Pile Thickness Changing Effects on the Response of Platform Deck and Supporting Piles

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Abstract
Impact forces from berthing of ships have significantly influences which appear for dynamic responses of these offshore structures and must be treated critical dynamic loads during design for these structures. Given their substantial impact on platform safety during berthing, considerations of berthing are important in the design stage. Abaqus program is used to simulate the soil, pile and deck in addition to all secondary members effecting in the response of platform. Model of the pile –soil interaction (PSI) is considered during analysis of platform. The plastic model (which is depended on plasticity theory) is done to simulate the soil where the soil is treated as continues material under long term deformations. Cam clay model is according to theory of plasticity to show the volume changing for different cases of a loadings. The mathematical model for soil is used. 3D brick elements to simulate the soil is performed (C3D20RP), 21 nodes, linear pore pressures, and quadratic equation for displacements. For piles and in addition members for platform deck, (B32) element to achieve that simulation is used where in each of that elements consist of (3Nodes) to make results more accurate. This paper studies the structural response for deck and piles of platform under impact load from ship berthing where Al-Basrah Oil Port (ABOP) represents a case study. Two models in this case are investigated during the F.E.A, with linear behaviour model for the piles and also for the deck, the soil has been treated with nonlinear model. results indicate the natural frequencies of structure are decreasing with any increasing thickness of pile also the results show decreasing in displacement response for pile and deck.

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Keywords: Offshore, Berthing Load, Pile, Soil Plastic Model, Abaqus.

1. Introduction

Fixed offshore plaatforms have usually used to support the above steel decks by using gravity concrete as a base or using the steel piles. The platform has been subjected and under different environmental of loading during its lifetime where sea waves, storms and earthquake are explained in API [1]. M.Fatimii [2] studies effects under dynamic impact loads taking in the the consideration pile –soil and its interaction by using 2D model of finite element to simulate the steel jacket structure. Ali mohmmad [3] considered the batter pile group under seismic loads where 3D Finite Element Method to find the dynamic response are used and the constitutive model to simulate soil for analysis is a Hardening Drucker-Prager model. In this paper the effect of different thicknesses for piles and its effects on the response of platform structure of ABOP under dynamic load of impact is studied.

2. Platform Description

AL-BASRAH OIL PORT (ABOP) south of iroq is taken a case for study the platform (A) for port taking as mooring from steel structure. The platform is supported by fourteen piles for the deck. Water 30 m depth. Without steel jacket, the superstructure is pile supporting and the piles are from the lower base of deck until reach stiff supporting soil where any jacket also diagonal members are not constructed. The inclined steel piles with ratio (1:4) are done.

Level for deck surface is 9 m more than Mean Sea Level (MSL) with piles its length reach to 34.5 m until the bed of sea and the total pile length 81.5 m to level of tip pile. The diameter is 1.20 m for each pile and sections for construction the deck is different where the dimension 9.15m *12.19m for each deck. Figure (1) shows the dimension of deck piles.

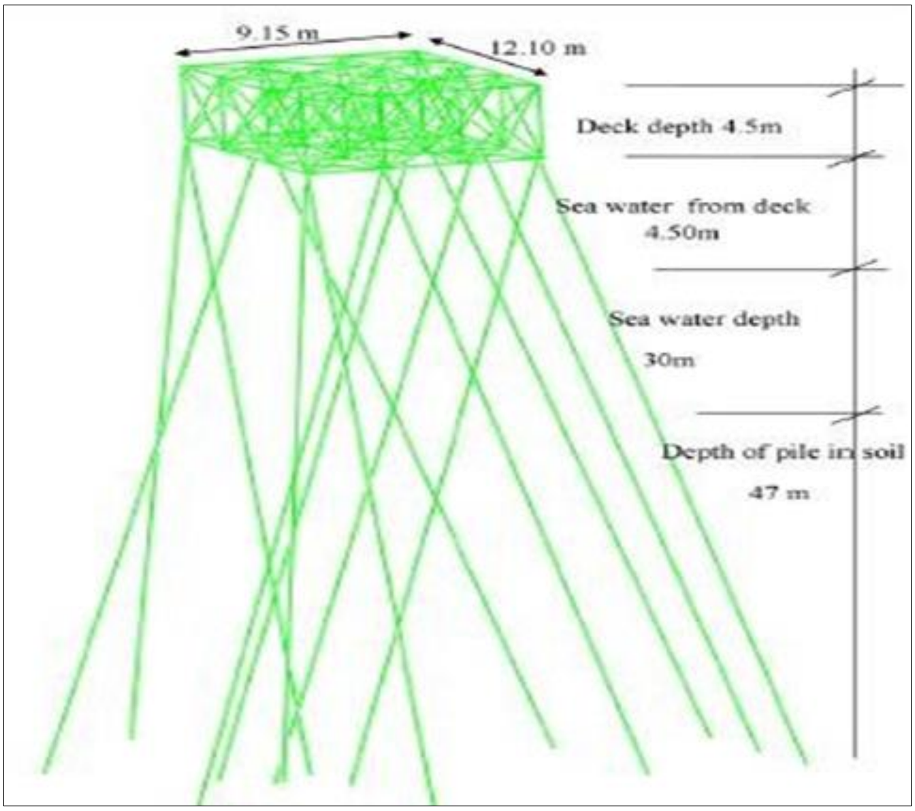

Fig 1: Fixed platform

3. Finite Element Analysis

Three-dimensional model by using a finite element for (ABOP) is performed on it. A ABAQUS (program) to simulate platform and at the same time the soil situation of nonlinear are done. In this paper, the elements used for soil, piles and the other members of deck are suitable with the behavior for actually situation of each elements.

3.1. Elements for Each Problems

Based on the library for the ABAQUS software program, the elements have been chosen depending on physical situation under these applied loads. For the soil, (C3D20RP) is used, featuring 20 nodes, linear pressure and quadratic shape function for all displacements [4]. For battered piles and for surface decking structural steel members, the B32 selected as simulation element for beams. This element deals with (3n) per member, allowing for greater accuracy in results by employing a quadratic polynomial equation. Each node has six degrees three for translations movement and threefor rotations movement (Figures 2 & 3).).

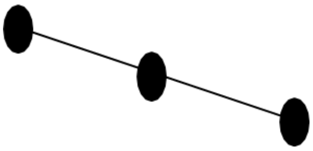

Fig 2: Quadratic frame element.

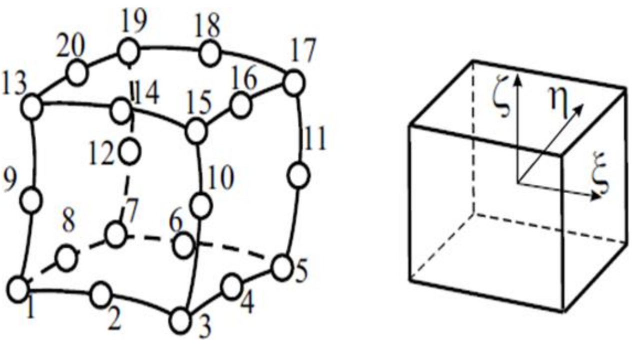

Fig 3: Brick element.

4. Soil in Constitutive Model

The relationship to show stress and strain behavior is defined as a constitutive model, which characterize material behavior as either elastic or behave as plastic. In laboratory the tests have been employed for determination required parameters for these models. By integrating both experimental and computational approaches, engineers can achieve a more comprehensive understanding of soil mechanics and improve the reliability of geotechnical designs.

4.1. Non-Linear Model

When the materials in plastic behavior are subjected to any loading, it undergoes both elastic strain and then to plastic strain, therefore it is not be able returning after that to its beginning state. Regarding to theory of elasticity, Hooke's law is using as suitable method for determining at elastic phase, while the plasticity theories are more required to estimate plastic stress strain relation. The plasticity theory has been used to specify the behavior of materials under the applied loads after exceeding the elastic phase [5]. This applied theory deals with specific parameters to characterize materials also, provides mathematical models to assess their response in both elastic and plastic deformation stages. Various plasticity models exist to represent any soil and made required analysis, and in this study, the Cam Clay model is employed.

4.2. CAM Clay Model for the Soil Simulation (CCM)

The model Cam Clay is depending on theory describing the plasticity and is used to find volume changes with various conditions of loading [6]. The critical state theory is employed in the cam clay model to make predication of strength for different kinds of soil under pressure and also when the volume changes have been found duo to shearing. The critical state theory contains 3 main stresses parameters (effective mean stress (p′) - devitoric stress (shear stress) q - specfic volume (ν)). Based on the principal stresses, the effectve mean stress and also shear stress are calculated.

$$p' = \frac{1}{3}(\sigma'_1 + \sigma'_2 + \sigma'_3)$$

$$q = \frac{1}{\sqrt{2}}\sqrt{(\sigma'_1 - \sigma'_2)^2 + (\sigma'_2 - \sigma'_3)^2 + (\sigma'_3 - \sigma'_1)^2}$$

where the specified volume considered as (υ = 1+e). In (p′-q) which is seen in figure (4), the yield surface which represent Cam clay envelop which is un ellipse shape and it is formed by equation (3)

$$\frac{q^2}{p'^2} + M^2\,(1 - \frac{p'c}{p'})$$

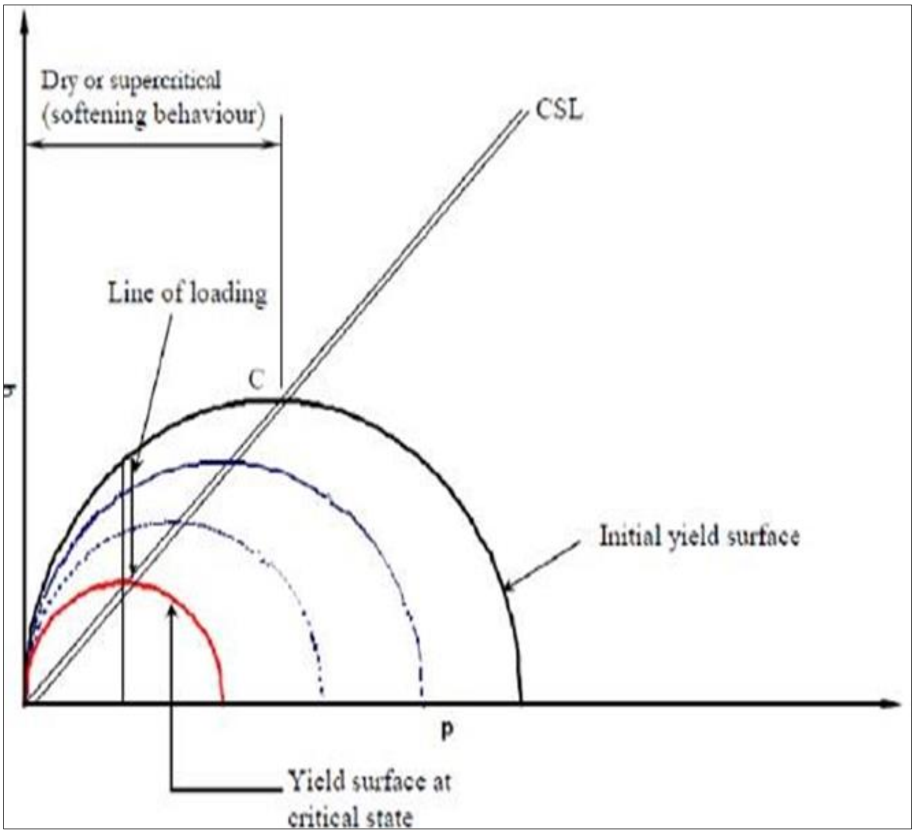

Fig 4: Surface of Cam clay yield (5).

5. Cam Clay Parameters

The CCM is widely used to simulate clayey soil behavior as plastic modeling. The model's parameters of this type of model are take it from laboratory experimental test, where defining yield criteria of surfac failure is a crucial step in its application. To establish the initial yield surface, historical field conditions must be considered. Figure (5) illustrates the calculated mean stresses, where the critical state line at this model intersects the yield failure surfaces at point of maximum deviatoric stress. Figure (6) illustrated the relationship between deviatoric stress, volumetric strain, in addition to mean effective stress under loading conditions. All soil parameters are summarized as shown at Table (1).

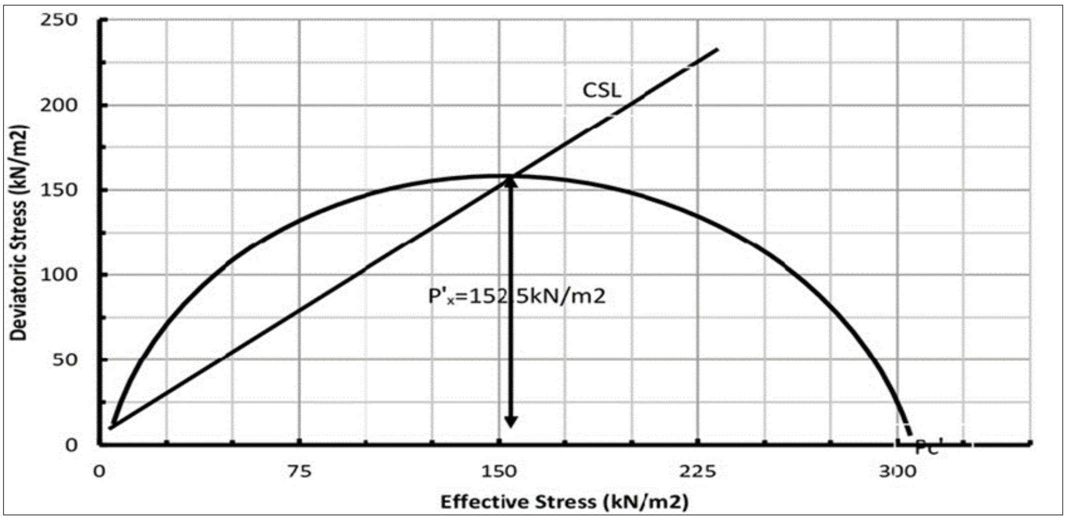

Fig 5: Critical State Line.

Table 1: Cam Clay Parameters.

	Parameter		
S. No.	**Soil**	**Elastic Model**	**Plastic Model**
2	ρ (kg/m³) = 2170	K = 0.027	λ = 0.173
3	e_0 = 0.45	υ = 0.3	Stress ratio M = 1
4	γw (kN/m²) = 9.81		Initial yield surface = 152.5 kN/m²
5	Shear stress (kN/m²)		Wet yield & flow stress rate = 1

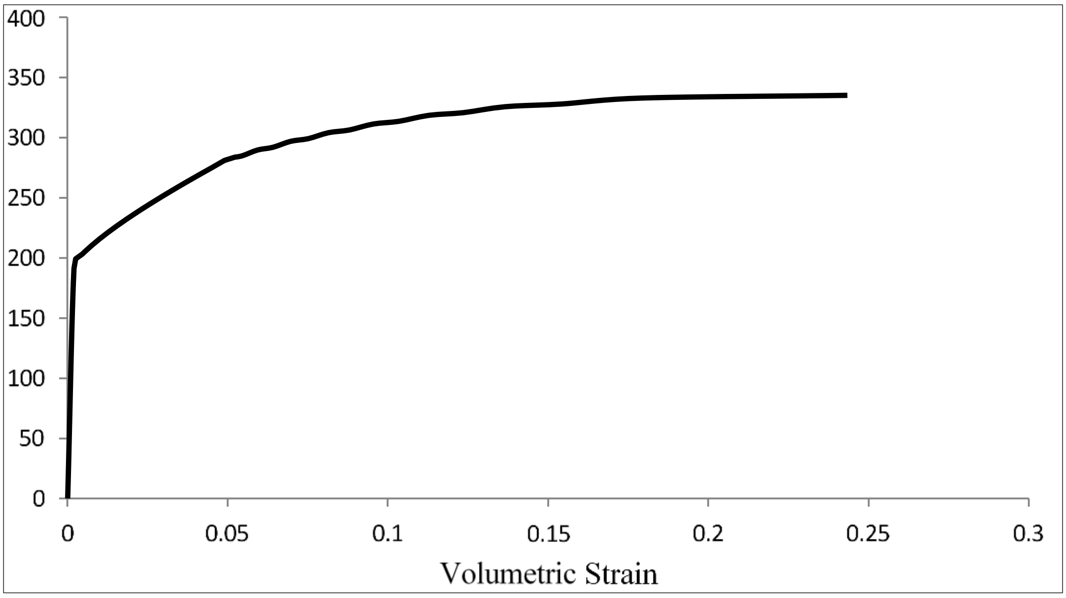

Fig 6: Strain –mean effective stress.

6. Load Representation

The platform is subjected to impact loads generated during ship berthing. These impact loads occur when the vessel comes into contact with the fender system, which absorbs the kinetic energy, thereby reducing the force transmitted to the berthing dolphin. To ensure structural safety, the kinetic energy of the berthing vessel is calculated and compared with the energy absorption capacity of the selected fender system. Based on this analysis, the required number of fender units is determined, that would be achievement the induced stresses remain within permissible limits and comply with allowable design criteria. In this paper, a new method is used to draw time reaction diagram for cylindrical rubber fenders subjected to impact load with different berthing velocity from ship berthing with 330,000 TON. Force envelop is used to contain response and to give accurate result in comparing with classical static method. This force envelop is used for the simulation vessel impact.

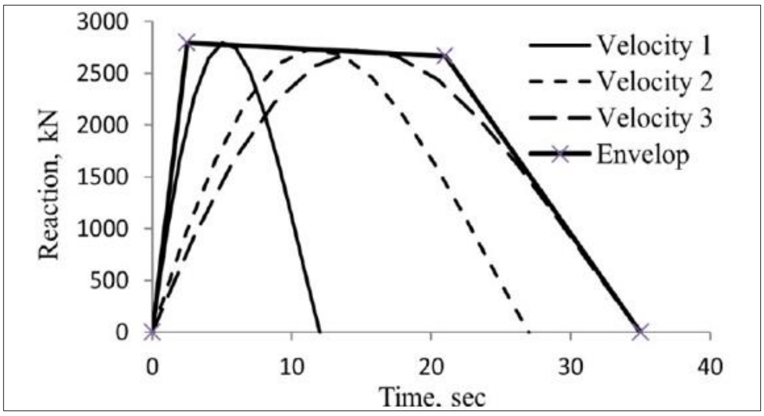

Fig 7: Force envelop time-reaction for different berthing velocities.

7. Pile Diameters and Thicknesses Effects on Response

Piles with the same thickness is discussed under changing its diameter. The analysis is done to find natural frequency for structure and the response of piles where platform responses are investigated. The frequencies of platform are illustrated at table (2).

Table 2: First natural frequency for the pile with different diameters and thicknesses.

Pile diameter	800mm	1000mm	1200mm
Thickness 25mm	0.1167	0.1170	0.1326
Thickness 16mm	0.1085	0.1157	0.1241
Thickness 12.5mm	0.1030	0.1122	0.1193

For same thickness the natural frequency is increasing as soon as increasing the diameters while for the same diameter there is also increasing in natural frequency with increasing thicknesses. these results are due to stiffness increasing for pile and then it is affecting in the value of natural frequency. In figure (8) to figure (11), there is reduced in the response for deck displacement with the increasing in diameters or thicknesses. For the same thickness, the reduction in deck displacement makes linearly decreases relationship as the diameter increases because the pile's stiffness becomes significantly higher. Decreasing in moment distribution along pile length is clear with increasing pile diameters.

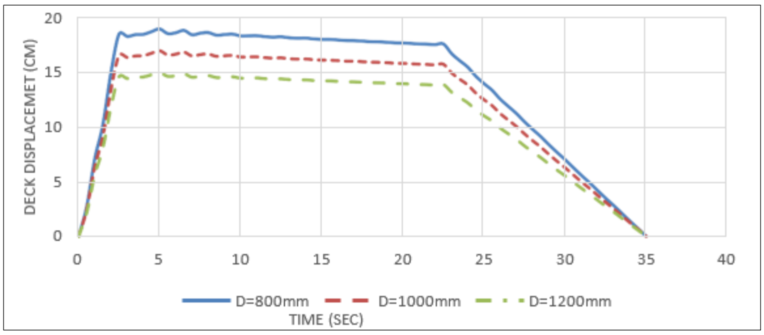

Fig 8: Deck displacement with time for pile thickness 25mm.

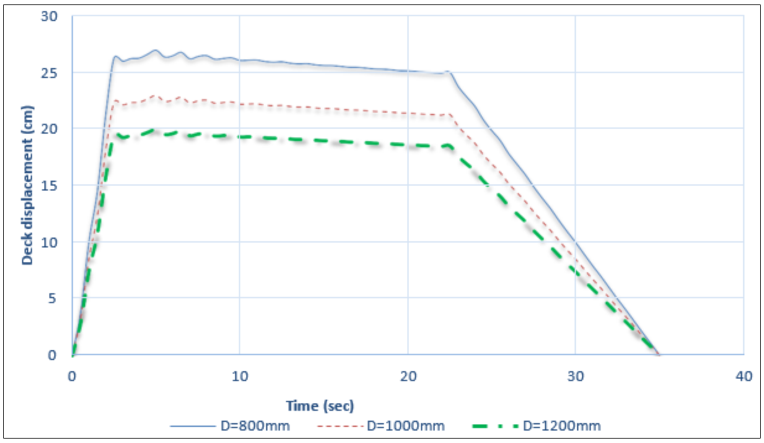

Fig 9: Deck displacement with time for pile thickness 16 mm.

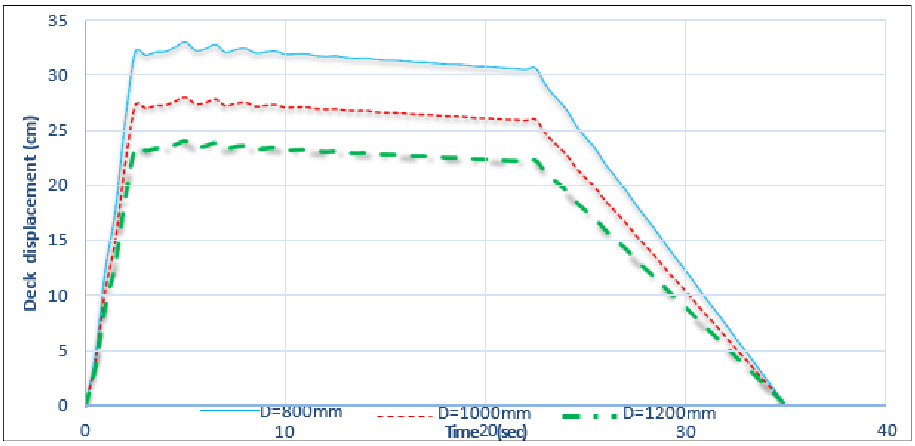

Fig 10: Deck displacement with time for pile thickness 12 mm.

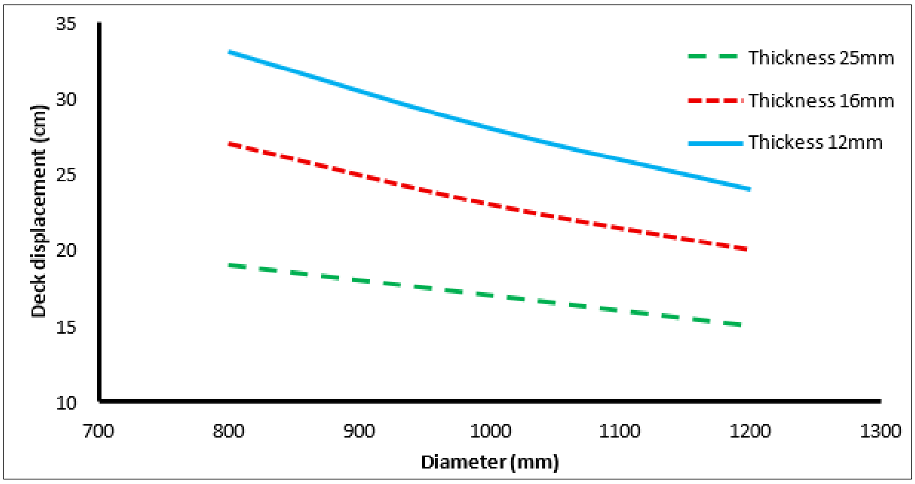

Fig 11: Deck displacement with diameters for different thicknesses.

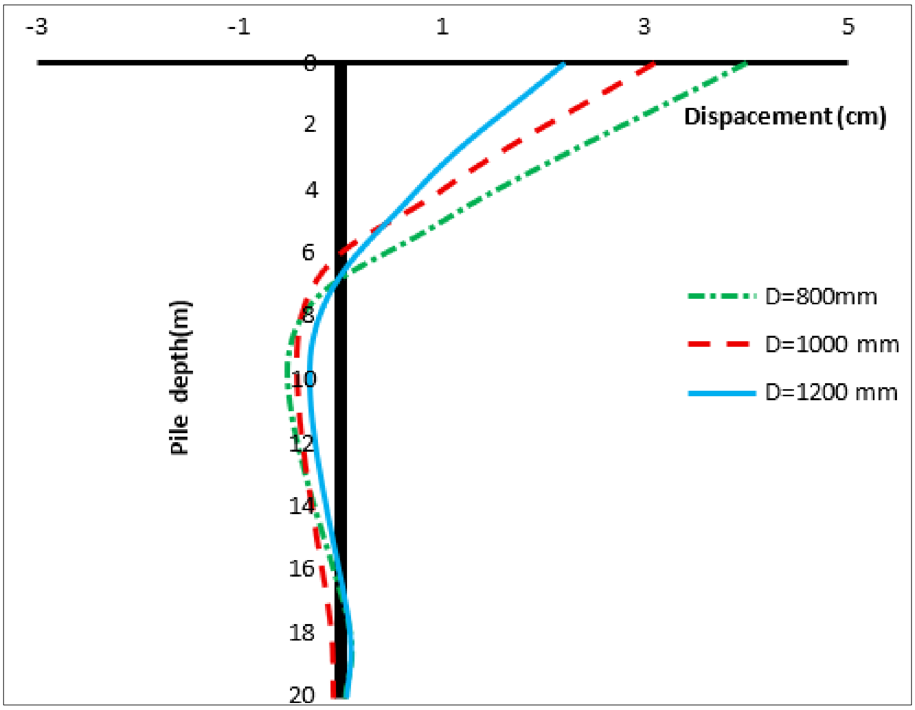

Fig 12: Pile head displacement with depth for different diameters.

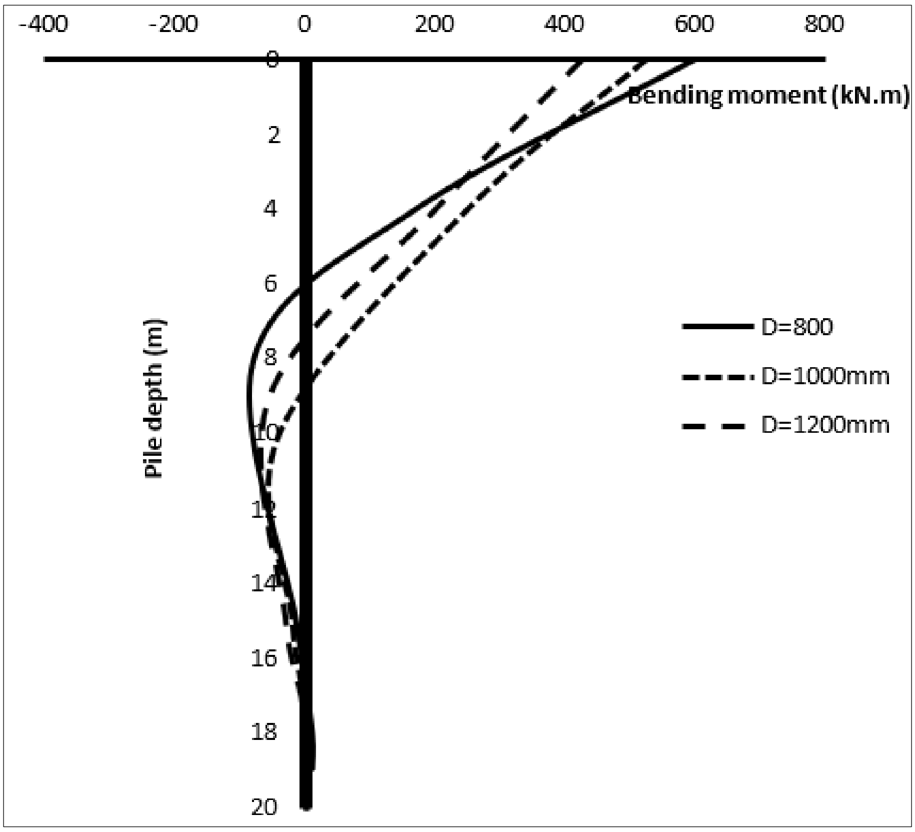

Fig 13: Moment distribution along pile for different diameters.

8. Conclusion

The main conclusions are:

1. For a constant thickness, increasing the diameter of the pile leads to an increase in natural frequency.
2. Larger diameters piles or thicker piles lead to a reduction in deck displacement response and also in pile head displacement response.
3. Larger diameters piles or thicker piles lead to a reduction in moment at head of piles and long its length.
4. Linearly relationship between diameter and deck displacement for the constant pile thickness.

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