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Study on Soil Structure Interaction under Lateral Load Using Sap-2000 Software

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ABSTRACT:The dynamic interplay between soil and structure, known as soil-structure interaction (SSI), is investigated in this paper, as are the consequences for building behavior during seismic occurrences. The study looks at the effects of altering pile depth, soil type, and soil layers on lateral and vertical displacements under seismic loads in high-rise buildings. A 10-story concrete moment resistant structure frame is studied using 12 SAP Models with varying soil conditions and subjected to zone 5 seismic pressures. While lateral displacement is impacted by pile depth and soil type, vertical displacement follows a direct proportionality to pile depth. Furthermore, the effect of soil layers on displacement is investigated. Comparisons show that lateral displacement is affected by changes in soil carrying capacity. This research increases our understanding of SSI and gives critical insights for constructing resilient high-rise structures in seismically active areas. Please feel free to modify and expand on this abstract in order to appropriately describe the scope and findings of your study.
KEYWORDS: Lateral load, Gravityload, Lateral Displacement, Vertical displacement.

I. INTRODUCTION

Soil-structure interaction (SSI) is the term used to describe the interaction between soil (the ground) and a structure erected on it. It is essentially a reciprocal stress exchange, with the kind of ground and the type of structure having an impact on how the ground-structure system moves. Particularly in seismically active areas is this true. A structural component with a direct connection to the ground is present in the majority of civil engineering constructions. Buildings on the surface are damaged by seismic waves develop from the bedrock through the soil layers during earthquakes. Structural displacements and Earth moving are dependent when such external forces act on these systems. The term "soil-structure interaction" (SSI) refers to this.

Different soil and structural combinations can either increase or lessen movement and the ensuing damage. A structure would sustain more damage if it were built on hard ground as opposed to soft ground. Foundation sinking, which is exacerbated by a seismic event, is a second interaction effect linked to mechanical properties of soil.

SSI consequences are disregarded in conventional structural design methods. Low-rise buildings and straightforward rigid retaining walls are examples of light structures on moderately stiff soil that do not consider SSI. But for high-rise buildings or substantial structures resting on relatively soft soils, such nuclear power plants or elevated roads on soft soil, the SSI becomes important.

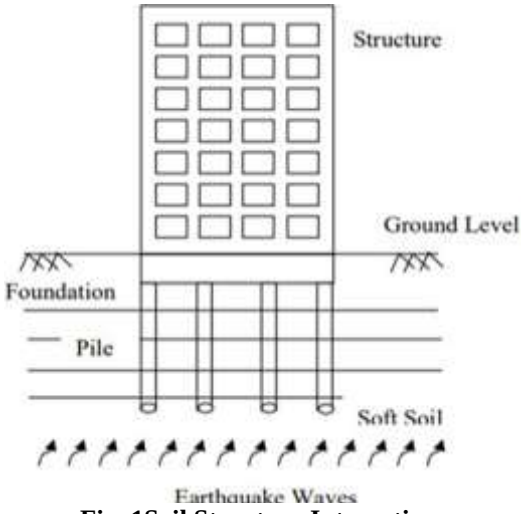

Fig. 1Soil Structure Interaction

II. METHODOLOGY

- Define Research Problem
- Conduct Literature Review

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- Selection of Structures and Load Calculation
- Analysis of Pile Foundation with Varying Pile Depth and Properties in SAP2000
- Result Analysis and Comparison
- Conclusion

Table 1 Characteristics of studied RC frame

Number of storey	G+10
Bay width (m)	5
Number of bays in X-direction	5
Total width in X-direction (m)	25
Number of bays in Y-direction	5
Total width in Y-direction (m) 3	25
Storey height (m)	3.2
Total height (m)	35.2

III. RESULTS AND DISCUSSIONS

Table 2: Displacement For Piles Under Different Layers of Soil in X Direction

Maximum Lateral Displacements in X-direction				
Pile depth (m)	Layer thickness (m)			Displacement (mm)
10	3.3	3.3	3.4	105
15	5	5	5	107
20	6.6	6.6	6.8	99

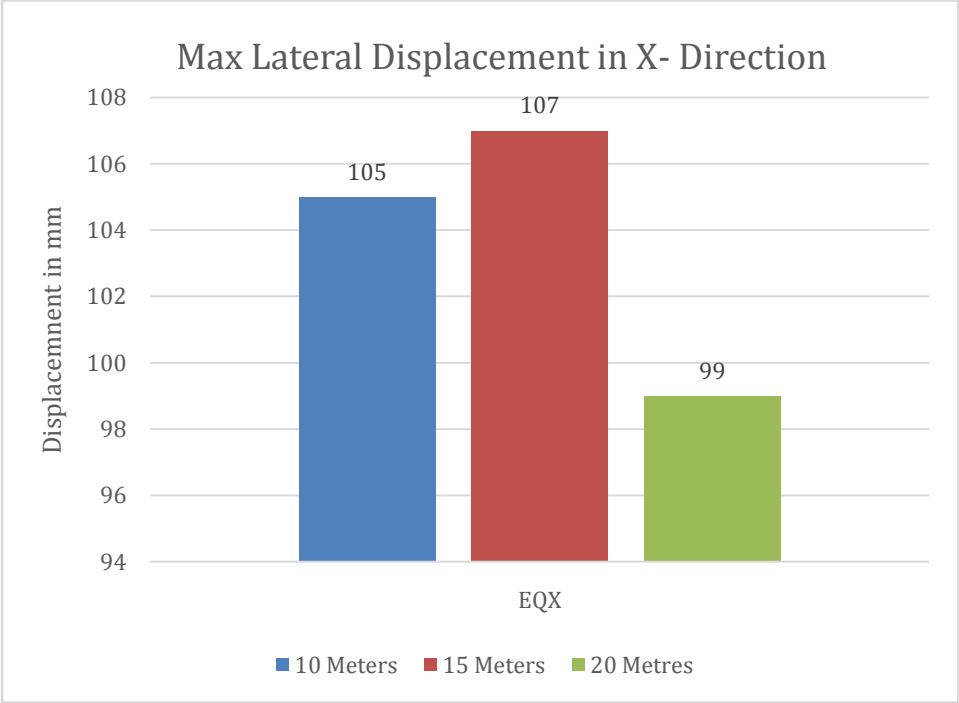

Fig. 2 Maximum Lateral Displacement chart in X direction

From the results it can be noted that piles with 20m depth in different soil layers has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.

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Table 3: Displacement For Piles Under Different Layers of Soil in Y Direction

Maximum Lateral Displacements in Y-direction				
Pile depth (m)	Layer thickness (m)			Displacement (mm)
10	3.3	3.3	3.4	105
15	5	5	5	107
20	6.6	6.6	6.8	99

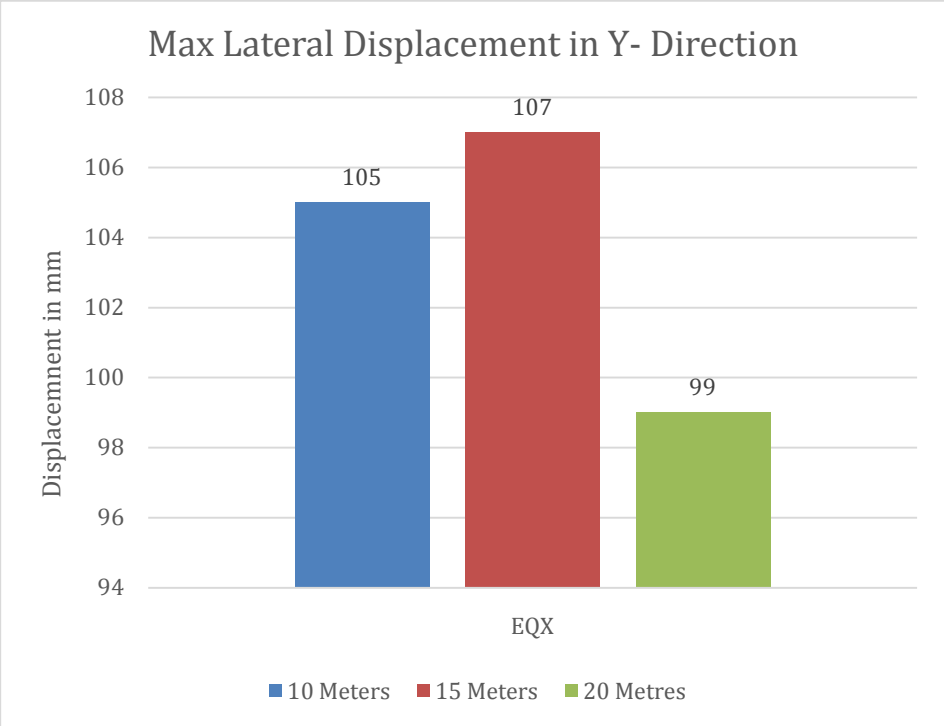

Fig. 3 Maximum Lateral Displacement chart in Y direction

From the results it can be noted that piles with 20m depth in different soil layers has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.

Table 4: Displacement For Piles Under Different Layers of Soil

Maximum Vertical Displacements				
Pile depth (m)	Layer thickness (m)			Displacement (mm)
10	3.3	3.3	3.4	6.52
15	5	5	5	7.13
20	6.6	6.6	6.7	7.77

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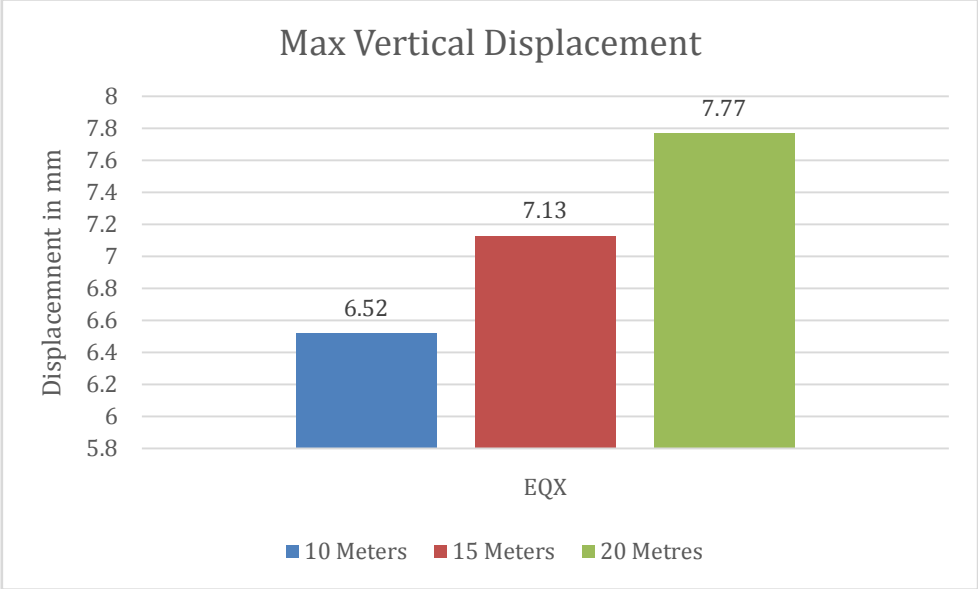

Fig.4 Maximum Vertical Displacement chart

From the results it can be noted that piles with 20m depth in different soil layers has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.

Table 5: Displacement For Piles Under Same Layer of Soil in X Direction

Maximum Lateral Displacements in X-direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	60	107
15	60	108
20	60	98

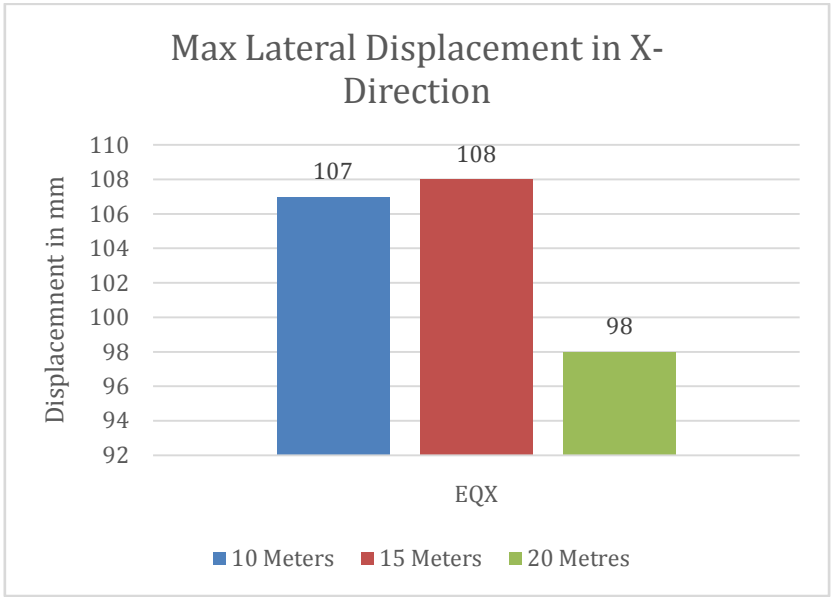

Fig. 5 Maximum Lateral Displacement chart in X direction

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From the results it can be noted that piles with 20m depth in different soil layers has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.

Table 6: Displacement For Piles Under Same Layer of Soil

Maximum Vertical Displacements		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	60	6.52
15	60	7.14
20	60	7.78

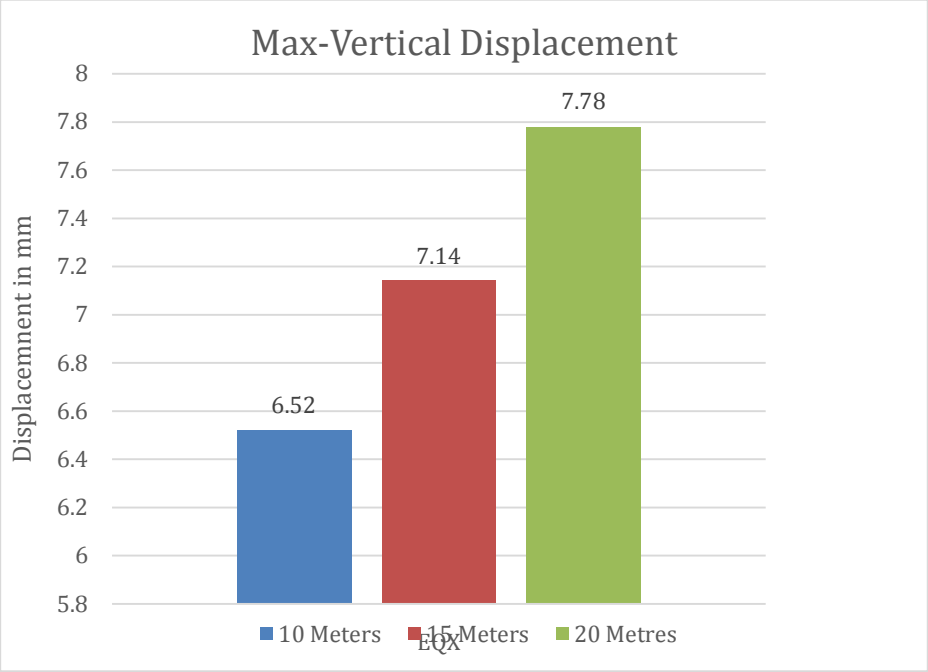

Fig.6 Maximum Vertical Displacement chart

From the results it can be noted that piles with 20m depth in same layers of soil has more vertical displacement compared to piles with 15m and 10m depth. Which indicates vertical displacement is directly proportional to the depth of the pile.

Table 7: Displacement For Piles Under Same Layer of Soil in X Direction

Maximum Lateral Displacements in X-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	120	104
15	120	105
20	120	95

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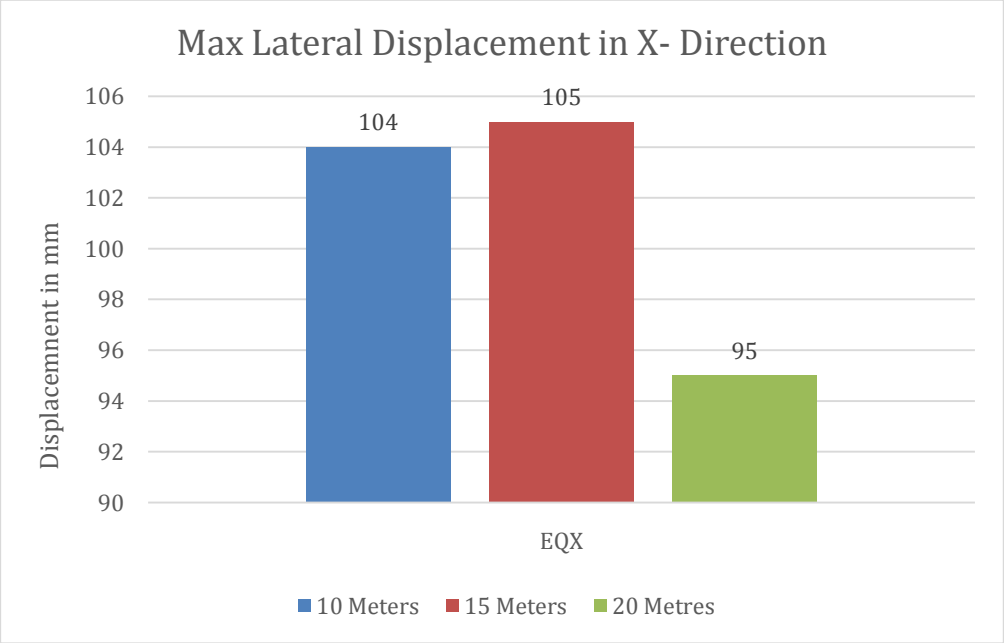

Fig.7 Maximum Lateral Displacement chart in X direction

From the results it can be noted that piles with 20m depth in same layers of soil has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.

Table 8: Displacement For Piles Under Same Layer of Soil in Y Direction

Maximum Lateral Displacements in Y-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	120	104
15	120	105
20	120	95

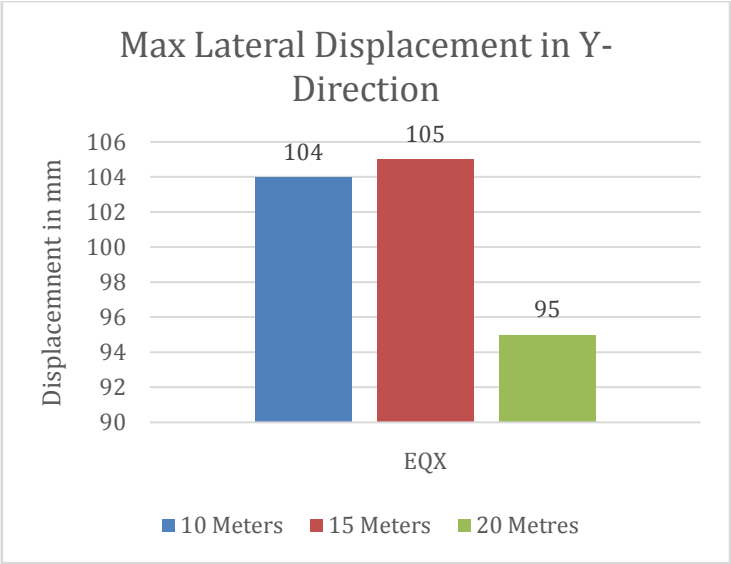

Fig.8 Maximum Lateral Displacement chart in Y direction

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From the results it can be noted that piles with 20m depth in same layers of soil has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to depth of the pile.

Table 9: Displacement For Piles Under Same Layer of Soil

Maximum Vertical Displacements in Y-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	120	6.52
15	120	7.14
20	120	7.78

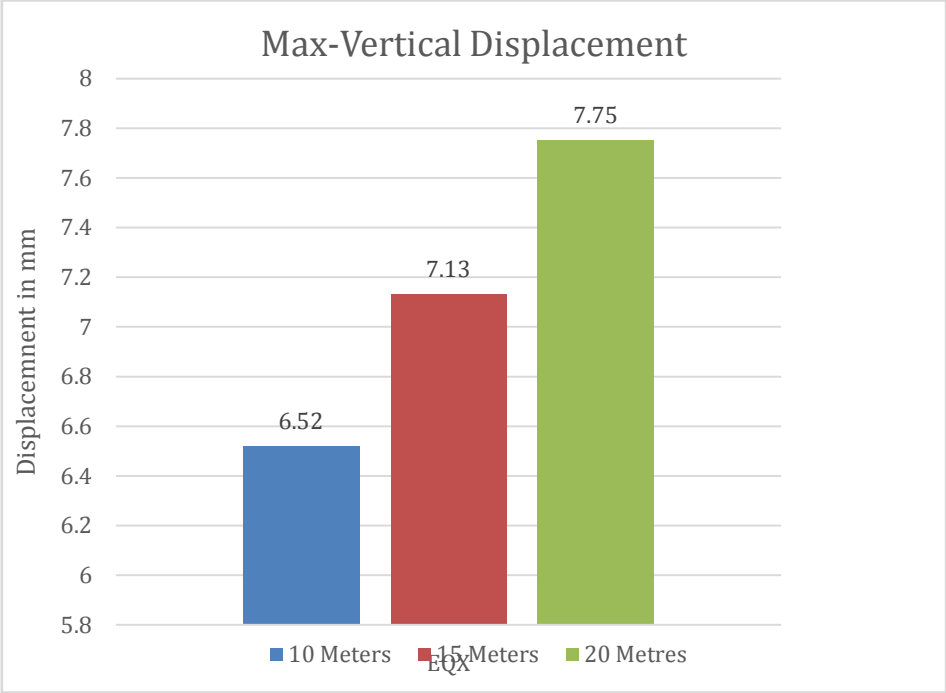

Fig.9 Maximum Vertical Displacement chart

From the results it can be noted that piles with 20m depth in same layers of soil has more vertical displacement compared to piles with 15m and 10m depth. Which indicates vertical displacement is directly proportional to the depth of the pile.

Table 10: Displacement For Piles Under Same Layer of Soil in X Direction

Maximum Lateral Displacements in X-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	180	117
15	180	103
20	180	94

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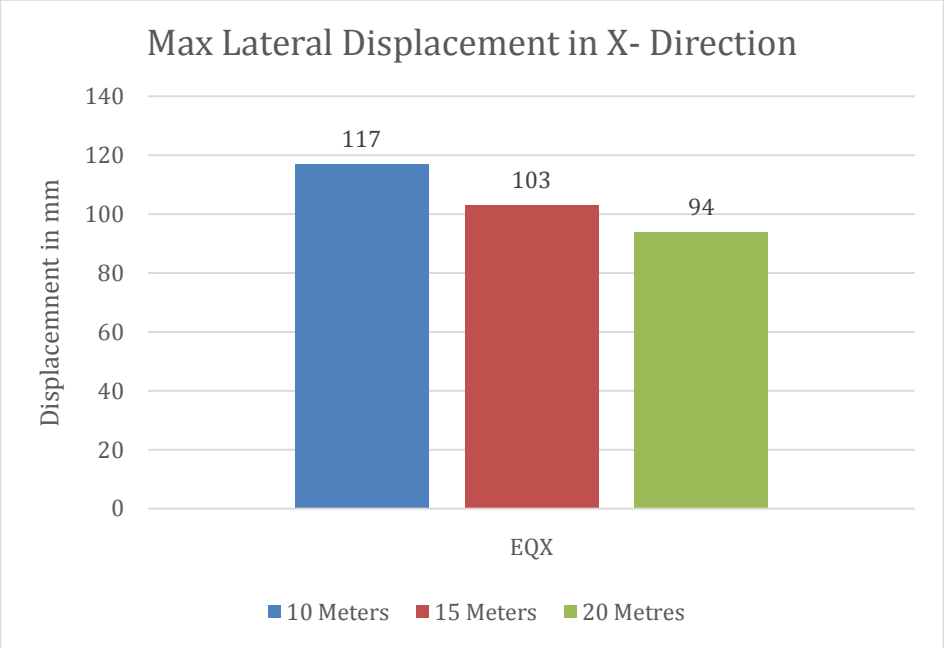

Fig.10 Maximum Lateral Displacement chart in X direction

From the results it can be noted that piles with 20m depth in same layers of soil has least lateral displacement compared to piles with 15m and 10m depth. Which indicates lateral displacement is directly proportional to the depth of the pile.

Table 11: Displacement For Piles Under Same Layer of Soil in Y Direction

Maximum Lateral Displacements in Y-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	180	114
15	180	103
20	180	94

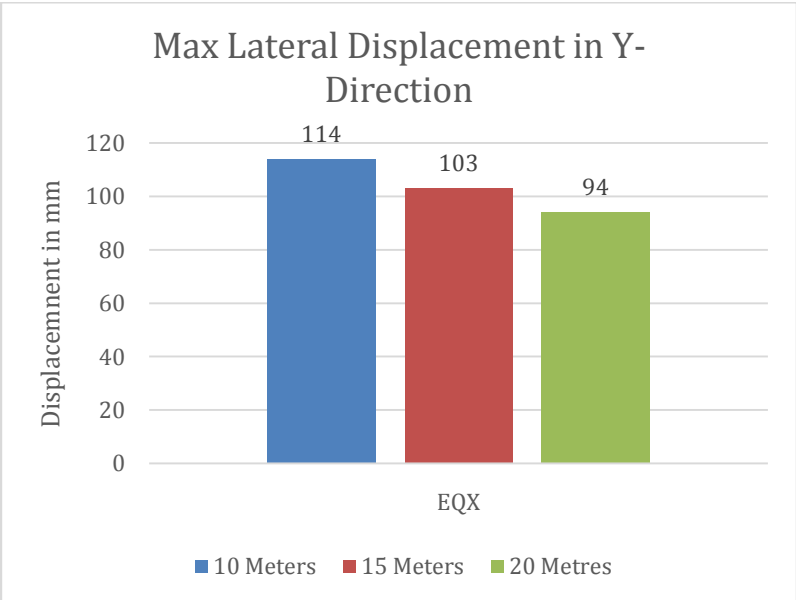

Fig.11 Maximum Lateral Displacement chart in Y direction

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From the results it can be noted that piles with 20m depth in same layers of soil has least lateral displacement compared to piles with 15m and 10m depth. Which indicates lateral displacement is directly proportional to the depth of the pile.

Table 12: Displacement For Piles Under Same Layer of Soil

Maximum Vertical Displacements in Y-Direction		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	180	6.52
15	180	7.14
20	180	7.78

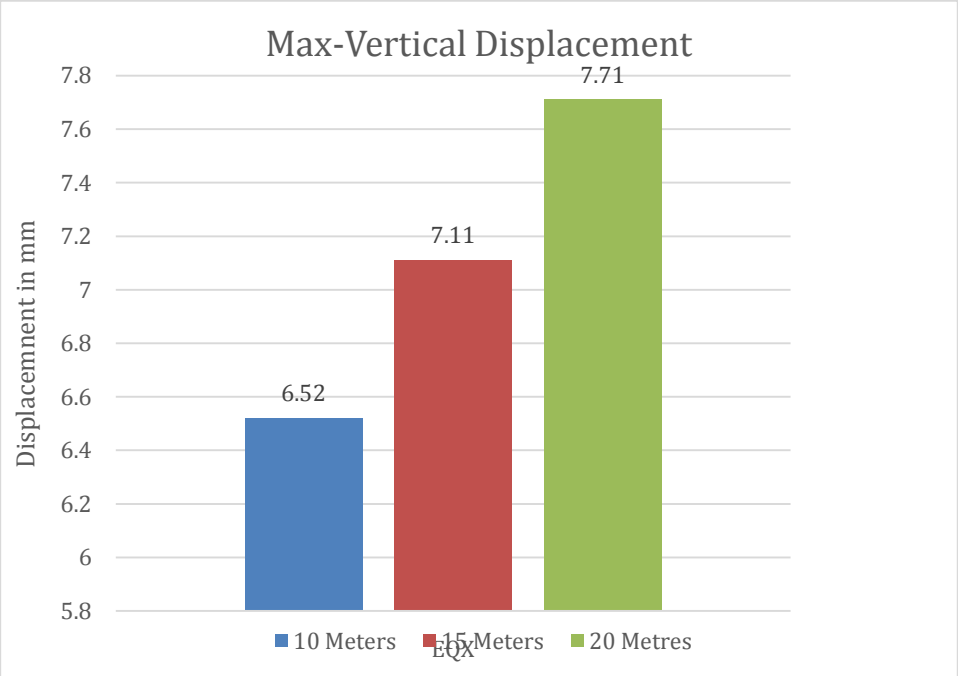

Fig.12 Maximum Vertical Displacement chart

From the results it can be noted that piles with 20m depth in same layers of soil has more vertical displacement compared to piles with 15m and 10m depth. Which indicates vertical displacement is directly proportional to the depth of the pile.

Table 13: Displacement For Piles Under Same and Different Layer of Soil in X Direction

Maximum Lateral Displacements in X-Direction				
Pile depth (m)	SBC (kN/m^2)			Displacement (mm)
10	60			107
10	120			104
10	180			117
10	Layer thickness			105
	5	5	5	

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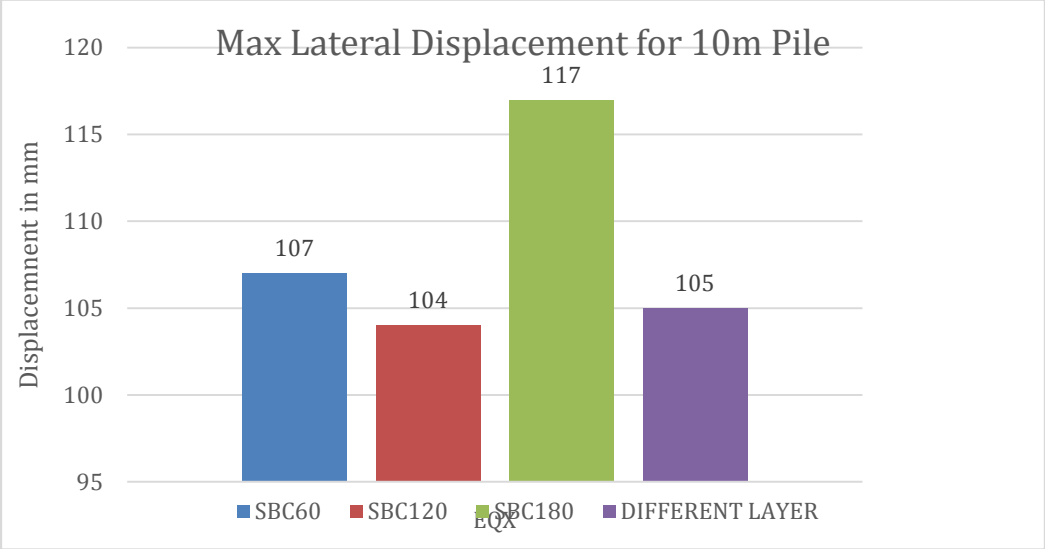

Fig.13 Maximum Lateral Displacement chart in X Direction

From the results it can be noted that piles with SBC 180 in same layers of soil has more lateral displacement compared to piles with SBC 120, 60 and different. But SBC 60 has more displacement compared to Different layer and SBC 120. Which indicates displacement is not directly proportional to the SBC of the pile.

Table 14: Displacement For Piles Under Same and Different Layer of Soil in X Direction

Maximum Lateral Displacements in X-Direction				
Pile depth (m)	SBC (kN/m^2)			Displacement (mm)
15	60			108
15	120			105
15	180			113
15	Layer thickness			107
	5	5	5	

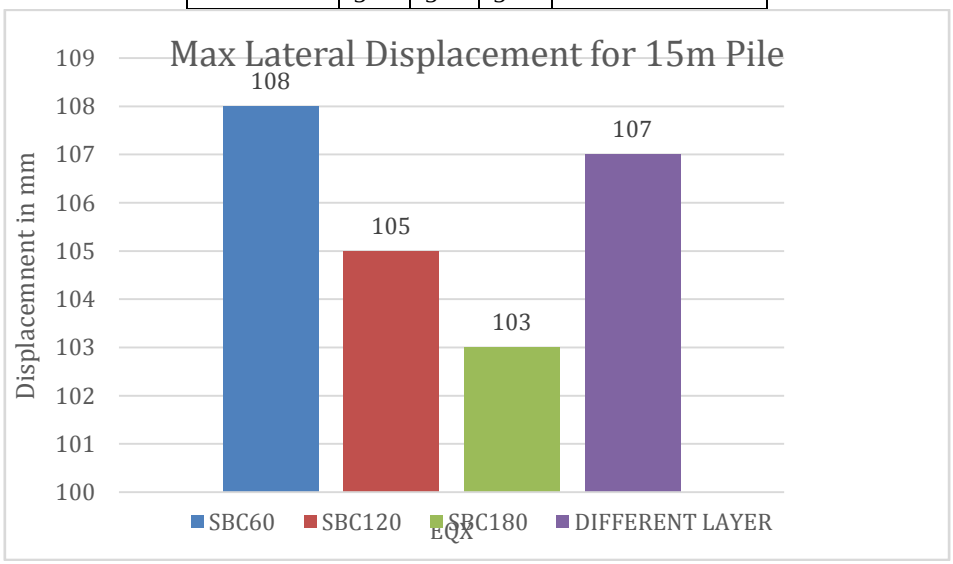

Fig.14 Maximum Lateral Displacement chart in X Direction

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From the results it can be noted that piles with SBC 60 in same layers of soil has more lateral displacement compared to piles with SBC 120, 60 and different layer. But Different layer has more displacement compared to SBC 60 and SBC 120.

Table 15: Displacement For Piles Under Same and Different Layer of Soil in X Direction

Maximum Lateral Displacements in X-Direction				
Pile depth (m)	SBC (kN/m^2)			Displacement (mm)
20	60			98
20	120			95
20	180			94
20	Layer thickness			99
	6.6	6.6	6.8	

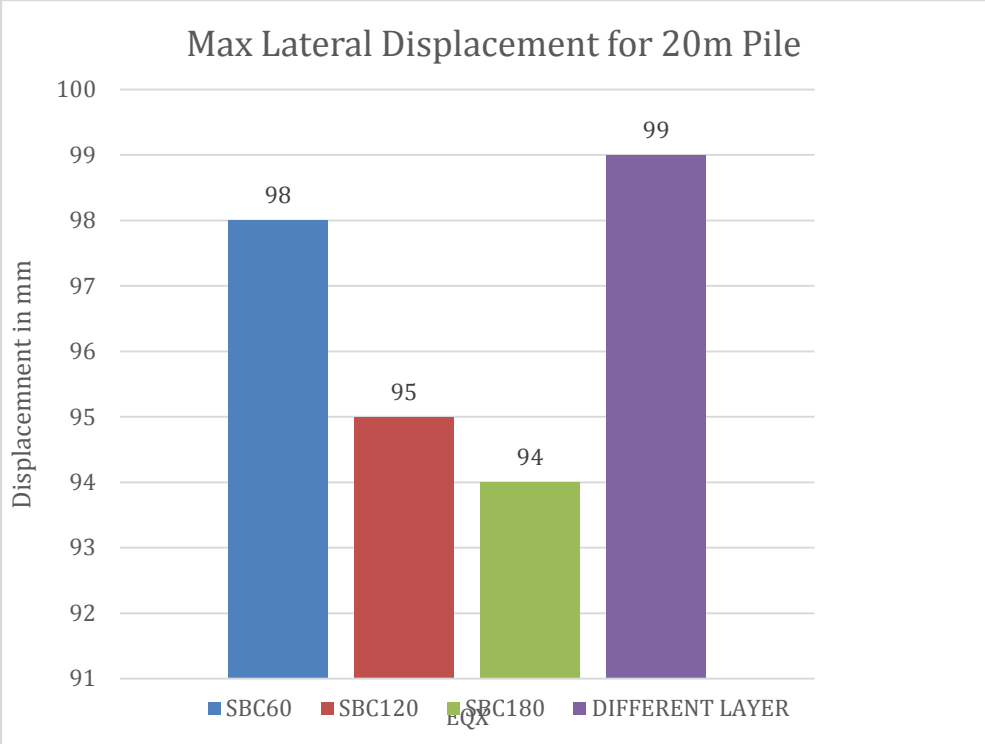

Fig.15 Maximum Lateral Displacement chart in X Direction

From the results it can be noted that piles with SBC 60 in same layers of soil has more lateral displacement compared to piles with SBC 120 and 180. But Different layer has more displacement compared to SBC 60.

Table 16: Displacement For Piles Under Same and Different Layer of Soil

Maximum Vertical Displacements		
Pile depth (m)	SBC (kN/m^2)	Displacement (mm)
10	60	6.524
10	120	6.52
10	180	6.528
10	Layer thickness	6.521

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	5	5	5	

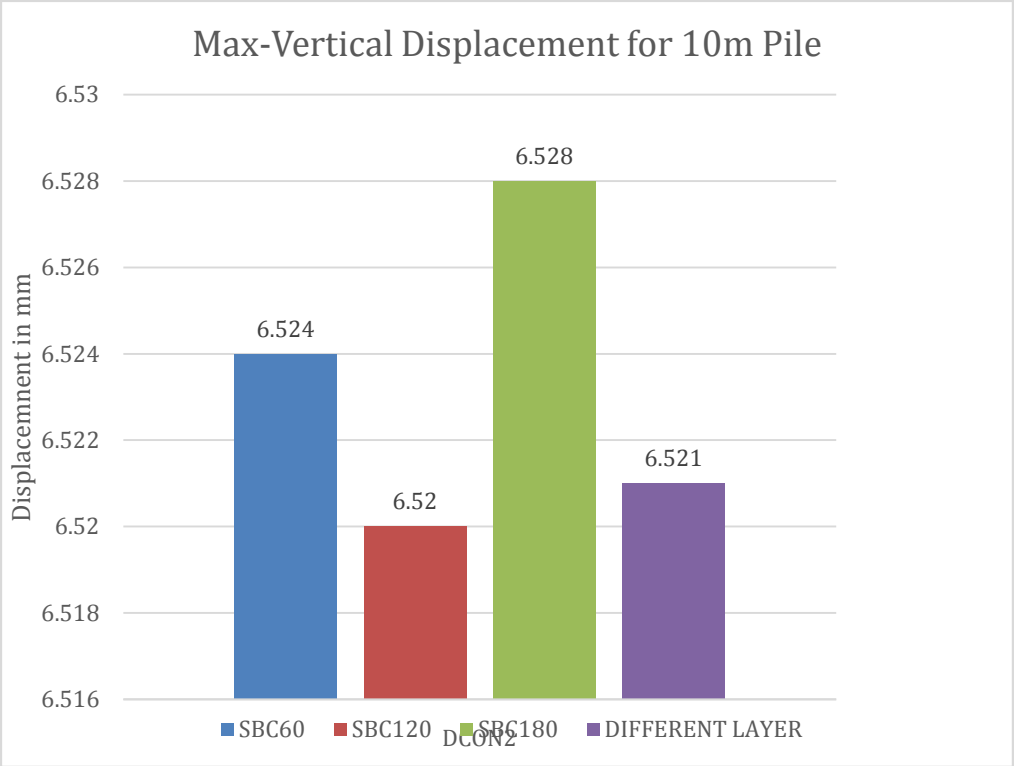

Fig.16 Maximum Vertical Displacement chart

From the results it can be noted that piles with SBC 180 in same layers of soil has more vertical displacement compared to piles with SBC 60, 120 and different layer. But SBC 60 has more displacement compared to SBC 120 and different layer.

Table 17: Displacement For Piles Under Same and Different Layer of Soil

Maximum Vertical Displacements				
Pile depth (m)	SBC (kN/m^2)			Displacement (mm)
15	60			7.14
15	120			7.13
15	180			7.11
15	Layer thickness			7.13
	5	5	5	

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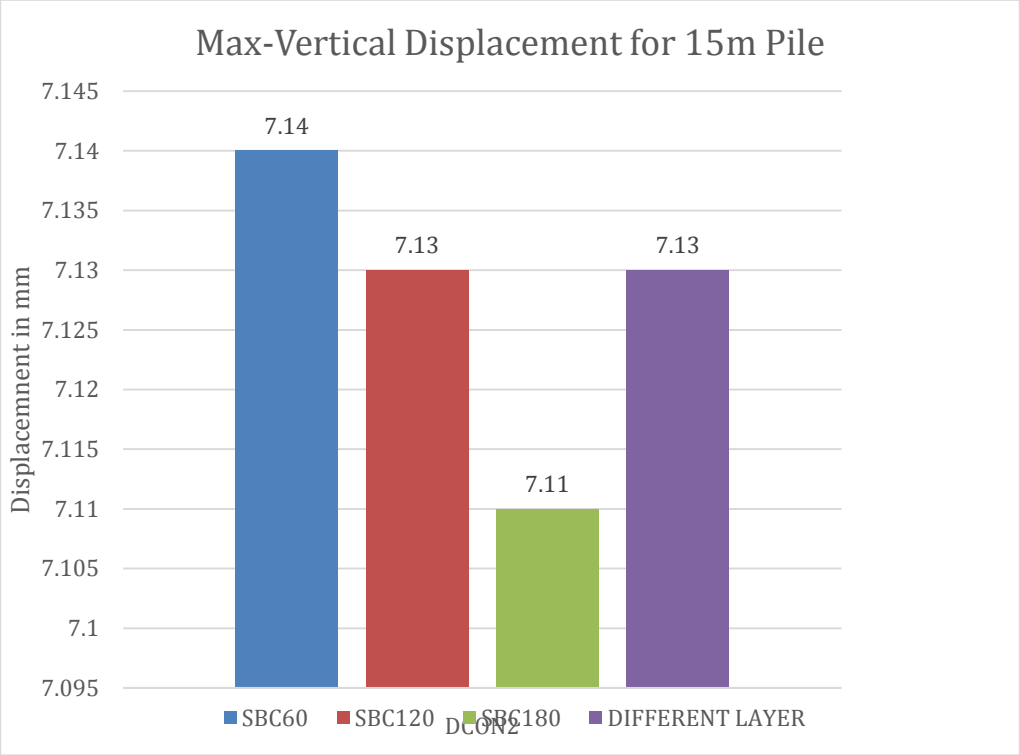

Fig.17 Maximum Vertical Displacement chart

From the results it can be noted that piles with SBC 60 in same layers of soil has more vertical displacement compared to piles with SBC 120, 180 and different layer. But SBC 60 and different layer are same and have more displacement compared to SBC 180.

Table 18: Displacement For Piles Under Same and Different Layer of Soil

Maximum Vertical Displacements				
Pile depth (m)	SBC (kN/m^2)			Displacement (mm)
20	60			7.78
20	120			7.75
20	180			7.71
20	Layer thickness			7.77
	6.6	6.6	6.8	

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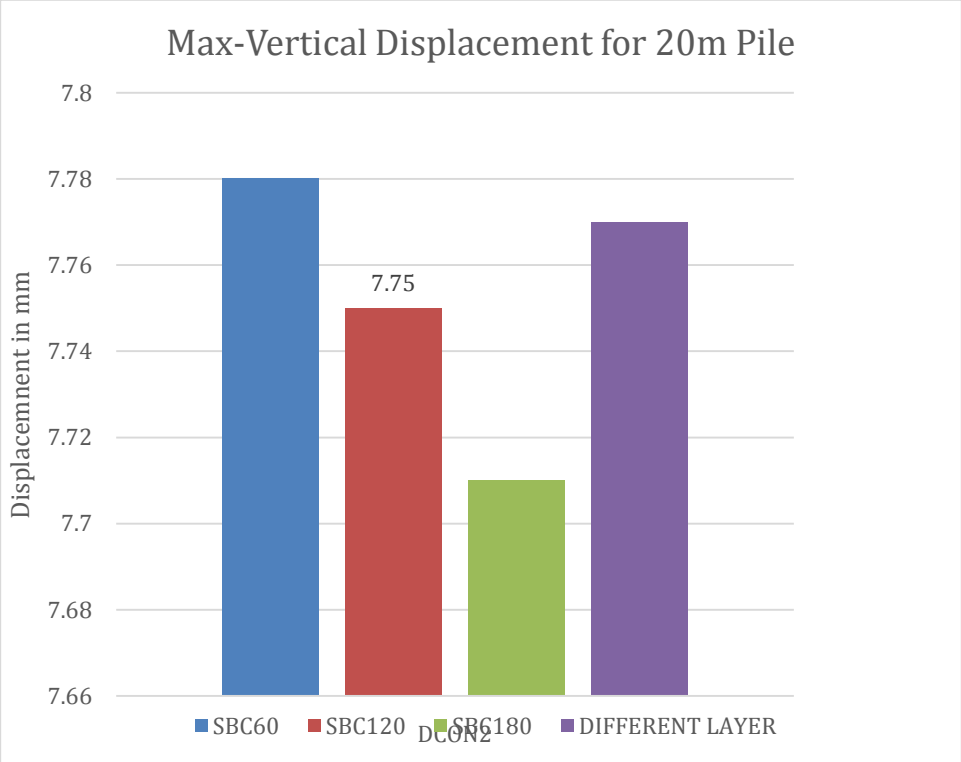

Fig.18 Maximum Vertical Displacement chart

From the results it can be noted that piles with SBC 60 in same layers of soil has more vertical displacement compared to piles with SBC 120, 180 and different layer. But different layer has more displacement compared to SBC 180 and SBC 120.

IV. CONCLUSION

- From the results it can be noted that piles with 20m depth in different soil layers has least lateral displacement compared to piles with 15m and 10m depth. But 15m has more displacement compared to 10m. Which indicates displacement is not directly proportional to the depth of the pile.
- From the results it can be noted that piles with 20m depth have more vertical displacement compared to piles with 15m and 10m depth. which indicates vertical displacement is directly proportional to the depth of the pile.
- From the results it can be noted that piles with 20m depth in same soil has least lateral displacement compared to piles with 15m and 10m depth. Which indicates lateral displacement is directly proportional to the depth of the pile.
- From the results it can be noted that piles with 20m depth in same soil has more vertical displacement compared to piles with 15m and 10m depth. Which indicates vertical displacement is directly proportional to the depth of the pile.
- From the results it can be noted that piles with 10m depth with SBC of 60KN/m^2 has more lateral displacement compared to same depth piles with SBC of 120KN/m^2 and SBC of 180KN/m^2 as well as different layers.
- With increase in depth of pile, it is seen that displacement is more for piles in soil of different layers compared to piles with soil of same layer properties.

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