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Study on Submarine Communication Cables

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Abstract- A submarine communications cable is a cable laid beneath the sea to pro-vide telecommunication links between countries. The first such cables carried telegraphy traffic. Subsequent generations of cables carried telephone traffic, then data communications traffic. All modern cables use fiber optic technology to carry digital pay-loads, which include telephone traffic, internet signals, and private data traffic. As of 2005, submarine cables link all the world's continents except Antarctica. In this paper we shall study about the cross-sectional details, laying and installation, proper maintenance and protective measures of submarine communication cables.

Keywords: Submarine communication cables, telegraphy, telephone traffic, data traffic.

I. INTRODUCTION

A submarine communications cable is a cable laid on the sea bed between land-based stations to carry telecommunication signals across stretches of ocean and sea, also lake or lagoon. The first submarine communications cables laid beginning in the 1850s carried telegraphy traffic, establishing the first instant telecommunications links between continents, such as the first transatlantic telegraph cable which became operational on 16 August 1858.

Subsequent generations of cables carried telephone traffic, then data communications traffic. Modern cables use optical fiber technology to carry digital data, which includes telephone, Internet and private data traffic.

Modern cables are typically about 25 milimetres (0.98 in) in diameter and weigh around 1.4 tons per kilometer (2.5 short tons per mile; 2.2 long tons per mile) for the deep-sea sections which comprise the majority of the run, although larger and heavier cables are used for shallow-water sections near shore.

Submarine cables first connected all the world's continents (except Antarctica) when Java was connected to Darwin, Northern Territory, Australia, in 1871 in anticipation of the completion of the Australian Overland Telegraph Line in 1872 connecting to Adelaide, South Australia, and thence to the rest of Australia.

II. CROSS SECTION OF MODERN COMMUNICATION CABLE

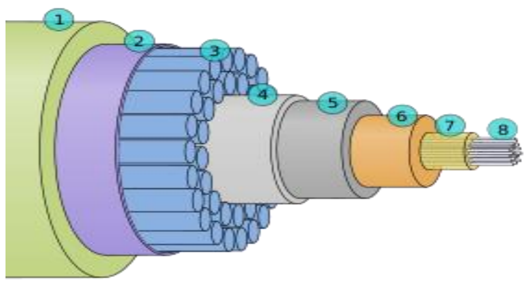

Fig 1. Cross Section of the Shore End of the Modern Communication Cable.
https://upload.wikimedia.org/wikipedia/commons/thumb/1/11/Submarinecablecross-section3Dplain.s vg/468px-Submarinecablecross-section3D_plain.svg.png

1. Polyethylene
2. Mylar type
3. Stranded steel wires
4. Aluminium water barrier
5. Polycarbonate
6. Copper and aluminium tube
7. Petroleum jelly
8. Optical fibers

III. LAYING THE CABLE

Installing a submarine transmission cable is a costly and challenging activity. The lifetime of a submarine cable might be tens of years and the technical interventions for its repairing in case of faults are also costly and difficult.

Fig 2. Installing Atransmission Submarine Cable, how they do it (photo credit :offshorewindindustry.com)

Therefore the cable route must be care-fully surveyed and selected in order to minimize the environmental impact and maximize the cable protection.

Fig 3. Specialized vessels for cable laying at sea; owner mentioned in the brackets https://electrical-engineering-portal.com/wp-content/uploads/2017/09/trench-sea-power-cable.jpg

Laying down the transmission cable on the seafloor is done by specialized vessels (Fig. 3). The most active vessels used for such operations are: Skagerrak (owned by Nexans), Giulio Verne (Prysmian), Team Installer (Topaz Energy and Marine) and C.S. Sovereign (Global Marine Systems Ltd). They are all equipped with a turntable for at least 4000 tons of cable and have the appropriate gear to handle it.

IV. STEPS INVOLVED IN INSTALLATION OF SUB-MARINE TRANSMISSION CABLES

- Selection of the provisional path;
- Obtaining permission from the relevant authorities;
- Survey of the path;
- Designing the cable system in order to meet the conditions of the selected path;
- Laying the cable, including burial in appropriate areas;
- A post-lay inspection may be necessary in some cases;
- Notification of cable position to other marine users.

The complexity of laying down the cable requires a coordinated work of many specialists in different fields. Path selection is done by power system engineers together with marine specialists. The survey is performed by geologists, geophysicists and oceanographers.

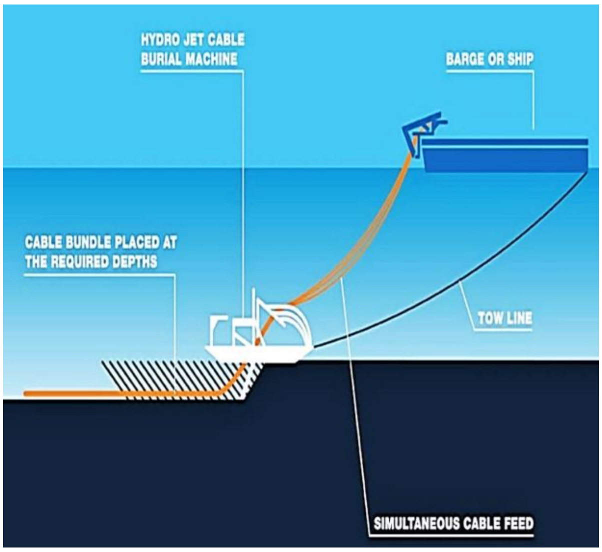

Fig 4. Simple sketch showing a submarine device used for installing the cable on the sea bed (source: hudsonproject.com) https://electrical-engineering-portal.com/wp-content/uploads/2017/09/trench-sea-power-cable.jpg

Laying the cable on the seafloor is executed by special structures engineers. The vessel represents just a part of the required gear needed for laying down the cable. It carries the cable and stands for the command centre. But once the cable is in the water other submersible equipment performs the task of settling the cable on its path."For shallow waters divers might be employed to assist the installation while for deep water Remotely Operated Vehicles (ROVs) are manipulated (Fig. 4)

The work is done with the help of acoustic instruments such as echo-sounders and accurate Global Positioning System (GPS) and differential GPS. The ROVs dig the trench in which the transmission cable is laid (Fig. 5 and Fig. 6), fix the cable on the right route and cover the cable with sediment. Burying the cable in the seabed is a slowly and costly operation but it is paid back by its reliability and extended lifetime.

Fig 5. The trench of a submarine power cable https://electrical-engineering-portal.com/wp-content/uploads/2017/09/trench-sea-power-cable.jpg

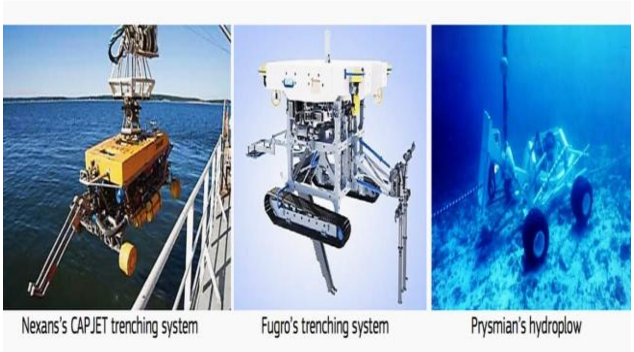

Fig 6. Various types of Remotely Operated Vehicles (ROV's) https://electrical-eeremotely-operated-vehicles.jpg

Cables are buried in the seabed in shallow waters in order to minimize the risks for damages. The trenches in which the cables are placed are dug by a submarine plough and covered by sediment or rocks.When it is not possible to use sediment as a cover other solutions are applied like using rocks or concrete mattresses (Fig 7) as cover or using articulated pipes.

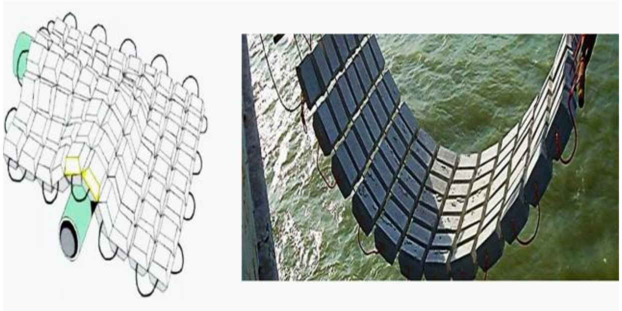

Fig 7. Concrete Mattresses https://electrical-engineering-portal.com/wp-content/uploads/2017/09/concrete-mattresses-for-cables.jpg

The rate at which the cable is laid-down depends on the type of the cable, the complexity of the cable configuration, the depth and properties of the seafloor (heterogeneous bathymetry and geology). In the case of communication cables a laying rate of 100-150 km/day, for new types even 200 km/day, is expectable.

"Due to the size of the transmission cable and the volume of work, which is usually bigger, power cables are installed at a lower rate. For power cables the average burial speed is about 0.2 km/h and depends largely on the seabed conditions".The depth of the trench is usually of 1 m, only exceptionally more, up to 10 m. With increasing size of ships channels will have to be dredged or deepened.

So in places the cables must be protected for such future works they have to be buried at a safe depth in the sediment. This is the case of the 30 km power transmission cable that connects the Malaysian island of PulauKetam with Port Klang which was buried 14 m under the seabed. The cables are buried in the seabed sediment up to depths of 400-600 m, below this depth they are simply laid down on the bottom of the sea. In places with strong sea currents or steep slopes they are fastened to the seabed. In order to check the cable security periodic surveys are envisaged.

V. PROTECTION MEASURES

Submarine power cables must be physically protected against natural hazards or human activity. Since a fault in the good functioning of a cable might have major implications in securing the power supply serious measures are devised.

Submarine cables are the subject of several international treaties which regulate their status. These documents establish norms regarding the rights and obligations for states that wish to lay such cables as well as for states whose territorial waters are crossed by the cables.

1. The Main Documents Dealing With Submarine Cables are:

- The International Convention for the Protection of Submarine Cables (1884);
- The Geneva Conventions of the Continental Shelf and High Seas (1958);
- United Nations Convention on Law of the Sea – UNCLOS (1982).

2. These Treaties Ensures:

- The freedom to install submarine cables on the high seas beyond the continental shelf and to repair existing cables without impediment or prejudice;
- The freedom to install and maintain submarine cables on the continental shelf, subject to reasonable measures for the exploration of the continental shelf and the exploitation of its natural resources;
- The freedom to install and maintain submarine cables in the exclusive economic zone of all states;
- The ability to install submarine cables in a state's territory or territorial sea subject to conditions and exercise of national jurisdiction;
- The freedom to maintain existing submarine cables passing through the waters of an archipelagic state without making landfall.

VI. THREATS TO CABLES

The main threats to a submarine transmission cable are external impacts due to pre-dominantly anchors and fishing gears. In order to minimize the risk of a cable tear due to a vessels' anchoring, "cable protection zone" or CPZ is established along the cable's path. These zones are legally de-fined and marked on nautical charts. In these areas activities that might damage or harm the cables are strictly regulated and controlled.

They may differ in size depending on the national rules/laws and the local conditions (e.g. naval traffic). For example around HVDC Inter-Island power cable in New Zealand a seven-kilometer wide CPZ is established and enforced (Fig. 8).

"Vessels are not allowed to anchor or fish in this area and the protection zone is constantly monitored from sea or air. Infringement of these rules attracts a fine up to $100,000. Enforcing this rule led to no faults due to human activity".

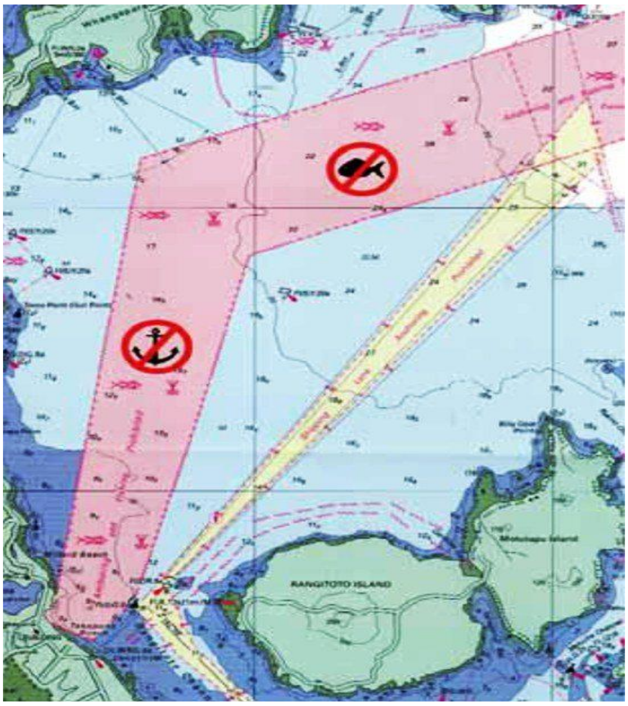

Fig 8. Cable protection zone in New Zealand https://electrical-engineering-portal.com/wp-content/uploads/2017/09/trench-sea-power-cable.jpg

An example of good practice is represented by the Kingfisher Information Service – Offshore Renewable & Cable Awareness project (KIS-ORCA), a joint initiative between Subsea Cables UK and Renewable UK, which raises awareness of submarine cable locations among operators in fishing industry for the North Sea and Western border of Europe.

Its website (Fig. 7) includes online up-dated maps picturing sea infrastructure (pipes, power and telecom submarine cables and accompanying equipment) with contact details in case of incidents.

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Fig 9. KIS-ORCA online map showing sea and submarine infrastructure.

Industry organizations such as Interna-tional Cable Protection Committee (ICPC) and North American Submarine Cable Association (NASCA) have drawn a set of recommendations regarding protective measures to be implemented for a safer and longer life of submarine cables (CSRIC, 2014).

VII. MAINTENANCE OF SEA CABLES

For an optimal operation the cable must be periodically checked and maintained in order to prevent deterioration.

This includes:

- Survey of the cable in order to check for possible tears or wears;
- Survey of the cable path in order to check the stability of the seabed and possible geodynamic processes that can threat the cable integrity;
- Preventive replacement of cable components when signs of wear are present or when they are approaching the lifetime end;
- Enforcing rules and regulations regarding the protection in the CPZ.

The operation is performed by specialized vessels with appropriate equipment. It depends heavily on the weather and sea conditions. In high latitude regions where the sea surface is covered with ice or crossed by floating icebergs these operations require additional care measures and lengthy times.

VIII. CONCLUSION

Currently 99% of the data traffic that is crossing oceans is carried by undersea cables. The reliability of submarine cables is high, especially when (as noted above) multiple paths are available in the event of a cable break. Also, the total carrying capacity of submarine cables is in the terabits per second, while satellites typically offer only 1,000 megabits per second and display higher latency. How-ever, a typical multi-terabit, transoceanic submarine cable system costs several hundred million dollars to construct.

As a result of these cables' cost and use-fullness, they are highly valued not only by the corporations building and operating them for profit, but also by national governments. For instance, the Australian government considers its submarine cable systems to be "vital to the national economy".

Accordingly, the Australian Communications and Media Authority (ACMA) has created protection zones that restrict activities that could potentially damage cables linking Australia to the rest of the world. The ACMA also regulates all projects to install new submarine cables.

Submarine cables are important to the modern military as well as private enterprise. The US military, for example, uses the submarine cable network for data transfer from conflict zones to command staff in the United States. Interruption of the cable network during intense operations could have direct consequences for the military on the ground.

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