Big Challenge to Overcome Difference in Bending Radius in Housing Unit Used in Submarine Telecommunication System and Seismic and Tsunami Observation System

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Abstract: KCS expanded our challenge to implement the network composed of cabled seismographs and tsunami units. The cable used for the network was exactly the same as the one used for submarine telecommunication system. On the other hand, the housing of the seismograph and tsunami unit was far larger and heavier than a housing used in telecommunication system. This paper describes how we achieved to lay and bury the system by covering the following points;

1) Design and modification to adopt the difference in a bending radius
2) Key points to be considered
3) Safety issue

1. Outline

After having experienced unprecedented disaster caused by the massive earthquake and tsunami in Japan in 2011, many projects in various fields have been launched to mitigate natural disaster as a national policy.

As part of the government’s effort to disaster-prevention measures, deployment of ocean-bottom seismic and tsunami observatory network in Japan has been expedited taking into account the lessons learnt from this Great East Japan Earthquake. The network is highly anticipated to detect earthquake and tsunami earlier than traditionally detected and will serve as effective disaster mitigation measure.

The entire network consists of a total length of 5,700 km submarine cable and 150 observatories, each equipped with seismometers and tsunami meters. The network is composed of six subsystems and Kokusai Cable Ship Co., Ltd. laid about one-third of the network from 2014 to 2015. Length of the cable laid was 1,700 km with 54 observatories. Cable and observatories are buried 1 meter from the seafloor up to a water depth of 1,500 m.

2. Desktop Study

KDDI Pacific Link, a cable layer used to build the systems, is a dedicated telecommunications installation vessel which is equipped with cable engines, ROV and cable plough being designed based on technical specifications and mechanical structures of telecom fiber-optic submarine telecommunications cable and optical submarine repeater.

The cable used for the network is exactly the same as the one used for submarine telecommunications system, whereas the observatory, a housing of the seismograph and tsunami sensor, is far larger and heavier than a housing used in telecommunications system. Therefore this fact required us to take look at the difference closely in order to deal with laying and ploughing operations of the system precisely, steadily and safely.

Comparison of mechanical specifications for seismic and tsunami observatory housing and typical telecommunications repeater housing is as follows.

Seismic and tsunami observatory housing
Length: 5.4 m
Minimum bending radius: 2.15 m
Weight in air: 1.1 ton

Typical telecommunications repeater housing
Length: 4.2 m
Minimum bending radius: 1.5 m
Weight in air: 0.5 ton

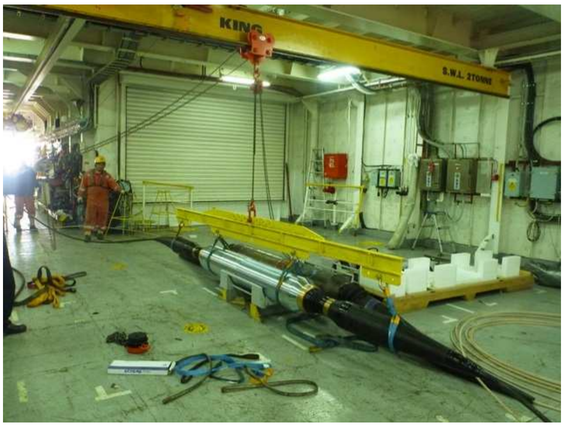

Photo 1: Mock seismic and tsunami observatory housing

In the course of our desktop study, critical problems were revealed which stood in the way of laying and burying these observatory housings with the existing equipment on-board the cable layer, namely a bending radius.
As described in the above, minimum bending radius of 1.5 m is commonly used to design both submerged plants and cable layers for telecommunications system. On the other hand, the submerged plant for this ocean-bottom seismic and tsunami observatory system we were about to handle had the minimum bending radius of 2.15 m.
The difference in the minimum bending radius had a great impact on mechanical structures of both the cable plough and on-board sheave.

In order to fulfill the requirements for laying and burying the observatory units, the following aspects were closely considered and studied.

- Mechanical structures
  Modified specifications of minimum bending radius on the vessel equipment.
- Operational side
  Reviewed and revised laying procedures of the larger-size housing by Linear Cable Engine (LCE).
  Reviewed and revised burying procedures by the cable plough.

A step-by-step process described below was followed to overcome the difficulties we encountered.
Step 1: Verification of mechanical structures of the vessel and vessel equipment along with the observatory housing unit by CAD drawing.

Step 2: Got a full and clear picture of burial operation by using miniature models of the cable plough and observatory housing and clarified the problems.

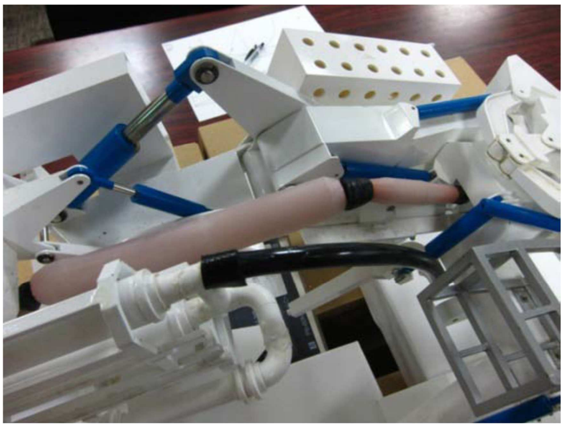

Photo 2: Miniature models, 1/20 size of the actual cable plough and housing unit

Step 3: Trial on-board in port to confirm the handling operation by using the mock seismic and tsunami observatory housing.

Step 4: Sea trial to confirm the handling and burial operations by using the mock observatory housing.

Step 5: Rectified the problems identified during the Step 4 and retrial at sea.

Step 6: Rectified every problem before actual operation.

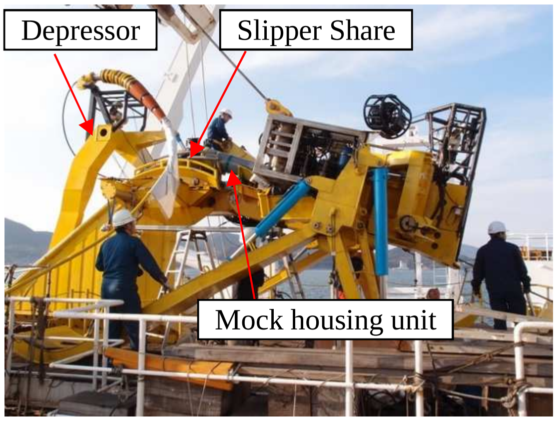

Photo 3: On board handling trial by using mock housing unit


Photo 4: Measurement of the gimbal angle

3 . Equipment Modification & On-board Trial

Following modifications were made to resolve the structural problems with the cable plough and on-board sheave ascertained during Step 1 and 2.

- Modifications to Plough

a) Slipper Share

Extended the range in application of the minimum bending radius from 1.5 m to 2.3 m. Replaceable slipper share was manufactured.

b) Depressor

As the slipper share being modified with larger bending radius to accommodate the large-size observatory housing unit, the housing unit interfered with the depressor when it passes through the slipper share. Changed the shape of the depressor and replaceable depressor was manufactured.

c) Cable Retainer/Distance Wheel Arm

Changed the shape of the cable retainer and distance wheel arm as they also interfered with the observatory unit. Replaceable retainer and distance wheel arm were manufactured.

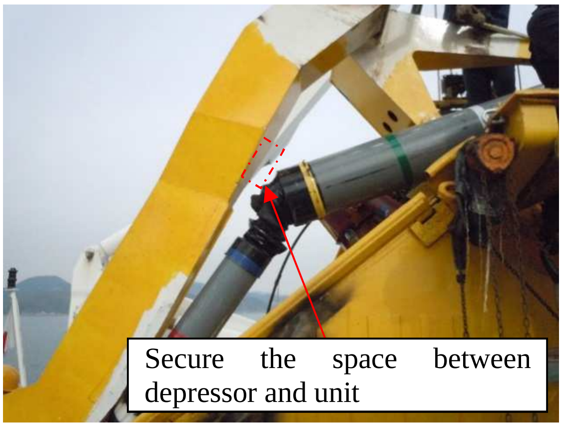

Photo 5: Mock unit and a new depressor

- Modifications to On-board Sheave

a) Chute over On-board Sheave

Obviously it was necessary to modify not only the slipper share of the cable plough but also on-board sheave as it has the same bending radius of 1.5 m. We came to a conclusion which was cost-effective option to manufacture a replaceable chute with rollers fitted to reduce frictional resistance and also to prevent cable and units from being damaged instead of modifying the entire on-board sheave. This chute can be fitted over the on-board sheave.

Photo 6: Fitting of replaceable chute

4. Sea Trial

Sea trial was carried out twice, one in February 2013 and another in March 2014, to verify and evaluate functional capabilities of the modified equipment.
We assembled the mock observatory unit with armoured cable for the trial at shallow water and with unarmoured cable for the deep water trial. Also, trials for laying and recovery operations were carried out by using Linear Cable Engine (LCE) with 20 pairs of tyres.

Photo 7: Trial for laying/recovery of the mock observatory unit by LCE

Since the housing unit is quite heavy, we learned that it gets stuck while going through LCE. Concerns over the possibility of damaging the cables assembled with the unit were observed. We developed an effective solution to this problem which is to adjust operation control conditions of each pair of the tyres respectively. Unexpected or urgent situation might make the already laid system to be recovered during actual operation. In case we may have to deal with such situation, we also did a trial for recovering the system. The trial revealed another issue we should consider, that is a space between the whisker guard of the vessel and the chute fitted over the on-board sheave. We modified the chute to minimize the space between the whisker guard and the chute so that the tip of the housing boot will not be caught in the gap.

With reference to burying the observatory housing unit, the following two (2) burial methods by the plough were considered.

A) To use typical method used to bury optical submarine repeater housing in telecommunications network system. The cable plough is towed by and behind the cable layer for simultaneous lay and burial.
B) To stop the cable layer 20 m before the cable plough after the observatory housing unit is laid on the seabed. Then make the unit pass through the cable the plough by winching the tow winch.

In order to achieve reliable and safe control and operation of the cable plough with the large size and weighty housing unit, we focused on the following main points when deciding which method to adopt for burial operation.

- Mitigate the shock to the unit and also the vibration of the unit especially when the unit goes into the entrance of bell-mouth and then when it passes

through the slipper share and the depressor.
- Stabilize the cable plough position.

The operation and control of the plough and the unit to deal with the above-mentioned points, we came to a conclusion that the Method B is viable in the light of safety, accuracy and assurance and operation can be implemented by changing modes of the cable layer, plough and LCE.

5. Actual Operation

Successful laying and burial operation was achieved based on the adequate consideration, analysis and evaluation towards how we can leverage a cable layer and its equipment used in submarine telecommunications system to lay and bury the seismic and tsunami observatory system, which has completely different design concept mechanically.
Fifty-four (54) earthquake and tsunami observatories were laid during the deployment of the systems. Among them, thirty-one (31) were deployed on the seabed surface and the other twenty-three (23) were deployed under the seabed by the cable plough, average burial depth was 147 cm and the maximum was 214 cm. A pitch of the buried units was almost zero degree.
In addition to these challenges, considering what is being expected from those observatories, it was essential to deploy the seismic and tsunami observatory housing units with high-accuracy position.
The requirement was to deploy the observatory unit within ± 500 m from the originally planned position in the waters of depths from 1,500 m to 5,600 m.
We had uniquely developed our own 3-D laying simulation system to meet such requirements in different operations and this simulation system was also used in this seismic and tsunami observatory deployment.
The 3-D simulation system was applied to all of the units deployed on the seabed surface, thirty-one (31) units.
How we applied the simulation system is described below.
During the deployment of the observatory unit, the unit is moved from the observatory unit stack to the inboard cable trough so as to mitigate the shock to the unit as well as the vibration of the unit. At the same time, measures to mitigate frictional resistance on each part where the weighty observatory unit passes through such as the inboard cable trough, LCE, the cable trough at the afterdeck and the chute is taken.
By making use of this time, we engineered a deployment plan for touch-down position of the observatory unit from the vessel position, cable length as well as data of current and water depth obtained.
At the end of the day, every observatory unit was within the requirement and the location deviation was 1 m at the minimum and 371 m at the maximum.

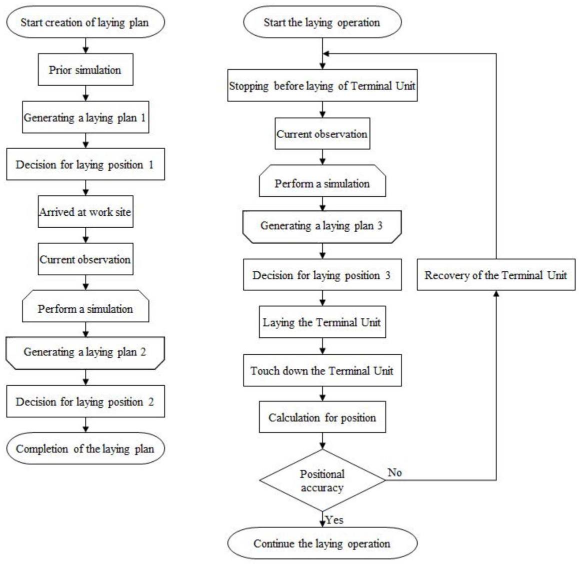

Figure 1: Working flow of 3-D simulation system

6. Conclusion

Although our vessel was constructed and dedicated to lay submarine telecommunication system, KCS established appropriate measures for laying seismic and tsunami observatory system by utilizing the same vessel. The submerged plants in the observatory system are different in size and mechanical structure from conventional telecommunication submerged plants.
It was confirmed that it is not necessary to have a vessel classified according to the purpose such as cable for telecommunication or observatory or marine resources exploration.
It is very likely that development and advancement of seismic and tsunami observatory network as well as exploration of marine resources will be a growing market and KCS believes that vessels for submarine telecommunication system can contribute to this rapidly growing market.

7. Acknowledgement

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