DETERMINATION OF RESERVE STRENGTH RATIO FOR AN EXISTING JACKET PLATFORM

By

Graham Tan Ban Hock

A project dissertation submitted to the
Civil Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
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CERTIFICATION OF APPROVAL

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Approved by,

____

(Prof. Dr. Kurian V. John)

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 reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

____

(GRAHAM TAN BAN HOCK)

ACKNOWLEDGEMENT

Foremost, I would like to express my sincere gratitude to my supervisor Prof. Dr. Kurian V. John for the continuous support of my final year project, for his patience, motivation, and immense knowledge.

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Last but not least, I would like to thank my family: parents and two sisters who have provided the much needed moral support to pull through not only this final year project but the ups and downs of university life.

ABSTRACT

Structural Analysis Computer System (SACS) software was used to model and carry out pushover analyses to determine whether an existing jacket platform is fit for continued usage. Through different combinations of dead loads, live loads, and storm wave and current directions, an RSR as low as 2.64 and as high as 4.00 was obtained. This variance of results showed the effects different live loads, and storm wave and current directions had on the RSR of a jacket platform. According to API RP-2A, a high consequence platform is required to have an RSR of at least 1.6. Hence the platform is deemed to be fit for continued usage.

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CHAPTER 1: INTRODUCTION

1.1. Background of Project

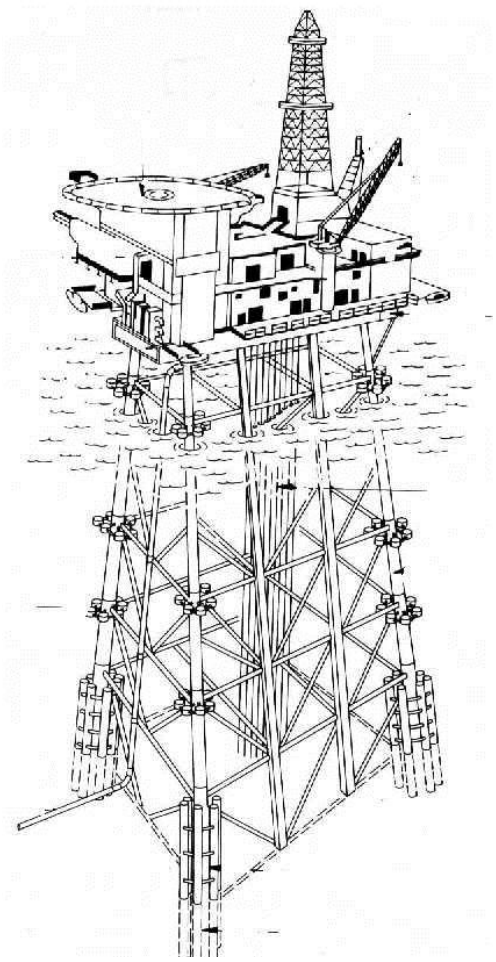

Figure 1: Example of a jacket platform

Jacket platforms have been around for a long time and is the most commonly installed offshore installation. The usual design lifespan of a jacket platform is anything between 30-40 years. Nevertheless, operations tend to last longer than initially planned causing the need to use jacket platforms even after the design lifespan has been exceeded. One such jacket platform is the F9JT platform that will be discussed in the following section.

Removing and replacing an old jacket platform with a new one will cost millions of dollars as well as months or even years of operation stoppage. By determining the reserve strength ratio (RSR) of a jacket platform its reliability for extended use can be determined.

In recent years, with the advancement of technology and the birth of powerful computers, pushover analyses of structures have been made possible. A pushover analysis is a non-linear analysis that will be able to determine the ultimate strength of a jacket platform. Once this ultimate strength is determined, the RSR of the jacket platform can then be determined by comparing the collapse strength to the design strength.

1.1.1 Platform Description

The F9JT platform is 4 pile leg oil producing platform found in the Kumang Cluster. The Kumang cluster is found off the coast of Bintulu, Sarawak with a water depth of 94.6m.

1.2. Problem Statement

Jacket platforms are offshore platforms that are required to withstand wind, wave, and currents. Being an offshore platform, it is first fabricated onshore before being transported out to sea. Once installed offshore, a jacket platform in usually expected to be in service for about 20-30 years.

Technological advances today have created the need for jacket platforms to continue production even after its design life. Similar to an onshore building, it is only reasonable to continue using the same platform as long as possible. By using the same platform as compared to using a new platform, cost and time can be saved. To do so, the structural integrity and reliability of the jacket platform must first be determined.

Jacket platforms are designed to withstand different loadings. It is important to note that these loadings do occur all at once. Hence it is vital to understand the significance of different load combinations to be able to determine the load combination that will produce the most significant Reserve Strength Ratio (RSR).

As a summary, the following are the problem statements that have been used as a basis for this project:

i) Necessity to determine the structural integrity and reliability of a jacket platform in terms of Reserve Strength Ratio (RSR) for qualification of reuse.
ii) Determination of the most significant load combinations to be used in determining the RSR of a jacket platform.

1.3. Objective and Scope of Study

The project looked into the determination of reserve strength ratio(RSR) of a jacket platform. The RSR determination was done using a pushover analysis. The Structural Analysis Computer System (SACS) was used to carry out the pushover analysis.

Based on the two problem statements aforementioned, two objectives were derived for this project and are as follows:

1) To determine the reserve strength ratio of an existing jacket platform using pushover analysis
2) To illustrate the significance of varying load combinations (Live Loads and Storm Directions) on RSR values.

1.4. Relevancy of Project

By being able to determine the reserve strength ration (RSR) of a jacket platform, its structural reliability can be determined to determine whether the jacket platform can be used after its design life is due.

Due to the nature of design codes which are conservative, most of the times jacket platforms are deemed safe for extended use. Nevertheless, if the pushover analysis yields results that deem the jacket platform unsafe for extended use minor structural reinforcements can be done as a pushover analysis pin points the weak points of a structure.

The project is highly beneficial to oil and gas companies all over the world as it provides an alternative to replacement of jacket platforms saving millions of dollars and time.

1.5. Feasibility of the project within the scope and time frame.

The project carried was divided into two sections which are Final Year Project 1 (FYP1) and Final Year Project 2 (FYP2). The first section was on finding, collecting, and reading of journals, technical papers, and books on the research topic to develop an understanding of the subject matter.

In the second section, the actual analysis work was carried out. This included the mastery of the SACS program as well as numerous analysis runs on the F9JT jacket platform. The project proved to be very feasible and was completed within the time frame given

Chapter 2: Literature Review

The following literature review has been done through the reading of journal papers, books, internet articles, etc.

2.1 Introduction to Jacket Platforms

There are over 9000 offshore installations all over the world (N, Mandal, B, & Rao, 2010). Malaysia's advancement in recent years in the oil and gas industry has led to the installation of about a total of 200 offshore platforms in Malaysia with 90 exceeding their design life (Potty & Akram, 2009). The following figure shows the example of a jacket platform.

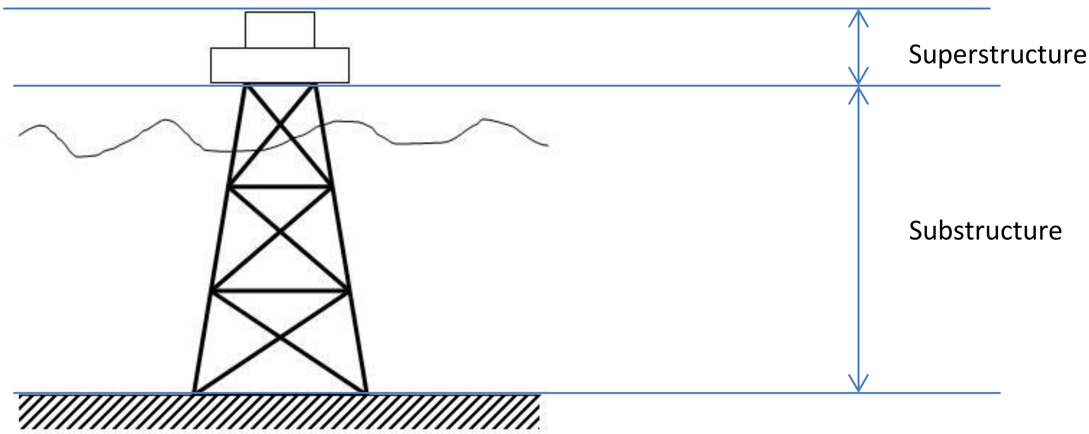

Figure 2: Two major segments of a jacket platform

Jacket platforms are divided into two major segments; substructure and topside. As topside members are assumed to fail before the substructure, only the substructure was taken into account for all analysis carried out in this project.

2.1.1 Jacket Substructure

The name ‘jacket’ for jacket platforms has actually been chosen due to the functions of its substructure or better known as the jacket legs. The jacket legs create an enclosure that will protect pipelines and risers from unwanted contact with incoming objects or life forms. As the legs of the platform are hollow, they form a template to aid pile driving during installation of the platform. Within the main legs of the jacket bracings can be found. These bracings cater for load paths as well as structure redundancy.

2.1.1.1 Jacket Bracings

Over the years numerous forms of bracings have been used based on capacities as well as physical restraints such as member sizes. The four more common bracings used are as follows:

i) Diagonal bracing
ii) K Bracing
iii) Diamond Bracing
iv) X-Bracing

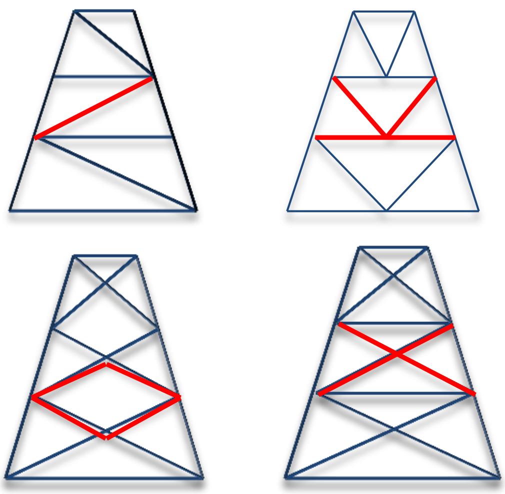

Figure 3: Jacket leg bracings

The two more commonly used bracings are the K-bracing and the X-bracing. X-bracing compared to k-bracing performs better: reserve strength and residual behavior (Stewart et. Al, 1993). Although the X-bracing requires the use of more members, it can take higher accidental loads.

2.2 Jacket Life cycle

Similar to any structure, the jacket platform has a life cycle. From the point of inception to the point of decommissioning, much thought has to be put into determining the numerous stages of a jacket's life cycle. The following diagram summarizes the life cycle of a jacket platform.

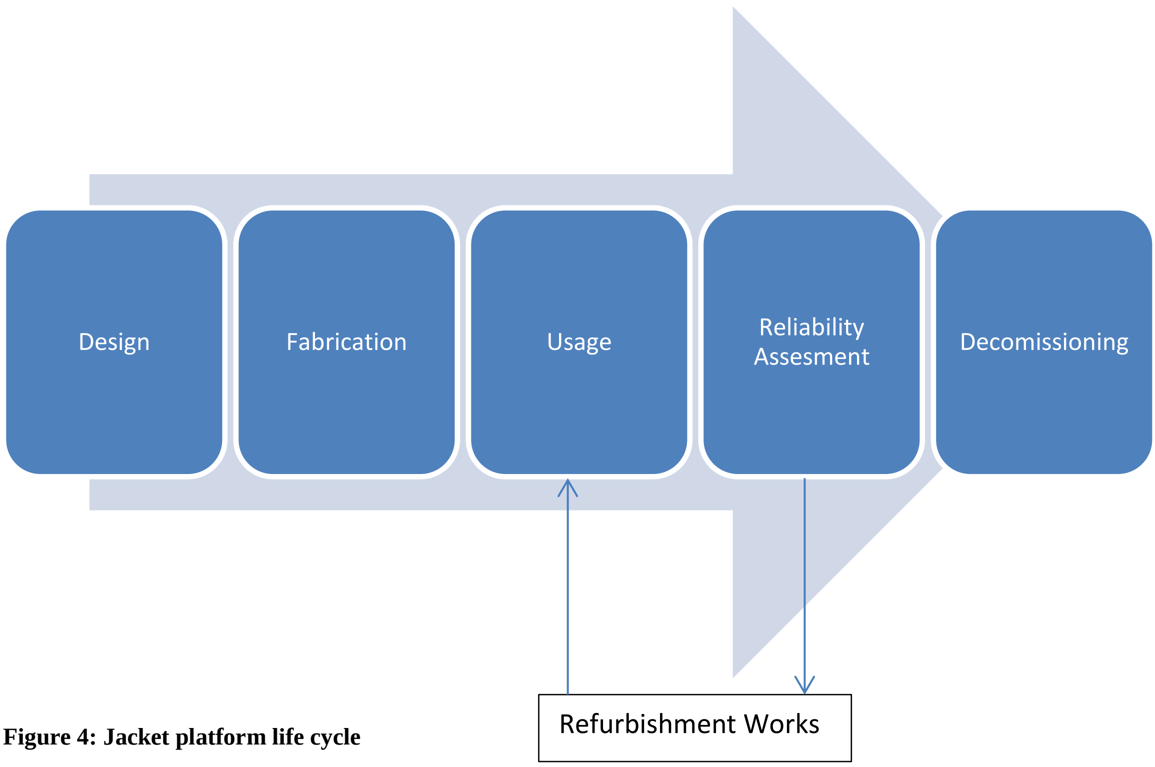

Figure 4: Jacket platform life cycle

Although jacket platforms are designed for a certain number of years, operations sometimes do exceed this design life creating a need for continuous usage of the platform. To fulfil this requirement of extended usage or reuse of the jacket platform, it can be removed, transported, upgraded, or reinstalled (API-RP 2A, 2000). Hence, the possible break in the life cycle at the stage of reliability assessment before the decommissioning stage. If a structure is deemed safe for continued usage or reuse at another site then it can undergo simple repairs and refurbishment works before continued usage takes place.

2.3 Reserve Strength Ratio

Designs of jacket platforms are done based on pre-existing industrial codes. These codes are generalised for design based on regions of operations and are conservative. Hence, it is not always necessary that a jacket platform can no longer be used once it has exceeded its design life. Through the ultimate strength analysis of a jacket platform, its capacity can be determined (Asgarian & Lesani, 2008).

The study on Reserve strength ratio was initiated by Llyod and Clawson (1984) discussed the sources of reserve and residual strength of ‘frame behaviour. Marshall (1979) and Bea (1976) ijdemonstrated reserve safety factor in numerous structures. Kallaby and Millman (1975) studied the inelastic capacity of the Maui jacket platform under earthquake loading. In depth researches were then carried out over the years until Bolt et. Al (1996) finally suggested the formula that tied the ultimate strength and design strength of a platform to its reserve strength ratio. The formula is as follows:

$$RSR = \frac{Ultimate\ Strength}{Design\ Strength}$$

Today this RSR is used to represent the reliability of a jacket platform for continuous usage or even reuse.

2.3.1 Determination of Ultimate Strength

Determination of the ultimate strength of a jacket platform can be done through linear and non-linear analysis. The most common linear analysis carried out to determine the ultimate strength of jacket platforms is the linear finite analysis. Although linear finite analysis allows for super-positioning of loads as well as resulting stresses, non-linear affects are accounted for using magnification factors that lead to over conservative figures. Non-linear analysis however takes into account the effects of material plasticity and large deflections directly into the analysis. One such non-linear analysis tool is the pushover analysis.

Non-linear pushover analysis is widely used as an analytical tool to evaluate the structural behaviour of not only jacket platforms but any forms of structures in the inelastic range and to identify the weakest points of the structure as well as the failure mechanisms (Kappos, Paraskeva, & Sekstos, 2011). According to Krawinkler and Seneviratna (1998), pushover analysis is to represent a structure in two or three dimensional models that account for all important linear and non-linear characteristics, apply incremental loads until a target displacement or failure is achieved. The following diagram shows a simple illustration of a pushover analysis carried out on a two dimensional frame.
The jacket platform is pushed till a desired displacement is obtained. The following figure details the different segments of the plotted graph.

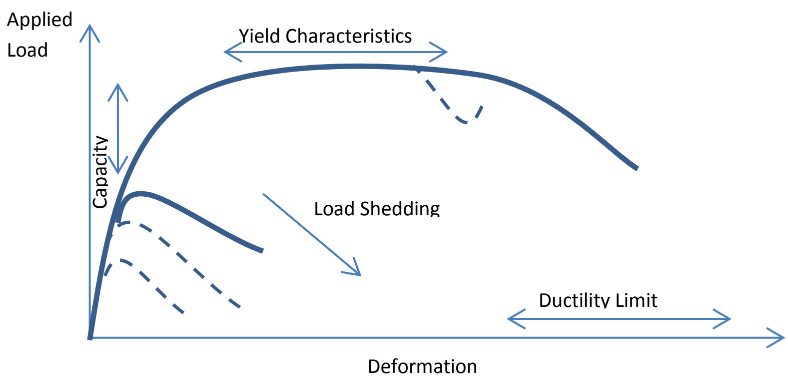

Figure 5: Description of non-linear curve components (Ultiguide, 1999)

The graph of load applied against deformation above shows the four main results desired from a pushover analysis which are:

1) Capacity
2) Yield Characteristic
3) Load Shedding
4) Ductility Limit

Once the capacity is known, the RSR of the jacket platform will be known as well.

Non-linear pushover analysis has been chosen to determine the ultimate strength of jacket platforms due to the following reasons as stated by Krawinkler and Seneviratna (1998):

1) Carefully performed pushover analysis provides insight into structural aspects that control structural performance.
2) Pushover analysis exposes weaknesses that may remain hidden in an elastic analysis.
3) Pushover analysis gives more accurate results compared to more conservative linear analysis.

CHAPTER 3: METHODOLOGY

Pushover analysis is used very commonly in determining the ultimate strength and ultimately the reserve strength ratio of a jacket platform. For the purpose of this project, Structural Analysis Computer System (SACS) software will be used and the following sections will be discussing about the pushover analysis with respect to SACS.

3.1 Modelling

Modelling in the SACS software is similar to many other software such as AutoCAD software or CATIA software. Users are allowed to model either in the two dimensional mode or the three dimensional mode.

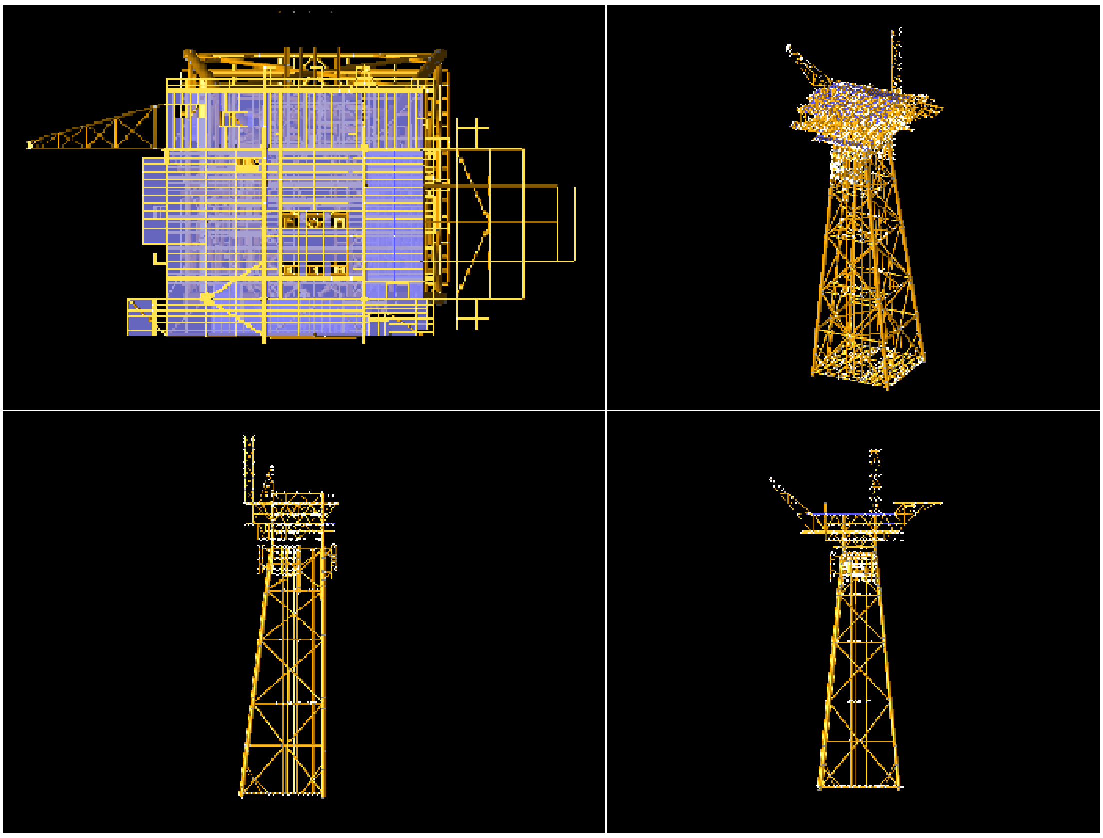

Figure 6: A finished SACS model of the F9JT platform

3.1.1 Modelling requirements

A standard SACS input file can be used for the modelling part. As this is true, ready-made models of existing platforms were used. This model is done by PETRONAS and contains all of the design loads (dead load, live load, wave and current). Nevertheless, certain precautions need to be taken during the modelling stages. The non-linear or indicated by 'NL' analysis type option must be specified in the model options line to enable the non-linear pushover analysis to be carried out.

3.1.2 Load Combinations

All load cases which are specified as part of a load step in the nonlinear plastic collapse analysis must be basic load conditions. However, because a load sequence may consist of numerous load conditions, any combination of basic load cases can be applied sequentially as part of the load sequence.

It is important to note however, that load combinations are accounted for in the Collapse input file by a load sequence consisting of basic load cases that define the combination applied sequentially. Alternatively, load combinations may be converted into basic load cases using the ‘Seastate program prior to execution of the Collapse Analysis.

For this project, load combinations are pulled from the SACS input file obtained from PETRONAS. In this input file were 9 live loads and 8 storm directions. As one of the objectives of the project is to illustrate the significance of carrying the load combinations, these live loads and storm directions have been paired to find the load combination that gave the most significant RSR value.

3.1.2.1 Live Load Lists

The following tables show the live loads used for the project and their components.

i) Live Load 1

No.	Load
6	Area Live Load
13	Piping & Equipment Operation Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
26	Storm Reacting @well #0145
37	Upward LL
42	Vent Boom Operation Wind +X-Direction
51	Rig @#0145 Operation Wind X-Direction

Table 1: Live Load 1 Component

ii) Live Load 2

No.	Load
2A	Jacket Appurtenance Submerged Weight
3A	Jacket Post Installed Appurtenance Submerged Weight
11A	Future Piping & Equipment Dry Weight
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
16	
18A	Riser/J-Tube Submerged Weight
27	Storm Rig Reaction Well @#0150
37	Upward Liveload -10 KN/MM2 @ Well #100/120
42	Vent Boom Operating Wind + X-Direction
43	Vent Boom Operating Wind + Y-Direction
52	Rig @#0150 Operating Wind X-Dir
61	Rig @#0150 Operating Wind Y-Dir
63	Storm Wave & Current Direction 45 Degree
95	Inertia Storm Wave & Current Direction 90 Degree
101	Helicopter Dead Load

Table 2:Live Load 2 Component

iii) Live Load 3

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
24	Storm Rig Reaction Well @#0130
37	Upward Liveload -10 KN/MM2 @ Well #100/120
58	Rig @#0130 Operating Wind Y-Dir

Table 3: Live Load 3 Component

iv) Live Load 4

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
21	Storm Rig Reaction Well @#0110
37	Upward Liveload -10 KN/MM2 @ Well #100/120
42	Vent Boom Operating Wind + X-Direction
43	Vent Boom Operating Wind + Y-Direction
46	Rig @#0110 Operating Wind X-Direction
55	Rig @#0110 Operating Wind Y-Dir

Table 4: Live Load 4 Component

v) Live Load 5

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
20	Storm Rig Reaction Well @#0105
37	Upward Liveload -10 KN/MM2 @ Well #100/120
42	Vent Boom Operating Wind + X-Direction

Table 5:Live Load 5 Component

vi) Live Load 6

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
19	Storm Rig Reaction Well @#0100
37	Upward Liveload -10 KN/MM2 @ Well #100/120
42	Vent Boom Operating Wind + X-Direction
43	Vent Boom Operating Wind + Y-Direction
44	Rig @#0100 Operating Wind X-Direction
53	Rig @#0100 Operating Wind Y-Dir

Table 6: Live Load 6 Component

vii) Live Load 7

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
22	Storm Rig Reaction Well @#0120
37	Upward Liveload -10 KN/MM2 @ Well #100/120
43	Vent Boom Operating Wind + Y-Direction
56	Rig @#0120 Operating Wind Y-Dir

Table 7: Live Load 7 Component

viii) Live Load 8

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
23	Storm Rig Reaction Well @#0125
37	Upward Liveload -10 KN/MM2 @ Well #100/120
43	Vent Boom Operating Wind + Y-Direction
57	Rig @#0125 Operating Wind Y-Dir

Table 8: Live Load 8 Component

ix) Live Load 9

No.	Load
6	Area Live Load
13	Pipings & Equipment Operating Weight
13A	Future Piping & Equipment Operating Weight
14	Electrical & Instrumental Operating Weight
25	Storm Rig Reaction Well @#0140
37	Upward Liveload -10 KN/MM2 @ Well #100/120
42	Vent Boom Operating Wind + X-Direction
43	Vent Boom Operating Wind + Y-Direction
50	Rig @#0140 Operating Wind X-Dir
59	Rig @#0140 Operating Wind Y-Dir

Table 9: Live Load 9 Component

3.1.2.2 Storm Directions Load List

The following tables details the loads used for the 8 different storm directions.

i) 0 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
62	Storm Wave & Current Direction 0 Degree
94	Inertia Storm Wave & Current Direction 0 Degree

Table 10: 0 Degree Storm Direction Components

ii) 45 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
41	Topside Operating Wind +Y-Direction
63	Storm Wave & Current Direction 45 Degree
94	Inertia Storm Wave & Current Direction 0 Degree
95	Inertia Storm Wave & Current Direction 90 Degree

Table 11: 45 Degree Storm Direction Components

iii) 90 Degree Storm

No.	Load
41	Topside Operating Wind +Y-Direction
43	Vent Boom Operating Wind + Y-Direction
64	Storm Wave & Current Direction 90 Degree

Table 12: 90 Degree Storm Direction Components

iv) 135 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
41	Topside Operating Wind +Y-Direction
65	Storm Wave & Current Direction 135 Degree
95	Inertia Storm Wave & Current Direction 90 Degree
96	Inertia Storm Wave & Current Direction 180 Degree

Table 13: 135 Degree Storm Direction Components

v) 180 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
66	Storm Wave & Current Direction 180 Degree
96	Inertia Storm Wave & Current Direction 180 Degree

Table 14: 180 Degree Storm Direction Components

vi) 225 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
41	Topside Operating Wind +Y-Direction
96	Inertia Storm Wave & Current Direction 180 Degree
97	Inertia Storm Wave & Current Direction 270 Degree
67	Storm Wave & Current Direction 225 Degree

Table 15: 225 Degree Storm Direction Components

vii) 270 Degree Storm

No.	Load
41	Topside Operating Wind +Y-Direction
68	Storm Wave & Current Direction 270 Degree
97	Inertia Storm Wave & Current Direction 270 Degree

Table 16: 270 Degree Storm Direction Components

viii) 315 Degree Storm

No.	Load
40	Topside Operating Wind +X-Direction
41	Topside Operating Wind +Y-Direction
97	Inertia Storm Wave & Current Direction 270 Degree
69	Storm Wave & Current Direction 315 Degree

Table 17: 315 Degree Storm Direction Components

3.1.3 Miscellaneous Inputs

The aim of the modelling phase is to create a model that is nearly of not totally identical to the actual platform itself. Hence, there's much information that needs to be input during modelling. Such inputs can be done manually or via the modelling wizard. Such inputs include but are not limited to:

i) Joint flexibility
ii) Member local buckling
iii) Pile plasticity
iv) Strain hardening
v) Collapse critical displacement

3.2 Collapse File

To run the pushover analysis, a collapse file is required in addition to the model file. The picture below is a sample of the collapse file.

```
CLPOPT      20  8 20         CN  LB  PP            SF2U   0.1 0.001 0.01      0.002
CLPOP2   0.25   20.0
CLPRPT P1R1M1       SMMSPW
LDSEQ AAA            DL       5   0.0     1.LL01    5  0.0    1.0 ST02  25    0.0    5 .
GRPELA              1A1 1A2 1A3 1A4 1A6 1A7 1A8 1A9 1AH 1B1 1B2 1B3 1B5 1B6 1B7
GRPELA              2A4 3A3 3A4 3A6 3A7 3A8 3A9 4A1 4A2 4A3 4A4 4A5 4A6 4A7 4A8
GRPELA              4A9 5A5 BL1 BL2 BL3 BL4 BL5 BL6 BL7 BSS BST C1A C1C C1G C1L
GRPELA              C2D C3G C4G C5G CON CRB CRC CRA CRN CS1 CT1 D1A D1B D1C D1G
GRPELA              D1H D1I D1J D1K D1L D1M D1P D1R D1S D2A D2B D2G DL1 DL2 DL3
GRPELA              DL4 FAA FAB FAC FAD FAE FAG JST JT1 JT2 P1B P1C P1D P2A P2B
GRPELA              P2C P2D P2E P2F P2G P2F P2J P3D P4A P4B P4C P4E P4G P4H P4I
GRPELA              P4J P4L P4M P4N P5G P5H P6G P6J RG1 RG2 RG3 RGS RGT RS1 RS2
GRPELA              RS3 RS4 RT1 RT2 RT3 RT4 T11 T13 T14 T22 TG5 TH5 TV5 TV6
END
```

Figure 7: Sample Collapse Input File

In this collapse input file certain criteria has been set based on the first two lines in the image above with the most left colum showing "CLPOPT". The following are some of the important criteria set:

1) Maximum of 20 iterations per load limit
2) Total of 8 member segments
3) Maximum of 20 iterations per member segment
4) Inclusion of buckling effects
5) Inclusion of pile plasticity

The load combinations selected are based on those found in the input (design) file and are shown in the collapse input file as DL (dead load), LL01 (Live load 1) and ST02 (Storm Condition 2).

3.3 Output

Once the analysis has been run, a very detailed report is be generated in a short period of time. The outputs of the analyses run are shown and discussed in Chapter 4

3.4 Project Activities

The following Gantt Chart details the project activities for both FYP1 and FYP2.

Project Activities Week	**S1**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Developing a clear understanding of pushover analysis and its significance regarding structural integrity and reliability - Reading various literature sources - Meeting with supervisor and post-graduate students to obtain verification of materials read																
Basic exposure on SACS																
Further in depth learning on SACS and the pushover analysis - Read various related literature - Obtainment of various jacket models - Obtainment of help from supervisor and post-graduate students to help with understanding					**M1**											
Pushover analysis on jacket models - Generate collapse input files - Identification of loading combinations - Running of the pushover analysis - Determination of Reserve strength ratio of jacket platform							**M2**									
Progress Report - Preparation and submission of progress report									**M3**							
Further analysis - More analysis runs to be carried out - Reading of more specific literature to verify and enhance results													**M4**			
Final Report - Preparation and submission of draft report - Submission of final report															**M5**	
VIVA																

NOTE: Legend to be found on following page

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Results

The pushover analysis for the project was run with multiple load combinations. A first run was done using the Strom Direction of 45 degrees and live load 1. This was followed by variations of all live loads.

Load	Design		1st Member Failure		RSR
	Load Step	Base Shear	Load Step	Base Shear	
LL01 ST02	15	9359.15	29	35104.66	3.75
LL02 ST02	15	9352.35	29	35097.72	3.75
LL03 ST02	15	9341.36	29	35087.91	3.76
LL04 ST02	15	9234.18	29	35008.66	3.79
LL05 ST02	15	9194.03	29	34940.97	3.80
LL06 ST02	15	8933.38	29	34680.22	3.88
LL07 ST02	15	9185.56	29	34936.75	3.80
LL08 ST02	15	9056.58	29	34801.95	3.84
LL09 ST02	15	9200.64	29	34943.65	3.80

Table 18: Results for Live Load Variation

Degree	Design		1st Member Failure		RSR
	Load Step	Base Shear	Load Step	Base Shear	
0	15	8180.84	24	22485.75	2.75
45	15	9359.15	29	35104.66	3.75
90	15	8798.54	30	35175.93	4.00
135	15	8895.05	26	28808.83	3.24
180	15	9137.98	23	24131.37	2.64
225	15	8733.62	29	33647.99	3.85
270	15	9007.14	25	27019.27	3.00
315	15	8976.04	25	24643.88	2.75

Table 19: Result for Storm Direction Variation

4.2 Discussion

The RSR was calculated by taking the design base shear at the load step where loads have fully developed and ultimate strength base shear at that of first member failure. This fulfills the formula mentioned earlier:

$$RSR = \frac{Ultimate\ Strength}{Design\ Strength}$$

Based on the table results it is seen that when live load combinations are varied, the change of RSR obtained at the end of the analysis has little or no significance. The difference is 0.13.

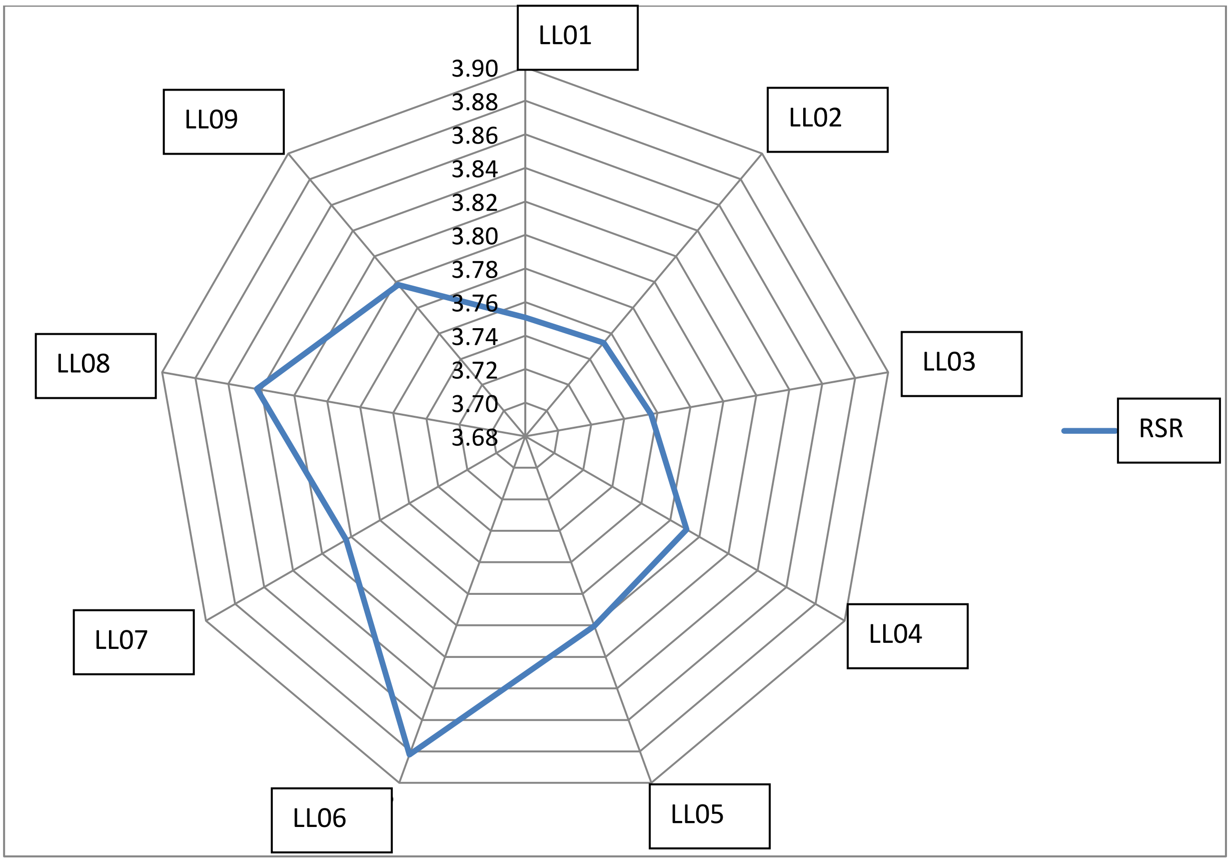

Figure 8: Radial Chart for Live Load Variation

Looking at the results where the live load combination was kept constant and the storm direction varied however, it is obvious that there is a very large difference between the final RSR values obtained. The difference is 1.21.

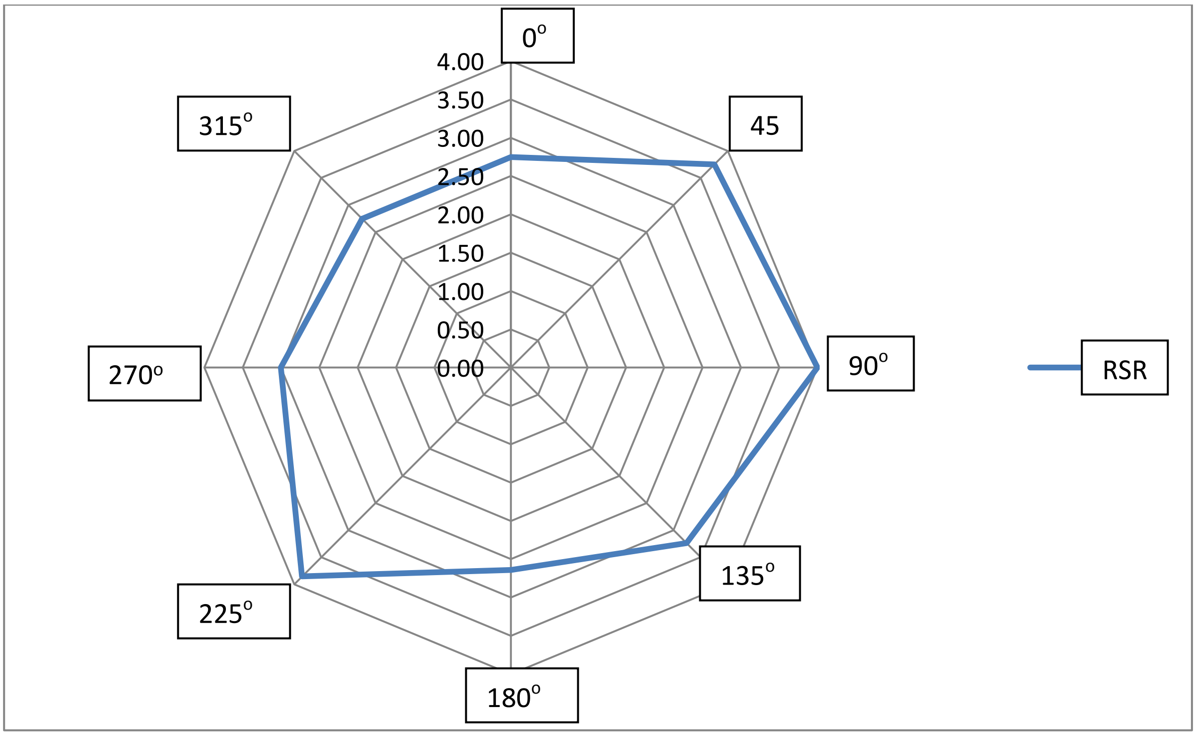

Figure 9: Radial Chart for Storm Direction Variation

The results show that storm directions have a more significant impact on final RSR values compared to that of live load variations. With this it is can be assumed that in future undertakings, the threats to a structure posed by storm directions should be addressed more urgently.

CHAPTER 5: CONCLUSION

Jacket platforms have been widely used all over the world for a number of decades now. With the prolonged usage, it is always necessary to determine the structural reliability and integrity of the jacket platform. A simple way of doing this is to determine the reserve strength ratio of the platform.

In this project, the Reserve Strength Ratio of an existing jacket platform was identified using the Structural Analysis Computer Systems (SACS) software. Models of pre-existing jacket platforms have been obtained from PETRONAS and after much consideration; the platform named F9JT was selected.

A collapse file was generated to run the loading combinations and to include exclusions of all topside member groups based on the assumption that the topside members will not fail before the jacket members or at least failure of topside members would have less impact on overall structure behaviour.

Based on the analyses run, it was found that live load combinations had not much significance on the final RSR values obtained as compared to the variation in storm directions. Hence it is important to note that fortifications should be done in the 180 degrees direction in the near future as the storm in that direction has yielded the lowest RSR value of 2.64.

In conclusion, the pushover analysis was successfully carried out and the smallest RSR value obtained is 2.64. The F9JT platform is a high consequence platform as it is an old platform that is still producing oil. According to API RP-2A WSD, all high consequence platforms are required to have an RSR of 1.6 or more. The F9JT platform has a 2.64 RSR value which means it is safe for continued usage.

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