NUMERICAL ANALYSIS OF SHALLOW FOUNDATION ON SLOPING GROUND BY USING GEO-5 SOFTWARE

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ABSTRACT

The study of the impact of load carrying capacity of foundations at shallow depth on slopes has caused a lot of interest in the last few decades. The load carrying capacity of a footing situated near a slope may be reduced. In fact, the distance between the foundation and the edge of the sloping ground influences the failure mechanism.In order to analyze the influence of the load carrying capacity of shallow foundations on slope a numerical analysis based on the finite element method (FEM) by using mohr coulomb model on Geo-5 software.for the investigate, Medium dense sand soil is used and the slope angle is considered 15, 30 and 35. A strip footing(B=2cm) is considered which is varying by the set back distance(d) by 0.5b m,1.5b m and 2b m and apply load.As a result load vs settlement curve drawn and investigate the bearing capacity.

Keywords:
SHALLOW FOUNDATION (STRIP FOOTING), GEO5 V.2021, and FINITE ELEMENT METHOD.

1.INTRODUCTION

Foundations are an important part of any construction, and their main function is to transfer concentrated loads from the building to the underlying foundation material. Basement excavations for high-rise buildings, bridge column and tower electrical transmission tower is the few examples, may be required to construct on the slope. On level ground, the load carrying capacity of a foundation is entirely determined by the shear strength of the soil under foundation and settlement criteria, whereas a foundation in the vicinity of a slope necessitated consideration of the slope's stability. When constructing a foundation near a slope, additional design criteria must be considered, which are typically difficult to analyse, making the design process complex and time-consuming. The Influencing geometrical parameter of slope like height of slope, inclination of slope, setback of footing from crest of slope and characteristics of soil and proximity of structure near slope affect load that a soil can carry, the load usually reduces than in case of flat ground.In Previous analysis, **Kusakabe et al. (1981)**In this study upper bound (UB) theorem has been used on the way to estimate the load carrying capacity of the slope, subjected to strip forces on top of the surface. In this study lower bound analysis was also considered.**Graham et al. (1988)** presented the load carrying capacity analysis of the shallow foundations (cohesionless soil slopes), taking the stress situations just below the footing under consideration. and sand properties considered in the stress characteristics approach are expressed by a critical state model. Various levels of stress, placement densities, and compressibility of sand are now all considered. Increased strain causes tensions would go from softening to hardening of the strain (Graham 1986). **Swami Saran et al. (1989**) Employing limit equilibrium (LE) and limit analysis (LA) methodologies, developed analytic approach and determine the load carrying capacity of footings next

to slopes. On side of the slope, one-sided rupture failure was considered, and partial mobilisation was assumed on the flat ground side. **Castelli and Motta (2010)** In this paper, using a limit equilibrium method to investigate a strip footing situated at a distance from slope of ground static and seismic bearing capacity, taking into consideration and effect of soil inertia and assuming circular failure mechanism. They developed an equation to calculate bearing capacity by considering the effect of seismic and presented comparison between the new technique and previous theories. **Georgiadis (2010)** This study contains finite element (FE) simulations on or near undrained soil slopes of strip footings, which were carried out to find the impact of various parameters on undrained bearing capacity. This research involved plane strain analyses, which were done out using the Plaxis software. **Jalili et al. (2021)** This paper used a 2-D finite element method to investigate the seismic behaviour of shallow foundations near to sandy slopes.
In this study the load carrying capacity of strip footing constructed on the top of slope is investigated using finite element analysis software geo-5.It includes footing responses to the various parameters including slope angle, footing distance ratio and depth of the embedment.

2. Methodology-
In this study, The numerical modelling in this study is done using the two-dimensional finite element approach. GEO-5 software is capable of performing such calculations. Strip footing is a type of shallow foundation. The 2D plane-strain framework is utilised for two-dimensional modelling due to the layout of the sandy soil slope and the shallow base. The strip foundation is composed of reinforced concrete with a width of 2m and a thickness of 1m, with mechanical behaviour of linear-elastic taken into account. The angle of slope (15,30, and 35) and the distance between the outside edge of the shallow foundation and the edge of the crest of slope (d = 0.5b, 1.5b, and 2.0b) are chosen as variables. or high strength concrete, the linear-elastic modulus is assumed to have a common value of ERC- = 25GPa, the Poisson's ratio is v = 0.15, and the specific gravity is RC = 25kN/m3. The dry sandy soil was modelled using the Mohr–Coulomb elastic–perfectly plastic criterion (MC) under the non-associated plastic flow rule (i.e., considering zero dilation angle for sand). For mesh, we have used 4484 nodes and 2439 element for analysis of bearing capacity of the shallow foundation on sloping ground.
We have used the properties of soil which shown below,

Table2.1: properties of soil

Sandy soil parameters	Values
Internal angle of friction of the soil	38
Soil cohesion (kPa)	0.01
Modulus of elasticity of soil (MPa)	42.5
Poisson’s ratio of soil	0.20
Dilatation angle for soil	0
Specific gravity of sandy soil (dry) (kN/m3)	20
Elastic modulus ofloading–unloading (MPa)	102

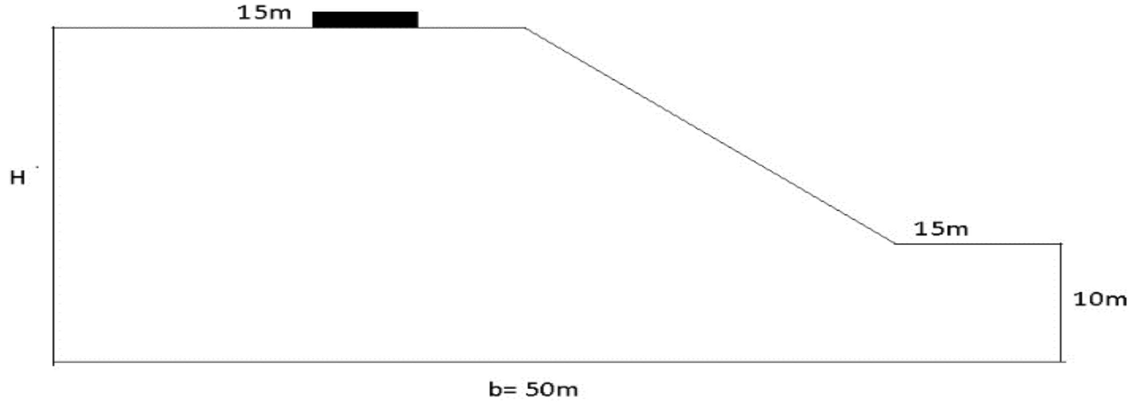
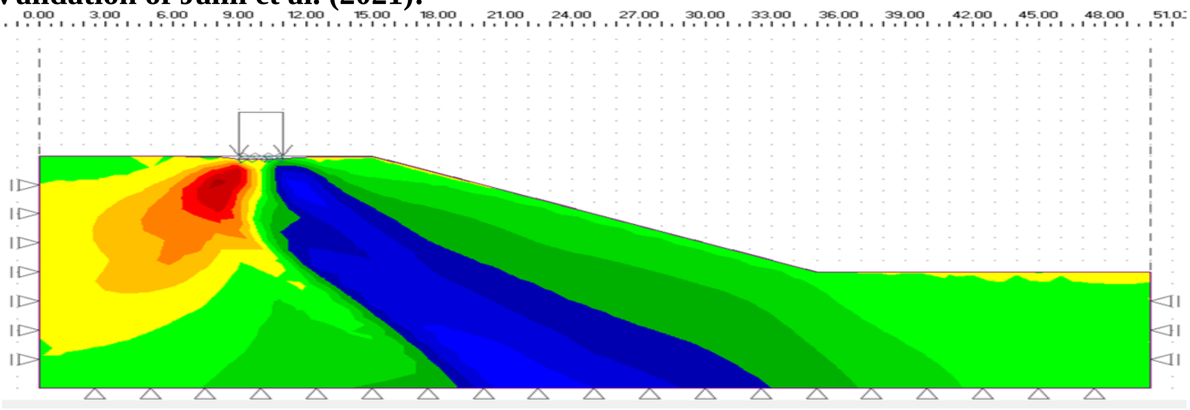


Fig2.1: Schematic diagram for analysis of strip footing on sloping ground

3.Validation:

For the validation research paper are taken as the reference paper so as to validate the Static surcharge load variations cause dynamic change of shear force in the foundation,for that we increase the setback distance (d) at a distance 0.5b and 1.5b respectively.(where b is the width of the footing), as we can see in result from the validation,as the distance between the foundation and the peak of the slope is increased, it nearly increases the shear force in the foundation.

3.1 Validation of Jalili et al. (2021):



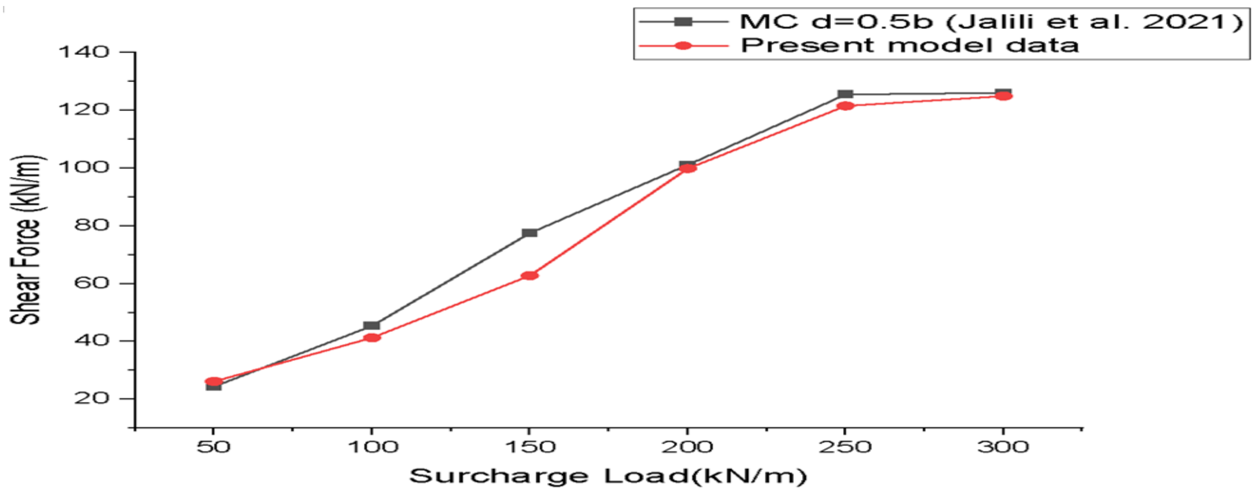


Fig.3.1: Analysis of validation on Geo-5 software jalili et al.(2021)

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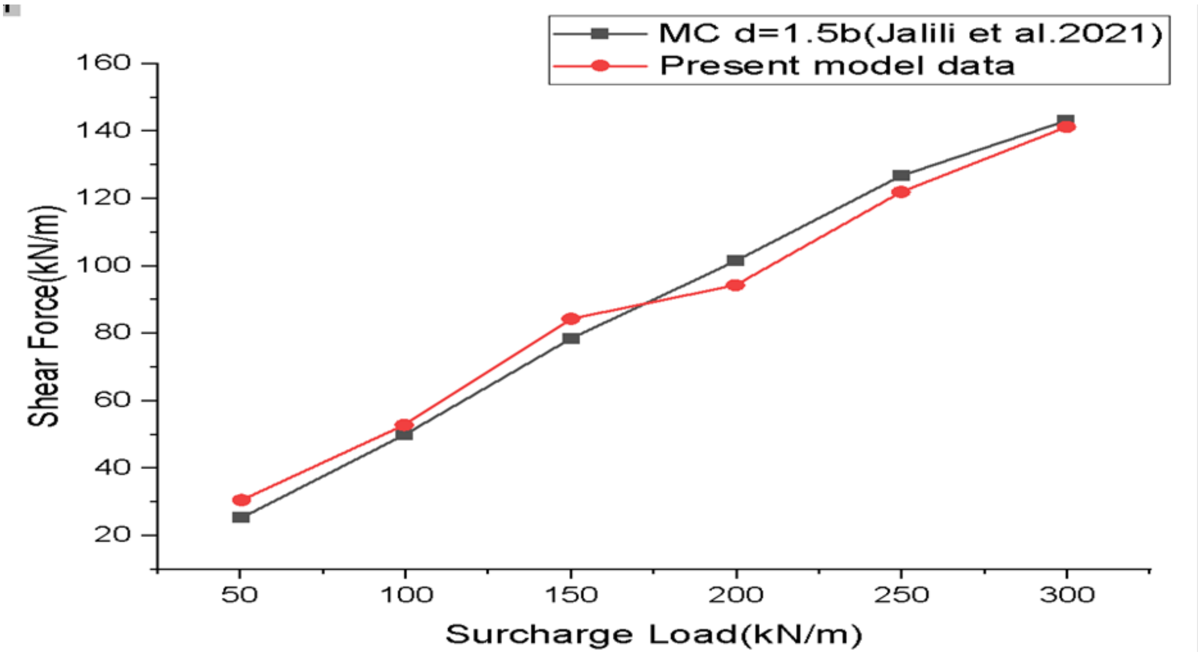

Fig.3.3: Validation graph between jalili et al.2021 and present study at d=1.5b from the crest

Table 3.1-Result of Jalili et al. (2021)

Jalili et al. (2021)			
s.no.	Surcharge load (kN/m)	Set back distance(d=0.5b) Shear force (kN/m)	Set back distance(d=1.5b) Shear force (kN/m)
1	50	24.39	25.37
2	100	45.37	49.95
3	150	77.54	78.52
4	200	101.14	101.52
5	250	125.50	126.78
6	300	126.10	143.16

Table 3.2-Result of present study

Present study			
s.no.	Surcharge load (kN/m)	Set back distance(d=0.5b) Shear force (kN/m)	Set back distance(d=1.5b) Shear force (kN/m)
1	50	26.14	30.58
2	100	41.26	52.88
3	150	62.8	84.36
4	200	99.88	94.32
5	250	121.58	121.98
6	300	124.96	141.6

4.Result and Discussion:

4.1 Result:

In this analysis we have varying the distance of the strip footing from d=0.5b and 1.5b and d=2b applied the surcharge up to 300 kN.

Case-1 when slope angle is 15,
In this analysis we have varying the distance of the strip footing from d=0.5b applied the surcharge up to 300 kN.

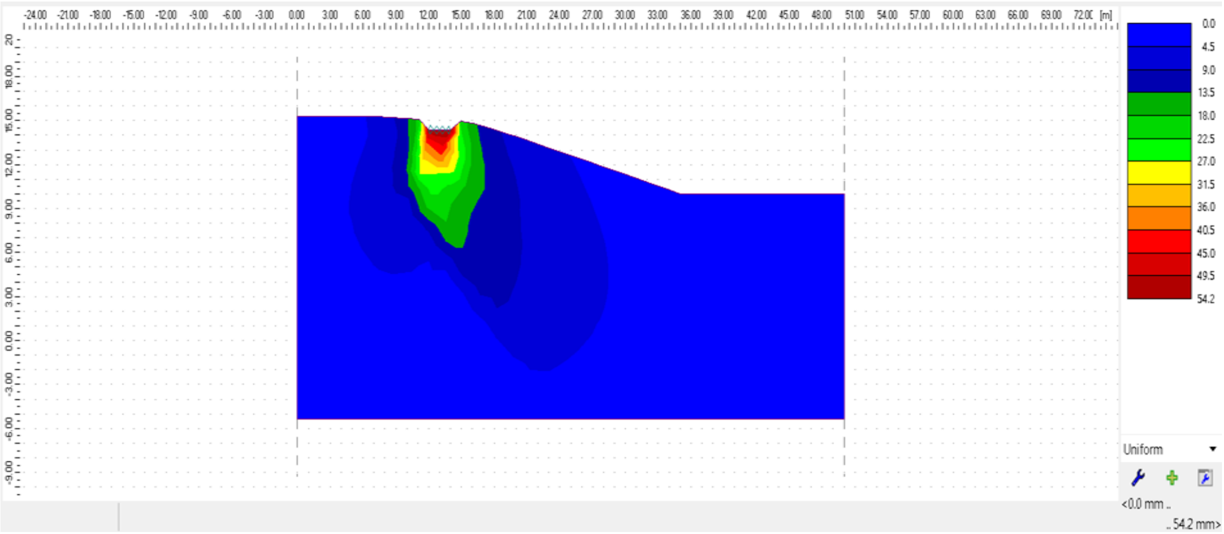

Fig4.1: case-1 analysis of strip footing on sloping ground at slope angle 20 and distance d=0.5b from the crest

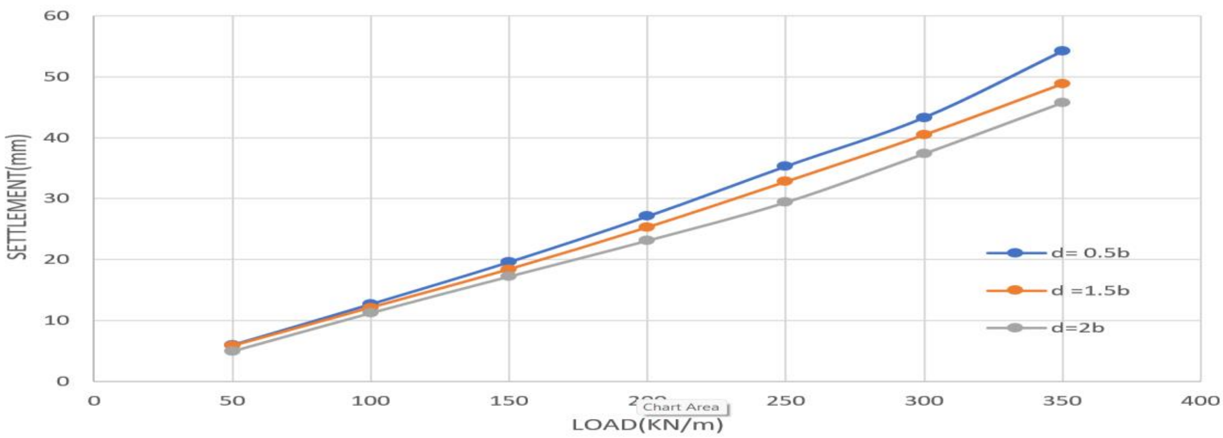

Fig4.2: Graph of load settelemnt curve at slope angle 20 and d=0.5b from the crest

Table4.1-Results of slope angle 15 and d=0.5b

Load (KN)	Settlement (mm) At d= 0.5b	Settlement (mm) At d =1.5b	Settlement (mm) At d=2b
50	6	5.8	4.9
100	12.7	12.1	11.2
150	19.6	18.4	17.2
200	27.1	25.3	23.1
250	35.3	32.8	29.4
300	43.3	40.5	37.4
350	54.2	48.9	45.8

From the graph we have seen that as we move away from the crest of the slope the settlement is decreases and the load carrying capacity of the soil is increases.

Case-2 when slope angle is 30,

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In this analysis we have consider the height of slope with respect to the slope angle. and further analysis same as the previous.

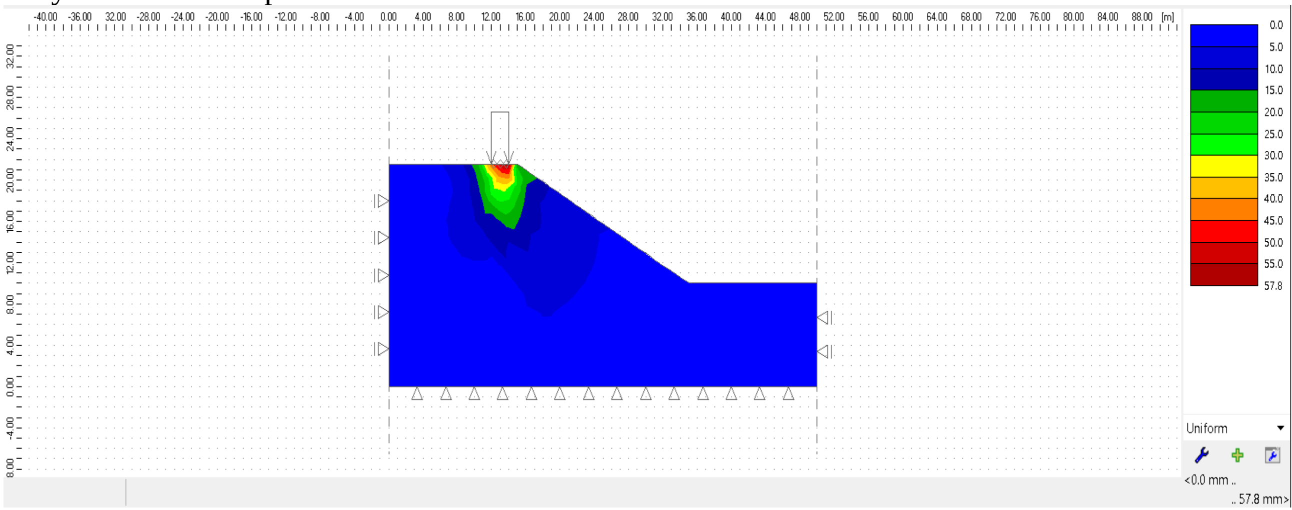

Fig4.3: case-2 analysis of strip footing on sloping ground slope angle 30 and distance d=1.5b from the crest

Table4.2- Results of slope angle 30 and d=1.5b

Load (KN)	Settlement (mm) At d= 0.5b	Settlement (mm) At d =1.5b	Settlement (mm) At d=2b
50	4.9	5.1	4.7
100	10.8	11.8	9.9
150	18.5	18.5	15.6
200	27.8	24.5	21.9
250	40.2	31.5	28.7
300	54.5	38.8	36.2
350	57.8	47.2	44

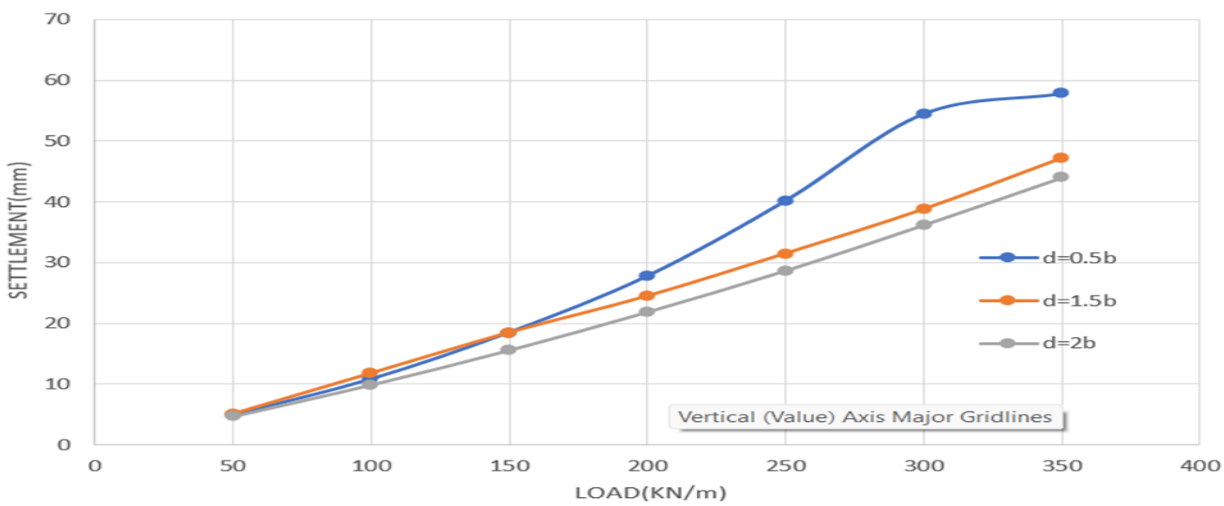

Fig4.4: Graph of load settelemnt curve at slope angle 30 and d=1.5b from the crest

From the we graph we have seen that at d=0.5b, as we increase the load the settlement of the foundation increases up to the influence zone after that settlement became constant due to structure failure. and as we go away (d=1.5b, d=2b) from the crest the settlement is decreases as the bearing capacity of the soil increases.

Case-3 when slope angle is 35,
This analysis is also done as the previous cases.

Fig4.5: case-3analysis of strip footing on sloping ground slope angle 35 and distance d=2b from the crest

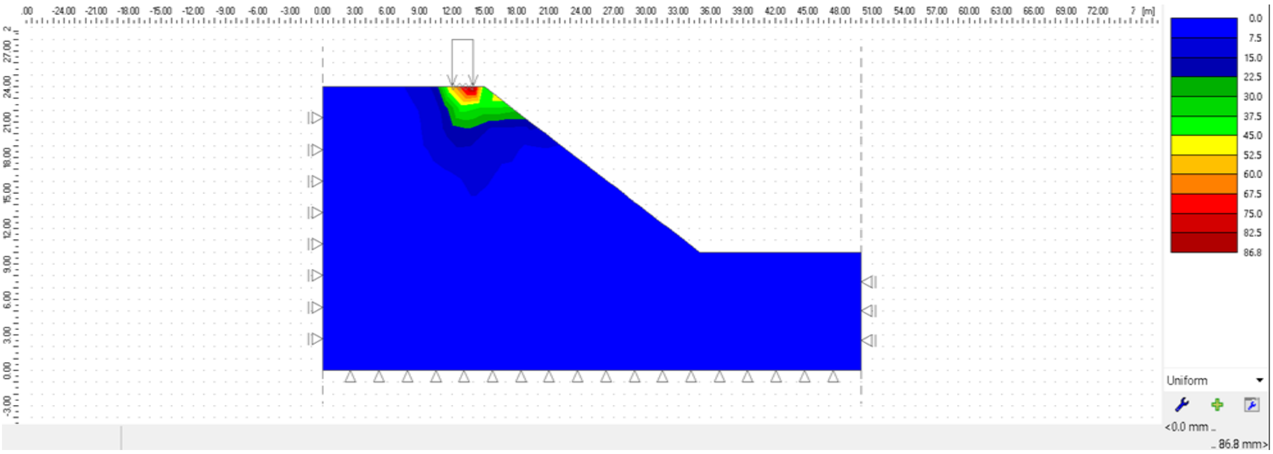

Table-4.3- Results of slope angle 35and d=b

Load (KN)	Settlement (mm) At d= 0.5b	Settlement (mm) At d =1.5b	Settlement (mm) At d=2b
50	4.9	4.8	4.7
100	11.3	10.4	10.4
150	22.3	18.2	17.3
200	41.1	25.4	24.7
250	86.8	34.4	32.2
300	86.8	43.4	40.6
350	86.8	54.1	50.7

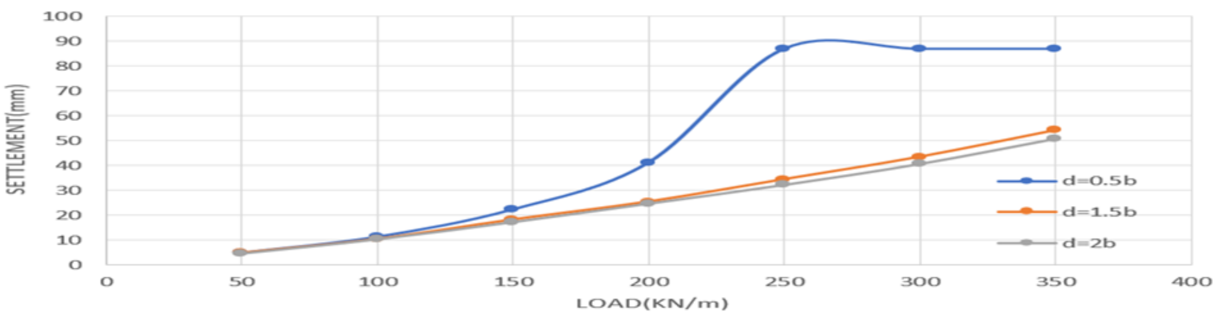

Fig4.6: Graph of load settelemnt curve at slope angle 20 and d=0.5b from the crest

From the graph we can see that at d=0.5b, the settlement after 200kN is drastically increases. Because the soil is reaching its ultimate bearing capacity and soil is not allowing to sustain further load that's why the graph is constant.

4.2-Discussion:

4.2.1-Effect of slope angle-

From the analysis of three cases at different slope angle, we can see that as we increase the angle of slope, the load carrying capacity of the soil decreases. Because the soil at the slope crest act as passive resistance from the slope sides. At the higher slope angle, the rate of reduction of the bearing capacity is very high and bearing capacity is also depends on the footing width ratio whereas at low slope angle effect of the footing width ratio is very less than the higher slope angle.

4.2.2-Effect of the footing distance ratio-

From the analysis of the three cases at different position of the strip footing, we can see that, as we move from the crest of the slope ultimate load bearing capacity increases because the settlement of that load decreases. Because of the confining area of the load distribution is increases.

5.Conclusion-

Parametric analysis of the maximum load bearing capacity of the footing placed on the sloping ground on the finite slope is performed by using the Geo-5 software considering the static condition. Some of the conclusions are drawn which shown below.

1- The influence of the angle of slope and distance of footing from the crest on the load carrying capacity of the footing on the slope is taken into account.

2-Bearing capacity increases as the footing placed away from the crest (d=0.5b, d=1.5b, d=2b) till the slope effect is diminished.

3- When the footing is located near the crest of the slope, it has the lowest load carrying capacity.

4-Failure is occurred due to increases in instability of the slope as the angle of slope increase due to this bearing capacity decreases.

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