Study and Analysis of the Optimum Path - Line of Submarine Cables in Persian Gulf and Oman Sea

Masoud Motamed and Elham Saeednia

Department of Marine Science and Technology

ISLAMIC AZAD UNIVERSITY - NORTH TEHRAN BRANCH
Valiasar Av., Tehran, Iran

ma.motamed@yahoo.com

Abstract— Almost all of transoceanic internet traffic is sent via submarine fiber optic cables. So, they can be known as "the backbone of the international telecommunications networks". In these Systems, planning and route selection processes can have an enormous impact on their life cycle costs. As repairing or replacing faulted portion of cables is a very costly procedure, much attention must be paid to the route selection and design process of the whole system. So, there would be a direct relation between the life cycle of a network and the cost paid for the design procedure. In Iran, Jask-Fojaira and Falcon projects have been the first projects executed in Persian Gulf that connect Iran to the world telecommunication network. In this paper, the optimal route for telecommunication cable in Persian Gulf is proposed based on the economic factors, safety measures and characteristics of seabed of this geographic area**.**

Keywords: submarine cable, optical fiber, laying cable, optical communication

1. INTRODUCTION

An optical fiber is made of glass or plastic that carries light through itself. Their advantage over metal cables is that they have less signal losses. Also, electromagnetic interferences don't affect fiber optics. As the new technologies have made it possible, each fiber of fiber optic cable has the size of one human hair. It is capable of transferring 10^{12}bits of information per minute. Laser producers send optic pulses through these fibers. The diameter of a cable is between 20 to 50 millimeters. The main problem existing about these cables is the breakability of glass against copper. This is the reason why the damage risk of this type of cable is more than that of older types.[1]

Today, the worldwide fiber-optic submarine cable network is growing rapidly to meet the demands for the data transmission. Since water covers a major part of the earth's surface, the importance of cables becomes more apparent. The main advantage of Submarine Cable Networks can be stated as follows:

- Their ability to transfer large volumes of telecommunications traffic with high speed, reliability & security
- Their cost-effectiveness for major routes such as those between Europe, SE Asia & USA
- Their ability to provide high quality communications without the delays that can be associated with satellite systems

Cable theory[2]

Light inside of core of the fiber gets protected by an internal reflection. This allows the fiber to act as a guide for the wave. Those fibers that support distribution paths or cross models are called multimedia (MMF).If a cable can only support one signal, it is called single mode (SMF).Multimedia fibers generally have big internal diameters. They are used for connecting communications between longer than 550 meters distance [3] .The heart of this cable is composed of a set of tiny glass fibers, with each fiber about the thickness of a human hair. Lasers shoot pulses of light through the glass fibers of the cables. One cable can contain between six and twenty-four glass fibers. The diameter of these cables ranges typically between 20 to 50 mm. The disadvantage of this kind of cables is the fragility of glass compared to copper. Beam trawl or dredging activities striking a fiber cable can easily render it useless without actually parting it. Before the installation of a cable, a route survey takes place, examining bathymetry, slopes, sediment types and other activities or obstacles (e.g. pipelines, old cables or material discarded on the bottom). In areas where a lot of activities take place, cables are usually buried in the seabed, to protect them. In many coastal areas, the burial depth ranges between 0.6 to 0.9 m. Cable ships with ploughs usually bury the cables as they are laid.[4]

Various cable types afford different levels of protection depending on the external threat from known and unexpected hazards, including the conditions on the ocean bottom. This does not present an insurmountable problem since cable manufacturing is a modular process that allows for providing different degrees of protection for the cable as the threat increases.

In general, the threat decreases with water depth. The further the system is from marine activity, the less the risk. Accordingly, the degree to which cables are protected varies inversely with the depth of water. In shallow waters and on continental shelves, cables are armored to provide additional external protection. Different levels of protection are achieved by varying the armor thickness and material or even the number of layers of armor. However, in deep waters cables have no external protection, yet they are robust enough to last the life of the system when, undisturbed**.**

Undersea cables are manufactured in a modular manner where the lightweight (LW) cable is used as the core structure. The other cable types are produced by adding to this core structure layers of protection depending on the system environmental conditions. Therefore the degree to which additional layers are added depends on the region in which the cable is to be deployed. The list below provides the structure and the degree of protection afforded by the different cable types:

1. **LW** (Lightweight): This is the basic undersea cable, suitable for deployment in deepwater, and contains the unit fiber structure, the inner strength members, the copper conductor, and insulating material.
2. **LWP** (Lightweight Protected), LWS (Lightweight Screened) or SPA (Special Application): This cable is the LW cable protected with a metallic barrier, and covered with a layer of abrasion resistant polymer. This cable provides additional protection against abrasion and is suitable for areas where fish/sharks are known to be a threat to cables.
3. **SAL** (Single Armor Light) or LWA (Light Wire Armor): This cable is the LW cable protected by a single layer of steel armor (armor) wires. This cable is suitable for ocean burial, where additional in-situ protection is necessary.
4. **SA** (Single Armor): This cable is similar to SAL or LWA cable with a single layer of larger diameter steel protection wires which provide greater cable strength. This cable is suitable for unburied armored applications.
5. **DA** (Double Armor): This cable has two layers of protective steel wires placed over the LW cable. This cable is suitable for areas near the shore, where abrasion damage is greatest.
6. **RA** (Rock Armor): This cable has several layers of protective steel wires placed over the LW cable. The outermost layer has a very short lay angle, providing a greater protection against abrasion as well as external aggression.[5]

The key elements to ensure success in setting a new submarine cable system are as follows:

- A thorough Cable Route Study
- Accurate data acquisition during the Route Survey
- Detailed analysis of survey data leading to optimum route planning and cable engineering
- Effective installation and burial of the cab.[6]

This paper deals mainly with the third stage which plays an important role in the life cycle of the system and also the costs of executing and maintaining the system. In this regards, first, the factors that are effective in determining the optimal fiber optic route are determined and then, the best route for Oman Sea and Persian Gulf is proposed based on these factors.

2 IMPLEMENTATION AND RESULTS

In general, the routing of a cable depends on a number of factors, the most important of which are: the end points to be connected, seabed characteristics, risks of cable damage, water depths, the routes and characteristics of cables already in place. It must be noted that in practice, a number of factors particular to any given cable installation may prevent adherence to certain of these criteria.

Laying cables under water is a theoretical and also practical subject. This process requires testing and scientific investigations of the area for selecting the optimal route, cable type and its protection. The optimal route is the one which is determined with regards to constraints like capabilities and costs. The cost constraints are considered by the route length factor since cable production and laying is a costly process which will increase by the length of the route. Other constraints that are considered in this study include the seabed characteristics and depth limitations.

On the whole, the danger of cable fault minimizes as the depth of water increases. The further the cable systems are from fishing activities the less danger for them. Therefore, the safety of cables increases with the depth of water. Based on this, the above parameter has been considered as the main one in determining the optimal route for cables in the Persian Gulf. Considering that the Persian Gulf has relatively shallow water this fact increases the relative likelihood of the cable fault because of fishing activities. On the other hand, since the costs of making the cables, their repair, installation and maintenances are high the length of the cables is important in dealing with cost constraints. For the same reason, the other factor to be considered in determining the optimal route is the length of the cable. Considering the topographic map of the Persian Gulf, The depth of this water decreases from north to south in the beginning and then it gradually increases. For the Persian Gulf coverage, first, there should be a route that would allow whole coverage of the region. Based on the depth of Persian Gulf, this route will begin in Kuwait. Then, this route would pass Saudi Arabia, Qatar and U.A.E until it reaches Iran.

In the present study, the starting point of this route has been chosen to be in Kuwait, the furthest west country in the Persian Gulf. The GPS point of the country is 29 degree and 42 minute. Using Geographical maps, the depth element of seabed in the Persian Gulf is determined by dividing it into blocks based on minutes. Then the required depth for the corresponding block is entered based on the GPS coordinates. If a block belongs to land, zero and if it belongs to shore area one is fed into the software. Table 1 shows this data set.

In order to consider the risk of cable damages, based on the fact that there is a direct relation between the risk of damage and the depth of water, risk factor is assigned to each block of seabed.

So, at any given point, the next point would be the one that has the minimum risk and also minimizes the total length of the route. There would be several blocks having similar amounts for depth and risk factor. In this case, the closest block should be selected reducing the slightest divergences. By now, the main route of the cable from the extreme west point of Persian Gulf to Oman Sea is formed (Because in that region the main India cable passes). The next step would be calculating the average depth from the shore to the main cable route. For this, the Geographical depths are sorted descending by the average shore depth up to the main cable and then these values are sorted again by distance between the shore and the cable. This way, some blocks are prioritized based on their GPS coordinates to be chosen for inserting branches from the main cable. The depths of each block and the proposed optimal route are presented in figures 2 and 3.

Based on depth, damage, risk, and minimal size of used cables the optimal branching points are suggested as following as is shown in figure 4:

Point 1: kish Island

Point 2: Bandar Abas

Point 3: Jask port

The seabed characteristic problem is dealt with by employing the best cable type that suits the characteristics of the region. While considering cable engineering protecting measures in the needed places, it must be taken into account that various types of cables have been manufactured that have different risk tolerances dealing with known or unknown dangers existing on the seabed. On the whole, the deeper the water the less dangers there are for cables. Therefore, the degree of cable protection requirements has an opposite relation with the depth of the water. Underwater cables are designed with an analytical method. Light weight cables (LW) are used as cores of the cables. Other types of cables are made by adding layers to the core based on the region and the environment. So, as Persian Gulf has a relatively shallow depth, it is required that protection covering be studied due to the danger of ships and fishing activities. It is recommended that RA cables be used since this type is appropriate for depths under 200 KM.

0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	10	15	24	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	17.5	31	36	33	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	22	31	42	42	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	21	34	54	50	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	23	45	61	45	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	45	50	60	63	60	1	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
0	0	0	0	1	20	30	40	60	65	80	1	1	1	1	1	80	50	1	0	0	0	0	0	0	0
0	0	0	0	1	10	15	20	45	60	70	84	70	70	60	65	1	100	1	0	0	0	0	0	0	0
0	0	0	0	1	1	1	10	20	40	45	50	60	47	30	1	1	100	200	1	1	1	1	1	0	0
0	0	0	0	0	0	0	1	18	23	20	24	30	30	1	0	1	150	550	450	350	300	200	200	1	1
0	0	0	0	0	0	0	1	10	10	15	10	23	1	0	0	1	280	900	1600	1200	1350	1210	1100	1150	1000
0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	1	350	1500	1450	3000	2500	2200	2400	2500
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1400	2900	3200	3250	3350
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1950	2700	3100	3300
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2600	3100

Fig .1

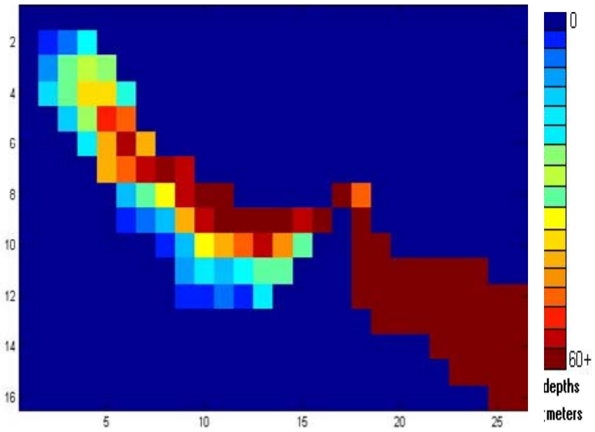

Fig.2

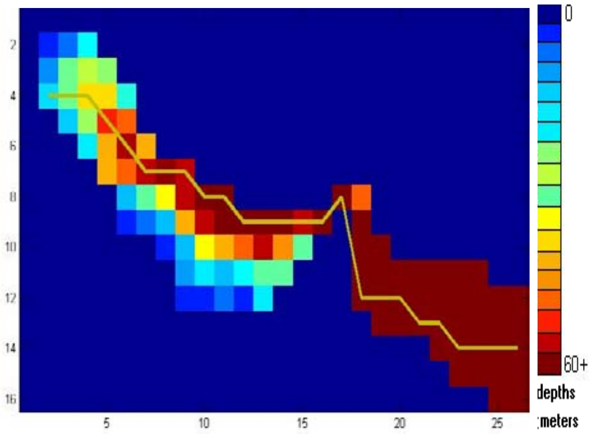

Fig.3

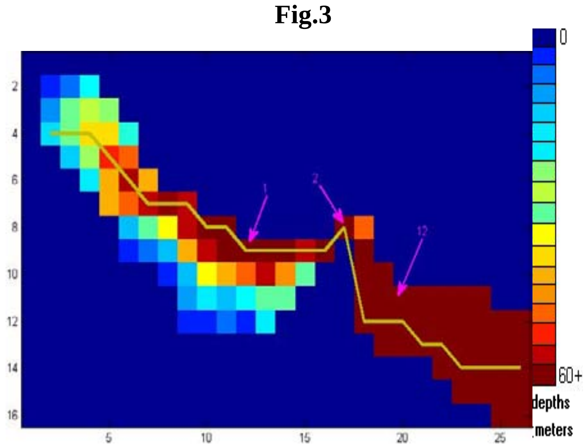

Fig.4

3 CONCLUTION

Iran is adjacent to 16 countries with more than 400 million population and has a unique strategic and geographic situation in the region. This clarifies the importance of it being connected to the worldwide communication network. Besides, the middle eastern countries can connect to fiber optic cable network through Iran.

In this paper, the optimal route for telecommunication cable in Persian Gulf is proposed based on the economic factors, safety measures and characteristics of seabed in this geographic area. Based on these factors, the optimal connection points are determined to be as follows: Kish Island, Bandar Abas, Jask port.

References

[1] “Sri Lanka Cable System Configuration”, Archived from South East Asia-Middle East-Western Europe 3, 02-01-2008, Retrieved on 07-14-2007 on the originalTelecom.

[2] www.iscpc.org/publications/Critical_Infastructure_2009_V2.pps

[3] “Sri Lanka Cable System Configuration”, Archived from South East Asia-Middle East-Western Europe 4, 01-31-2008, Retrieved on 08-04-2007 on the originalTelecom.

[4] F.M,“CABLES AND PIPELINES”, ANALYSIS Chapter 2: Infrastructure in the BPNS Maritime Institute Cables and pipelines, Renard Centre of Marine Geology University Gent Els Verfaillie & Vera Van Lancker Maritime Insti uteUniversity Gent.

[5] “Cable Engineering for Protection”, SCIG Information Guide,
Section:4, Issue : 1

[6] R. R, M. L, D. B, T. K,” Marine Survey & Cable Routing”, Sub Optic
2004 Short Course