Route Design/Cable Laying Technologies for Optical Submarine Cables

OHTA Tsutomu, NISHIYAMA Tomohisa

Abstract

Submarine cable systems will carry traffic for long-term over 25 years after entered into service. In order to construct a submarine cable system that can withstand for such a long period of time, it is required to conduct a marine route survey to identify the condition of the seabed in which the system is to be installed and to design the cable route based on the survey results. The assembled cable system is installed by a cable ship between the terminal stations to configure a communication system. This paper introduces how a submarine cable system installation is implemented by following the project flow step by step.

Keywords

marine route survey, route design, cable laying, burial, cable laying ship

1. Introduction

A submarine communication cable with a large-capacity communication capability is an essential infrastructure component for communication between two countries or areas. To construct a communication system, the seabed conditions between the two landing points of the cable route are surveyed and then a submarine cable to suit the seabed conditions is manufactured and assembled. Next, the assembled cables and submersible components are loaded onto a special purpose vessel (cable ship) that is used to physically connect the two landing points via submarine cables. This paper describes the workflow of the marine works until complete the construction of a submarine cable system.

2. Marine Route Survey

In order to construct a fault free submarine cable system it is important to carry out a marine route survey to understand the conditions of the seabed where the cable is to be laid and to design a cable route based on the achieved information by the survey. The marine route survey consists of geophysical survey by means of acoustic sounding methods and a geotechnical survey using sub-bottom profiling. The survey will be carried out by a purpose built survey vessel equipped with a multi-beam echo sounder running along the planned cable route and develops a survey chart that describes the birds-eye view of the seabed (**Fig. 1**). Survey charts will visualize the

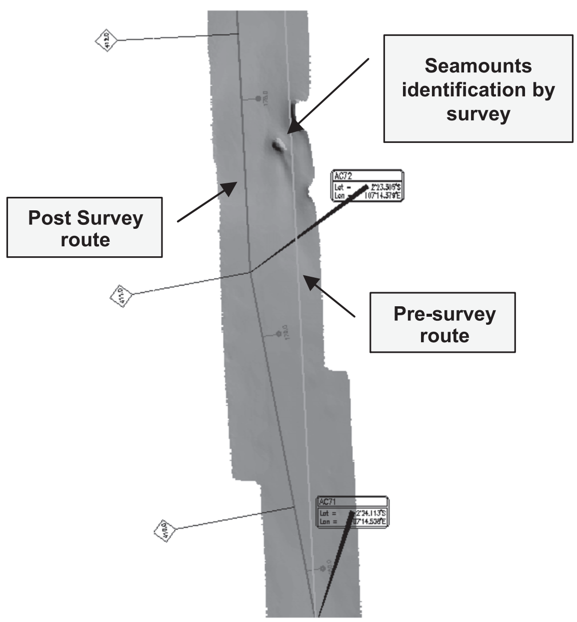

Fig. 1 Sea floor condition.

seabed conditions and exposes the presence of any slopes that are not suitable for cable laying.

The geotechnical survey indicates the presence of rocks or rock beds below the seabed that may hinder the burial work described in the later section. The characteristics of the sediment layers can be identified using a sub-bottom profiler by analyzing the time lag of the acoustic signal reflections. A strong reflection represents that hard sediment exists, thus the cable route should be designed to avoid such area. Since the seabed condition may not be accurately identified by sub-bottom profiling, the actual seabed samples may be retrieved from the seabed using a core penetrating sampler which serves to improve the accuracy of judgments. The results obtained will be described as a route survey chart. This will be used as the basis for determining the cable types and protecting methods of the cable system.

3. Route Design

Based on the results of marine route surveys and information regarding existing structures (such as fish nets etc.), the cable route is designed by taking into consideration the ease of the proposed laying work and the security of the system. As the number of laid submarine cables has increased recently, the cable routes in those congested areas that should be designed to reserve a safe distance from adjacent systems so that the routes are also acceptable from future maintenance point of view. The route survey report describes the optimum cable route, the cable type selected based on the survey results and the reasons for selections as well as the conditions of the surrounding sea area (climate change, fisheries, ocean floor developments, shipping traffic, etc.).

After the cable route has been determined, the result is compiled into the route position list (**Fig. 2**).

The route position list shows the locations of the submarine cables and components by indicating their latitudes and longitudes. It will then be used as an important reference to support the cable laying work. Each event indicates us where (the latitude and longitude of each submarine position), what (cable type and submarine equipment), how (surface laying or burial) the submarine cable system will be placed and the exact location where the cable ship should alter its course (AC points) in order to lay the cables along the designated cable route on the seabed.

Pos No.	Event	Latitude	Longitude	Distance (km) Between Positions	Distance (km) Cumulative Total	Cable Type	Approx Depth (m)	Target Burial (m)
1	BU KAR;LW	21 ° 07.000 ' N	64 ° 36.000 ' E		0.000		0	
				19.212		SA		0.0
2	AC	21 ° 03.477 ' N	64 ° 25.561 ' E		19.212		8	
				10.317		SA		0.0
3	CX IS FLAG FALCON Se	21 ° 00.199 ' N	64 ° 20.737 ' E		29.529		11	
				9.088		SA		0.0
4	AC	20 ° 57.312 ' N	64 ° 16.489 ' E		38.616		22	
				96.993		SA		0.0
5	AC	20 ° 37.527 ' N	63 ° 24.704 ' E		135.609		28	
				23.700		SA		0.0
6	CX IS Planned	20 ° 33.525 ' N	63 ° 11.743 ' E		159.309		31	
				46.368		SA		0.0
7	MB EZ OMN	20 ° 25.695 ' N	62 ° 46.401 ' E		205.678		31	
				4.992		SA		0.0
8	AC	20 ° 24.852 ' N	62 ° 43.674 ' E		210.669		38	
				21.468		SA		0.0
9	AC	20 ° 19.178 ' N	62 ° 32.903 ' E		232.137		41	
				8.182		SA		0.0
10	CX IS SEA-ME-WE 3 se	20 ° 15.788 ' N	62 ° 29.873 ' E		240.319		45	
				9.001		SA		0.0
11	AC	20 ° 12.059 ' N	62 ° 26.541 ' E		249.320		95	
				24.614		SA		0.0
12	AC	20 ° 04.732 ' N	62 ° 14.737 ' E		273.934		99	
				27.147		SA		0.0
13	AC	20 ° 00.006 ' N	61 ° 59.993 ' E		301.082		204	
				29.871		SA		0.0
14	BU1C FUJ	19 ° 58.000 ' N	61 ° 43.000 ' E		330.953		326	

Fig. 2 Route Position List (RPL).

4. System Assembly and Loading to Cable Ship

The Straight Line Diagram (**Fig. 3**) is a graphic representation of the route position list in order to instruct the factory to produce the submersible plants. The straight line diagram

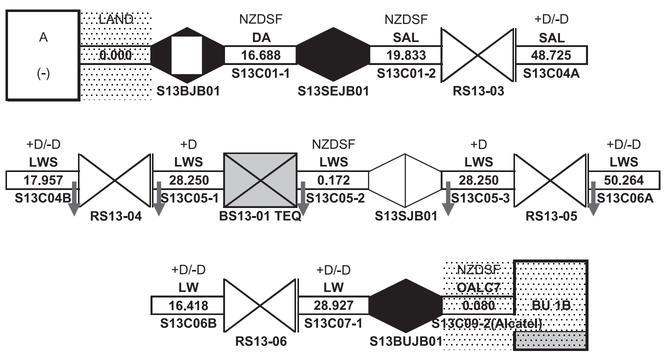

Fig. 3 Straight Line Diagram (SLD).

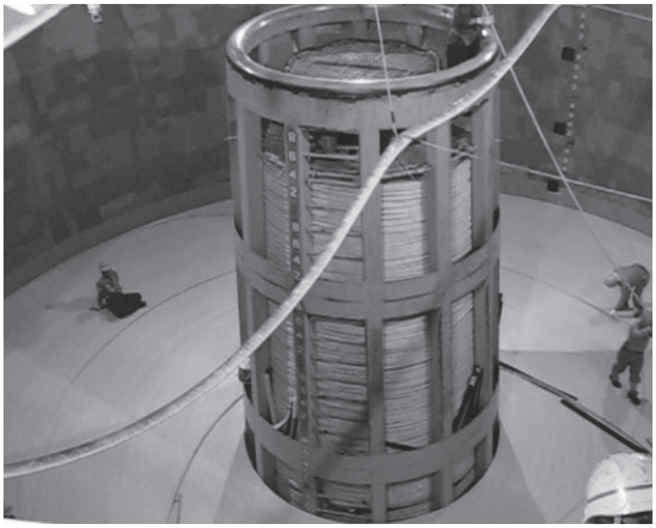

Photo 1 Cable loading (View inside a cable tank).

is a system configuration diagram represented in a line format which displays the connectivity of the submersible system components such as submarine cables and repeaters.

Based on the straight line diagram, submarine cables and repeaters are manufactured at their respective factories. The repeaters are then transported to the cable factory and assembled to the cables according the straight line diagram to form a continuous cable system.

The assembled system will be ready for loading/shipment after its performance has been confirmed in the presence of the customer.

The assembled cables and repeaters will be loaded from the cable factory to the cable ship to enable the cable laying work to proceed. The cable is loaded from the factory by cable hauling machine and coiled by port labors into the cable tank of the cable ship (**Photo 1**). The loading work is continued night and day and loading of a 1,000-kilometer cable system takes about a week. After completion of loading, the cable ship then starts its transit towards the designated installation site.

5. Cable Laying Work

Since submarine cables must coexist with other seabed user such as fisheries industries, etc. mutual understanding and cooperation is necessary among the related entities. In order to deal with the fishing activity which is one of the main causes of submarine cable failures, the cables are often buried below the seabed instead of being laid on its surface. This arrangement is intended to ensure both the fishing activity and the cable system can share the limited seabed and exist in long term towards the future.

5.1 Route Clearance

Route clearance will be performed prior to cable installation in the burial section. Regretted but various items of waste (fishing gear, ropes, sunken ships, anchors, etc.) exists on seabed hence these must be removed as not to hinder the cable burying work. Such obstacles are removed by towing a special clearance gear called ‘Grapnel’ along the planned cable burial section of the cable route.

5.2 Landing

The first work to be conducted by the cable ship on arrival at the cable landing site is the landing of the cable (**Photo 2**).

Photo 2 Cable landing.

The cable is floated from the cable ship stationed offshore at its water depth approach limit. This work connects one end of the communication system with the landing site terminal station.

5.3 Cable Laying Ship

A cable ship is a purpose designed/rigged vessel dedicated to be used for laying submarine cables and submarine equipment (repeaters and branching units). There are three cable ships in Japan for industrial use. The most significant features of these vessels are the large capacity cable tank and the stack for accommodating the submarine equipment. In addition, the ship is equipped with a sheave with a larger diameter than the cable’s minimum bending radius that facilitates the laying of the cable by feeding it out from the stern. As the work is conducted 24 hours a day, most of the crew onboard is required to operate at 2 or 3 shifts during the cable laying operation. The number of persons on board for staffing the day and night shifts is between 40 and 50, although this number varies depending on the duration of the operation and the capacity of the ship. NEC will also dispatch its representatives as cable laying supervisors and as cable testers to continuously monitor the transmission characteristics of the laid cable. The cable ship is equipped with the power feeding equipment to energize the cable system during the lay as well as test equipment for the use of electrical and optical testing. All of these personnel work on board for the period from the start to the end of the work, which may sometimes be for as long as three to four months.

Photo 3 Cable and repeater laid in the Pacific Ocean.

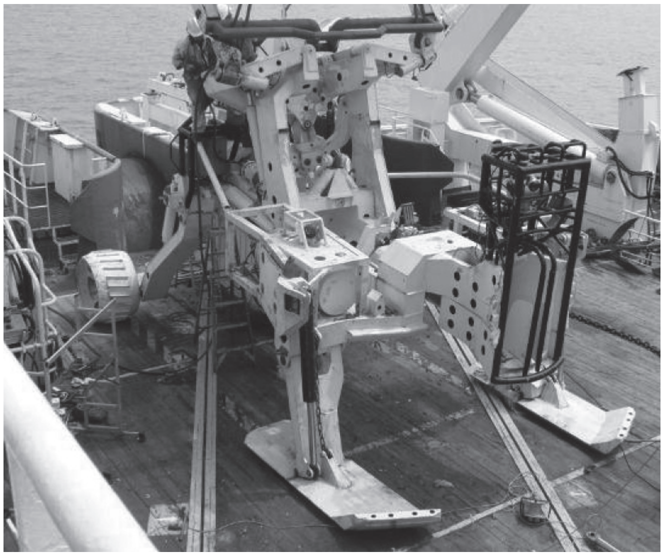

Photo 4 Cable burying equipment.

5.4 Cable Laying/Burial

Cables and submersible plants are usually either laid on the seabed surface or buried below the seabed. The surface laying process consists simply as the name implies of placing the submarine cables and the submersible plants on the seabed surface. The submarine cables and repeaters are designed to withstand a maximum depth of 8,000 meters in consideration of the possibility of crossing the Japan Trench (**Photo 3**).

The submarine cable loaded on the cable ship is fed from the cable tank, hauled by equipment called the cable engine that adjusts the laying speed, tension and length to be laid along the seabed surface.

On the other hand, in order to provide protection against faults caused by external aggression, the cables and repeaters are sometimes required to be buried below the seabed using towed-type cable burying equipment (**Photo 4**).

The cables are buried below the seabed in a method that reminds us of agricultural plowing. When the penetrating share is towed along the seabed surface, a ditch will be formed which the depth will depend on the height of the penetrating share. This means that the cable passing through the penetrating share of the cable burying equipment makes it possible to bury the cable in the ditch. In general, cable burial is applied until a water depth of about 1,000 meters is reached. 1,000 meters water depth is in general the maximum water depth at which fishery activity is conducted. The depth of the burial produced by the cable burying equipment is variable and can be 3 meters at maximum.

Cables are usually buried from the shallow area towards the deeper area. In other words, after the landing work is completed, the cable burying work is started and then it changes to the surface laying work as the deep-sea areas are reached. The cable installation work completes when the submarine cables and submarine equipment loaded in the cable ship has been installed. Depending on the size/complexity of the cable system, there may be cases in which several cable ships are used and installation work proceeds in parallel. The period from cable loading to the completion of the laying can be between one to six months. After the cable laying work has completed, an overall system performance test is conducted before the cable system is commissioned and delivered to the customer.

6. Conclusion

During 2008 and 2009, NEC implemented three large-scale projects for over 5,000 kilometers. The workflow of submarine cable construction is basically identical regardless of the project. The marine work begins with route survey and then proceeds to the route design, submersible plant manufacturing and assembly, loading and laying. However, as the degree of difficulty varies significantly depending on the location of the cable system and operating season, a flexible approach is required that corresponds to the topography and conditions to suit the unique characteristics of each projects. We will continue to contribute our highly reliable methodology to construct a submarine cable system.

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Authors' Profiles

OHTA Tsutomu
Installation Manager
Ocean Engineering Department
Mobile & Global Network System Division
NEC Networks & System Integration Corporation

NISHIYAMA Tomohisa
Assistant Manager
Ocean Engineering Department
Mobile & Global Network System Division
NEC Networks & System Integration Corporation