International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 04 | Apr 2020 www.irjet.net p-ISSN: 2395-0072

DYNAMIC ANALYSIS AND RESPONSE OF K TYPE & KT TYPE FIXED JACKET OFFSHORE SUBSTRUCTURE

Gokul Raj S[1], KRP. Satheeshkumar[2]

[1]PG STUDENT CE, KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE, TAMIL NADU, INDIA
[2]ASSISTANT PROFESSOR CE, KUMARAGURU COLLEGE OF TECHNOLOGY, COIMBATORE, TAMIL NADU, INDIA

Abstract - *Dynamic Analysis of the structure is considered to be one of the important tool for understanding the structures behavior under diverse environmental conditions and to understand performance of the structure under various combinational loads. The main motto of this project is to model and analyze a moment resisting offshore substructure by varying the joints as K Joint and K T Joint. The substructure was analyzed for Airy's wave function with various load combinations. Brief study was carried out on behavior of the substructure under dynamic loads. The mode shapes was determined and natural frequency and natural time period were compared for K Joint and KT Joint. Wave height was assigned using Design Wave method. It was found that for the system analyzed, the base shear for K joint was 120 KN and with max displacement of 0.120 m and for K T joint base shear was 135 KN and with max displacement of 0.075 m.*

Key Words: **K Joint, KT Joint, Mode Shapes, Natural Frequency, Airy's Wave, offshore Substructure**.

1. INTRODUCTION

Offshore construction is the installation of structures and facilities in a marine environment, usually for the production and transmission of electricity, oil, gas and other resources. It is also called maritime engineering. Construction and pre-commissioning is typically performed as much as possible onshore. To optimize the costs and risks of installing large offshore platforms, different construction strategies have been developed. One strategy is to fully construct the offshore facility onshore, and tow the installation to site floating on its own buoyancy. Offshore structures have special economic and technical characteristics. Economically, offshore structures are dependent on oil and gas production, which is directly related to global investment, which is in turn affected by the price of oil. For example, in 2008 oil prices increased worldwide, and as a result many offshore structure projects were started during that time period. Technically, offshore structure platform design and construction are a hybrid of steel structure design and harbor design and construction. In this study Airy's function were used to impart the wave loads to the substructure. The analysis was performed only for the substructure of the offshore platform.

2. METHODOLOGY

Dynamic analysis of fixed offshore Substructure for K Joint & KT Joint was performed to visualize the response under various combinational loads like wind load, seismic load, and wave load. To study the response of the structure Response Spectrum Analysis was performed for K joint & KT joint of offshore Substructure model using SAP2000.

Methodology can be summarized as below

- The model of K Joint & KT Joint Substructure was modelled using SAP2000.
- Modal analysis was performed to visualize the mode shapes of the K Joint & KT Joint offshore Substructure.
- Response Spectra analysis was performed to the K joint & KT Joint offshore Substructure to visualize the peak acceleration experienced by the Substructures.

3. DESCRIPTION OF MODEL

Platform Orientation	135° w.r.t Grid North
Overall Dimension	18.2 m x 24.15
Water depth	22 m w.r.t MSL
Design Life	30 Years

The platform considered in the study is a six legged production platform. Water depth at the location is 200 m. The platform is designed based on the API recommended criteria for 50 years return period. In the study a structure made of steel is used with fixed base for calculation. The type of steel used is A36. A36 has a density of 7,800 kg/m^3 Young's modulus for A36 steel is 200 GPa, Poisson's ratio of 0.26, shear modulus of 75 GPa. Total height of the structure is 200m. Overall Dimension of the Structure 18.2 m X 24.15m.

All the vertical legs and the diagonal bracings are 1.5m diameter and wall thickness is 0.075m. The horizontal bracings are 0.650 m diameter and wall thickness is 0.035m. The computer 3D model of the structure is shown in below fig1 represents the K joint and KT Joint Offshore Substructure.

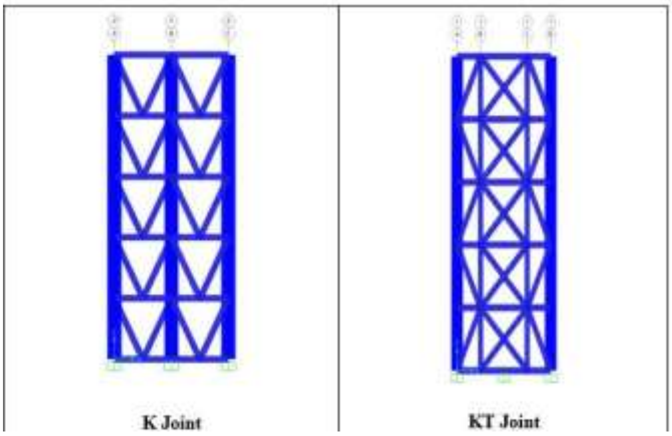

Fig 1 Represents K Joint & KT Joint

The sectional properties of K joint & KT Joint consisting Legs, Vertical brace are tabulated Shown below

Table 1

Description	Diameter (mm)	Wall thickness (mm)
Legs (Ungrouted)	1500	75
Horizontal Chords	650	35
Inclined Braces	650	35

4. Environmental Loads

The offshore substructure is going to experience various adverse loadings like wind load, wave load, seismic loads other than the gravity loads.

4.1 Wave load

Wave loads are determined by two methods by design wave method and spectral method. The forces exerted by waves are most dominant in governing the jacket structures design especially the foundation piles. The wave loads exerted on the jacket is applied laterally on all members and it generates overturning moment on the structure. The wave loads were assigned based on Airy's wave theory. The below shown figure represents wave loading to the substructures.

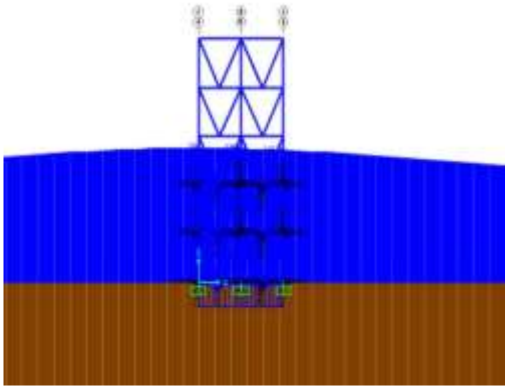

Fig 2 Wave Loading

The maximum design wave height can be determined using design wave method Maximum wave by empirical formula

$$H_{max} = 1.86\ H_S$$

4.2 Loads cases

Various load like wind load, seismic load were assigned for nonlinear static types to study the response of the structure due to various adverse loading. Load cases defined to study the response is shown in the below figure.

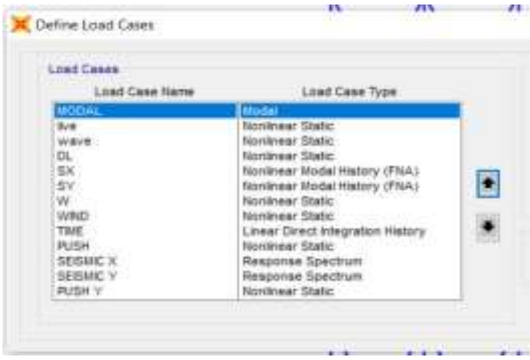

Fig 3 Load cases

5. Modal Analysis

Modal analysis was performed for the K joint & KT joint to visualize the mode shapes and modal mass participation of the K Joint and KT Joint offshore Substructure. Modes shapes for K Joint & KT Joint is represented in the following figures fig2,3

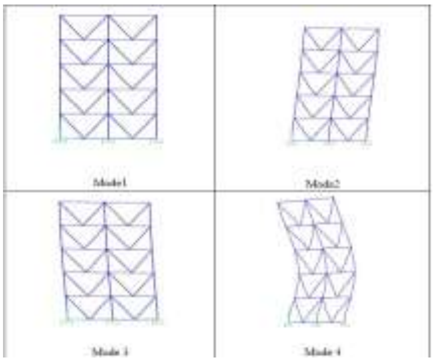

Fig -2: Mode shapes of K Joint

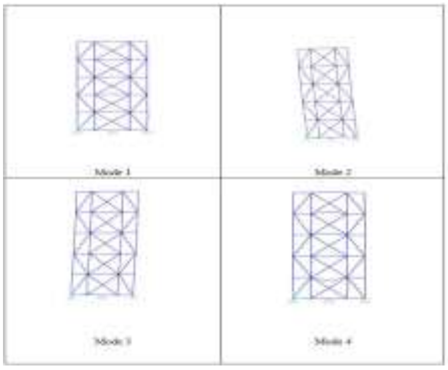

Fig 3 Mode shapes of KT Joint

Every structure has its own natural time period and natural frequencies, so, modal analysis was performed to determine the natural frequencies, and natural time period of the K Joint & KT Joint offshore substructure and the natural period and natural frequency was tabulated in tables 2 & 3 shown below.

Table 2

Mode	Natural Frequency (cyc/sec)	Natural time Period (sec)
Mode1	4.64	0.215
Mode2	4.67	0.213
Mode3	6.24	0.160
Mode4	14.98	0.064

Table 3

Mode	Natural Frequency (cyc/sec)	Naural time Period (sec)
Mode1	4.35	0.229
Mode2	5.82	0.171
Mode3	6.43	0.155
Mode4	16.45	0.069

From the modal analysis performed for K Joint & KT joint offshore substructures it was found that K Joint offshore Substructure model experienced lesser natural period and natural frequency than that of the KT Joint offshore substructure model. Therefore, as known, structure with lesser time period is considered to be more stable so the K Joint was considered to be more stable than KT Joint substructure.

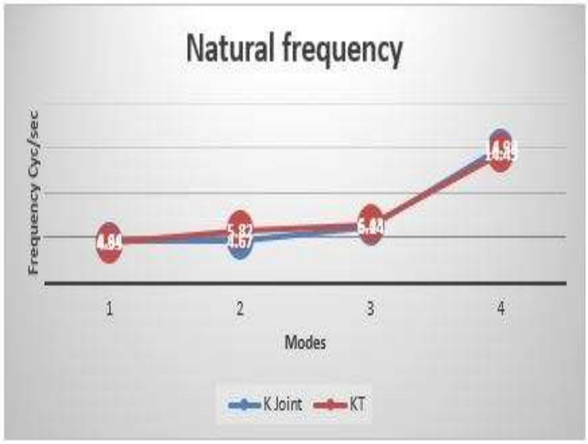

Fig 4 Comparison Mode shapes and Natural Frequency

5. Response Spectra Analysis

In extreme cases, where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is required, such as non-linear static or dynamic analysis like in seismic performance analysis technique. Pseudo Spectral acceleration that describes the maximum acceleration in an earthquake on an object – specifically a damped, harmonic oscillator moving in one physical dimension. The below shown figures 4,5 represents the Spectral Acceleration for K Joint & KT Joint Fixed Offshore Substructure.

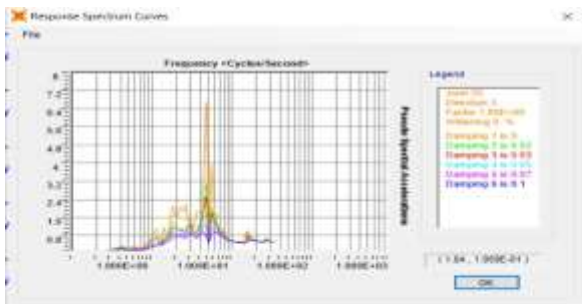

Fig 4 Frequency Vs Pseudo Spectral Acceleration K Joint Substructure

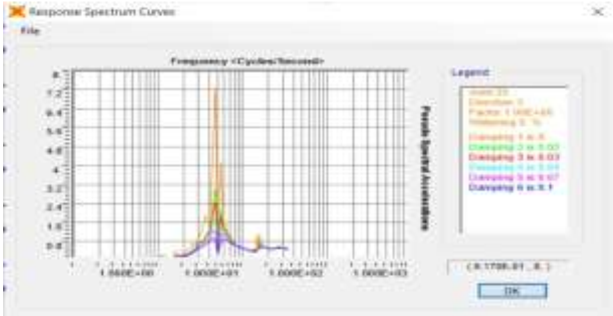

Fig 5 Frequency Vs Pseudo Spectral Acceleration KT Joint Substructure

From the analysis it was found the joint 25 of K joint and joint 13 of KT Joint experienced greater acceleration that the joints near the free end was less.

6. CONCLUSIONS

- The offshore substructure model was modeled and analyzed with wave loading using using airy's wave theory using design wave method.
- The response of the offshore substructure under various combination of environmental loads were studied.
- The modal analysis was performed and mode shapes were determined with natural frequency and natural period for the offshore structure.
- The modal analysis was performed for K Joint and K T joint and were compared, from the analysis it was found that 4^{th} mode shape was found to be predominant with natural frequency of 14.98 for K Joint and 16.45 for KT joint and had a mass participation factor 90%.
- Response Spectra curves where plotted to study the response of the K joint KT joint and was found that the joint 25 near base experienced maximum acceleration than the joints at free end.
- The KT Model had displacement of 0.025m which was comparatively less that K joint model which had a displacement 0.03m, so KT model possessed less displacement than KT Model.
- KT joint structure have lesser time period of 1.5 sec than the K joint Structure 2 sec, so lesser the time period more stable is the structure. By overall comparison KT model performed was found to be better than K joint Model.

REFERENCES

[1] API (American Petroleum Institute) recommended practice 2A-WSD (RP 2A-WSD) 21st edition (2000) for design of offshore structures, USA.

[2] API RP 2A – WSD, "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design, 21TH Edition, 2000".

[3] Sadeghi K, ''Coasts, Ports and Offshore Structures Engineering'' -2001.

[4] Merin Thomas1, Diana Augustine (2018) Fatigue analysis of offshore steel structures International Research Journal of Engineering and Technology Volume: 05 Issue: 04.

[5] Vaibhav Dahiwalkar Behaviour of Jacket Platform Subjected to Ship Impact International Journal of Engineering Research & Technology Vol. 4 Issue 08, August-2015.