CHAPTER ONE HUNDRED TWENTY THREE

FIELD INVESTIGATIONS IN THE TOW STUDY PROGRAMME FOR COASTAL SEDIMENT TRANSPORT IN THE NETHERLANDS

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ABSTRACT

Field campaigns were conducted in 1981 and 1982/83 on the Dutch coast near Egmond. Measurements were made of surface elevations, water velocities and sediment concentrations in 3 to 8 surf zone locations and 2 to 5 offshore locations simultaneously. A total of 50 measurement series was obtained under a variety of weather conditions, resulting in offshore wave heights of 0.2 to 4.6 m. A description is given of the field set-up, the instruments and measurements, and the collected data. The quality of the various measurement systems and the data produced has been investigated extensively by intercomparison of instruments and devices in the field. The results are reported here.

1.0 INTRODUCTION

The TOW Study Programme for Coastal Sediment Transport in the Netherlands aims to improve our knowledge of the phenomena governing the sediment transport in the coastal zone in order to develop methods for a detailed and accurate prediction of the coastal morphology. The TOW Programme is financed by the Dutch Government. The organization of the Programme is a joint effort of the Public Works Department (Rijkswaterstaat), the Delft University of Technology and the Delft Hydraulics Laboratory. The Programme includes theoretical studies, laboratory investigations and investigations in the field. The different subjects are covered by 8 task groups.

Within the above framework the Field Experiments Task Group has sofar conducted two field campaigns on the Dutch coast. In this paper a summary is given of the objectives, the set-up of the campaigns, the instruments involved, the measurements, the collected data, the data analysis and the quality of the data as measured by the instruments under different conditions.

2.0 OBJECTIVES

The collection of simultaneous data on waves, currents and sand transport phenomena in the nearshore area requires an extensive measurement system. No sufficient information was available on the requirements for the well functioning of such a system as a whole. A general objective of the present study was to test such a measurement system in nature in order to study the functioning of the different

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Photo 1 Surf zone measurement stations 1982/83 campaign

Photo 2 Close-up of surf zone measurement station

parts of the systems. Execution of measurements had to be possible during conditions of windforce 8 Beaufort and higher. The constructional provisions had to be sufficient for the safe exposure of the measurement set up to the conditions present at the Dutch coast during the winter season. Occurrence of storms of windforce 10-11 Beaufort is normal then.

In detail the objectives of the field investigations can be distinguished as follows:

- collection of data to study the hydraulic and morphologic phenomena in the nearshore areas of the coast.
- collection of data to study the functioning of devices and instruments for the measurement of wave heights, waterlevels, currents, sediment concentrations and bottom configuration under various conditions inside and outside the surfzone.
- testing of the system for data acquisition and data analysis at the site.
- testing of the various constructional provisions.
- collection of experience in the execution of field campaigns.

The latter 4 objectives were covered by the Field Experiments Task Group. The study of the hydraulic and morphologic phenomena is being covered by the other task groups in the TOW programme.

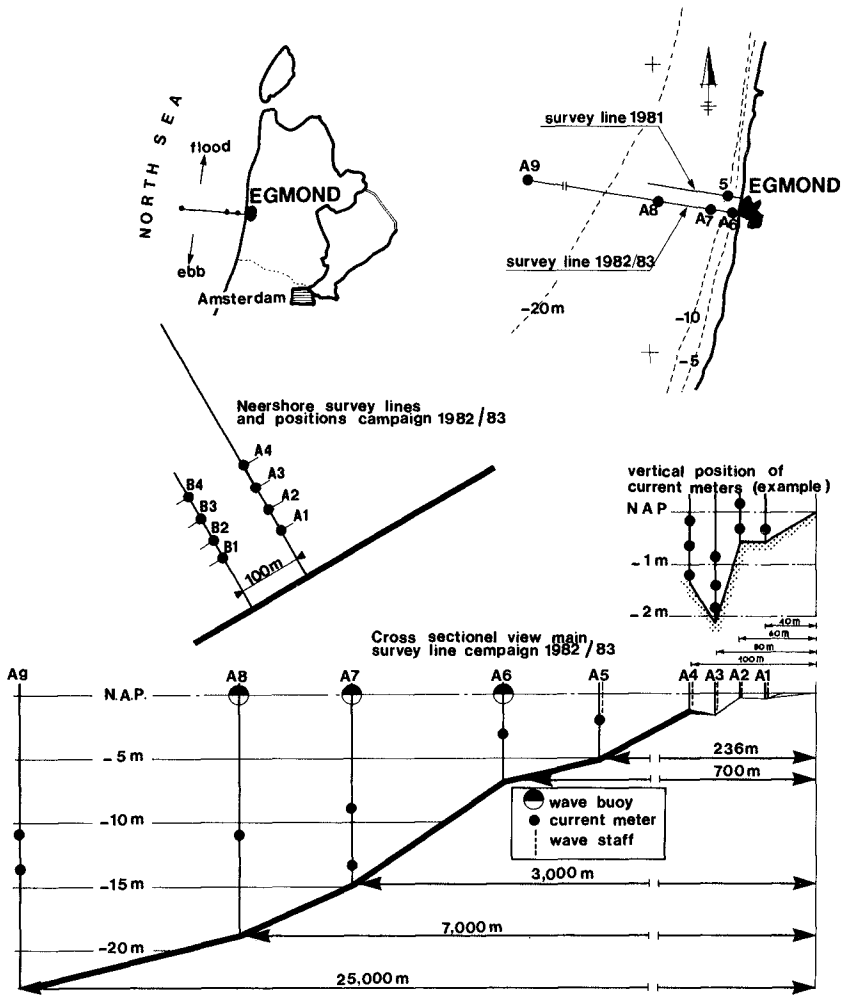


Fig. 1 Location and measurement set-up

3.0 FIELD CAMPAIGNS

3.1 Set-up

Both field campaigns were conducted on the Dutch coast near Egmond. The location near Egmond was selected because of its relative uniformity in bottom topography and hydraulic conditions alongshore. The first campaign was held in May and June 1981 during relatively calm weather conditions. The second campaign was held from September 1982 to January 1983 when weather conditions were relatively rough.

Simultaneous measurements of surface elevations, velocities and sand concentrations were carried out along a main survey line perpendicular to the coast. In the 1981 campaign 3 surf zone stations and 2 offshore stations were present. In the 1982/83 campaign 4 surf zone stations and 5 offshore stations were installed, while also a second survey line was added 100 m south of the main line with 4 additional surf zone stations (see Fig. 1). The surf zone stations consisted of a working platform on scaffolding, lightly constructed of steel pipes that had been driven into the bottom by fluidizing the sand. From the platforms the instruments could be installed on sensor piles. The platforms were mutually connected by a foot jetty, which was also used for the cable connections with the shore. An impression may be obtained from Photos 1...4. In the offshore region instruments were either placed on or moored to the bottom. In this case signals were transmitted to the shore by radio, with the exception of self-recording tidal current meters. Data acquisition was done directly inshore of the main survey line in a facility of portable cabins by means of a HP 1000 computer and subsystem.

3.2 Instruments and Measurements

Whether an instrument meets the measurement requirements, in general, will have to be judged on the data produced by that instrument under the desired conditions. In this respect a problem arises when no representative data measured by other instruments are available, such as is the case with data collected in the surf zone during a severe storm. By means of theory the order of magnitude of a phenomenon can be estimated. It is also possible to calibrate instruments under controlled conditions which are a close approximation of reality. However, the confidence that a signal produced by a device is sufficiently representative can only be based on information provided by the measuring practice itself.

Therefore the instrumental set-up is chosen in such a way that the data collection is done under a great variety of external conditions, whereby the variety of positioning is small and the signals are measured simultaneously by as many instruments as possible.

By intercomparison of signals collected by identical instruments the variability of a certain phenomenon with place can be determined. Hereafter intercomparison of signals collected by non-identical instruments can give information about the influence on the representation of signals caused by other factors specifically those related to the measuring principle of the instrument. Finally, the general review

Photo 3 Surf zone stations under storm conditions at intermediate tidal level

Photo 4 Surf zone stations under storm conditions and at high tidal level

of the results of all measurements of this kind provides an impression of the reliablility of the representation of a signal by a measuring device under certain conditions.

The phenomena of interest in the conducted field campaigns of 1981 and 1982/83 are:

- surface elevations;
- mean waterlevels;
- instantaneous watervelocities in the surf zone;
- mean current velocities outside the surf zone;
- sand concentrations in the surf zone;
- bottom topography.

Surface elevations were measured by means of Plessey wave staffs and Data Well waveriders. Common aspects of the functioning of both instruments are unexpected disturbances of the measuring signal, zero stability, response of instruments under several wave conditions. With respect to the Plessey wavestaff the effect of the presence of a protective pipe mounted around the staff was studied also.

Absolute values of the mean water level were measured by means of Plessey wave staffs, Vega pressure sensors and a TPD tidal recorder. Point of interest is the inter-exchangeability of the values. Relative values of the mean waterlevel were measured by DAG 6000 self contained pressure meters.

Instantaneous water velocities were measured by means of the following instruments

- Marsh McBirney (USA) - electromagnetic current meter
- Colnbrook (UK) - electromagnetic current meter
- NSW (GFR) - electromagnetic current meter
- Vector Akwa (Neth) - acoustic pulse travel time current meter
- ASTM (Neth) - acoustic doppler shift current meter.

The following aspects being characteristic for the functioning of the instruments in the surf zone were studied:

- representation of velocities by different meters under various conditions
- effects on the representation of velocities under high concentrations of entrained air and sand particles
- characteristics of the represented velocities in situations when the sensor is subject to sudden transitions of air to water and vice versa (measurements in passing wave crests)
- representation of velocities during measurements in one vertical in 5 points simultaneously
- effects on the measurement of the horizontal velocity signals caused by interaction of the vertical velocity component and the shape of the probe.

Mean current velocities outside the surf zone were measured by NBA and Flachsee underwater current meters usually in one point in the vertical. In one location the distribution of the mean velocity in the vertical was studied by means of two current meters.

Sand concentrations were measured by means of a suction sampler system and the ASTM acoustic backscatter meter. One point of interest is to know the conditions for the correct functioning and calibration of both instruments. A large number of practical aspects of the functioning still has to be cleared. Another important aspect is to have sufficient knowledge of the processes involved in the variation of the sand concentration over time and depth. The ASTM is capable of producing instantaneous values of the sand concentration measured in a point.

The bottom configuration was measured periodically by levelling (by foot) and echosounding (by boat). From this system no detailed information about instantaneous changes of the bottom topography in time and place is obtained. Therefore, echosounding equipment of 1 MHz working frequency was installed in the measuring locations in the surf zone and its capability of producing additional information about the instantaneous local bottom elevation was studied.

Directions of wave crests inside the surf zone were measured by video recording the wave field in the surf zone using a reference system for the wave crest positions. Information about the direction of breaking wave crests can be obtained from the images by determining the angles made by the passing wave crests.

4.0 COLLECTED DATA AND DATA ANALYSIS

Data acquisition was done at the site by means of a HP 1000 computer and subsystem. This computer was implemented with facilities for data analysis techniques. Also facilities for plotting of the results were available. The availability of data analysis and plotting facilities at the site proved to be an essential part in checking the quality of the measured data. Already at the site a start was made with a selected number of time series analysis which serve as an inventory of the collected data. The total volume of work involved in making this inventory was such that the greater part was done at Delft Hydraulics Laboratory on the same HP system after the ending of the measurements.

The total number of instruments used during the 1982/83 campaign was 34. The total number of measurement series of both campaigns amounts 52. The measurement series are varying in duration from 40 minutes to 13 hours. The weather conditions vary from calm weather to windforce 9 Beaufort, and there is variation in the number of instruments and their distribution over the different measuring positions. The collected data are inventorized in Derks (1982, 1983). A summary of the collected data is given in the table below.

campaign	number of measurement series	duration of measurement series	number of parameters	offshore significant wave height
1981	5	5 hours	20-25	0.2-1.5 m
	20	30-45 minutes	10-20	0.3-2.5 m
1982/83	17	1- 3 hours	10-20	0.3-2.5 m
	10	3-13 hours	35-45	0.2-4.6 m

Table 1 Collected data

Analysis of the collected data is principally carried out by and under responsibility of the different task groups. Current study aspects are wave energy decay between 3 km offshore and the beach (see Battjes and Stive, 1984), low frequency velocity characteristics (see Gerritsen and Van Heteren, 1984), wave driven currents and sediment transport in the horizontal plane (see Boer et al, 1984) and wave kinematics and directionality (see Van Heteren and Stive, 1984). An important aspect is the assessment of the quality of the data as measured by the various measurement systems. Since there are no absolute standards, in general, a judgement of the performance of instruments and devices must be made by intercomparison of signals. As described above this aspect was covered in the set-up of both campaigns. The evaluation was conducted by the Field Experiments Task Group and is reported in Derks (1982, 1984). A summary of the results is given in the following section.

5.0 PERFORMANCE OF MEASUREMENT SYSTEMS

5.1 Surface Elevations

In deep water, at distances of 700, 3,000 and 7,000 m offshore, surface elevations were measured by means of Data Well wave riders, floating vertical accelerometer buoys moored by an elastic cable. During the Egmond measurements it was noted that disturbances of the signal occurred during high sea. Under these conditions the radioconnections could be interrupted by capsizing of the buoy. No data are available for intercomparison of the buoys with other measurement systems.

In shallow water up to distances of 250 m offshore, surface elevations were measured by means of Plessey wave staffs, resistance staffs mounted at fixed positions. The signal produced by this instrument showed a lot of irregularities during the measurements. Spurious peaks of large steepness and amplitude and sudden changes of the mean signal level occurred. During the 4 months measurements the calibration factors also showed a significant variability. In general wave height distributions and spectra could be determined by careful screening of the signals and by eliminating the peaks on basis of their steepness.
Intercomparison of the results determined by the Plessey wave staff and the Vega pressure meter at positions with a local depth of 1-2 m showed that the pressure is not hydrostatic. Cross spectral analysis shows that the coherence value is very close to 1 at the frequency range from 0-0.5 Hz, while the gain value over this range drops almost

linearly from 1 to 0. The presence of the perforated protection pipe resulted in 10% lower values of the significant wave height ($H_{1/3}$) although the total variance of the signal is not influenced.

5.2 Mean Water Level

Comparative measurements were made with the Plessey wave staff - Vega pressure sensor and the Plessey wave staff - TPD tidal recorder in combined positions. As a consequence of the irregularities shown by the wave staff signal and the large variability of the calibration factors, no correct water levels could be determined from the Plessey wave staff signal.

Other combinations of instruments were not studied. The signals measured by the TPD tidal recorder, the Vega pressure sensor and the DAG 6000 pressure sensor individually showed no irregularities.

5.3 Instantaneous Water Velocities inside the Surf zone

Criteria for intercomparison of signals

The functioning of a number of current meters in the surf zone was studied by intercomparison of signals produced by pairs of instruments. The instruments were placed on the same elevation. The mutual horizontal distance between the two instruments was varied up to a range of 2.50 m. The signals were measured in two or three orthogonal directions whose orientation was according to the direction of the main survey lines of the measurement set-up. The differences between a pair of signals produced by instruments in two different postitions however, are not fully due to the functioning of the instruments, but partially due to the spatial variability of the velocity signal. In order to be able to make a correct judgement this spatial variability was studied. This was done by intercomparison of signals produced by pairs of identical instruments.

The measurements were carried out with a pair of electromagnetic Marsh McBirney current meters and a pair of acoustic Vector Akwa current meters under a variety of conditions of wave height and water depth. As a consequence the differences in the concentrations of sand and air were relatively large.

The results of the measurements showed that the signals of the water velocity inside the surf zone in general have the following characteristics:

(1) the time averaged value of the velocity component parallel to the coast is relatively large while the variance of the signal is relatively small. In other words the velocity signal parallel to the coast has a relatively large static component and a relatively small dynamic component. The velocity signal perpendicular to the coast has just reverse characteristics.

(2) From the measurements with pairs of identical current meters it appears that the spatial variability of the velocity signal in the surf zone within a horizontal distance of 2.50 m is as follows (see also Fig. 2 for an example):

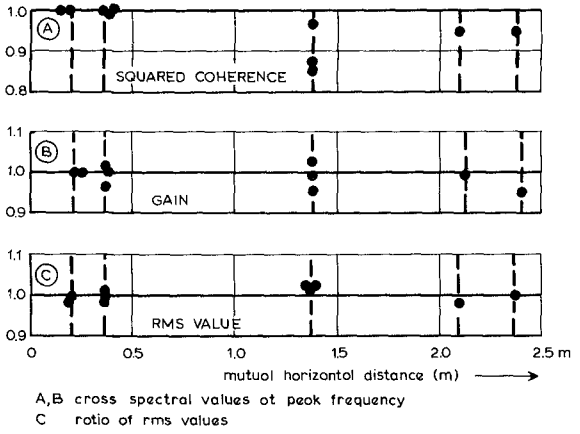


Fig 2 Spatial variability of onshore velocity derived from two closely spaced, identical Marsh McBirney current meters

basic characteristics	velocity component parallel to the coast	velocity component perpendicular to the coast
mean value	relatively small variation	relatively large variation
variance	relatively small variation	relatively small variation
coherence and gain between signals in the same direction	relatively small	relatively large

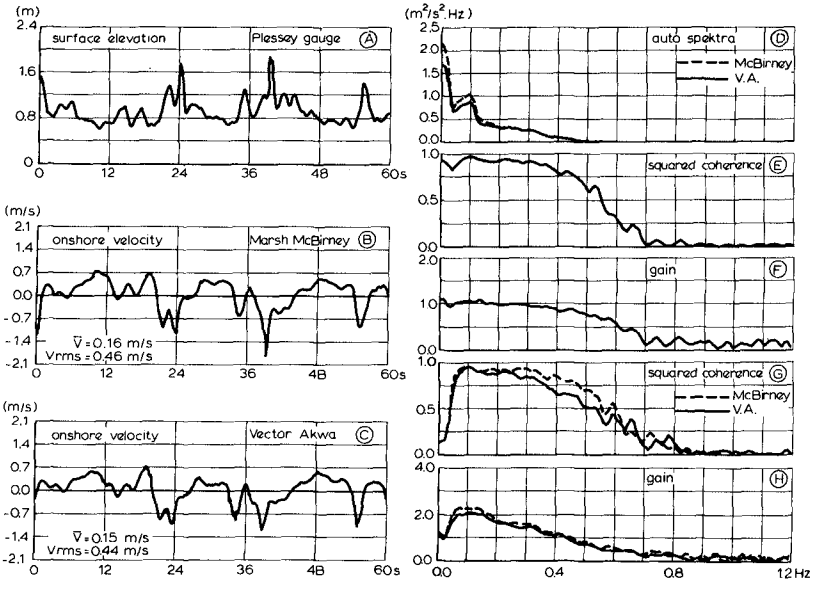
Most suitable for the intercomparison of signals produced by closely spaced current meters in the surf zone are those characteristics that show the least spatial variability with distance and the highest coherence and gain mutually. In this sense the coherence and gain of the velocity signals perpendicular to the coast, the mean value of the velocity signal parallel to the coast as well as the variance of the signals in both directions are the most suitable criteria.

The comparison of velocity signals provides a relative measure of the similarity between two velocity signals. Influences that affect both instruments equally, are not detected. A more absolute judgement of the quality of the measured signals can be obtained by means of the intercomparison of the separate velocity signals and the signal of the local surface elevations.

Representation of the velocity signals in the surf zone by different currentmeters

(1) In the present study information on the quality of the velocity signal in the surf zone, as represented by the different current-meters, is obtained in two ways:
   a) directly from cross spectral analysis between two velocity signals,
   b) indirectly from cross spectral analysis between the separate velocity signals and the local surface elevation.

From a) it appears that although the measuring principles of the inspected currentmeters in some cases may be very different, the represented signals are quite similar. It appeared that unless special conditions are present, the difference between two signals produced by non identical currentmeters is of the same order of magnitude as the difference between two signals produced by identical instruments.
The results of b) indicate that the currentmeters also in a quantitative sense give a good representation of the velocity signal. An example is given in Fig. 3. An illustration of the results that may be obtained is given in Fig. 4.



A,B,C recorded time series of surface elevation and onshore velocities
D,E,F cross-spectra between onshore velocities
G,H cross-spectra between surface elevation and onshore velocity

Fig 3 Intercomparison of closely spaced (1.70 m apart) current meters

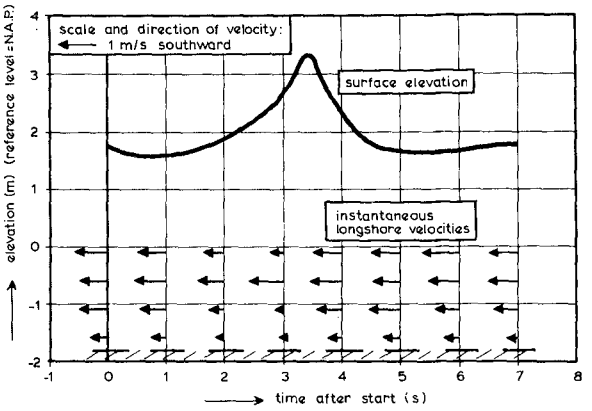


Fig. 4 Instantaneous longshore velocities and surface elevation

(2) Of the inspected current meters the Marsh McBirney electromagnetic current meter gives the best representation of the velocity signal in the depth region 0,2 m away from the bottom up to the wave trough level. The influence of high concentrations of entrained air and sediment in the water appears to be small. Disturbances of the signal were observed when the sensor was close to the sand bottom (< 0.2 m). Unless the instrument is provided with a special proximity execution (optional), disturbance of the measured velocity signal happens when the electromagnetic field of another electromagnetic current meter comes too close (distance < 0.50 m). When the sensor is positioned above the level of the wave troughs of the Marsh McBirney current meter seems to respond reliably.

(3) The representation of the velocity signal by the NSW electromagnetic current meter is equivalent to that of the Marsh McBirney current meter, however no data are available about characteristics of the represented signal when the sensor is positioned above the level of the wave troughs.

(4) The representation of the velocity signal by the Colnbrook electromagnetic current meter is not equivalent to that of the Marsh McBirney current meter. Although the coherence values calculated in the intercomparison of Colnbrook signals and Marsh McBirney signals are equivalent to the values calculated in intercomparison of signals from identical instruments, mean values, gain values and the variances show systematic differences. This may be caused by the instability of calibration factors. It is also recommended to check the exact position of the volume of measurement of the Colnbrook probe, since the disc-shaped Colnbrook probe, being different from the spherical probe of the Marsh McBirney, may generate an electromagnetic field of different

shape. From the calculated coherence values it could be seen that the shape of the signal represented by the Colnbrook current meter is hardly influenced by highly concentrated entrained air and sediment. When the probe is positioned above the level of the passing wave troughs disturbance of the Colnbrook signal occurs so the characteristics of the signal are not suited for measurement of velocity in passing wave crests. Also disturbances of the signal occur when the Colnbrook probe is positioned close to the bottom or close to the electromagnetic field of other instruments.

(5) The Vector Akwa acoustic current meter gives the best representation of the velocity signal in the depth region near the bottom. In the upper depth region the quality of representation is somewhat less compared to the Marsh McBirney current meter. This is probably caused by the presence of air bubbles. The influence of high concentrations of sediment on the representation of the signal by the Vector Akwa current meter is negligible. Strong disturbances of the signal occur during measurements in breaking waves when the sensor is positioned above the level of the wave troughs. Compared to the Marsh McBirney currentmeter, the instrument's response seems less reliable in this region.

(6) The representation of the velocity signal by the ASTM acoustic (doppler shift) current meter in general is equivalent to the Marsh McBirney current meter. It appears from the available data that the representation of the velocity signal by the ASTM current meter is not influenced by entrained air and sediment in the water. The applied range of measurement positions extends from 0.20 m above the bottom up to the surface level. In comparative conditions the ASTM current meter does not show any disturbances of the signal like the Marsh McBirney current meter in positions close to the bottom or like the Colnbrook current meter in positions close to the water surface. No information is available about the characteristics of the represented signal when the sensor position is above the wave trough level.

5.4 Mean Current Velocities outside the Surf Zone

Mean current velocities and direction of current outside the surf zone were measured by means of Flachsee and NBA automatic current meters. Comparative measurements between the instruments were not made. The mean current velocity was determined every 10 minutes. By means of the NBA current meter both mean values and instantaneous values of the current direction were recorded. By means of the Flachsee current meter only instantaneous values of current direction could be measured. Rupture of mooring constructions during rough wheather conditions may cause loss of instruments. In the present study 3 NBA current meters were lost this way.

5.5 Sand Concentrations in the Surf Zone

From the present study no clear conclusions appear whether the pumping system or the ASTM can be used for determining representative figures on the sand concentration in the surf zone. This was mainly

caused by the fact that during the measurements the knowledge about the sand concentration governing processes was insufficient. As a consequence it was not possible to indicate the requirements that had to be put on the measurement system. In the present study measurements were only done in single points. Intercomparison between results produced by the ASTM and the pumping system could not be made as it is presently known that only values obtained by averaging over the bed are useful for this purpose.

Generally it can be said that the pumping system in principal seems to offer a useful method for determining sand concentration values in the surf zone. From the point of view of measuring technique the system in its actual shape is not easily manageable during extensive measurements especially when the wheather is rough. Under these conditions it is desirable to have a continuous analog electric signal of the measured sand concentration. Also it is necessary to improve the reliability of the functioning of the pumping system. In its present shape the functioning of the system is too vulnerable.

From the present study it appears that concentration values over 100 kg/m^3 have to be measured. For the functioning of the pumping system these values are not critical. The ASTM however also needs to be adjusted for measurement of similar values. Unlike the pumping system the ASTM is capable of producing instantaneous values of sand concentration.

5.6 Bottom Topography

The present system for measurement of bottom topography consists of periodically levelling and echo sounding (by boat) of the beach profile in fixed lines. This system offers rather limited results. A dense net of highly accurate bottom positions determined at short time intervals cannot be obtained by this system. A structural improvement of the measuring system for bottom topography is not expected to be possible at short terms.

A contribution to improve the existing system is offered by using 1 MHz echo sounding equipment in fixed positions inside the surf zone. With this equipment the bottom elevation can be monitored instantaneously offering possibilities to study short term relations between local bottom elevation and other parameters. It appeared from the measurements that this system effectively can be used for detecting locally instantaneous bottom elevation in the surf zone at a higher accuracy than is possible by means of leveling or echo sounding by boat. Also, with this system measurements can be performed under conditions when the other systems can not be applied.

5.7 Wave Crest Directions in the Surf Zone

From the 1981 measurements it appeared that indeed it is possible to obtain information about the wave crest directions in the surf zone by means of the applied system (3.2). However, the system is selective as in the wave field only the crests of breaking waves can be distinguished. This implies that only information is obtained about

the direction of the breaking wave crests. Of course wave directions in the surf zone also can be obtained from the horizontal velocity vector and the surface elevation.

6.0 CONCLUSIONS

The 1981 and 1982/83 campaigns together yielded a total number of more than 50 measurements. The collected data are being studied in order to enlarge the existing knowledge and to improve theories of the surf zone processes.

In addition to the above mentioned study purposes the data have been used to investigate the accuracy of the representation of the measured signals collected by the different measurement systems. The conclusions of the latter study are as follows:

(1) On basis of the results of the present study it is possible to select and design systems for accurate measurement of instantaneous water particle velocities in the surf zone under conditions up to windforce 10-11 Beaufort. The measurement positions in the horizontal and vertical plane (including positions above the level of the wave troughs) can be freely chosen. It is necessary to check some minor matters concerning the functioning of the available current meters.

(2) The results of the present study are not sufficient to design a system capable of producing accurate values of the sand concentration in the surf zone that are representative for a certain time and place. In order to achieve such a system it will be necessary to improve the reliability of the functioning of the pumping system. Moreover it is necessary to have sufficient knowledge of the processes determining the sand concentration. The study on these aspects and the comparative study between the pumping system and the ASTM should be continued.

(3) The available system for the measurement of bottom topography produces periodic readings of bottom positions by means of echo sounding and levelling. Sufficiently detailed readings in time and place presently cannot be obtained by this system. The available 1 MHz echo sounding equipment can produce valuable additional information on instantaneous bottom elevation in a number of measurement positions. The study of the use of this equipment should be continued.

(4) It is recommended to study the accuracy of the available systems for the measurement of mean water levels.

(5) In the used system for measurement of surface elevations, consisting of moored Data Well wave riders and Plessey wave staffs mounted in fixed positions, disturbances of the signals occur. Problems related to the wave buoys possibly can be solved in combination with the selection of a measurement system for wave directions. It is recommended to use other wave staffs.

ACKNOWLEDGEMENT

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