Effect of Raft Thickness on Settlement and Straining Actions in the Raft Rested on Piles

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ABSTRACT

*The present study is mainly based on the determination of the effect of raft thickness on settlement and straining actions in the raft rested on piles and the effect of the contact of the raft to the soil . The pile diameter is fixed (D = 0.5 m) , spacing between piles are fixed (Sp = 4.5D) with various raft thickness (D_R = 1m, 1.25m, 1.5m,1.75m and 2m). The pile length is 32D and the dimensions of raft are 10*10 m . Finite element package of a PLAXIS 3D version 2013. (a finite element code for soil and rock analysis) has been used to determine the bending moment, the shear force on the raft and The settlement of piled raft foundation. In the case of rested piled raft foundation it was found that the bending moment in the raft increase from 7% to 14%, the shear force in the raft increase 1% to 0.5% and the settlement of piled raft decrease from 4%to 2% by increasing the raft thickness.in the case of raft act as slab connected the piles it was found that the bending moment in the raft increase from 8% to 14%, the shear force in the raft increase 0.5% and the settlement of piled raft increase from 2% to 1.5% by increasing the raft thickness. It also found that the bending moment in the raft in the case of slab connected the piles is greater than the case of piled raft rested on the soil by 10% to 6% It also found that shear force in the raft as slab connected the piles is greater than rested piled raft by 13% .The settlement in the case raft act as slab connected the piles is greater than rested piled raft by 25% to 15%*

Keywords Raft thickness, Pile Raft Foundation

1. INTRODUCTION

The straining action and the settlement in piled raft foundation is affected by a number of different factor as raft thickness .

Elgendy, M. et al. (2009) presented an analysis for piled raft foundation by finite element method. Varied cases have been carried out to get the optimization of the piled raft. It was observed that the maximum settlement in piled raft slightly decreases with increase of raft thickness. For 0.1m increase in raft thickness reduces settlement about 1 %. The moment in piled raft is affected by pile length, pile spacing, pile diameter and raft thickness. The increase in pile length and pile spacing decreases the moment, while the increase in raft thickness increases the moment. The Moment in piled raft is nearly does not affected by pile diameter. Elsami, A. (2010) conducted a study on optimized piled-raft foundations performance with connected and non-connected piles. It was concluded Raft thickness has no significant effect on the average settlement and internal shear forces, but, has a great effect on the differential settlement and the maximum internal moment. The higher thickness of the raft gives higher maximum internal moment but the lower in the differential settlement.

John, R. and Gahlot, R. (2015) presented an approximate analysis of piled raft by finite element program piles were modeled as spring raft as beam on elastic foundation .It was observed that raft was 1.5 m and the settlement was found to be 16 mm and differential settlement was also 12.68 mm. After increasing the thickness to 3.0 m with an increment of 500mm, it has been observed that the settlement reduces to 10.00 mm, whereas differential settlement reduces to 3.14mm. It is also observed that with increase in raft thickness the dead load increase which results in increase in maximum bending moment . However increase in raft thickness is advantageous for punching shear.

Tjandra, D. et al. (2015) Studied the analysis of piled raft foundation on soft soil using PLAXIS 2D. The raft and the piles were modeled as plate elements. On the surface, there is a 5 m thick fill layer. The next layer is soft clay from 5 m to 13 m depth. The silty clay is from 13 m to 20 m. The design process for piled rafts in this study involves three stages. A preliminary stage was to assess the required raft thickness. A second stage was done to assess the required pile length in the piled raft system. The final stage was to obtain the optimum number of piles. In order to determine required raft thickness considering the settlement, the thickness was varied

between 0.4 to 1.6 m in the preliminary stage. The settlement of raft decreases with the increase in raft thickness. When the raft thickness varied from 0.8 m to 1.6 m, the settlements of raft have no significant difference. Thus, for further analysis the raft thickness of 0.8 m was used.

Rabiei. M. (2016) presented an analysis of piled raft foundation to study the effect of raft thickness on oiled raft foundation . finite element program take place in this study. model with 9 piles was analysis with various raft thickness .It was found that as the raft thickness increase the bending moment of the raft increase .The settlement and the differential settlement decrees as the raft thickness increase

Deshapande, R. D. et al. (2016) conducted a Parametric Study on the behavior of raft foundation for an irregular high-rise building finite element analysis were used it was found that the maximum settlement has decreased with the increase in the raft thickness .The maximum bending moment increases with the increase in the raft thickness .Soil pressure increases with the increase in the raft thickness. The maximum shear force increases with the increase in the raft thickness .

Roy, S. (2017) studied the pile-raft-soil interaction by finite element analysis . modelling of the foundation soil for the piled raft system was done with 15 nodes elements. Piles and raft are modelled as solid plate element. The complete model with 15 nodes for individual soil element. It was found that Load sharing between the raft and pile for different raft thickness and pile spacing and ratio of raft width to pile diameter are plotted. The percentage of load shared by the raft is found to decrease with increase of raft thickness. Raft with lower thickness is found to take more load than the thicker raft. Further, plotted data shows that increasing the raft thickness does not influence the load sharing to the pile as a whole

Saif . A. et.al. (2021) presented Parametric Study of Piled Raft Foundation for High Rise Buildings it was found that

1. Maximum pressure, settlement and differential settlement decreases only up to a limit on increasing raft thickness. After that increasing raft thickness has no significant benefit. Rather the maximum moment increases with increasing raft thickness and may lead to uneconomical sections and higher steel demand

2. Proposed model:

In the present study, a theoretical analysis has been done for a selected site (in governmental project in Semesta city, Beni-suef, Governorate, Egypt). Fig. (1) illustrates a borehole for the pervious site was chosen to be used in the analysis. The soil consists of six layers and simulated by a semi-infinite element isotropic homogenous elastic material

The analysis model consists of piled-raft foundation consists of 25 piles their diameters are fixed (D = 0.5m) and the spacing between piles is fixed (Sp = 4.5D) and they have various raft thickness (D_R= 1 m,1.25 m,1.5 m 1.75 m and 2 m) with pile length 32D. Analysis carried out on two rested piled raft and raft act as slab connected the piles The details and variation of these selected parameters are listed in table (1)

3.FINITE ELEMENT MODEL:

The used computer program for proposal a three-dimensional finite el**e**ment package of a PLAXIS 3D version 2013 model in order to simulate theoretically effect of raft thickness in piled raft pile raft foundation .The raft are represent as plate rested on 25 embedded piles while the soil are represented by Mohr- coulomb model involves five input parameters , i.e. E and v for elasticity ,Φ and c for soil plasticity and ψ as angle of dilatancy.

Depth (m)		legend of borhole	end of layer	S.P.t or %Rec	un confined QU KN/m2	Description
1 2			2			Silty sand and trace of clay
3 4			4			silty sand
5 6 7 8 9 10 11 12			12	12	100	medium stiff clay
13 14 15 16 17 18 19 20			20	33		dense sand

Fig. (1): Borehole Log for Soilused Sesmeta, Beni-Suef Governorate, Egypt Proje

Table (1): Investigated cases of study

N0.	Number of piles	pile diameter (m)	The contact of the raft to the soil	Raft Thickness(m)	Pile spacing	Length Of the piles
1 2 3 4 5	25	0.5	Rested on the soil	1.00 1.25 1.50 1.75 2.00	4.5D	32D
6 7 8 9 10	25	0.5	Raft act as slab connected the piles	1.00 1.25 1.50 1.75 2.00	4.5D	32D

Table (2): Properties For Soil Layers

Parameters	Name	Silty sand and traces clay	Silty sand	Medium to stiff clay	dense sand	unit
Material model	-	Moher column	Moher column	Moher column	Moher column	-
Thickness	T	2	2	8	8	m
Young,s modulus	Es	7500	8000	3000	15000	kN/m^2
Unit weight	ɣ	17	16.6	17	18	kN/m^3
Poisson ratio	υ	0.3	0.4	0.3	0.25	-
Cohesion	c	25	12.5	30	0	kN/m^2
Friction angle	Ø	25	35	0	37	°

Table (3): pile and raft properties

Parameters	Pile	Raft
Material model	Elastic	Elastic
Types of material	Concrete	Concrete
Diameter (m)	0.5	-
Pile length (D)	32	-
Unit weight (kN/m^3)	25	25
young's modulus Es (kN/m^2)	24*10^6	24*10^6
Poisson ratio (υ)	0.2	0.2
Cohesion (Cu) (kN/m^2)	-	-
Friction angle (Ø) (°)	-	-

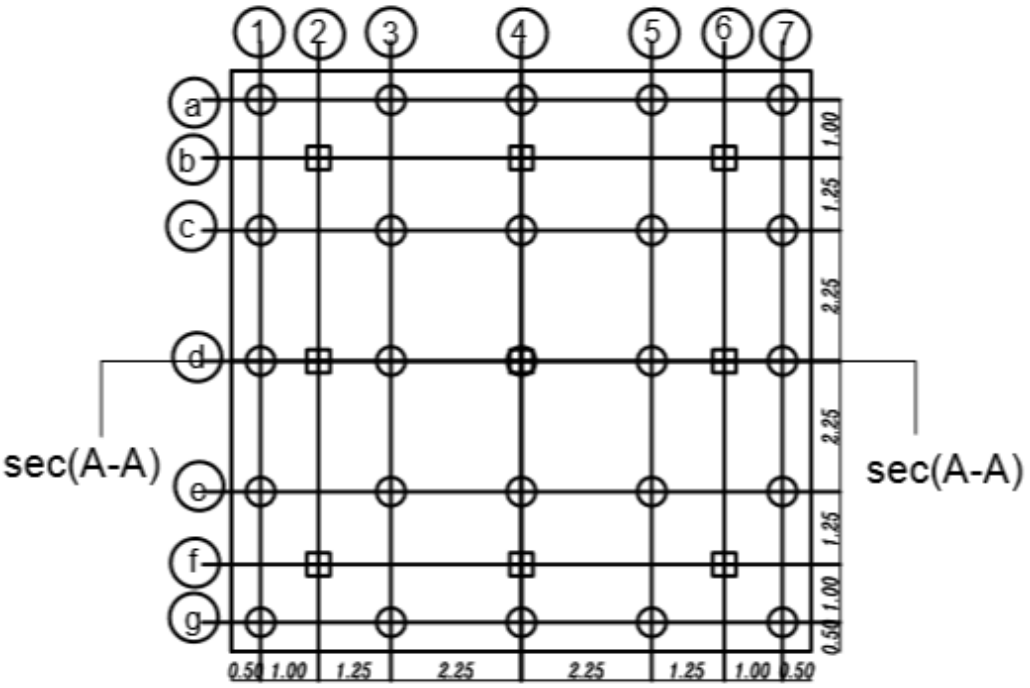


Fig (2) plane of piled raft foundation
all dimension in meter

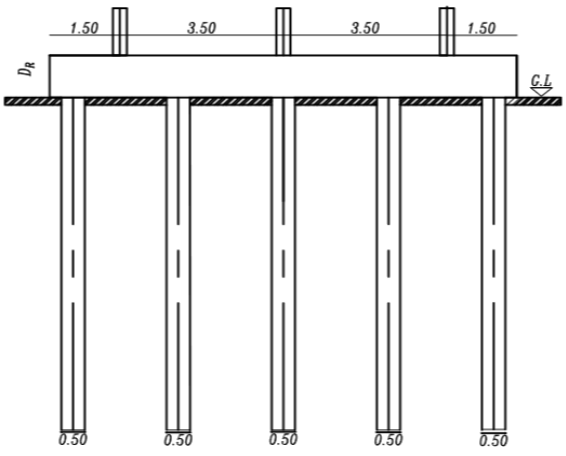


Fig (3) Cross section of piled raft foundation rested on soil
all dimension in meter.

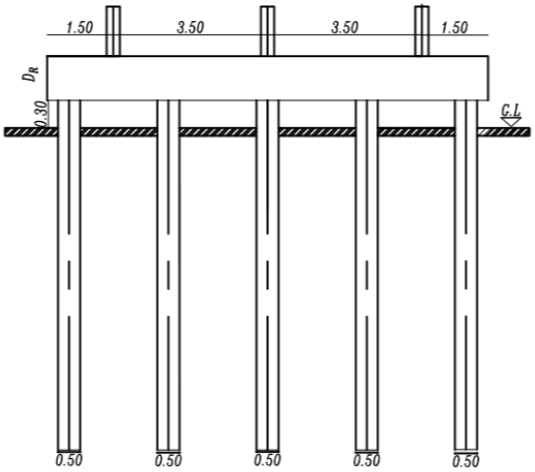


Fig (4) Cross section of piled raft foundation as raft act as slab connected the piles
all dimension in meter.

4 -Parametric study

The effect of raft thickness on the following:

1. The vertical settlement of piled raft
2. The bending moment on the raft
3. The shear force on the raft

5. Finite Element Results:

The obtained results of selected examples for different cases are shown in figures (6 to 17) as follows:

Figure (6) and (7) shows the bending moment on the raft in the two cases rested on the soil and raft act as slab connected the piles from the soil (Lp = 32D, D = 0.5 m , Sp =4.5D and raft thickness =1m).

Figures (8) and (9) shows the vertical displacement of the soil under the raft in(x-y) plane (as shading) for the two cases (Lp = 32D, D = 0.5 m and Sp =4.5D and raft thickness =1m).

Figures(10) and(11) shows the vertical displacement of soil under the raft in(x-z) plane (as shading) for the two cases (Lp = 32D, D = 0.5 m , Sp =4.5D and thickness =1m).

Figures (12) and (13) shows the vertical displacement of soil under the raft in(x-z) plane as (contour line) for the two cases (Lp = 32D, D = 0.5 m ,Sp =4.5D and thickness =1m) . From these figures, it can be shown that settlement decreasing by increasing pile length.

Figures (14) and (15) shows the shear force on the raft for the two cases (Lp = 32D, D = 0.5 m and Sp =4.5D and raft thickness =1m

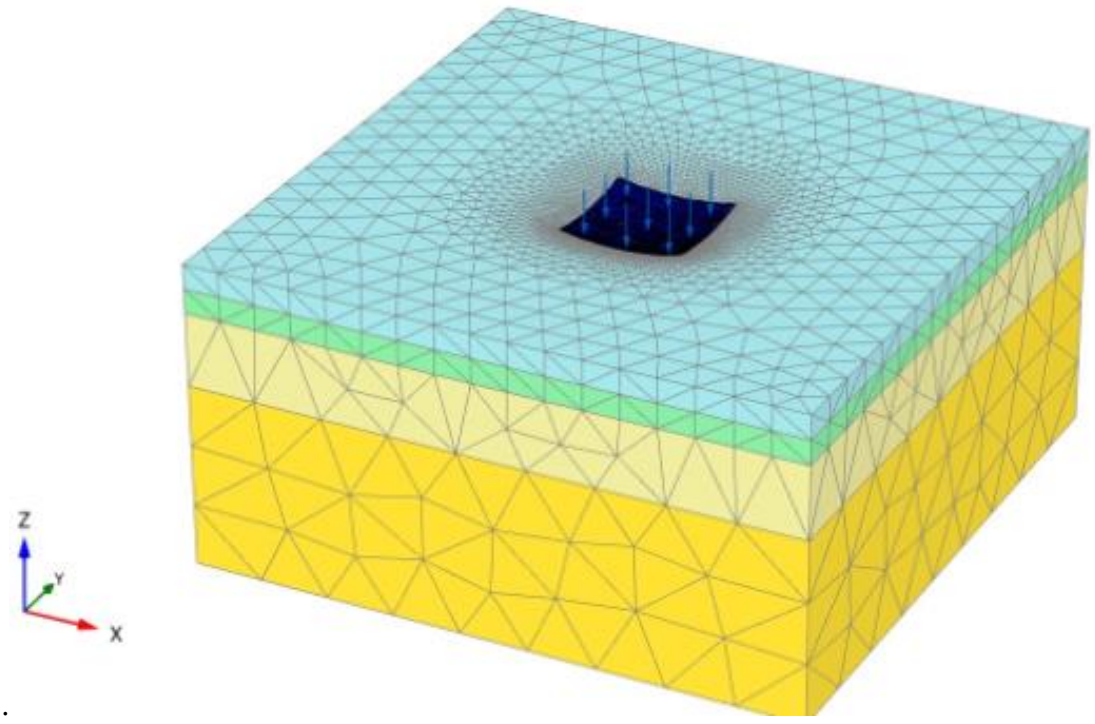


Fig (5) The deformed mesh of piled raft foundation with raft thickness 1m

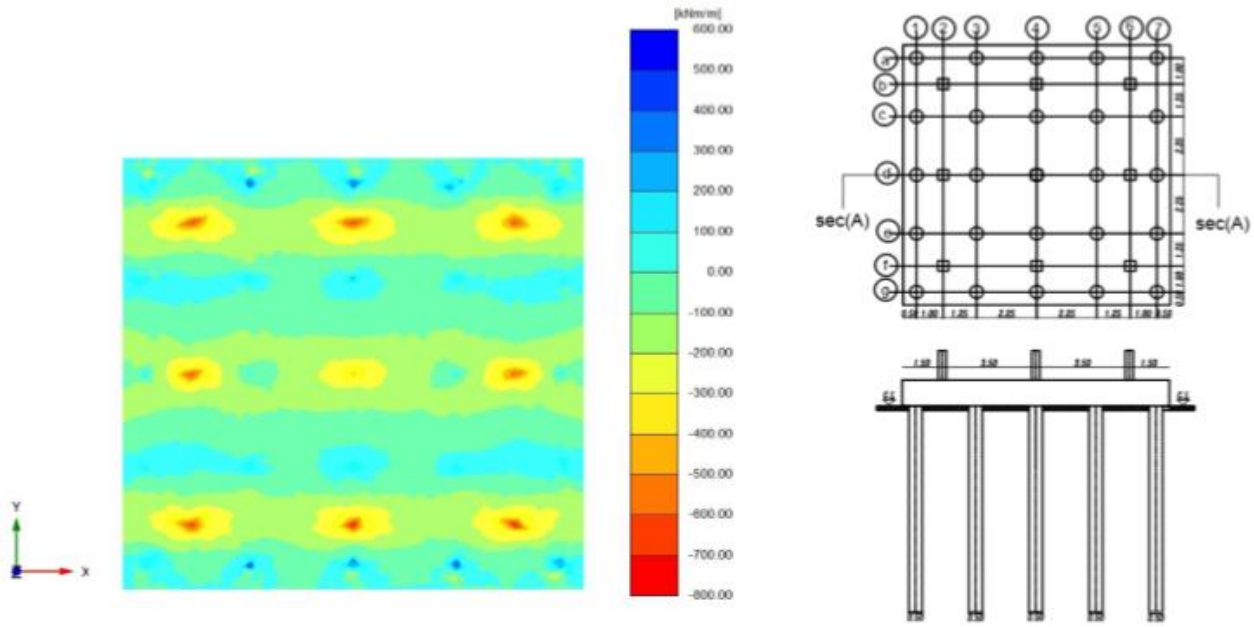


Fig (6) The bending moment of piled raft rested on the soil with raft thickness 1m

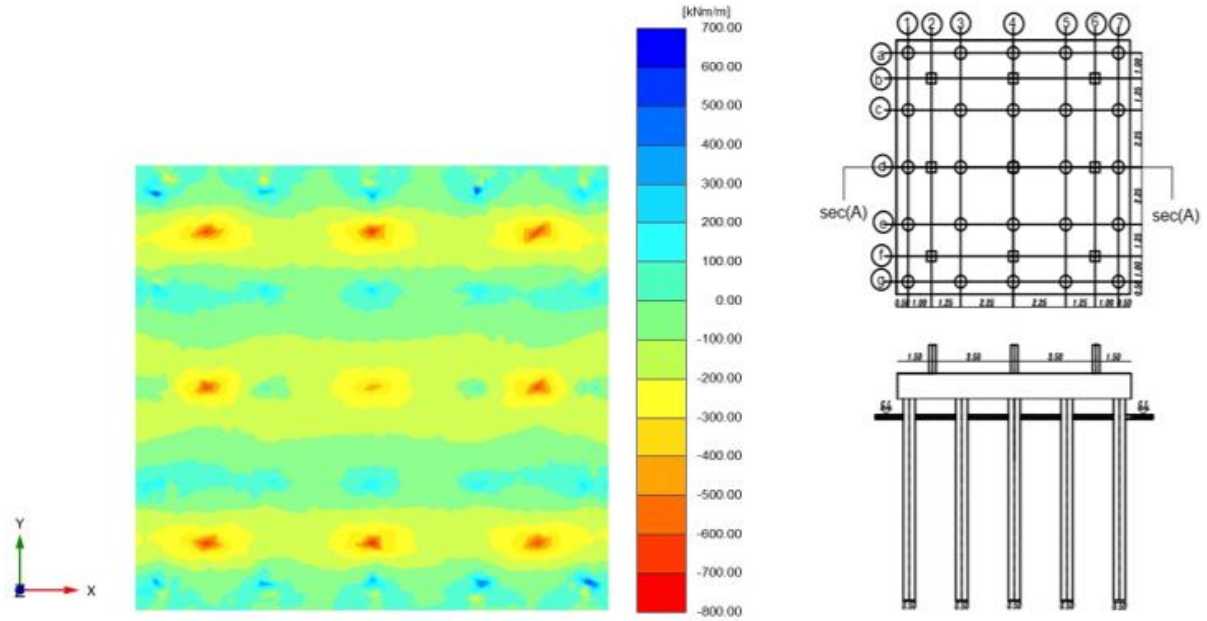


Fig (7) The bending moment of piled raft as raft act as slab connected the piles with with raft thickness 1m

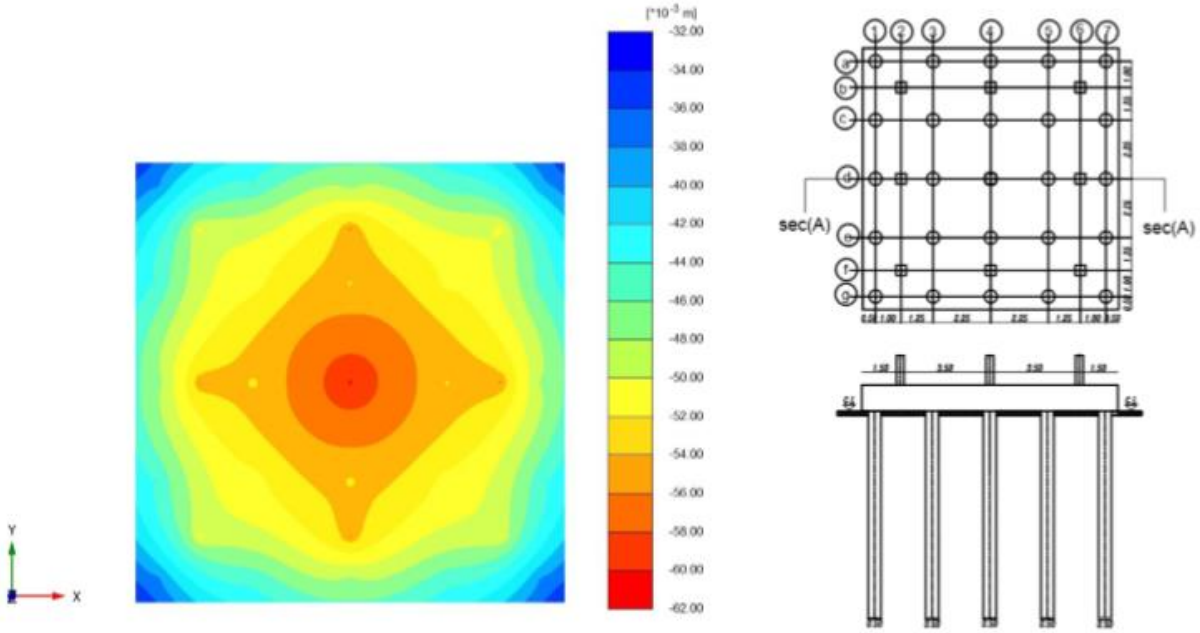
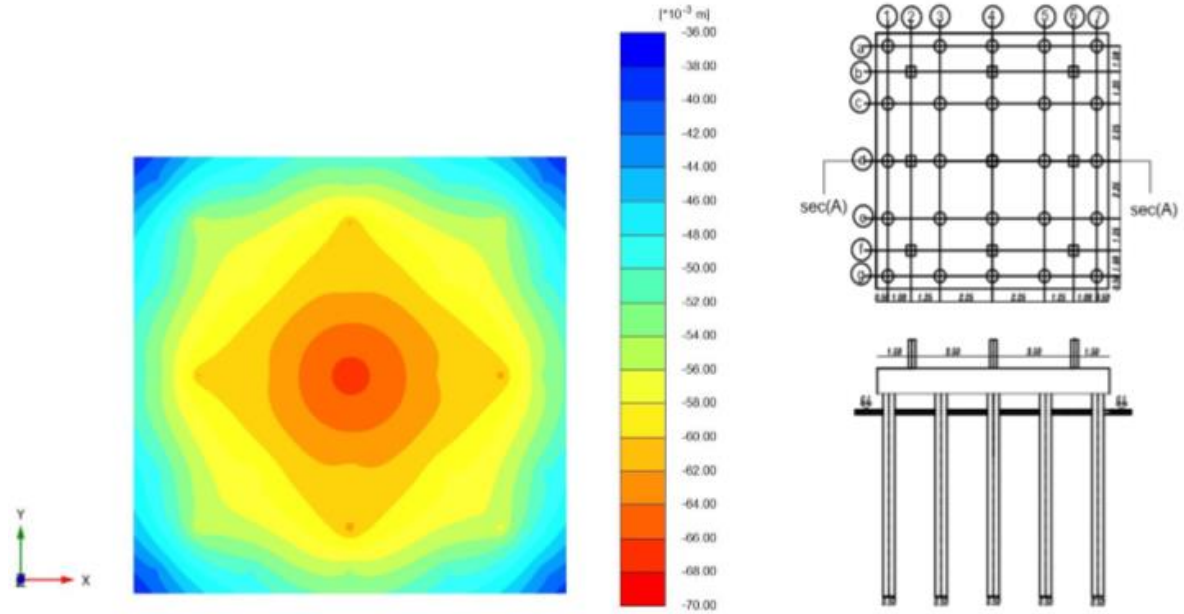


Fig (8) The vertical displacement of the soil under the raft in piled raft foundation rested on the with raft thickness 1m



Fig(9) The vertical displacement of the soil under the raft of piled raft foundation as raft act as slab connected the piles with raft thickness 1m

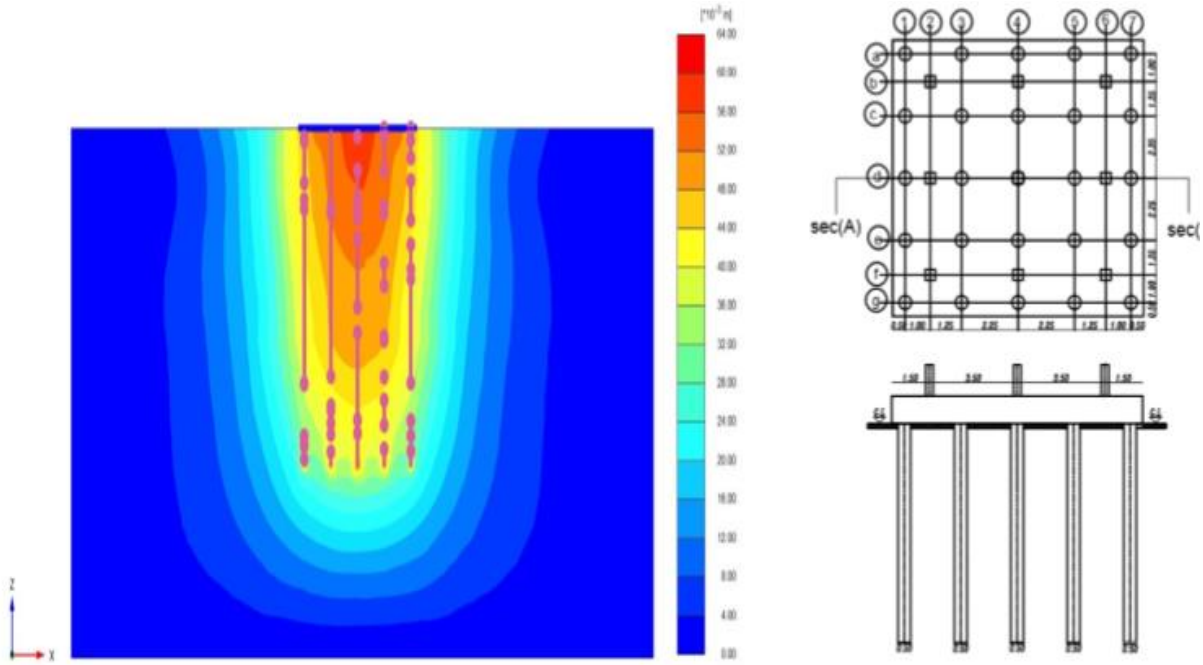


Fig (10) The vertical settlement as shading for the soil in XZ plane of piled raft foundation rested on the soil with raft thickness 1m

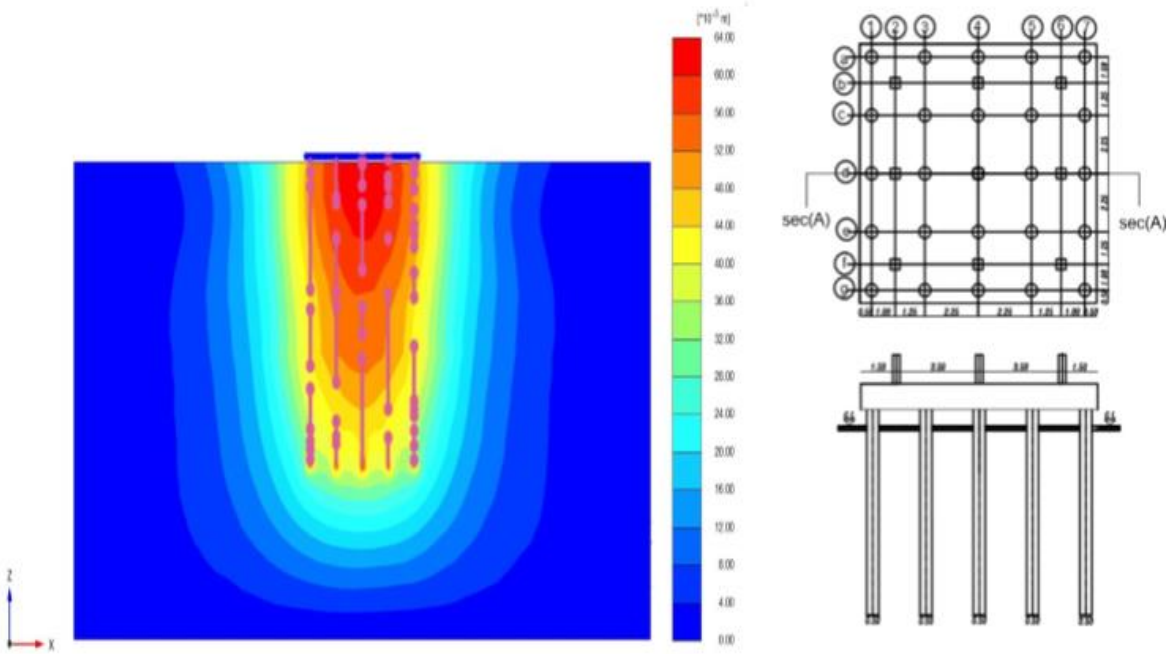


Fig (11) The vertical settlement as shading for the soil in XZ plane of piled raft foundation as raft act as slab connected the piles with raft thickness 1m

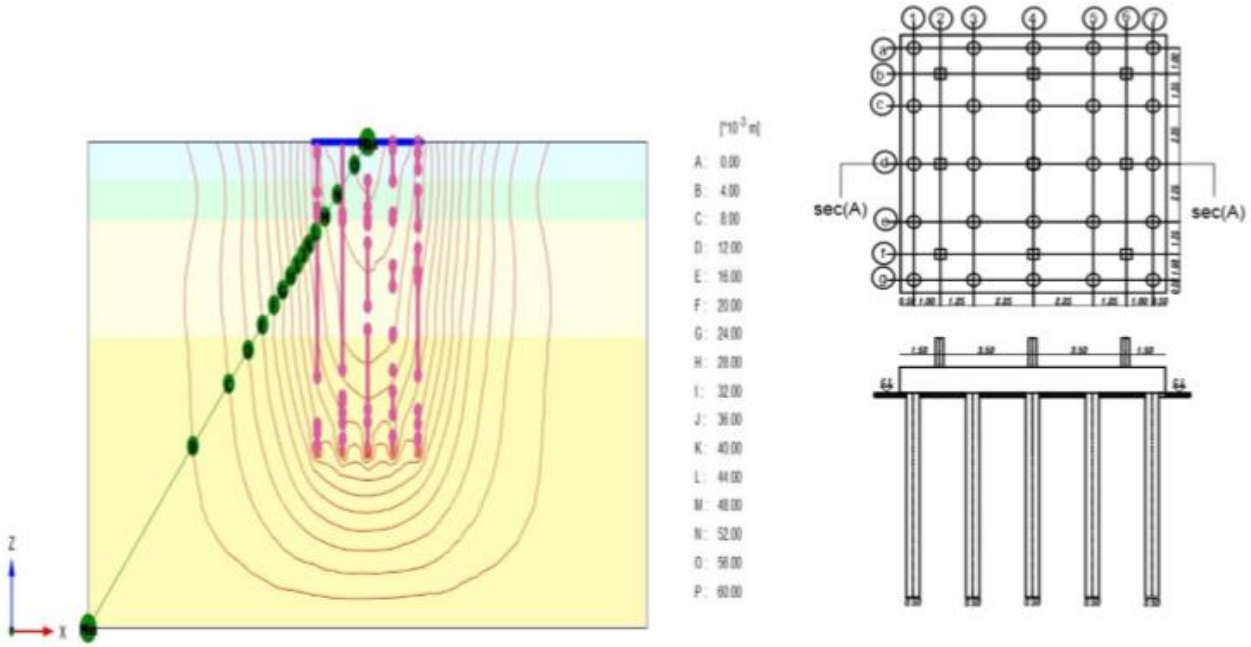
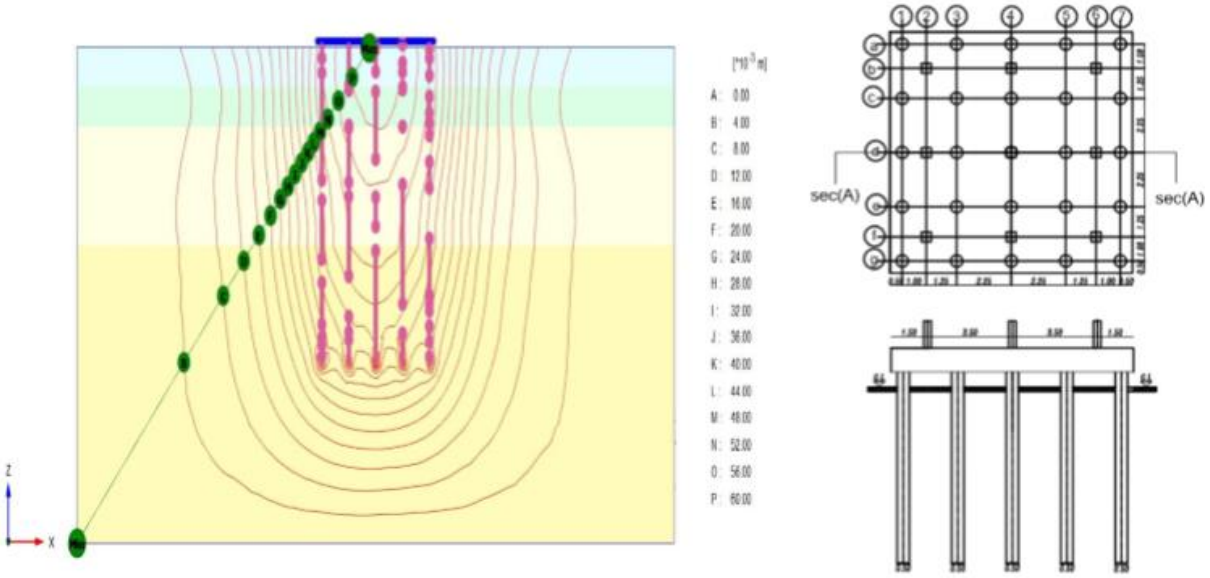


Fig (12) The vertical settlement as contour for the soil in XZ plane of piled raft foundation rested on the soil with raft thickness 1m



Fig(13) The vertical settlement as contour for the soil in XZ plane of piled raft foundation with raft act as slab connected the piles with raft thickness 1m

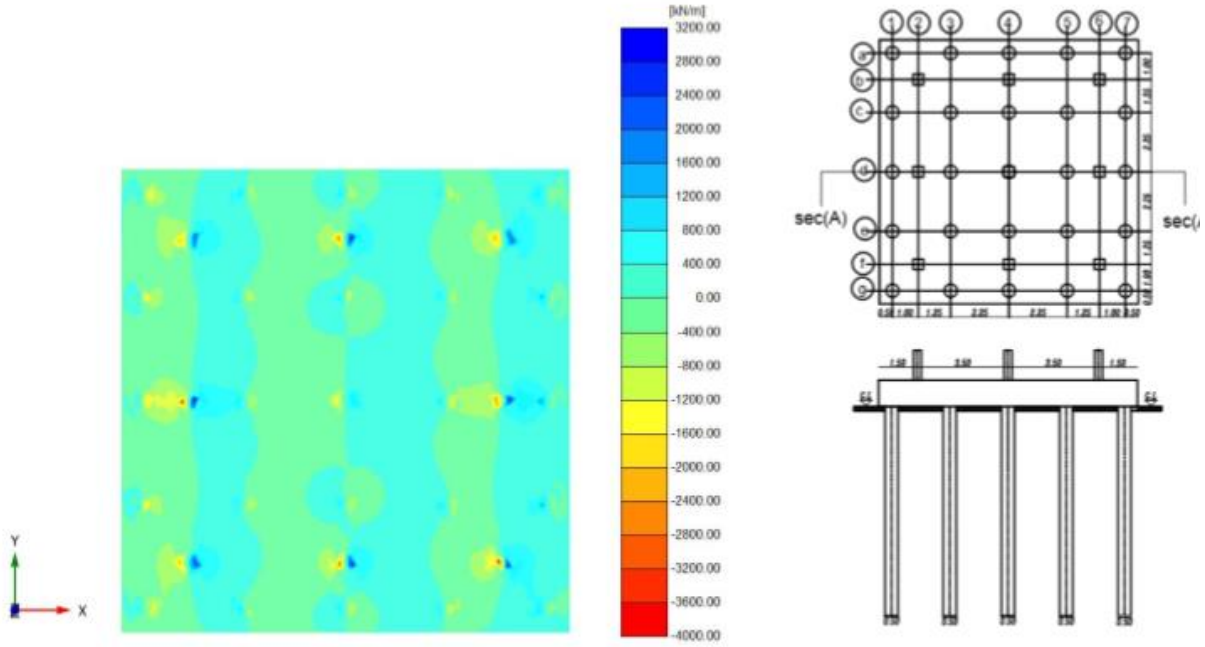


Fig (14) The shear force of raft for piled raft foundation rested on the soil with raft thickness 1m

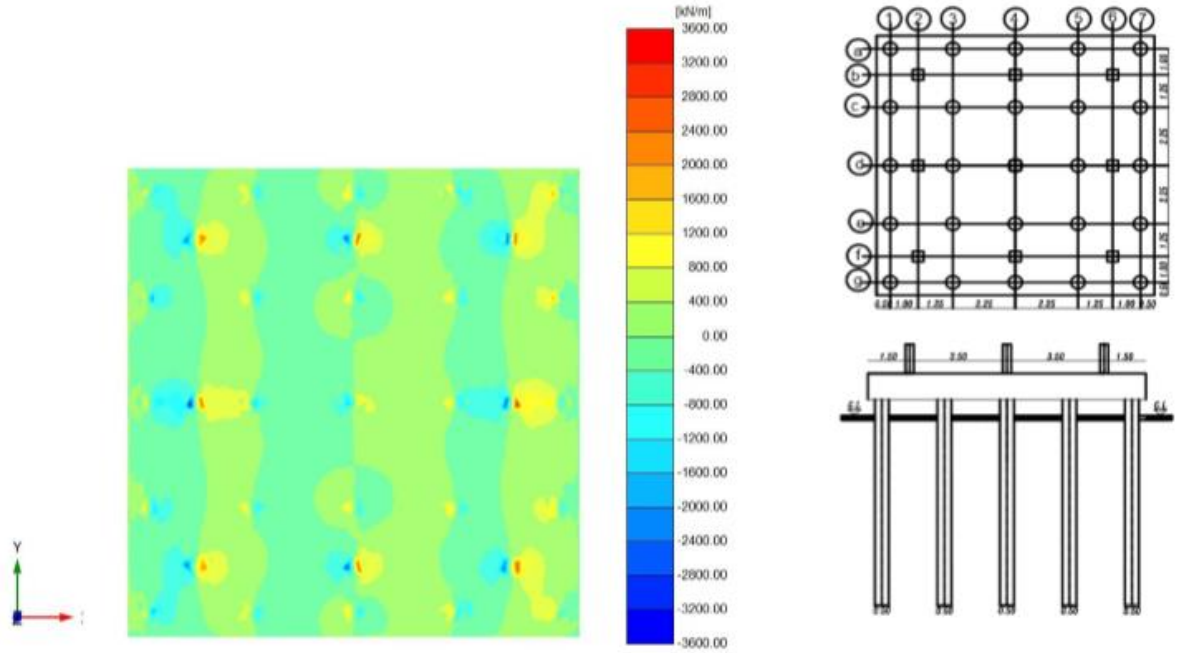


Fig (15) The shear force of raft for piled raft foundation as raft act as slab connected the piles with raft thickness 1m

6. Analysis of results :

Figures (16), (17) shows the relation between vertical settlement on the raft in the two cases in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D in sec (A-A)

Figures (18), (19) shows the relation between vertical settlement on the raft in the two cases in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D in sec (B-B)

Figures (20) and (21) shows the relation between bending moment of the raft in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D in sec(A-A)

Figures (22) and (23) shows the relation between bending moment of the raft in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D in sec(B-B)

Figures (24), (25) shows the relation between the shear force on the raft in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D ,in sec (A-A) from these figures, it can be shown the pile length don't have significant effect on the shear force on the raft

Figures (26), (27) shows the relation between the shear force on the raft in the two cases with various raft thickness where D_R = (1m, 1.25m, 1.5m and 1.75m and2m) for (D = 0.5 m), with pile length 32D in sec (B-B)

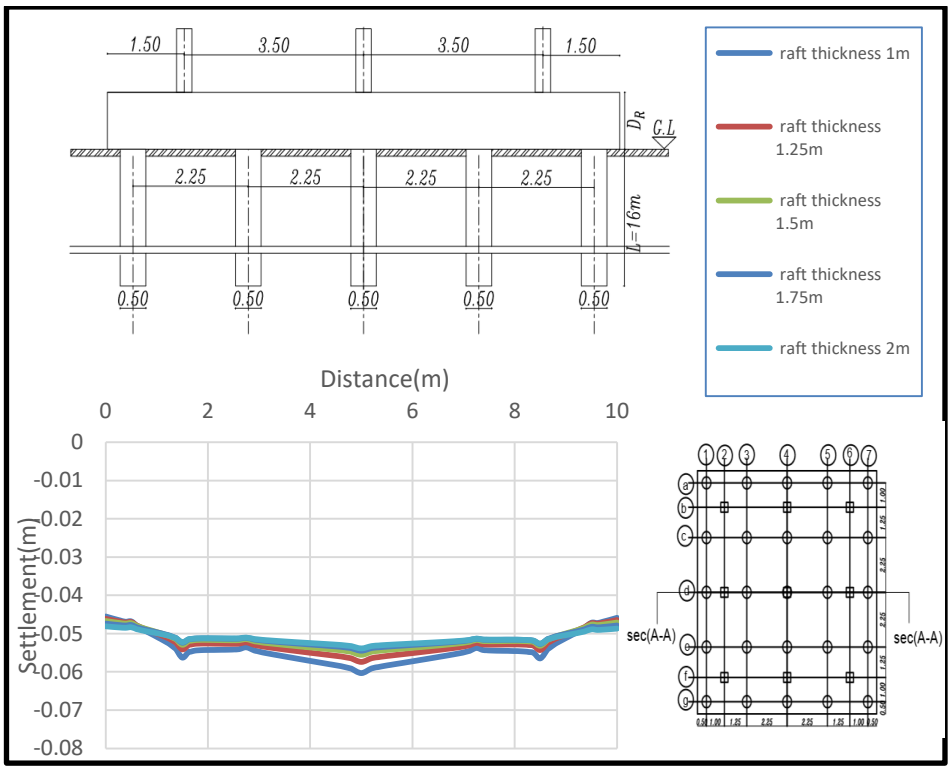


Fig (16) The relation between raft thickness and the settlement of piled raft foundation rested on the soil at sec (A-A)

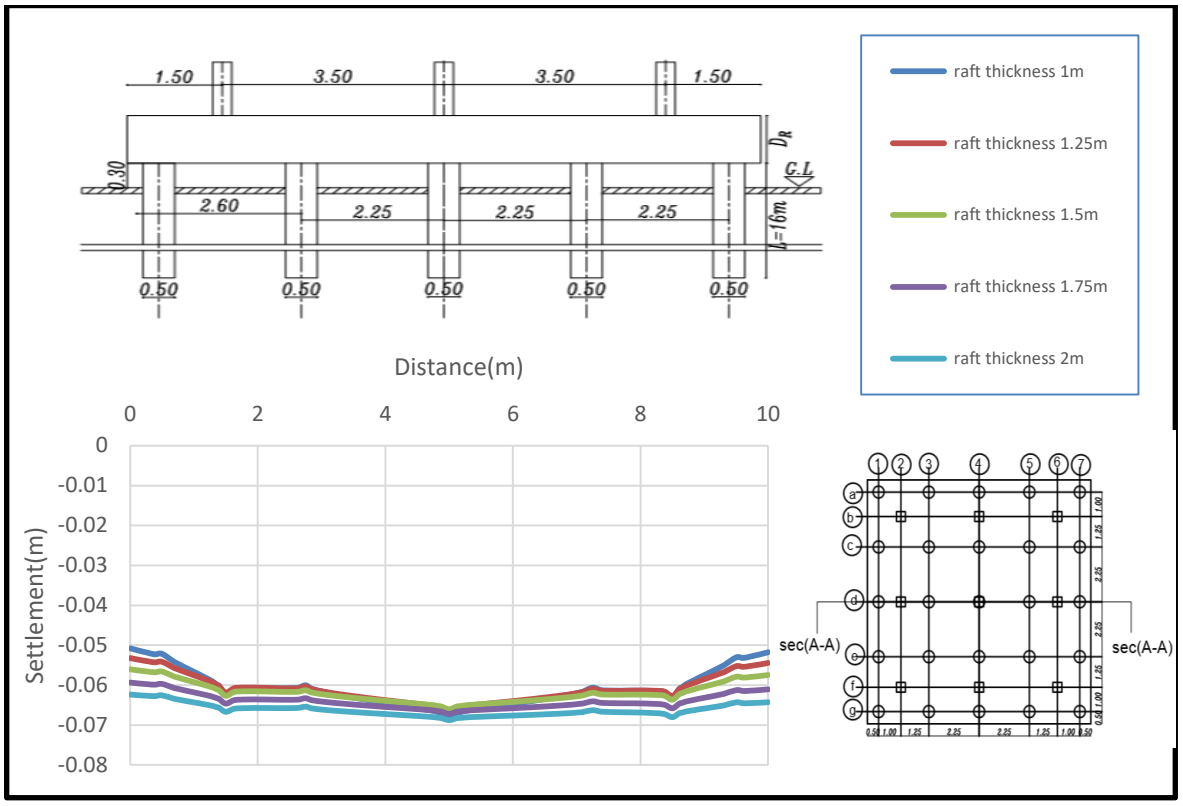


Fig (17) The relation between raft thickness and the settlement of piled raft foundation as the raft act as a slap at sec (A-A)

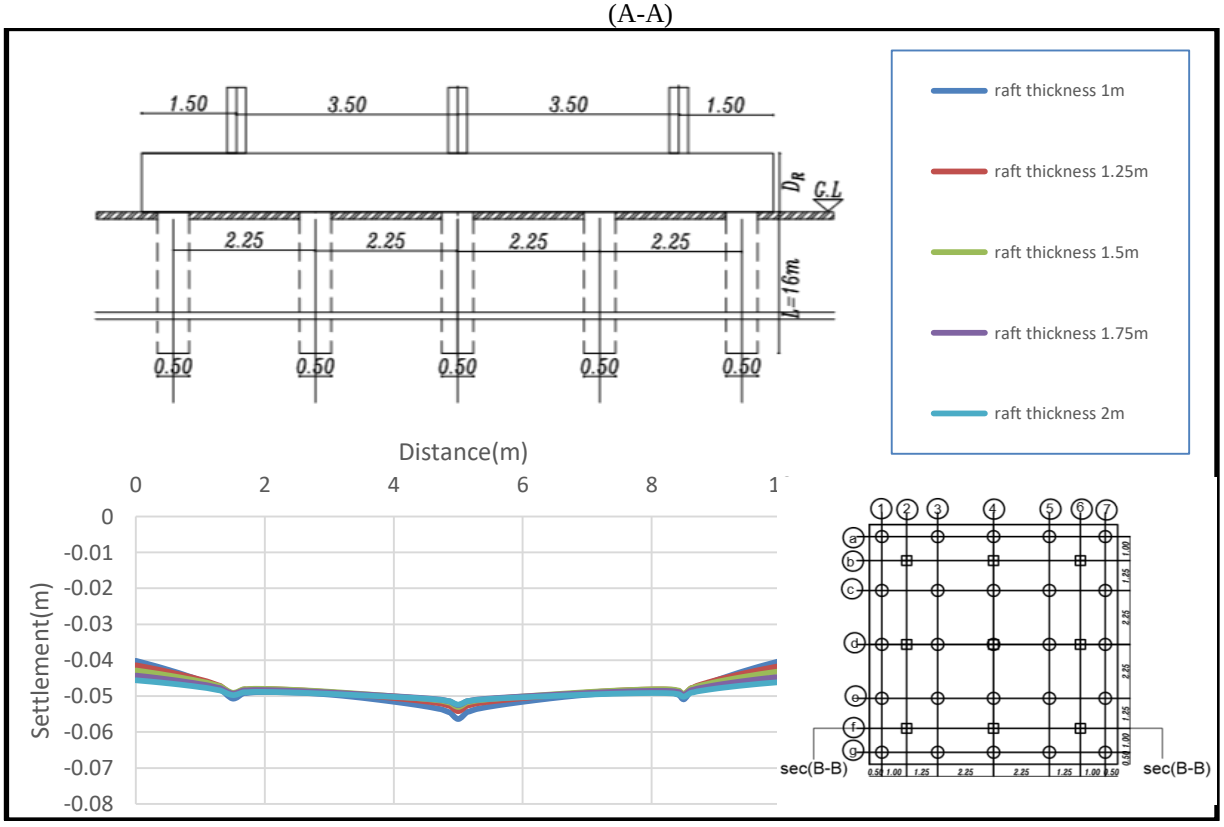


Fig (18) The relation between raft thickness and the settlement of piled raft foundation rested on the soil at sec (B-B)

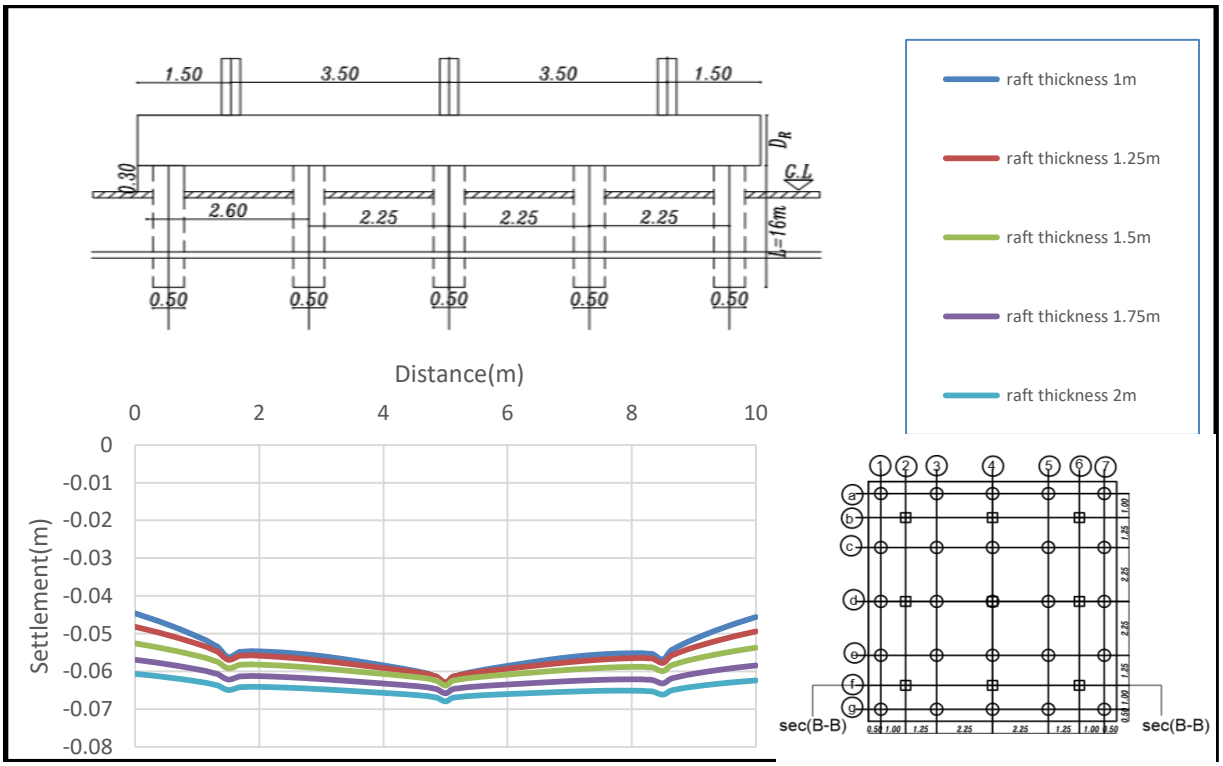


Fig (19) The relation between raft thickness and the settlement of piled raft foundation as the raft act at sec(B-B)

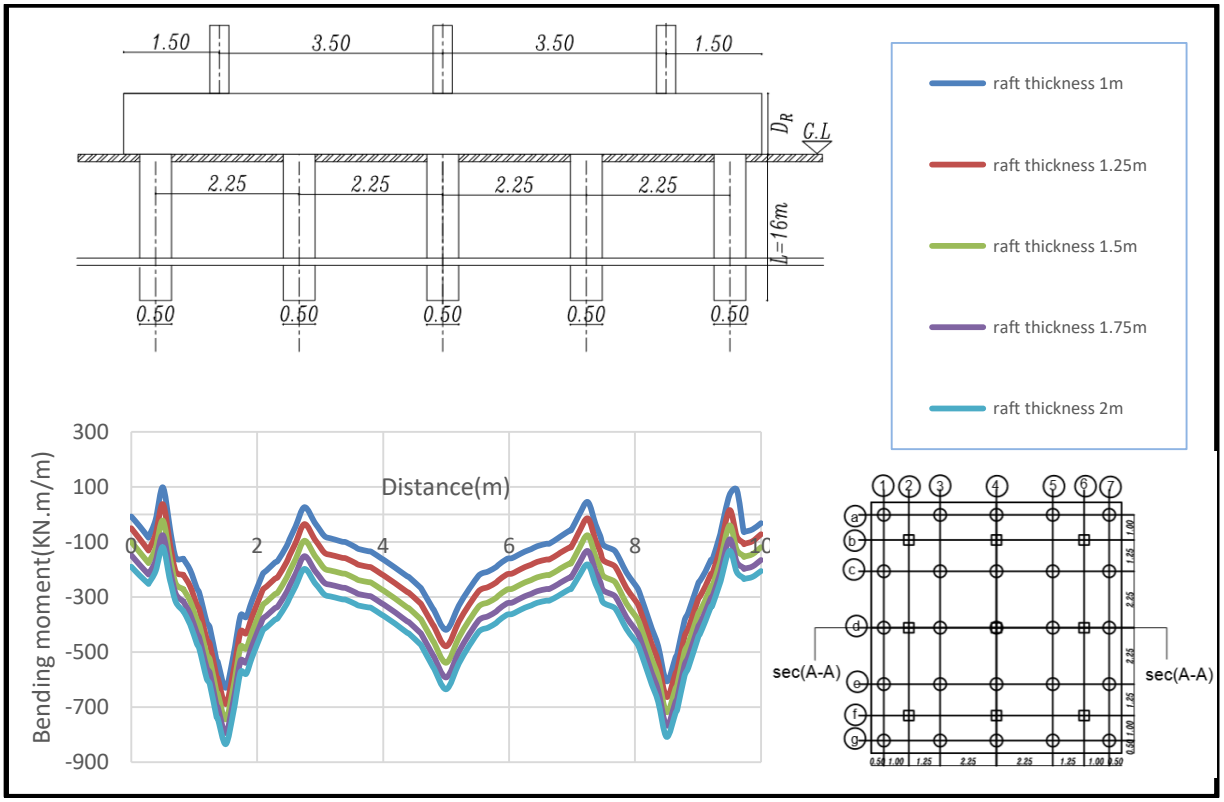


Fig (20) The relation between raft thickness and the bending moment on the raft of piled raft foundation rested on the soil at sec (A-A)

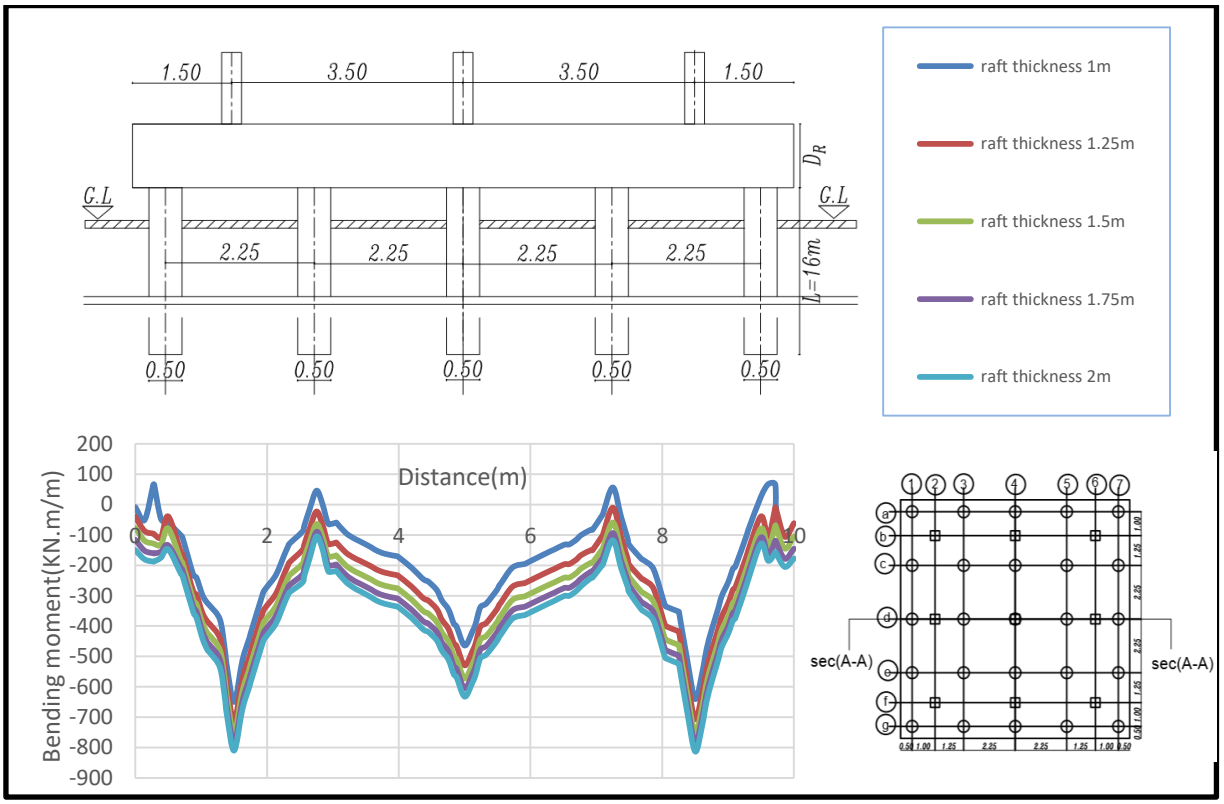


Fig (21) The relation between raft thickness and the bending moment on the raft of piled raft foundation as the raft act as slap connected the piles at sec (A-A)

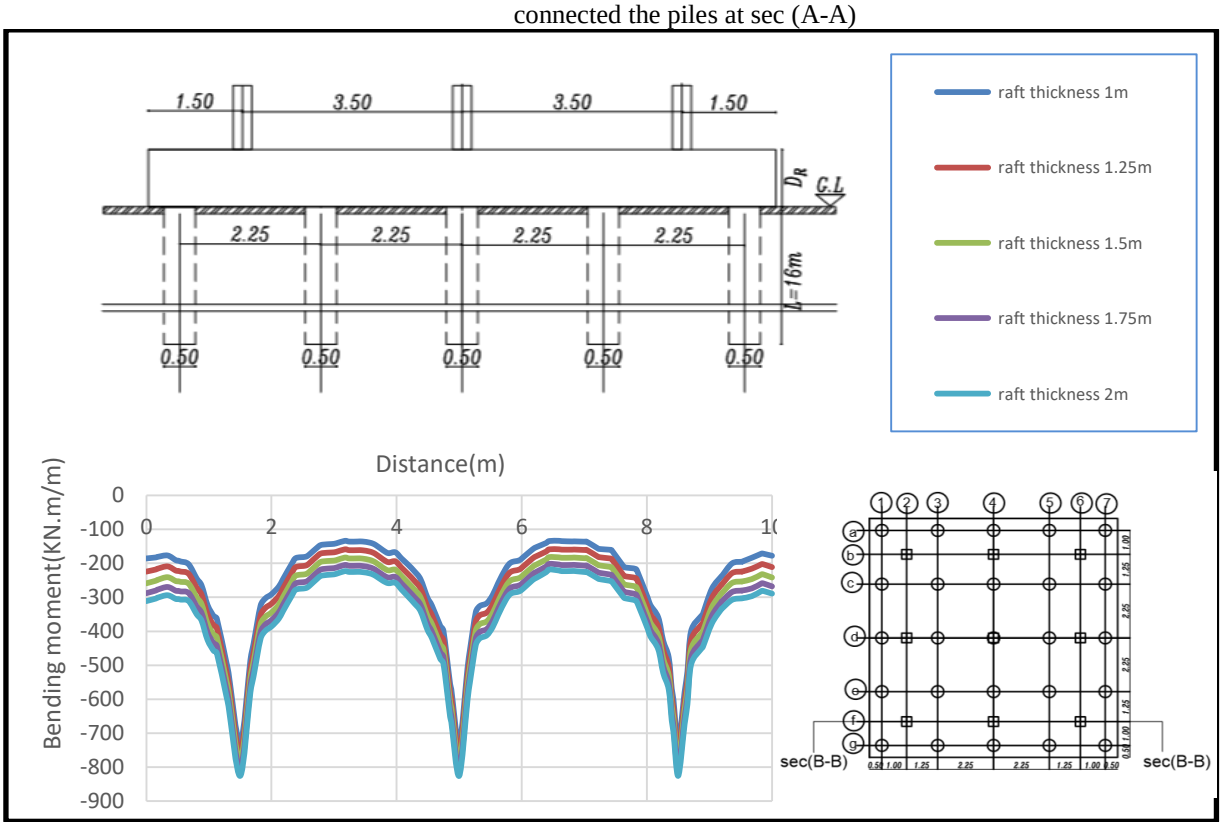


Fig (22) The relation between raft thickness and the bending moment on the raft of piled raft foundation rested on the soil at sec (B-B)

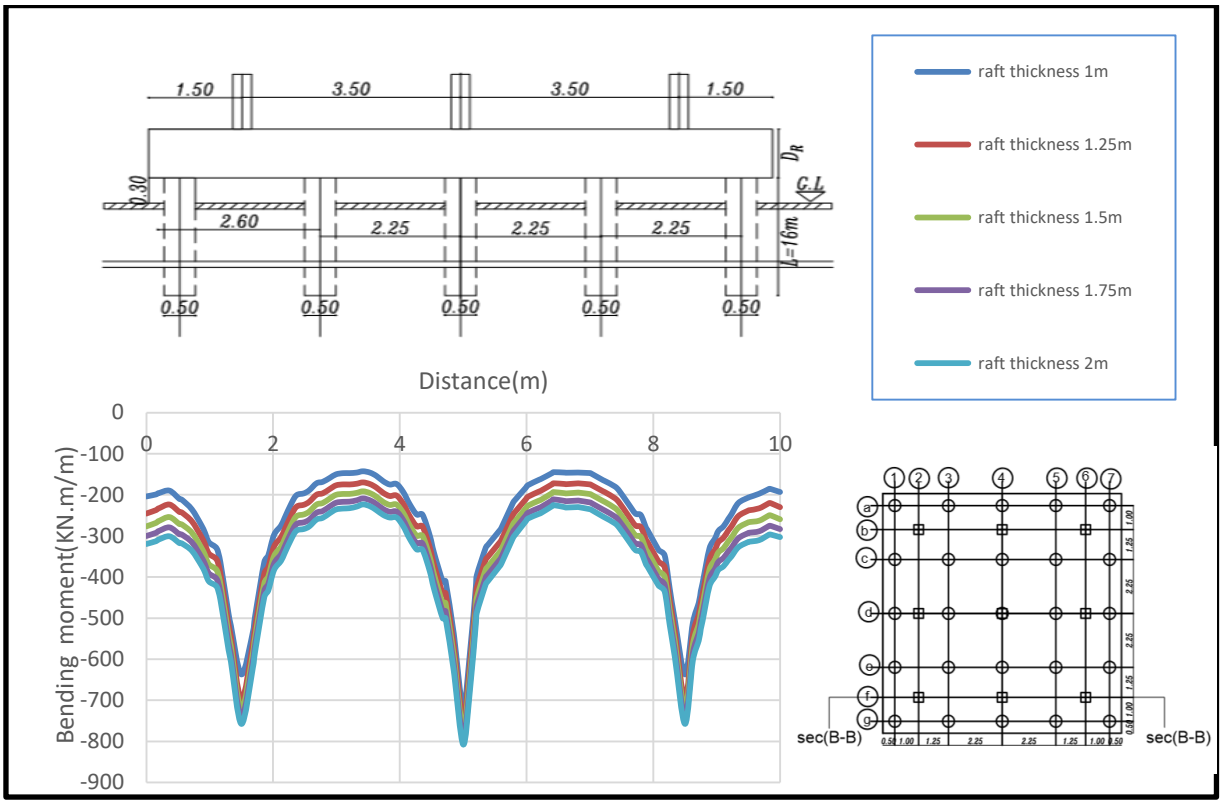


Fig (23) The relation between raft thickness and the bending moment on the raft of piled raft foundation as the raft act as slap connected the piles at sec (B-B)

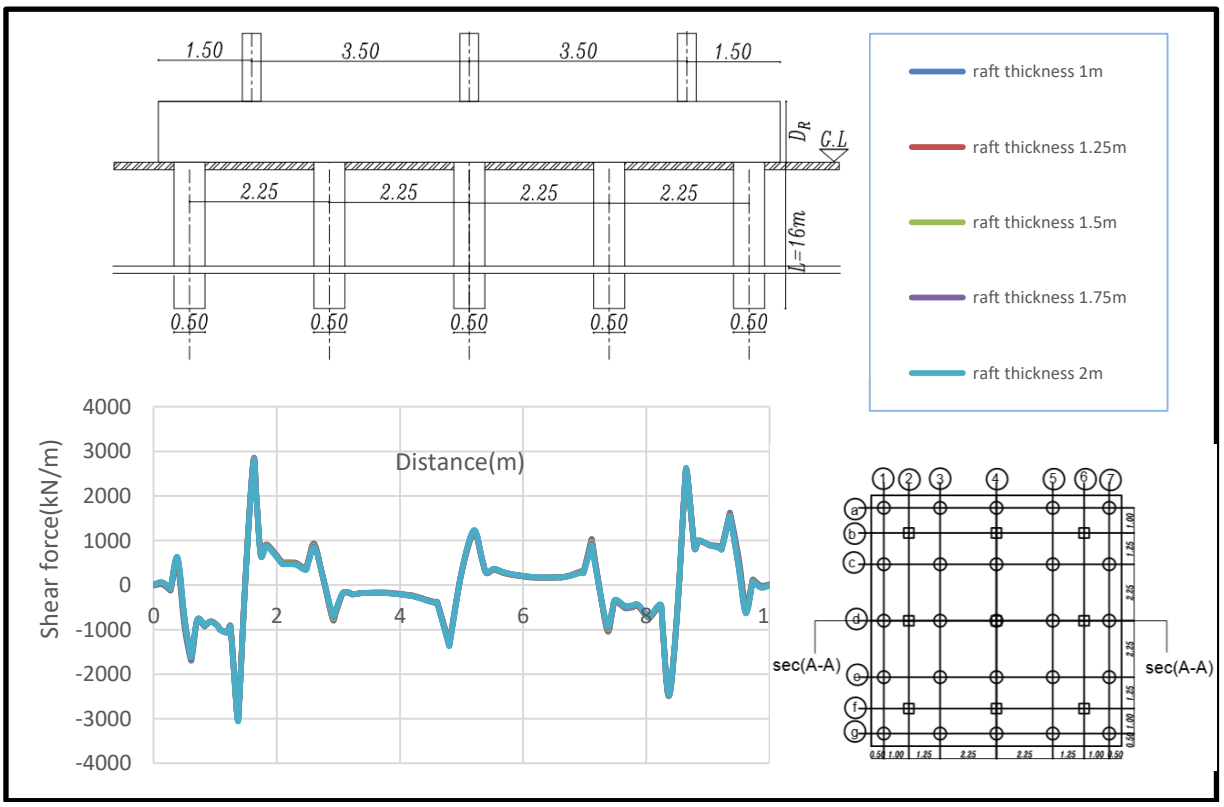


Fig (24) The relation between raft thickness and the shear force on raft of piled raft foundation rested on the soil at sec (A-A)

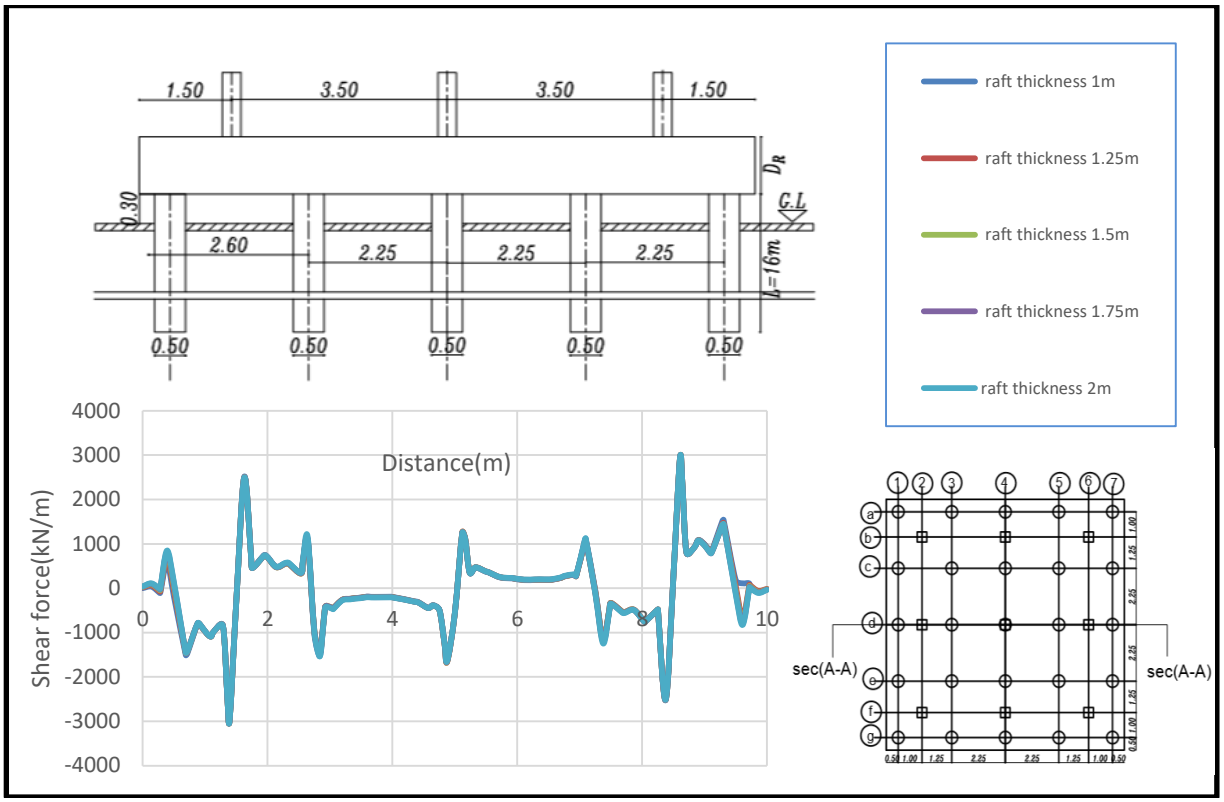


Fig (25) The relation between raft thickness and the shear force on raft of piled raft foundation as raft act as slab connected the piles at sec (A-A)

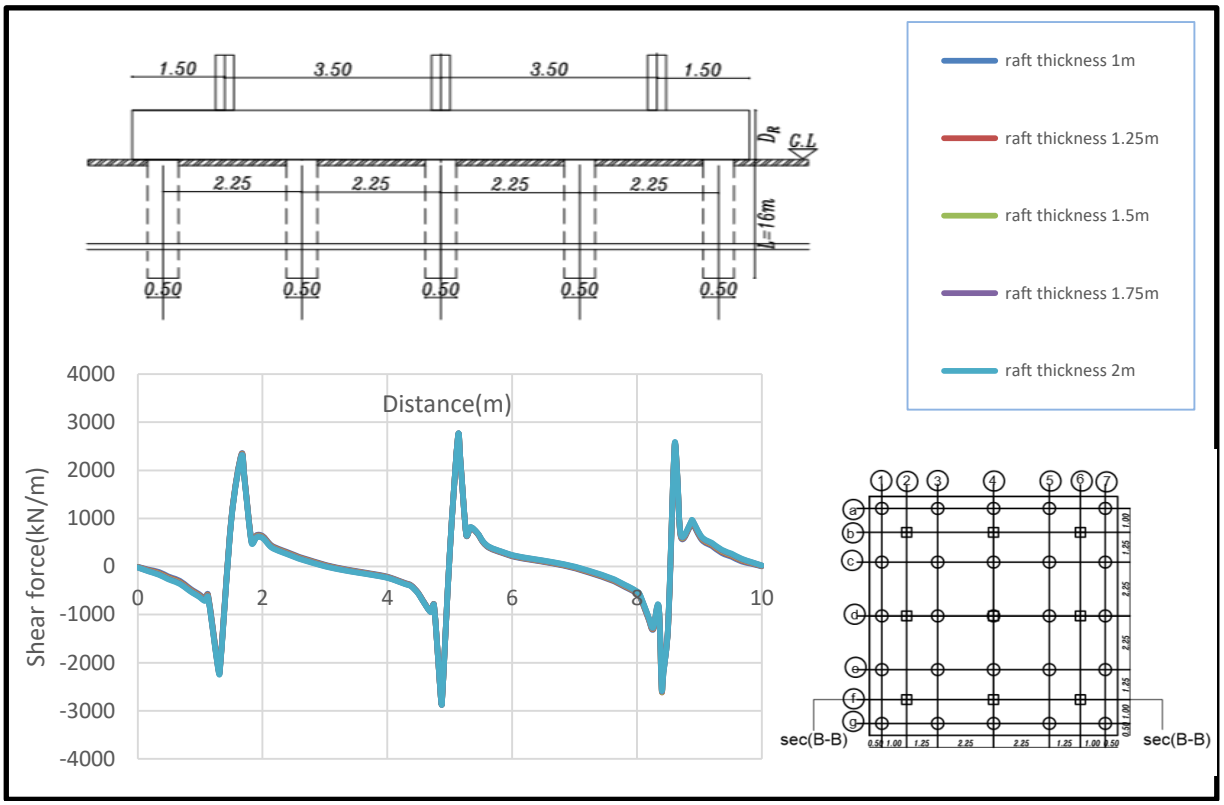


Fig (26) The relation between raft thickness and the shear force on raft of piled raft foundation rested on the soil at sec (B-B)

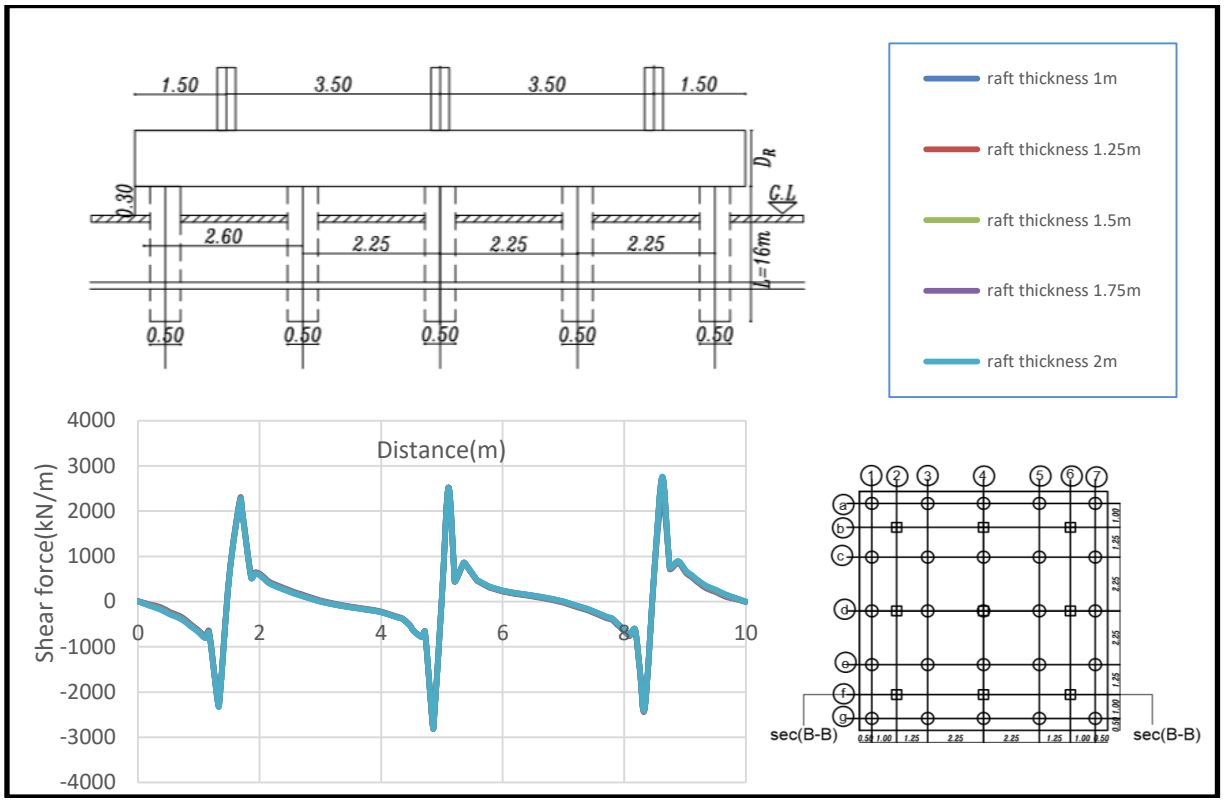


Fig (27) The relation between raft thickness and the shear force on raft of piled raft foundation as raft act as slab connected the piles at sec (B-B)

7.Conclusions:

From the present study, the followings are concluded:

i. In case of rested piled raft increasing pile length leads to

- The bending moment in the raft increase from 7 to 14 %
- The settlement decreases from 4 % to 2 % of piled raft foundation
- the shear force in the raft decreases from 1% to 0.5%

ii. In case of raft act as slab connected the piles increasing pile length leads to

- The bending moment in the raft decreases from 14 to 4 %
- The settlement increase from 1.5% to 2 % of piled raft foundation
- the shear force in the raft decreases from 1% to 0.5%

iii. The comparison between the two cases piled raft rested on the soil and piled raft act as slab

- The bending moment in the raft in the case of raft act as slab connected the piles is greater than the case of rested piled raft by 10 % to 6%
- the settlement in piled raft in the case of raft act as slab connected the piles is greater than the case of rested piled raft by 25% to15%
- The shear force in raft in the case of raft act as slab connected the piles is greater than the case of rested piled raft by 13%

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