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CONSIDERATIONS ABOUT USING A SECONDARY REVERSE CHUTE DURING A CABLE LAY PROCEDURE

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Abstract: *During cable laying operations, there are situations when cable loose contact with the chute. This situation is inacceptable since the cable control is lost. To avoid this situation, in a real cable laying operation it was used a reversed chute. In this paper is presented the adopted solution and the calculus behind it. All the data on that paper are protected by the copyright laws and belongs to S.C. Marine and Offshore Consultants S.RL.*http://marineoffshoreconsultants.com/

Background

This paperwork is meant to provide information, with respect to inverse chute reactions and cable side wall pressure values during the most critical operational situations during a cable lay operations using a cable lay barge

Assumptions and Model Description

Based on the informations about cable laying barge (CLB) and area where the operation is held, there were have simulated in Orcaflex the following waves Hs = 1m (Tp = 5.6 s), 1.25m (Tp = 6.2), 1.5m (Tp = 6.8 s) at 7 m water depth as well as Hs = 1m (Tp = 5.6s) at 2 m water depth. The range of 2-7 m water depth has been deemed conservative for the operational range of 'CLB' laying route.

The directions of wave incidence have been considered to vary at a 45° step, 0° being considered from the stern rotating counter-clockwise through the starboard stern quarter (45°), towards starboard beam (90°), starboard bow quarter (135°) and towards head waves (180°).

Due to the model symmetry, only the 0-180° heading range has been considered.

A 0.78 safety factor has been considered for both MBR and pulling force (tension) according to Recommended Practice DNV-RP-F401.

Thus, the allowable value limits considered in this report are 88.92 kN at MBR (axial tension), a MBR of 4.87 m at TDP and 23.4 kN/m (sidewall pressure).

Results of the analyses show that axial tensions stay far below the allowable (88.92 kN at MBR) values for this particular cable. At the same time, the SWP also stays within the allowable limits. However, due to the ramp angle and shallow water particulars of the operation, the declination of the cable is too low in order to have chute contact at all times. In consequence, a reversed chute has been proposed and modelled.

This model geometry has been used in Orcaflex in order to simulate the reactions and SWP at support 15 (i.e. reversed chute).

Analysis

Based on the results of the analysis there could be concluded that cable integrity in terms of allowable maximum tension, SWP and MBR is conserved during cable lay operation as long as the tension, declination angle, barge heading follow the recommendation of the present study, under the envisaged environmental conditions.

Movement of the barge is considered further dumped by presence of the 5th anchor which was conservatively not considered in this analysis. Effect of 5th anchor will result in reduced barge response and subsequently lower tension at chute.

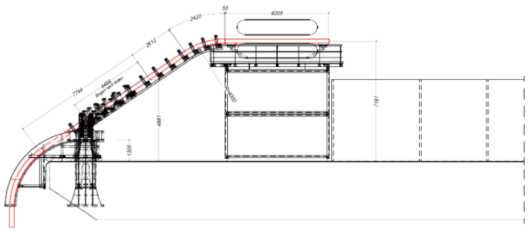

Figure 1 - Cable highway during cable lay (side view)

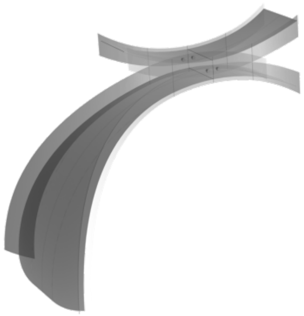

Figure 2 – Chute + Reversed Chute Proposal (ISO View)

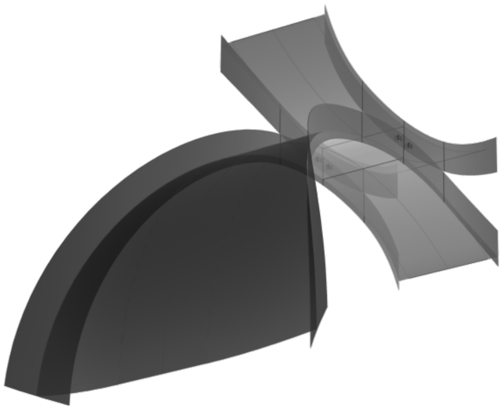

Figure 3 – Chute + Reversed Chute Proposal (ISO View)

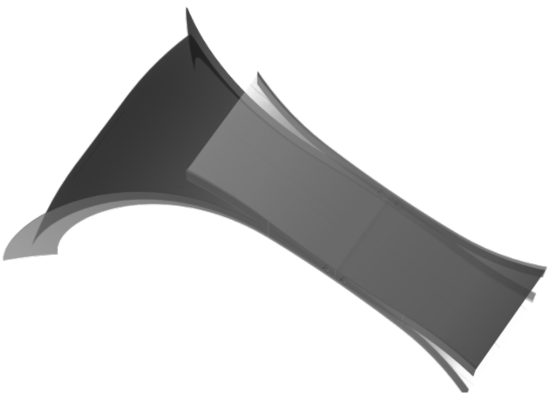

Figure 4 – Chute + Reversed Chute Proposal (ISO View)

Acceptability Criteria

For the current analysis there have been made the following assumptions:

i. No wind shielding has been applied

ii. The current runs collinear with the wave direction and thus varies with the wave incidence angle.

iii. The cable should not withstand compression loads, in this respect the minimum tension at the tensioner is set to 10 kN.

iv. The cable tension anywhere along the cable should be below 114 kN x 0.78 = 88.92 kN provided the MBR is above the minimum 3.8 m. However, the cable exiting the tensioner shall withstand the highest loads.

There have been considered as reference the values given by manufacturer for the cable:

- Max. Pulling force @ MBR: 114 kN
- Allowable side wall pressure: 30 kN/m
- MBR: 3.8 m (at TDP)

The prioritization of allowable parameters considered in the analysis are as follows:

1. Minimum 10 kN at Tensioner (axial force)
2. Maximum 88.92 kN at Tensioner (axial force)
3. Minimum Bending Radius (MBR) at Touch Down Point (TDP) 3.8 m / 0.78 = 4.87 m.
4. Declination angle δ (defined as the angle of the chute exit catenary tangent with Vz – direction minus Ox, minus Oz) should be greater than Pitch(max) taken from the RAO (1.4° - LC 1.2.2) + Ramp Angle (35°) + 90°.

   δ> 126.4° or other limiting devices should be present to insure a chute maximum lift-off of 0.2 m
5. Moreover, the SWP maximum allowable value has been set to 30 · 0.78 = 23.4 kN/m

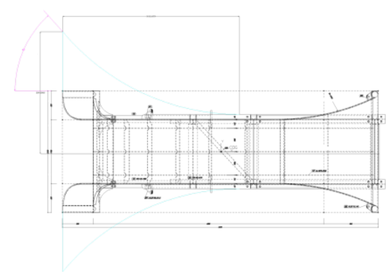

Figure 5 – ‘CLB’ – actual Chute recommended curvature (blue curve) – 4000 mm

Proposals for highway lift-off prevention

Considering the previous chapter second table results, a need to restrain / prevent the cable from lifting off the chute appears.

We therefore propose the installation of a fixed or hinged (preferable) reversed chute-like shaped structure having the same MBR as the original chute (4.0 m), on top and a bit aft of the aft CLB chute. The clearance between the upper reversed chute-like structure and CLB aft chute was considered at 0.37 m.

Coordinate System origin is at the intersection of the water plane with longitudinal plane at 32.5 m from the aft of the barge.

Axis orientation:

- Ox positive towards the Fore end
- Oy positive towards portside
- Oz positive upwards

Coordinates of the chute center (Support 14):

- Xc: - 31.1 m
- Yc: - 4.399 m
- Zc: - 0.8 m

The added reversed chute has a 4 m radius circle sector with the following center coordinates (Support 15):

- Xc': - 35.5 m
- Yc': - 4.399 m
- Zc': + 6.3 m

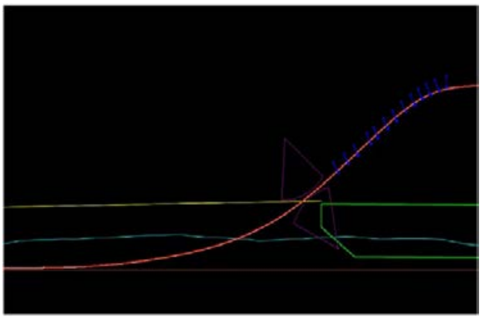

Figure 6 OrcaFlex Model - 'CLB' (installation option – aft + reversed chutes and highway - modelled)

Results

The two most critical results for declination were chosen for the current study, they are presented below (considering minimum chutes radius at no time below 4 m):

Water Depth	Heading (°)	Hs case	Hs(m) [m]	Tp(s) [m]	Reversed Chute: Reaction Force at Reversed Chute (kN)		Reversed Chute: SWP (kN/m)		δ [°]		Chute contact clearance [m]		Reversed Chute contact clearance [m]	
					Min	Max	Max	U.R.	Min	Max	Min	Max	Min	Max
(1) Max Water Depth 7 m	(2) 45° SS Quarter Fwd	(2)	1.25	6.2	0	18.5	2.90	0.12	106.5	121.2	0.0	0.1	0.0	0.1
(2) Min Water Depth 2 m	(3) 90° SS Beam	(1)	0.9	5.6	0	2.53	1.32	0.05	108.5	114.5	0.0	0.1	0.0	0.1

Following to the above summarization, there can be concluded that although the declination angle remains low, the chute lift-off is minimal, meaning that the cable barely loses contact with the chute during the most severe situations and as soon as it does, its vertical tendency to lift is suppressed by the chute-like structure above it.

At the same time, maximum side wall pressures peak at 2.90 kN/m – case 1.2.2 (abt 12 % of the allowable 23.4 set by the parent analysis) and remain within the allowable, varying insignificantly throughout the cable lay Load cases.

There should also be noted that the configuration of the deployment arrangement would have to be able to pass through the closed chute or chute + reversed chute proposed hinged system.

Reaction forces in the above chute (meaning towards the centre of the Support 15), normal to the cable (direction oz positive, ox negative), for the worst scenario (1.2.2 above presented) are as follows:

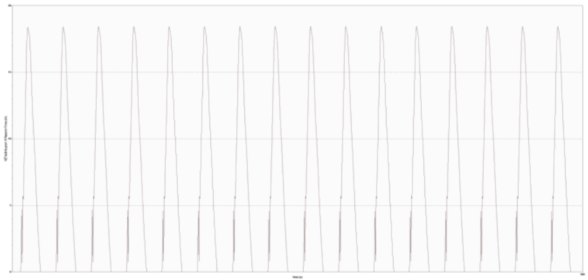

Figure 7 – Reaction force in the reversed chute maxing 18.5 kN

Maximum reaction forces should be used as a minimum for the design of the reversed chute.

Please note that the above chute geometry proposal is in principle only. No structural engineering has been carried out (only geometrical particulars of the chutes have been looked into so that at no time the cable MBR is exceeded (less than 3.8 m).

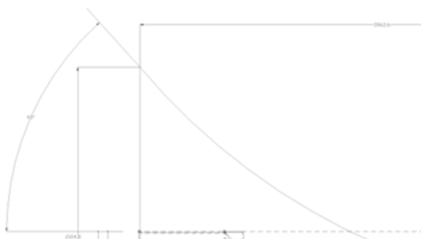

Figure 8 – Chute horizontal range proposal +/- 48°

The recommended tension setting if the tensioner is to be set to automatic tension keeping would be between 15 and 20 kN.

CONCLUSION

As it was proven by calculus, this solution was successfully used in an real operation, the reversed chute being effective in controlling a high voltage cable in high waves.

BIBLIOGRAPHY:

[1] Orca flex documentation
[2] LOC maritime operation procedure manual