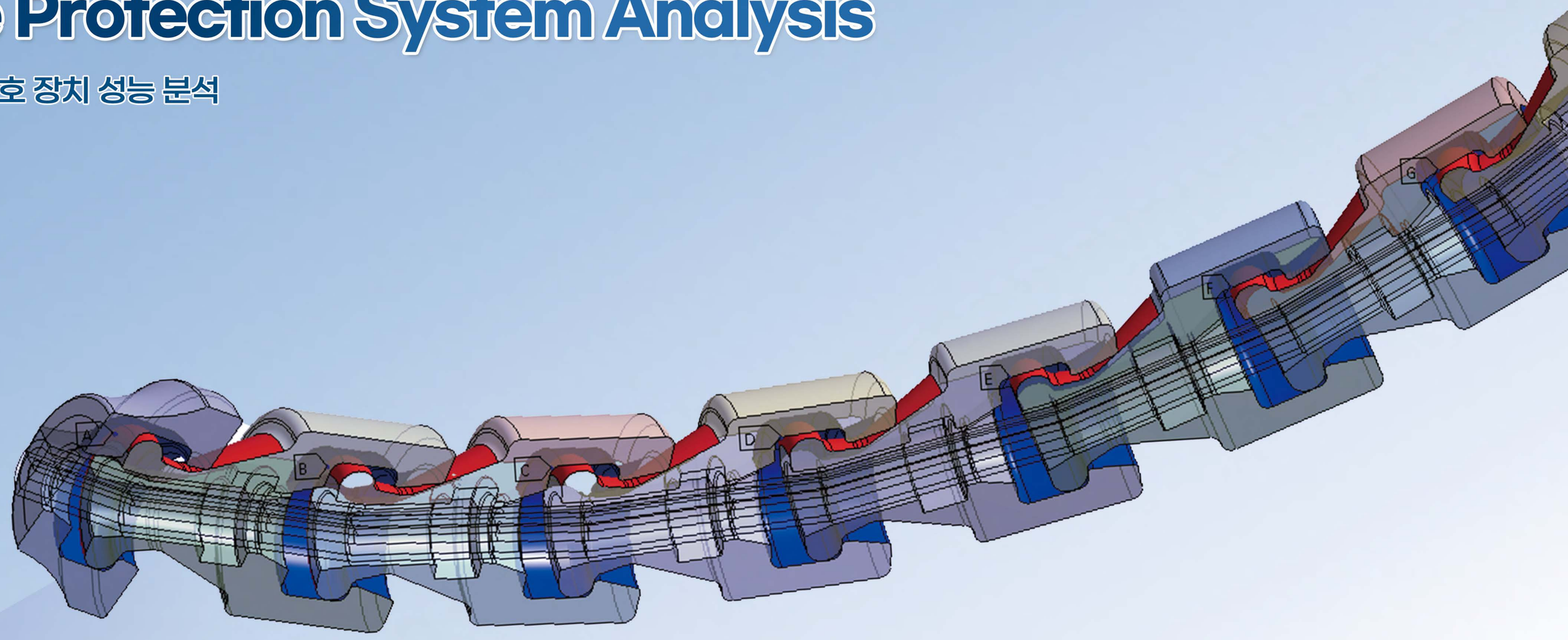
Lifting and Moving Technology
SEHO ENGINEERING

PROJECT WORK REPORT

Cable Protection System Analysis

해저 케이블 보호 장치 성능 분석



SEHO ENGINEERING Co., Ltd.
Ulsan City, South Korea
+82-52-223-3221
+82-52-223-3558
seho@sehoenc.co.kr
www.sehoenc.co.kr

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Cable Protection System

It was reviewed to analyze the characteristics of CPS devices for cable protection installed in offshore wind power. Offshore wind power generator has power cable that sends electricity to the land and it risk breaking due to fatigue, as it moves hundreds of thousands of times a day due to waves and currents. In addition, as power cable is swept away by waves, there is a risk of damage to the upper generator side and buried cable on the seabed. Therefore, it is recommended to install a Cable Protection System (CPS) on offshore wind generators that can minimize the movement of power cables caused by seawater and prevent cable damage.

Fixed offshore wind power generators have limited cable movement, so installation work is carried out to protect the cable by installing CPS in a limited location.

Project Period

[The 1st Contract] 2022. 04 ~ 2022.10 / [The 1st Development Plan] 2023. 05 ~ 2023. 06

Scope of Work

- Fatigue Analysis, Structural Analysis, Motion Characteristics Analysis of CPS device
- Shape Design of CPS device
- Design Condition & Scope

(1) Capacity Test Equipment for Electric Wire
- Safety Working Load (SWL)
- Over Load Test for FAT : SWL * 1.3
- Tension device : Hydraulic cylinder
- Load Cell : ton

(2) Strength Test Equipment for Cable Protector (CPS device)
- Safety Working Load (SWL)
- Over Load Test for FAT : SWL * 1.3
- Tension device : Hydraulic cylinder or Winch
- Load Cell : ton

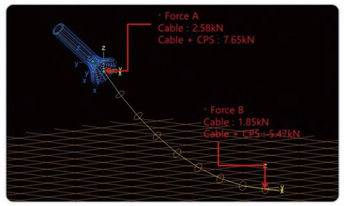
(3) Drop Test Equipment
- Test Capacity : 300Kg
- Driving System : Winch

(4) Design Items
- Basic design of test equipment : 3 cases
- Structural Analysis of Test Equipment
- Analysis of Fatigue in Cable
- CFD Analysis of Cable

Structural Analysis

● Analysis Results - Environmental Condition Analysis

OrcaFlex Numerical Model of J-Tube Seal



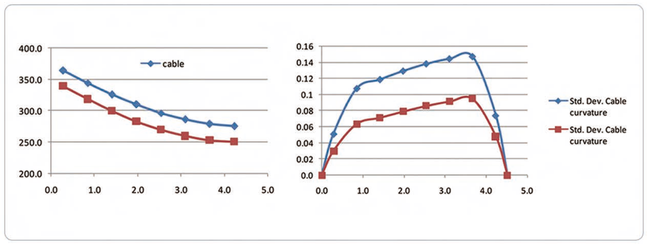
Analysis of External Force

	Cable	Cable + CPS	Increase (%)
Mass per unit length (t/m)	0.05	0.15	300
Force A (kN)	2.58	7.65	297
Force B (kN)	1.85	5.47	296

Environmental Condition Analysis

Applying environmental condition in the same direction to the modeling and analyzing the external force results and the Curvature results indicating the shape of the cable together in both Cable and Cable + CPS will confirm the following Damping characteristics. According to the results of the analysis, The force at the end of the J-Tube seems to be about 0.78tons. And when comparing before and after CPS installation, Curvature(the shape characteristic of the cable) decreased by 5.12°. It can be seen that this contributes sufficiently to ensure that the deformation characteristics of the power cable can be maintained within the protection limit radius of the power line.

Result of Stress Analysis



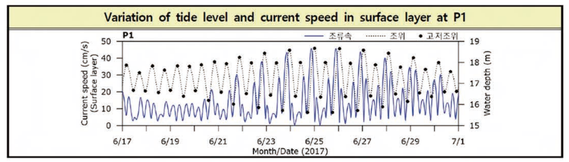
Mid Segment	Max von Mises stress (kPa)		
Arc length (m)	cable	c+CPS	Reduced ratio
0.2823	364.0	339.2	6.8%
0.8468	344.0	318.5	7.4%
1.4113	325.9	299.7	8.0%
1.9758	310.0	283.3	8.6%
2.5403	296.5	269.8	9.0%
3.1048	286.1	259.5	9.3%
3.6693	278.9	253.0	9.3%
4.2338	275.5	250.4	9.1%

By analyzing the stress distribution characteristics of the two OrcaFlex modeling results, it can be check that cables containing CPS devices produce about 8.4% of low stress. In addition, when analyzing the standard deviation of the external force acting from the environment for one minute, cables equipped with CPS show a standard deviation of about 1/2 compared to cable installation alone. It is analyzed that the cable has less stress concentration due to fatigue under normal environmental load conditions, which reinforces the cable's protection against long-term fatigue loads.

FE Analysis

The stress concentration of CPS affects wear and tear due to repeated loads applied to CPS. Therefore, by changing the shape of CPS to a quadratic model, it is expected to increase the contact area between CPS to reduce the load and reduce the radius of curvature of the cable by resistance of the increased area. Based on the modified CPS model, it has been changed to connect seven CPS according to the structural characteristics installed at a height of 2 m under the sea and the minimum radius of rotation of the cable. At this time, there is a distance of about 400mm from the radius to 3m, which is the minimum radius of rotation of the cable. Accordingly, the forced displacement was increased by 50mm, and the result was compared between the model with CPS installed and the model with only cable installed. As a result of the load analysis for the final shape, it was confirmed that there was an attenuation characteristic of about 4%.

The tidal current data from areas of the sea where CPS is installed



Sub-surface current speed of 1 and 50 years return period (P1)					
Return period	Tidal range (cm)	Current speed (cm/s)	return period	Tidal range (cm)	Current speed (cm/s)
1 year	317	38	50year	352	42

The stress change according to the influence of the currents in the sea area where CPS is installed occurred as shown in the table on the right, and a stress of about 31 Pa occurred in CPS7.

The maximum stress that occurs when installing the J-tube of CPS is 31.5950 Pa, which occurs in CPS7, CPS8, and CPS1 in the order of maximum stress.

The change in stress due to the tidal current is not large, and load has been analyzed as a major factor in stress.

This interpretation is a 2D interpretation and does not take into account the shaking interpretation in the Z direction, so it should be a composite evaluation with reference to the analysis results using OrcaFlex above.

CPS Displacement & Stress Variation with Load Combination

Load case	Applied load		Deformation [mm]	Remarks
LC01		- Fy	6.7200	
LC02	- Fx	- Fy	6.6777	
LC03	+ Fx	- Fy	6.7624	

Load case	Applied load		Max. stress		Remarks
LC01		- Fy	CPS1	10.5710	
			CPS2	2.2119	
			CPS3	1.9892	
			CPS4	4.1213	
			CPS5	5.9524	
			CPS6	5.0126	
			CPS7	**31.3900**	**Max**
			CPS8	24.742	
LC02	- Fx	- Fy	CPS1	10.9100	
			CPS2	2.2053	
			CPS3	1.9287	
			CPS4	3.8976	
			CPS5	5.6396	
			CPS6	4.8781	
			CPS7	**31.1900**	**Max**
			CPS8	24.4210	
LC03	+ Fx	- Fy	CPS1	10.2330	
			CPS2	2.2210	
			CPS3	2.0513	
			CPS4	4.3454	
			CPS5	6.2718	
			CPS6	5.1440	
			CPS7	**31.5950**	**Max**
			CPS8	25.0660	

Work Performance Records for the last 3-years

No.	Project Name	Company / Contractor	Duration	Remarks
14	ITER - VS - Coil in Situ Winding Work - Staging & Prototype Design	IO / Yujin MS	2022~2023	On-going
13	Vacuum Insulated Pipe Design & Analysis	DuckCheun	2022~2023	On-going
12	Artificial Structure for Display	Government / GSI	2023	On-going
11	HD-10,000 F/C Mooring Design & Analysis	SK Ocean Plant	2023	On-going
10	Consulting of Method Statement for FOWT	SK Ecoplant	2022	Finish
9	Design of Special Lifter for Ship's Propulsion	Zvezda / DH Ent	2021~2023	Finish
8	Barossa FPSO - Structural Analysis	BWO / FG Ind.	2021~2022	Finish
7	Mumbai Trans Harbour Link Project - Marine Work & Installation Analysis	Daewoo TATA / DWST	2021~2023	Finish
6	Cable Protection System(CPS) Design Analysis	DWNT / Panduite	2022	Finish
5	ITER - Bracing Tools Manufacturing Design	IO / Yujin MS	2022	Finish
4	Lifting Work Procedure for Floating Crane	Kumyong	2022	Finish
3	Vibration Analysis for SCR	WK Industry	2021	Finish
2	Power System Design of Air Boat	Government / KUMHA	2021~2022	Finish
1	Development of Mine Laying System Design	Government / KUMHA	2020~2022	Finish

Software & Tools

ANSYS
Structural Analysis

ENGYS
Applications by Industry
CFD & Optimisation

Orca3D
Orca3D
Marine Design for
Rhinoceros

OrcaFlex
Dynamic Analysis Software
for Offshore Marine Systems

SACS
Structure Analysis
Computer System for
Offshore Plant

PATRAN & FEA2007
Hull and General
Structural Analysis
Program

Rhino
Geometric
Modeling

MIDAS-NFX
Structural Analysis
& Civil Engineering

MOSES
Multi-Operational Structural
Engineering Simulator,
Motion & Stability Analysis

OPTI-MOOR
Mooring Analysis

NASTRAN
Analysis Solver

AUTO-CAD
2D & 3D Drawing

3D MAX
3D Drawing

IN-HOUSE SOFTWARE
Ballasting Calculation,
Towing Calculation,
Lug Calculation,
Welding Calculation and Etc.

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