La mer 27: 193-199, 1989
Société franco-japonaise d'océanographie, Tokyo

Operational experiences of Datawell waverider buoys*

S.G. DIWAN**, A.K. SURYAVANSHI** and B.U. NAYAK**

Abstract: The experiences gained by NIO, Goa since 1980 in the use of Datawell waverider buoys under the long-term wave measurement projects applicable to coastal and ocean engineering problems at nine locations along the west and east coast of India are briefly described in this paper. Information on waverider buoys, mooring, deployment and retrieval techniques, and the type of wave recording system used etc. are presented. Various operational problems associated with measuring and recording equipment, leading some times to loss of valuable wave data etc. have also been discussed. The damages occurred to waverider mooring system due to natural as well as man-made causes including remedial measures adopted have been briefly described.

1. Introduction

India has about 6000 km long coast line and many marine structures are expected to be installed in near future. Design wave is an important parameter which plays a major role in optimising the investment for such huge expensive project. Design wave and various important wave parameters can be obtained from the statistical and numerical analysis of the long-term data collected at the particular project site.

National Institute of Oceanography (NIO), Goa, initiated the comprehensive wave measurement programme in 1980. Fig. 1 indicates nine locations along the west and east coast of India where Datawell waverider buoys were deployed as a part of this wave measurement programme. From Table 1, it may be noted that a total of 25 waverider buoy deployments have been carried out at nine different locations, yielding 2199 buoy-days of operations at sea, out of maximum possible of 2348 buoy-days. This works out to an in-service percentage of 93.06 and the average duration of each buoy deployment is 87.96 days ranging between 6 days off Daman at initial stages to 291 days at Bombay High. The average buoy days per adrift comes to 244.3 days.

A moored waverider buoy is capable of operating unattended for long durations of 10 or 18 months at sea depending upon whether the buoy is 70 cm or 90 cm in diameter respectively. Waverider mooring lines were designed so as to withstand hazardous sea conditions for longer periods of time. Mooring components supplied by M/s Datawell bv were used in all moorings. Fig. 2 shows a typical disassembled view of waverider buoy mooring.

The recording equipments were installed in a building located on the shore, which was free from electrical disturbances. When the waverider buoy was installed near the offshore platform at Bombay High, the recording equipments were installed in the radio room of the platform. Various instrumental and mooring problems encountered during the wave measurement programme by NIO using Datawell waverider buoys are briefly described in this paper.

2. Handling of waverider mooring

A locally available mechanised boat, usually a fishing trawler having a derrick boom and a 2 tonne winch was generally selected for handling waverider buoys. The size of the boat varied from 12 meters to 16 meters. Most of the time the same trawler was used for keeping a watch on the moored waverider buoy, which was most essential in severe fishing activity area. Supply vessels owned by M/s Garware, India, and M/s Mountego Seahorse corp. U.S.A. were used for operations at Bombay High. The positioning of waveriders at Daman, Umbergaon, Kakinada, Bombay High was taken using Magnovax 1107, a satellite navigation system.

* Received April 13, 1989
** National Institute of Oceanography, Dona Paula, Goa, India-403004

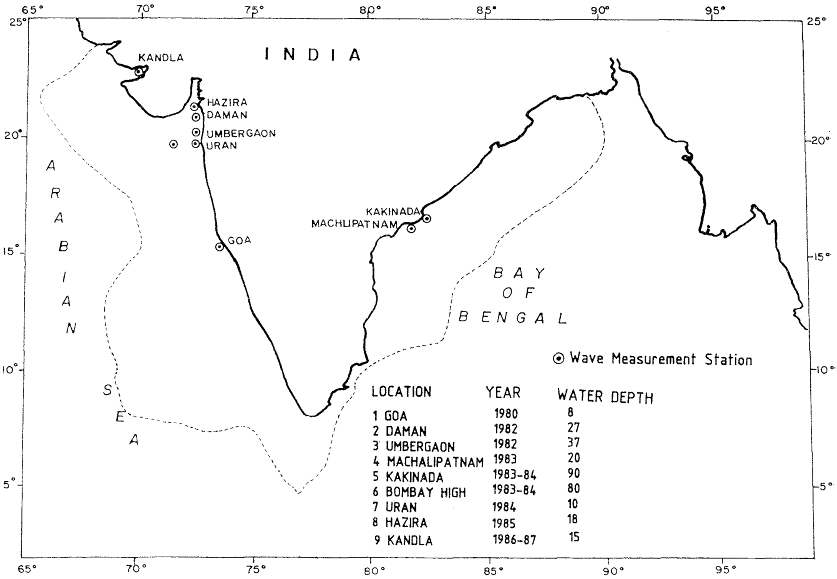

Fig. 1. Waverider buoy deployed locations.

Table 1. Waverider buoy performance off the east and west coast of India.

Sl. No.	Location of wave-rider buoys	Period of study Start	Finish	No. of buoy days possible X	Actual no. of buoy days Y	$\frac{X}{Y}\times 100$ %	No. of deploy-ments	Adrift
1.	Off Goa[1)]	22-5-80	2- 8-80	70	70	100	1	Nil
2.	Off Daman	14-5-82	26-11-82	197	172	87.3	5	4
3.	Off Umbergaon[2)]	10-6-82	23-11-82	167	113	67.6	3	1
4.	Off Machalipatnam	9-5-83	18-12-83	224	224	100	2	Nil
5.	Off Kakinada[3)]	14-5-83	1- 9-84	477	461	96.6	5	3
6.	Bombay High	22-5-83	12-12-84	571	537	94.05	3	Nil
7.	Off Uran	26-6-84	16-10-84	113	113	100	1	Nil
8.	Off Hazira[4)]	22-6-85	13-12-85	205	195	95.1	3	Nil
9.	Off Kandla[5)]	22-6-86	11- 5-87	324	314	96.9	2	1[6)]
			Total	2348	2199	93.06	25	9

1) Due to failure of accelerometer data could be collected for only 51 days.
2) Second redeployment delayed due to non availability of waverider buoy.
3) Buoy lost on 1 Sept. 1984 and is not yet traced.
4) The buoy was recovered on 3 Aug. 1985 and 17 Oct. 1985 for checking the pits on hull which were filled with Araldite.
5) Buoy was recovered to inspect mooring components status as current speeds of 4 to 5 knots were common in the area.
6) Buoy was drifted along with the whole mooring over a distance of 500 meters due to strong currents prevailing in the area.

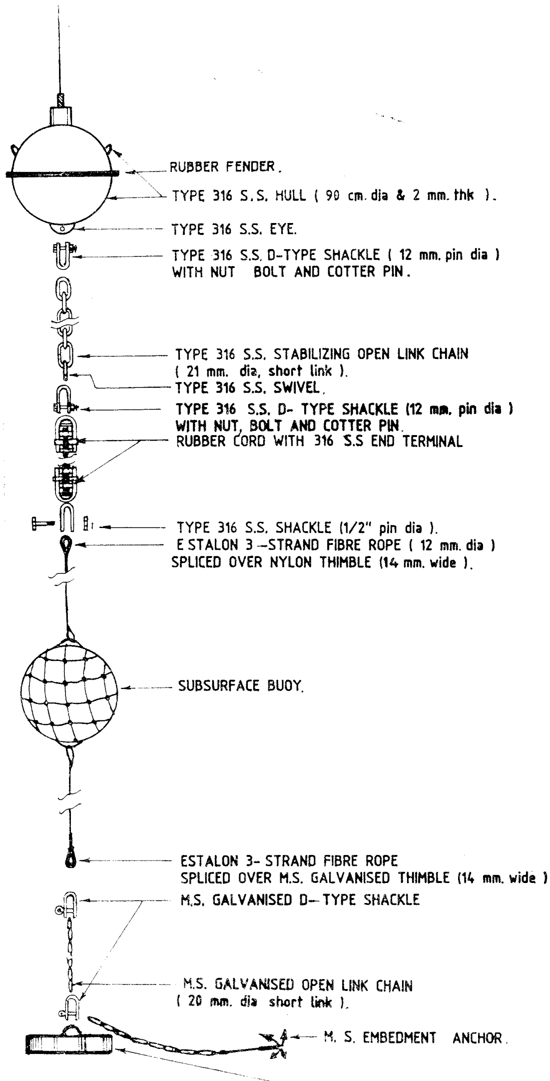

Fig. 2. A disassembled view of a typical waverider buoy mooring system.

Anchor last method was adopted for the waverider buoy deployment. Before paying out the mooring gear, the boat was made to proceed towards the desired buoy location. Opposing the sea surface current/wind, whichever was dominant at the time of deployment of the waverider buoy, the buoy was first dropped in sea from the stern of the boat with the boat cruising at about 2 knot speed. Then the connected mooring line was paid out manually under moderate tension. Ultimately, the anchor was

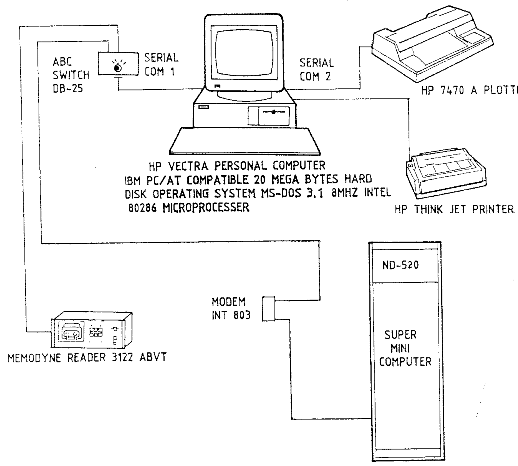

Fig. 3. Data processing system for digitised wave data.

dropped from the stern of the boat. During recovery operation, the waverider buoy was first hauled up and kept on the deck of the boat. Then the upper slack part of the mooring including the rubber cord and the floating polypropylene rope was manually pulled up on the deck. Finally winch was operated for hauling up the dead weights and the sub-surface buoys on the deck. Proper manoeuvering of the boat was very important particularly when the sea was rough for safe retrieval of the waverider buoy and its mooring.

3. Wave receiving/recording station

The Datawell Waverider Receiver (WAREP) in conjunction with Digital Magnetic Tape Recorder (DIMA) was used to receive and record the wave data transmitted by the waverider buoy. The analog wave records were obtained on 10 cm wide chart paper used in the WAREP while digital data were recorded on Verbatim 300 H type digital cassette in DIMA. Both these units were generally operated on 220 volts AC mains supply and on failure of the mains supply, the units were set to automatically switch on to the external standby 12 volt DC (80 AH) lead acid battery. Whenever these recording equipments were used in remote coastal villages where frequent power failures used to occur for extended period of time, a portable 500 watt AC/DC petrol generator was used to charge the batteries and the recording equipments were operated on these batteries.

Recently Digital Waverider Receiver (DIWAR) along with personal computer HP-85B is procured from M/s Datawell, Netherland, and is used for wave data collection off Calcutta. The software computes on-line energy spectrum, significant wave height "Hs" and significant wave period "Tz". The computed values are stored in the data cartridge.

4. Data processing techniques

The WAREP was operated in program mode to record 20 minute wave data at every 3 hours continuously. The analog wave records were analysed using Tucker's method to determine the

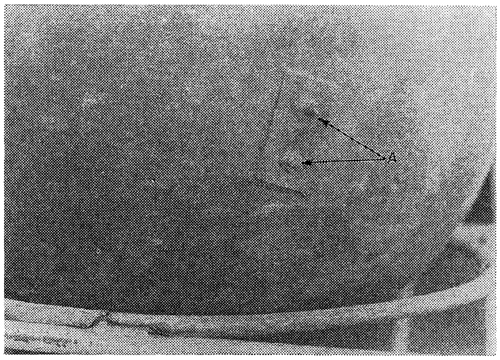

Fig. 4. Failure of U-eye on bottom of waverider buoy (A).

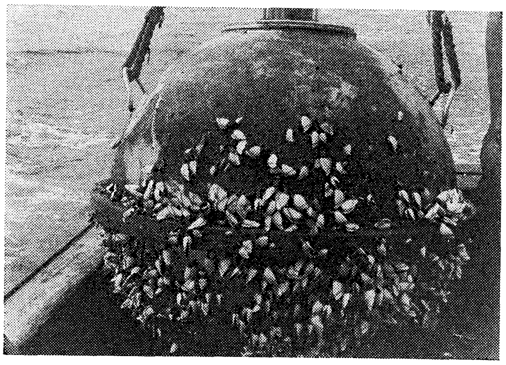

Fig. 5. Growth of barnacles on waverider hull.

Table 2. Electronic failure of buoy and receiving equipment.

Type of failure	Possible cause	Measures taken	Remarks
1. Flash light not glowing	Transistor 2N4897 in flash light circuit was faulty.	With replacement of new transistor flash light started working.	This type of fault occurred in 4 instances.
2. No flash light and R.F. transmission	Short circuit in H.F. autotransformer & leakage of seawater damaging top pcb.	Replacement of flash tube assembly, roof hatch O-ring & top pcb.	Water entered in top pcb housing due to damaged O-ring.
3. Zero line of WAREP modulated by 40 sec time period wave	Spinning of waverider due to surface disturbances caused due to close movement of watch-keeping boat.	Watch-keeping boat was anchored at least 500 m away from the buoy.	The disturbance disappeared after about 24 hours when the disturbed fluid surrounding the accelerometer platform came to steady state.
4. Total failure of WAREP	a) Rectifier diode in 24 volt power was open. b) Power supply pcb converting DC voltage to 220 v AC faulty.	Rectifier diode replaced. Faulty pcb replaced.	Performance of WAREP in humid & dusty environment was most reliable.
5. No movement of WAREP pen	Pen holder arm jammed due to over pressing of the recorder pen in the pen holder.	Bent in the pen arm of pen holder assembly was removed.	Such problems arised for 3 times.
6. DIMA failure	a) Deck drive pcb faulty. b) Digital clock pcb-E faulty.	Pcb-B replaced with new one. Faulty pcb-E replaced with new one.	This fault occurred 3 times. This fault occurred 2 times.
7. Partial recording of digitised data by DIMA in each cassette	Magnetisation level of magnetic tape dropped down slowly below opti mum level, due to faulty lot of Verbatim cassettes.	Use of new lot of Verbatim cassettes enabled to obtain good data.	Quite an amount of digitised data was lost due to this problem.

significant wave height "Hs" and zero crossing wave periods "Tz". The DIMA unit interfaced with WAREP in program mode records digitised data on cassettes for every 0.5 seconds interval. Memodyne Tape Reader 3122 ABVT is interfaced to HP Vectra Personal Computer where all raw wave data from data cassette are read and stored on hard disk (Fig. 3). This PC is interfaced to super mini computer ND-520 and raw data are transferred to it using a software NORLINK. For statistical, zero upcrossing and spectral analysis of the digitised time series wave data a software package NEPTUN-5 was used on ND-520 computer. This programme carries out

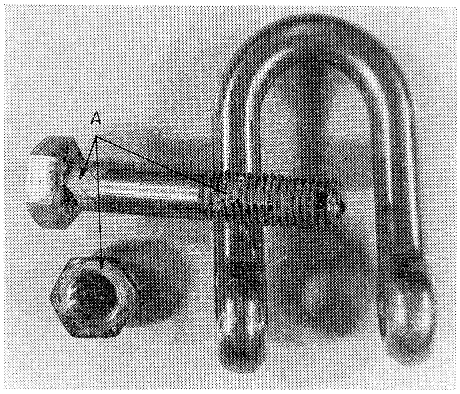

Fig. 6. Corrosion of D-type st. steel 316 shackle (A).

Table 3. Mechanical and operational faults and failures.

Type of failure	Possible cause	Measures taken	Remarks
1. Rubber cord slipping out of its end terminals	Improper manoeuvering of supply vessel during recovery under strong current caused rubber cord to stretch beyond its tolerable limits.	Avoided the recovery of waverider mooring with supply vessel under strong currents.	This problem arised during wave measurement at Bombay High, where ONGC supply vessels were used for deployment/recovery operations.
2. Snapping of rubber cord	Man made causes a) Entanglement of drifting fishing nets with the waverider mooring. b) Cutting of rubber cord by fishermen to free the net. c) Passing boat/vessels running over the mooring. Natural failure due to prolonged use under complex nature of forces.	To overcome all these problems a watch keeping boat with few crew was made to anchor about 500 m from the buoy day & night. This boat used to be withdrawn during bad weather.	Earlier when watch keeping boat was not used, the buoy used to adrift many times & search operation used to be carried out by using Direction Finder (OAR model Fr-206).
3. Failure of accelerometer suspension of waverider buoy	The buoy was hit by a fishing trawler resulting in breakage of accelerometer suspension.	Triangular guard was fixed to the buoy to safeguard it from collision.	One buoy deployed off Goa is in irrepairable condition due to damage of accelerometer.
4. Failure of the bottom U-eye of waverider buoy (Fig. 4)	The buoy was drifted to shore & the U-eye was broken by the local fisherman while removing stabilising chain.	Measures are underway to weld a new U-eye to this waverider buoy.	This is a rare problem and has happened during the wave measurements off Daman.
5. Failure of data transmission from the waverider buoy	Splashing seawater entered the whip antenna base socket through the damaged socket sealing washers which got damaged due to placing them wrongly.	The damaged socket sealing washers were replaced. They were placed in position with the thicker spongy washer below the hard Delrin washer.	The socket sealing washers were replaced quite oftenly.
6 Partial submergence of the waverider buoy	a) Entanglement of the mooring with plants & bushes during floods in adjoining river.	Periodical checks were carried out by sending divers to check the mooring line during floods in adjoining river.	This problem was encountered during the wave measurement off Kakinada.
	b) Growth of large colonies of barnacles on the waverider surface (Fig. 5).	Cunnifer (90/10) buoys are being used in location known for severe biofouling. A few 90 cm dia cunnifer buoys have been procured.	Barnacle growth has resulted in severe pitting on a 316 st. steel buoy deployed at Bombay High.

the necessary checks on both raw and computed data to have a control over the quality of the data. The raw data are subjected to various checks on spikes, steepness, constant level of signal etc. The program computes the energy spectrum of the time series using fast fourier transform.

5. Major problems faced during wave measurement programme

The wave data collection programe was sometimes seriously affected due to various reasons such as electronic failure of waverider buoy or recording equipment or dirifting or loss of the waverider buoy from its location etc. Some of the problems faced by NIO during the wave measurement programmes are summarised in Tables 2, 3 and 4.

6. Problems in data processing equipment

The DIMA records digital wave data on cassettes as 12 bit binary word. When this cassette s run on Memodyne Tape Reader 3122 ABVT

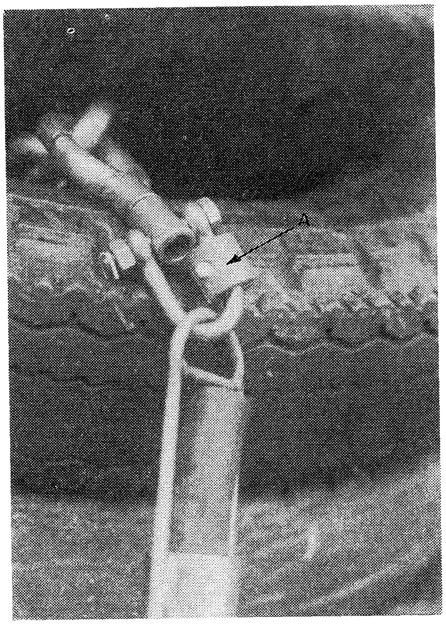

Fig. 7. Cathodic protection of U-type shackle (A).

Table 4. Marine corrosion of waverider buoys and mooring hardwares.

Forms of corrosion & location	Possible cause	Measures taken	Remarks
1. Crevice corrosion on 316 st. steel waverider buoy at the following locations			
a) In & around the O-ring grooves	Formation of oxygen concentration cells due to trapped seawater in & around the O-ring area.	Periodical replacement of O-ring & application of silicone grease were done.	This problem was more predominant during monsoon because of repeated splashing of seawater.
b) On the bottom hull surface	Oxygen concentration cells were formed on the bottom hull surface due to the attachment of marine foulers & deposition of fine sediments.	Cunnifer (90/10) buoys were used in the area known for severe biofouling. When 316 st. steel buoys were deployed in these locations they were recovered periodically & redeployed after cleaning. For subsequent projects the hull surface was painted with double coat of zinc chromate primer & a sealing coat of epoxy paint. The paint was applied after filling the pits with Araldite adhesive.	The biofoulers resulted in severe pitting (0.8-1mm deep) on one of the buoys deployed at Bomby High. The paint worked satisfactorily & the buoys with deep pits are still in use.
2. Crevice corrosion of D-type 316 st. steel shackle	Formation of oxygen concentration cells in the crevicies between U-body, bolt & nut (Fig. 6).	The design of D-shackle is modified, in which the bolt has enough play in the axial direction after tightening the nut. In few instances, zinc sacrificial anodes were clamped to the shackle (Fig. 7).	The modified D-shackles worked satisfactorily.

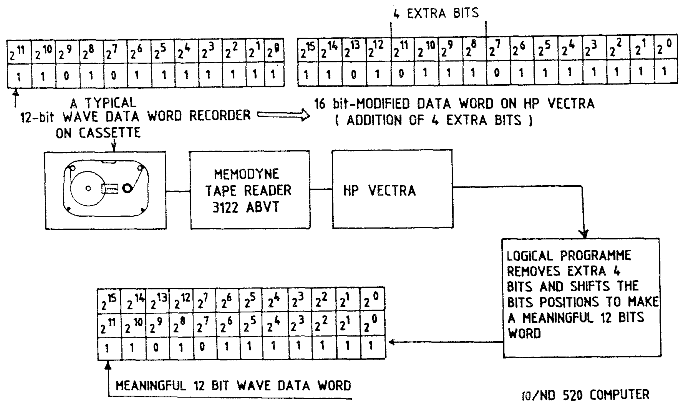

Fig. 8. Method of 12 bit data recovery.

interfaced to HP-Vectra pc, a 12 bit word is modified to 16 bit word in which 4 extra non-significant bits are added. While using this data for computer analysis the extra 4 bits have to be removed so as to retrieve the original 12 bit wave data word. The logical problem was solved on ND-520 computer as explained in Fig. 8. After solving this problem, the collected data could be analysed using the software program NEPTUN -5 on ND-520 computer.

7. Conclusions

The success of the long term wave data collection and analysis using Datawell waverider buoy depends on proper functioning of various electronic equipment, proper design of mooring of the waverider buoy and its successful operation at sea. Based on the experiences gained in wave measurement programes at NIO, the following conclusions are drawn.

i) The small fishing trawlers of 36-50 ft. length can be successfully used for deployment and retrieval of the waverider buoys in the coastal waters. Offshore supply vessels are found to be inconvenient for recovery operations as they have minimum handling facility and they could not be manoeuvered as desired.

ii) Continuous watchkeeping on the waverider buoy reduces chances of loss of the waverider buoy or their drifting from the moored location particularly at high fishing activity area.

iii) Regular checking and replacement of the mooring at an interval of 6 to 9 months ensures long term wave data collection with minimum of interruptions.

iv) Scrap ship chain links are most suitable for using as anchor weights as they are convenient to handle from small boats equipped with minimum handling facility.

v) The waverider buoy made up of 90/10 Copper-Nickel alloy hull is found to be more resistant against marine corrosion and biofouling.

vi) A double coat of zinc chromate primer paint with a suitable sealing coat on the 316 stainless steel hull of the waverider buoy was found to give satisfactory corrosion protection for 3 to 4 months of operation in sea.

Acknowledgement

The authors are grateful to Dr. B.N. DESAI, Director, NIO for his keen interest and encouragement.

References

GERRITZEN, P.L. and J.G.A. VAN BREUGEL (1979). Operational and service manual for waverider.

HUMPHERY, J.D. (1975). Waverider moorings and their modifications at I.O.S. Society for Underwater Technology, Proceedings, October. p. 42-46.

HUMPHERY, J.D. (1982). Operational experiences with waverider buoys and their moorings. I.O.S. Report No. 145.