Non-Linear Dynamic Analysis of Off- Shore Structure with Different Bracing System

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Abstract - *Now a day, offshore platforms are very popular in oil industries. Offshore structures should be designed for severe environmental loads and strict requirements should set for the optimum performance. The nonlinear analysis of offshore platform subjected to extreme time history induced forces can play a major role in the design of the offshore structures. Time history plus current kinematics are generated using 5th order Stokes time history theory. The horizontal components of the time history velocity and acceleration fields are multiplied by a time history kinematics factor that is intended to account for direction spreading and irregularity of the time history profile. The results show that the nonlinear response analysis is quite crucial for safe design and operation of offshore platform.*

1.INTRODUCTION

Offshore structures may be analyzed using static or dynamic analysis methods. Static analysis methods are sufficient for structures, which are rigid enough to neglect the dynamic forces associated with the motion under the time-dependent environmental loadings. On the other hand, structures which are flexible due to their particular form and which are to be used in deep sea must be checked for dynamic loads. Dynamic analysis is particularly important for waves of moderate heights as they make the greatest contribution to fatigue damage and reliability of offshore structures. The dynamic response evaluation due to wave forces has significant roles on the reliable design of the offshore structure. In the design and analysis of fixed offshore structures many nonlinear physical quantities and mechanisms exist that are difficult to quantify and interpret in relation to hydrodynamic loading. The calculation of the wave loads on vertical tubular members is always of major concern to engineers, especially recently when such studies are motivated by the need to build solid offshore structures in connection with oil and natural gas productions. The effects of various wave patterns on offshore structures have been investigated by numerous researchers in the past.

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1.1 System Architecture

The first step is to design and decide section required for static load as mentioned in the previous chapter. After modeling section boundary conditions for offshore structures is applied. The EL-Centro earthquake loading is applied from time history analysis load case from SAP 2000.After that comparative analysis is performed for various bracing and slope.

1.2 Ground Motions and Linear Time History Analysis

Dynamic analysis using the time history analysis calculates the building responses at discrete time steps using discredited record of synthetic time history as base motion. If three or more- time history analyses are performed, only the maximum responses of the parameter of interest are selected

2. Ground Motion Records

Off shore platforms are subjected to ground motions. The ground motion has dynamic characteristics, which are peak ground acceleration (PGA), peak ground velocity (PGV), peak ground displacement (PGD), frequency content, and duration. These dynamic characteristics play predominant rule in studying the behavior of RC off shore platforms under seismic loads. The structure stability depends on the structure slenderness, as well as the ground motion amplitude, frequency and duration. Based on the frequency content, which is the ratio of PGA/PGV the ground motion records are classified into three categories:

a) High-frequency content PGA/PGV>1.2
b) Intermediate-frequency content0.8<PGA/PGV<1.2
c) Low-frequency content PGA/PGV<0.8

2.1 Statement

The study of platform is a fixed Jacket-Type platform currently installed in the Suez gulf, Red sea, 1988, The offshore structure is a four legs jacket platform, consists of a steel tubular-space frame. There are diagonal brace members in both vertical and horizontal planes in the units to enhance the structural stiffness. The Platform was originally designed as a 4-pile platform installed in 30m water depth. The height of wave is considered as 18m.Wave period 24 sec. Wave water density10.58kg/m^3.The model variation is taken on the basis of bracing pattern and inclination in vertical leg. Single, double and knee bracing patterns are considered with 0º, 20º and 30º inclination in vertical leg.

a) Vertical leg cross-sectional dimension;
   i. Outer diameter=0.762m
   ii. Inner diameter=0.664m
b) Platform Thickness=0.05m
c) Horizontal members pacing=6m
d) Bracing diameter=0.32m

2.2 Density of various materials considered for design

a) Concrete=25kN/m3
b) Insulation=1kN/m3
c) Structural steel=78.5kN/m3

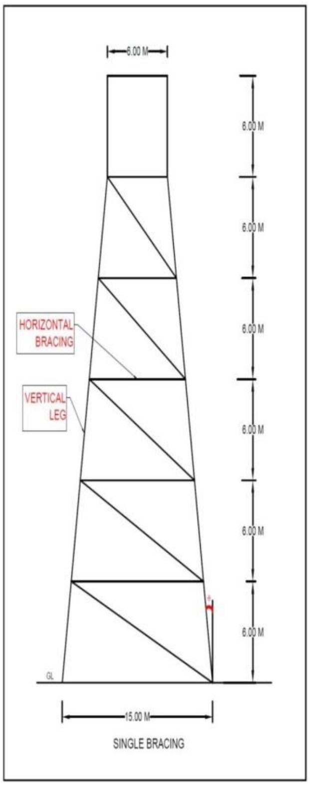
2.3 Description of loading

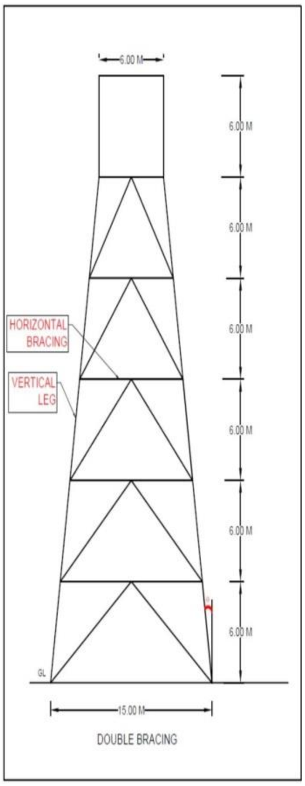
a) Dead load=Self weight of structure

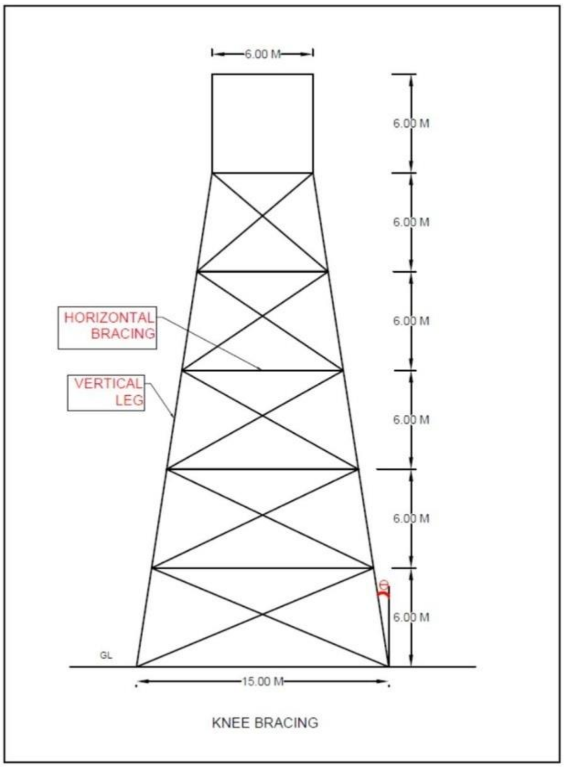
b) Live load=3kN/m2

c) Wave load=18mheightwaveintensity

d) Earthquake load=Time history(EL-Centro)







2.4 Material Properties

The following table shows the concrete and steel bar properties, which are used for 33dowelling of the reinforced concrete of off-shore platforms in SAP2000.Concrete and steel bar properties as per IS 456.

Concrete Properties		**Steel Bar Properties**	
Unit Weight	25 (KN/m^3)	Unit Weight	76.9729 (KN/m^3)
Modulus of Elasticity	22360.68 (Mpa)	Modulus of Elasticity	2x10^5 (Mpa)
Poisson Ratio	0.2	Poisson Ratio	0.3
Thermal Coefficient	5.5x10^{-6}	Thermal Coefficient	1.170x10^{-6}
Shear Modulus	9316.95 (Mpa)	Shear Modulus	76923.08 (Mpa)
Damping Ratio	5(%)	Yield Strength	415(Mpa)
Compressive Strength	30(Mpa)	Tensile Strength	485(Mpa)

Table -1: Material Properties

2.5 PERFORMANCE ANALYSIS

The main objective of this study is to examine the behavior of Off-shore structure with different bracing system with different angles provided to structure.

a) Single bracing for 0°structure.

b) Double bracing for 0°structure.

c) Knee bracing for 0°structure.

d) Single bracing for 20°structure.

e) Double bracing for 20°structure.

f) Knee bracing for 20°structure.

g) Single bracing for 30°structure.

h) Double bracing for 30°structure.

i) Knee bracing for 20°structure.

All above cases are analyzed for time history analysis. The analysis is carried out using SAP 2000 software .The compression is made between different bracing system.

Fig 1: Sketch Map of Platform Model.

Idealization of above problem statement is modeled infinite element analysis tool SAP2000. Following models are prepared for comparative analysis of offshore steel structures.

2.6Discussion on results

2.6.1 Time Period

1. From figure4.10, 4.11 and 4.12 results of time period of vertical leg with 0°inclination, shows that double racing has less time period.
2. As time period is inversely proportional to stiffness, double bracing model with vertical leg 0° inclination possess more Sstiffness.
3. Most of the mode shapes of double bracing model shows less time period as compared to other two bracing pattern system.

2.6.2 Base Shear

1. It is observed from results of base shear single bracing pattern shows higher value of base shear resistivity then further knee bracing and then double bracing.
2. Provision of single bracing in off-shore structure, increases the performance of structure in terms of base shear resistivity.
3. From the results it shows that model with double bracing shows less base shear resistivity than the other models.

2.6.3 Natural Frequency

1. From the table, value of Natural frequency is higher in terms of double bracing.
2. As Natural Frequency of structure is directly proportional to stiffness of structure, so double bracing structure with 0° inclination in vertical leg have more stiffness then the other two models.

2.6.4 Deformation

1. From the graphs it is seen that single bracing system shows more displacement as compared to double bracing system and knee bracing system.
2. Deformation of all models are compared and its seen that the least deformation is observed in double bracings in vertical leg with 30° inclination.

3. CONCLUSIONS

Safe and cost-effective design of offshore platforms depends to a large extent on the correct assessment of response demands which is expected to be encountered by the structures during its life span. However, the functioning of the drilling operation takes place during fair weather window, the structure as a whole need to withstand extreme design conditions. The extreme design conditions are site specific. It is crucial to reduce the overall response of a jacket platform subjected to environment loads. The periodic inspection and monitoring of offshore platforms for certification needs the study of the responses of structures owing to wave and wind forces. A finite element formulation has been developed for the nonlinear response of a fixed offshore platform jacket Where, three-dimensional beam element incorporating large displacement, time dependent wave forces is considered. The time dependent wave force has been considered as a drag component of the wave force, which is a function of second-order water particle velocity; hence the nonlinearity due to the wave force has been included. The offshore structural analysis is used to obtain platform displacement response under varying external loadings. The deflection of the platform is studied for individual and combined wind and wave forces. Offshore platform jacket displacement, axial forces, bending moments, and natural modes and frequencies of free vibration are evaluated.

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