Escola Politècnica Superior d'Enginyeria de Vilanova i la Geltrú

UNIVERSITAT POLITÈCNICA DE CATALUNYA

EPS - PROJECT

TITLE: The Modular Design of a Seismic Buoy

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The Modular Design of a Seismic Buoy

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Abstract – SARTI (Sistemas de Adquisición Remota y Tratamiento de la Información) are a research group based in Vilanova i la Geltru who are collaborating with an international team of four students for the European Project Semester 2016.

The brief that has been assigned to the team is to redesign a seismic buoy, making it smaller, more compact, lightweight in order to allow for easy deployment.

Seismic buoys are currently very large and consist of several different individual, but connected parts. Ocean Bottom Seismometers (OBS) are much smaller however, they do not allow for the real-time transmission of data.

This was done by researching different buoys and they way that they are currently deployed. The team's first design was evaluated and all of the disadvantages of they design was taken into account.

This, along with taking into account the drag coefficient enabled the team to create a design that was much improved and had more advantages.

The team produced a compact design which solved many of the stated problems. However, more work by future teams will have to take place in order to finalise the finer details of this project.

Keywords – compact, easy to deploy, redesign, seismic buoy.

I. Introduction

The European Project Semester (EPS) and International Design Project Semester (IDPS) are international exchange programs where multi-disciplinary teams work together to complete assigned projects with a company. This took place at the Universitat Politécnica de Catalunya (UPC) on the Escola Politécnica Superior d'Enginyeria de Vilanova i la Geltrú (EPSEVG) campus.

The team was assigned the project by SARTI and the brief was to redesign a seismic buoy. It had to be smaller, more compact lighter (in order to allow for easier deployment) and allow the transmission of real time data. This data would be sent back to the laboratory before recovery and provide the technicians with data, showing that the seismometer is still recording.

The team also had to design a mechanism for coiling the cable inside the body of the buoy.

Seismic buoys include sensors which are placed onto the ocean floor to collect data on the seismic activity in the specific area.

These previous buoys are made from several individual parts including: the surface buoy, the cable, the anchor and the seismometer. The previous buoys were too large and heavy. This increases the amount of manual labour required in order to deploy these buoys. As they are so large, a large ship is needed to transport the buoy to its predetermined location. On-board this ship is also a large crane. This crane lifts the different components into the water sequentially, starting with the surface buoy, following with the cable with any extra instrumentation and finishing with the anchor and the seismometer.

The new design makes it much easier to deploy the moored buoy as it would not be necessary to use the conventional sequential method of deployment. Instead, all of the components can be deployed at the same time.

II. The Design

The design of the buoy changed many times over the course of the project.

The first developed design was spherical and opened by removing the entire top. This was changed as it was impractical to have to remove the entire top of the buoy in order to fix anything inside.

The second of the developed shapes was based on the body of a shark; slightly narrower at the front and back, wider in the middle and flat on the bottom. This shape allows the water to move more freely and with more ease around the buoy than the first spherical design. This was changed once again.

The final design is based on the shape of a bullet. This shape was chosen over one of other developed deigns due to the drag coefficient. This means that due to the more streamlined body, the resistance on the buoy will be lower and therefore the water and the current will move around it faster and more freely.

The buoy has to maintain its direction in the water and the method that was chosen for this was to use fins. These fins are of a convex shape, and are similar to the fins that are used on surf boards, but the size of the and shape of the fins were adjusted to the size the teams buoy. There will be one of these fins on the base of the buoy.

All of the electronics are encompassed in a separate watertight chamber, with a door.

There is an open section on the base of the buoy. This is because the coiled cable mechanism is not inside the watertight chamber. All of these parts move and therefore could not be sealed in the same way as the non moving parts.

As the buoy is classified as a special buoy the yellow colour signals to the marine traffic that it is not a navigational buoy. These buoys often have a yellow cross on the top.

As the anchor is lighter than traditional anchors, there was the chance that the surface buoy would drag the anchor along the sea bed. To overcome this the team put grips on the base of the anchor. This will give more resistance to the anchor and therefore keep it in the pre-determined location. It is a torus shape and the seismometer is inside the centre at the base in order to record the data.

The buoy will be moored close to the shore. This is because it will be tested at a depth of only 20m. Due to this satellite communication is not required. Inside the buoy there is an antenna. This connects to the GSM mobile network and is how the buoy will communicate with the lab. This antenna will be inside the buoy and will be the same as the one that is issued with the buoy that SARTI already own.

III. The Power Supply

The team had to consider the best method of powering the buoy, whilst taking into account the design of the buoy.

Power is needed to keep the internal electronics and equipment working constantly in order to enable them to provide updates of the information that will be processed and recorded at the laboratory.

Previous buoys used two different sources of power. Some only used large internal batteries. These batteries were chosen to last the length of time that the buoy was deployed. The other, used a combination of solar panels and batteries. This way the solar panels can charge the internal batteries. This means that they had a much longer life span.

The solar powered charger can be placed onto the top of the buoy. It is completely waterproof and can be separated into six different segments or just used as one. The chosen solar panels are 12V, 2000mA and will generate enough power throughout the day to keep the lithium batteries for the electronics running throughout the night.

IV. The Deployment Latches

In order for the buoy to be automatically deployed upon entry to the water, the team had to identify a suitable method to attach the components together.

It was decided that the latches would be more reliable if an automatic spring mechanism was built in. This would ensure the release of the anchor to the ocean floor. The design chosen is shown in the diagram on the next page.

Here it is shown that the anchor (green) is attached to the surface buoy (blue) by a

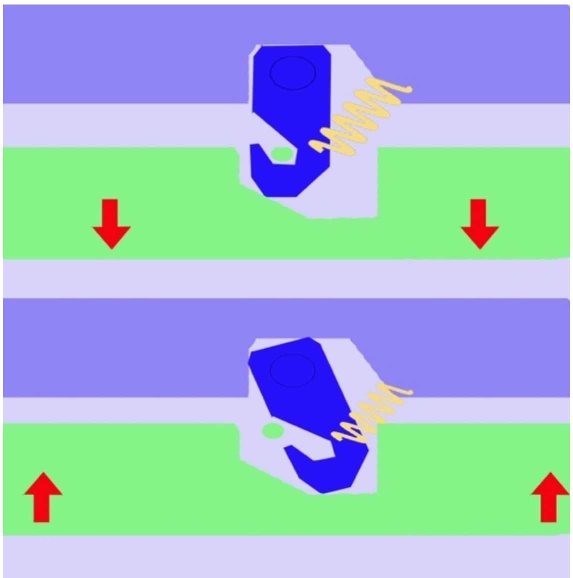

Figure 2: Diagram showing how the latches function.

latch that is holding the weight due to the direction of force that the anchor contains.

In the top half of the image, it shows that the force of gravity pulling the anchor downward is what holds the two parts together, making it an assembled unit. However, upon impact with the water the direction of force changes and the anchor is pushed upward causing the surface buoys latches to release the anchor. This process is helped with the use of a spring (yellow) that can ensure that the latch doesn't return to the previous position. Figure 2 shows what each latch looks like.

These latches are crucial to ensure to the design of a smaller more compact design as

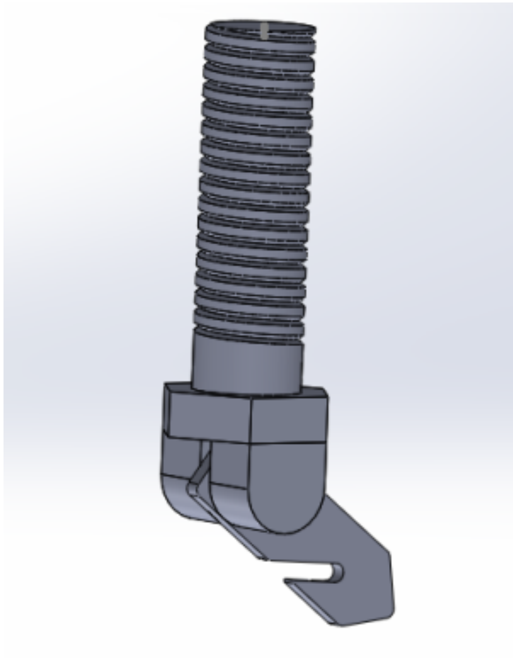

Figure 1: Diagram showing an individual latch.

it releases the anchor upon deployment, which was one of the team's main criteria.

The latches are connected to an internal metal frame. This helps to evenly distribute the weight of the anchor on the underside of the buoy. The frame also acts as the counterweight for the buoy.

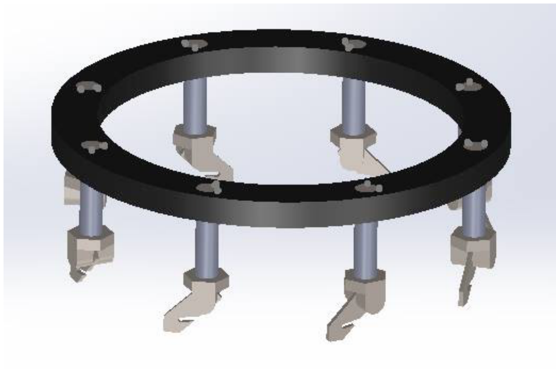

Figure 3: Diagram of the latch frame.

V. The Coiled Cable Mechanism

The coiled cable mechanism had many different designs, but the team chose the simplest and most compact design from the previous ones.

This mechanism resembles a screw thread and this is a very simple way to evenly distribute the cable onto the cylinder. This device only had to connect to the motor. As the mechanism turns the cable rolls into the spaces between the peaks as shown in figure 4.

The square shows a zoomed in section of this mechanism.

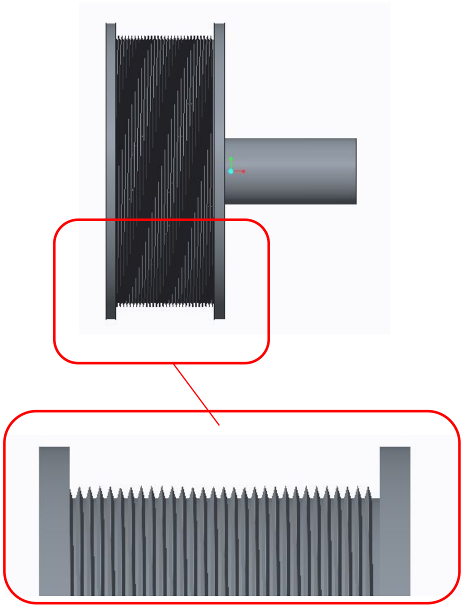

Figure 4 :Diagram showing a zoomed in section of the coiled cable mechanism.

VI. The Materials

The materials that were used for this buoy differ depending on the component. Polyurethane (PUR) was chosen for the surface buoy due to its UV resistance, strength and its ability to be moulded into different shapes. Polyamide 6 was chosen for the coiled cable mechanism as it does not corrode underwater. It is self lubricating and low maintenance. Concrete was chosen for the anchor as it is dense and can be broken down by the sea after the recovery of the seismometer.

VII. Recovery

After the length of time data needs to be recorded at the location of the buoy, it will be recovered. The only item that is not recovered is the anchor.

Mechanical release clips are attached to the anchor and to the ends of three sections of cable. Figure 5 shows how these cables are attached to the anchor.

The seismometer will still be connected to the anchor; it doesn't have the ability to float away. This relieves tension between the cable and the seismometer and also allows for more accurate data. This is due to the fact that there should not be any interference from the anchor in the data.

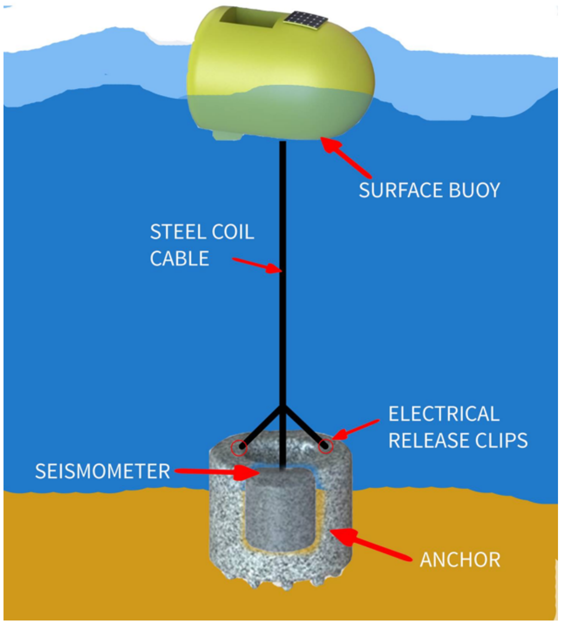

Figure 5: Diagram showing the mechanical release clips.

VIII. The Cable

An inductive modem cable was chosen for this project. It easily transmits data from the seismometer, through the cable, through an inductive modem and into the electronics in the buoy.

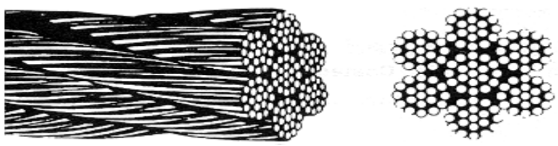

Figure 6: A diagram depicting the steel cable.

The cable will be a plastic jacketed galvanised steel wire rope. It is 7 x 19 cable. This means that it has seven strands and there are 19 wires in each strand.

IX. Conclusion

This project was focussed purely on the design. Another team will have to continue this work and figure out all of the finer details. However, the team managed to design a buoy that was about 50% smaller then the original buoy.

To conclude, many of the redesigns that the team made were new and innovative. Having a buoy that deploys automatically upon entry to the water has never been done before. This is the same for coiling the cable inside the body of the buoy.

Further work will have to be done on this project in order to work on the finer details. The team mainly focussed on the design and not on all of the electronic aspects.

REFERENCES

[1] N. Hall, "Shape effects on drag," in NASA - Glenn Research Centre, 2015. [Online]. Available: https://www.grc.nasa.gov/www/k-12/airplane/shaped.html. Accessed: Jun. 7, 2016.

[2] (No Date) Available at: http://www.liftingsafety.co.uk/files/product/3385/automatic-hook-system-3385.pdf (Accessed: 20 April 2016).

[3] D&M Plastics Inc. Custom Rotational Moulding. (s.f.). Recuperado el 3 de Junio de 2016, de http://www.plasticmoulding.ca/polymers/polyethylene.htm

[4] *Mechanical and physical properties*. (4 de Mayo de 2012). Recuperado el 3 de Junio de 2016, de http://www.worldstainless.org/what_is_stainless_steel/Mechanical_and_physical_properties

[5] *Nylons (Polyamide) - British Plastics Federation*. (s.f.). Recuperado el 4 de Junio de 2016, de http://www.bpf.co.uk/plastipedia/polymers/polyamides.aspx

[6] *PlasticEurope-Polyurethanes (PUR)-PlasticsEurope*. (s.f.). Recuperado el 25 de Mayo de 2016, de https://www.google.es/search?espv=2&biw=617&bih=525&q=Polyurethane+%28PUR%29&oq=Polyurethane+%28PUR%29&gs_l=serp.3..0i7i30i19j0i7i10i30i19l2j0i19l2j0i7i5i30i19j0i30i19l3j0i5i30i19.6108.20096.0.21080.20.14.2.4.4.0.164.1630.0j12.12.0....0...1c.1.64.serp..2.

[7] *Polyamides (PA)*. (s.f.). Recuperado el 25 de Mayo de 2016, de http://www.ensinger-online.com/en/materials/engineering-plastics/polyamides/

[8] *Polyethylene typical properties*. (s.f.). Recuperado el 2 de Junio de 2016, de http://www.wshampshire.com/pdf/psg_uhmw_polyethylene.pdf

[9] *Polyurethano (PUR) Typical Properties Generic PUR*. (s.f.). Recuperado el 2 de Junio de 2016, de https://plastics.ulprospector.com/generics/45/c/t/polyurethane-pur-properties-processing

[10] *POREX*. (s.f.). Recuperado el 24 de Mayo de 2016, de http://www.porex.com/technologies/materials/porous-plastics/pe/

[11] *SteelConstruction.info*. (s.f.). Recuperado el 25 de Mayo de 2016, de http://www.steelconstruction.info/Steel_material_properties

[12] Elert, G. (2001) *Density of concrete*. Available at: http://hypertextbook.com/facts/1999/KatrinaJones.shtml (Accessed: 29 May 2016).

[13] M. E. Systems, "Best Marine Solar panels - e Marine Systems," 2016. [Online]. Available: https://www.emarineinc.com/Best-Marine-Solar-Panels. Accessed: Jun. 4, 2016.