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Modeling and Simulation of Wave load on Periodic Support for Isolation system of offshore platform.

S.A. Afolalu, O.O. Ajayi, O.M. Ikumapayi, S.B Adejuyigbe.

ABSTRACT: The wave-induced dynamic load is one of the most important excitations to be dealt with in the design of offshore structures and the platforms. In order to perform a reliable design of an offshore structure, it is important to obtain an exact evaluation of its dynamic response to wave load but also to examine the ways of reducing the response. The work analyzed the effects of wave load on periodic support of isolation system of jacket offshore platform. The platform considered herein as an example to examine the effectiveness of the proposed vibration control strategy for offshore structures. In this section, a parametric study for the jacket offshore platform with installation of the periodic support to enhance isolation system due to its attenuations ability over broad frequencies and the effects of wave load on offshore jacket platforms installed with energy dissipation devices such as periodic support were presented. The offshore jacket platforms are modeled as multi-degrees-of-freedom and the general equation for fluid forces acting on a cylinder, considering the relative motion of the body in the fluid as per the Morison's equation was applied to form the basis of modeling of the wave load and supports. The analyzes of the effects of wave load on the offshore platform especially with periodic support was considered due to its attenuations over broad frequencies. It could be realized from the result that increase in waves load varies the increase in frequency domain of the system which enhances subjection to vibration.

Keywords: Platform, Isolation, Vibration, Wave, Damping,

1. INTRODUCTION

In the past study, a scale model of the steel jacket for fixed offshore platform originated in Gulf of Mexico and which has already spread worldwide. It is suitable to build in water depth from a few meters to more than 300m. a jacket structure which serves as bracing for piles driven through the inside of the legs of the jacket structure into soil for many tens of meters and the deck structures is fixed upon the jacket structure [1]. Most of the previous experimental investigations and theoretical studies were concentrated in the analysis of dynamic properties, vibration isolation schemes and vibration-reduction effectiveness. Support gearbox systems on the airframes of helicopters. When designed properly, the passive periodic strut can stop the propagation of vibration from the gearbox to the airframe within critical frequency bands, consequently minimizing the effects of transmission of undesirable vibration and sound radiation to the helicopter cabin. Localization of a wave in a damped one dimensional periodic structure using an energy approach and this method is based on vibration energy flow, and excellent agreement with exact results is demonstrated for a periodic beam system. [2]

Among the various types of offshore structures, the steel jacket platform is the most common in use. Over the years, it has assumed a multi-functional role, being used for oil exploration, drilling as well as production. Conventionally, such platforms are built up to a depth of about 100–150 m, though some of them have exceeded 200 m [3]. Usually, they are built from tubular steel members. These structures have a very low time period ranging between 2 and 8 s. An offshore structure such as a steel jacket platform apart from the operational loads also experiences environmental loads such as wind, wave and earthquake loads.

- S.A Afolalu is currently pursuing his PhD degree program in Mechanical Engineering Department, Federal University of Agriculture Abeokuta Ogun-State, Nigeria. afoniran@yahoo.com.
- O.O. Ajayi is a PhD holder currently lecturing in Mechanical Engineering Department, University of Lagos. Akoka. Nigeria. bosun_ajayi@yahoo.com
- O.M Ikumapayi is a researcher in Mechanical Engineering Department, University of Lagos, Akoka. Lagos. Nigeria. Ikumapayi.omolayo@gmail.com
- S.B Adejuyigbe is currently a Professor in Mechanical Engineering, Federal University of Oye-Ekiti. Ekiti-State. Nigeria. samueladejuyigbe@yahoo.com.

The safety of structures can usually be ensured by increasing their stiffness so as to shift the natural frequencies away from the resonating of frequencies. However, this approach is generally costly requiring excessive construction material [4]. An alternate approach is to implement a passive and or active control mechanism to regulate the structural motion as desired [5]. Passive control devices do not require external energy but they have a inherent limitation. On the other hand, an active control mechanism can be effective over a wide frequency range with the desired reduction in the dynamic response [6]. The active control approach is now of current concern to many researchers and there are several attempts exploring its application to offshore structures.[7] and [8] studied the response of offshore platforms with an active tuned mass damper installed and found that such mechanism is quite effective in reducing the response of platforms due to wave loading. [1] Studied the application of certain active and passive control mechanisms to reduce the dynamic response of steel jacket platform due to wave-induced loading[9] demonstrated the effectiveness of mechanical added dampers using stochastic analysis for offshore platform demonstrated the effectiveness of an active control system for articulated leg platforms in view of minimizing the wave induced response [10]. Examined the effectiveness of the lateral vibration control for wave-excited response of offshore platforms with Magneto rheological dampers. Recently, [11] studied the response of offshore jacket platforms with an active tuned mass damper under wave loading. Although, there had been several studies for effectiveness of the active and passive control mechanisms in controlling the response of offshore platforms under wave loading. However, very few studies are reported on the effectiveness of the periodic support in controlling the response of offshore platforms under a parametric variation to study the influence of important system parameters and comparative performance.

In study of vibration isolation in offshore structures platform, it is useful to identify the three basic elements of all vibrating system: object to be isolated, the isolation system and base or platform of the system. It is not possible to mount the machine directly on suspension type mount the structure may be treated as a whole [11]. The isolation of the structures may start at the platform and continue through isolation of the structures foundations (perhaps isolating the platform base with resilient materials) up to complete isolation of the offshore platform.

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It is obviously most cost effective to deal with the vibration at the most practicable point near to the machine as there is less mass to be isolated, technology of isolation, shock and damping embodies both theoretical and experimental facets prominently. Thus methods of analysis and instruments for the measurement of shock and vibration are of primary significance. The result of analysis and measurement are usually used to evaluate shock and vibration environments to devise testing procedures and testing machines and to design and operate equipment and machinery [12].

2. MATERIALS AND METHODS

2.1 Waves Forces on Structural Members

The basic periodic structures is that when a wave is traveling in a medium and meets a transition in that medium, a part of it will propagate and another part will be reflected. In a regular structure the wave is expected to travel without any change until it reaches the boundaries of that structure, but when the structure exhibits a change in its geometry and/or material properties, the incident waves will divide as described before. A part of the reflected wave will interact with the incident wave in a manner that will generate distractive interference. This research presents a new approach to isolate the vibration aspects of offshore platform structures, by making the platform legs as periodic structures. A periodic structure consists of an assembly of identical elements connected in a repeating array which together form a completed structure. Examples of such structures are found in many engineering applications. These include bulkheads, airplane fuselages, and apartment buildings with identical stories. Each such structure has a repeating set of stiffeners which are placed at regular intervals. The study of periodic structure has a long history. Wave propagation in periodic systems has been investigated for approximately 300 years. When constructive interference occurs, the frequency is characterized by being the pass band of the structure; while, if they destructively interfere, the frequency is characterized by being the stop band of the structure. If the structure setup is repeated for several times, it is known as periodic structure. The destructive effects will show more significantly when the repetitions of the structure unit increase in number because as the part of the wave that propagates incorporates other similar changes in the medium, another part of it is destructed and so on. Periodic structure is a structure that consists fundamentally of a number of identical structural components that are joined together to form a continuous structure. An illustration of a simple periodic beam is presented in Fig. 1 and 2 below.

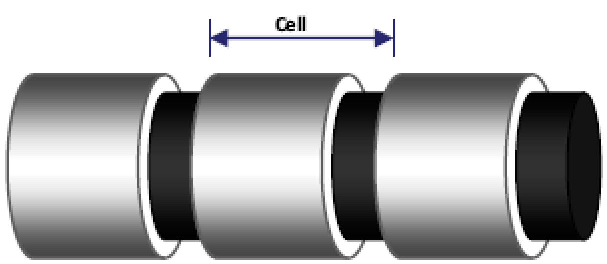

Fig. 1 An illustration of a simple periodic beam.

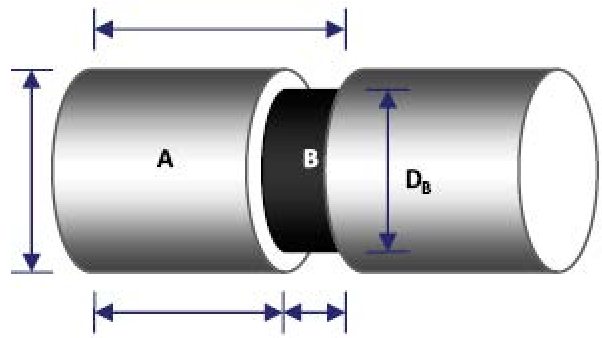

Fig 2. Beam geometry.

2.2 Wave Theories

In considering the effect of waves as one of the environmental loading factors that could affect vibration isolation of an offshore platform structures. The theory is very necessary to put into consideration. Calculation of particle velocities and accelerations and the dynamic pressure as functions of the surface elevation of the waves. The waves are assumed to be long-crested, i.e. they can be described by a two of dimensional flow field, and are characterized by the parameters: Wave height (H), period (T) and water depth (d) as shown below in fig 3

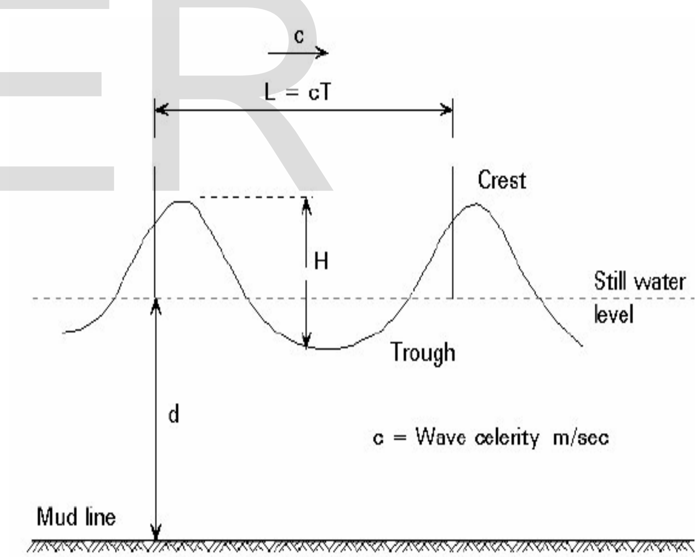

Fig 3 Wave Symbol.

Offshore platform structures that exposed to waves experience substantial forces much higher than wind loadings. The forces result from the dynamic

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pressure and the water particle motion as indicated in fig 6. Two different cases can be distinguished. Large volume bodies, termed hydrodynamic compact structures, influence the wave field by diffraction and reflection. The forces on these bodies have to be determined by costly numerical calculations based on diffraction theory.

Slender, hydro dynamically transparent structures have no significant influence on the wave field. The forces can be calculated in a straight-forward manner with Morison's equation. As a rule, Morison's equation may be applied when D/L £0.2, where D is the member diameter and L is the wave length.

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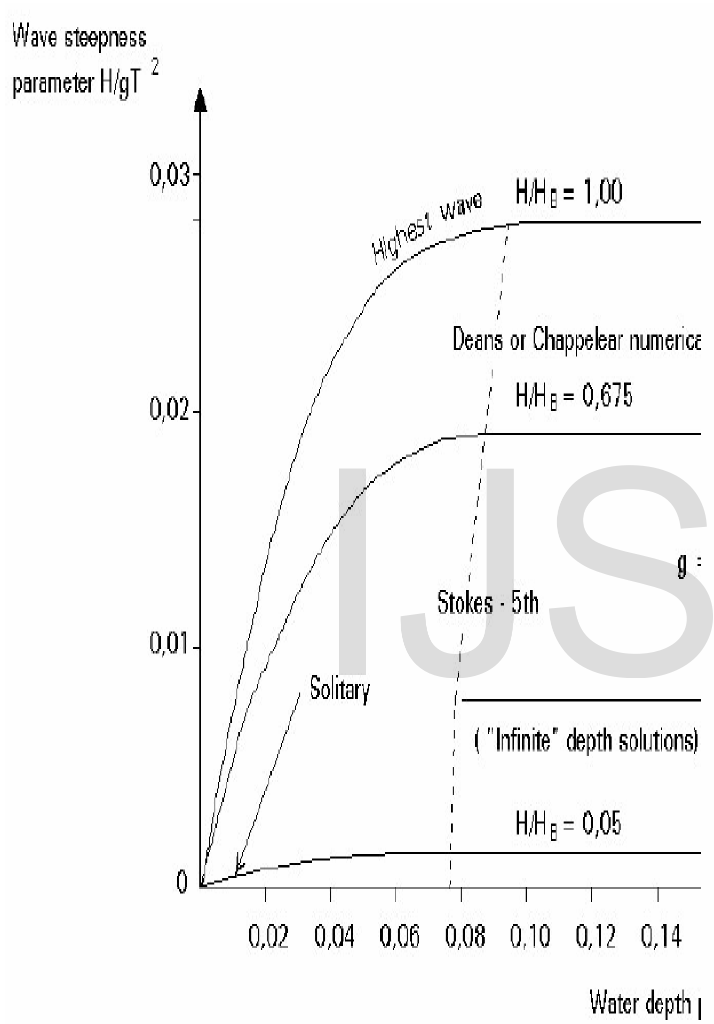

Fig 4 Wave theory selection graph

In reality waves do not occur as regular waves, but as irregular sea state as shown in fig 4 and 5.

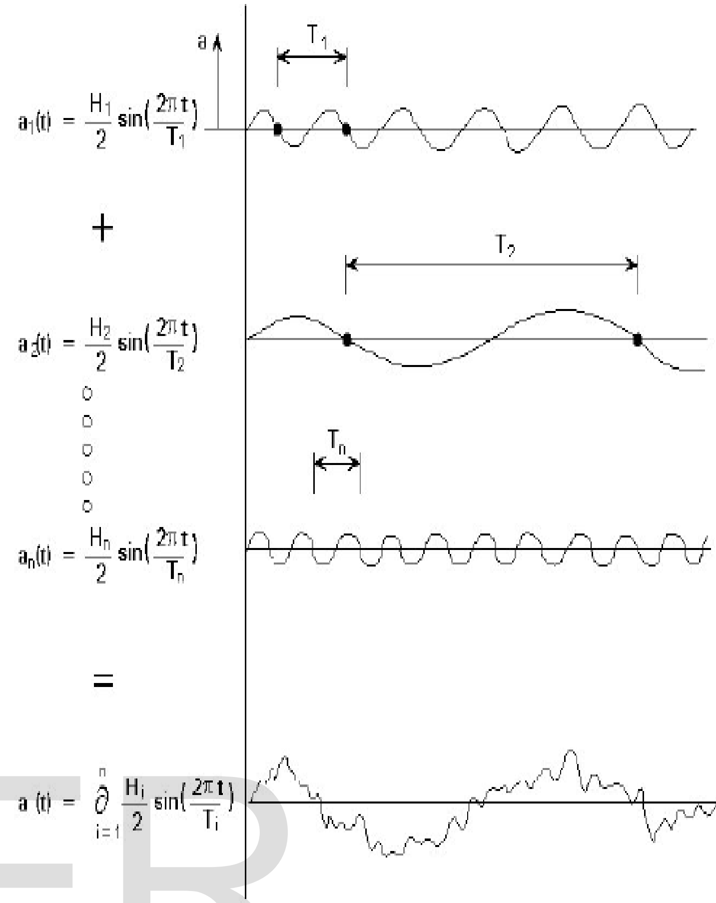

Fig 5 Modeling of random seas

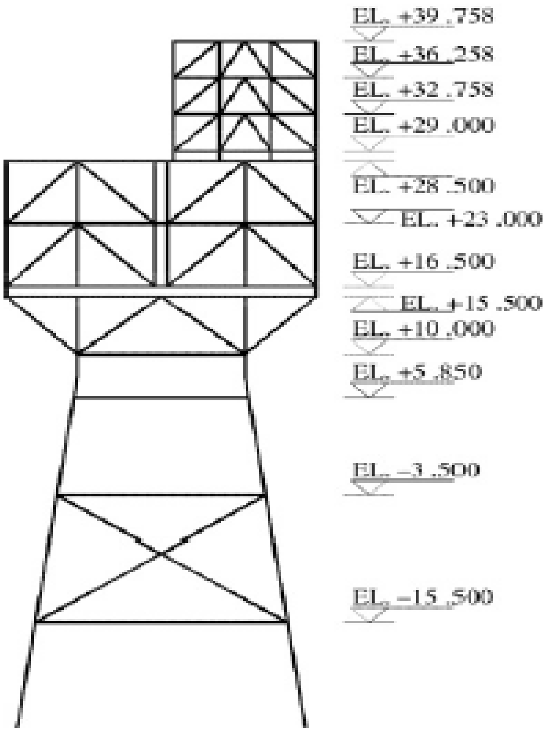

Fig 6: Elevation view of a Platform and analytical modeling of the structure

3. Results and Discussion

3.1 The effect of the parameters on the periodic support system offshore platform.

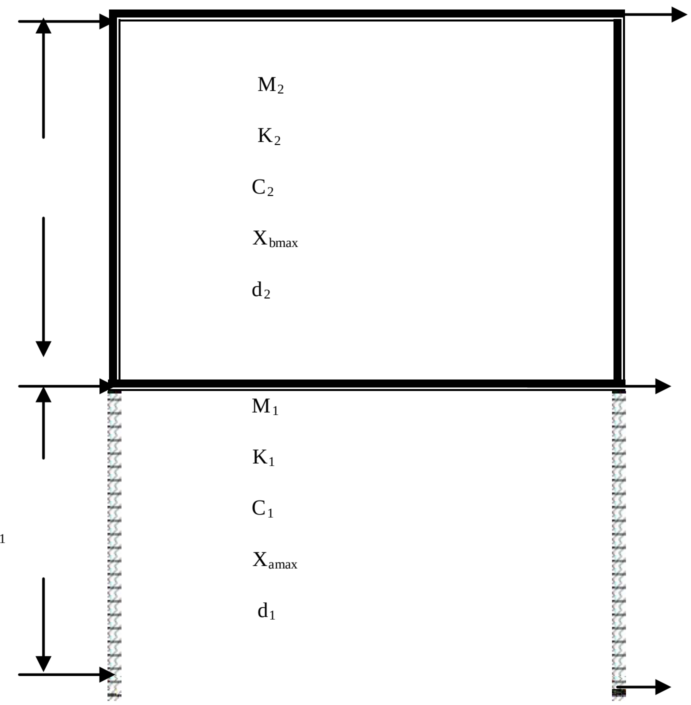

Fig 7. Simplified model of the isolated structure.

The simplified model of the damping isolation system is represented by above in fig 7. The stiffness and damping coefficient of the system are represented by K_2, C_2, and the stiffness and damping of the jacket structure are denoted by K_1, C_1. M_2 represents the mass of the deck module above the damping isolation system and M_1 is the mass of the jacket and piles.K_2 and C_2 are designed based on the vibration control objectives.

Since large inter-story drift of the isolation level is not allowed for the jacket platform to meet the drilling and production requirements due to wave load.

3.1.1 Modeling of wave Load

With the help of MATLAB represented in fig 8, the wave load at each levels of the drift shown in fig 9 below could be analyzed to obtain the value of the forces at each level.

General equation in obtaining the wave force is;

$$F_n = K_{bn} [(x_n(t) - x_n(t) - d_n(t)]$$

For the structure;

$$F_1 = K_{b1} [(x_1(t) - x_2(t) - d_1(t)]$$

For the Platform and support

$$F_2 = K_{b2} [(x_2(t) - x_2(t) - d_2(t)]$$

Where;

F_1 = wave force at structure floor.

K_{b1} = brace stiffness structure floor.

X_i = lateral floor displacement at structure floor.

d_1 = device displacement at structure floor.

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F_2 = wave force at the platform and support

K_{b2} = brace stiffness at the platform and support

X_2 = lateral floor displacement at structure floor.

d_2 = device displacement at structure floor.

The equation of the system of two degree freedom could be written below base on the model analysis of the simplified platform structures [13];

$$\begin{bmatrix} m_1 & 0 \\ 0 & m_2 \end{bmatrix} \begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + \begin{bmatrix} c_1 & -c_1 \\ -c_1 & c_1 + c_2 \end{bmatrix} \begin{Bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{Bmatrix} + \begin{bmatrix} k_1 & -k_1 \\ -k_1 & k_1 + k_2 \end{bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix}$$

In variables of the equation in state space is given by:

$$\mathbf{A} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -\frac{k_1}{m_1} & \frac{k_1}{m_1} & -\frac{c_1}{m_1} & \frac{c_1}{m_1} \\ \frac{k_1}{m_2} & -\frac{k_1 + k_2}{m_2} & \frac{c_1}{m_2} & -\frac{c_1 + c_2}{m_2} \end{bmatrix}$$

$$\mathbf{C} = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix} \qquad \mathbf{D} = \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$$

This is represented in MATLAB as

:

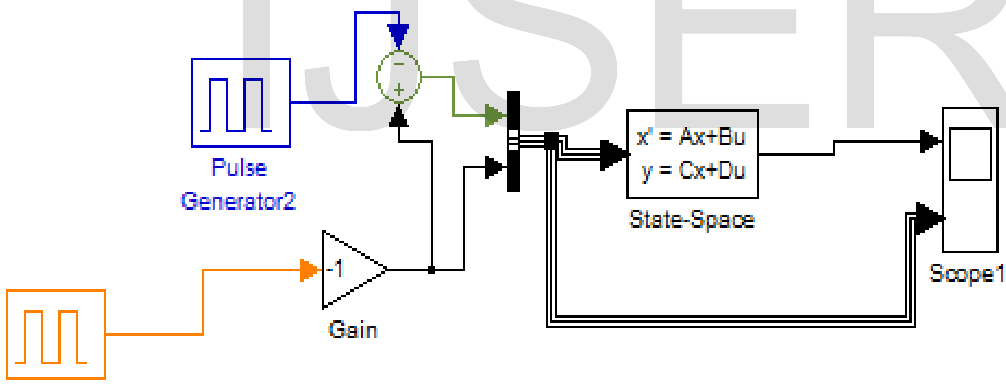

Fig 8 Matlab for the State of two degree of freedom for platform and Supports.

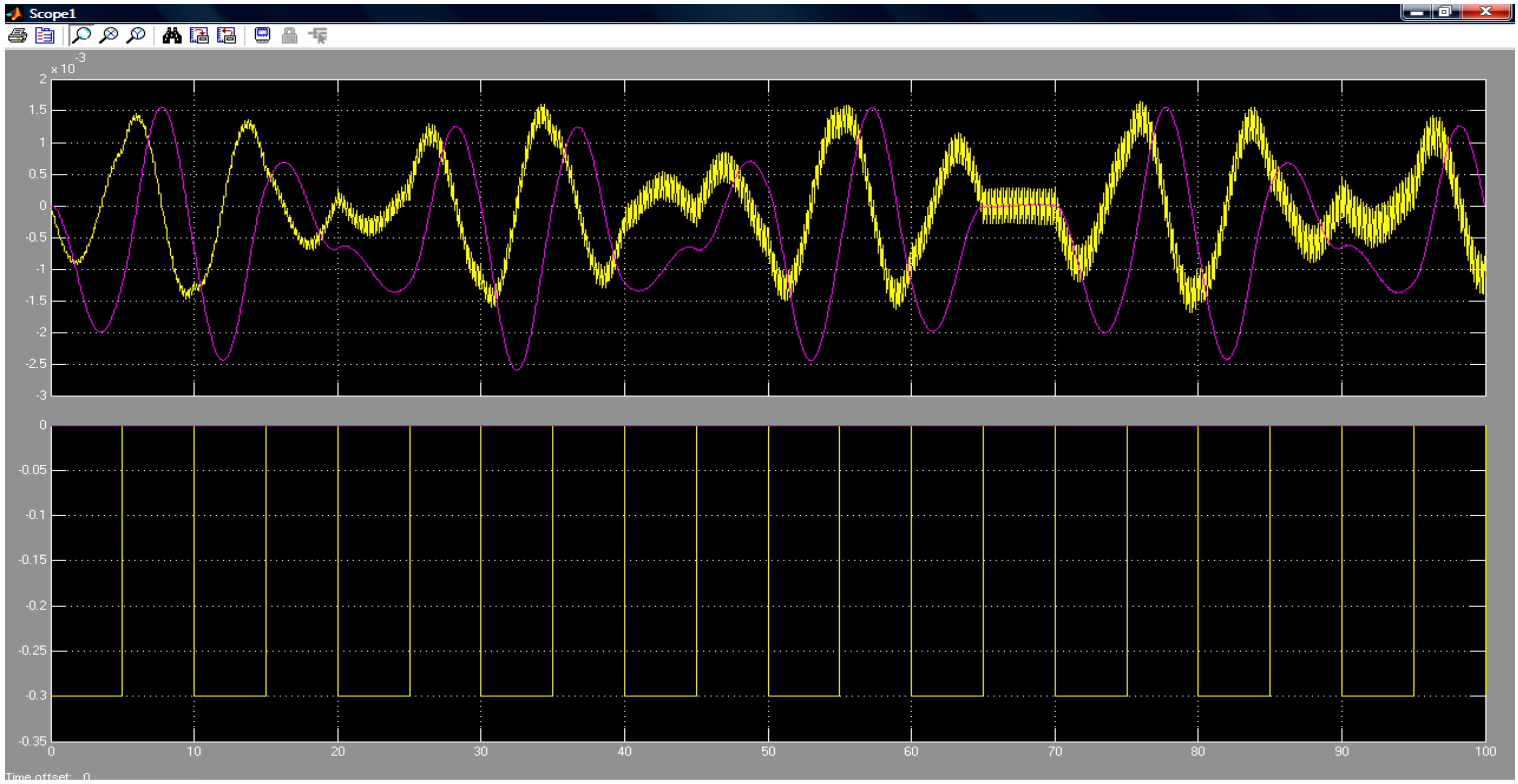

Fig 9. The response to input or forcing function represented as pulse signal

3.2 DISCUSSION.

The objective of the present study is to analyze the effects of wave load on periodic support of isolation system of jacket offshore platform above. In this section, a parametric study for the jacket offshore platform with installation of the periodic support to enhance isolation system due to its attenuations ability over broad frequencies is presented. The effects of wave force f on the maximum Inter-story drift of isolation level under wave load with factors of ξ_t and γ_t was shown in fig 9. Variation effects of wave load against the each level of X_{amax} and X_{bmax} on the maximum inter-story drift at two different levels (structure and platform base under wave forces respectively) were determined.

The result analyzed above in fig 9 verified that X_{bmax} decreases as ξ_t increases, and X_{amax} increases as ξ_t increases. In addition, as γ_t increases, the effect of ξ_t on X_{bmax} max is more significant in compares the result under the two levels (structure and the platform base when prone to wave load). Also the effect of ξ_t and γ_t on J_d and J_a under wave load was determined with increase in J_d and J_a and increase of γ_t but are less.

4. CONCLUSION

Basically the project has shown and proves further the effects of parameters variables due to wave load on offshore jacket platforms. The modeling and simulation of the system has indicates the response of the system attenuation to wave periodic excitation devices such as damper and periodic support.

Offshore jacket platforms are modeled and simulated as multi-degrees of freedom and equation considering the relative motion of the body in the fluid as basis of modeling of the wave load. Base on the simulated result, the variable parameters determined how best isolation system could be prone to environmental loads.

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