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Influence of Conductor Pipe Diameter on the Global Structural Performance of a Fixed Offshore Wellhead Platform

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Conductor Pipe;
In-Place Analysis;
Structural Response
SACS;
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ABSTRACT – Offshore wellhead platforms are continuously subjected to environmental loads from waves, currents, and wind; therefore, structural assessment is required to ensure safe operation, particularly when design modifications are proposed. This study evaluates the influence of conductor pipe diameter variation on the global structural performance of an existing fixed offshore wellhead platform by comparing the existing 20-inch conductor pipe configuration (CP20) with a modified 30-inch conductor pipe configuration (CP30). The assessment was conducted through in-place analysis using SACS software under 1-year operating and 100-year storm conditions. The structural performance was evaluated based on displacement response, member unity check, joint unity check, and pile axial capacity. The results show that both CP20 and CP30 configurations satisfy the strength requirements, with maximum member unity checks of 0.81 under operating conditions and 0.96 under storm conditions, which are below the allowable limit of 1.00. The joint unity checks also remain far below the allowable limit, with values of 0.177 under operating conditions and 0.172 under storm conditions. The pile axial capacity is also satisfactory, with pile safety factors ranging from 29.41 to 34.04 for CP20 and from 29.41 to 30.21 for CP30, which are significantly higher than the minimum requirement of 1.50. However, several displacement responses exceed the allowable limits. The pilehead displacement under storm conditions reaches 6.49 cm for CP20 and 6.51 cm for CP30, exceeding the allowable limit of 5.08 cm. The vertical deck displacement under storm conditions reaches 7.42 cm for CP20 and 7.44 cm for CP30, exceeding the allowable limit of 4.00 cm. In addition, the horizontal displacement exceeds the allowable limit of 3.10 cm under both operating and storm conditions, with values increasing from 5.9194 cm to 8.4834 cm for CP20 and from 5.9294 cm to 8.5323 cm for CP30. These findings indicate that increasing the conductor diameter from 20 inches to 30 inches has a limited effect on global strength capacity but produces a slight increase in displacement response due to the larger hydrodynamic loading area. Therefore, the CP30 modification can be considered acceptable from a strength-capacity perspective, but further evaluation of serviceability performance.

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INTRODUCTION

Offshore wellhead platforms play a critical role in supporting offshore oil and gas production activities. During operation, platform structures are subjected to environmental loads, including waves, wind, and ocean currents, which may significantly influence their structural response [1]. One component that contributes to these environmental loads is the conductor pipe, as its presence increases the projected area exposed to hydrodynamic forces. The stability and response of conductor pipes are governed by the combined effects of environmental loading and the operational conditions of the offshore platform [2]. Therefore, evaluating the influence of conductor pipe diameter variation is necessary to ensure the safety and structural performance of offshore wellhead platforms.

Numerous studies have investigated offshore structural analysis, particularly in-place analysis and structural response evaluation under environmental loading. Previous research has shown that wave, current, and wind loads have significant effects on displacement, stress distribution, and the overall stability of offshore structures [1, 2]. In addition, studies on conductor pipes have indicated that variations in parameters such as wall thickness, diameter, and environmental loading can influence their mechanical behaviour and dynamic response [2]. However, studies examining the effect of conductor pipe diameter variation on the global structural response of wellhead platforms remain limited, particularly under operating and storm conditions using SACS analysis based on API RP 2A.

Previous studies on in-place analysis and offshore structural assessment have commonly focused on evaluating the safety and performance of offshore platform structures subjected to environmental loads. These analyses typically include member unity checks, joint unity checks, structural deflection assessment, and pile capacity evaluation using SACS software based on the API RP 2A-WSD standard [2, 3]. Moreover, conductor pipes are recognised as important structural components influencing offshore platform response because they are directly exposed to waves, currents, and wind loads [4, 5].

Based on the existing literature, in-place analysis of offshore structures has generally focused on the global strength [6], fatigue performance [7], and reliability of offshore platforms [8, 9]. Meanwhile, studies related to conductor pipes have mostly examined their individual stability and dynamic response under environmental loading [2, 10-13]. Nevertheless, research on the influence of conductor pipe diameter variation on the global response of offshore wellhead platforms remains relatively limited, particularly for operating and storm condition assessments using SACS analysis based on API RP 2A-WSD [3] and company standards applied in offshore platform design [14].

In offshore oil and gas operations, structural design modifications may be required to accommodate operational needs or to optimise the use of company resources, including the utilisation of available material stock. El-Reedy [15] provides a comprehensive reference for the design, construction, operation, assessment, and maintenance of offshore structures, including fixed platforms, subsea pipelines, lifecycle analysis, non-destructive testing, and structural integrity management for harsh marine environments [16]. proposed a generic methodology combining process simulation, energy analysis, and optimisation routines to size, evaluate, and rank offshore platform layouts based on production profiles, petroleum properties, and operational requirements, thereby supporting more efficient design of oil and gas processing and utility systems. In this case, the company plans to use a 30-inch conductor pipe on an existing wellhead platform as part of an effort to optimise the available material inventory.

Changing the conductor pipe diameter from the original 20-inch design to a 30-inch pipe, with an approximate weight of 7.4 tonnes, may influence the structural response of the platform under applied loads, particularly under in-place conditions. This modification can affect load distribution, internal forces, and the utilisation level of structural members within the wellhead platform system [17]. Therefore, an in-place analysis is required to evaluate whether the proposed modification satisfies the applicable structural safety and stability criteria. This study focuses on assessing the structural feasibility of using a 30-inch conductor pipe to ensure that the modification is safe, technically acceptable, and compliant with relevant engineering requirements prior to field implementation.

METHODS

The object of this study is an existing offshore wellhead platform, modelled as a fixed offshore platform consisting of deck framing, jacket members, conductor pipes, and pile foundations. The analysis was conducted for two conductor pipe configurations, namely CP20 and CP30, to evaluate the influence of conductor diameter variation on the global structural response of the platform.

The primary variable in this study is the conductor pipe diameter configuration. Other parameters, including environmental data, soil data, structural geometry, material properties, and design criteria, were treated as fixed parameters to enable a direct comparison between the two conductor configurations. The structural response of the platform was evaluated under operating and storm conditions. The evaluation parameters included member unity check, joint unity check, relative horizontal displacement, relative vertical displacement, and pile safety factor.

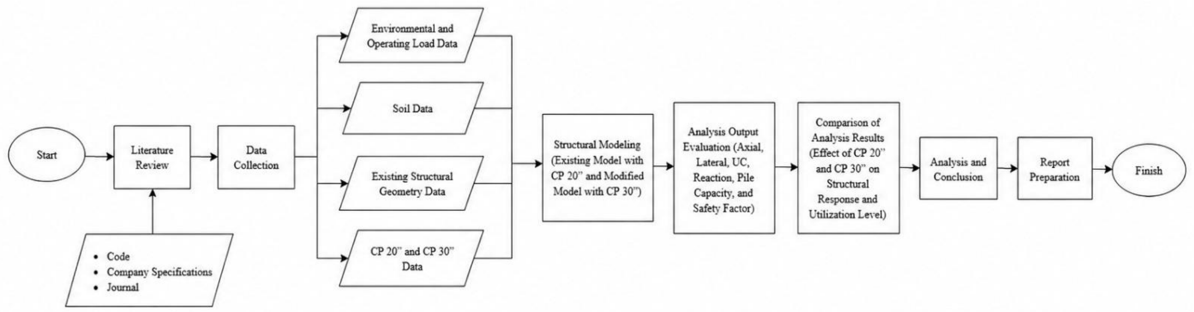

Figure 1. Research workflow for the in-place integrity assessment

Input data and load conditions

The environmental and foundation parameters used in the analysis were obtained from engineering data adopted during the structural evaluation process. The operating condition represents a one-year environmental condition, whereas the storm condition represents a 100-year environmental condition.

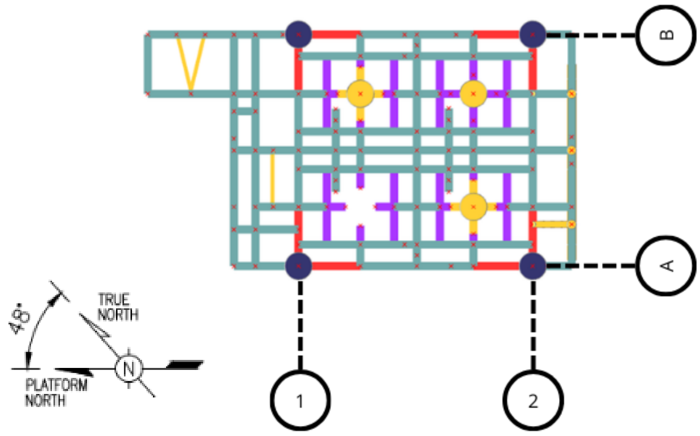

Figure 2. Structural framing layout of the platform. The three conductor pipes are indicated by the yellow solid circles in the figure.

In addition, the platform model includes three conductors located in the well bay area, as illustrated in Figure 2. The conductors were incorporated into the structural model and considered in the in-place integrity assessment. The main data used in this study are summarised in Table 1.

Table 1. Environmental and foundation input parameters used in the analysis.

Parameter	Operating condition	Storm condition	Notes
Water depth	6.08 m	6.08 m	Project input
Mudline elevation	-3.00 m	-3.00 m	Project input
Wind speed	27.2 knots	44.4 knots	1-minute average
Wave height	4.92 m	6.56 m	Return-period wave
Wave period	5.50 s	5.90 s	Associated period
Current speed at 0% depth	2.60 m/s	4.00 m/s	Current profile
Current speed at 50% depth	3.00 m/s	4.59 m/s	Current profile
Current speed at 100% depth	4.00 m/s	5.25 m/s	Current profile
Conductor diameter (CP20)	20 in	20 in	Existing condition
Conductor diameter (CP30)	30 in	30 in	Modified condition
Conductor thickness (CP20)	0.508 m	0.508 m	Existing condition
Conductor thickness (CP30)	0.508 m	0.508 m	Modified condition
Pile outside diameter	0.508 m	0.508 m	Steel pipe pile
Pile wall thickness	0.016 m	0.016 m	Steel pipe pile
Pile penetration	90 m	90 m	Used in capacity check

Structural Modelling and Evaluation Criteria

Structural modelling was performed using the finite element method in SACS software. The platform was modelled as a fixed offshore platform consisting of frame elements, jacket members, conductor pipes, and pile foundations. Each structural element was defined based on the geometry, material properties, and sectional dimensions obtained from the structural data used in this study. The analysis was conducted for two model configurations: the existing model with CP20 conductor pipes and the modified model with CP30 conductor pipes.

The structural evaluation was carried out using the working stress design approach in accordance with API RP-2A WSD. Structural utilisation was assessed using the unity check (UC) parameter, as expressed in Equation (1). Pile capacity was evaluated based on the pile safety factor, as shown in Equation (2). In addition, the serviceability performance of the structure was assessed through structural displacement responses, including relative horizontal displacement and relative vertical displacement, based on the allowable limits summarised in Table 2. The structure was considered to satisfy the design criteria when the displacement values remained below the allowable limits, the member and joint unity check values did not exceed 1.0, and the pile safety factor met the required minimum value.

$$UC = \frac{\text{working stress}}{\text{yield stress}} \leq 1.0 \quad (1)$$

$$FOS = \frac{\text{Pile compression capacity}}{\text{Maximum pile load}} \quad (2)$$

Table 2. Design acceptance criteria adopted in the in-place assessment.

Assessment parameter	Acceptance criterion	Allowable value used	Purpose
Pilehead displacement	D/10	5.08 cm	Foundation and lateral stability
Horizontal displacement	H/200	4.00 cm	Platform lateral serviceability
Vertical deck displacement	L/200	3.10 cm	Deck serviceability
Member unity check	UC <= 1.0	1.00	Member strength
Joint unity check	UC <= 1.0	1.00	Tubular joint capacity
Pile axial safety factor	FOS > 1.50	1.50	Axial foundation capacity

RESULTS AND DISCUSSION

Displacement Response

Displacement response was evaluated to determine whether the change in conductor pipe diameter modifies the global serviceability performance of the offshore wellhead platform. As shown in Table 3 and Figure 3, the pilehead displacement under the 1-year operating condition remains unchanged at 3.15 cm for both the CP20 and CP30 models, which is below the allowable limit of 5.08 cm. This indicates that increasing the conductor diameter from 20 inches to 30 inches does not significantly affect the foundation response under normal operating loading. Under the 100-year storm condition, however, the pilehead displacement increases slightly from 6.49 cm for CP20 to 6.51 cm for CP30. Although this difference is small, both values exceed the allowable limit, indicating that the lateral foundation response is governed primarily by the extreme environmental loading rather than by the conductor diameter modification alone.

The deck displacement response shows a similar trend. The vertical deck displacement under the operating condition remains within the allowable limit, with values of 2.98 cm and 2.91 cm for CP20 and CP30, respectively. In contrast, the storm condition produces vertical deck displacements of 7.42 cm and 7.44 cm, both of which exceed the allowable value reported in the design criteria. The horizontal displacement response is more critical, as it exceeds the allowable limit under both operating and storm conditions. For the CP20 model, the horizontal displacement increases from 5.9194 cm under operating conditions to 8.4834 cm under storm conditions, while the CP30 model produces slightly higher values of 5.9294 cm and 8.5323 cm, respectively. These results suggest that the platform serviceability is controlled by lateral flexibility of the global structural-foundation system, particularly under storm loading.

Table 3. Summary of maximum displacement responses before and after modification.

Condition	Load case	Conductor Pipe 20" (cm)	Conductor Pipe 30" (cm)	Allowable (cm)	Status
Pilehead displacement	1-year operating	3.15	3.15	5.08	OK
Pilehead displacement	100-year storm	6.49	6.51	5.08	NO
Vertical deck displacement	1-year operating	2.98	2.91	4.00	OK
Vertical deck displacement	100-year storm	7.42	7.44	4.00	NO
Horizontal displacement	1-year operating	5.9194	5.9294	3.10	NO
Horizontal displacement	100-year storm	8.4834	8.5323	3.10	NO

Overall, the displacement results indicate that the larger conductor pipe slightly increases the hydrodynamic loading area and therefore produces a marginal increase in global displacement, especially under the storm condition. However, the magnitude of this increase is less than 1% for the reported displacement parameters, demonstrating that the conductor diameter variation has a limited influence on the global deformation pattern.

The exceedance of the allowable displacement limits should therefore be interpreted as an existing serviceability issue of the platform system rather than a direct consequence of the CP30 modification. Further design assessment should focus on lateral stiffness, foundation interaction, and possible strengthening measures if compliance with serviceability limits is required.

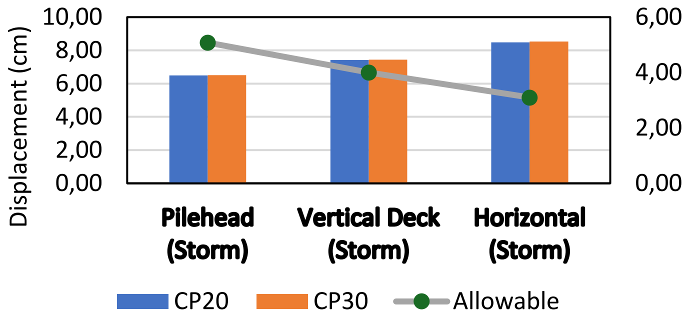

Figure 3. Comparison of displacement responses with allowable limits.

Member and joint unity checks response

Table 4 shows that all member and joint unity check values remain within the allowable limit for both conductor configurations. The maximum member unity check is 0.81 under the 1-year operating condition and increases to 0.96 under the 100-year storm condition for both CP20 and CP30. Although the storm condition produces a higher member utilisation, the maximum value remains below the allowable unity check of 1.0, indicating that the primary structural members retain sufficient strength capacity under the evaluated loading conditions. The identical member unity check values for CP20 and CP30 further demonstrate that increasing the conductor pipe diameter does not significantly alter the force distribution in the main load-resisting members of the platform.

Table 4. Summary of maximum member and joint unity checks.

Parameter	Load case	CP20	CP30	Allowable	Status
Maximum member UC	1-year operating	0.81	0.81	<= 1.00	OK
Maximum member UC	100-year storm	0.96	0.96	<= 1.00	OK
Maximum joint UC	1-year operating	0.177	0.177	<= 1.00	OK
Maximum joint UC	100-year storm	0.172	0.172	<= 1.00	OK

The joint unity check values are also well below the allowable limit, with maximum values of 0.177 under the operating condition and 0.172 under the storm condition. These low utilisation ratios indicate that the tubular joints have substantial reserve capacity and are not the governing component in the present assessment. The results also imply that the conductor pipe modification does not introduce a significant additional demand on the joint system. Consequently, from a strength-based perspective, both the existing CP20 configuration and the modified CP30 configuration satisfy the member and joint acceptance criteria specified in the adopted working stress design assessment.

Pile axial capacity

The pile axial capacity results indicate that the foundation system has a large reserve capacity for both conductor configurations as shown in Table 5 and Figure 4. For the CP20 model, the maximum pile load increases from 200.6 kN under the 1-year operating condition to 232.2 kN under the 100-year storm condition, while the corresponding factor of safety decreases from 34.04 to 29.41. For the CP30 model, the maximum pile load under the operating condition increases to 226.0 kN, reducing the factor of safety to 30.21, whereas the storm condition gives a maximum pile load of 232.2 kN and a factor of safety of 29.41. All pile factors of safety are substantially higher than the minimum requirement of 1.50, and the pile unity check values remain far below 1.0.

These findings show that the increase in conductor diameter has a minor effect on the axial foundation demand and does not compromise pile capacity. The larger conductor configuration increases the operating pile load because of the additional environmental load transferred through the structure, but the change remains small relative to the available compression capacity. Thus, while displacement governs the serviceability assessment, the axial pile capacity is not critical for either conductor configuration. The contrast between the displacement exceedance and the high pile axial safety factor indicates that the platform response is controlled by lateral stiffness and deformation compatibility rather than by axial foundation strength.

Table 5. Summary of pile axial capacity before and after conductor pipe modification.

Condition	Load case	Max pile load (kN)	Compression capacity (kN)	FOS	Pile UC	Status
CP20"	1-year operating	200.6	6827.8	34.04	0.06	OK
CP20"	100-year storm	232.2	6828.6	29.41	0.05	OK
CP30"	1-year operating	226	6827.8	30.21	0.07	OK
CP30"	100-year storm	232.2	6828.6	29.41	0.05	OK

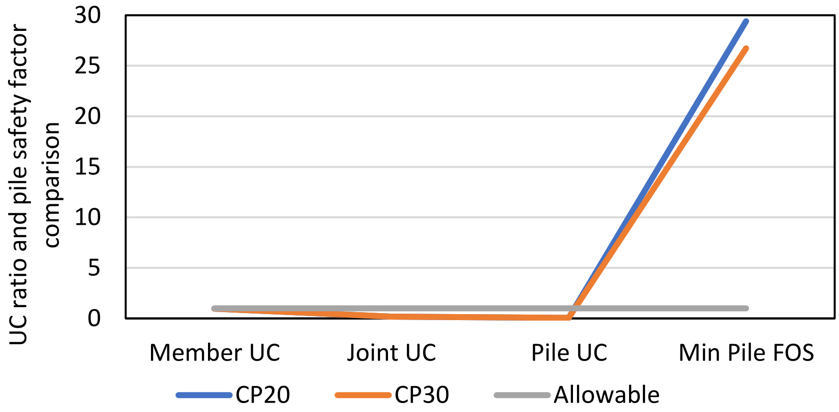

Figure 4. Comparison of UC member, joint and pile for CP20 and CP30

Engineering Implications of the CP20–CP30 Modification

The combined results indicate that the structural consequence of increasing the conductor pipe diameter from CP20 to CP30 is more evident in serviceability response than in strength capacity. Member unity checks, joint unity checks, and pile axial capacity remain within the allowable limits for both operating and storm conditions, showing that the global strength of the platform is not significantly affected by the conductor modification. ISO 19902 provides requirements and recommendations for fixed steel offshore structures, including jackets, towers, and other offshore oil and gas-related structures for both operating and storm conditions [12]. Abdel Raheem, et al. [18] also explained that in-place analysis is used to evaluate structural integrity under operating and storm conditions, including displacement responses, stresses in structural members and joints, and unity checks using SACS. However, several displacement parameters exceed the allowable limits, particularly under the storm condition, and the CP30 model generally produces slightly higher displacement responses due to the increased projected area subjected to wave and current loading. This behaviour suggests that the platform has adequate strength reserve but limited displacement margin under extreme environmental loading.

From an engineering perspective, the CP30 modification may be acceptable in terms of member strength, joint capacity, and axial pile capacity, but it should not be assessed solely on strength-based unity checks. The displacement exceedance indicates that additional serviceability checks, global stiffness assessment, and possible structural strengthening should be considered before implementation. Henry, et al. [19] stated that SACS reports structural responses in terms of member, joint, and foundation utilisation ratios, where values below 1.0 indicate code compliance. This approach is consistent with the assessment criteria applied in the present study. Possible mitigation measures may include reassessment of pile–soil interaction parameters, refinement of environmental load modelling, local strengthening of the jacket or deck framing system, or verification of allowable displacement criteria against project-specific operational requirements. Therefore, the conductor diameter modification should be interpreted as structurally feasible from a strength standpoint, but requiring further attention from a serviceability and deformation-control perspective.

CONCLUSION

This study evaluated the influence of conductor pipe diameter variation on the structural response of an existing offshore wellhead platform by comparing CP20 and CP30 configurations under 1-year operating and 100-year storm conditions using in-place analysis in SACS. The results show that increasing the conductor diameter from 20 inches to 30 inches has a limited effect on the global strength response of the platform, as the maximum member unity checks, joint unity checks, and pile axial capacity values remain within the allowable criteria for both configurations. The main difference between the two models is observed in the displacement response, where the CP30 configuration produces a slight increase in lateral and vertical deformation, particularly under storm loading, due to the larger hydrodynamic loading area. Several displacement parameters exceed the allowable limits, indicating that serviceability, rather than member strength or axial pile capacity, governs the structural assessment of the platform. Therefore, the CP30 modification can be considered acceptable from a strength-capacity perspective, but further evaluation of platform stiffness, pile–soil interaction, and deformation control is recommended to ensure compliance with serviceability requirements under extreme environmental conditions.

REFERENCES

[1] S. K. Chakrabarti, "Handbook of Offshore Engineering, Elsevier," *The Netherlands,* 2005.

[2] J. Yang, F. A. Abimbola, and A. Y. Adetowubo, "A study on dynamic response and stability of conductor pipe in shallow-water field," *Journal of Offshore Mechanics and Arctic Engineering,* vol. 147, no. 5, p. 051801, 2025. doi: 10.1115/1.4067839

[3] American Petroleum Institute, "API Recommended Practice 2A-WSD: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platform – Working Stress Design," vol. Twenty-First Edition, October 2007.

[4] Y. Bai and Q. Bai, *Subsea engineering handbook*. Gulf Professional Publishing, 2018.

[5] A. S. Swamidas and D. V. Reddy, "Offshore Platforms," in *Springer Handbook of Ocean Engineering*: Springer, 2016, pp. 745-754.

[6] J. M. Gere and S. Timoshenko, "Mechanics of Materials. ed," *Boston, MA: PWS,* 1997.

[7] A. Gholizad, A. Golafshani, and V. Akrami, "Structural reliability of offshore platforms considering fatigue damage and different failure scenarios," *Ocean engineering,* vol. 46, pp. 1-8, 2012. doi: 10.1016/j.oceaneng.2012.01.033

[8] B. K. Yuda, M. A. M. Putra, H. Sulistianto, M. F. Sany, I. C. Ibrahim, and B. R. Wijaya, "From Instability to Integrity: A Comprehensive Strategy for Deeper 30" Conductor Pipe Penetration in Offshore North West Java, Indonesia," in *Offshore Technology Conference*, 2026: OTC, p. D031S041R007.

[9] S. Z. A. Syed Ahmad *et al.*, "Offshore structural reliability assessment by probabilistic procedures—a review," *Journal of Marine Science and Engineering,* vol. 9, no. 9, p. 998, 2021. https://doi.org/10.3390/jmse9090998

[10] *DNVGL-ST-N001: Marine Operations and Marine Warranty*, DNV GL, Hovik, Norway, 2018.

[11] *DNVGL-RP-C203: Fatigue Design of Offshore Steel Structures*, DNV, Hovik, Norway, 2016.

[12] N. ISO 19902, "Petroleum and natural gas industries-Fixed steel offshore structures," *International Organization for Standardization,* 2007.

[13] American Institute of Steel Construction, "AISC 335-89: Specification for Structural Building – Allowable Stress Design and Plastic Design (include in AISC Manual of Steel Construction, Allowable Stress Design)," vol. Ninth Edition, 1989.

[14] R. D. Cook, *Concepts and applications of finite element analysis*. John wiley & sons, 2007.

[15] M. A. El-Reedy, *Offshore structures: design, construction and maintenance*. Gulf Professional Publishing, 2019.

[16] T.-V. Nguyen, Y. M. Barbosa, J. A. da Silva, and S. de Oliveira Junior, "A novel methodology for the design and optimisation of oil and gas offshore platforms," *Energy,* vol. 185, pp. 158-175, 2019. doi: 10.1016/j.energy.2019.06.164

[17] L. Zhong *et al.*, "An Analytical and Numerical Investigation of the Force Distribution in Deepwater Surface Conductor Joints," in *ISOPE International Ocean and Polar Engineering Conference*, 2025: ISOPE, pp. ISOPE-I-25-003.

[18] S. Abdel Raheem, E. Aal, A. Shafy, M. Fahmy, M. Omar, and M. Mansour, "In-place analysis for design-level assessment of the fixed offshore platform," *Ships and Offshore Structures,* vol. 16, pp. 1-12, 07/04 2020, doi: 10.1080/17445302.2020.1787931.

[19] Z. Henry, I. Jusoh, and A. Ayob, "Structural integrity analysis of fixed offshore jacket structures," *Jurnal Mekanikal,* 2017.