048 data points. The rest of the nearshore records, which are not used for any comparison with offshore records is digitized with 1024 data points.

3.4.2 Comparison of performance of waverider and pressure recorder

In the present investigation since the data derived from two different systems are to be used, their comparability had to be established. A comparison of relative performance of the two systems carried out by Kurian and Baba (1986) proves the comparability of the two systems for the major part of the gravity wave spectrum when the attenuation correction for pressure recorder data are suitably applied. The salient results of Kurian and Baba (1986) are reported below.

(i) The major uncertainty in the use of pressure recorder data is related to the pressure attenuation correction required for the wave height. The pressure attenuation correction formula used is,

\[ H = H'K \cosh \left( \frac{2\pi d}{L} \right) / \left[ \cosh \left( \frac{2\pi d}{L} \right) (1-z/d) \right] \]  

where \( H \) and \( H' \) are the corrected and uncorrected wave heights respectively, \( z \) and \( d \) are the transducer and station depths respectively, \( L \) is the wave length and \( K \) is the instrument factor. The wave height parameters of pressure recorder corrected for pressure attenuation using

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average period and without the instrument factor gives the best comparison with waverider heights.

(ii) The spectrum from the pressure recorder is corrected for attenuation using the relationship

\[ S(f) = S'(f) \frac{\cosh 2\pi d/L}{\cosh 2\pi d/(L(z+d))} \] ....(3.2)

where \( S'(f) \) and \( S(f) \) are the uncorrected and corrected pressure spectrum respectively. The wave spectra obtained from both the pressure (corrected for pressure attenuation) and waverider records compare well.

3.4.3 Wave refraction analysis

In connection with the present investigation, wave refraction analysis is carried out for the coastline extending from Quilon to Cochin for different deep water wave characteristics. A numerical model recommended by Kurian (1987) based on the refraction programme by Dobson (1967) is used. The refracted wave height is

\[ H = H_o K_r K_s K_f \] ....(3.6)

where \( H \) is the refracted wave height, \( H_o \) is the deep water wave height and \( K_r, K_s \) and \( K_f \) are the refraction, shoaling and friction coefficients respectively. The model has the provision for the simultaneous usage of two depth grids, one coarse offshore grid and another fine inshore grid. In the present analysis only one grid is used since the fine scale bathymetric charts for the nearshore area was not available. Since the purpose of the present analysis is only the identification of the zones of convergence and divergence, the accurate computations in the nearshore zone employing the fine scale grid is not a must. Due to the same reason no friction factor is used in this analysis.
For preparation of depth grids, the Naval Hydrographic Charts nos. 220 and 221 were used. The procedure followed for computation of depths at grid points from the irregularly spaced soundings in Charts is as given in Kurian (1987). The depth grid covered an alongshore extension of about 200 km, with a grid element of 1.78 km from Quilon to Munambam. Wave orthogonals with a deep water spacing of 0.5 km were computed for predominant periods 8, 9 and 10 s and directions of 240, 270, 280 and 300° N. The refraction diagram so prepared are used for the identification of zones of convergence and divergence, which are important in the case of mudbank formation.

3.4.4 Estimation of suspended sediment load

Suspended sediment load is determined following the gravimetric method. Pre-weighed membrane filter paper of pore size 0.45 μm and diameter 47 mm is used for this purpose. A filtering unit along with suction pump is employed for the filtration. Samples of volume 900-1000 ml are filtered. In order to remove the error due to salt in the residue, distilled water of volume 50 ml each is poured 3 times after the filtration of each sample. The filter paper with the residue is transferred to a petri dish and kept in room temperature for drying. The initial and final weights are taken to an accuracy of 2 decimals of a milligram. In order to apply correction for the probable loss of weight of the filter paper during filtration, the filtration procedure described above is repeated with the filtrate in 3 cases and the average loss of weight is applied as correction to the value of each sample.

3.4.5 Salinity determination

Salinity of each water sample is determined on the filtrate of each sample by Mohr's volumetric method. The silver nitrate used was standardized using standard sea water.
3.4.6 Viscosity measurement

The viscosity of the fluid mud samples are measured using Brookfield HBT viscometer (Fig.3.12), which consists of a motor, gear train, torque pointer, calibrated spiral spring, spindle, etc. The motor and the gear transmission are at the top of the instrument inside the motor housing. The main case of the viscometer contains a calibrated spring, one end of which is attached to the pointer while the other is attached directly to the dial. The dial is driven by the gear transmission and in turn, drives the pivot shelf through the calibrated spring. Below the main case is the pivot cup through which the lower end of the pivot shaft protrudes. A bearing inside the cup rotates with the dial; the pivot shaft rides on this bearing at the pivot point. The viscometer measures viscosity by measuring the force required to rotate a spindle in a fluid. The Viscometer has 8 rotating speeds from 0.5 to 100 rpm in eight unequal increments and a maximum driving torque of 57496 dyne-cm.

The spindles are made of stainless steel with different diameters. To measure the viscosity, an appropriate spindle is selected and hooked it to the viscometer, such that the torque readings are not too small to lose accuracy or too large to exceed the maximum capacity of the driving spring. The spindle is suitably centered in the sample container and immersed to the mid-point of the shaft's narrow position. A motor speed is selected and when the motor starts to turn, the torque builds up in the driving spring since the spindle motion is resisted by the fluid. The displacement of the pointer in dial scale gives the shear stress. Viscosity is calculated from this reading by multiplying with the factor for the corresponding rpm and spindle.
Synchronous Motor

Housing

Gear train

Dial

Calibrated Spiral Spring

Jewelled Bearing

Pivot Shaft

Pivot Cup

Immersion Mark

Spindle

Sample Container

Fig. 3.12 Skeletal structure of Brookfield viscometer
3.4.7 Sediment analysis

The grain size of the fluid mud sample is determined using Sedigraph 5000D Particle Size Analyzer. In this the sedimentation velocity of the particles in a homogeneously dispersed slurry under gravitational force using a collimated beam of x-ray is measured. The particle size is determined from the sedimentation velocity.

Since the sedigraph cannot be used for grain size determination of higher grains, the particle size of surfacial samples are determined by pipette analysis method. In this method materials coarser than 63 is recovered by wet sieving. The residue is dried and weighed. The sediment washed off in the wet sieving is made up to a known volume with water and is placed in a tall cylinder. After stirring, the fluid is allowed to settle and during the settling 20 ml samples of the suspension are drawn off in a repeatable manner from a fixed distance beneath the surface. The samples are then evaporated and weighed. The residue represents the total amount of sediment finer than a particular size in suspension. This size is related to the settling velocity of the grains and the time of sampling. The velocity is calculated from Stokes' law assuming that the grain density is 2.65 g/cm³. The results, combined with sieve analysis of the sand fraction gives a complete grain size distribution.

3.4.8 Mineralogical study

The mineralogical assemblages of surfacial and fluid mud samples are examined by x-ray diffraction method. Air-dried powdered samples are scanned from 2° to 30° 2θ at 2° min⁻¹ with CuK radiation. The major clay minerals are identified by computing its inter-planar spacing from its principal reflections. Kaolinite is identified by its reflection at 7.15 and 3.57 Å, montmorillonite 14Å, illite 10Å and gibbsite 4.9Å. The relative proportions of the clay miner-
als are determined by measuring the area of their principal reflections. The percentages of major clay minerals are thus determined. Even though a true quantitative evaluation of clay minerals are not possible by this method, a reasonable good approximation of clay minerals can be obtained.