[Lahane * *et al.*, 7(6): June, 2018]
ICTM Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

MODIFICATIONS AND REINFORCEMENT IN VALEPORT BOTTOM MOORING FRAME FOR TIDE GAUGE DEPLOYMENT

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DOI: 10.5281/zenodo.1290473

ABSTRACT
Tide is an important oceanographic phenomenon and has significant influence in global scale. Tides enhance the fish productivity which is of economical importance. Also, the tide generated current is commercially significant for navigation. One of the important oceanographic an instrument is tide-gauge, that measure and records tide parameters. It is deployed to the seabed either in a semi-spherical plastic dome or in a metal mooring frame. The existing pre-deployment technique involves usage of heavy chains and synthetic ropes, which is tedious and time consuming process. In this paper, we present low-cost, portable and robust modifications in existing ValePort mooring frame which is used for tide gauge deployment. The redesigned frame can be readily assembled /dissembled during and after its use. Further it offers easy maintenance and servicing, and can be use over a longer period.

Keywords: ValePort tide gauge, pyramidal mooring frame, deployment technique, synthetic ropes, stainless steel components, counter-weights.

I. INTRODUCTION

Tide gauge (Model 730W) & Midas WTR (Fig. 1), manufactured by M/s ValePort Limited, United Kingdom is a self-recording Water & Tide Recorder [1,2] deployed to the seabed for extended period to measure wave and tide parameters, such as significant wave height, tide pressure and surface elevation etc. For obtaining adequate, reliable and quantative data, the instrument should be ideally housed in a rigid cage like structure and to be moored at the bottom of the seabed. For this purpose, the tide gauge is mounted inside the pyramidal metal frame, manufactured by M/s ValePort Limited United Kingdom (Fig. 2). In offshore region, where very strong under water currents are encountered, the frame as well as the instrument drift and eventually instrument get damaged. To carry out measurements in such a hostile condition, counter weights need to be attached to the frame in order to couple the mooring frame to the seabed as well as make it stable at its mooring position. In this paper, we present low-cost, robust modifications in the existing design of the mooring frame so that it can be efficiently deployed.

Fig. 1: ValePort's Wave & Tide Recorder

Fig. 2: Pyramidal mooring frame

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II. MATERIALS AND METHODS

Existing Pre-deployment Technique

The existing pre-deployment technique involves initial tying of heavy iron chains at the base of the metal frame (Fig. 3) using thin synthetic (Polypropylene, Sisal etc) ropes. For reliable tidal data, it is very important that the instrument should not be inclined or tilted during mooring and while sitting at the seabed. Therefore the tide gauge is mounted inside a stainless steel mooring frame and tied to the base of the frame using thin synthetic ropes (Fig. 4).

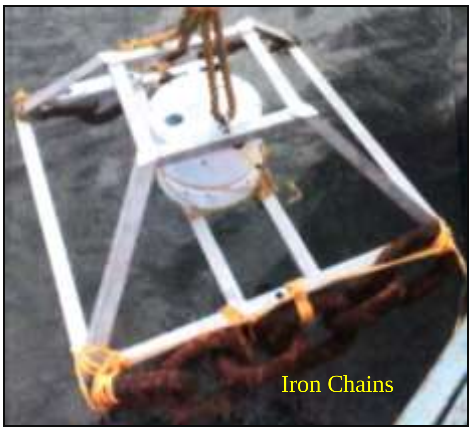

Fig. 3: Heavy iron chains tied below the base of the frame

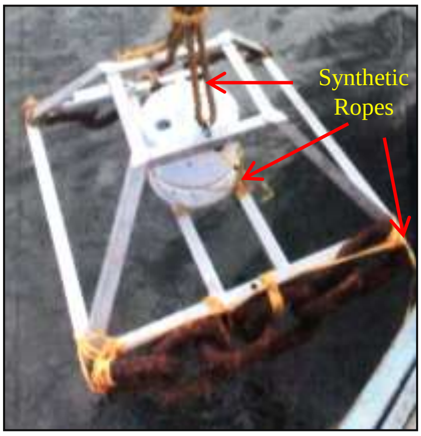

Fig. 4: Tide gauge tied on the base of the frame.

Further, a thick synthetic rope is tied through shackles (Fig. 5b) located on the upper part of the frame or sometimes through the four edges of the upper frame (Fig. 5a) in such a way, so that the mooring frame can be lifted up uniformly and finally the entire frame along with the tide gauge is deployed in the sea using an automated winch on-board the vessel.

Fig. 5a: Lifting of Tide gauge & metal frame using winch.

Fig. 5b: Deploying of Tide gauge with metal frame.

Disadvantages of existing pre-deployment technique

Use of heavy iron chains

Iron chains, which are normally used as a weight are extremely heavy (weighs from 50 kg to 200 kg). During the field program, minimum 4 to 6 persons are required for loading, tying, deploying, retrieval and unloading

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Impact Factor: 5.164
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the chains. Since the chains are made of iron metal, regular use and contact with sea water it corrodes and rusts faster. Also while tying the chains to the frame base, there may be a possibility of trapping of the fingers between the iron rings, which are clubbed together to form the chain. Most importantly, if seabed is rocky, the chain may entangle with the rock, which in turn may incline the frame and the instrument. As a result the frame will not sit properly on the sea bed and may affect the tidal data recorded by the instrument.

Use of Synthetic ropes

For tying of tide gauge inside the mooring frame

The tide gauge is housed in the frame using nut bolts at the base of the instrument. For safety purpose, the instrument is tied to the base of the frame using thin (approx. dia: 4 mm) synthetic (Sisal) ropes as shown in Fig. 4.

For lifting and deploying the frame

For lifting and deploying the entire mooring frame with the instrument, thicker (approx. dia: 24 mm) synthetic (Polypropylene) ropes are used to tie the frame in such a way so that the frame can be lifted up and deployed in the sea uniformly. But here also the unevenness during the lifting is observed. When lifted up through winch i.e. the mooring frame appears to be inclined due to load concentrated at one point (Shift of center of mass). Sometimes there may be a possibility that rope may hit the sensor of the instrument while lifting and deploying.

Drawbacks of synthetic ropes

- Synthetic ropes are severely weakened by prolonged exposure [3] to Sunlight.
- Prolong use of knots in rope decrease the rope strength by as much as 60% [3].
- Heavy use of the synthetic ropes over a time period shows signs of ageing and worn, this results into loss in tensile strength. Hence, replacement of synthetic ropes is must and which is cost effective.
- Synthetic ropes are being damaged by fish bites [4].

Innovative Modifications and Reinforcement to the Mooring Frame

To fix and tie the Tide gauge into the mooring frame, lifting the entire frame (with instrument) using synthetic ropes and finally deploying it, takes about one to two hours. To avoid the use of synthetic ropes and heavy iron chains every time in pre-deployment process, an inexpensive, portable and robust modifications were carried out to the mooring frame. Earlier, Kumar et al. (2004) [5] attempted to build mooring frame for DCM12 current meter during 2003, and collected satisfactory data.

SS plates at the base of the mooring frame

The mooring frame manufactured by ValePort consists of pyramidal shape metal frame with lot of empty space (Fig. 6a). Near the base of the frame, four stainless steel (SS) plates were welded perpendicular to existing metal plate at the base (Fig. 6b).

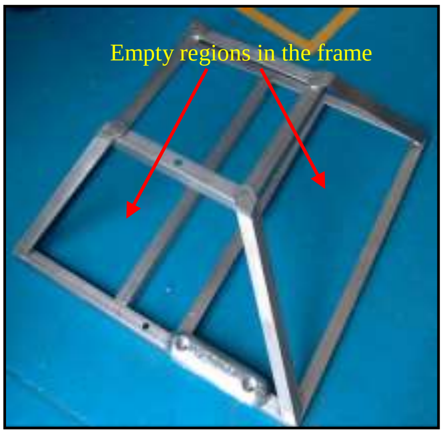

Fig. 6a: Original mooring frame

Fig. 6b: Stainless Steel Plates reinforced at base of the frame (Top-View)

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MS cylindrical blocks as counter weights

To avoid the use of chains as counter weights, Mild steel (MS) cylindrical block was designed and developed. This block is drilled through its center (inner dia: 30 mm) (Fig. 7b) for inserting it through the rods reinforced on the base of the frame. The cylindrical block has been provided a specific step-like shape at the top, such that the diameter of the upper most part is smaller as compared to the diameter of the rest of the block (Fig. 7a).

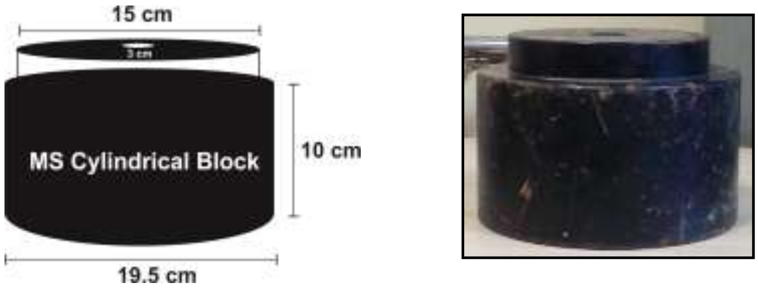

Fig. 7a: Cylindrical block schematic & actual image

Fig. 7b: Top-View

The objective behind this portable design is to get a grip, hold and lift the block easily by hands. There are total 4 cylindrical blocks developed which are identical in all aspects. Each block is duly powder-coated by anti-corrosive paint. In total there are 4 blocks that are used as Counter weights.

SS rod for stacking the counter weights

Fig. 8a: SS rods for holding the counter weights

Fig. 8b: Closer-View

Two stainless steel rod having diameter slightly smaller (approx. 28 mm) than the central drilled hole of the cylindrical block is reinforced on the SS plates at the base of the frame (Fig. 8a). Each rod is threaded at the top and is provided with a SS nut and a spacer (Fig. 8b). Two L-shape stainless steel extensions (Fig.9a) are attached vertically near each SS rod on both sides of the frame. The aspect of these L-shape extensions is to provide support to the counter weights and to protect the instrument. Each cylindrical weight is inserted into the rod with its top side facing downwards. Such two weights are placed one upon the other in a stack form (Fig. 9b).

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Fig. 9a: L-shaped SS extensions

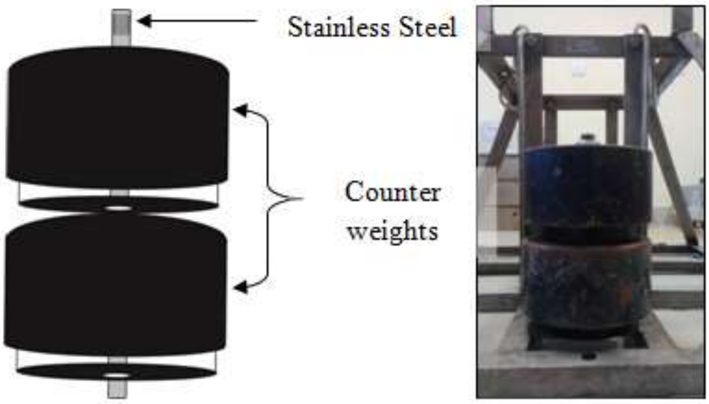
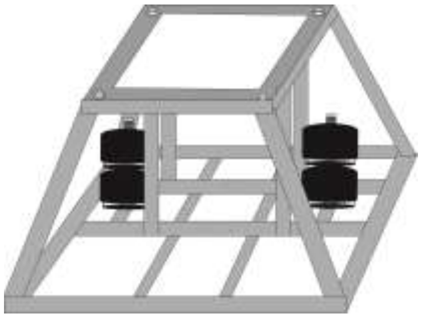


Fig. 9b: Counter weights stacked together

Two sets of counter weights are placed into two such stainless steel rods situated at both sides of the frame (Fig. 10). Each cylindrical block weighs about 25 kg; hence a total weight of 100 kg is equally distributed. It may mention here that some areas on the west coast of India such as Dahej, Hazira and few estuaries have extreme under water currents. Therefore, there are chances of drifting of the frame which may lead to error in the data and perhaps the loss of instrument. In case of rocky seabed as discussed earlier, since the counter weights are now located on the frame, the percentage of hitting the instrument from bottom of the frame is negligible as compared to iron chains tied at the base of the frame.



Schematic diagram

Actual image

Fig. 10: Counters weights placed into the frame

SS Nut-bolts for holding the tide gauge into the frame

The frame has eight drilled holes on its base. Four groves are provided on the base of the instrument (Fig. 11a).The instrument is mounted on the base frame by coinciding groves with holes of the frame and fixing it using four stainless steel nut-bolts (Fig. 11b). The important aspect of the eight drilled holes on the base of the frame is, to mount the instrument and fix it anywhere on the base.

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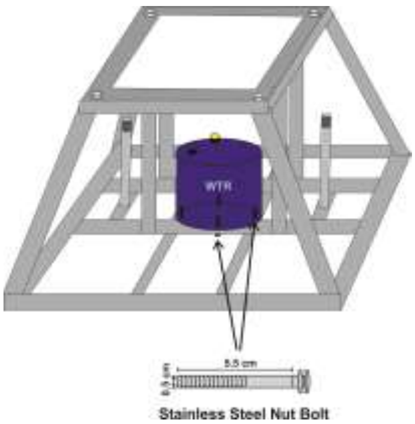
Fig. 11a: Drilled holes on frame & groves on tide gauge base



Schematic diagram

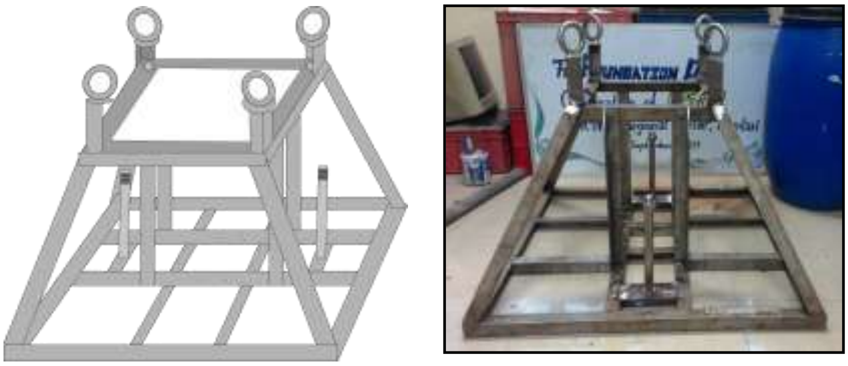
Actual image

Fig. 11b: Tide gauge placed in the mooring frame

SS Hook- loop assembly

In existing pre-deployment method, a thick synthetic rope (diameter: 24 mm) was used, which was worn either through four pyramidal edges of the frame or through two shackles located on upper square frame as shown in Fig. 5a & 5b. To overcome the drawbacks caused by the ropes, a stainless steel assembly is developed and implemented at four corners of the upper square frame. The assembly includes a thick stainless steel ring welded on a C-shape extension also made of stainless steel, which is bolted on the edges of the frame. The whole assembly is detachable and is called "Hook-loop"(Fig. 12a). Such four hook-loops are fitted diagonally on the frame facing each other (Fig. 12b). The objective behind the thicker circular ring welded to a C-shape extension, is to lift maximum load. Each of these is high capacity hook-loops which can lift maximum load of one ton.

Fig.12a: Detachable Hook-loop assembly



Schematic diagram

Actual image

Fig. 12b: Hook-loop assemblies

SS Wire-rope with Snap hooks

In existing pre-deployment method, the frame is lifted and deployed using thicker synthetic ropes (Fig. 5a & 5b). Due to this, the frame is unbalanced while lifting. Also, synthetic ropes itself have few drawbacks as discussed earlier. Therefore, the synthetic ropes are now been replaced by stainless steel (7x7, 304 type) wire-ropes [6] with ring on one end and snap hook on the other end (Fig. 13a). Each rope is of high capacity strength, which can easily lift load up to one ton. For our purpose, four such wire ropes with snap hooks are clubbed together in one set (Fig. 13b). The most important advantage of using stainless steel wire rope with snap hooks is, it can be clamped to the frame easily and faster as compare to tying the ropes and can lift the frame straight uniformly without unbalancing it. After connecting all the components viz. counter weights, wire rope & snap hooks to the frame, the entire mooring frame is ready for mounting the instrument (Fig. 14).

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Fig. 13a: Stainless steel wire rope with rope clip & Snap hook

Fig. 13b: Stainless steel wire rope & Snap hook set

Schematic diagram

Actual image

Fig. 14: Mooring frame with counter weights & SS Component

Redesigned Pre-deployment Technique – An Easy Approach

Besides unevenness caused by the tying of synthetic ropes which unbalances the dome while lifting, another major drawback is the time duration required for deploying the instrument. The new redesigned pre-deployment technique makes use of inexpensive, portable and robust components designed which can be easily assembled and can be readily implemented to the mooring frame. After connecting all the components viz. counter weights, snap hooks, SS wire ropes to the frame and the instrument fixed inside, the entire frame is all set for mooring (Fig. 15a). The total time required for installing the counter weights into the frame, placing the instrument in the frame, fixing the instrument to the base of the frame, connecting the SS wire rope set to the frame and finally lifting and deploying the entire frame with instrument in the sea (Fig. 15b), is about 10 to 15 minutes. Due to this, the time span of the entire process is reduced to more than half as compared to the existing pre-deployment method. This proves to be time efficient technique.

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Fig. 15a: Tide Gauge & Counter weights mounted on the mooring frame

Fig. 15b: Tide gauge-in-Mooring frame deployment using SS wire ropes

III. RESULTS AND DISCUSSION

Field Testing and Tide data comparison

In the Premonsoon phase, ValePort tide gauge was moored in Panvel creek (Maharashtra, India) using existing pre-deployment technique for time duration of 15 days. Tide level data was continuously recorded every 10 min while the pressure accuracy in this instrument is 0.01% FSO (Full Scale Output) [7]. In the time series plot (Fig. 16), few kinks were observed in water level data (blue curve lines) during the neap tide. Since in the old pre-deployed technique, chains are tied below the mooring frame using synthetic ropes (Fig. 5a & 5b). Due to unevenness in tying of weights the total mass of the frame is not equally distributed, which lead to mass unbalance in the frame, as a result the frame may have inclined towards one side, while mooring and sitting on the seabed. Also during the neap tide, when the water level is low, currents are strong enough to drift the unbalanced frame over the sea bed. Because of these factors, the error is incorporated in the data while recording. This error in the data is observed as kinks in the graph. The new redesigned pre-deployment technique was tested in post monsoon phase tested at the same place with the same instrument. The time series plot (Fig. 16), showed no kinks in the water level data (red curve lines). In new redesigned pre-deployment technique, cylindrical weights are mounted on both sides on the base of the frame (Fig. 10); hence the total mass is equally distributed over the frame. As a result, the frame is stable during mooring and while sitting at the sea bed. Because of the balanced weights, the frame is steady at the position where it was moored and is unaffected by the strong underwater currents. The data in the graph was recorded during the Neap tide. This provides satisfactory justification for using the low cost, portable and robust modifications reinforced in ValePort bottom mooring frame for tide gauge deployment.

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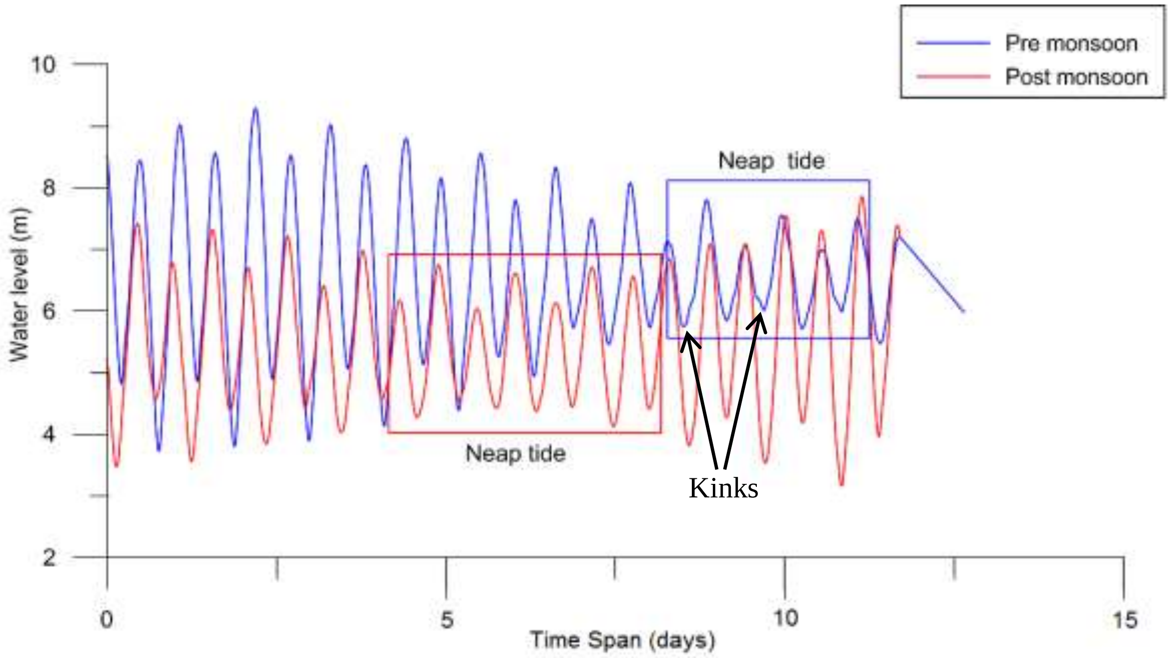

Fig. 16: Comparison between pre monsoon and post monsoon water level

IV. CONCLUSION

The new redesigned pre-deployment technique has several advantages over the older technique;

- It uses low-cost, portable and robust components which can readily assemble and implemented and can be easily dissemble, during and after the use.
- Most of the components are made from marine grade (306L) Stainless Steel material; there are no issues of ageing, rotting or worn as in case of synthetic ropes.
- It offers easy maintenance and servicing, and can be used over a longer period.

V. ACKNOWLEDGMENTS

The author is thankful to Dr. S.W.A. Naqvi, Former Director, CSIR-NIO for providing needed facilities to carry out this work. The author is grateful to Dr. A.K Chaubey, Scientist-in-Charge, CSIR-NIO Regional Centre, Mumbai for his valuable guidance, support and encouragement during design and development of the frame, as well as offering constructive comments on the manuscript. I wish to thank Mr. Shirish Pathare, HBCSE-TIFR and Mr. K.P. Naidu, Jyoti Engg.Works for their valuable inputs during the development and fabrication stages of the components. Also, I like to put on record the help and support readily provided by our colleagues, Mr. Amol Abhale and Mr. Dinesh Gupta.

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Lahane, R. D. (2018). MODIFICATIONS AND REINFORCEMENT IN VALEPORT BOTTOM MOORING FRAME FOR TIDE GAUGE DEPLOYMENT. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(6), 342-352.