Numerical Study of Topology Optimization of Jacket Platform: A Review

by

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22726

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CERTIFICATE OF APPROVAL

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Approved by,

(Dr. Mokhtar B Awang)

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CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MEGAT AMIRUL ADLI BIN MEGAT ISKANDAR

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ABSTRACT

Topology optimization of Offshore Platform is a mathematical method that optimizes material layout of the offshore platform within a given design space, for a given set of loads, boundary conditions and constraints with the goal of maximizing the performance of the platform and to optimize the capital cost of the platform. In this paper, the optimization of the offshore platform is compared between researcher's paper article to know into details of the principle used and the methodology for the optimization. The highlight of the optimization is on the structural of the offshore platform and the topside of the platform. Aside for those, the technology being used would also affect on the optimization for the platform. The industry has been imposing new technology and better design as time goes by. However, this latest upgrade would still be based on the previous research that have been done on the similar subject. Thus, by reviewing several research papers, we could obtain the findings that could be used to propose numerically for the topology optimization process.

ACKNOWLEDGEMENTS

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Chapter 1: Introduction

1.1 Background Study

In extracting the oil resource, the development of offshore oilfields takes a significant long-term period and this period occur at the early stage of the project. Many aspects take into account such as operational, engineering, financial and economic. Despite all that, there are also issues on the data scarcity and uncertainty on the reservoir and the market due to no way of forecasting with accuracy the actual behavior of the fluids flow or the trend of the oil market in the upcoming decades.

In exploitation of the oilfield, these parameters are important to be determined on the project development; the drainage area; the production concept; the number, location, characteristics, and types of wells to be drilled; number and arrangement of platforms in the specific case of offshore fields; the project/operational schedule; the distribution of flowlines, manifolds and risers; the installation of processing plant at each platform. According to the Concession Contract for Exploration, Development and Production of Oil and Natural Gas (Agência Nacional do Petróleo,Gás e Biocombustíveis – ANP,2013) "All these initial decisions should be made in a short period of 180 days after the declaration of the field commerciality, in the particular case of the Brazilian territory. Apart from their complexity, such decisions affect the behavior of production overtime, the recovery factor that can be achieved, the future decisions, the revenue, the economic analysis and, consequently, they have outcomes in all activities during the oilfield's productive life"

An offshore platform consists of two main parts that are topside and substructure or jacket. On the topside is where all the process and operation of crude oil and gas are being done. This topside is being supported above the sea water surface level. This topside is being supported by the substructure or jacket. The jacket connects the topside to the seabed so that the topside would not be drifted by the sea wave or other factors. Jacket platform has been a part of the supporting part in the upstream operation as it is the foundation of the offshore platform. Jacket in generally works in between the depth of 10m to 200m. However, jacket have various type as it is depending on the number of legs of the jacket. Based on the upstream operation in Malaysia, Malaysia have been implanting manned platform for a large oil and gas field while for a field that are at some distance from the shore, the field would be produce by unmanned platform/satellite platform (M. Razalli, 2005).

In this project, we would look into detail on how to optimize the offshore platform hence having cost optimization on the structure. The topside where all the operation occur would contribute on the tonnage of the platform and this weight are being supported on the substructure. The topside could be optimized by knowing the production or operation that are being commission thus from there the development team could planned during the development phase on the facilities design. A platform consists of two part and one of the parts is the topside where oil and gas production and processing are taken place, living quarters and other uses. (Xiaojie. T. et al., 2019). The weight and the size of the topside plays an important role as it would affect the design of the substructure or jacket. The heavier the topside, thus the tonnage(weight) of the substructure or jacket would also have an increment. Thus, would have a higher capital expenditure due to the fabrication cost of the substructure. Hence, designing and optimizing the offshore platform play a crucial role as it would pertain to the facilities development cost.

1.2 Problem Statement

Offshore platform has been operated for many years and were develop from time to time. However, the offshore platform could be optimized from the current design to get a lower and optimize cost. The offshore could be optimize in the aspect of substructure design, topside facilities, topside tonnage and technology used for the platform. The optimized design of the offshore platform is yet to be deliberated. Thus, in this project, the entire paper would be focusing on the optimizing the design of offshore platform substructure and the optimizing the tonnage(weight) of the topside based on the production or operation of the platform.

In the aspect of substructure design, the material and leg-geometry would be one of the factors to contribute in the capital expenditure. The material plays a role where it would cause the difference in the weight of the substructure. The leg-geometry would be considered in the design due to the number of legs being considered in the development plan depends on the total tonnage of the topside.

Besides the substructure of the platform, the topside would also include in this project to be stated as a related problem. As the topside are the site where all the process and operation occur, it would also mean that it will contribute to the weightage of the platform as all the facilities are located on the topside. The facilities of oil and gas on the topside are designed to cope with the maximum production capacity. Thus, each facility would operate at efficient performance theoretically during highest production (Nguyen T-V et al., 2019). Having to reduce the weightage of the topside would definitely reduce the project and operation cost.

Apart from that, the current technology being used for the fabrication and installation of the offshore platform could still be improved as it would ease on the project execution phase. Fabrication period is when the project is approved, and the facilities are being procured and fabricate by the service provider so that the operator could then operate the facilities during production while installation is when the fabrication phase are done and the fabricated product are being towed to the production field and install at the location. Fabrication and installation are taken place from months to years. This will cause the capital expenditure to increase when the period of days is increase as the capital expenditure would include overhead cost, utility cost and etc. Thus, by implanting new technology to this operation, it would help in reducing the period of the fabrication and installation. Not only that, it would also might be advantageous to the operator for decommissioning of the field.

1.3 Objectives

The aim of this project is to optimize the offshore platform from the previous and current offshore platform design that are being operated in the oil and gas industry today including the overall parts of the platform from the surface facilities until the substructure at the seabed. The detailed objectives are stated as below:

i) To reassess the weightage of the offshore platform's jacket and optimization of the jacket structure
ii) To analyse the fundamental numerical equation of topology optimization
iii) To identify the parameter affecting the performance of the jacket platform

1.4 Scope of Work

In this project the scope of work will be on the topology optimization of offshore platform and study on the designing of an offshore platform and the technology currently available in the industry market. The project would be a part of the Front-End Engineering Design (FEED) where conceptual identification and conceptual design involve in proposing the optimize design of the offshore platform through numerical method. Beyond that, to make this project valuable in the current industry, the design of the optimized offshore platform would then develop an estimation cost to compare the design develop with the design that are being used in the industry nowadays through costing benchmark. At the same time, all the input of this project would be technically justified based on the current or future supply and demand requirement. The scope of work is fine and executable as a final Mechanical Engineering student.

Chapter 2: Literature Review

2.1 Upstream Offshore Platform

Crude oil is one of the most contributor to the production energy that consume by the position of crude oil on top of the list (IEA, 2017). Offshore platform plays an important role in extraction of production (oil and gas) as the platform are equipped with facilities such as power generator, injection equipment, pumps, risers and etc. to produce and extract the production from the reservoir to the surface.

Oil and gas offshore platform are similar in terms of structural design and the included operations such as pumping, compression and separation but the platform are varying in the aspect of the production of production and water over time. The platform may be develop based on the characteristics of the field and the properties of the fluid. (Nguyen T-V, 2019). The design of the topside of the offshore platform should be where the consumption of energy is minimized and maximize on the oil and gas production. The power or energy consumption by an offshore platform may be energy-intensive where the range is in between of few MW up to several hundreds. This is due to the based on the conditions of the field such as the reservoir pressure and temperature, the petroleum properties and etc. (Bothamley M., 2004).

The offshore platform used in the field would not be the same as every field would have different production and operation in specific. The platform would also locate based on where the production and subsea facilities are like planned during development phase. The platform would be located just above the manifold that is on the seabed as one of the criteria for the offshore platform location. The purpose of the of locating the offshore platform is to use the least of the capital cost in facilities for production of resources and have the highest Net Present Value (NPV) for the production achieve (Rodrigues H.W.L et al., 2016).

2.2 Optimizing the offshore platform design

Offshore platform is to produce the resources or the oil and gas from the reservoir to the surface for further process and storage. Depending on the platform, the facilities exist on the platform are for to accommodate the production, processing and transportation stage where as for in the aspect of storage, the production will be stored in a vessel such as Floating Production Storage and Offloading (FPSO) or Floating Storage and Offloading (FSO) and the nearest onshore terminal to the field. The reason why the production could not be stored on the platform in a large capacity due to the platform is producing everyday thus it could not cater the accumulated volume of production by time thus the production has to be transported elsewhere.

Operating the offshore platform would induce in high Operating Expenditure (OPEX) where in commissioning the platform would add up into the Capital Expenditure (CAPEX). Thus, the design of the platform is significant in affecting the CAPEX and thus could reduce the CAPEX.

Based on Nguyen T-V et al., in designing the optimize offshore platform there are two objective that need to be considered that are the separation of the production should be at the highest point while the consumption of energy is minimized and to minimize the total energy consumed. The separation and compression phase of the production may result in lower power consumption however could increase the content of methane and ethane in the liquid phase where it would be a liability during crude oil exportation. The problem in optimizing is a non-linear meaning it can be formulated as mixed-integer non-linear problem and it could be solved by genetic algorithm where match the decision variables and the result would be evaluated by converging to optimums. Optimizing the temperature and pressure level lead to selecting the plant layout and next determining the capacity of each facilities on board based on the production profiles. Besides that, the sizing of the utility plant is based on the assessment of the utility plant where assessment on the technical parameters such as heat-to-power (H/P) ratio and comparing with average ratio of the thermal to electrical demand (TD/ED). The configuration of the plant on the number and selection of engines is based on the space available on the platform and the maximum weight that could be cater. In sizing the utility plant, safety margin would be taken into account due to the final power consumption may outgrow the forecasted because of the higher oil production or additional drilling operation. “For low and high electric power outputs, an equal load distribution between each gas turbine/combined cycle is generally the most efficient option. On the contrary, for intermediate conditions, operating one to several gas turbines at maximum load and the remaining demand to another one is a better alternative.” (Barbosa et al., 2018). Nguyen T-V et al., emphasizes more on the optimization of the topside part of the offshore platform where the sizing and the utilization of the topsides would be based on the demand and the facilities installed.

According to Xiaojie T. et al. in the article of Topology Optimization Design for Platform Jacket Structure, the article focuses more on the structure of the platform’s substructure. In his study, they approach the problem through analytical method and numerical method. The method or the objective of the study is to optimize by determine the stiffest possible structure or finding solution with the least compliance, for a given space by providing the volume constraints. The method used is Solid Isotropic Microstructure with Penalization (SIMP) method. The method presumes the materials that are isotropic and take the element relative density as the continuous design variable (M.P. Bendsoe,1988). There are several approaches to solve the topological problems such as Optimality Criteria (OC) method, Sequential Linear Programming (SLP) method and Method of Moving Asymptotes (MMA) method. However due to the efficiency and firm of algorithm, MMA method is used by the researchers in the paper to obtain the result from the continuum topology optimization problem. Based on Xiaojie T. et al, besides focusing on the structural analysis, the paper also focuses on design load analysis with static and dynamic analysis where the topological optimization analysis of continuous body structure is assumed to have wind load, current load and wave load in extreme condition. Thus, in this paper the optimization would only cover on the substructure part where structural analysis is conducted with design load analysis. The paper successfully proved that through method and analysis conducted, the mass of the jacket could be reduced up to 13.7% and the stress value could be deduced by 46.31%. hence, prove that the optimized substructure has a more improved force transmission path and is better to go against the environment load with less materials.

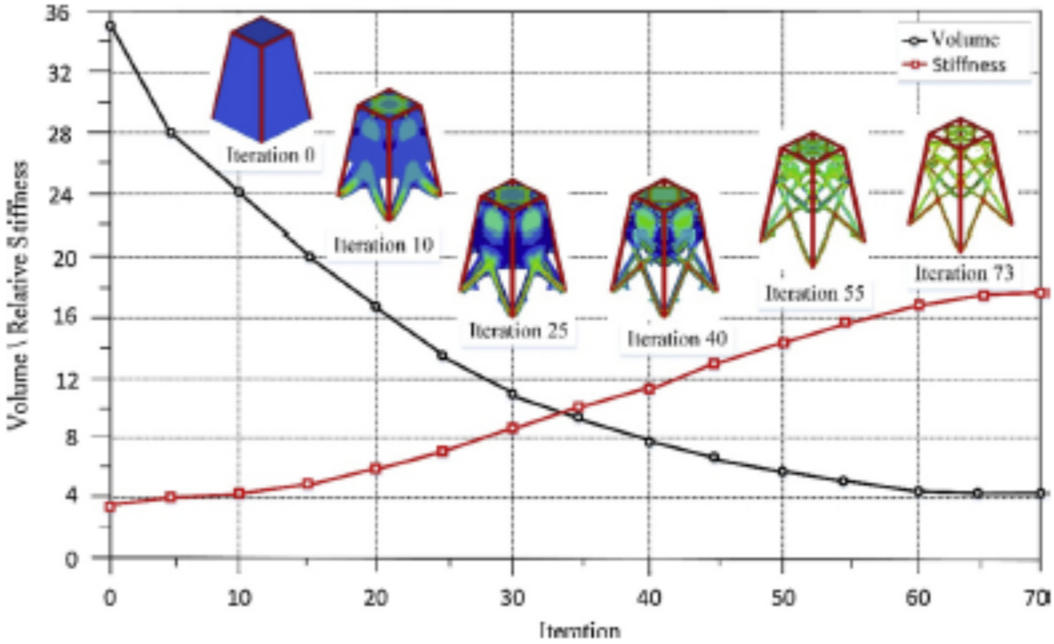

Figure 1 Evolution in Topology Optimization of Jacket Structure (Xiaojie Tian, et al. 2019)

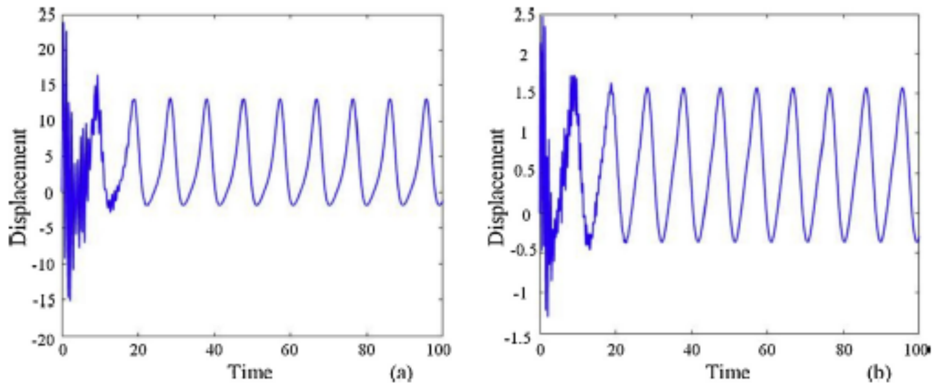

Figure 2 Time-displacement curve of platform top points (a) pre-optimized model, (b) optimized model (Qingyang Wang, et al. 2019)

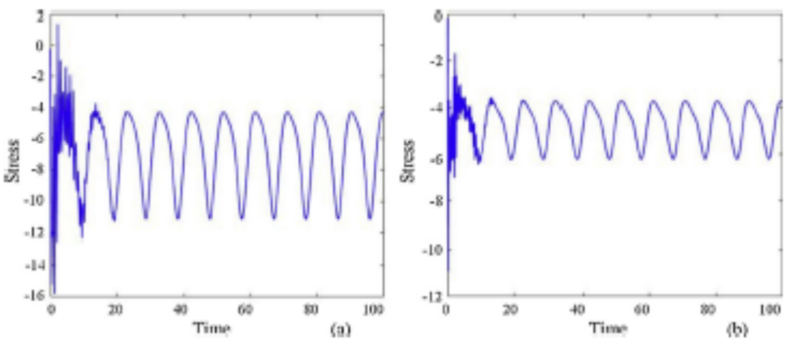

Figure 3 Time-Stress curve of platform top points (a) pre-optimized model, (b) optimized model (Qingyang Wang, et al. 2019)

Furthermore, besides the research by Xiaojie T. et al., the research made by Nasseri T. et al, are almost similar to the objective by Xiaojie T. et al. where Nasseri T. et al. focuses the optimization of offshore platform on the substructure or jacket. The paper objective was to reduce the tonnage (weight) of the structure and the cost without neglecting the design regulations set for the offshore operation. The variables that plays the main role in the optimization are the outer diameter and the thickness of the jacket's members. Based on the genetic algorithm for the optimization algorithm, we could obtain the final dimensions of the members. The design criteria for this optimization problem would be the constraints that are applied to the platform such as the axial and flexural stresses, buckling of members and displacement of offshore structure that should content the offshores design regulation. The outer diameter of the jacket's member would directly be affected by the drag forces of wave, current and wind either the members are located above or below the sea level. In this paper, the jacket were divided into four main groups for the structural members which includes leg, horizontal members, diagonal braces and vertical braces and based on the result, each of this main groups would produce different contribution result for the optimization process and the degrees of importance were investigated in this research. The final result shows that the major contribution of the optimization was from the horizontal members of the jacket and the least contributor was the vertical braces.

Chapter 3: Methodology

In solving the topology optimization is mainly comprise of numerical and analytical method. The main objective for most designs is to optimize structural rigidity, so the primary purpose of topology optimization is typically to provide a linear function with meaning in the field of equilibrium displacement. That linear function is called compliance, and it is the reverse of global stiffness, so that the system reaches optimum rigidity while compliance is minimised. Our goal is to describe the most rigid feasible structure for a given system or find the appropriate response with minimum compliance, by having volume limits.

3.1 Method of Topology Optimization

SIMP method is used for continuum structures in developing the topology optimization. A continuous dataset from 0– 1 to an elastic content element is applied in the SIMP approach. The importance of small variables is omitted to simplify topology optimization. By the interpolation rule, SIMP method can equate the design variable's density with the elastic factor modulus. The structure variables are known as the continuous variable between full void or the fill, where the value x_{min} in the functional lower limit of element density implemented in the numerical realisation to mitigate singularity.

$$\begin{aligned}&\mathbf{xmin: c(x) = U^T KU = \sum_{e=1}^{N} (x_e)^P u_e^T k_o u_e}\\&\mathbf{subject\ to: v(x)/v_o = f}\\&\mathbf{KU = f}\\&\mathbf{0 \leq x_{min} \leq x_i \leq 1}\end{aligned}$$

(Eq. 1)

Where;

U = Global Displacemnt Matrix

F = global force matrix

K = global stiffness matrix

u_e =displacement vector

k_o =stiffness matrix of element

x = vector of design variable

xmin = minimum vector of relative density

N = total number of finite elements discretized by the design area

p = penalty factor

V(x) = material volume

v_o = design volume

f = specified volume ratio

The functional equation for the model of SIMP is as in Eq (2);

$$\mathbf{E^P(x_e) = E^{min} + x_e^P (E^0 - E^{min})} \qquad \textbf{(Eq. 2)}$$

Where;

E^0 = elastic modulus of solid material part

E^{min} = elastic modulus of void part

3.2 Method of Solving

In solving the optimization issue, several approaches are used and among them, MMA is the most suitable method that could be used. In this paper MMA is used in order to address the continuum optimization issue with respect to efficiency and robustness of algorithms. With the introduction of Method of Moving Asymptotes (MMA), the MMA method transforms an implicit optimal problem into a series of explicit simple sub problem approximation. It is more adaptable to complex topological problems and more suited with multiple constraints and complex objective functions for the optimum issue.

$$(\mathrm{MMA}) \begin{cases} \min\limits_{x} \tilde{f}_0\left(x^{(k)}\right) \\ s.\ t.\ \tilde{f}_i\left(x^{(k)}\right) \leq 0 \\ \alpha_j^{(k)} \leq x_j \leq \beta_j^{(k)} (j = 1, 2, \ldots, n; i = 1, 2, \ldots, m) \end{cases}$$

(Eq. 3)

a(k) & $\beta(k)j$ = moving limits

f_i = approximating function

There are certain numerical instabilities, such as the checkerboard pattern, mesh-dependent optimizing defects, which cause some complexity for topological configuration removal during the process of topology optimization. To achieve simple, homogenous and easily functional features of the desired structural topology, numerical instability needs to be curbed. The key approach is to use a more robust model of finite element and to filter the density or sensitivity of the element etc. This research, which is based on convolution filtering, uses the sensitivity filtering process. It's an element-focused local constraint system. In its filter radius, the sensitivity of this element can be replaced by the weighted average value of each factor sensitivity. The sensitivity adjustments guarantee the independence of the mesh.

$$\frac{\partial c}{\partial x_e} = \frac{1}{x_e \sum_{f=1}^{N} \hat{H}_f} \sum_{f=1}^{N} \hat{H}_f x_f \frac{\partial c}{\partial x_f}$$

(Eq. 4)

$$\hat{H}_f = r_{\min} - \mathrm{dist}(e, f), \{f \in N \mid \mathrm{dist}(e, f) \leq r_{\min}\}, e = 1, \ldots N$$

(Eq. 5)

H_f = Convolution operator (Weight factor)

The distance of the center of e of the element to the center of f of the element is defined as the control function dist(e,f). The convolution operator, H_f is assumed as – outside of the filter area. The convolution operator reduces linearly with the distance of element f.

3.3 Analysing design load

Offshore platforms have long been engaged in sea development. The sea and environmental conditions in the working region have a significant effect on structural safety and operating efficiency. And it is the first role in the designing of offshore installations to assess environmental load and weather conditions on the site. As seen in Figure, offshore structures face a number of environmental conditions, such as a wind load, wave load, current load, sea ice load and earthquake load.

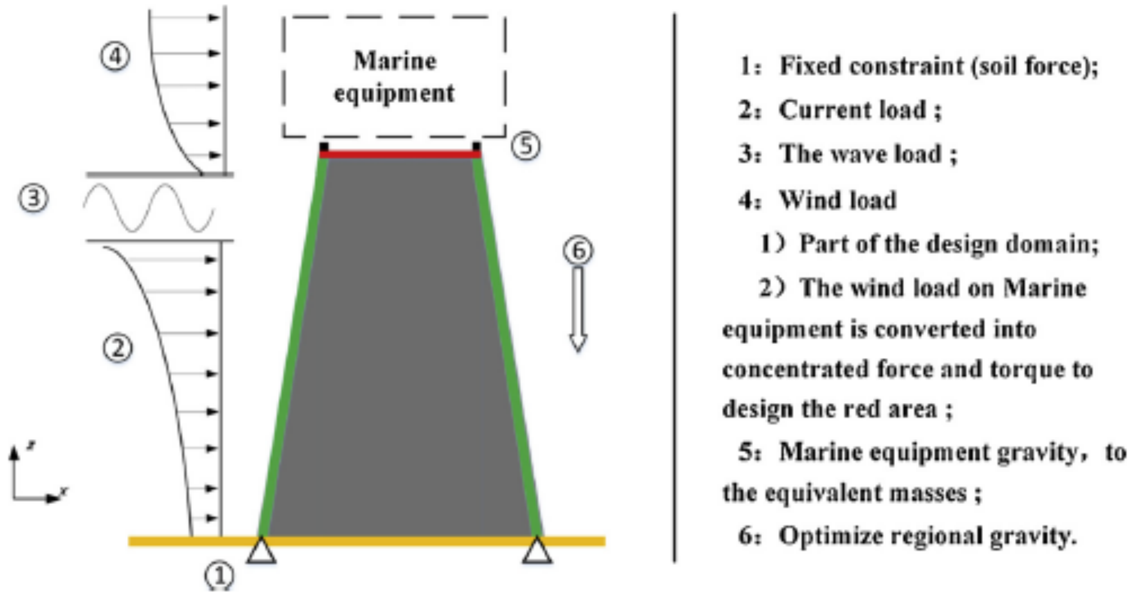

Figure 4 Distribution of loads on the jacket platform (Xiaojie Tian, et al. 2019)

3.3.1 Wind Load

Calculation for the wind load on an object and pressure applied to the platform rod around the wave load zone could be clarified below:

- Wind Load (Force):

$$F = (\rho/2)u^2C_sA$$

(Eq. 5)

- Pressure (Wave Load):

$$P = (\rho/2)u^2C_s$$

(Eq. 6)

F= Wind force

P= Wind pressure

ρ= mass density of air (1.22 kg/m^3)

u= wind speed

C_s= shape coefficient

A= area of object

The shape coefficients in the table 1 will be recommended for the perpendicular wind applying to the angles with respect to every projected area when there is absence of the input. For the initial optimization model, the shape coefficient is assumed as 1.0.

Table 1 Coefficients for Wind Shape (Guijie Liu, et al. 2018)

Area	Shape Coefficient (C_s)
Beams	1.5
Sides of buildings	1.5
Cylinder Sections	0.5
Overall Projected wind area of platform	1.0

3.3.2 Current Load

The velocity of the ocean current usually changes very naturally over time. The ocean current is often used as a reliable flow for practical analysis in engineering design and the force acting on the subject is only dragging its force. Although we cannot neglect the velocity induced by the waves in the coexistence of waves and current conditions. The drag force induced by overlaying the momentum of the current particle and the wave water particle should be taken into consideration at this point in evaluation of the current load. The equation below is the drag force/unit area in the water:

$$P_1 = \frac{1}{2}\rho C_D U_c^2 (\mathrm{Pa}) \qquad \textbf{(Eq. 7)}$$

C_D = drag force coefficient [assumed as 1.0]

ρ = seawater density [1025 kg/m^3]

U_c = current velocity

3.3.3 Wave Load

Usually defined $D/L \leq 0.2$ for the object that have a small scale. D is assumed for an object as the characteristic length while L indicates the wavelength.

$$L = T\sqrt{gh} \quad \textbf{(Eq. 8)}$$

T = wave period

g = acceleration gravity

h = water depth

For a small-scale component on the wave force and current force for a unit length, drag force and inertia force is calculated by using Morrison formulate and then union in the same phase as below:

$$F = \frac{1}{2}\rho C_D A\ |u_x|\ u_x + \rho C_M V \dot{u}_x \quad \textbf{(Eq. 9)}$$

While the pressure at the wave load zone is as below:

$$P = \frac{1}{2}\rho C_D\ |u_x|\ u_x + \rho C_M \dot{u}_x \quad \textbf{(Eq. 10)}$$

Where;

A = projection area per unit length pile column perpendicular to the vector u_x

V = drainage volume for unit length of the component

u_x = velocity vectors perpendicular to axial component

$\dot{u}_x$ = acceleration vectors perpendicular to axial component

C_M = inertia force coefficient [assumed 1.6]

The topological study of the continuous structural optimisation is conducted in this paper in severe terminology, namely wind load, current load and wave load. Static analysis and dynamic analysis of the jacket is conducted under the same environmental load before and after optimisation. The severity of load changes very little with wind load intensity and ice load at sea under different environmental circumstances, which is a constant calculation value. They should be measured according to the correct criteria for the wind load and the current load. The amount reported on the ice is really large for the volume of ice. However, in the subsequent review it is not used because the jacket also has an ice-breaking function.

The magnitude of the wave and current load varies greatly with the depth and time of the water. The wave theory and Morrison equation can be expressed as in Fig. 5. The wave and the current load are seen to shift regularly and have a maximum value of 3/4. Fig. Fig. 5(b) corresponds to the 3/4 load curve. The maximum current and wave load value of the model is used in the subsequent analysis. The load applied is therefore based on the load curve as shown in Fig. (b) 5.

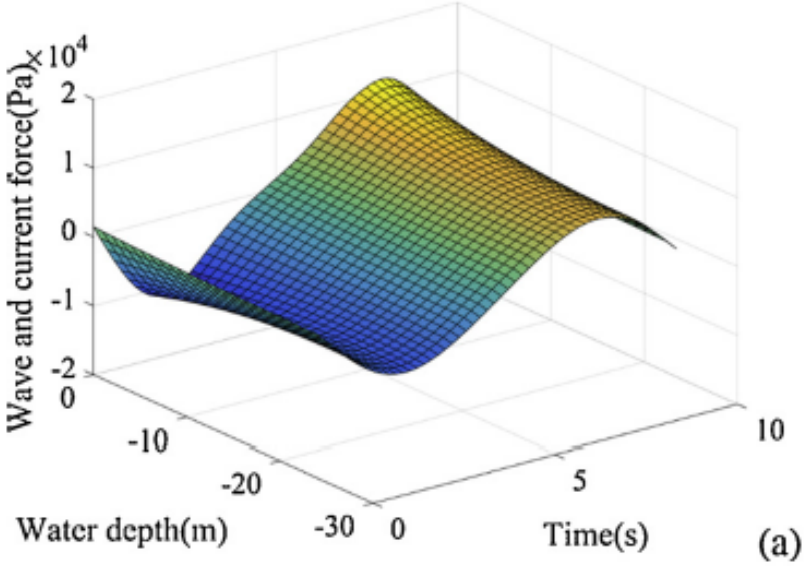

Figure 5 (a) The Variation of current and wave load related to time and water depth (Wei Deng, et al. 2018)

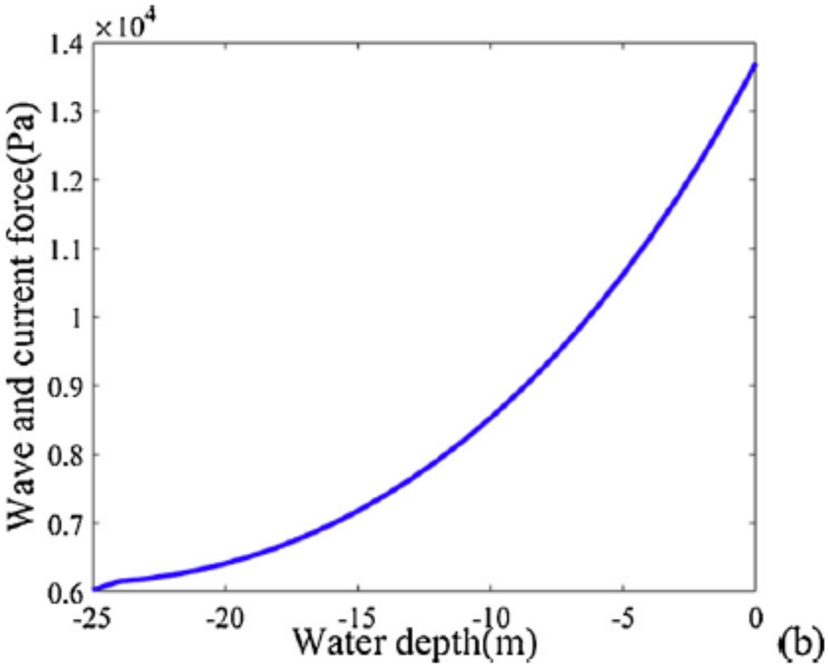

Figure 5(b) During 3/4 Period of Current and Wave Load Varies with Water Depth (Wei Deng, et al. 2018)

3.4 Constrained Condition

The optimization of the framework of the jacket platform is focused on stiffness, strength and stability. The rigidity constraint is accomplished by the apex side of the jacket platform displacement constraint. The engineering design refers to the structural tall steel structure and "the constraints of the elastic steel structure interlayer displacement are 1:200-layer heights," which is one of the architectural regulations of Japan. This paper only takes account of the elastic phase. The permissible tensile, bending, and compression stress of platform members is, as specified in 'specification for the construction and classification of offshore fixed platforms,' that is one of the requirements of the China Classification Society.

3.5 Reference Jacket Model

The platform JZ20-2MUQ is a baseline in this review. The Liaodong Harbour, Bohai Sea, is a JZ20- 2MUQ site. It is a conventional four-legged jacket structure. The water depth of the jacket being built for is 25 m. The total length of the jacket is 40.5 m. The pile diameter is 1 m. The platform has a surface space of 11 to 11 square metres, while the peak level is 6.75 square metres. Jacket structure typically consists primarily of a configuration of type X and type K. A 4-layer K-tube framework and four X-tube structures are used to weld the jacket in this analysis.

Since leg columns, piles, and braces are tube designs, pipe elements can be model easily and accurately. The form of variable used here is PIPE59, which at each node occurs six degrees. And it is a uniaxial feature with the capacity for tension compression, torsion and bending. The system loads may contain hydrodynamic and buoyant effects of the water and the extra water mass and the internal pipes are often included in the element load. For the simulation pipe members and pile of the jacket below seabed point, PIPE59 feature is therefore highly important.

The major component of the support structure is constructed of steel Q235, which has been commonly used for the construction of the jacket frame. The material properties of steel Q235 is as in Table 2:

Table 2 Q235 Material Properties (Guijie Liu, et al. 2018)

Property	Value
Young's Modulus	2.1×10^{11} N.m^{-2}
Poisson Ratio	0.3
Shear Modulus	7.6×10^{11} N.m^{-2}
Material Density	7800 kg.m^{-3}
Allowable normal stress	192×10^{6} N.m^{-2}

On the water surface, the coordinates system is set, and the base is a mud surface at four corners. The upper component is a lumped weight added through a multi-point constraint to the top of the structure. Fixed constraints are imposed on the bottom, whereas the impact of platform legs with soil is equivalent to a fixed restriction.

3.6 Project Timeline

Work Commitment	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
FYP I														
Selection of Project Title	■													
Extensive Literature Review		■	■	■										
Venting through data and extracting needed data					■	■	■							
Analyzing the data							■	■	■					
FYP I Proposal Defence										■				
Familiarisation of CATIA and Hyperworks Software									■	■	■	■		
Submission of Interim Report													■	
FYP II														
Setting up the softwares based on data	■	■												
Conducting the Simulation		■	■	■	■	■								
Compare Result with Theoretical Value							■	■	■					
Analysis Proof Checking										■	■	■		
Presentation and Viva													■	
Submission of Dissertation														■

Chapter 4: Result and Discussion

This paper uses the topology approach to utterly neglect the original structure design and constructs the structure space as a monolithic continuum structure. Added rational constraints, such as external loads and output, with an iterative approach provides the right answer to the objective. The desired structure should be accomplished. The aim of optimization is to improve the structure's service life and reduce design and development costs.

Using various optimization approaches and solution strategies, the original configuration may be modified by a series of iterations. Until convergence is achieved, optimized results from topological data would be reconstructed to assess its performance compared to the pre-optimization model. If optimization of topology cannot satisfy the expectations performance, it is important to amend the development parameters and to optimize the structure to the point where a good topology structure is achieved. The arrangement accomplished by the optimisation of the topology does not inherently reflect the final configuration.

In order to prevent intermediary density iterations and explain the structured configuration, the entity density value of the design space should be near the ends of 0–1 during the topology optimisation phase. Around the same time, an engineered design should be assured that the structural weight can be minimized according to safety criteria to allow a more quality delivery of materials

From reviewing several research papers, a few of expected results are found using the similar approach. The findings as follow:

4.1 Expected Result

In the optimization process, the transverse properties of the jacket members change only as decision variables of the issue of optimization, while their other geometrical and physical features and amounts of gravity and sea environment forces, including the wave, current and wind, are kept constant throughout the process. The change in drag forces of wave, current and wind on a unit length of tubular parts therefore depends on the amount of the external diameter change. However, the variation of the wave's inertia force in these members 'unit length depends on their changing external diameter square.

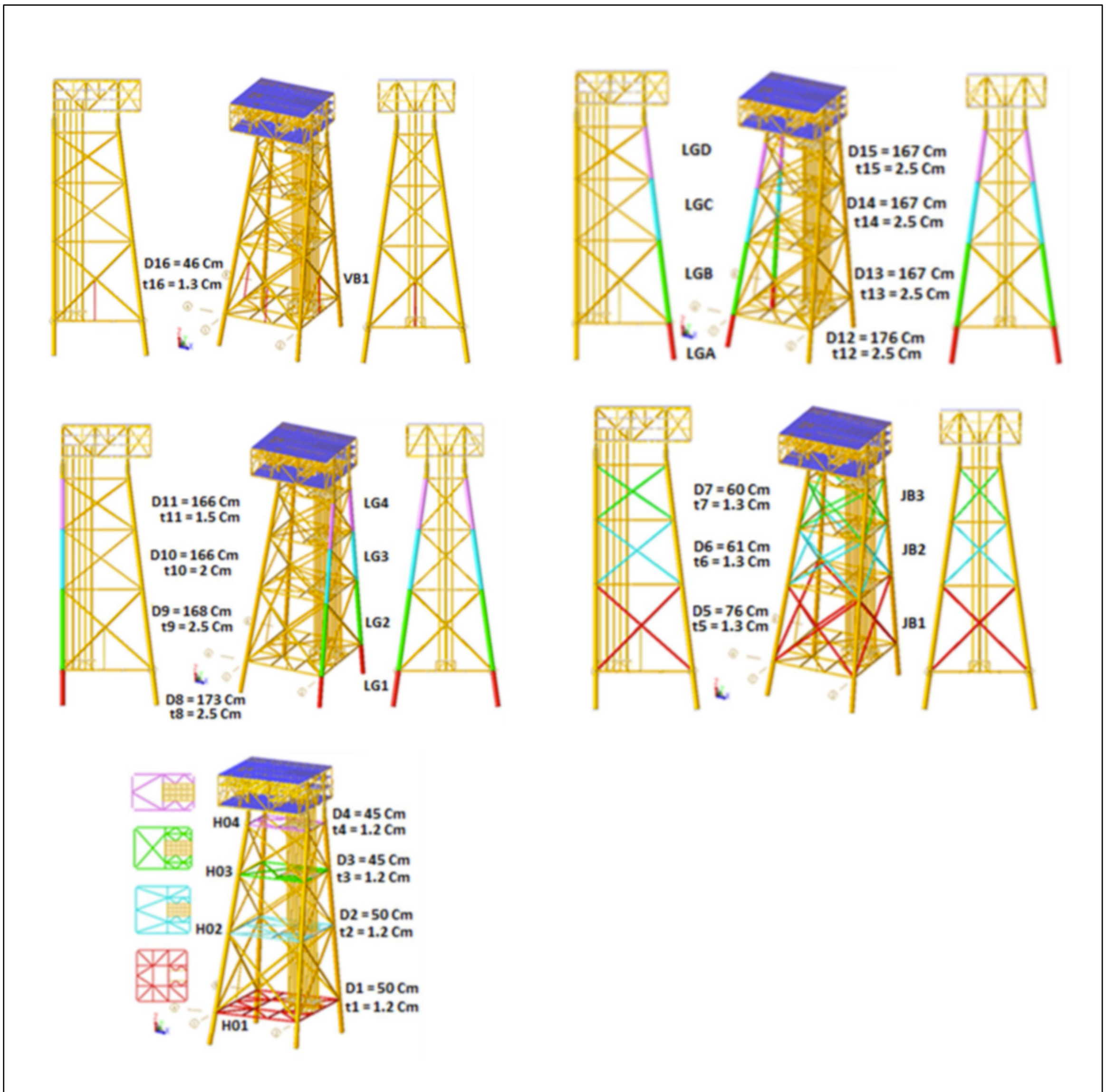

Figure 6 Section of Jacket by Group Members (Taha Nasseri et al., 2014)

The tubular members of the platform jacket have been optimized and the values of the outer diameter and the thickness are in table

Table 3 Value of Outer Diameter and Thickness after Optimization (Taha Nasseri et al., 2014)

Member Group	Outer Diameter (cm)	Thickness (cm)
H01	44	0.9
H02	36	0.5
H03	45	0.5
H04	44	0.7
JB1	90	1.1
JB2	68	0.7
JB3	93	0.8
LG1	255	2.4
LG2	168	1.9
LG3	166	1.5
LG4	165	1
LGA	282	2
LGB	167	2.1
LGC	166	1.6
LGD	166	1.2
VB1	95	0.4

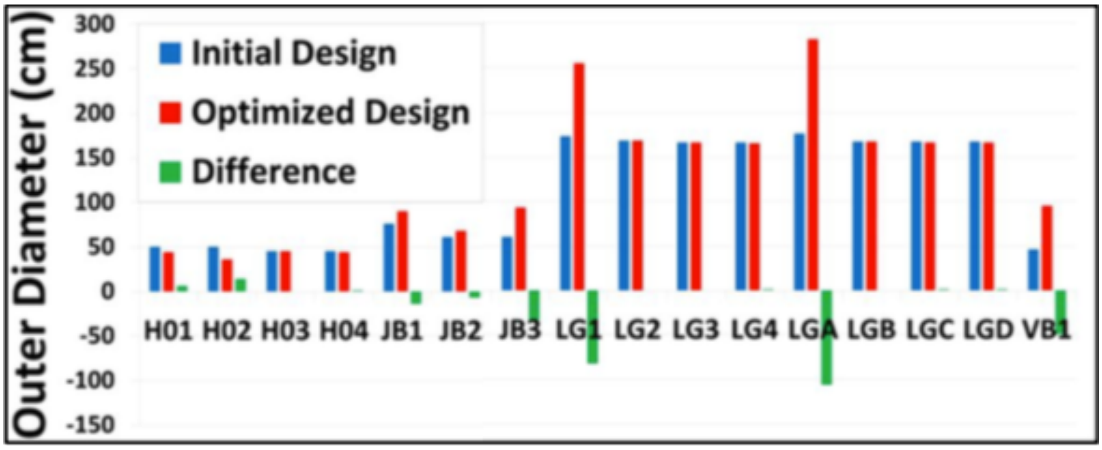

Figure 7 Bar Chart of Outer Diameter of Initial and Optimized Design and the Difference (Taha Nasseri et al., 2014)

Figure 7 displays all member sections of the jacket actual and optimized external diameter. The external diameters of horizontal sections and legs, with the exception of vertical and diagonal bracing braces and the legs underneath the loam including LG1 and LGA, are almost constant during optimisation. In the optimization process, sea environmental forces on the unit/length of the individual elements and their effects on the base may be modified when the longitudinal tubular structures change their outer diameter. The overall cumulative environmental force on the platform dropped from 7265.590 KN to7645.602 KN based on the constant scale of the external diameter of the horizontal and the leg of the jacket due to sea environmental forces and the rise in the outside diameter of the diagonal and vertical braces. The structure has been revised to 5093.33 KN, 859.221KN and 1693.051 KN in the improved version, respectively, with overall marine environmental forces of the sea, the current and wind in the original configuration equivalent to 4677.732 KN, 825.186 KN and 1762.672 KN. Although the weightage of the platform experience reduction, the summation of the sea environmental force applied on the platform have risen. Thus, wave has the biggest quota than the other two in the increment due to the inertia aspect.

In the optimization issue it is planned to reduce the quantity of steel used in the structure to improve the construction of the fixed offshore structure. Figure 8 shows that for thirteen jacket sections the volume of steel material necessary reduce in total by 168 tones, but that for JB1, LG1 and LGA the volumes of steel material necessary increase by 20 tons respectively. Ultimately, the 148 Ton drop is 23 percent of the original product jacket weight. Figure 10 illustrates the percentage of participation in the optimization phase of these seize part jacket groups. Figure 9 indicates the volumes of steel components included in the original and optimized structures of the sixteen component sections of the jacket and their differences.

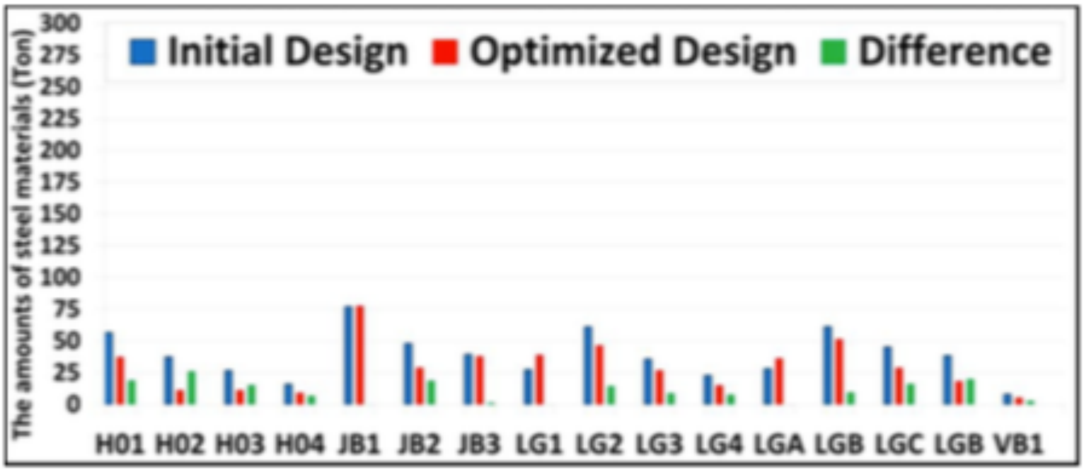

Figure 8 Bar Chart of Amount Steel Material Used for Initial and Optimized Design and the Difference (Taha Nasseri et al., 2014)

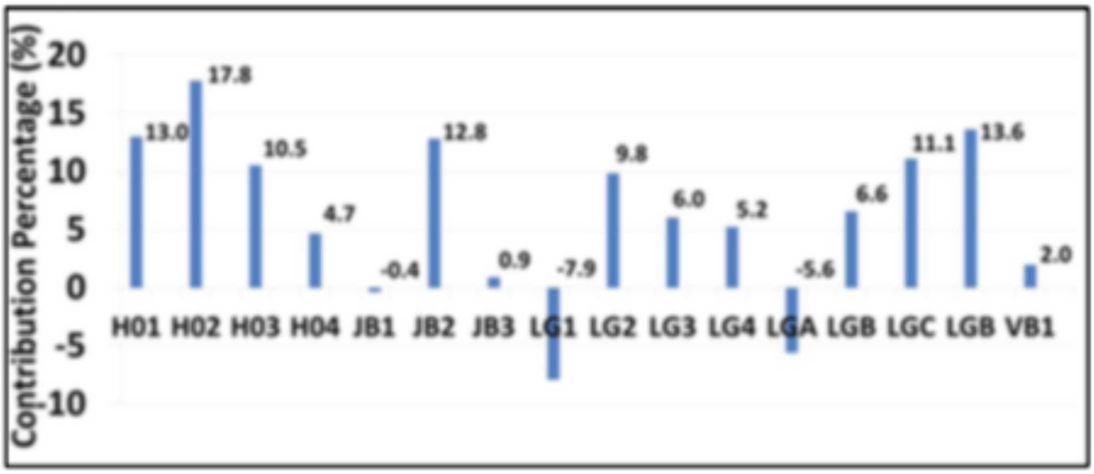

Figure 9 The Comparison of Percentage Contributed by the Group Member in the Optimization Process (Taha Nasseri et al., 2014)

This figure indicates that, with a combination of 17.8, 13.6 and 13 and 44.4 respectively, the highest output is from the three H02, LGB and H01 elements. For three elements of JB1, LG1 and LGA input percentages were low, and for the optimization issue external diameters were decreased. Yet JB1 should be acknowledged that these three elements are only exposed to environmental influences. This group should not therefore be considered as a decision variable in the optimization problem. Figure 11 calculate and displays the total percentage of participation in four main groups. As these figures indicates, the most important contribution to the optimisation process is provided by horizontal jacket members with 46 percent. The second and third grades of the allocation percentage are the legs and diagonal braces at 39% and 13% respectively. Ultimately, vertical braces have the least value in optimization with a percentage level of 2 percent. With respect to this group category they may be omitted from the optimisation process by rising environmental forces.

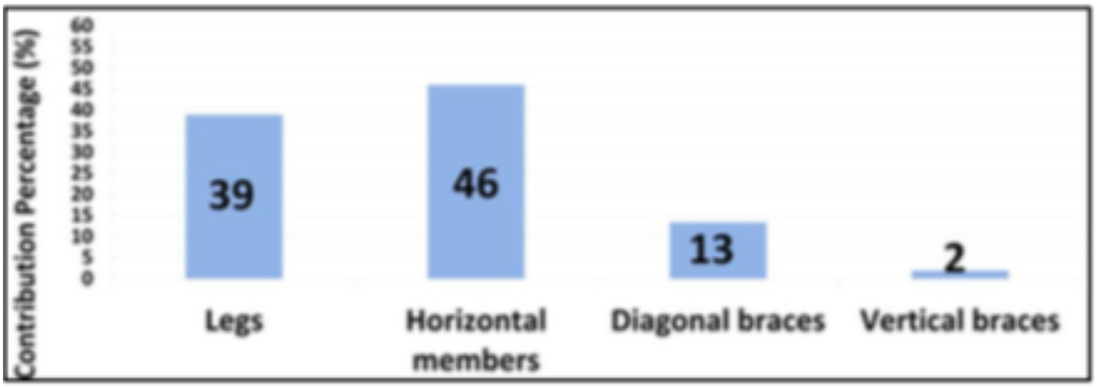

Figure 10 The Contribution Percentage Between the Group Members (Mohammad Hadi Afshar, et al. 2019)

Chapter 5: Conclusion and Recommendation

5.1 Conclusion

Topology Optimization of the offshore platform jacket could reduce the amount of materials used for fabrication thus making the jacket lighter and more cost effective. The topological optimization through SIMP method shows a positive feedback on the result of the propose changes to the structure. The project went on by studying and analysing the findings of other researchers.

5.2 Recommendation

Full simulation run on the complete dimension of the platform should be done with having the topside full design applied to the jacket structure as it will cause for imbalance distribution to the truss members.

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