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Design of portable A-frame for oceanographic data collection

Saif Khan Sunny[1], Shehrina Tabassum Supti[2], M. Abul Hossion[3,*]

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ABSTRACT

Bangladesh is blessed with vast area of fresh water river system and the largest bay in the world called the Bay of Bengal. Unfortunately, these water mass is mostly unexplored in terms of scientific data. To enhance the collection of scientific data at a larger scale, this study proposes the design of portable A-frame for the deployment of oceanographic instruments in local boats and trawlers in Bangladesh to collect pollution data. There are various types of A-frame or cranes but they are not suitable for ocean going boats or trawlers. In this study, a simple, low cost and portable A-frame is designed with a mechanical winch to deploy oceanographic data collection instrument with a 1000 kg load capacity up to 50 m water depth. The design is conceptualized from the experience during several sea trips with computer aided design. The designed A-frame can be constructed using locally available materials which can be set on wooden boats, trawlers and metal boats securely with necessary functional capacity. This will enhance the capacity of the researchers to collect data as a part of the exploration of fresh and salt water resources which are critical to address the challenges for sustainable development.

1. Introduction.

The sustainable development goal (SDG) 14 is the ‘life below water’ which was set to conserve and sustainably use the oceans, sea and marine resources. To achieve the SDG-14, we need to work on the threats to the ocean such as i) marine pollution, ii) over fishing, ii) warming of ocean, iv) acidification v) eutrophication. Bangladesh is a south Asian country blessed with the Bay of Bengal (BoB) as a part of Indian Ocean. This binds us with the ‘United Nations Decade of Ocean Science for Sustainable Development (2021-2030)’. The decade of ocean science urges to reverse the cycle of decline in ocean health and gather ocean stakeholders worldwide behind a common framework. At present, the BoB is seen as a great prospect in the Blue Economy. All the economic activity related to the seas and ocean-based exercises in a sustainable way is termed as a blue economy. With the successful delimitation of our maritime boundary with the two neighboring countries, Bangladesh has been endowed with a huge maritime area that is excellent for Blue Economy. Realizing the ‘SDG-14’ and ‘decade of ocean science for sustainable development’ to be achieved by 2030, this study is conducted on oceanic data collection tools.

In situ data collection is an important part of the ocean research, where an ocean-going vessel is required. An oceanographic research vessel can benefit the research. At present, researchers use improvised fishing boat, hydrography survey vessels and wooden trawlers to collect oceanic data. In the recent years (2018-2022), the oceanographic research has been boosted by universities, institutions, and other organizations. Most of the time the data collections points are limited near the coast line and top of the surface. This is due to the lack of proper vessels and equipment. To understand the surface and sub-surface resources, it is necessary to collect data from the deep ocean both in terms of distance from the coast and the depth of water. It is also important to collect the aquatic data from the rivers.

There are various ways and means to collect oceanic data

[1]Department of Oceanography & Hydrography, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka-1216, Bangladesh, e-mail: sunnysaifkhan@gmail.com.

[2]Department of Naval Architecture and Offshore Engineering, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka-1216, Bangladesh, e-mail: shehrina17.sh@gmail.com.

[3]Department of Physics, Bangabandhu Sheikh Mujibur Rahman Maritime University, Dhaka-1216, Bangladesh, e-mail: abulhossion.phy@bsmrmu.edu.bd.

*Corresponding author: M. Abul Hossion. E-mail Address: abulhossion.phy@bsmrmu.edu.bd.

such as buoy, satellites, programmed or remotely controlled submersible etc. Beside these, the data can be collected physically by visiting the ocean using an ocean going ship. The oceanic data collection involves lowering the sampling devices from the ship to the ocean. This task involves the use of cranes, winches, ropes and customized frame attached to the ship. Thus one cannot use any ship as oceanic data collection platform. On the other hand, using a proper research vessel is costly and not always available. Particularly, Bangladesh does not have any ocean going research vessel. To mitigate the absence of an ocean going research vessel, we have designed a versatile portable A-frame. The portable A-frame can be fitted in any vessel such as wooden trawlers, fishing boats, and any other cargo vessels. The proposed design can lower an oceanic data collection device to collect water and sediment sample from the ocean and river.

1.1. Oceanographic data.

Bangladesh is a maritime nation with 118,819 square kilometers of ocean area and its resource. Unfortunately the BoB is mostly unexplored. It is the United Nation's two mandates, SDG-2030 and Ocean Decade 2021-2030 that urges us to explore the BoB for its prospects to the development of Bangladesh. The prospect can only be established from the exploration and data collected from the ocean. Bangladesh Oceanographic Research Institute (BORI) as a government body and several universities in Bangladesh as a community has started to explore the BoB since 2016. These institutions are collecting data on the productivity such as phytoplankton assemblages, base line information, mechanisms of physicochemical parameters, presence of heavy metals in surface waters which are mostly from the coast of Bangladesh. These data collection also includes in-situ measurement of physical characteristics of seawater (such as temperature, salinity, and density) collected with a single fire module CTD (Conductivity, Temperature, Depth) in the northern Bay of Bengal (NBoB). The hydrocarbon exploration in the BoB is another part of the ocean floor data for energy resources specially gas.

Using the existing vessel facility, the in-situ data of physical parameters, heavy metals, elements, Total Organic Carbon (TOC), nutrients, and chlorophyll-a were collected across the shallow continental shelf which is near the coast which is only 10 km from the nearest coast of Bangladesh. On the other part of BoB, our neighboring country India has been exploring the Indian ocean using the proper research vessels. The Indian Oceanographic Research Vessel named 'Sagar Kanya' and Fishery Oceanographic Research Vessel (FORV) named 'Sagar Sampada' are equipped with proper equipment to collect necessary samples and data from the BoB.

1.2. The A-Frame.

Mechanical frames and cranes are used to handle heavy object. These are commonly employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy equipment. Various frames such as gantry crane and hanging mechanism are used in these industries but these are not portable. For fish sampling using a trawler, a portable gear is designed by. The design and construction of a solar powered electric crane by, 20 tonnes truck crane by were also explored. For lighter loads (below 500kg), a mini-climbing crane with a capacity of 200 kg is designed by which is suitable for the handling oceanographic data collection tool with some adjustments.

2. Design of the A-frame.

The design of the portable A-frame is considered in the context of data collection from BoB near the coastline of Bangladesh using ocean going boats or trawlers. Various types and sizes of boats and trawlers have been examined to make the design of the frame. Locally available cranes and winches are also analyses to construct the design. Primarily by calculating the scale ratio AutoCAD 2007 was used to draw the layout of the structure.

2.1. Design Concept.

There are many cranes or A-frame designs, which has the fit ability and portability constraints that required custom design. Specifically, the structure must hold any oceanographic instruments which are used usually. Additionally, there was a need to minimize the size of the frame so that it can easily be transported. Finally, the structure required stabilization in an undulating sea condition as well as rolling and pitching of boats. Hence the metal A-frame was designed in such a way that it will fit within any fishing boats or trawlers at installed condition and can be carried in folded condition by two persons. The frame is constructed of mild steel (a type of low carbon steel) elbow shape bar welded and bolted together for ease of assembly. The complete structure is divided into four parts: Base, support, hanger and winch as shown in Figure 1-4.

Figure 1: Drawing layout of the A-frame: Main structure base (1), hanger (2); Supporting bars (3a,b,c,d & 4), and winch (5).

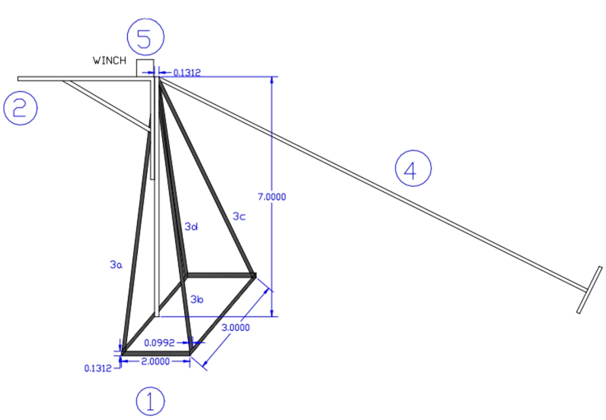


Figure 2: Schematic of the adjustable length support bar (fig-1(4)).

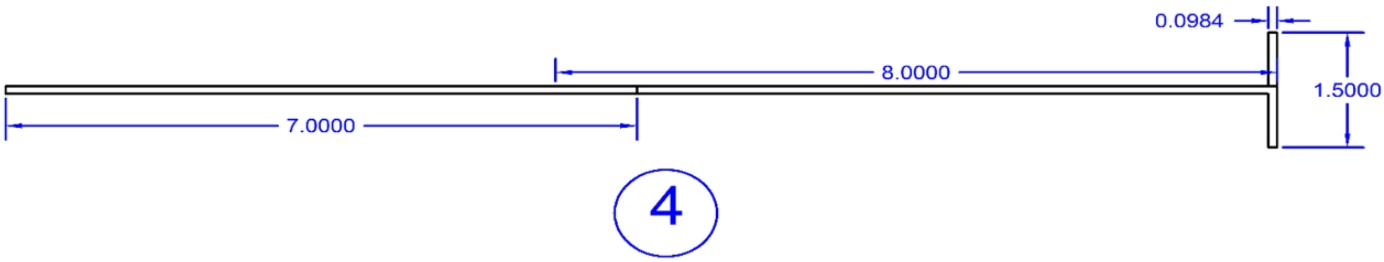


Figure 3: Schematic of the shape and dimension of the different angles used in the frame from left; base, support and hanger respectively.

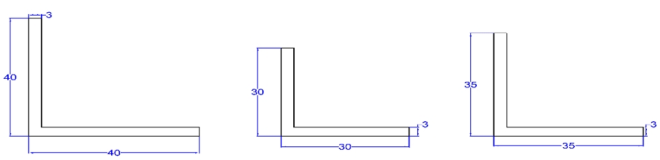
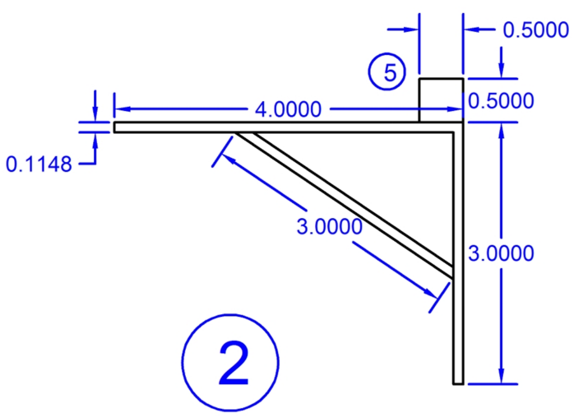


Figure 4: Schematic of the hanger design.



2.2. Main Structure.

The main part of the fixed structure is the base and the hanger. The base is a rectangle (3×2 feet) and the vertical column is 7 feet in height as shown in figure-1(1). The base structure is made by screwing mild steel angle bars together to make the rectangular structure. The hanger is an 'L' (vertical bar height 3 feet and horizontal extent 4 feet) shape structure. The hanger and the vertical column can be attached and removed from the base by screwing the nut which is attached with a hinge. This hanger is free to move in 180º angle around the vertical axis with necessary locking mechanism.

2.3. Supporting Structure.

The support bars are the elbow shape mild steel bar used to support the main structure consisting of four bars of different length as shown in Figure1(2) and one adjustable bar of maximum 14 feet once extended as shown in Figure1(4). The adjustable bar is made using two similar sized elbow-shaped bars, one is 8 feet and another is 7 feet as shown in Figure 2. It can be adjusted depending on the boats. This part gives the suitability to fit the frame in any kinds of wooden boats or metal vessel such as trawlers, survey vessels etc. These steel bars are can be assembled with the boat by screwing nuts and bolts.

2.4. Hoist.

The hoist is an electric motor with steel wire rope which is attached at the one end of the hanger as shown in Figure 1(5). The size of the hoist is 0.75 square feet (1.5 × 0.5) and weighs 12kg. The hoist can carry a maximum of 1000 kg when it is attached to the hanger near top of the vertical column. Two free wheels are used to extend the rope upto the outside extent of the hanger. The hoist has a steel wire of 60 m to operate. A 2.2 KW 220 V power supply is required to operate it which is usually a generator carried on board the boat.

3. Results and Discussion.

The oceanographic data collection involves the researchers to deploy instruments under water. Figure 5 shows the lowering of CTD for water and grabbers for sediments sampling without using any tool. This possesses a particular risk in case of an increased current and depth. Proper lowering tools such as cranes and hydraulic levers are too heavy to be mounted on a small boat. This study designs a low cost, portable and light weight A-frame for lowering oceanographic sampling tools. The designed A-frame contains 12 pieces of angle bars of total weight of 30kg given in Table-1. The weight of the complete structure is 42.8 kg. The A-frame can carry a load up to a maximum of 600 kg. The tension in the rope varies due to the buoyancy of water and ocean current. Using the A-frame it is expected that it can deploy an instrument up to 50 m depth. The frame hanger can rotate 90º left or right from the central position. The main structure can be folded within a (8 × 4) square feet area.

Table 1: Dimension of the materials used for the design of the A-frame.

Parts	Size of metal as in Fig-3 (mm)	Shape	Average weight (kg/feet)	Type	Length of metal (feet)	Total Length (feet)	Total Weight (kg)
Supporting	30 × 30 × 3	Elbow	0.40	Mild Steel	4.3 ×2 7.4×2 8+7	38.4	15.4
Base	40 × 40 × 3	Elbow	0.55	Mild Steel	2+2+3+3 7	17	9.4
Hanger	35 × 35 × 3	Elbow	0.50	Mild Steel	4+3+3	10	5.0
Winch	457× 152 × 152	Rectangular	-	Metal body & steel cable	Steel cable length 60m	-	12.0
Nuts and bolts	-	-	-	Metal	-	-	1.0
						Total	42.8*

* $T_W = W \times T_L$, where, T_W= Total Weight (kg), W= Average weight (kg/feet), T_L= Length of the angle bar (feet)

Figure 5: Image of lowering the data collection tools, water sampler CTD (left) and sediments grabber (right) from a wooden boat without the use any cranes.

Source: Authors.

4. Application.

The designed A-frame is versatile in the sense that it can be separated into three parts which makes it easily transportable. It is small and lightweight and can be set up on any type of boat. The Bay of Bengal has a gentle slope which gives only 50m of depth even at middle ground (100 km from the coast of Bangladesh). Thus the A-frame can be used to survey the maritime boundary of Bangladesh except the EEZ. The additional 10 m cable is kept for safety purposes in the view of a variation in the tidal and current effects at a particular location. The load capacity of the electrical hoist is 1000 kg which makes it suitable to carry and roll smaller oceanographic tool and instruments. The instruments used by local universities and institutions weights not more than 100 kg. Thus it can be an alternative to the dedicated research vessel for the collection of oceanographic data at a 100km distance from the cost, in the tidal rivers, estuaries and inland rivers.

Conclusions.

Exploration of the resources in the fresh and salty waters of Bangladesh is the key to achieving the SDG-2030 along with the Ocean Decade-2021-30 outcomes. A research vessel is a crucial part of this exploration which is missing in the context of Bangladesh. This study provides with a timely alternatives to the exploration tool. An indigenously designed A-frame with powered hoist is proposed to facilitate oceanographic data collection using wooden boat or any other metal vessel. This will increase data collection capacity by individuals at a larger scale in the sense of time and cost. The design is based on the application of simple mechanical concepts that were applied to the A-frame development. This can be used in any boat and up to fifty-meter water depth to collect data with instruments like CTD, Grabber and water sampler to study the water quality, plankton, sediments and other physical parameters.

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Nomenclature.

NBoB - Northern Bay of Bengal.
CTD - Conductivity-temperature-depth.
TOC - Total Organic Carbon.
FORV - Fishery Oceanographic Research Vessel.
BORI - Bangladesh Oceanographic Research Institute.
BSMRMU - Bangabandhu Sheikh Mujibur Rahman Maritime University.
IORV - Indian Oceanographic Research Vessel.

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