ABDUL MUIZZ BIN ISMAIL B. ENG. (HONS) CIVIL ENGINEERING SEPTEMBER 2012

STUDY OF OPTIMUM LEG DIAMETER FOR MALAYSIAN FIELD BASED ON UC VALUE

ABDUL MUIZZ BIN ISMAIL

CIVIL ENGINEERING
UNIVERSITI TEKNOLOGI PETRONAS
SEPTEMBER 2012

Study of Optimum Leg Diameter for Malaysian Field Based on UC Value

by

Abdul Muizz bin Ismail

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

SEP 2012

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Study of Optimum Leg Diameter for Malaysian Field Based on UC Value

by

Abdul Muizz bin Ismail

A project dissertation submitted to the

Civil Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfillment of the requirement for the

Bachelor of Engineering (Hons)

(Civil Engineering)

Approved by,

____

(Mohd Shahir Liew)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEP 2012

CERTIFICATION 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.

ABDUL MUIZZ BIN ISMAIL

ABSTRACT

There are about 200 platforms currently being operated by various operators in Malaysia. These platforms are currently operating under the Peninsular Malaysia Operation (PMO), Sabah Operation (SBO) and Sarawak Operation (SKO). Most of these platforms were built and installed more than 20 years ago and already exceed their life design. During that particular time, the data used for the design was based on the one that has been used for the Gulf of Mexico. The data has still being used to design the new platform in term of defining the size of the member. Hence, it is very significant to make a study on the unity check ratio (UC) for these platforms and do the comparison using between these platforms. This is to determine for any platform that has already been over designed.

ACKNOWLEDGEMENTS

The special thank goes to my supportive supervisor, AP Ir Dr Mohd Shahir Liew. The supervision and guidance that he gave truly help the progression and smoothness of my final year project. The co-operation is much indeed appreciated.

I would also like to extend my thanks to Mr Azhari Haron, my internship supervisor for the assistance and advice in making this study successful. Needless to mention that Madam Zuraida, postgraduate student in who assist me to provide the metocean data from her study.

I am grateful to all my friends in UTP, for being the surrogate family during the many years I stayed here and for their continued moral support.

Finally I am forever indebted to my parents for their understanding, endless patience, and encouragement when it is most required. Your advice will always be my motivation to complete this study with full effort and commitment.

TABLE OF CONTENTS

LIST OF FIGURES

List of Table

CHAPTER 1

INTRODUCTION

1.1 Project Background

Oil is one of the greatest discoveries in the 20th century. The importance of oil in the human life is the fact that cannot be denied. The early discovery was mainly on land as early as 1900. During the middle of 20th century the exploration has begun near the shore and shallow water.

In Malaysia, the oil exploration has started since the beginning of 20th century in Sarawak. The first discovery was in 1909 and the first production was in 1910. Sarawak Shell is the company that has been given the right for the exploration of the oil on that time. Only in 1974 PETRONAS was incorporated as the oil and gas company.

There are about 200 platforms currently being operated by various operators in Malaysia. These platforms are currently operating under the Peninsular Malaysia Operation (PMO), Sabah Operation (SBO) and Sarawak Operation (SKO). Most of these platforms were built and installed more than 20 years ago and already exceed their life design. During that particular time, the data used for the design was based on the one that has been used for the Gulf of Mexico. Hence, it is very significant to make a study on the unity check ratio (UC) for these platforms and do the comparison using a current Metocean data. This is to determine for any platforms that has already been over designed.

1.2 Problem Statement

There are a lot of platforms in the Malaysian field under PMO, SBO and SKO. These platforms were operated by various operators and have been installed about 20-30 years before. During that particular time, there was no exact data of the environmental load for Malaysian field. Hence, the size of the members was defined conservatively pertaining to the available data on that particular time. However, the size of the members for the past years have been used regularly by the consultant who responsible to design the new platforms. The data used for the design was referred to the metocean data used in the Gulf of Mexico. As the actual metocean data in Malaysian field is lower than the one used in Gulf of Mexico, it has result to the possibility of overdesign platform that has been installed. Hence, the member size of the platform should be smaller to obtain the optimum design criteria.

The practice that has been applied by most of the consultants in design is to apply the standard size for each member. As what we can see, the member size of the platforms is relatively very similar to each other.

1.3 Objectives and Scope of Study

This project is a study and research based which emphasized on the optimum design for the offshore structure within Malaysia field based on the UC value.

The objective of this study is to identify the optimum leg diameter for the offshore structure based on the optimum UC value using the latest metocean data available.

Apart from that, the study is also to assess the result in terms of the differences of the UC value for the platforms under PMO, SBO and SKO. This is to indicate whether the platforms were being overdesign or already meet the optimum requirement.

CHAPTER 2

LITERATURE REVIEW

In the structural design, the structure is required to have an adequate margin of safety to against the demands. Demand can be described as load and the capacity is the required strength to resist the loads. It is very significant to withstand the combination of loads on the structure. “Structural design should be performed to satisfy the criteria for strength, serviceability, and economy”. (Chen and Richard Liew ; 2003). According to Blake (1994) “It was based on the premise that the stresses in the steel and concrete should not exceed certain permissible values, related to the strengths of the materials by safety factors, when the structure was subjected to the maximum loads that it would need to carry in service”. There are several formats of design being practiced in the industry which is allowable stress design, plastic design and load and resistance factor design.

Engineers are required to ensure the design for each of the elements of the structure is comply with the standards. Apart from that, it is also compulsory for the engineers to ensure that the structures also comply with the capacity check in the standards. According to PTS (2010) “All members and joints shall be designed in accordance with the latest edition of API RP 2A and AISC”.

In the current world, the technology evolution has given a very good advantage to engineers to come out with more accurate design. Hand calculation might give a lengthy and complicated report. “It is a challenge for engineers to design efficient and cost-effective systems without compromising the integrity of the system. The conventional design process depends on the designer’s intuition, experience, and skill. This presence of a human element can sometimes lead to erroneous results in the synthesis of complex systems” (Arora, 2002).

The design of offshore structure also needs to comply with certain standards and more concern with environmental loads. This makes the difference between offshore and onshore structures. The accuracy of the environmental load will give better result on the design analysis to determine the capacity of the structures. “With the increase in natural disasters like tsunami, typhoon, and rise in water level from global warming, it is very important for engineers to model the environmental load accurately" (Azman, Dr Kurian, & Dr M. Shahir , 2011)

The unity check ratio (UC) is simply the ratio of actual demand over the allowable capacity. UC may also be understood as the ratio of the component stress to it allowable stress which is calculated by the critical stress divided by the factor of safety. For certain cases, UC represents the stress ratio and might also represent the deflection ratio or a ratio for other design criteria. The common ways to discuss the UC is about to discuss about the yield unity check of the structure. "The unity check represents an "envelope" check. All of the design load cases are checked for the member and the worst-case value is stored. These checks encompass all types of checks pertinent to the material and according to the assumptions and limitations of each design material module (*https://www.iesweb.com)*". This is to evaluate the structure under combination of loads usually axial compression and bending stress.

UC is known as capacity check for the structure including offshore and onshore structures. The standard requirement to assess the UC is to ensure that the value of the UC is less than or equal to 1.0. If the UC is greater than 1.0, some modification should be done on the design of the structure. In case where the value is fall around 0.2-0.3, it indicates that the structure is overdesigned. For the UC fall around 0.8-1.0, it shows the design of the structure is optimum.

During the design stages, the size and dimension of the structures could be modified to achieve the optimum UC value (*https://www.iesweb.com)*. Hence, the optimum leg dimension for the platform is possible to be identified based on the UC value.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Project work

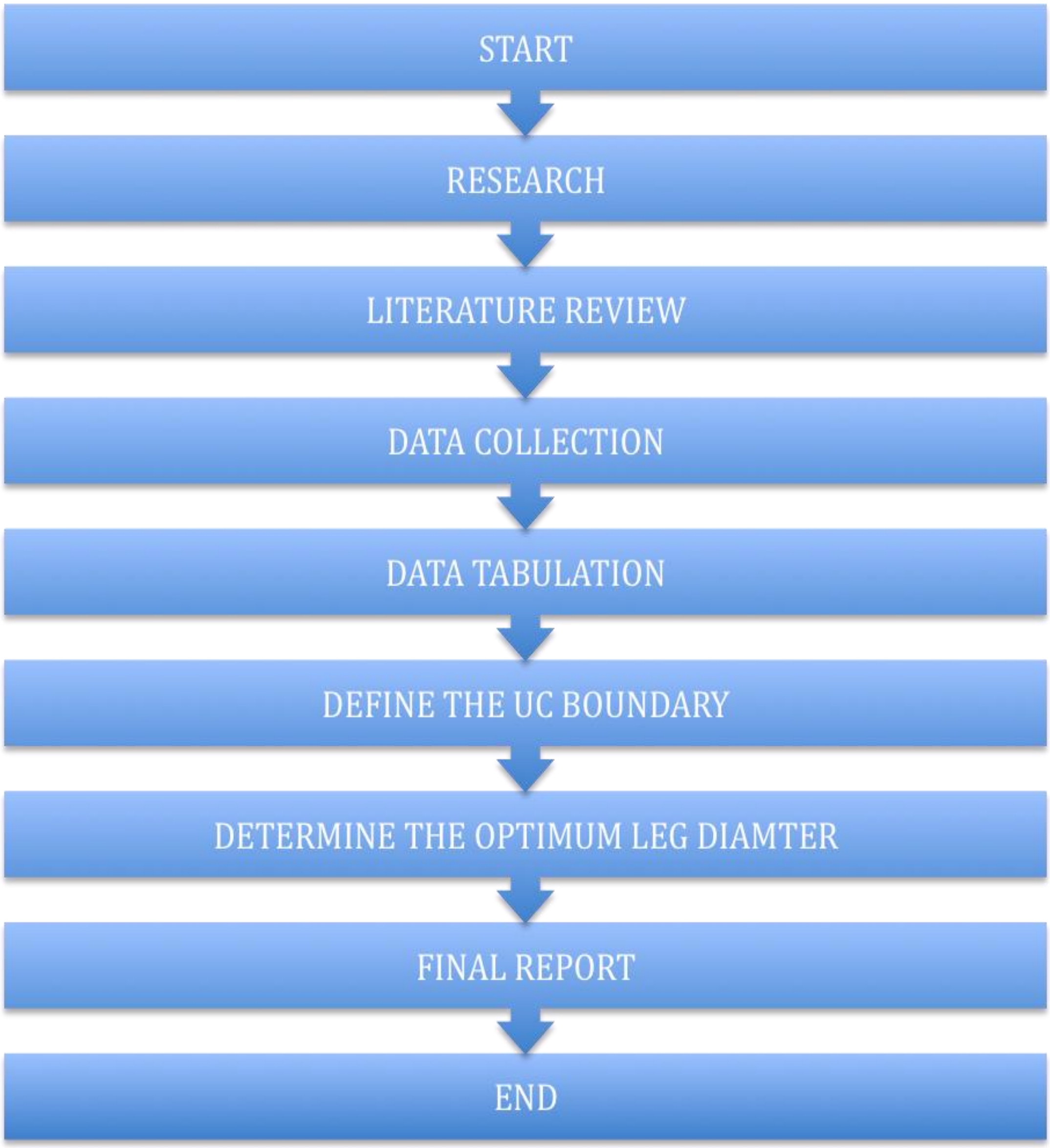


Figure 3.1: Project Activities Flow

The project is a study base project. Specifically, it is a study of the optimum leg diameter based on the UC value.

First and for most, the project will begin with the research on several issues which had been mention in the research methodology below.

The project begins with the selection of the title. Title is automatically reflecting the scope of work that is necessary to be done. Once the title is confirmed, the project was proceed with the literature review on the unity check ratio (UC). From here, it will provide significant information regarding the implementation of the UC value in offshore structures.

After completing the literature review, the author will proceed to obtain the necessary data of the platform. For this project, it is required to obtain minimum three data of platform each from Peninsular Malaysia Operation (PMO), Sabah Operation (SBO) and Sarawak Operation (SKO). The type of platform from each region should be similar.

For this study, author has selected Structural Analysis Computer Software (SACS) to run the necessary analysis for the platforms. This software is widely used by the structural designers to analyze the capacity of the structures under the loads imposed on the structures especially for offshore structures.

In this study, the significant data required is the sacs input file of the three platforms to check the result of the static in-place analysis. The original output during the time where the platforms were designed is checked. This check is focusing on the unity check (UC) value for all the members of the structures. This check also to observe and verify the earlier hypothesis which stated that the platforms in Malaysia water was overdesign. The pattern of the UC value for each platform also needs to be observed properly to spot any significant differences. This is also to confirm if the different environmental condition for each region would affect the capacity of the structures to resist the loads.

From here, author need to classify a list of the entire members diameter together with its wall thickness of the leg and pile of the structure. The size of the member is quite similar to the existing platform. So here comes the cause of the possibilities of overdesign of the structures.

Then, author will use different set of member diameter for the leg and pile. However, it is necessary to have controlling factor while changing the size of the member. So, author need to sustain the D/T ratio for the members.

The member size of the leg and pile in input file will be changed to certain percent of the original size until it approaching the optimum criteria of the UC value. The UC value obtained will be tabulated in order to observe the pattern of the UC value for each platform from different region.

Apart from that, the author will carry out the in-place analysis by using the current metocean data to compare the UC value with the previous data.

By using the latest metocean data available, it is really meaningful to determine the optimum diameter for each region. All this finding will be included in the final report after this.

CHAPTER 4

RESULT & DISCUSSION

This section will discuss about the analysis that have been conducted on platforms that have been selected. This section will be separated on data collection and the data analysis pertaining to the hypothesis of this study.

4.1 Input Preparation

Some modification towards the data has been done on the sacs input file before the analysis. The size of each member has been reduced to certain percentage.

Table 4.1.1: Input for ABU platform

LEG 1	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)	LEG 2	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)
1	923-2001	LG8	0.358	0.514	43.575	1	924-2002	LG8	0.235	0.352	49.787
2	919-923	LG6	0.349	0.507	45.272	2	920-924	LG6	0.211	0.310	46.919
3	791-919	LG5	0.074	0.117	58.108	3	796-920	LG5	0.241	0.333	38.174
4	394-410	L3E	0.034	0.050	47.059	4	292-413	LG3	0.132	0.173	31.061
5	270-289	L2G	0.020	0.028	40.000	5	271-292	L2E	0.044	0.056	27.273
6	198-257	LG7	0.033	0.046	39.394	6	259-271	L2F	0.098	0.128	30.612
7	986-19	L1A	0.000	0.000	0.000	7	203-259	LG2	0.099	0.131	32.323
8	19-198	L1A	0.016	0.024	50.000	8	33-203	L1A	0.011	0.019	72.727
LEG 3	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)	LEG 4	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)
1	928-2004	LG8	0.222	0.326	46.847	1	927-2003	LG8	0.291	0.441	51.546
2	922-928	LG6	0.200	0.298	49.000	2	921-927	LG6	0.270	0.410	51.852
3	912-922	LG5	0.131	0.209	59.542	3	898-921	LG5	0.210	0.316	50.476
4	501-389	L3A	0.151	0.181	19.868	4	494-382	L3C	0.513	0.722	40.741
5	277-377	L2E	0.018	0.024	33.333	5	992-370	L2C	0.065	0.093	43.077
6	260-277	L2F	0.051	0.063	23.529	6	258-992	L2H	0.157	0.209	33.121
7	244-260	LG2	0.051	0.064	25.490	7	239-258	LG7	0.090	0.126	40.000
8	173-244	L1A	0.012	0.022	83.333	8	159-239	L1A	0.004	0.007	75.000

Table 4.1.2: Input for F9JT-a18 platform

LEG 1	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)	LEG 2	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)
1	601-924	L50	0.334	0.459	37.425	1	604-923	L50	0.219	0.296	35.160
2	501-918	L36	0.323	0.453	40.248	2	504-919	L36	0.212	0.289	36.321
3	401-501	L15	0.302	0.432	43.046	3	404-504	L15	0.204	0.294	44.118
4	301-401	L43	0.383	0.561	46.475	4	304-404	L43	0.284	0.411	44.718
5	201-301	L14	0.392	0.537	36.990	5	204-304	L14	0.309	0.418	35.275
6	178-201	L47	0.402	0.562	39.801	6	187-204	L47	0.315	0.434	37.778
7	177-178	L46	0.614	0.815	32.736	7	186-187	L46	0.490	0.641	30.816
8	101-176	L12	0.623	0.823	32.103	8	104-185	L12	0.505	0.656	29.901
LEG 3	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)	LEG 4	JOINT	MEMBER	UC(ORI)	UC(85%)	DIFF(%)
1	603-715	L50	0.233	0.313	34.335	1	602-739	L50	0.318	0.437	37.421
2	503-729	L36	0.225	0.289	28.444	2	502-738	L36	0.322	0.438	36.025
3	403-503	L35	0.169	0.242	43.195	3	402-502	L35	0.250	0.360	44.000
4	303-403	L42	0.211	0.304	44.076	4	302-402	L42	0.278	0.404	45.324
5	203-303	L34	0.225	0.302	34.222	5	202-302	L34	0.269	0.365	35.688
6	184-203	L45	0.233	0.322	38.197	6	181-202	L45	0.282	0.393	39.362
7	183-184	L44	0.362	0.488	34.807	7	180-181	L44	0.431	0.588	36.427
8	103-182	L32	0.364	0.477	31.044	8	102-179	L32	0.419	0.563	34.368

Table 4.1.3: Input for SUPG-B platform

LEG 1	JOINT	MEMBER	UC(ORI)	UC(90%)	DIFF(%)	LEG 2	JOINT	MEMBER	UC(ORI)	UC(90%)	DIFF(%)
1	301L-401L	LG15	0.165	0.207	25.455	1	319L-419L	L15	0.104	0.130	25.000
2	237A-301L	L11	0.078	0.096	23.077	2	219L-220A	L18	0.023	0.025	8.696
3	203A-237A	L13	0.072	0.088	22.222	3	186A-187A	L16	0.015	0.015	0.000
4	101L-173A	LG2	0.015	0.010	-33.333	4	119L-186A	LG4	0.013	0.010	-23.077
5	101L-001	LG1	0.001	0.001	0.000	5	119L-019	LG1	0.001	0.001	0.000
LEG 3	JOINT	MEMBER	UC(ORI)	UC(90%)	DIFF(%)	LEG 4	JOINT	MEMBER	UC(ORI)	UC(90%)	DIFF(%)
1	399L-499L	L15	0.106	0.132	24.528	1	381L-481L	L15	0.134	0.168	25.373
2	299L-399L	L19	0.043	0.051	18.605	2	830-829	L13	0.061	0.075	22.951
3	195A-299L	L17	0.010	0.017	70.000	3	189A-281L	L17	0.016	0.025	56.250
4	199L-195A	LG2	0.030	0.037	23.333	4	181L-189A	LG2	0.041	0.052	26.829
5	199L-099	LG1	0.001	0.001	0.000	5	181L-081	LG1	0.001	0.001	0.000

4.2 Data Collection

Three platforms each from PMO, SKO and SBO was obtained to run this study. These three platforms are ABU for PMO, F9JT-a18 for SKO and SUPG-B for SBO. The sacs input file for all these platforms are used to evaluate and assessment the result of the static in-place analysis.

ABU is a 4-legged drilling platform located in Kertih with water depth of 60.7m. This platform is belongs to PMO.

F9JT-a18 is one of the platforms in the Kumang Kluster Development Project. It is a drilling platform and it has four legs. The water depth for this platform is 94.8m and operated under SKO.

Selatan South Processing Platform (SUPG-B) is a 6 legged drilling and processing platform. The platform topside consists of five (5) modules and was supported by a Module Support Frame (MSF). The SUPG-B substructure is a 6-legged launch steel template structure with piles driven through the legs in a water depth of 42.8m

The static in-place analysis has been conducted for these three platforms using the original sacs input file with the original size for the leg and pile of the structures. From the report generated by sacs on unity check partition, it shown that the UC value for most of the leg members are fall within range 0.0 to 0.5 which indicates the structural is overdesign.

Table 4.2.1-UC Table Sample for ABU

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY

GROUP I - UNITY CHECKS GREATER THAN 0.00 AND LESS THAN 0.75

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/mm2	BENDING STRESS Y N/mm2	BENDING STRESS Z N/mm2	SHEAR FORCE FY kN	SHEAR FORCE FZ kN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
33- 203	L1A	0.011	108	1.0	0.33	-2.51	1.39	0.16	-0.21	3.6	3.6	0.000		0.000	
159- 239	L1A	0.004	108	1.0	0.45	0.63	-0.32	0.03	0.01	3.6	3.6	0.000		0.000	
173- 244	L1A	0.012	108	1.0	0.39	-2.98	-0.18	-0.06	-0.22	3.6	3.6	0.000		0.000	
959- 173	L1A	0.000	108	1.0	0.09	-0.01	0.00	0.00	0.00	1.7	1.7	0.000		0.000	
984- 159	L1A	0.000	108	1.0	0.09	-0.02	0.00	0.00	0.00	1.7	1.7	0.000		0.000	
985- 33	L1A	0.000	108	1.0	0.09	-0.01	0.00	0.00	0.00	1.7	1.7	0.000		0.000	
986- 19	L1A	0.000	108	1.0	0.09	-0.02	0.00	0.00	0.00	1.7	1.7	0.000		0.000	
992- 370	L2C	0.065	108	10.1	-8.05	-6.52	1.91	0.02	-0.10	5.5	77.8	0.000		0.000	
271- 292	L2E	0.044	108	10.0	10.33	-1.73	-1.22	-0.02	-0.03	8.1	80.9	0.000		0.000	
277- 377	L2E	0.018	108	9.9	3.04	-2.12	1.19	0.03	-0.09	8.1	80.8	0.000		0.000	
259- 271	L2F	0.098	108	3.0	22.13	5.14	-1.92	0.00	-0.07	13.1	53.9	0.000		0.000	
260- 277	L2F	0.051	108	3.1	6.02	8.63	-1.00	-0.01	-0.03	13.1	53.9	0.000		0.000	
270- 289	L2G	0.020	108	10.1	-1.85	-1.41	-3.03	-0.06	-0.03	5.5	77.8	0.000		0.000	
257- 270	L2H	0.053	108	0.0	-7.86	4.57	0.38	0.04	-0.03	3.0	42.9	0.000		0.000	
258- 992	L2H	0.157	108	0.0	-28.83	5.61	2.61	-0.01	-0.01	3.0	42.9	0.000		0.000	
501- 389	L3A	0.151	108	2.0	27.66	-3.44	14.09	0.00	0.07	3.4	37.3	0.000		0.000	
377- 389	L3B	0.134	108	10.8	26.94	7.15	-7.42	-0.02	0.00	3.4	37.2	0.000		0.000	
494- 382	L3C	0.513	108	10.9	-97.23	20.42	10.18	0.04	0.07	3.4	37.4	0.000		0.000	
370- 382	L3D	0.515	108	10.9	-96.90	20.93	-11.13	-0.06	0.09	3.4	37.5	0.000		0.000	
394- 410	L3E	0.034	108	8.7	-5.54	-0.04	1.67	-0.06	-0.02	3.3	72.6	0.000		0.000	
289- 394	L3F	0.143	108	10.9	-21.54	3.49	12.21	0.03	0.01	1.7	37.5	0.000		0.000	

Table 4.2.2-UC Value Sample for F9JT-a18

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY

GROUP I - UNITY CHECKS GREATER THAN 0.00 AND LESS THAN 0.80

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/mm2	BENDING STRESS Y N/mm2	BENDING STRESS Z N/mm2	SHEAR FORCE FY kN	SHEAR FORCE FZ kN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
102- 179	L32	0.419	OP04	2.5	-68.55	4.64	2.51	-0.13	-0.11	36.6	36.6	0.388	ST04	0.377	OP05
103- 182	L32	0.364	OP02	2.5	-57.69	7.16	0.83	0.09	-0.12	36.6	36.6	0.345	ST02	0.310	OP01
179- 180	L33	0.416	OP04	0.0	-68.16	-2.22	-3.95	0.08	0.14	37.6	37.6	0.378	OP05	0.372	ST04
182- 183	L33	0.355	OP02	0.0	-57.17	-0.06	5.35	-0.10	0.08	37.6	37.6	0.329	ST02	0.310	OP01
202- 302	L34	0.269	OP04	17.7	-44.71	-4.18	0.05	0.00	-0.14	39.7	39.7	0.242	ST04	0.235	OP05
203- 303	L34	0.225	OP02	17.7	-37.22	-3.83	-0.54	0.01	-0.11	39.7	39.7	0.208	ST02	0.188	OP01
402- 502	L35	0.250	OP04	19.0	-41.62	0.72	-0.97	0.00	-0.01	46.6	46.6	0.236	OP05	0.223	OP03
403- 503	L35	0.169	OP02	19.0	-27.95	0.36	1.02	0.01	-0.01	46.6	46.6	0.152	OP01	0.139	ST02
501- 918	L36	0.323	SM01	4.2	-57.62	-2.98	0.01	-0.02	-0.14	30.3	30.3	0.315	OP06	0.306	OP05
502- 738	L36	0.322	OP04	9.8	-54.78	-10.39	-0.30	0.01	-0.11	18.9	18.9	0.317	OP03	0.314	OP05
503- 729	L36	0.225	OP01	9.8	-27.77	-8.74	-16.31	-0.23	-0.11	18.9	18.9	0.218	OP02	0.191	OP09
504- 919	L36	0.212	OP09	4.2	-35.86	-4.70	-0.29	0.01	-0.15	30.2	30.2	0.208	SM03	0.201	OP01
602- 702	L38	0.305	OP04	1.3	-42.72	22.20	-7.42	-0.12	2.23	5.0	5.0	0.279	OP05	0.272	OP03
603- 703	L38	0.157	OP02	1.3	-23.80	6.47	-6.94	-0.01	1.12	5.0	5.0	0.138	OP03	0.124	ST02
701- 801	L39	0.531	OP06	0.7	-82.85	30.23	-9.71	0.48	1.45	1.3	1.3	0.509	SM01	0.487	OP05
702- 802	L39	0.654	OP04	0.6	-83.58	60.32	-15.54	-0.12	2.22	1.2	1.2	0.594	OP05	0.587	OP03
703- 803	L39	0.326	OP02	0.6	-46.51	20.96	-13.82	-0.01	1.11	1.2	1.2	0.280	OP03	0.260	OP01
704- 804	L39	0.269	OP09	0.0	-47.22	-0.21	9.58	-0.39	0.61	1.3	1.3	0.264	SM03	0.236	OP01
302- 402	L42	0.278	OP04	23.8	-41.40	2.06	-0.97	-0.01	0.02	60.7	60.7	0.250	OP05	0.239	ST04
303- 403	L42	0.211	OP02	23.8	-31.49	1.68	0.72	0.01	0.01	60.7	60.7	0.188	ST02	0.181	OP01
301- 401	L43	0.383	SM01	26.1	-55.82	2.51	-4.60	-0.07	0.02	60.3	60.3	0.354	OP06	0.319	OP05

Table 4.2.3- UC Table Sample for SUPG-B

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY

GROUP I - UNITY CHECKS GREATER THAN 0.00 AND LESS THAN 0.75

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/mm2	BENDING STRESS Y N/mm2	BENDING STRESS Z N/mm2	SHEAR FORCE FY kN	SHEAR FORCE FZ kN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
203-243A	LTA	0.059	GRA1	0.0	-4.60	5.49	-5.53	0.00	-0.01	32.5	36.5	0.048	GRA2	0.000	
208-109B	LTA	0.014	GRA1	0.0	0.68	2.47	0.80	0.00	-0.01	27.7	36.3	0.012	GRA2	0.000	
208-250A	LTA	0.022	GRA1	0.0	-2.23	2.18	-0.16	0.00	0.00	32.5	36.5	0.018	GRA2	0.000	
103B-102B	LTA	0.031	GRA1	9.1	-2.50	2.67	-2.69	0.00	0.01	36.7	46.7	0.025	GRA2	0.000	
103B-105B	LTA	0.025	GRA1	0.0	2.95	1.66	1.84	0.00	0.00	30.4	36.3	0.020	GRA2	0.000	
110B-107B	LTA	0.014	GRA1	9.1	0.17	2.96	0.30	0.00	0.01	36.7	46.7	0.011	GRA2	0.000	
110B-109B	LTA	0.014	GRA1	7.3	1.33	1.74	0.55	0.00	0.00	30.4	36.3	0.012	GRA2	0.000	
244A-243A	LTA	0.057	GRA1	0.0	-7.39	3.51	-1.19	0.00	-0.01	28.8	36.5	0.046	GRA2	0.000	
251A-250A	LTA	0.033	GRA1	7.0	-3.57	0.41	3.10	0.00	0.00	28.8	36.5	0.027	GRA2	0.000	
175A-103B	LTB	0.031	GRA1	13.1	-0.52	6.23	-1.81	0.00	0.01	57.1	57.1	0.025	GRA2	0.000	
179A-110B	LTB	0.032	GRA1	13.1	-1.24	5.65	-0.39	0.00	0.01	57.1	57.1	0.026	GRA2	0.000	
211A-244A	LTB	0.037	GRA1	10.3	1.97	6.13	-2.01	0.00	0.01	44.9	44.9	0.030	GRA2	0.000	
214A-251A	LTB	0.035	GRA1	10.3	2.97	4.20	2.24	0.00	0.01	45.0	45.0	0.029	GRA2	0.000	
211A-243A	LTC	0.016	GRA1	6.9	1.32	0.30	-2.53	0.00	0.00	32.8	43.6	0.013	GRA2	0.000	
214A-250A	LTC	0.005	GRA1	6.9	0.05	0.62	1.12	0.00	0.00	32.9	43.6	0.004	GRA2	0.000	
251-243A	LTD	0.012	GRA1	7.9	0.67	0.85	2.01	0.01	0.00	36.9	44.2	0.009	GRA2	0.000	
257-250A	LTD	0.006	GRA1	7.6	-0.26	0.41	-1.11	0.00	0.00	36.9	44.2	0.005	GRA2	0.000	
175A-105B	LTE	0.012	GRA1	8.2	-1.39	0.80	0.65	0.00	0.00	38.4	43.2	0.010	GRA2	0.000	
179A-109B	LTE	0.010	GRA1	8.2	-1.24	0.66	0.06	0.00	0.00	38.4	43.2	0.008	GRA2	0.000	
251-105B	LTF	0.008	GRA1	7.7	-0.96	0.55	-0.39	0.00	0.00	35.5	43.9	0.007	GRA2	0.000	
257-109B	LTF	0.008	GRA1	6.6	-1.13	-0.09	0.26	0.00	0.00	35.5	43.9	0.006	GRA2	0.000	

From the report on the UC value above, it shows the patterns of the UC are mostly very low. Only few of them have exceeded 0.5 which indicates it covers more loads compared to other members. The original design of these platforms has result the lower UC as compared to the final UC after the reduction in size of the leg members.

The lower UC also indicates that the platforms might have high reserve strength ratio (RSR) value. For the assessment and structural integrity campaign later, high RSR will be meaningful in case the operator decided to continue the operation of the platforms after it achieved the design life of the platform.

However, the reduction in size member will definitely reduce the RSR as well. The RSR can be determined by conducting pushover analysis using the appropriate software like SACS, USFOS or SESAM. The output should be assessed whether it is still within the acceptance by the operator or vice versa.

4.3 Data Analysis

<u>PMO</u>

For ABU platform in peninsular water, author has changed the leg and pile diameter of the platform by reducing the size to certain percentage. Author has reduced the member size up to several set of 15%, 17% and 20% of the original size. However, the D/t ratio is to keep constant.

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY

GROUP I - UNITY CHECKS GREATER THAN 0.00 AND LESS THAN 0.75

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/mm2	BENDING STRESS Y N/mm2	BENDING STRESS Z N/mm2	SHEAR FORCE FY kN	SHEAR FORCE FZ kN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
33- 203	L1A	0.021	108	1.0	0.32	-5.50	2.76	0.20	-0.27	4.3	4.3	0.000		0.000	
159- 239	L1A	0.007	108	1.0	0.60	1.37	-0.89	0.01	0.03	4.4	4.4	0.000		0.000	
173- 244	L1A	0.022	108	1.0	0.43	-6.44	-0.17	-0.06	-0.28	4.3	4.3	0.000		0.000	
959- 173	L1A	0.000	108	1.0	0.09	-0.01	0.00	0.00	0.00	2.1	2.1	0.000		0.000	
984- 159	L1A	0.000	108	1.0	0.09	-0.02	0.00	0.00	0.00	2.1	2.1	0.000		0.000	
985- 33	L1A	0.000	108	1.0	0.09	-0.01	0.00	0.00	0.00	2.1	2.1	0.000		0.000	
986- 19	L1A	0.000	108	1.0	0.09	-0.02	0.00	0.00	0.00	2.1	2.1	0.000		0.000	
992- 370	L2C	0.093	108	10.1	-10.35	-8.10	1.43	0.00	-0.07	6.6	93.7	0.000		0.000	
271- 292	L2E	0.058	108	10.0	13.46	-2.84	-0.72	-0.01	-0.03	9.7	97.4	0.000		0.000	
277- 377	L2E	0.024	108	9.9	3.35	-3.94	0.94	0.02	-0.07	9.7	97.4	0.000		0.000	
259- 271	L2F	0.135	108	3.0	29.10	8.57	-2.46	0.01	-0.06	15.8	64.9	0.000		0.000	
260- 277	L2F	0.063	108	3.1	6.73	11.52	-1.23	0.00	-0.03	15.8	65.0	0.000		0.000	
270- 289	L2G	0.027	108	10.1	-2.14	-2.11	-3.67	-0.05	-0.02	6.6	93.7	0.000		0.000	
257- 270	L2H	0.073	108	0.0	-8.90	8.30	-1.04	0.04	-0.03	3.6	51.7	0.000		0.000	
258- 992	L2H	0.209	108	0.0	-36.69	8.35	4.73	-0.01	-0.01	3.6	51.7	0.000		0.000	
501- 389	L3A	0.181	108	2.0	34.45	-9.92	12.28	0.01	0.06	4.2	44.9	0.000		0.000	
377- 389	L3B	0.162	108	10.8	33.73	7.76	-8.09	-0.01	0.00	4.1	44.8	0.000		0.000	
494- 382	L3C	0.722	108	10.9	-133.95	25.30	12.10	0.02	0.06	4.1	45.1	0.000		0.000	
370- 382	L3D	0.726	108	10.9	-133.59	26.10	-13.66	-0.04	0.06	4.1	45.1	0.000		0.000	
394- 410	L3E	0.050	108	10.9	-7.15	-1.48	-1.65	-0.07	-0.03	4.0	87.4	0.000		0.000	
289- 394	L3F	0.187	108	10.9	-28.21	5.54	14.18	0.02	0.01	2.1	45.1	0.000		0.000	

Figure 4.3.1: ABU - 17% Member Size Reduction

According to the table above, author notice there are increments in the UC value as compared to the UC of original member size. The increment is quite significant FOR certain member almost 80-90%.

Author has selected eight critical sections of members for each leg for comparison. These critical sections have been identified as the members that carry load the most from the topside and all the appurtenances like riser and boat landing. Author has selected the section at the top, middle and at the bottom of the leg to be assessed and compared.

For this purpose, author has tabulated the data for the respective members and present onto the graph. The percentage difference also plotted on the graph.

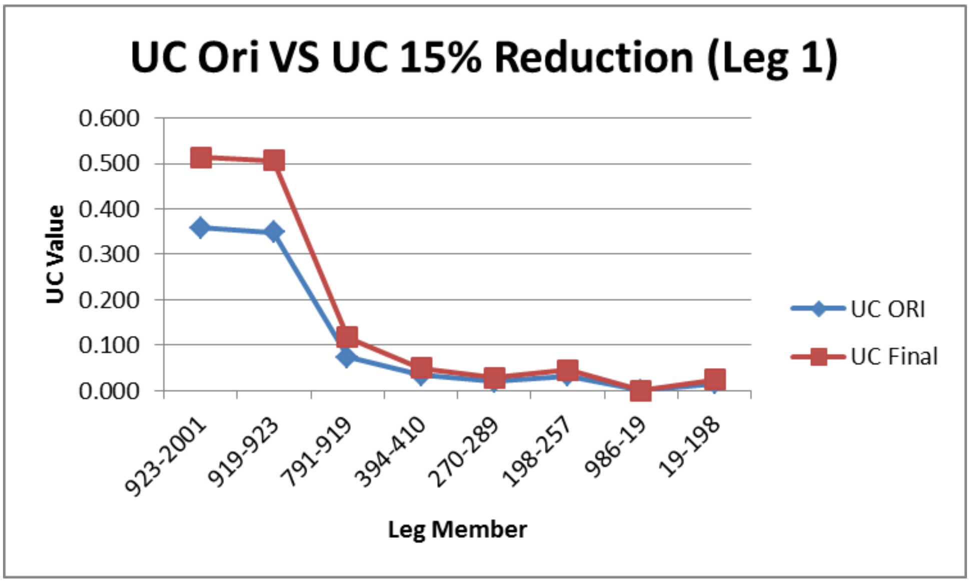


Figure 4.3.1: UC Leg 1 ABU

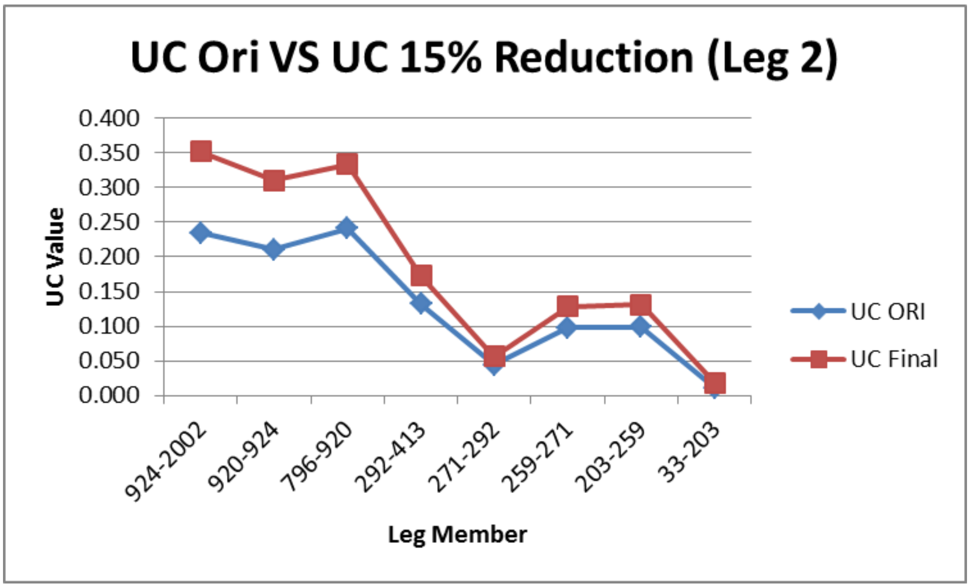


Figure 4.3.1: UC Leg 2 ABU

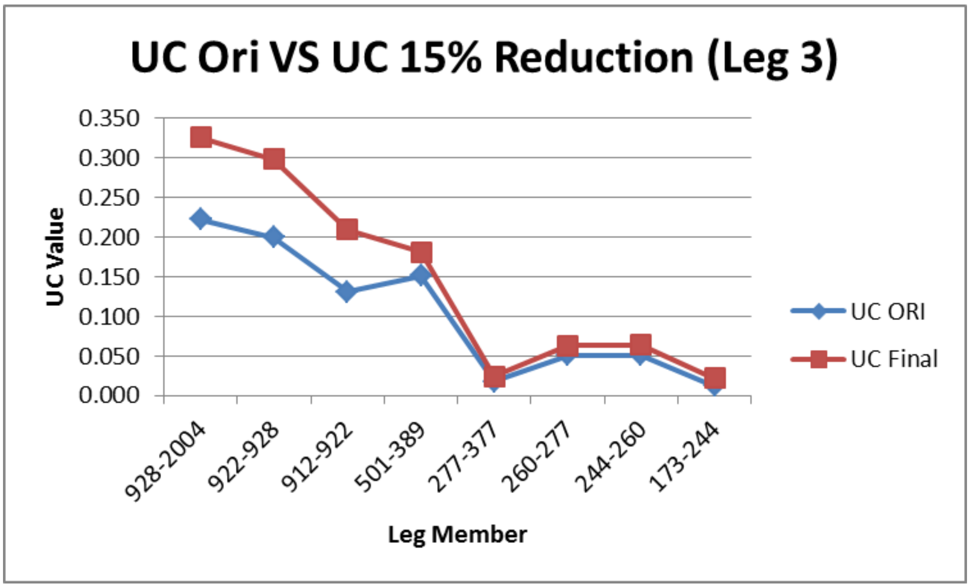


Figure 4.3.3: UC Leg 3 ABU

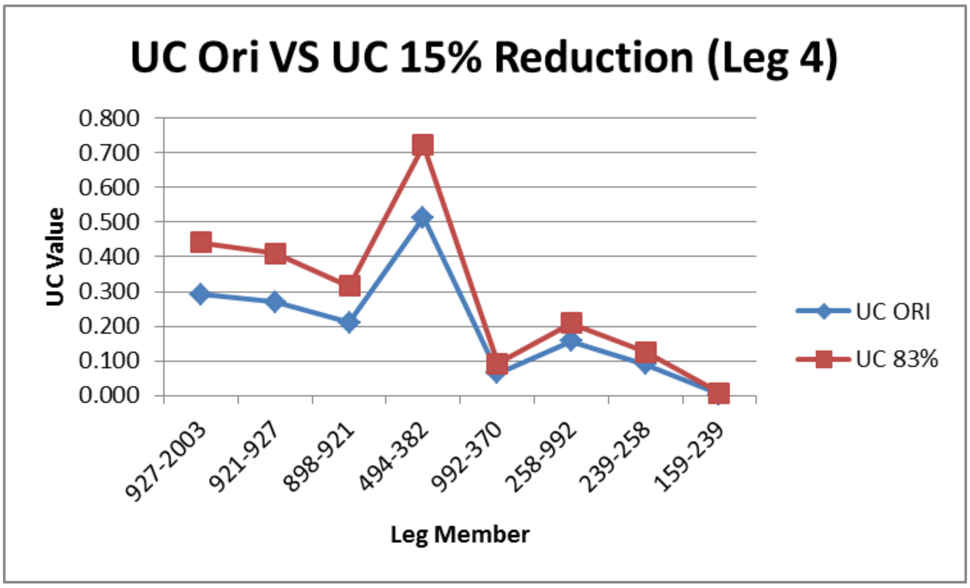


Figure 4.3.4: UC Leg 4 ABU

From left on the x-axis is the member at the upper side of the jacket and it shows this part carry more loads. The difference in UC value of original and the final value is very significant to verify that the platform is overdesign.

From the graphs above, it shown for all sections, as the size of the members was reduced then the UC will increased. It also shown that the UC is higher at the upper members compared to the lower member. This is because the leg at the top need to carry the most of the load from the topside before it was distributed to the brace and the leg below.

Only for the leg at the leg 4 it shown UC is higher at the middle member. This happen as at this side, the members also required to support the load from the topside as well as the load from the boat landing structures and the risers. As the higher load imposed on the structure will cause the higher UC.

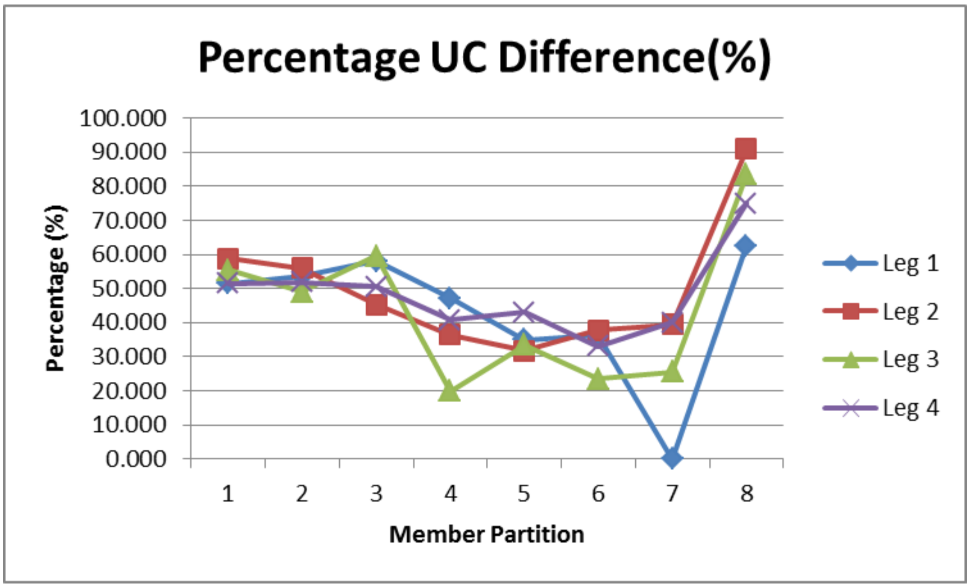


Figure 4.3.5: UC Diff (%) ABU

Based on the figure above, it shown the percentage UC difference prior to four row of the ABU platform. From the graph, it shown the highest increment was at the front right row with almost 90% and the lowest was indicate by one member on the front left row. Most of the UC had increased to 30-40 % as the result of the reduction of the size of leg diameter.

F9JT-a18

For F9JT-a18 platform in Sarawak water, author has changed the leg and pile diameter of the platform by reducing the size to certain percentage. Author has reduced the member size up to several set of 15%, 17%, 18% and 20% of the original size. However, the D/t ratio is to keep constant.

SACS-IV MEMBER UNITY CHECK RANGE SUMMARY

GROUP II - UNITY CHECKS GREATER THAN 0.80 AND LESS THAN 1.00

MEMBER	GROUP ID	MAXIMUM COMBINED UNITY CK	LOAD COND NO.	DIST FROM END	AXIAL STRESS N/mm2	BENDING STRESS Y N/mm2	BENDING STRESS Z N/mm2	SHEAR FORCE FY kN	SHEAR FORCE FZ kN	KLY/RY	KLZ/RZ	SECOND-HIGHEST UNITY CHECK	SECOND-HIGHEST LOAD COND	THIRD-HIGHEST UNITY CHECK	THIRD-HIGHEST LOAD COND
205- 207	5DB	0.925	CS01	0.0	1.01	19.24	-0.19	0.00	-0.03	85.5	85.5	0.925	OP01	0.925	OP02
207- 209	5DB	0.925	CS01	0.0	0.58	19.29	0.51	0.00	-0.03	85.7	85.7	0.925	OP01	0.925	OP02
210- 205	5DB	0.925	CS01	0.0	0.07	14.80	-0.31	0.00	-0.03	66.5	66.5	0.925	OP01	0.925	OP02
210- 209	5DB	0.925	CS01	0.0	0.23	8.26	0.30	0.00	-0.02	67.1	67.1	0.925	OP01	0.925	OP02
101- 176	L12	0.823	SM01	2.5	-131.07	1.05	-7.90	0.02	0.01	42.9	42.9	0.755	OP06	0.681	OP07
176- 177	L13	0.820	SM01	0.0	-131.04	-0.85	-6.15	0.02	0.06	44.0	44.0	0.752	OP06	0.674	OP07
177- 178	L46	0.815	SM01	3.0	-130.88	2.18	-5.00	0.00	0.05	44.0	44.0	0.747	OP06	0.669	OP07
210- 204	V1V	0.814	CS01	1.7	0.18	-4.21	-0.39	0.00	-0.01	94.9	44.8	0.814	OP01	0.814	OP02

Figure 4.3.6: UC after 15% **size reduction**

Figure above shown the UC obtained after the in-place analysis conducted on the modified sacs input model.

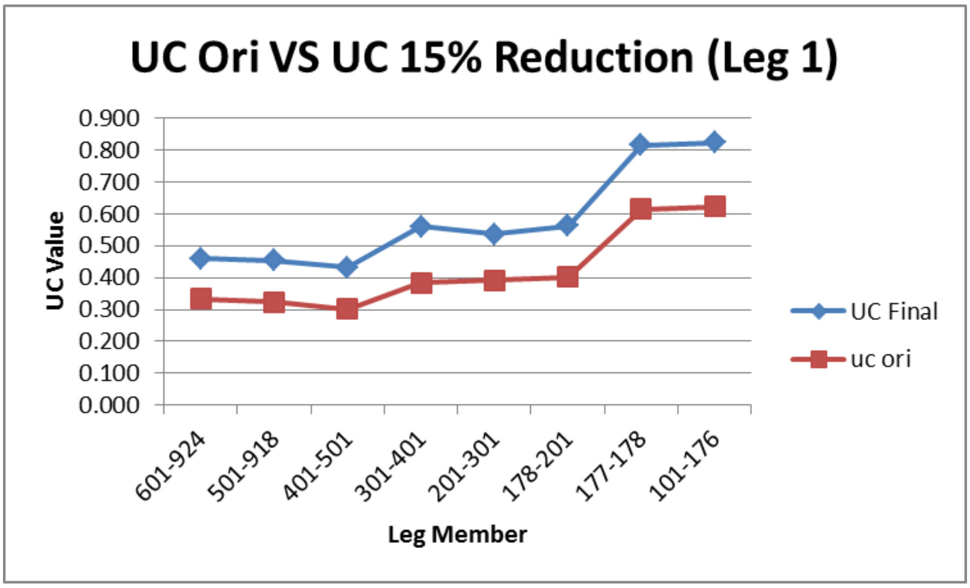


Figure 4.3.2: UC Leg 1 F9JT-A18

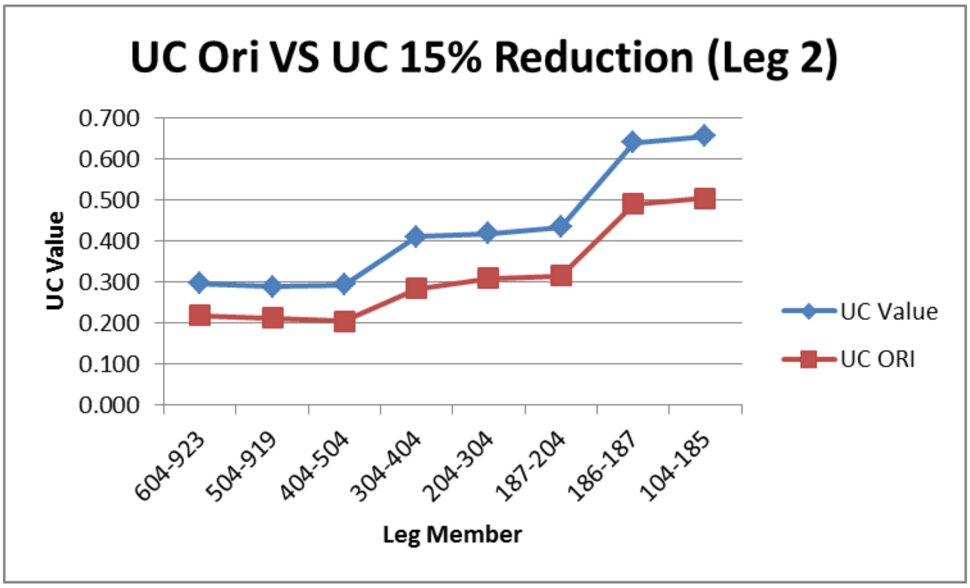


Figure 4.3.2: UC Leg 2 F9JT-A18

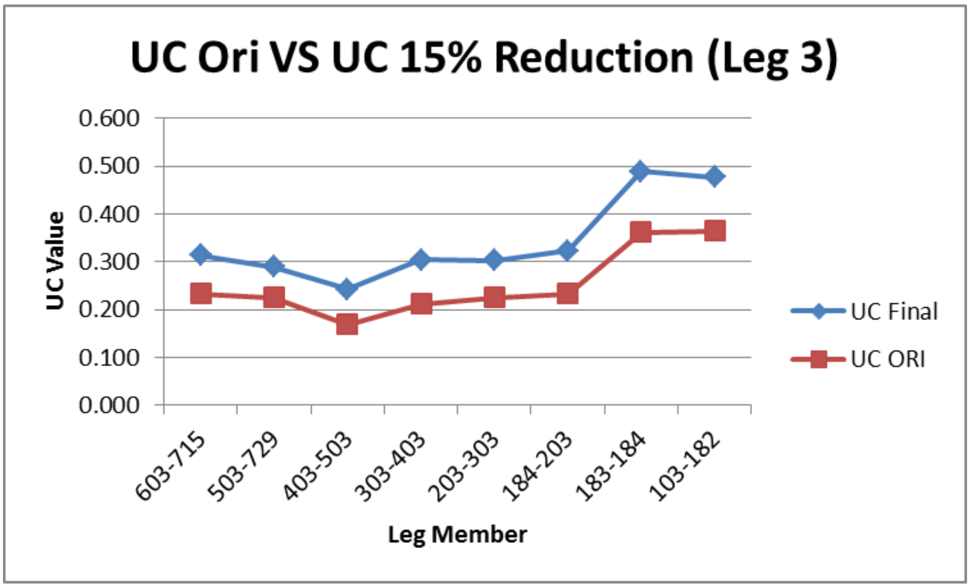


Figure 4.3.3: UC Leg 3 F9JT-A18

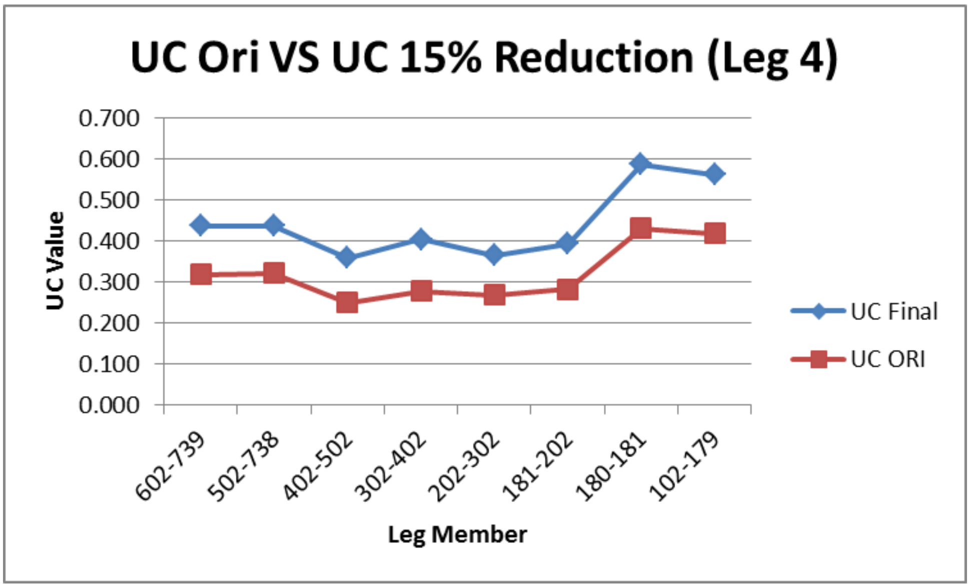


Figure 4.3.4: UC Leg 4 F9JT-A18

For this platform, based on the UC on the several selected members it shows the gradual increment for each members. As plotted on the graph, the UC is increasing from left side to right. The member at right is located on the lower segment of the leg. This indicates that the lower member carry more loads that is transferred from the topside down to the bottom.

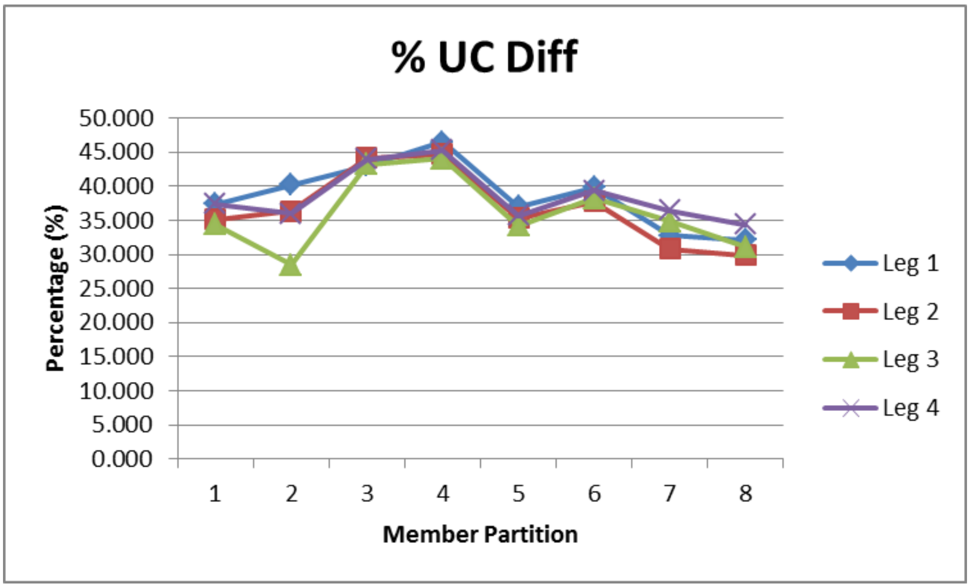


Figure 4.3.5: UC Difference F9JT-A18 Platform

Based on the figure above, it shown the percentage UC difference prior to four legs of the F9JT-A18 platform. From the graph, it shows the increment is higher at the middle member which indicates a very significant changes for the optimum member size. Most of the UC had increased to 30-40 % as the result of the reduction of the size of leg diameter.

SUPG-B

For SUPG-B platform in Sabah water, author has changed the leg and pile diameter of the platform by reducing the size to certain percentage. Author has reduced the member size up to several set of 15% and 10% of the original size whilst the D/t ratio is to keep constant.

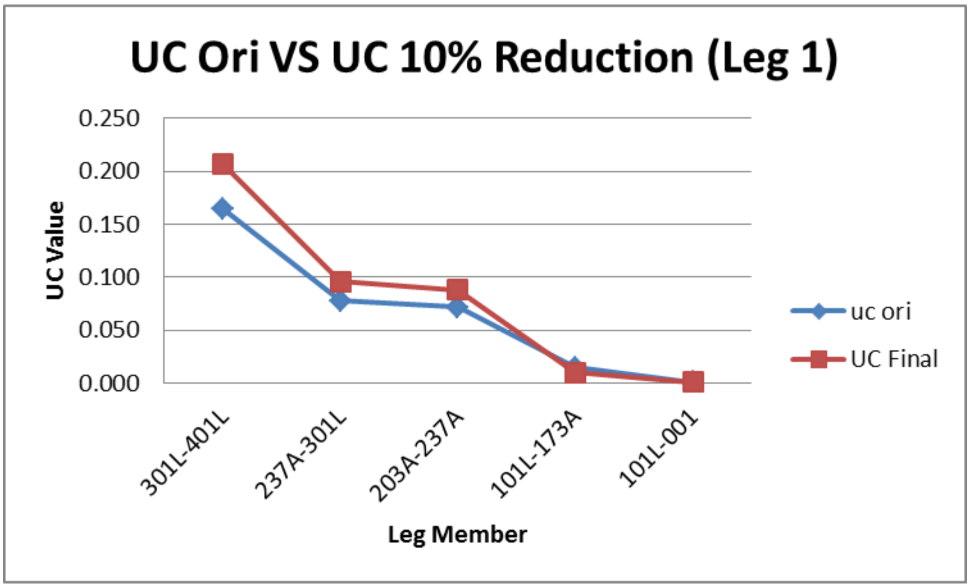


Figure 4.3.6: UC Leg 1 SUPG-B

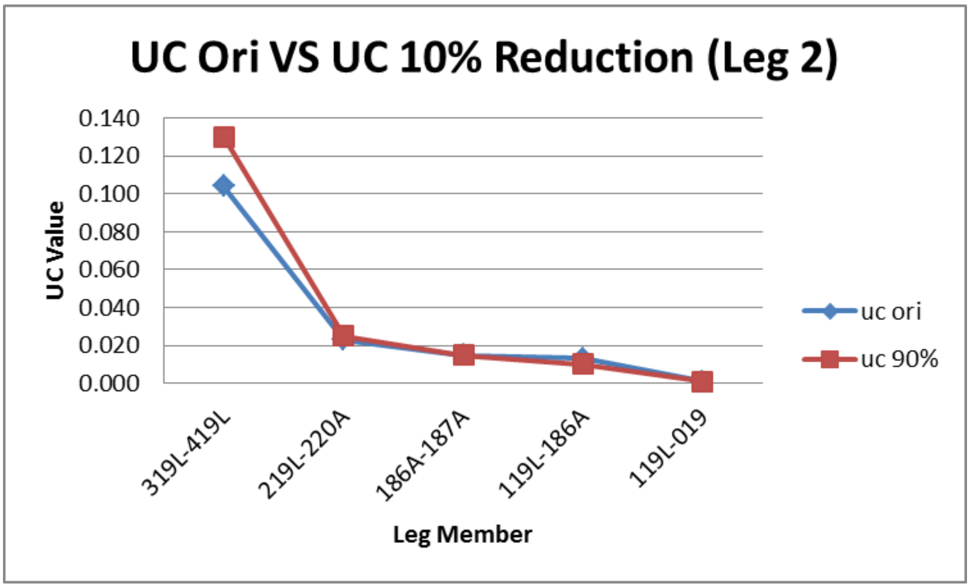


Figure 4.3.7: UC Leg 2 SUPG-B

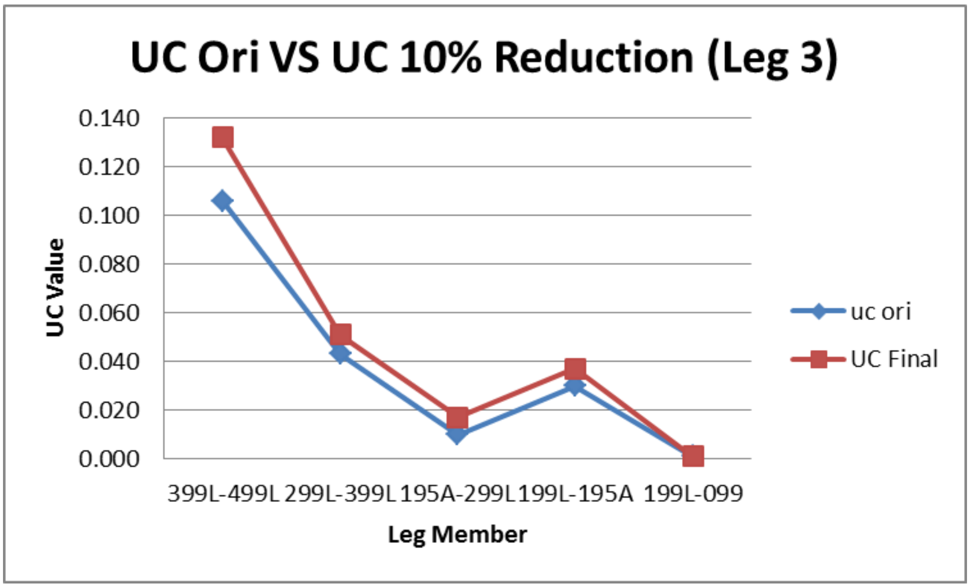


Figure 4.3.8: UC Leg 3 SUPG-B

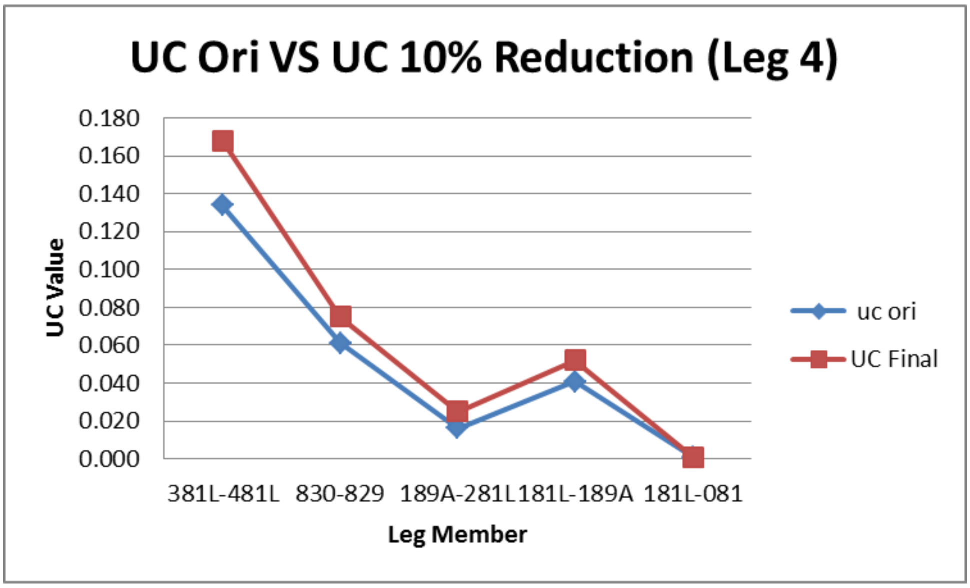


Figure 4.3.9: UC Leg 4 SUPG-B

For this platform, the original UC obtained is very low to only within 0 to 0.17. However author only manage to reduce the original size of the leg to only 10%. The final UC is increased to only 0.22. The UC is higher at pile which indicates the load from the topside is transferred to the pile. As compare this platform with two previous platform, this platform consist five modules on top of the jacket and carries more load. The member size of this platform is seen to be almost similar to the common size for the 4-legged platform. As this is 6-legged platform, it might be the reason that the size reduction is smaller than the standard 4-legged platform.

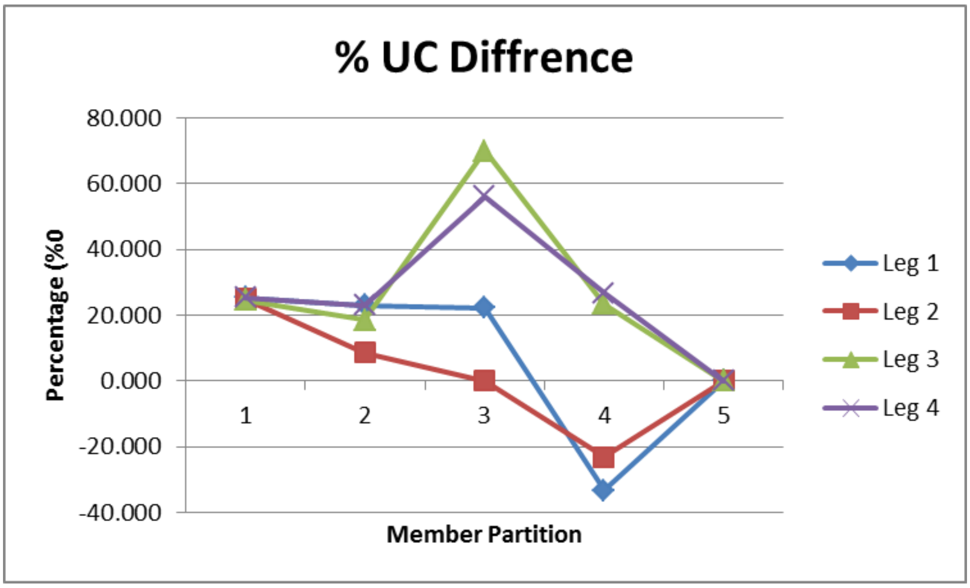


Figure 4.3.10: UC Difference SUPG-B

The graph above shows the percentage UC difference on the four selected leg. From the graph, it shows the increment is higher at the middle member which indicates a very significant changes for the optimum member size. However there are two segments that shows the final UC is lower than the initial UC. This might be due to changes in load distribution from the topside.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this study, author has select three platforms for the sample of the study. Based on the analysis conducted on these three platforms, author found out that the size of the leg platform can be reduced to certain percentage.

The final UC of the platforms are higher than the original UC in the static in-place analysis. For ABU and SUPG-B platforms, the UC is higher at the top segment of the jacket while the UC for the F9JT-A18 platform the UC is higher at the bottom of the jacket.

In this study, metocean criteria are following as what is provided in PETRONAS Technical Standars (PTS). However, the value is not much difference as these three platforms can be a new platform with less than 10 years operation and the metocean criteria already updated.

The increment in the UC for all these three platforms may indicate that the platforms are overdesign. Furthermore, these platforms was installed less than 10 years which indicate that most of the consultants still designing based on the existing platforms without thorough study on optimization of the structures.

5.2 Recommendation

The reduction in size of the members will give a concern on the reserve strength ratio (RSR) of the structures. This will caused the RSR is also reduce. The reduction in RSR will be a concern in structural integrity campaign. Lower RSR will give more risks to the structure when it is exposed to the severe load than one which analyzed in static in-place analysis.

Further study need to be carried to determine the RSR value for these platforms. The pushover collapse analysis is necessary to assess the RSR of these platforms. The RSR obtained also need to be checked with the operator like PETRONAS either it meets the minimum requirement or not.

Necessary action also need to be done by PETRONAS to do a revision on the new platform that will be design after this. For the existing platform, it may be the advantage for the operator to increase its activity on the platform.

REFERENCES

1. *https://www.iesweb.com/educational/va8/design/essentials/index.htm*. (n.d.). Retrieved June 20,2012,from https://www.iesweb.com/:https://www.iesweb.com/educational/va8/design/essentials/index.htm#Unity_Checks_

2. Jeom Kee Paik, A. K. (2003). Ultimate Limit State Design of Steel-Plated Structures. In A. K. Jeom Kee Paik, *Ultimate Limit State Design of Steel-Plated Structures* (p. 1). J.Wiley

3. H.Hsu, T. (1984). *Applied Offshore Structural Engineering.* Houston: Gulf Publishing Company.

4. Roger L. Brockenbrough, F. S. (1994). *Structural Steel Designer's Book* (3rd Edition ed.). USA: McGrawHill Inc.

5. Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms—Working Stress Design. (2000, December). *API RECOMMENDED PRACTICE 2A-WSD (RP 2A-WSD), 21st Edition*.

6. Petroleum and natural gas industries — Fixed steel offshore structures. (2007, November 3). *Petroleum and natural gas industries - Fixed steel offshore structures (ISO 19902:2007)*. British Standard,European Committe for Standardization.

7. K.Chakrabarti, S. (2005). *Handbook Of Offshore Engineering.* Illinois, USA: Elsevier.

8. Fah, E. C. (1999). *Structural Engineering Handbook.* CRC Press LLC.

9. Blake, L. (1989). *Civil Engineeer's Reference Book.* UK: Reed Educational and Professional Publishing Ltd.

10. W.F , C., & J.Y, R. (2003). *The Civil Engineering Handbook.* USA: CRC Press LLC.

11. Code of Standard Practice for Structural Steel Buildings and Bridges.(2007, March 7). Chicago, Illinois, USA: AISC.

12. Specification for Structural Steel Buildings. (2005, March 9). Chicago, Illinois, USA: AISC.

13. Arora, J. S. (2002). *Introduction to Optimum Design.* Iowa: Elsevier Academic Press.

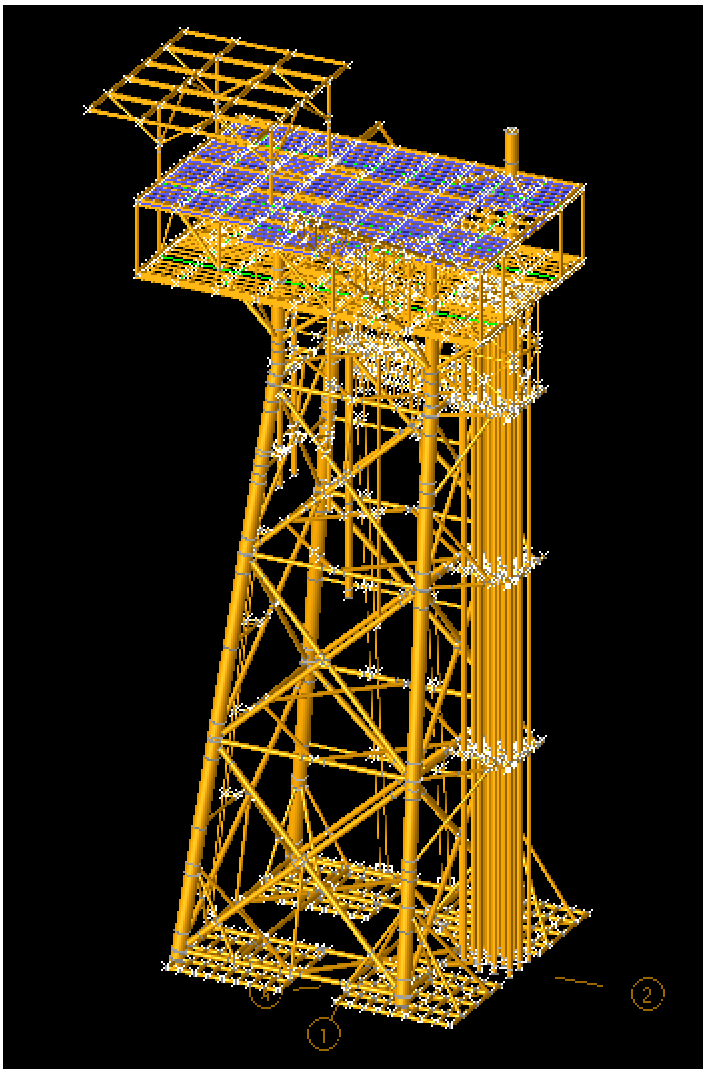
14. Azman, M. F., Dr Kurian, V., & Dr M. Shahir , L. (2011). Environmental Load Modeling for Offshore Malaysia. *2011 IEEE Symposium on Business, Engineering and Industrial Applications (ISBEIA)*,. Langkawi, Malaysia.

APPENDICES

Activities/Gantt Chart and Milestone

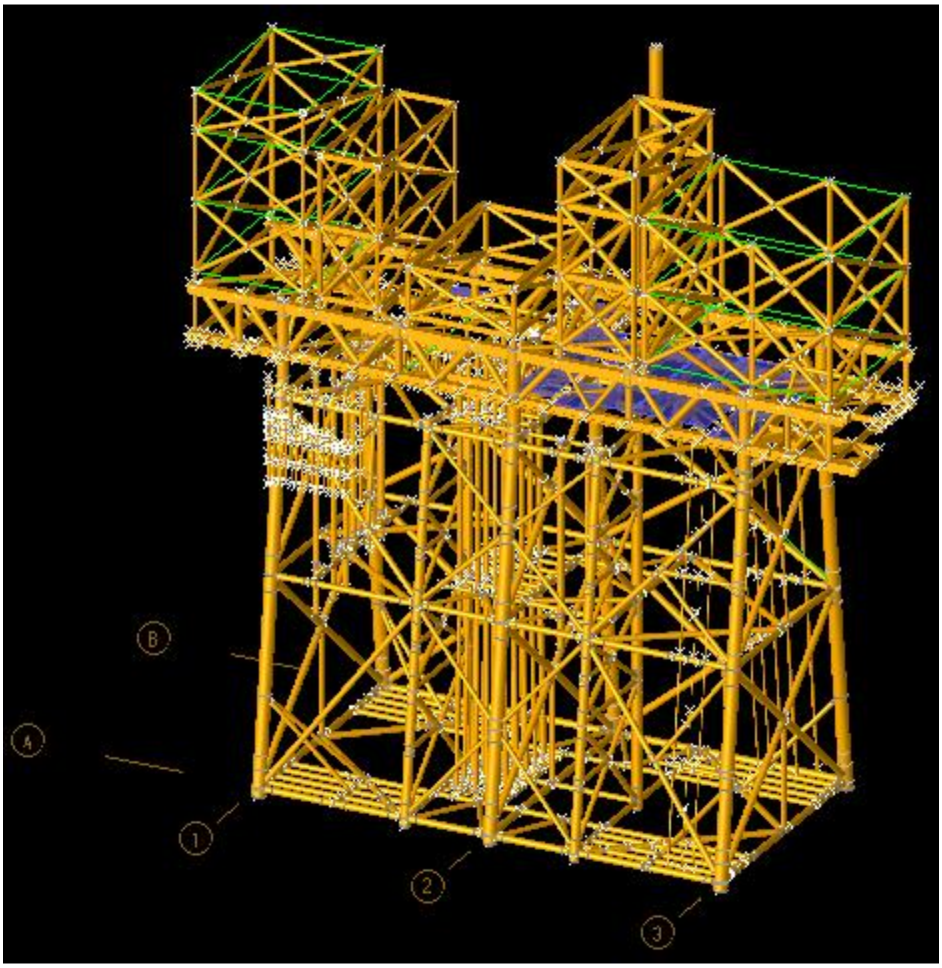
Table 1: Gantt chart and Key Milestone

No	Detail/Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continue															
2	Submission of Progress Report															
3	Pre EDX															
4	Submission of Draft Report															
5	Submission of Dissertation (Soft Bound)															
6	Submission of Technical Paper															
7	Oral Presentation															
8	Submission of Project Dissertation (Hard Bound)															

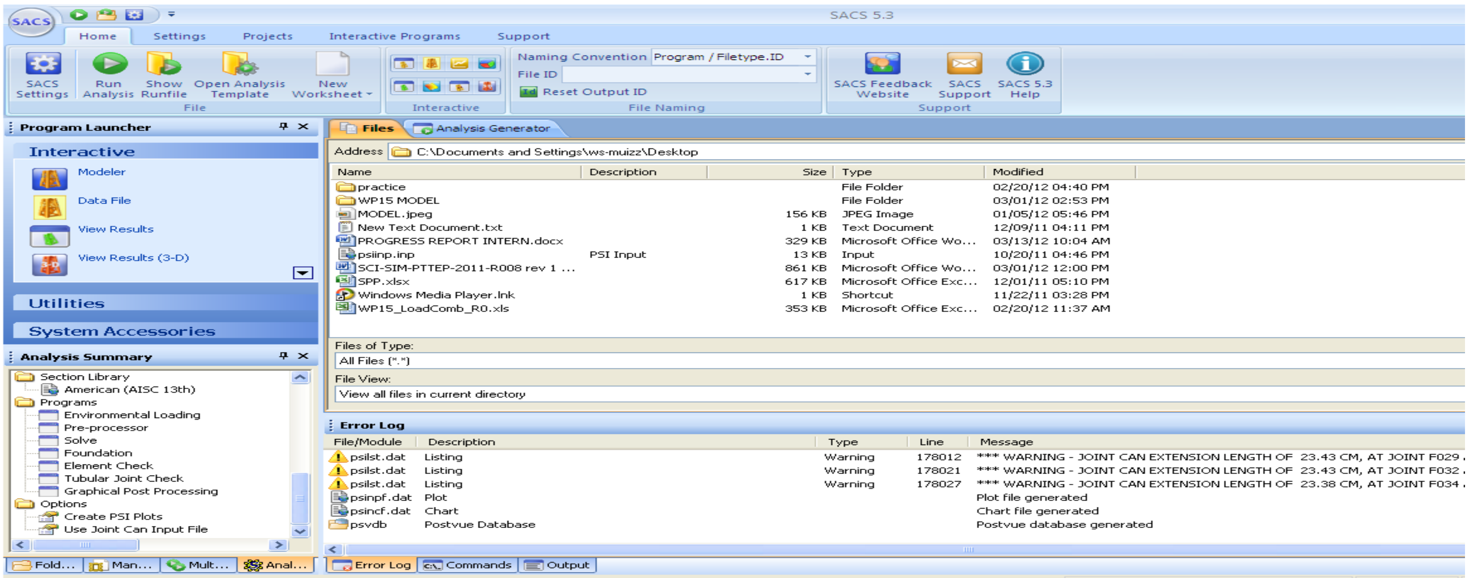


ABU Platform Model

F9JT-A18 Platform Model



SUPG-B Platform Model



SACS Interface

1.1 Peninsular Malaysia Operation (PMO) (Water depth 70m)
(Note: The criteria in table below is considered as the extreme among all the sites in PMO)

Parameters	Units	Operating Criteria	100-year Storm Event
WIND			
1-min mean	m/s	*20*	*29*
3-sec Gust	m/s	*22*	*33*

WAVE [1]			
H_s	m	*4.38* [1]	*5.77*
T_z	sec	*6.91*	*8.06*
T_p	sec	*9.74*	*11.37*
H_{max}	m	*8.44*	*11.65*
T_{ass}	sec	*8.38*	*9.64*

OCEAN CURRENT			
At Surface	m/s	*1.24*	*1.67*
At Mid-depth 0.5*D	m/s	*0.98*	*1.33*
At near seabed 0.01*D	m/s	*0.27*	*0.36*

Metocean Data used for ABU Platform

1.4 Samarang (Water depth 50m)

Parameters	Units	Operating Criteria	100-year Storm Event
WIND			
10-sec mean	m/s	*21*	*36*
3-sec Gust	m/s	*24*	*40*

WAVE			
H_s	m	*3.7*	*5.6*
T_z	sec	*7.2*	*8.4*
T_p	sec	*10.1*	*11.9*
H_{max}	m	*6.9*	*10.8*
T_{ass}	sec	*9.4*	*11*

OCEAN CURRENT			
At Surface	m/s	*1*	*1.3*
At Mid-depth 0.5*D	m/s	*0.9*	*1.1*
At near seabed 0.01*D	m/s	*0.5*	*0.7*

Metocean Data used for SUPG-B