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Parametric Study Of Slope Stabilization With Micro Piles By Using Physical Modeling Methods

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***Abstract**:* The largest environmental challenges that Northern India faces today is the landslides. In this paper, a physical modeling method based on load – settlements curve to find the load carrying capacity of micro piles. Parametric study of highway embankment by CBR type arrangements which involves manually loading arrangements, proving ring & dial gauge. Method of static point bearing micro piles in sandy soil has been developed. The formulation for calculating the load – settlement curve by proving ring and dial gauge. Special attention is given to determine the spacing of micro piles in different arrangements (single row, double row and staggered or zigzag pattern of micro piles) with the aim of achieving the maximum load carrying capacity of the micro piles arrangements. Thus, a new design method for micro piles for earthen slope stabilization is proposed that includes details about choosing arrangements of the micro piles with existing highway embankment, selecting micro plies arrangements with maximum load carrying capacity, and considered end bearing piles. Evaluating the angle for staggered piles, calculating the spacing required to stabilize the slope. The utilization of the technique, to a highway embankment land slide which was manually modeled to have experimentation in Punjab region, India, is described, and manipulating the data show which envisage the change of soil slope definitely stopped by obtaining a suitable outcomes of the embankment is observed, proved the good response of this of the technique.

Keywords: Manually modeled soil embankment; Dial Gauge, Proving ring, CBR Type Arrangements: Stabilizations, Micro piles, Piles capacity, Load-settlement curves.

1. Introduction

An earth slope is an unsupported, slanted surface of dirt mass. Earth slope is formed for railway arrangements, road way embankments, dams and the numerous different areas. For any land-based structure, the establishment is critical and must be solid to help the whole structure. All together for slopes to be solid,

the soil around it assumes an extremely basic part. Along these lines, to work with soils, we need legitimate learning about their properties and components which impact their behavior (Zing et al., 2009). The strategy of soil adjustment achieves the required properties in soil required for development work. The cast of earth work would be least if the inclines are made steepest. Be that as it may, exceptionally soak slants may not be steady. A trade off must be setup amongst safety & cost, and also the slant gave is never excessively soak or not excessively level. At the end of the day, the steepest slants which are safe and stables should be provided. The disappointment of slope might be prompt death toll and property. It is, therefore, fundamental to check the stability of proposed slope. With the advancement of present-day strategies for testing of soil and stability examination, a protected and conservative plan of a slope is conceivable [3].

Nomenclature

Q_g	ultimate load of the group pile
Q_u	ultimate load of the individual pile
N	Number of piles in the group
Q_p	The point resistance or tip resistance of piles
Q_s	Resistance developed by friction between the pile & soil.
q_p	Ultimate bearing capacity of soil at the head of pile
A_p	Area of the pile trip.
f_s	Skin friction between the sandy soil & surface of the pile
A_s	The effective surface area of the pile
D	Diameter of piles
A	Area of piles
N_q	Bearing capacity factor
ϕ	Angle of shearing resistance
$\tan\delta$	Coefficient of friction between sand and the pile materials
L	length of piles
θ	Angles between micro pile patterns

The geotechnical engineers should have a careful learning of the different strategies for checking the stability of slopes and their restrictions. Along a blended surface the disappointments of soil mass happen. At the point when a colossal mass of soil slides concerning the staying slant mass. A slope disappointment happens when the force causing failure is more prominent than shearing resistance developed along a basic surface of disappointment. From the soonest beginning stage of advancement work, the head of enhancing soil properties has gone to the light. Obsolete municipal foundation of the Chinese, Romans and Incas utilized distinctive methodologies to improve soil quality and soon, a portion of these strategies were powerful to the point that their structure still exists. It is hard to anticipated the behavior of soil after leading, in this manner strengthen the soil after construction has become visible. There are different methodologies available to strengthen the dirt, after development. By using the micro piles, the geotechnical engineers should find the satisfactory technique to better the existing slants in a more cost-efficient way. Sometimes structure like foundation, embankments, water bodies are constructed or arranged close to the sides of oceans, lake & rivers it is found that the bearing capacity of dirt mass decreases significantly with the age of structure it is consequently fundamental to reinforce the bearing ground. Some mathematical instruments are too proposed which can be utilized for investigation of slope in specific conditions [2].

Here, in this venture, slant adjustment has been finished with help of micro piles. The adjustment in the shear quality parameters has been stressed upon and similar examinations have been finished using particular techniques for shear obstruction estimation.

2. Static methods for driven or point bearing piles in sandy soil

Point bearing pile action in group

$Q_g = N\,Q_u$ (1)

Where $Q_g$ultimate load of the piles works in group,Q_u = the ultimate load of the pile for individual behavior of pile action, N = Total number of piles working in the group.

Ultimate capacity of a single pile inserted into sandy soil is obtained using equation

$Q_u = Q_p + Q_s$ (2)

Where,$Q_p = q_p A_p$ (3)

The point resistance or tip resistance of piles is Q_p

Resistance developed by friction between the pile & soil is Q_s and $Q_s = f_s A_s$ (4)

In equations (2) & (4)

q_p= It is denoted for Ultimate bearing capacity of soil at the head of pile

A_p= It is mention for Area of pile at the top.

f_s= This shows skin friction between the sandy soil & surface of the pile

A_s = the effective surface area of the pile in when pile contact with the soil.

Determine the point resistance ,$Q_p = A_q \bar{q} N \le A_p q_l$ (5)

Determine the, $\bar{q}\left(\frac{D_b}{B}\right)_{cr}$ (6)

Determine actual $\left(\frac{D_b}{B}\right)$ ratioforpile

Determine N_q for $\left(\frac{D_b}{B}\right)$ ratio for the pile

N_q= Bearing capacity factor which depends upon the angle of shearing resistance ϕ.

$Q_u = \bar{q} N_q A_p + K \tan\delta$ (pile perimeter) $\left(\frac{\bar{q}}{2}\right)$ D (7) tan δ=Coefficient of friction between sand and the pile materials

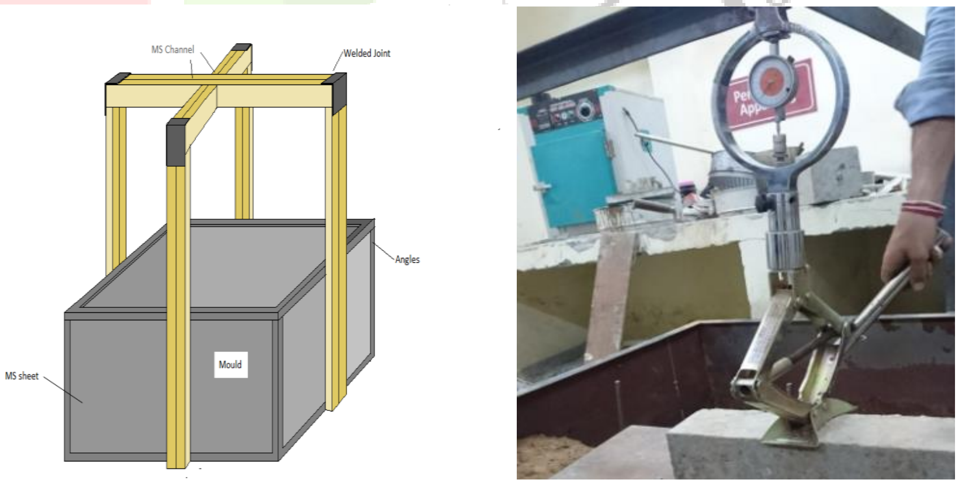
The values of k and δ, as given in table 1, based on the studies carried by Broms (1966)

Table 1 Values of δ and K (…)

Material of pile	K (loose sandy soil)	K (dense sandy soil)	δ
Timber	1.5	4.0	0.67
Concrete	1.0	2.0	0.75
Steel	0.50	1.0	20

3. Arrangement of experimental setup

The experimental arrangement was arranged in a container to flow the site situation (natural & environmental conditions) to check the effect of micro pile embedded in soil by choosing the various positions like as single, double and staggered piles are used. The effect of the spacing ("center to center spacing between different numbers of piles"), effect of angles with respect to numbers of pile used was considered. A box ("container") with dimensions of 150 ×150 × 62 cm was used with base plate of thickness 0.3 cm to analyze the experimental work in laboratory. With the help of channels section & MS sheets box are prepare for work. A calibrated proving ring with dial gauge used in "CBR" apparatus of least count 0.002 mm, fixed with MS channels of box to obtain the load values. For the application of loading manually operated mechanical jack was setup with arrangement to taking the response of load values corresponding to standard settlements. Distribution plates are used on the surface of embankments to distribute the load whole of the length. Dial gauges were fixed cross channels to measure the settlement. In the experiment settlements of soil was kept at standard intervals corresponding to load values. Soil fills in the container layer by layer to make the slope for experiment. Thermo-mechanically treated steel bars was used as micro pile. The experiment was performed in laboratory by optimize the site condition.



(a) Container with cross Channels (b) Loading arrangement

(c) Micro pile embedded in soil

Figure 1 (a) Container with cross Channels (b) Loading arrangement (c) Micro pile embedded in soil

4. Testing

To analyze the site conditions (original site), the testing was arranged in a box with application of loading. Generally, three types of field cases are considered (a) single row of pile: The center-to-center distance between different numbers of piles are varied. (b) Double row of pile: two rows are considered for test the stability of slope. The horizontal spacing of piles was varied but the vertical spacing of piles was constant. (c) Staggered patterns of piles, spacing and angles between piles are also varied. The diameter of piles for this experimental study was considered constant as 10 mm for all pile patterns like single, double & staggered. The size of model highway embankment and length of pile were also considered constant through the whole testing. The testing details are given below:

I **Test on virgin soil (Sandy) (when no pile was used).**

For the virgin soil no piles are inserted in soil and plot the load v/s settlement graph. Set the dial gauge and proving ring reading at zero before starting the experiment. Load is manually applied by the jack and distribution plates distribute the load whole of the embankment length. Dial gauge was placed near to the loading arrangement (load distribution plates). When load is applied on soil, the proving ring takes the load values corresponding standard settlements values taking in dial gauge. After taking the reading draw the load v/s settlement curves

PHOTO ABD LOAD VS SATLEMENT CURVE, ALSO SHOW THE DIFFERENT TYPES OF TESTS PERFORMED ON SOILS

II Single row of piles was used

In single row pile patterns, pile was installed in soil by calculating the different numbers of piles corresponding to horizontal spacing ("center to center distance") between the various numbers of piles. With change the in numbers of piles, the spacing of pile changes. Load is applied when piles is embedded in soil and note the value of loads corresponding to standard settlements. Plot the graphs for each cease to find the best results.

Table 2 Different Parameters Used for testing for single row micro pile patterns

S. No.	Horizontal Spacing (mm)	No. of piles used
1	740.00	3
2	493.30	4
3	370.00	5
4	296.00	6
5	246.60	7
6	211.43	8
7	185.00	9
8	164.44	10
9	148.00	11
10	134.54	12
11	123.33	13
12	113.85	14

III Double row patterns of piles

In this case vertical center to center spacing for all the cases of double row was considered constant. Horizontal center to center spacing between piles varied for all the cases and different numbers of piles were used for different conditions. In this case pile angle was notice most important. The load in proving ring was measured at specified settlement and plots the graph between load v/s settlements

Table 3 Different Parameters Used for Testing for Double Row Micro Pile Patterns

S. No.	Horizontal Spacing (mm)	No. of piles used
1	740.00	6
2	493.30	8
3	370.00	10
4	296.00	12
5	246.60	14
6	211.43	16

IV Staggered patterns of piles

Last case staggered patterns of piles, horizontal spacing between piles varied with change in numbers of piles and angles also changes with spacing between piles angled. Staggered patterns of piles are differed from single, double patterns of piles. In this case angle of pile patterns was most important and highlighted to check the performance of the soil response on piles. Measure the loads corresponding to specific settlement.

Table 4 Different Parameters Used for Testing for Staggered Micro pile Patterns

S. No.	Horizontal Spacing (mm)	No. of piles used	Spacing between angled piles	Angle between piles (°)
1	740.00	5	530.83	46
2	493.30	7	453.03	57
3	370.00	9	422.64	64
4	296.00	11	408.03	69
5	246.60	13	399.70	72

5. Data collections

I Comparison of load carrying capacity of virgin soil and single row micro pile soil

The load carrying capacity of soil was improved by installing the single row micro pile with appropriate spacing on soil embankment. The experiment was performed to check the load carrying capacity and response of soil in embankment. Inserting the pile in soil, soil gets densified due to material of micro pile and soil. The results are obtained by installing the single row of micro pile patterns in soil with suitable spacing between piles was calculated. Soil was modeled in a container and a pile was optimizing to analysis the results.

From the single row patterns pile results, it was notice that the load carrying capacity of was definitely improved. Settlement of soil; was checked at standard values 2.5, 5, 7.5, 10 and 12.5 mm. Hence, it was observed that the capacity of soil to resist the load is increased from 13.8 KN to 30 KN by optimizing the single row pattern of eleven numbers of micro piles.

It was observed that the best results were find at 2.5 mm settlement for eleven numbers of piles with horizontal Centre to Centre spacing was 148 mm. It was observed that load carrying capacity increased by two times of its earlier observation. The max load carrying capacity, which soil carried was in case when horizontal center to center spacing was 148 mm for 11 no, of piles in single row. It was observed was load carrying capacity of virgin soil was increased by 47 % by installing the 11 no, of pile in single row with 148mm spacing between the pile at specified settlement (2.5mm) as shown in figure 2.

For settlement of 5mm it was noticed that the load carrying capacity by soil with single row pile pattern increased 21kn to 42.8 kN. The load carrying capacity was increased by 49% as shown in fig. therefore from the result as discussed above it has been observed or concluded that single row micro pile pattern may be used to improve the capacity and life of the structure in sandy soil.

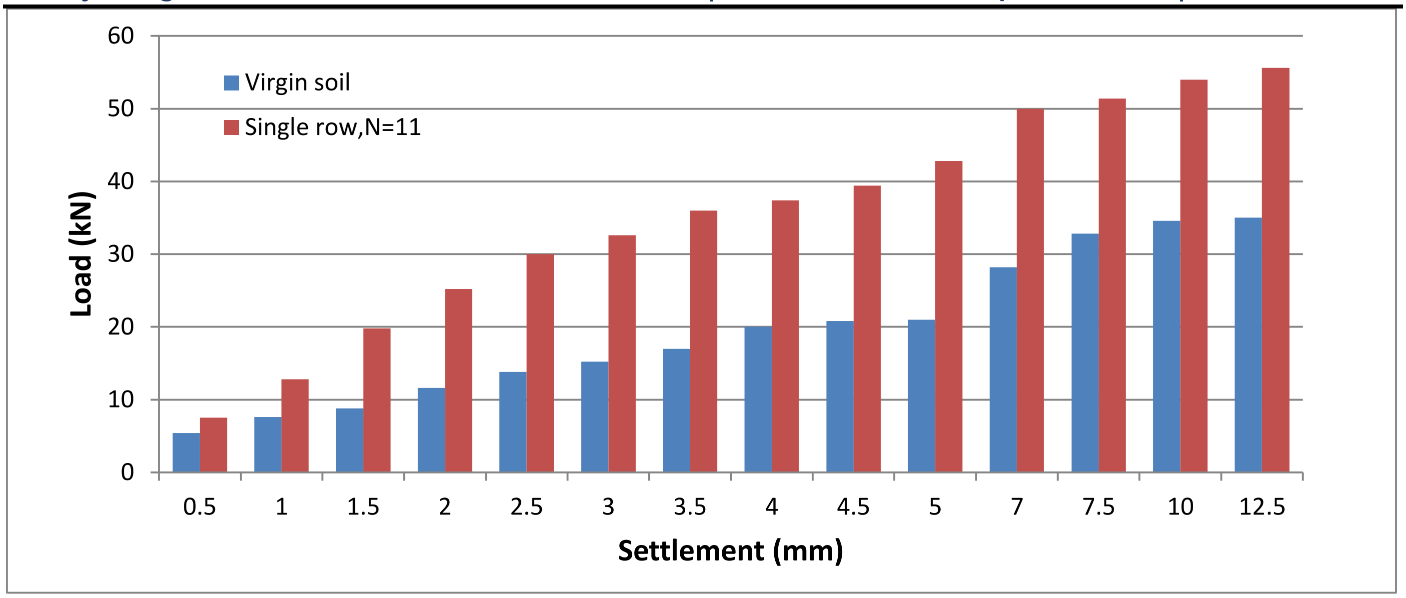


Figure 2 Load settlement curve b/w virgin soil & single row (N=11)

II Comparison of load carrying capacity of virgin soil and double row micro pile soil

In this case, pile arrangement is double row with horizontal Centre to Centre spacing between piles were varied and Centre to Centre vertical spacing was considered constant for different numbers of piles. Double row pattern was found to check the development of soil capacity. The capacity of soil to resist the load increases with appropriate spacing between piles. It was notice that first the capacity of soil to resist the load increases after changing the spacing and numbers of piles capacity of soil was decreases. Settlements are check at standard values corresponding to load. It was noticed that the settlement of soil can be taken into account when load was applied by mechanical jack on the soil was modeled in a container and piles was optimized to perform the experiment. Hence, it was observed that the load carrying capacity of soil was increased from 13.8 KN to 29.2 KN by double row pile pattern arrangement. For six numbers of piles with center-to-center horizontal spacing was740 mm and vertical spacing was 380 mm, diameter of piles is constant (10 mm) was observed best and economical pile patterns. Capacity of load carrying soil was increased two times of earlier values. It was observed that load carrying capacity of virgin soil was increased 50% by installing the six numbers of piles in double row pattern with 740 mm center to center spacing between piles at standard 2.5 mm settlement as shown in fig.3. For measure settlement at 5 mm, mention that the load carrying capacity by soil with double row pile pattern increased 21 KN to 41.6 KN. The capacity was increased 50% by using six numbers of piles as shown in fig.3.

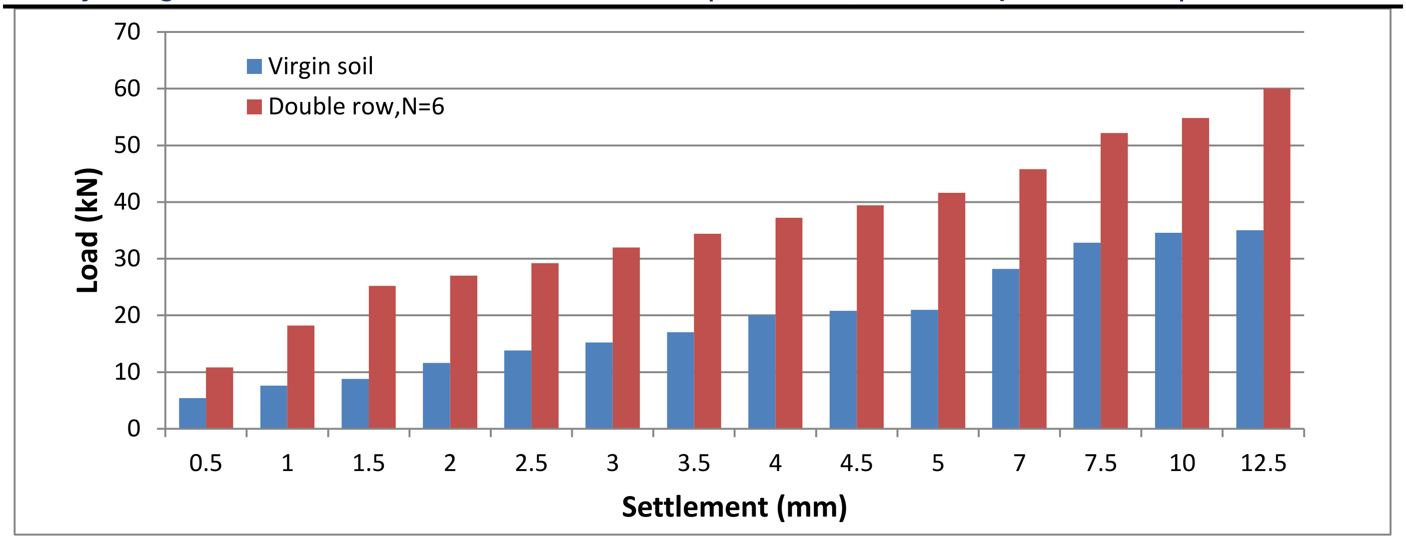


Figure 3 Load settlement curve b/w virgin soil & double row (N=6)

III **Comparison of load carrying capacity of virgin soil and staggered pattern of micro pile soil**

In staggered pattern of micropile arrangement, horizontal spacing ("center to center spacing)" between piles was varied and angled pile spacing ("center to center spacing') between piles also varied with angles. Most focus was given to angles of piles patterns in staggered case and chooses the best angle pattern for best results. The staggered pattern of pile were performed to check the load carrying capacity and response of soil at angle with suitable spacing and also optimize the numbers of piles from the staggered pattern of pile results. It was observed that load carrying capacity of soil was definitely improved. Micropile angles are calculated corresponding to spacing of piles. It was observed that the load carrying capacity of soil increased when horizontal center to center spacing was 296 mm and numbers of piles was eleven. Horizontal spacing of piles was 296mm and spacing between angled piles was 408.03mm. The most important is angle that was calculated 69°. At 2.5 settlements for elven numbers of piles load carrying capacity is increased 13.8 KN to 25 KN by optimizing the pile arrangement as shown in fig.4.

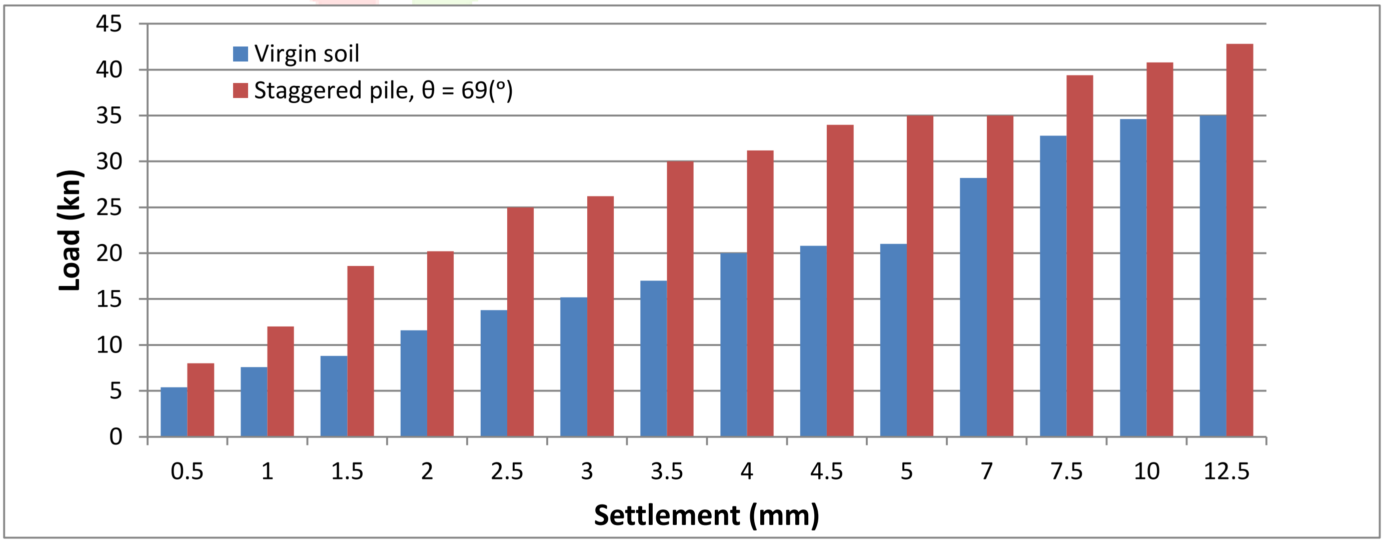


Figure 4 Load settlement curve b/w virgin soil & staggered piles (θ = 69°)

5.2 Conclusion:

The following conclusion can be concluded from the experimental study:

It was observed that the spacing between piles is the most important point to be considered that in a group of pile, every pile must behave as a single pile as seen in our cases with proper spacing. It is not necessary that the capacity of group piles to resist the load is equal to the sum of the capacity of each single pile to resist the load. The spacing between the piles should be such that the stresses transferred by piles to soil should not overlap. For this, the spacing between piles must not be more or less. There should be an appropriate spacing between adjacent piles. If the piles in group are provided closer to each other, then the loops of stress transmission from pile to soil can overlap due to which load carrying capacity of a group pile get reduced. The efficiency of a group of pile depends upon the spacing between the piles. The spacing between piles should be such that the group of piles reaches up to 100% efficiency for carrying the load.

- In single row pile pattern, the maximum load carrying capacity of soil is 30 KN at settlement 2.5 mm with centre-to-centre spacing 148mm for eleven numbers of piles.
- In double row pile pattern, the ultimate load carrying capacity 29.2 KN of soil was observed for six numbers pile with centre to centre horizontal spacing 740 mm and vertical spacing 380 mm.
- In staggered pile pattern, the ultimate load carrying capacity of 25 KN was observed with horizontal spacing of piles was 296mm and spacing between angled piles was 408.03mm. Best angle was 69° observed in this parametric study.
- To find the economical and best result in compression of three patterns of piles, it was observed that double row pile pattern, the ultimate load carrying capacity 29.2 KN of soil for six numbers of pile with centre to centre horizontal spacing 740 mm and vertical spacing 380 mm was optimum. Load carrying capacity was increased by 50% as compare to virgin soil but for economical six numbers of piles was used as compare to single and staggered patterns of pile. Hence, it is observed that double row pile pattern is economical and best as compare to single row and staggered patterns of piles.
- The utilization of the technique, to a highway embankment land slide which was manually modelled to have experimentation in Punjab region, India, is described, and manipulating the data show which envisage the change of soil slope definitely stopped by obtaining a suitable outcome of the embankment is observed, proved the good response of this of the technique.

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