Journal of Subsea and Offshore
-Science and Engineering-, Vol.6

June 30, 2016

Subsea Pipeline Analysis of Nosong-Bongawan Field, Malaysia

Nurul Nabila,[a], Mukminah,[a], Muhammed Amirul Asyraf,[a], Fahd Ezadee,[a] and J.Koto,[a,b,*]

[a)] *Department of Aeronautic, Automotive and Ocean Engineering, Faculty of Mechanical Engineering, Universiti Teknologi Malaysia*
[b)] *Ocean and Aerospace Engineering Research Institute, Indonesia*

*Corresponding author: jaswar@utm.my and jaswar.koto@gmail.com

Paper History

Received: 3-June-2016
Received in revised form: 28-June-2016
Accepted: 30-June-2016

ABSTRACT

The Nosong-Bongawan North field is located in Block B310 in Offshore Sabah Area, approximately 75km North of Labuan and approximately 30km North of SUPG-B, Malaysia. This paper discussed subsea pipeline of the Nosong-Bongawan field development using Subsea Pro Simulation to determine wall thickness and stress and ANSYS to determine the deformation due to buckling of pipeline. Simulation results were compared with the actual operating data.

KEY WORDS: *Nosong-Bongawan North Field, Subsea Pipeline, Stress, Wall Thickness, Buckling, Deformation.*

NOMENCLATURE

WHP	Wellhead Platform
MMSCFD	Million standard cubic feet of gas per day

1.0 INTODUCTION

The Nosong-Bongawan North field is located in Block B310 in Offshore Sabah Area, approximately 75km North of Labuan and approximately 30km North of SUPG-B. PETRONAS is currently undertaking the development of this field. The business target of the Nosong-Bongawan Gas Development is to deliver 50 MMSCFD production to SUPG-B, and ultimately to LGAST. The Nosong and Bongawan fields are at 90m and 95m water depth respectively.

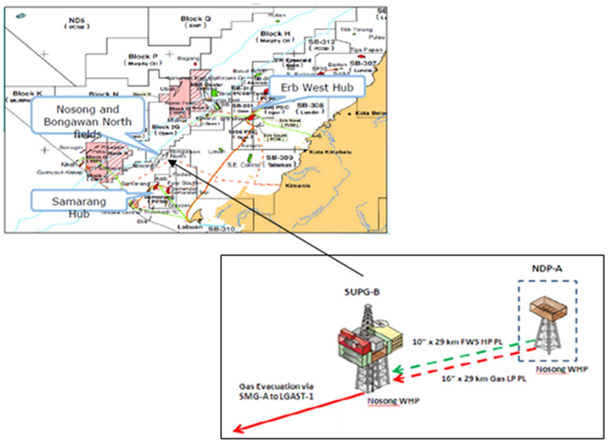


Figure.1: Nosong-Bongawan field development.

This paper attempted to develop a comprehensive subsea development plan for the Nosong field. The subsea development encompasses all the processes required to transport the gas from the well to the pre-processing facility located on the NDP-A bottom-founded platform. After that, this project will address the piping requirements to transport the gas from the NDP-A platform to the SUPG-B platform

2.0 DEVELOPMENT OF NOSONG FIELD

2.1 Overall Overview of Nosong Field

PETRONAS undertakes the development of Nosong North field which is located in Block B310 in Sabah Area, approximately 75km North of Labuan and approximately 30km North of Sumandak Central Processing Platform (SUPG-B CPP). As described in the previous scope section, this report covers only the bottom-founded platform (fixed platform) and so the selection is shallow water area (75 km) to the onshore.

Nosong Gas Development facilities hub scopes are comprised of following:

- One (1) Wellhead Platform (WHP).
- Two (2) dedicated new trunk lines; 10-inch FWS (High Pressure) ; approximately 30km from WHP to existing SUPG-B.
- Offshore modification and tie-in WORKS at existing SUPG-B

2.2 Nosong Field Development

2.2.1 Business Target of Production

The business target by the stakeholders of this Nosong Gas Development project is to deliver **50 MMSCFD** production by **June 2017** to SUPG-B CPP, and ultimately to Labuan Gas Terminal (LGAST). The Nosong field is at 90m water depth.

2.2.2 Specific Location of Field

From exploration and the field study, the location (geodetic data) of the field is furnished by them is as table follow. The geodetic data for the offshore pipelines are referenced to Universal Transverse Mercator (UTM) local projection with Timbalai 1948 local datum.

Table.1: Datum and local projection info.

Local Datum	Detail Information
Datum	Timbalai 1948
Spheroid	Everest 1830 (1967 Def)
Semi-major axis	6 377 298.556 m
Semi-minor axis	6 356 097.550 m
Inverse flattening	300.8017

Local Projection	Detail Information
Map projection	UTM Zone 50°N
Grid projection	Universal Transverse Mercator
Latitude of origin	00° 00’ 00” N
Longitude of origin	117° 00’ 00” E
False Easting at origin	500 000 m
False Northing at origin	0 m
Scale factor at origin	0.9996

2.2.3 Regulation, Design Codes and Standard

The design of the pipeline system in order of priority are conformance with the requirements of the PETRONAS Technical Standards (PTS) and international codes and standards as specified in PTS, unless specified otherwise.

If the Government or Local Authority Laws and Regulations are more stringent than the PTS, the former takes precedence. Deviations from these standards shall be agreed upon and approved by Petroliam Nasional Bhd. For any deviation/ conflict from applicable rules, codes and standards, the prevailing priorities will be according to following sequence:

- PETRONAS Technical Standards (PTS)
- National or Local Rules and Regulations
- International Codes (API, ANSI, AISC, ASME, DNV and ISO)

As for pipeline, the primary code for the design of the pipeline and riser systems shall be in accordance with PTS 31.40.00.20, September 2012 Rev 0, ‘Pipeline and Riser Engineering’ and its supplementary documents.

2.2.4 Malaysian Government, Local Authority Laws and Regulation

The field development was governed by the below government and local authority laws and regulations as follows:

- Petroleum (Safety Measures) Act 302, 1984 (incorporating all amendments up to 1 January 2006)
- Petroleum (Safety Measures) (Transportation of Petroleum by Pipeline) Regulation, 1985, PU(A) 85/1985
- Department of Occupational Safety and Health (DOSH), Malaysia

2.3 Standard and Specifications

2.3.1 Technical Specifications

The specification of the platform shall be complying with the Petronas Technical Specification (PTS).

Table.2: Technical Specifications

Specification
Pipeline and Riser Engineering
Riser Design
Installation and Commissioning of Cathodic Protection Systems
Design of Cathodic Protection Systems for Offshore Pipelines (Amendments/Supplements to DNV RP F103)
Protective Coatings and Linings
Linepipe Induction Bends (Amendments/supplements to ISO 15590-1)
Linepipe Specification (Amendments/supplements to API 5L 44th Edition / ISO 3183:2007)
Pipeline Fittings (Amendments/Supplements to ISO 15590-2)
Pipeline and Riser Engineering
Carbon and Low Alloy Steel Pipeline Flanges for Use in Oil and Gas Operations (Amendments/Supplements to MSS SP-44)
Pipeline Transportation Systems – Pipeline Valves (Amendments / Supplements to API Spec 6D/ISO 14313)
Design of Pipeline Pig Trap Systems
Concrete Coating of Linepipe
External Polyethylene and Polypropylene Coating for Linepipe

External Fusion Bonded Epoxy Powder Coating for Linepipe
Bituminous Enamel Coating of Steel Linepipe
Elastomer Coatings and Monel Sheating for Offshore Riser Protection
Hydrostatic Pressure Testing of New Pipelines
Pre-commissioning of Pipelines
Welding of Pipelines and Related Facilities (Amendments/Supplements to ANSI/API STD 1104)

2.3.2 Industry Codes and Standards

Besides PTS, the field also shall in conformance with API and ASME as shown in Table.3 and Table.4, respectively.

2.3.2.1 American Petroleum Institute (API)

Table.3: API specification

API	Description
API RP 1111	Design, Construction, Operation and Maintenance of Offshore Hydrocarbon Pipelines, May 2011
API Spec 5L	Specification for Line Pipe, 45th Edition, December 2012
API Spec 6D	Specification for Pipeline Valves, October 2012
API Std 1104	Welding of Pipelines and Related Facilities, 21st Edition, September 2013

2.3.2.2 American Society of Mechanical Engineers (ASME)

Table.4: ASME specification

ASME	Description
ASME VIII Div. 1	Rules of Construction of Pressure Vessel, July 2013
ASME B31.8	Gas Transmission and Distribution Piping Systems, January 2013
ASME B16.5	Pipe Flanges and Flanged Fittings, April 2013
ASME B16.9	Factory-Made Wrought Butt Welding Fittings, February 2013
ASME B16.20	Metallic Gasket for Pipe Flanges – Ring-Joint, Spiral-Wound, and Jacketed, June 2013
ASME B36.10M	Welded and Seamless Wrought Steel Pipe, 2010

2.3.3 Water Depth

The water depths at the offshore facilities/platforms are presented in Table.5 below and are taken from Nosong WHP (NDP-A) to Sumandak (SUPG-B CPP) Pipeline route.

Table.5: Water Depths at Facilities

Location	Approximate Water Depth wrt. Mean Sea Level (m)
NDP-A	89.3
SUPG-B	42.81

The water depths along the proposed pipeline routes from Nosong WHP to Sumandak SUPG-B are presented in Table 4.5 below and are taken from Nosong WHP to Sumandak SUPG-B Pipeline route survey information (which is not covered in this report).

Table.6: Maximum and Minimum Water Depth along Pipeline Routes

Pipeline	Water Depth wrt. MSL (m)	
	Minimum	Maximum
16-inch NAG LP Pipeline from NDP-A to SUPG-B	36.82	89.27

2.3.4 Tidal and Surge Data

The tidal and surge data to be used for wellhead, manifold and pipeline design and riser at NDP-A platform are extracted from Nosong Bongawan Metocean Criteria. The tidal and surge data to be used for riser design at existing SUPG-B are extracted from Metocean Criteria at Sumandak Tepi and Sumandak Selatan as shown in Table.7:

Table.7: Tidal and Surge data for Nosong field and compared also with Sumandak Tepi and Sumandak Selatan area

Criteria	Nosong Bongawan	Sumandak Tepi & Sumandak Selatan
Highest Astronomical Tide (m)	0.94	**1.23**
Mean Sea Level (m)	0	**0**
Lowest Astronomical Tide (m)	-1.17	**-0.97**
1 Year Storm Surge (m)	0.3	**0.3**
100 Year Storm Surge (m)	**0.6**	**0.6**

2.3.5 Wave Data

The wave data to be used for pipeline design and riser at NDP-A platform are as given in Table.8 and Table.9 and are extracted from Nosong Bongawan Metocean Criteria.

Table.8: Wave criteria for return period of 1 year

Direction	Omni	N	NE	E	SE	S	SW	W	NW
H_s (m)	3.9	3.9	3.2	1.6	2	2	2.7	3.1	3.5
T_p (sec)	9.7	9.7	8.8	6.3	6.9	7	8.1	8.6	9.2
H_{max} (m)	6.8	6.8	5.7	3	3.6	3.7	4.9	5.5	6.2
T_{ass} (sec)	9	9	8.2	5.9	6.4	6.5	7.6	8	8.5

Table.9: Wave criteria for return period of 10 years

Direction	Omni	N	NE	E	SE	S	SW	W	NW
H_s (m)	4.6	4.6	3.9	2.0	2.4	2.4	3.3	3.7	4.2
T_p (sec)	10.6	10.6	9.7	6.9	7.6	7.7	8.9	9.4	10.0
H_{max} (m)	8.1	8.1	6.8	3.6	4.3	4.4	5.9	6.5	7.3
T_{ass} (sec)	9.8	9.8	9.0	6.4	7.1	7.2	8.3	8.8	9.3

2.3.6 Current Data

The current data to be used for project development especially for pipeline design and riser at NDP-A platform are as given in Table.10 and Table.11 which are extracted from Nosong Bongawan Metocean Criteria.

Table.10: Current data for return period 1 year

Direction	Omni	N	NE	E	SE	S	SW	W	NW
At surface (1.0D) (cm/s)	114	71	114	74	53	64	82	74	51
Mid Depth (0.5D) (cm/s)	91	57	91	59	42	51	65	59	40
Near ottom (0.1D) (cm/s)	53	33	53	34	25	30	38	34	24
Near Seabed (0.01D) (cm/s)	25	15	25	16	11	14	18	16	11

Table.11: Current data for return period 10 years

Direction	Omni	N	NE	E	SE	S	SW	W	NW
At surface (1.0D) (cm/s)	143	89	143	93	67	80	103	93	64
Mid Depth (0.5D) (cm/s)	114	71	114	74	53	64	82	74	51
Near ottom (0.1D) (cm/s)	67	42	67	43	31	37	48	43	30
Near Seabed (0.01D) (cm/s)	31	19	31	20	14	17	22	20	14

Notes:

At other water depths not specified above, the current velocities shall follow the 1/7th rule. The formula is as below:

$$V_z = V_d \cdot \left(\frac{z}{d}\right)^{1/7} \qquad (1)$$

Where, d is total water depth, z is depth of interest above seabed, V_z is current speed at depth 'z' metres and V_d is current speed at the surface

2.3.7 Seawater Properties

The seawater properties are presented in Table.12

Table.12: Sea Water Properties

Parameters		Values
Sea Water	Density	1025 kg/m^3
	Kinematic Viscosity	0.96 x 10^{-6} m^2/s (At 25°C)
	Mean Surface Temperature	28.5 °C
	Mean Seabed Temperature	21.1 °C

2.3.8 Marine Growth

In the absence of more accurate data, the marine growth thickness for the risers is considered to be 90mm at Mean Sea Level. Marine growth is assumed to decrease by 1mm for every 2m of water depth. The Marine growth density is 1025 kg/m^3.

2.3.9 <u>Soil Properties</u>

The soil properties along the proposed pipeline route are extracted from the Nosong WHP to Sumandak SUPG-B Pipeline Route Survey Report. The soil properties with respect to KP as summarized below.

Table.13: Nosong WHP to Sumandak SUPG-B Pipeline Route Soil Properties

Kilometer Point	Drop Core	Soil Type	Su (kPa)
0 - 0.5	DC-1.0	Very loose SAND with shell fragments	N/A
0.5 - 1.5	DC-2.0	Very loose SAND with shell fragments	N/A
1.5 - 2.5	DC-3.0	Very loose SAND with shell fragments	N/A
2.5 - 3.5	DC-4.0	Very loose SAND with shell fragments	N/A
3.5 - 4.5	DC-5.0	Very loose clayey SAND with shell fragments	N/A
4.5 - 5.5	DC-6.0	Very loose clayey SAND with shell fragments	N/A
5.5 - 6.5	DC-7.0	Very loose clayey SAND with shell fragments	N/A
6.5 - 7.5	DC-8.0	Soft grey sandy CLAY with shell fragments	14
7.5 - 8.5	DC-9.0	Very soft grey sandy CLAY with shell fragments	11
8.5 - 9.5	DC-10.0	Soft grey sandy CLAY with shell fragments	12.5
9.5 - 10.5	DC-11.0	Very soft grey sandy CLAY with shell fragments	5
10.5- 11.5	DC-12.0	Very soft grey sandy CLAY with shell fragments	7

11.5 - 12.5	DC-13.0	Very soft grey sandy CLAY with shell fragments	7
12.5 - 13.5	DC-14.0	Very soft grey sandy CLAY with shell fragments	9
13.5 - 14.5	DC-15.0	Very soft grey sandy CLAY with shell fragments	9
14.5 - 15.5	DC-16.0	Very soft grey sandy CLAY with shell fragments	5
15.5 - 16.5	DC-17.0	Very soft grey sandy CLAY with shell fragments	5
16.5 - 17.5	DC-18.0	Very soft grey sandy CLAY with shell fragments	7
17.5 - 18.5	DC-19.0	Very soft grey sandy CLAY with shell fragments	3
18.5 - 19.5	DC-20.0	Very soft grey sandy CLAY with shell fragments	5
19.5 - 20.5	DC-21.0	Very soft grey sandy CLAY with shell fragments	5
20.5 - 21.5	DC-22.0	Very soft grey sandy CLAY with shell fragments	6
21.5 - 22.5	DC-23.0	Very soft grey sandy CLAY with shell fragments	7
22.5 - 23.5	DC-24.0	Very soft grey sandy CLAY with shell fragments	8
23.5 - 24.5	DC-25.0	Very soft grey sandy CLAY with shell fragments	3
24.5 - 25.5	DC-26.0	Very soft grey sandy CLAY with shell fragments	4
25.5 - 26.5	DC-27.0	Very soft grey sandy CLAY with shell fragments	5
26.5 - 27.5	DC-28.0	Very soft grey sandy CLAY with shell fragments	10
27.5 - 28.5	DC-29.0	Very soft grey sandy CLAY with shell fragments	3
28.5 - 29.5	DC-30.0	Very soft grey sandy CLAY with shell fragments	6
29.5 - 30.5	DC-31.0	Very soft grey sandy CLAY with sheTestll fragments	6
30.5 - 31.5	DC-32.0	Very soft grey sandy CLAY with shell fragments	6
31.5 - 31.9	DC-33.0	Very soft grey sandy CLAY with shell fragments	4

The soil geotechnical properties along the pipelines are taken from Laboratory Test of Nosong WHP to Sumandak SUPG-B Pipeline Route Survey (Ref. 10) and are summarised below.

Table.14: Nosong WHP to Sumandak SUPG-B Pipeline Route Soil Properties

Drop Core	Depth	Water Content	Wet Density	Dry Density
	(m)	(%)	(Mg/m^3)	(Mg/m^3)
DC-1.0	0.8	40	1.95	1.39
DC-2.0	0.8	40	1.92	1.37
DC-3.0	0.8	40	1.92	1.37
DC-4.0	0.8	39	1.95	1.4
DC-5.0	0.72	39	1.95	1.4
DC-6.0	0.72	39	1.95	1.4
DC-7.0	0.77	37	1.95	1.42
DC-8.0	0.8	40	1.92	1.37
DC-9.0	0.3	33	1.83	1.38
DC-10.0	0.3	33	1.83	1.38
DC-11.0	0.3	35	1.83	1.36
DC-12.0	0.3	35	1.83	1.36
DC-13.0	0.4	40	2.29	1.64
DC-14.0	0.4	41	1.94	1.38
DC-15.0	0.4	32	2.03	1.54
DC-16.0	0.4	30	2.06	1.58
DC-17.0	0.4	36	2.01	1.48
DC-18.0	0.4	35	2	1.48
DC-19.0	0.4	34	2	1.49
DC-20.0	0.4	42	1.91	1.35
DC-21.0	0.2	21	1.84	1.52
DC-22.0	0.4	34	2.05	1.53
DC-23.0	0.4	46	1.91	1.31
DC-24.0	0.4	34	1.99	1.49
DC-25.0	0.4	35	1.99	1.47
DC-26.0	0.3	38	1.89	1.37
DC-27.0	0.3	38	1.7	1.23
DC-28.0	0.2	42	1.93	1.36
DC-29.0	0.4	45	1.8	1.24
DC-30.0	0.3	38	1.7	1.23
DC-31.0	0.3	38	1.7	1.23
DC-32.0	0.2	40	1.87	1.34
DC-33.0	0.2	39	1.87	1.35

3.0 SUBSEA PIPELINE ANALYSIS

3.1 Pipeline Design Parameter

The pipeline design and calculation is the most crucial part in any subsea field development process. The parameters will be taken into consideration in this work are: structure of pipe, weight of pipe, design pressure and pipeline stress.

The pipeline design and operational data is based upon Pipeline Steady State Hydraulic Analysis Report and Corrosion Design Basis Memorandum is presented in Table.15. The hydrostatic test pressure shall be 1.5 times maximum allowable operating pressure / design pressure of the pipeline system or the pressure that produces hoop stress in the weakest component equal to 90% of SMYS, whichever is smaller. In the event of pig stuck during pigging operation, it is anticipated that the riser and spool at NDP-A side may be exposed to a build-up of topside pressure. Therefore, all flanges at NDP topside, riser and spool has been rated to NDP-A topside pressure and the NDP-A riser and spool has been designed to withstand NDP-A topside pressure.

Table.15: Pipeline Design and Operating Data

Parameter		10-inch FWS HP Pipeline from NDP-A to SUPG-B	16-inch NAG LP Pipeline from NDP-A to SUPG-B
Flow Medium		FWS	NAG
Min. Product Density (kg/m^3)		117.68	14.64
Max. Product Density (kg/m^3)		266.68	41.49
Internal Corrosion Allowance (mm)		3	3
Corrosion Allowance for Riser Splash zone (including external) (mm)		6	6
Outside Diameter (mm)		273	406.4
Design Pressure for NDP-A Topside, Riser and Spool (bar)		186.2	186.2
Design Pressure for Subsea Pipeline, SUPG-B Topside, Riser, Spool (bar)		137.9	82.74
Hydrotest Pressure for Pipeline System (bar)		206.85	124.11
Max. Design Temperature (°C)		80	80
Min. Design Temperature (°C)		0	0
Maximum Operating Temperature (°C)		68	64
Pipeline and Riser Design Life (years)		25	25
Linepipe Type		HFW	
Material Grade for Linepipe		API 5L	
NDP-A Topside Rating		1500	1500
Subsea Flange Rating (Note 2)		1500	1500
SUPG-B Topside and Pipeline System Rating		900	600
Proposed External Anti-Corrosion Coating	Above Splashzone	1mm thk. Glass Flake Filled Polyester	1mm thk. Glass Flake Filled Polyester
	Riser Splashzone	12.7mm thk. Neoprene over 0.5mm thk. FBE	12.7mm thk. Neoprene over 0.5mm thk. FBE
	Submerged Risers and Bends	0.5mm thk. FBE	0.5mm thk. FBE
	Subsea Pipeline	5.5mm thk. AE with Concrete Weight Coating	5.5mm thk. AE with Concrete Weight Coating

3.2 Pipeline Material and Steel Properties

The material thermal properties and densities of the pipelines and risers are shown in Table.16.

Table.16: Material Thermal Properties and Densities

Coating Type	Density	Thermal Conductivity
	(kg/m3)	(W/m.K)
Asphalt Enamel (AE)	1280	0.69
Fusion Bonded Epoxy (FBE)	1400	0.3
3 Layer Polyethylene (3LPE)	925	0.6
3 Layer Polypropylene (3LPP)	900	0.22
Concrete Coating	3044	2.1
Carbon Steel Pipe	7850	45.35
Neoprene Coating	1450	0.265

The design will be based on the following steel material properties shown in Table.17.

Table.17: Steel Properties

Description	Unit	Value
Young's Modulus, E	MPa	207000
Poisson's Ratio,	-	0.3
Coefficient of Thermal Expansion	^{0}C	11.7 x 10-6

4.0 SUBSEA STRENGTH ANALYSIS

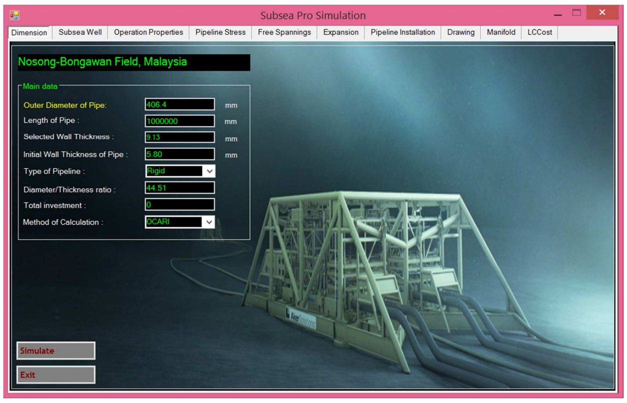
3.1 Pipeline Design Parameter

The pipeline analysis is carried out using Subsea Pro Simulation to determine wall thickness and ANSYS to determine total deformation during operation. The pipeline is subjected to internal pressure and hydrostatic pressure.

Table 18 and Figure.2 show wall thickness and stress analysis using Subsea Pro Simulation. The simulation result shows very close to the actual wall thickness.

Table.18: Actual and simulation result wall thicknesses.

	Actual	Subsea Pro Simulation
Wall Thickness (mm)	9.525	9.130



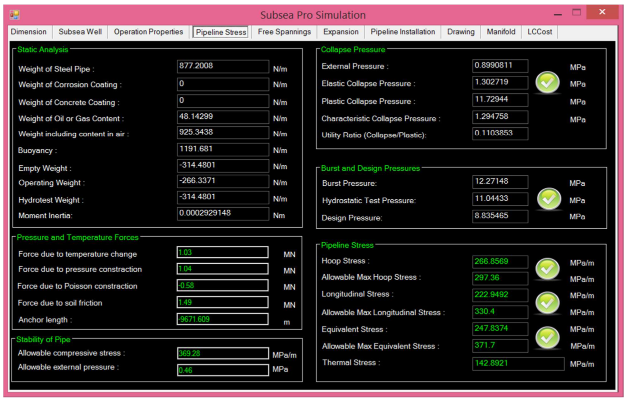


Figure.2: Wall thickness and stress analysis using Subsea Pro Simulation.

Two types of analysis were carried out, the first is static analysis and the second is buckling analysis. The table below shows the characteristics of the pipeline.

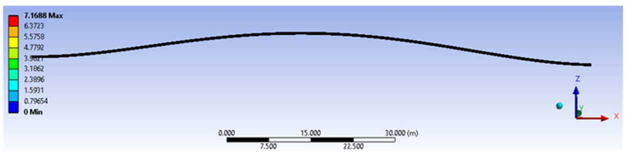


Figure.3: Maximum Deformation (100m free span)

The analysis shows that the maximum deformation is 7.1688m at the middle of the pipeline. This analysis is carried out for 100m free span. As we can see the maximum deformation is quite high. Therefor a shorter free span is considered to decrease the maximum deformation.

Figure.4: Maximum Deformation (50m free span)

The figure above shows maximum deformation for 50m free span. As can be seen, the value is now 0.4486m only which is considerably lower than for 100m free span. The pipeline will require support on the middle of free span to offset the buckling load.

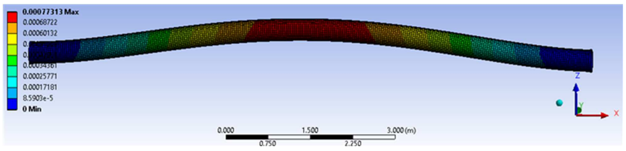


Figure.5: Maximum Deformation (10m free span)

The figure above shows maximum deformation for 10m free span. The maximum value is 0.0008 m which is almost zero. This proves that the shorter the free span, the smaller the static deformation. However, selecting the optimum free span must include other factor such as cost and efficiency.

5.0 CONCLUSION

In conclusion, this paper discussed subsea pipeline of Nosong-Bongawan field development, Malaysia. Wall thickness and stress of the subsea pipeline were analyzed using Subsea Pro Simulation and ANSYS. The simulation result shows the simulation result was very close to the actual wall thickness.

ACKNOWLEDGEMENTS

The authors would like to convey a great appreciation to Universiti Teknologi Malaysia and Ocean and Aerospace Engineering Research Institute, Indonesia for supporting this research.

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