Nonlinear Random Vibrations of High Seas Mooring Platform

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Abstract

This paper concentrating about upgrades the security variable of the oil era stages, which are considered as the greatest creation improvement on the planet. Iraq had the front line of the oil era countries, which dismisses the north Arabian Gulf, which should be authorized by the improvement of oil stages and give an examination exploration focuses remembering the deciding objective to upgrade the security of these structure. So we expect upgrading the wellbeing component of these structures through the interest by putting a complete response for the issue of waiting nerves in the joints of structures, which realized the breakdown and flooding of these stages, bringing on excessive mishaps impact particularly the national economy. In this investigation, the extra bothers of the oil stage due to the wave weights were considered. The structure of the stages was introduced to a strain, weight, and shear stretch as a result of the extra weights achieving a structure split and frustration. Constrained Element Method (FFM) and ANSYS14 Program was used as a piece of solicitation to deal with the issue delivered in foremost the aftereffects of the Random Vibration happened due to the persevering wave stacks that affected particularly on the stage structures. An Excitation Equation of the Random Vibration was speculated using Fourier Equation to learn the information limit. Have been taking a shot at the structure of the stage is really unmistakable estimations first structure stage with a compass of 25 cm were made to respond to three vectors (x, y, z) and the second with a compass of 50 cm were showing results as outlines and hence it should be seen that the structure stage with a scope of 25 cm more responsive structure of the stage with a compass of 50 cm.

Keywords Random Vibration, Fluid, Platforms, Fourier equation

الاهتزاز اللاخطي العشوائي للمنصات النفطية في اعالي البحار

المستخلص

هذا البحث يتمحور حول تحسين عامل الأمان في منصات إنتاج النفط ، والتي تعتبر من أكبر هياكل إنتاج النفط في العالم.احتل العراق صدارة الدول في إنتاج النفط ، الذي يطل على شمال الخليج العربي ، التي يجب تفعيلها من خلال بناء منصات النفط و توفير مختبرات البحوث من أجل تحسين سلامة هذه البنية. ولذا فإننا نتطلع إلى تحسين عامل الأمان في هذه الهياكل من خلال البحث عن طريق وضع حل نهائي لمشكلة الضغوط المتبقية في مفاصل الهياكل ، والتي تسببت في انهيار وفيضانات هذه المنصات ، مما تسبب في خسائر باهظة تؤثر بشكل مباشر على الاقتصاد الوطني في هذا البحث تم دراسة الإجهادات المتبقية على منصة النفط بسبب الأحمال الموجية التي تعرض بنية المنصات إلى التوتر ، والضغط ، و إجهاد القص بسبب الضغوط المتبقية مما تسببت في كسر الهيكل ومن ثم الفشل. حيث تم استخدام طريقة العناصر المحدودة FEM و برنامج ANSYS14 من أجل حل المشكلة الناتجة من تأثير الاهتزاز العشوائي الناجم عن موجة مستمرة الأحمال التي أثرت مباشرة على هيكل المنصة ومن خلال النتائج نلاحظ إن قمة المنصة أكثر استجابة من وسط المنصة والوسط أكثر استجابة من القاعدة . حيث تم العمل هنا على هيكل منصة بنصفي قطرين مختلفين الأول هيكل منصة ذو نصف قطر(٢٥) سم وتم إيجاد الاستجابة بثلاث متجهات (x,y,z) والثاني ذو نصف قطر (٥٠) سم وتم إظهار النتائج على شكل مخططات ومما تجدر الملاحظة إليه إن هيكل المنصة ذو نصف قطر (٢٥) سم أكثر استجابة من هيكل المنصة ذو نصف قطر (٥٠).

كلمات مرشدة الاهتزاز العشوائي ،الموائع ، المنصات ،معادلات فورير

Nomenclature

[K]	element stiffness matrix	N/m
[B]	strain-displacement matrix	……..
[D]	stress-strain matrix	……..
K.E.	kinetic energy	KJ
P.E.	potential energy	KJ
g	Gravity of acceleration	N/m
L	Length	M
V	Velocity	m/s
M	Mass	Kg
F	Force	N
P	Load	N

1. Introduction

The developing requirement for more vitality sources as of late has driven the exploration for protected and dependable routines for the extraction of oil from beneath ocean water. This has prompted the development of seaward oil stage structures to get entrance to the oil holds. [1]

There are more than 6000 stages structures with different sort now remaining in the seaward water 34 nations. Seaward stages comprise comprehensively of two segments: (1) offices for boring and generation operations, frequently called the topsides, (2) the supporting structure and its establishment. The topsides characterize the capacity of the stage. Included in the topside stage could be penetrating rings and related gear, oil and/or gas-handling hardware, transportation pumps and/or compressors, and utilities and living quarters. Most real stages additionally have a helideck for helicopters. [2]

The principle dynamic excitations rely on upon wind, ocean waves, ice and seismic tremors. In view of building encounters vibration sufficiency lessens 15% the life of the structure improved twofold. Seaward stages have numerous uses including oil Exploration and creation, route, boat stacking and emptying, and to bolster connects and highways. Seaward oil creation is a standout amongst the most unmistakable of these applications and speaks to a huge test to the outline engineer. [3]

These mooring platforms are typically used in sea depths in ranging from 1,500 and 3,000 feet (450 and 900 m).

1.2 Types of Offshore Platforms

. **1-Compliant Towers:** These platforms consist of narrow, flexible towers and a piled foundation supporting a conventional deck for drilling and production operations. Compliant towers system are designed to sustain significant lateral deflections and forces,

2-Drillships: A drillship is a maritime vessel that has been fitted with drilling apparatus. It is most often used for exploratory drilling of new oil or gas wells in deep water but can also be used for scientific drilling.

3-Floating Production Systems: are large ships equipped with processing facilities and moored to a location for a long period.

4-Tension-leg Platform: TLPs consist of floating rigs tethered to the seabed in a manner that eliminates most of the vertical movement of the structure.

5-Spar Platforms: Spars are moored to the seabed like the TLP, but whereas the TLP has vertical tension tethers the Spar has more conventional mooring lines.

6-Semi-submersible Platform: These platforms have legs of sufficient buoyancy to cause the structure to float, but of weight sufficient to keep the structure upright.

Fig. (١): Compliant Tower

Fig(2): Fixed part of mooring platform

2.1 Random Vibration

Irregular vibration is movement which is non-deterministic, implying that future conduct can't be absolutely anticipated. The arbitrariness is a normal for the excitation or info, not the mode shapes or characteristic frequencies.

2.2 Vibration due to Water Waves sea

The vitality in most sea waves begins from the wind blowing over the water's surface. Huge torrent or seismic ocean waves are created by quakes, space flotsam and jetsam, volcanic ejections or vast marine avalanches. Then again, tides, biggest of all sea waves result from the joined gravitational power applied on the seas by the sun and the moon. [4].

1. **Body waves** (Examples: Secondary and essential seismic waves).

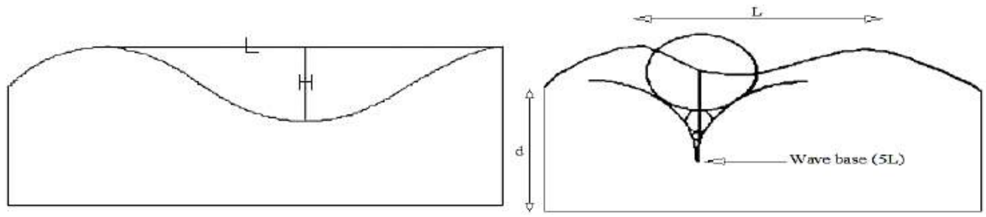
2. Surface waves (Examples: Rayleigh waves) Water waves are Rayleigh-sort surface waves portrayed by an orbital movement. Fig.(2) demonstrates the parts of a surface wave.

3. Internal (Waves framed at the interface between two layers that vary in thickness). The orbital movement of water declines exponentially with profundity. At profundities more noteworthy than one a large portion of the wave length the orbital movement is insignificant and the wave no more feels base as demonstrated in Fig.(3). Profound water waves are those where the profundity is more prominent than (0.5) the wave length. Waves are unaffected by the bottom, but they misshape because of communication with the ocean depths. Water waves are named: [5]

- Deep water waves ($d/L > 0.5$ or $d > o.5L$).
- Intermediate water waves ($0.5 > d/L > 0.05$).
- Shallow water waves ($d/L < 0.05$).

Where: L: wave length, d: water depth.

Waves can be isolated into consistent (monochromatic) and unpredictable (ghostly) waves. A consistent wave train has an altered bearing and adequacy, and it is intermittent in both space and time. Customary waves are basic and can be approximated well in research center trials. Besides, any arbitrary, sporadic wave can be decayed into consistent wave segments by means of Fourier examination. Waves in nature are basically sporadic, comprising of numerous individual parts with diverse amplitudes, headings and periods. Wave are generally created by the wind push in Deep Ocean and spread towards shoreline [5]. It is constantly accepted that the water waves are spoken to as a two dimensional plane waves, that they are proliferate over a smooth level bed in water of consistent undisturbed profundity (h) [6].Fig.(4) shows the general type of the x z-plane wave train fitting in with these suspicions. Here the wave is dynamic in the positive x-course, and the z-hub measured positive upwards from the mean water level, the wave stature H, the wave length L, the wave period T, and η the rise of the water over the mean water level. Waves on the surface of the sea with times of (3 to 25) sec are basically created by winds and are a principal element of seaside locales of the world. Other wave movements exist on the sea including inner waves, tides, and edge waves



(a) (b)

Fig. (3): (a) Components of Surface (b) Orbital Motion

Where: L: wave length, H: wave height**,** L: wave length, d: water depth

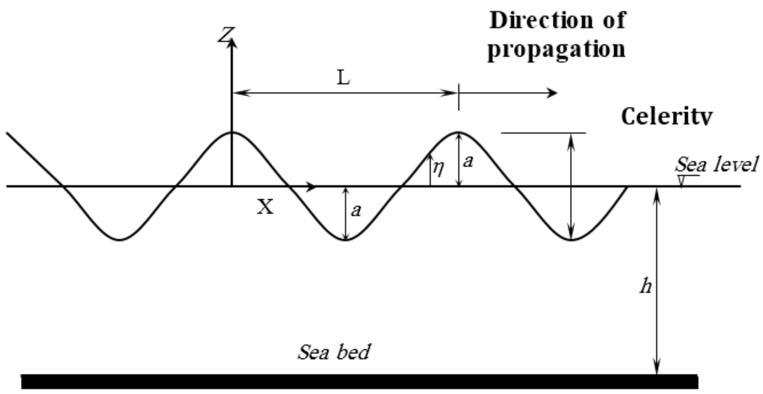


Fig. (4): Definition of terms used in the wave equations

2.3 Finite Element Formulation:

FEM is most ordinarily utilized as a part of numerical investigation for getting approximated answers for wide mixed bag of building issues [7]

Numerous physical phenomena in designing and science can be depicted as far as fractional differential mathematical statements. When all is said in done, tackling these mathematical statements by traditional investigative techniques for subjective shapes is practically inconceivable. The limited component system (FEM) is a numerical approach by which these incomplete differential mathematical statements can be fathomed pretty nearly. From a building point of view, the FEM is a strategy for taking care of designing issues, for example, stress examination, warmth exchange, liquid stream and electromagnetic by PC reenactment [8].

Since the genuine issue is supplanted by a less difficult one in discovering the arrangement, we will have the capacity to discover just an inexact arrangement as opposed to the definite arrangement. On account of basic limited component examination (FEA), these improved expressions relate powers to relocations, and arithmetical mathematical statements relating physical amounts at specific focuses, called hubs, of the component are produced [9].

The burdens and strains are administered by Hook's law and just tiny removal happens, the limited component mathematical statement for static investigation is:

$$[K]\{U\} = \{Rv\} \tag{1}$$

$$[K] = \int [B]^t [D]\,[B]\,dv \tag{2}$$

Where:

[K] = element stiffness matrix, [B] = strain-displacement matrix, [D] = stress-strain matrix

The removal reaction U is a straight capacity of the connected burden vector RV When this is not the situation, a non-direct examination is performed, in the non-straight investigation the power dislodging relationship is not direct and relies on upon the current express (that is, present uprooting, constrain, stretch, and strain). Mixed bag of nonlinear FE projects are accessible to take care of these sorts of issues. These projects explain the nonlinear relationship by taking a progression of little straight steps or additions. Every cycle is more or less as computationally requesting as a solitary straight emphasis. [10]. ANSYS is a limited component examination, programming bundle with ability to break down an extensive variety of distinctive issues. There are two approaches to utilize ANSYS. Intuitively through the graphical client interface GUI, and through the utilization of group records and ANSYS summons [11]. By used Lagrange equation:

$$\frac{d}{dt}\left(\frac{\partial K.E}{\partial \dot{q}}\right) - \frac{\partial K.E}{\partial q} + \frac{\partial P.E}{\partial q} + \frac{\partial D.E}{\partial \dot{q}} = Q(t) \tag{3}$$

Using model shown in Fig.(5). to obtain the equation of motion to platform structure

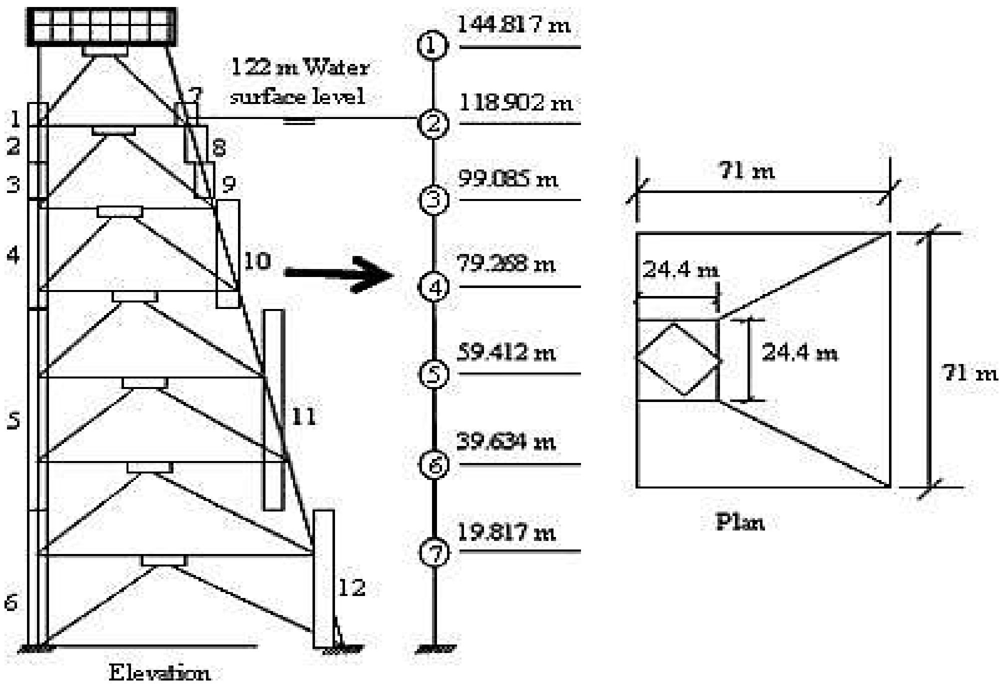


Fig.(5): Platform structure

The total kinetic energy:

$$K.E = \frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2\, v_2^2 + \frac{1}{2}m_3\, v_3^2 + \frac{1}{2}m_4\, v_4^2 + \frac{1}{2}m_5\, v_5^2 + \frac{1}{2}m_6\, v_6^2 + \frac{1}{2}m_7 v_7^2 \qquad (4)$$

Assume:

$V1 = (L_1\dot{\theta}_1)^2$

$V2 = \left(L_1\dot{\theta}_1 + L_2\dot{\theta}_2\right)^2$

$V3 = (L_1\dot{\theta}_1 + L_2\dot{\theta}_2 + L_3\dot{\theta}_3)^2$

$V4 = (L_1\dot{\theta}_1 + L_2\dot{\theta}_2 + L_3\dot{\theta}_3 + L_3\dot{\theta}_4)^2$

$V5 = (L_1\dot{\theta}_1 + L_2\dot{\theta}_2 + L_3\dot{\theta}_3 + L_3\dot{\theta}_4 + L_5\dot{\theta}_5)^2$

$V6 = (L_1\dot{\theta}_1 + L_2\dot{\theta}_2 + L_3\dot{\theta}_3 + L_4\dot{\theta}_4 + L_5\dot{\theta}_5 + L_6\dot{\theta}_6)^2$

$V7 = (L_1\dot{\theta}_1 + L_2\dot{\theta}_2 + L_3\dot{\theta}_3 + L_4\dot{\theta}_4 + L_5\dot{\theta}_5 + L_6\dot{\theta}_6 + L_7\dot{\theta}_7)^2$

The total potential energy:

$$\mathrm{P.E} = \mathrm{m_1 g}L_1(1-\cos\theta_1) + \mathrm{m_2 g}\;[L_1(1-\cos\theta_1) + 2(1-\cos\theta_2)] + \mathrm{m_3 g}[L_1(1-\cos\theta_1) + 2(1-\cos\theta_2) + L_3(1-\cos\theta_3)] + \mathrm{m_4 g}[L_1(1-\cos\theta_1) + 2(1-\cos\theta_2) + L_3(1-\cos\theta_3) + L_4(1-\cos\theta_4)] + \mathrm{m_5 g}[L_1(1-\cos\theta_1) + L_2(1-\cos\theta 2) + L_3(1-\cos\theta_3) + L_4(1-\cos\theta_4) + L_5(1-\cos\theta_5)] + \mathrm{m_6 g}[L_1(1-\cos\theta_1) + 2(1-\cos\theta_2) + L_3(1-\cos\theta_3) + L_4(1-\cos\theta_4) + L_5(1-\cos\theta_5) + L_6(1-\cos\theta_6] + \mathrm{m_7}g[L_1(1-\cos\theta_1) + 2(1-\cos\theta_2) + L_3(1-\cos\theta_3) + L_4(1-\cos\theta_4) + L_5(1-\cos\theta_5) + L_6(1-\cos\theta_6) + L_7(1-\cos\theta_7)]$$

2.3.1 Model Generation within ANSYS

Every one of the hubs and components naturally differentiate, with the immediate era strategy, focus the area of each hub and the size, shape, and integration of each component before characterizing these elements in your ANSYS model [11].

2.3.2 Meshing Model

Built solid model, established element attributes, and set meshing controls, you are ready to generate the finite element mesh.

2.3.3 Defining the Analysis Type and Applying Loads

In this progress, we will characterize the examination sort (i.e. static, transient, and so forth.) and examination alternatives (vast avoidance, substantial strain, and extensive uprooting), and afterward apply load steps, Specify burdens utilizing the customary system for applying a solitary load exclusively to the proper element, apply complex limit conditions as even limit conditions.

3. Result & Discussion

3.1. Reviewing the Results

Review these results in POST1, the general postprocessor, or in POST26, the time-history postprocessor.

3.2. Geometry

In the numerical model, the tower's structure is modeled with circular solid cross section (R=25, 50 cm), with dimensions shown below:

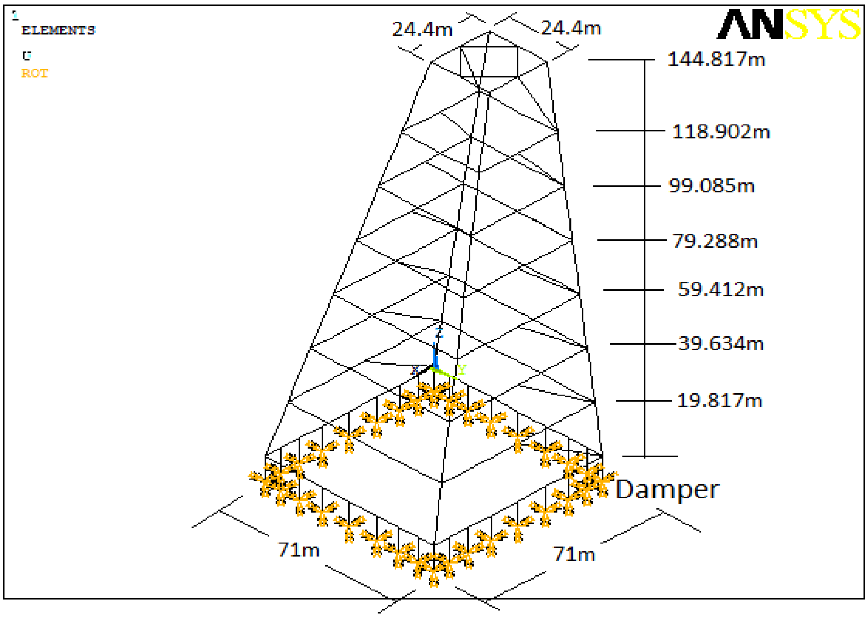


Fig.(6): Tower's Dimensions

3.3. Elements Used:

In the present inspection, the structure is coincided utilizing Beam component called BEAM188. This component is suitable for dissecting thin to respectably squat/thick shaft structures .BEAM188 is a straight (2-hub) or a quadratic bar component in 3-D. BEAM188 has six or seven degrees of flexibility at every hub, with the quantity of degrees of opportunity relying upon the estimation of KEYOPT (1). At the point when KEYOPT (1) = 0 (the default), six degrees of flexibility happen at every hub. These incorporate interpretations in the x, y, and z bearings and turns about the x, y, and z headings. At the point when KEYOPT (1) = 1, a seventh level of flexibility (twisting greatness) is likewise considered. This component is appropriate for straight, expansive revolution, and/or extensive strain nonlinear applications. [8]

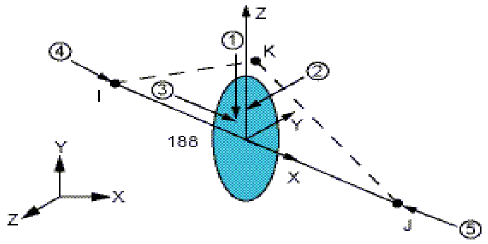


Fig.(7): Beam188 element

The influence of the soil can be articulated to by damper, component COMBIN14 was utilized on the base of the tower.COMBIN14 has longitudinal or torsional ability in 1-D, 2-D, or 3-D applications.

3.4. Mesh Development

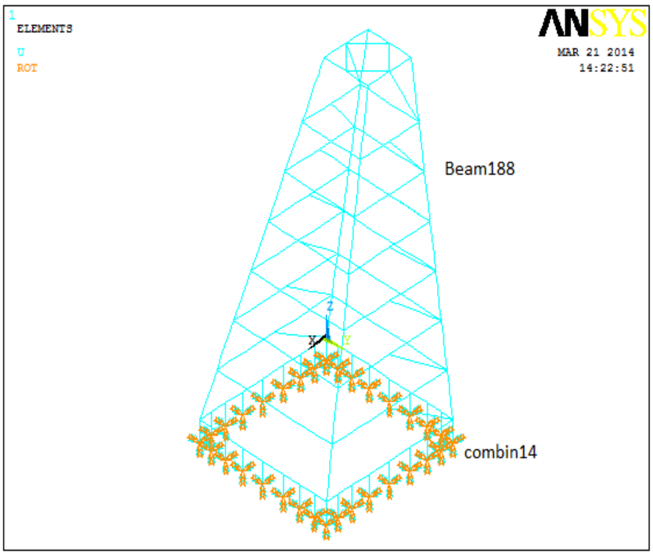


Fig.(8): The mesh of the structure

3.5. Material Properties

Mechanical properties of the material are; Density= 7850 kg/m^3, Modules of Elasticity = 210 *10^{6}kN/m^2, Shear Modulus = 80.9*10^{6}kN/m^2, Passion's ratio = 0.3, Soil: K=1000 kN/m, C= 1000-2000 kN.s/m, Load = Psinωt and cross section R=25 cm, where P=3.44MPa, the deformation of the structure through time (0 to 0.15 sec).

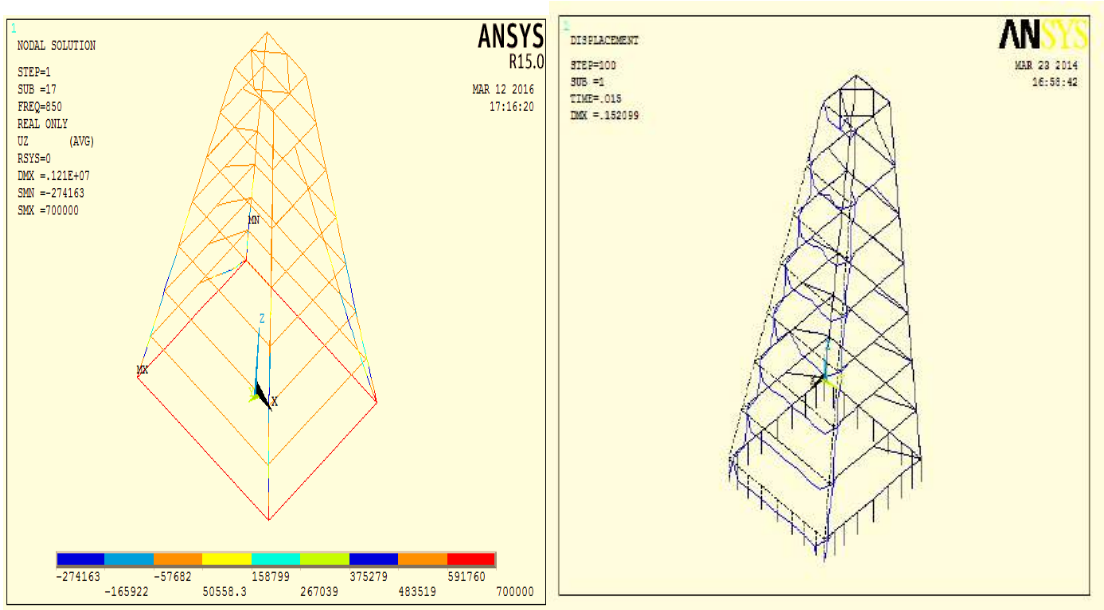


Fig.(9): Response of the structure for R=25cm (Load=Psin(ωt))

Figures (10) and (12) demonstrate that the reaction in x-bearing and z-course separately with time. For low1 expanding time from 0 to 1.5 prompts a reduction accordingly from 0 to - 0.6 in x-heading and from 0 to 3.5*10^{-2} in z-direction. For low2 expanding time from 0 to1.5 prompts a diminishing accordingly from 0 to - 0.091 in x-course and from 0 to - 5.6*10^{-2} in z-bearing. For mid1increasing time from 0 to 1.5 prompts an abatement accordingly from 0 to - 0.092 in x-bearing and from 0 to - 4.9*10^{-2} in z-heading. For mid-2 expanding time from (0 to 1.5) prompts a diminishing accordingly from 0 to - 0.1 in x-heading and from 0 to - 5.62*10-2in z-bearing. For top1 expanding time from 0 to 1.5 prompts a reduction accordingly from 0 to - 0.09 in x-bearing & from 0 to - 4.85*10^{-2}in z-course. For top2 expanding time from 0 to 1.5 prompts a reduction accordingly from 0 to - 0.08 in x-heading and from 0 to - 6*10^{-2}in z-course .

Figure (11) demonstrates that the reaction in y-bearing with time. For low1 expanding time from 0 to 1.5 prompts a lessening accordingly 1.9*10^{-2}. For low2 expanding time from 0 to1.5 prompts an abatement accordingly 5.8*10-2.For mid1increasing time from 0 to 1.5 prompts a lessening accordingly 4.6*10^{-2}. For mid2 expanding time from 0 to 1.5 prompts a decline accordingly $6.3*10^{-2}$. For top1 expanding time from 0 to 1.5 prompts a decline accordingly $5.7*10^{-2}$. For top2 expanding time from 0 to 1.5 prompts a reduction in response$6.4*10^{-2}$.

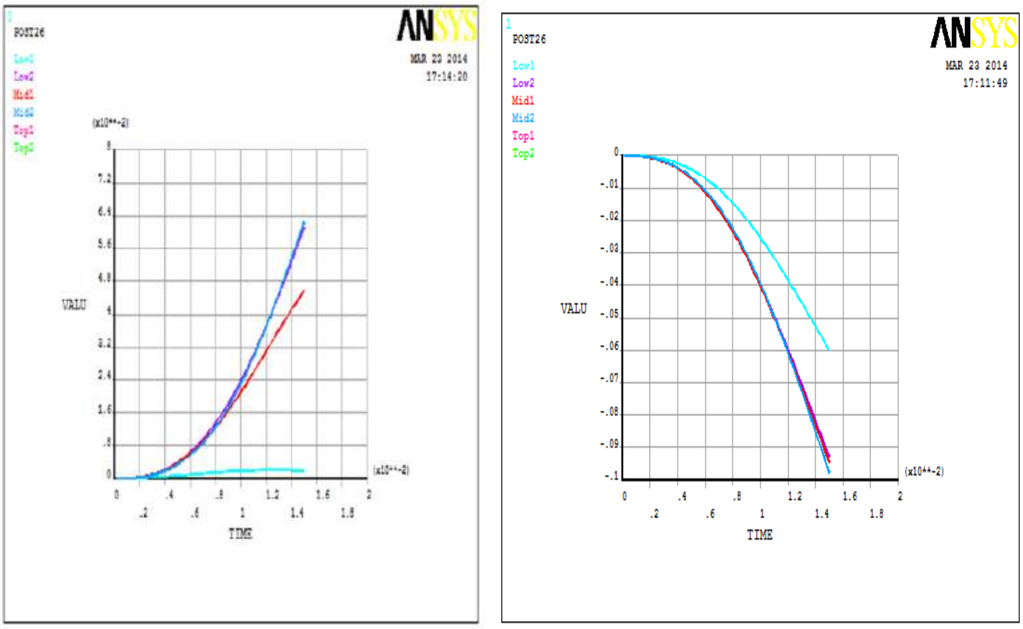


Fig.(10): Response in x and y direction with time domain of the structure for R=25cm (loadPsin(ωt))

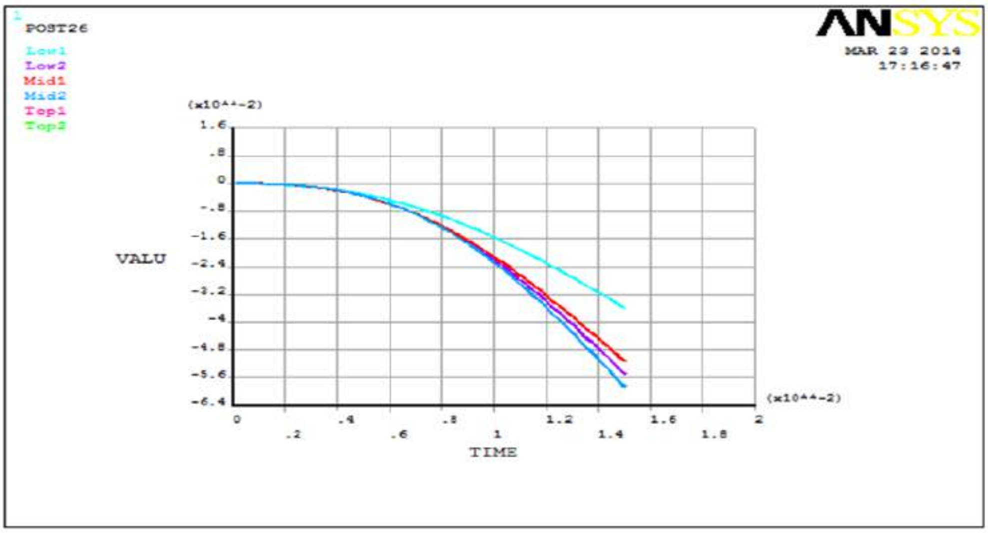


Fig.(11): Response in z- direction with time domain of the structure for R=25cm (load Pin(ωt))

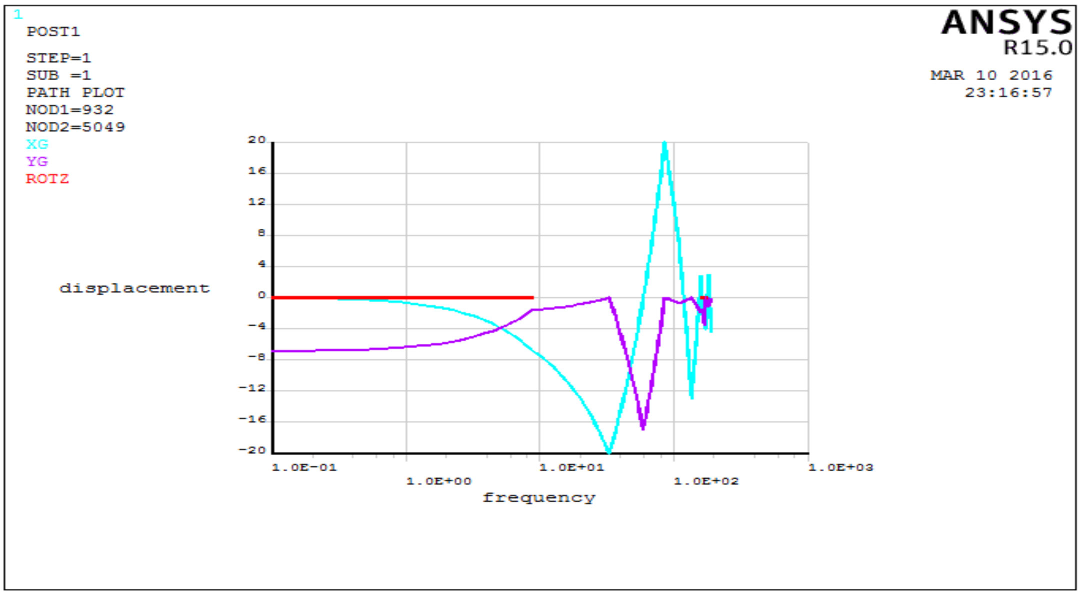


Fig.(12): Response in x, y and z direction with frequency domain of the structure for R=25cm(Load=P sin(ωt))

In case of R=50 cm, the deflection of the structure will be:

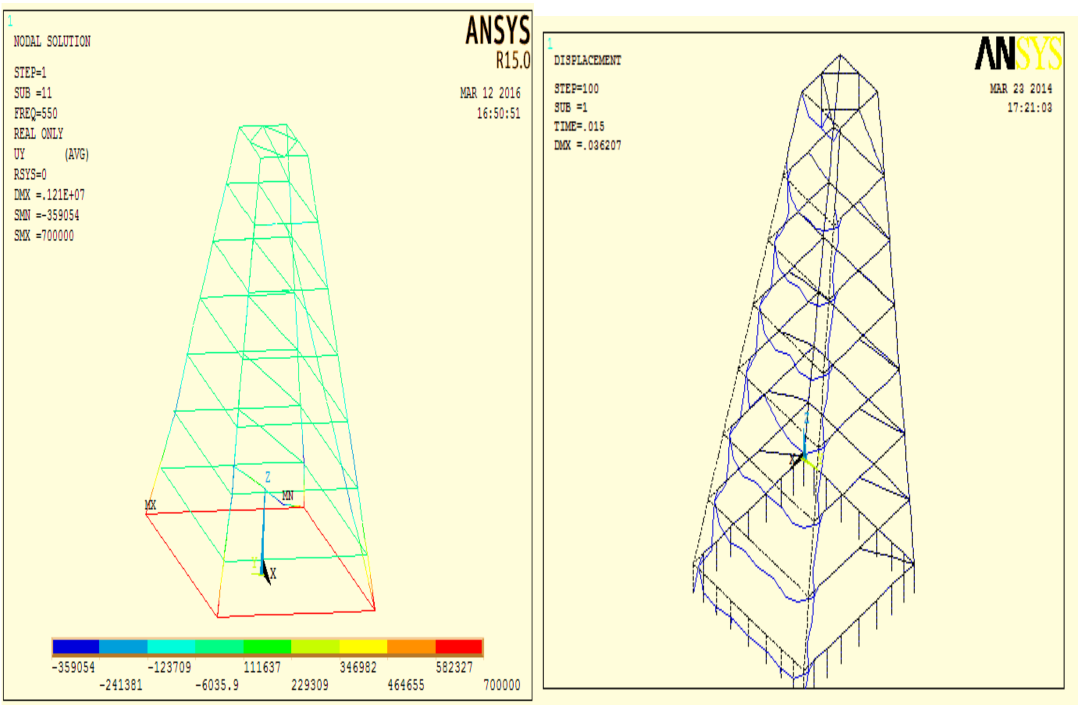


Fig.(13): Response of the structure for R=50 cm (Load=P sin(ωt))

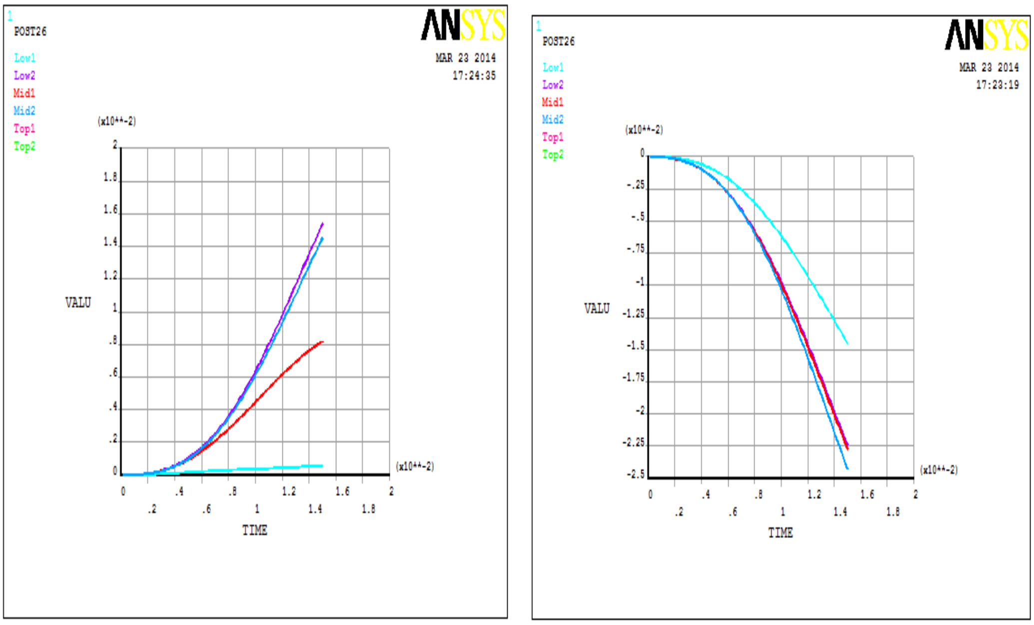


Fig.(14): Response in x and y direction with time domain of the structure for R=50cm(Load=P sin(ωt))

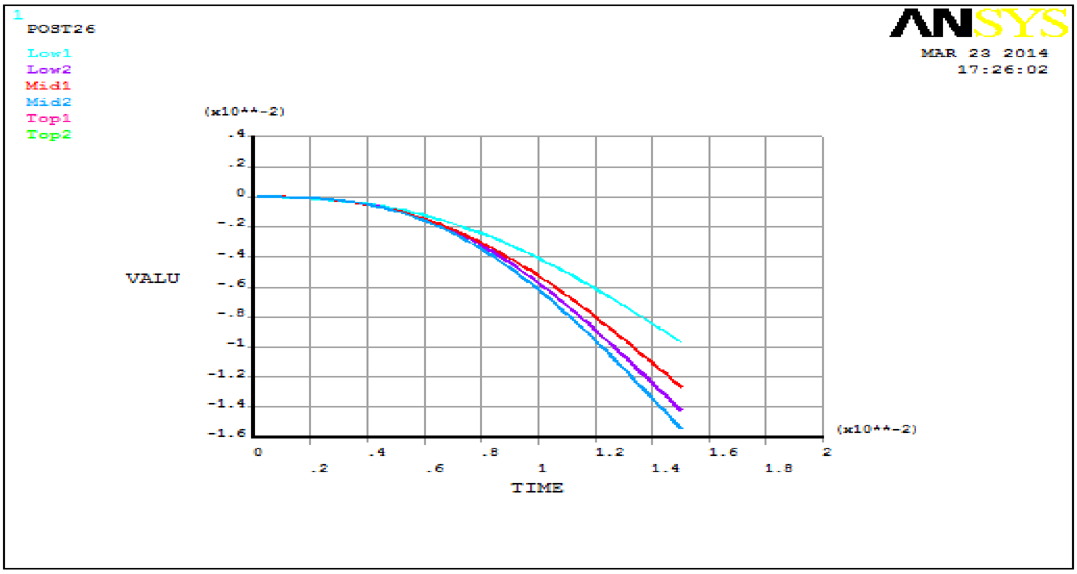
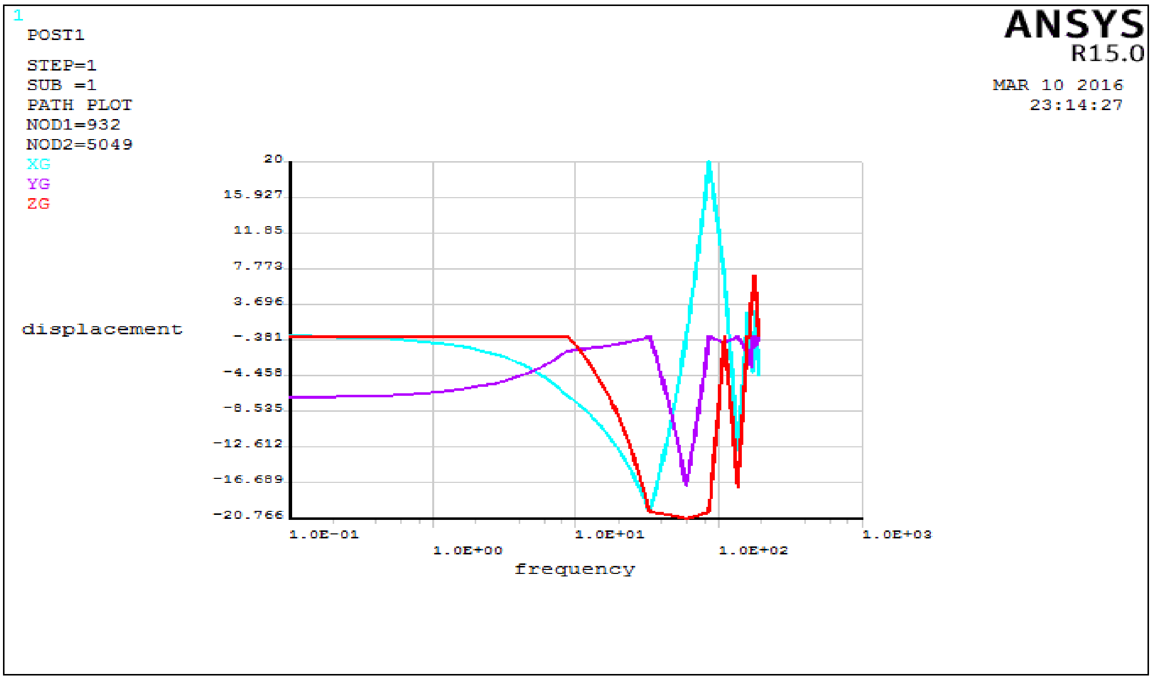


Fig.(15): Response in z- direction with time domain of the structure for R=50cm(Load=P sin(ωt))



Fig(16): Response in y, x and z direction with frequency domain of the structure for R=50cm(Load=P sin(ωt))

For constant Load, Load = P and cross section R=50 cm, where P=3.44MPa ,the deformation of the structure through time (0 to 0.15 sec) .

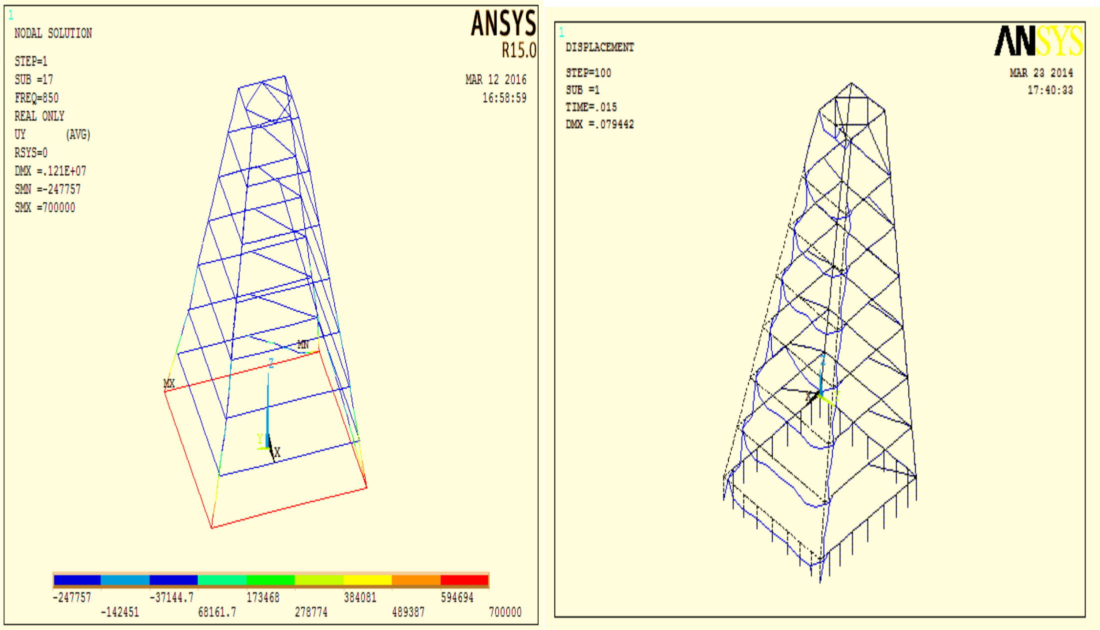


Fig.(17): Response of the structure for R=50cm(constant Load)

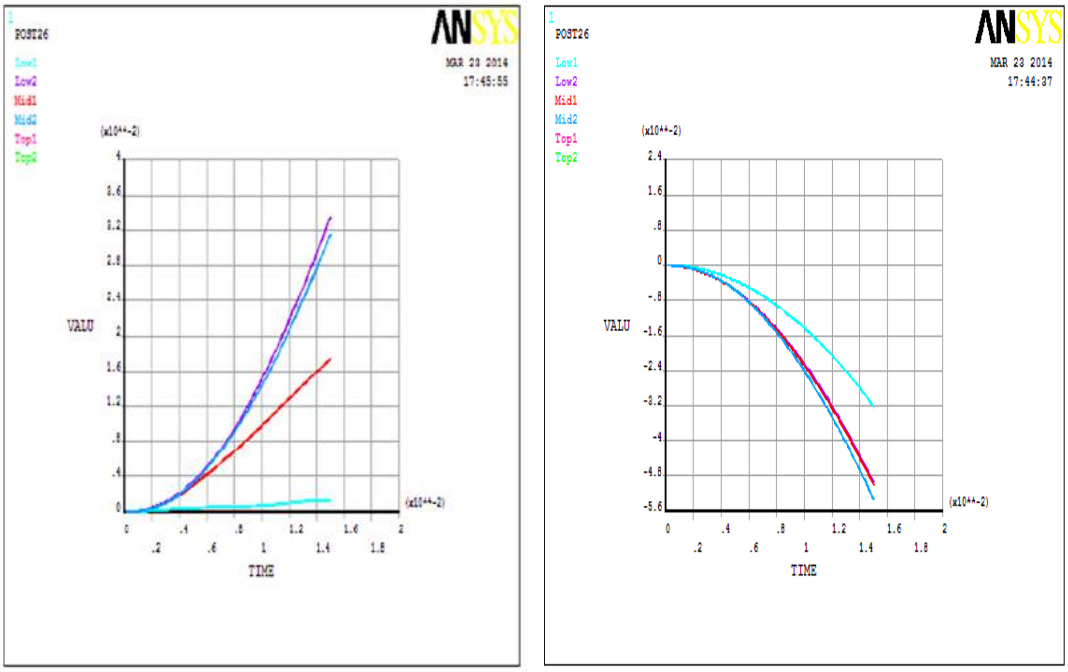


Fig.(18): Response in x and y direction of the structure for R=50cm(constant Load)

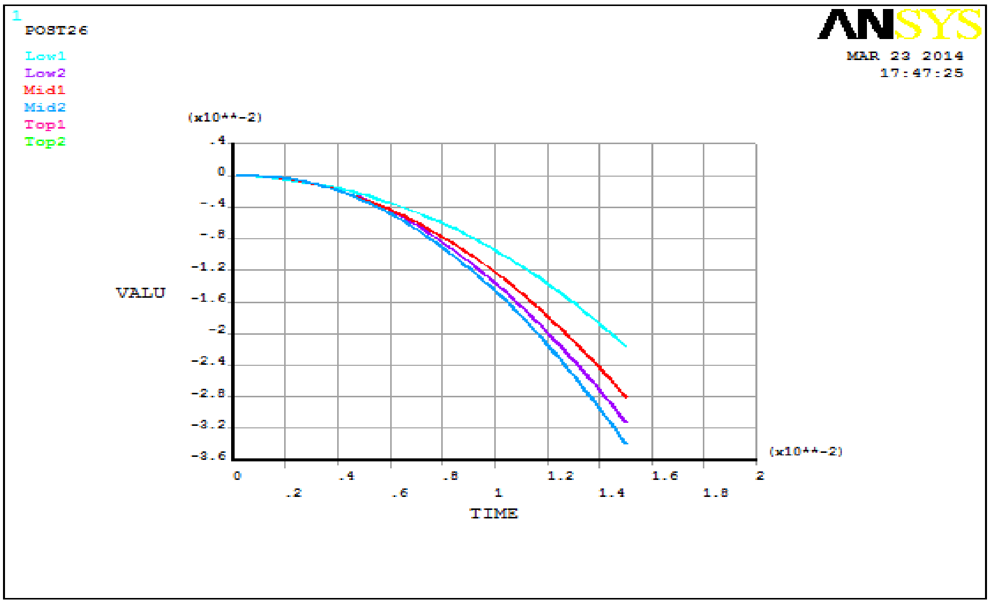


Fig.(20): Response in z- direction of the structure for R=50cm(constant Load)

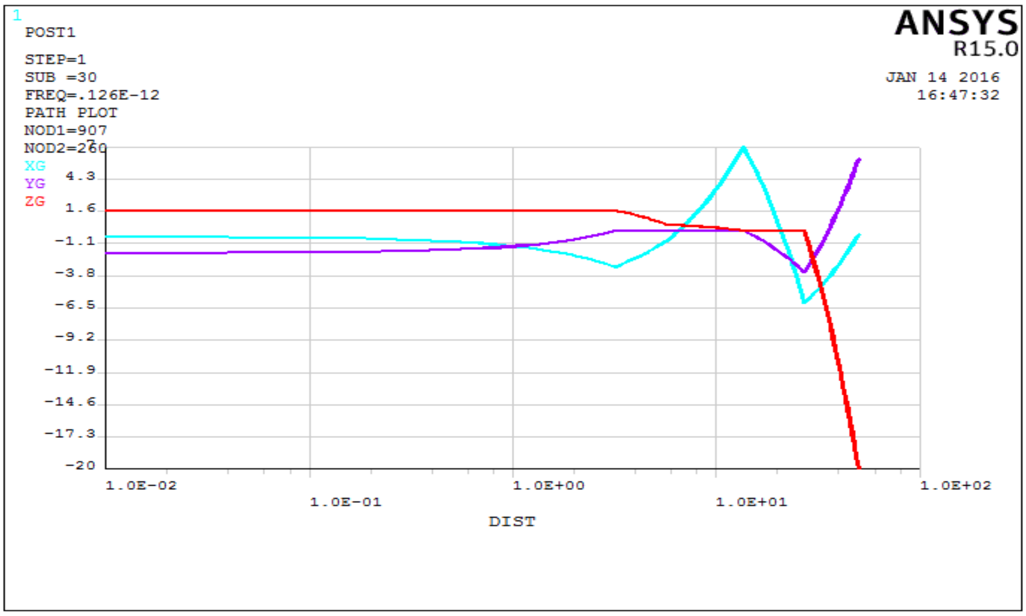


Fig.(19): Response in y, x and z direction with frequency domain of the structure for R=50cm(constant Load)

For constant Load, Load = P and cross section R=25 cm, where P=3.44MPa the deformation of the structure through time (0 to 0.15 sec).

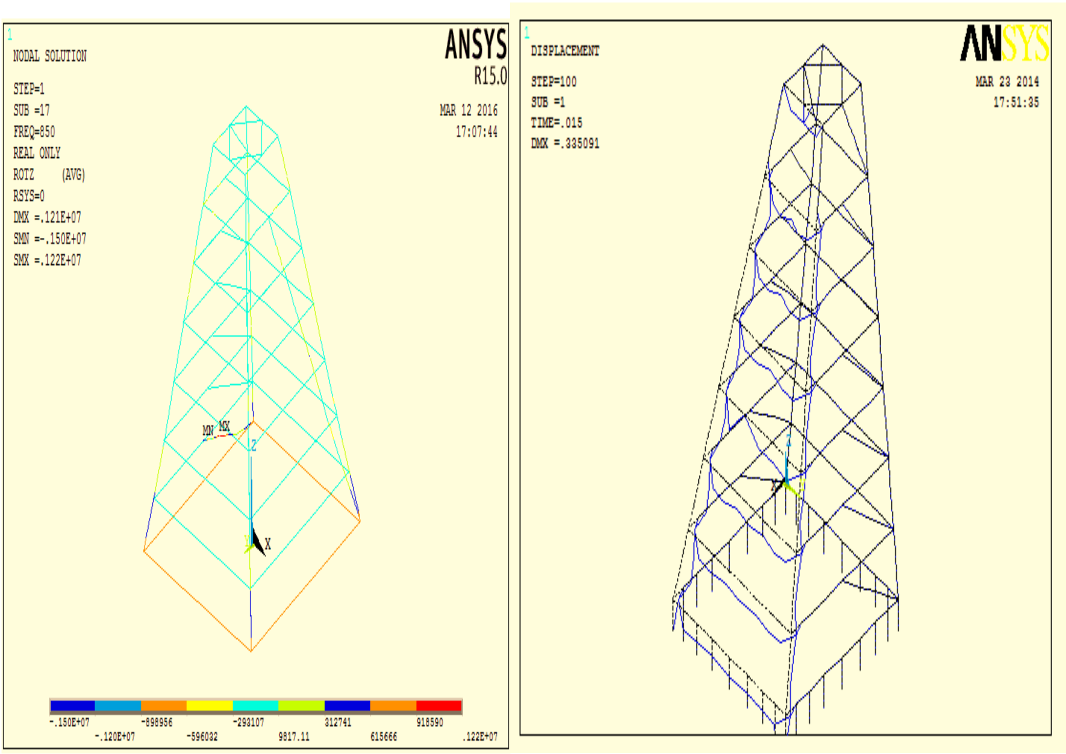


Fig.(21): Response of the structure for R=25cm(constant Load)

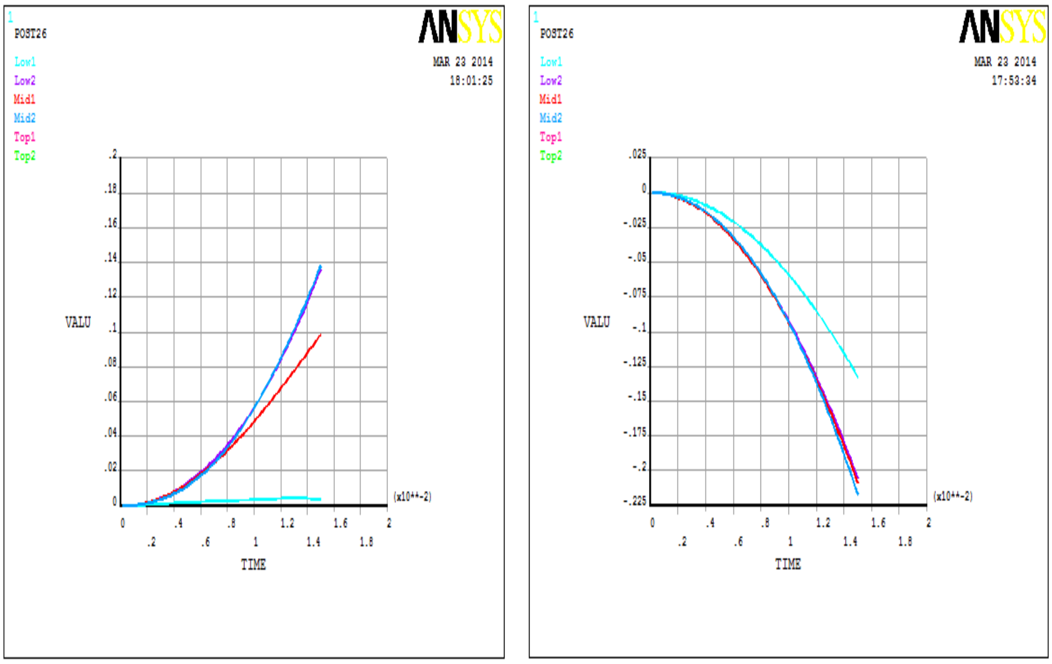


Fig.(22): Response in x-an y direction with time domain of the structure for R=25cm(constant Load)

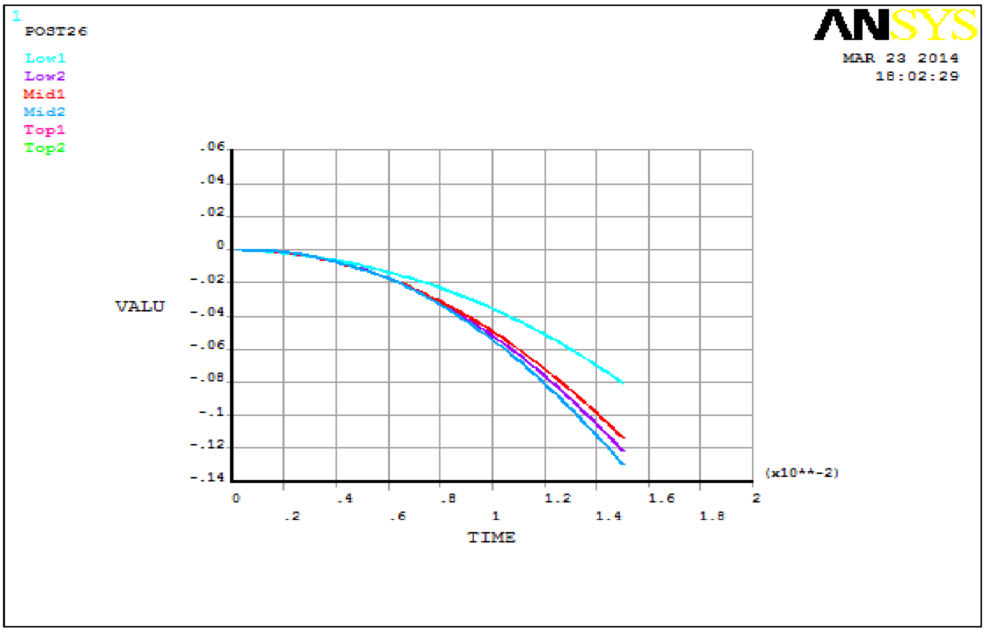


Fig.(23): Response in z- direction with time domain of the structure for R=25cm (constant load)

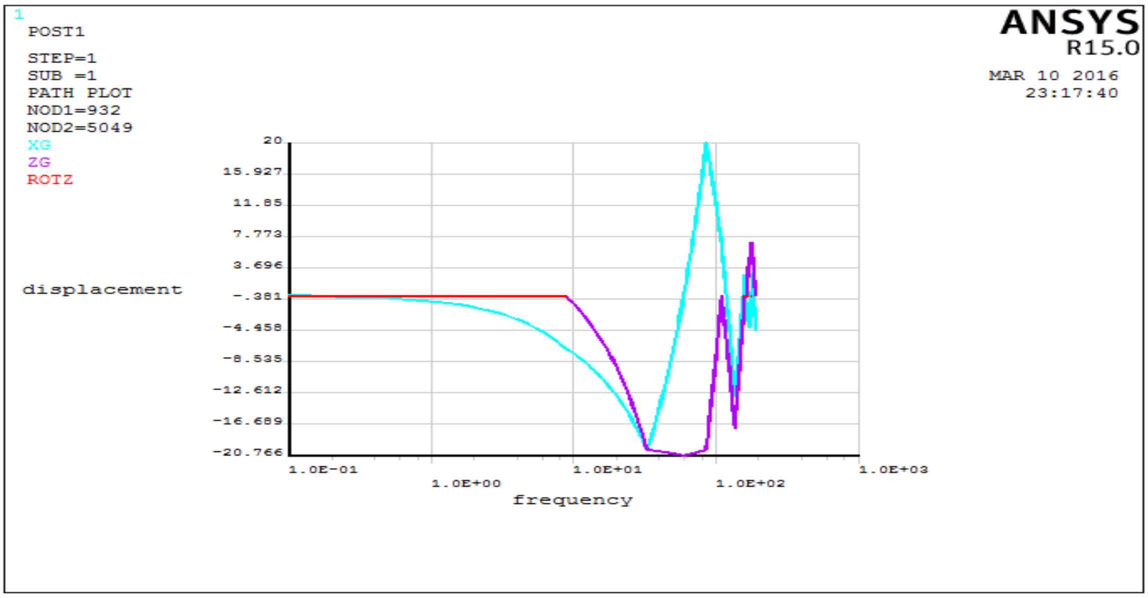


Fig.(24): Response in y, x and z direction with frequency domain of the structure for R=25cm(constant Load)

4. Conclusions

In this paper, the residual stresses of nonlinear random vibrations of high seas of the oil stage because of the wave loads are considered. The structure of the legs can be void to a strain, pressure, and shear rigidity because of the persistent stresses bringing about a structure crack and disappointment. To improve this exploration, the leftover anxieties of the oil stage because of the wave vibration are contemplated. The structure of the platforms can be presented to a pressure and shear push of the remaining stresses bringing about a structure crack and disappointment. Improvement the safety element of these structures.by solution to the issue of persistent anxieties in the joints of structures. Interface component model, gave more satisfactory and sensible results than different models considered. As the most seaward structures are made of steel, along these lines the weakness impact is a definitive outline variable. For every seaward structure with soil-structure cooperation issues subjected to vibration loads Sea wave the principle work is focused on discovering the whole solidness and mass frameworks of the continuum which include the presuming of the inflexibility and mass mesh for the soil structure, and solidness grid for the interface components. Safety element of these structures is presented by solution to the issue of lingering anxieties in the joints of structures. The interface component model, gave more adequate and sensible results than different models considered.

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