OPTIMUM ANALYSIS OF OFFSHORE STRUCTURES LIFTING PADEYES USING FINITE ELEMNT METHOD

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To my beloved Wife, Parents, Daughter, family, lecturers and friends

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ABSTRACT

Padeye design and analysis plays an important roles during the lifting, load out and installation of heavy structures. This study addressed the different dynamic amplification factors that are adapted in the oil and gas industry based on different design codes. This study explains the impact of limiting the effective thickness of the cheek plate with respect to the main plate of the padeye and the advantages of increasing the effective thickness of the cheek plates. It also touched on the fabrication requirements to achieve the required effective thickness of the cheek plates. In addition, a sensitivity study about the impact of the out of plane force on the padeye design is addressed and the maximum out of plane angle that shall be considered is recommended. A finite element analysis using London University Structure Analysis System (LUSAS), is conducted and compared with the hand calculation. The benefits and advantage of using FE analysis is addressed in this study. At the end of this research a guideline on the design of the padeye is developed. It has been found that the dynamic amplification factor can be reduced to a lower value of 1.15 instead of 1.35. The effective thickness of the cheek plate can be increased to 100% with proper fabrication and welding sequence. Finite Element analysis is a good tool to have better analysis and design of the lifting padeyes.

ABSTRAK

Analisis dan rekabentuk *padeye* memainkan peranan yang penting semasa kerja mengangkat, memindah dan pemasangan sruktur berat. Kajian ini menumpukan kepada perbezaan faktor amplifikasi dinamik yang digunakan dalam industry minyak dan gas berdasarkan kepada piawaian rekabentuk. Kajian ini juga menerangkan kesan had ketebalan berkesan plat pipi terhadap plat utama *padeye* dan kesan terhadap kebaikan penambahan ketebalan plat pipi. Turut dikaji ialah keperluan proses penyambungan untuk mencapai ketebalan plat pipi yang diperlukan. Sebagai tambahan, kajian keberkesanan terhadap kesan tindakan daya diluar satah pada *padeye*. Perkara ini diselidiki dan pengiraan manual nilai maksimum diluar satah dipertimbangkan untuk cadangan. Analisis Kaedah Unsur Terhingga menggunakan London University Structure Analysis System (LUSAS) digunakan untuk tujuan perbandingan hasil kajian dengan nilai pengiraan manual. Kelebihan dan kebikn menggunakan kaedah unsur terhingga turut diberikan dalam kajian ini. Berdasarkan hasil perbandingan, satu rujukan panduan rekabentuk *padeye* telah dibangunkan. Hasil kajian juga mendapati bahawa nilai factor amplifikasi dinamik boleh dikurangkan kepda 1.15 berbanding 1.35. Ketebalan berkesan plat pipi pula boleh ditingkatkan sehingga 100% menggunakan aturan pemasangan dan kimpalan yang berkualiti. Secara keseluruhannya, kaedah unsur terhingga didapati amat sesuai digunakan untuk analisis dan rekabentuk pengangkat *padeye*.

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BC	-	Bearing Capacity
COG	-	Centre Of Gravity
CS	-	Total Stress
GLND	-	Global Nobel Denton
IPB	-	Inplane Bending
OPB	-	Out of Plane Bending
OSS	-	Out of Plane Shear Stress
POS	-	Pull Out Shear
PTS	-	PETRONAS Technical Standard
TLS	-	Tensile Stress
TS	-	Tension Stress
ISS	-	Inplane Shear Stress
VM	-	Von Mises Stress

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CHAPTER 1

INTRODUCTION

1.1 Background

Lifting operation is a daily activity in construction industry. It is classified into heavy lifting operation and normal lifting operation. There is no clear definition of the type of the lifting and it varies from one industry to another. In the oil and gas construction industry heavy lift is one of the most common activities knowing the size of the structures and the equipment used in this industry. Offshore structure construction is one of the most challenging construction as it is complicated structures need to be constructed onshore and then transported to be installed offshore.

The construction of the offshore structure involve daily lifting as all the structural members need to be erected and assembled to form the different type of structure. In addition majority of the equipment is preferred to be installed on the structure during the construction stage onshore. The installation of the equipment on the structure is done by lifting using onshore cranes.

The lifting of the structural members for the erection and assembly is usually done by connecting lifting slings to shackles that are connected to temporary lifting lugs or padeyes which is welded on the structural members or frames. Equipment installation is done using the same method of connecting the lifting attachments to padeye welded on the equipment itself, equipment skid beam or support frame. Safe lifting and installation of the equipment is very crucial as some of this equipment are very expensive and can easily cost up to millions dollars.

One of the methods of load out of the structures after the completion of the fabrication is by lifting. The crane hook will be attached to lifting slings that connected to shackle attached to lifting padeyes. The lifting padeyes need to be design, fabricated and inspected carefully to ensure that it is capable to carry the load of whole structure. The weight of the lifted structure including all the installed equipment may be up to few thousands metric tons.

The installation of the sub structure offshore require crane barge to perform the upending operation using slings attached to shackles and padeyes. For the super structure lifting is one of the most common method of installation offshore. Knowing the harsh environment offshore, lifting operation is one of the most challenging and critical activity offshore.

Heavy lifting operation onshore during the fabrication stage and offshore during the installation stage shall be done safely. Failure of the lifting can be catastrophic as it may result on the loss of facilities that costs billions of dollars, fatality of personnel and damaging the reputation of the contractors as well as the oil and gas operating companies.

Safe operation is the top priority in all industry especially in oil and gas industry. Hence many guidelines and specification of heavy lifting has been developed to ensure safe lifting operation. Padeye design, fabrication and integrity play very important roles to ensure safe operation. Failure of one padeye during the lifting operation may result on big disaster either offshore or onshore as it will result on the loss of the structure and fatalities; hence padeyes design is very important.

1.2 Problem statements

There is very limited published information and guideline regarding the concept of the design of the lifting padeyes. In addition, there are no clear guidelines on the analysis of the lifting padeyes.

The dynamic amplification factors considered in the design of the padeye is differ from one operator to another and does not match the dynamic amplification factor used by the installation barge. Hence the higher value of the amplification factor might govern the design of the lifting.

The orientation of the padeye is usually finalized at very later stage of the fabrication after conducting the weighing activities of the structure to confirm the location of the centre of gravity "COG". The late confirmation of the orientation of the padeye may affect or delay the load out of the structure which has big cost impact to the operator and fabricator as it might result on delay of the first hydrocarbon due to late load out and late installation of the structure.

The padyes is mostly designed to resist out of plane bending of 5% of the total lifting weight and out of plane angle of degree. Hence the orientation of the padeye is important to ensure that the out of plane bending is within the design limits. There is no clear study on whether the out of plane bending is governing the lifting padeye design or not. In addition there is no sensitivity study on the effect of the increments of the out of plane bending on the design of the lifting padeyes.

1.3 Objectives

The main objectives of this project are described as follows:

1. To determine the accurate dynamic amplification factor that needs to be considered in the design of the lifting padeyes.

2. To conduct sensitivity study on the effect of the out of plane bending moment on the design of the lifting padeye and to study the benefits of considering the actual thickness of cheek plate without limiting the thickness to 50% to 75% of the main plate thickness and the limitation on achieving this

3. To establish configuration of lifting padeyes that can be fabricated easily, economically and installed prior the weighing activity and the confirmation of the exact location of the COG

4. To provide detailed guideline about the design of the lifting padeyes.

1.4 Scope of study

This study is focusing on the design and analysis of the padeyes that used for the heavy lift operation of the topsides structure of offshore platforms. It considers the structure weight and the required capacity of the padeyes. The study is using manual calculation and FE analysis to establish proper padeye configuration.

This study does not address the rigging arrangements, sizes of slings or shackles to be used in the lifting operation. It does not explore the load formulation methods and the load that need to be applied on the padeyes.

The study assume that the design load of the padeye is formulated properly base on the structural analysis and the actual weight of the structure. The study does not cover the welding requirements or welding capacity to achieve the required integrity and strength of the padyes.

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