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Effect of Fiber Ratio on the Behavior of Strip Footing on Bamboo Fiber Reinforced Cemented Sand

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Abstract: The bearing capacity of soil is an important factor for designing the type of foundation. A strip footing is a type of shallow foundation which is provided for the load bearing wall. To improve the bearing capacity and settlement of sand, several techniques can be adopted. Providing reinforcement is one of the widely used techniques. In this paper the effectiveness of bamboo fiber reinforcement on cemented sand was studied. Tests were conducted at different Cement kiln dust ratios and Bamboo fiber ratios. Finite element computer code Plaxis 3D was used for numerical modelling. Experimental and numerical studies show that fiber insertion to cemented sand increases ultimate bearing capacity and reduces settlement up to 0.75%. After that substantial increase was not noted. Experimental results and numerical results were with close agreement.

Keywords: Bamboo fiber ratio, Cement Kiln dust ratio, bearing capacity, Settlement

1. Introduction

1.1 General

In geotechnical Engineering, bearing capacity is the capacity of soil to support the loads applied to the ground. The bearing capacity of soil is the maximum average contact pressure between the foundation and the soil which should not produce shear failure in the soil. A footing or foundation is the supporting base of a structure, which transmits the loads to the natural ground. The bearing capacity of soil is an important factor for designing the type of foundation. Overestimation of bearing capacity may lead to structural failure and catastrophic damage to buildings while underestimating it results in an uneconomical design. The study of ultimate bearing capacity of strip footing is important as they are commonly used shallow footings under wall. For practical considerations, a long wall footing (length-to-width ratio more than about five) may be called a strip footing.

Researches are carried out to improve the foundation soil condition by including new material into the soil in various forms. Providing reinforcement is one of the widely used techniques. Addition of cement is another widely used technique. Cementation of sand results in increased brittle behavior as peak shear strength increases. However, the high cost of cement motivated the search for a suitable alternative stabilizing material with low or no cost, such as cement kiln dust (CKD) for the stabilization of sandy soil.

Natural or artificial cementation of soil particles contributes to settlement reduction and bearing capacity increase which are the two key design considerations in the field of geotechnical engineering.[1] Cementation of sand results in increased brittle behavior as peak shear strength increases. [1] Adding fiber to sandy soil results in greater peak shear strength and increases ductile behavior. Bamboo fiber is a suitable fiber to in cooperate into cement matrix.

1.2 Previous studies

From the previous studies it was found that addition of CKD increases ultimate bearing capacity of strip footing and it also contributes to settlement reduction. [1] It was also found that fiber inclusion makes brittle behavior of soil to ductile. [1] The reinforcement in soil mass increase bearing capacity and reduce settlement. [8]Fiber materials are cost effective compared with other materials. [7] From the studies it was found that Ultimate bearing capacity of strip footing increases with increase in thickness of reinforced layer. [5] Studies show that caution should be there when applying model scale footing test results to full scale foundation. [2]

2. Materials and Methodology

The materials required for the study consist of locally available sand collected from Pavaratty, Thrissur, Kerala. Cement kiln dust from Walayar, Palakkad, Kerala. Bamboo fiber collected from Thrissur. Model strip footing of size 0.5m x 0.495m x 0.025m and model tank of size 0.5m x 0.5m x 0.6m. These are required for laboratory modelling of the footing. The numerical modelling was performed using PLAXIS 3D finite element software.

Table 1 .Properties of Sand

Sl No	Soil property	Values
1	Percentage of gravel	0
2	Percentage of sand	96.1
3	Percentage fines	3.9
6	IS soil classification	SP
7	Specific gravity	2.66
8	Maximum dry density(kN/m^3)	17.66
9	Minimum dry density(kN/m^3)	14.84
10	Relative density (%)	40
11	Angle of internal friction	36^0
12	Maximum dry density(kN/m^3)	18.2
13	Optimum moisture content (%)	7

2.1 Methodology

2.1.1 Laboratory Modelling

Sand was filled in the tank by raining technique. Top was leveled and model strip footing was kept and load was applied by a hydraulic jack of 50kN. Load and settlement was read using proving ring and dial gauge in the arrangement. Cemented sand layer was prepared by mixing sand with cement kiln dust ratios of 3%, 6%, 9% and 12% at optimum moisture content. The tests were conducted with U/B= 1.2, where U is the thickness of reinforced layer and B is the width of the footing. First sand bed was prepared excluding top 60mm at a relative density of 40%. Then cemented sand was filled at this 60mm and compacted. The optimum was found. For the same thickness of reinforcement layer reinforced sand layer was prepared by randomly mixing 0.25%, 0.5%, 0.75% and 1% bamboo fiber to 3%, 6%, 9%, 12% cement kiln dust. The optimum fiber percentage was found.

Fig. 1. Laboratory experimental setup

2.1.1 Numerical Modelling

Finite element computer code Plaxis 3D was used for numerical modelling to supplement the results of model laboratory tests. A variety of soil models are built into the computer code chosen for this study. It was decided to use the non-linear Mohr Coulomb criteria to model the sand for its simplicity, practical importance and the availability of the parameters needed. Linear elastic model was used for mild steel footing. The input values for Plaxis 3D analysis is given in Table2.

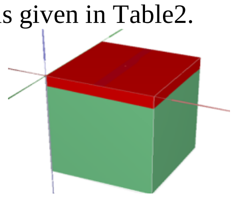


Fig. 2. Geometry

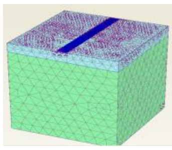


Fig. 3.Meshing

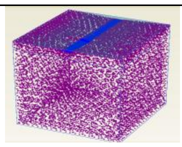


Fig. 3. Settlement of footing

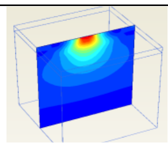


Fig. 4. Deformation Pattern

Table 2. Input data for Plaxis 3D Analysis

Sl No	Parameters	Soil	Reinforced soil	Footin g
1	Modulus of Elasticity (kN/m^2)	30000	35000	$2X10^8$
2	Poisson's Ratio (μ)	0.3	0.3	0.2
3	Cohesion (kN/m^2)	1	(29,55,75,98 101)*	-
4	Angle of internal friction (^{0})	36	(37,38,41,44 45)	–
5	Dilatancy angle (ψ)	6	(7,8,11,14, 15)	–

* Results of tests conducted at CKD = 9% and RF = 0,0.25%,0.5%,0.75% and 1%

3. Results and Discussion

3.1 Laboratory Modelling

The details of parametric study are given in Table 3.

Table 3. Details of parametric study

Serie s	Study on effect of	Constant Parameter s	Variable Parameters
A	Unreinfor ced	U/B=1.2	CKD(%)=3,6,9, 12
B	Fiber ratio+ CKD ratio	CKD=9% U/B=1.2	RF(%)=0,0.25, 0.5,0.75,1

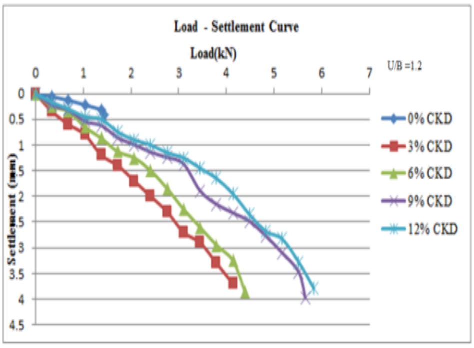
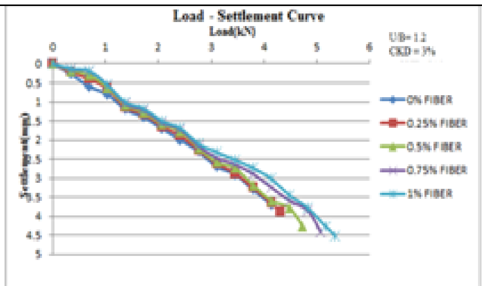
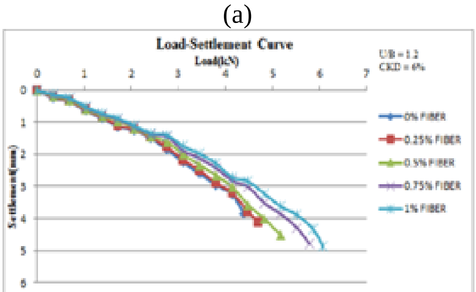


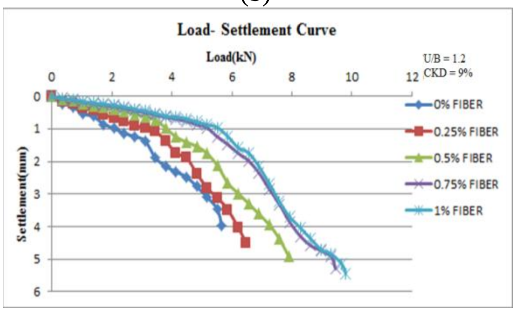
Fig. 5. Load settlement curve to study effect of cement kiln dust



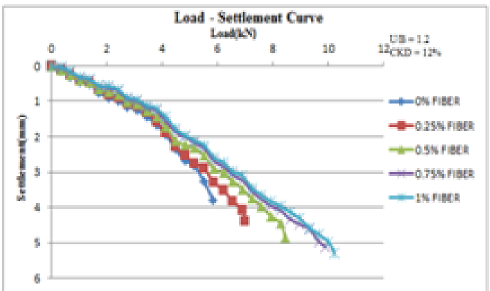
(a)



(b)



(c)



(d)

Fig. 6. Load settlement curve to study effect of fiber reinforcement, a-3%CKD,b- 6% CKD, c- 9% CKD, d-12% CKD

3.1.1 Effect of cement kiln dust ratio

From the experiments conducted it was found that ultimate bearing capacity of strip footing increases up to 9% of CKD and after that significant increase was not found. 4.14kN, 4.69kN, 6.49 kN and 7.04 kN and 3.7mm, 3.85mm, 4.12mm and 3.99mm are the ultimate loads and settlements at 3%, 6%, 9% and 12% CKD respectively. As the ultimate bearing capacity increases settlement also increases up to 9%. At 12% CKD, settlement decreases and this may be due to the change of soil response to brittle. So 9% is optimum CKD percentage. The bearing capacity increases by the addition of cement kiln dust and this will be due to rearrangement of particles of the mix and making the matrix more compact.

3.1.1 Effect of fiber ratio

On adding fiber to optimum percentage of cemented sand, load carrying capacity increases and settlement decreases. This may be due to bonding and friction produced by the fibers. The ultimate load increased by 11% at 0.25% fiber and 47% at 0.75% fiber. No significant increase is found after this. So 0.75% is optimum fiber percentage. Fiber reinforced cemented sand can sustain load even after failure of cemented soil. So significant effect can be observed when cemented sand is reinforced with fiber.

3.2 Numerical Modelling

All the tests done for laboratory modelling were repeated for Numerical Modelling. Comparison is given below.

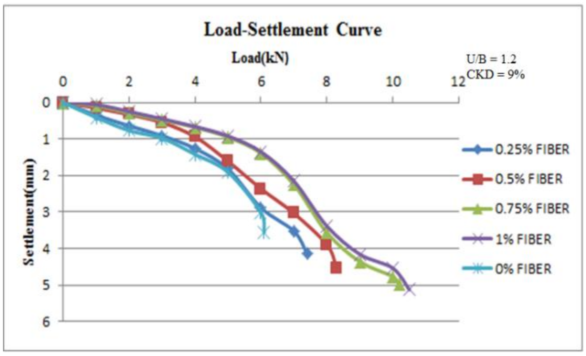


Fig. 7. Load settlement curve to study effect of fiber reinforcement

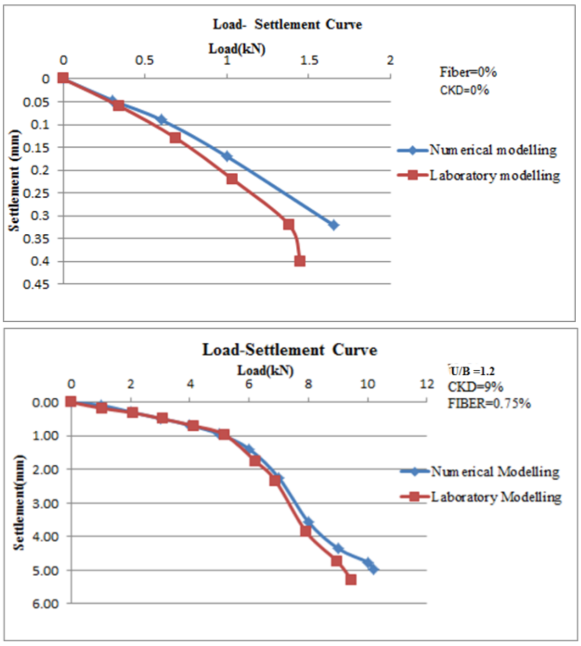


Fig 8. Comparison of laboratory and numerical modeling

Table 4. Comparison of laboratory modelling and numerical modelling

CKD=9%		Laboratory Modelling		Numerical Modelling	
U/B	RF (%)	q_u (kN/m^2)	Settlement (mm)	q_u (kN/m^2)	Settlement (mm)
1.2	0	226	3.98	240	3.55
	0.25	259	4.51	276	4.13
	0.5	315.6	4.92	332	4.52
	0.75	378	5.29	408	4.98
	1	392	5.43	420	5.12

4. Conclusion

When cement kiln dust is added to sand at 3, 6, 9, 12%, ultimate load increases and optimum is at 9%. Addition of bamboo fiber to cemented sand in 0.25, 0.5, 0.75 and 1 percentages increases the load and reduces settlement.

Ultimate is at o.75% fiber. The ultimate load increases from 1.35kN to 9.45 kN when sand bed is reinforced with 9% ckd and 0.75% fiber. Study shows that there is close agreement with laboratory and numerical modelling.

References

[1] Ahmed M. Nasr., “Behavior of strip footing on fiber-reinforced cemented sand adjacent to sheet pile wall”, Geotextiles and Geomembranes, 42 (2014) 599-610.

[2] Amy, B., Alan. J., “Scale effects of shallow foundation bearing capacity on granular material”, J. Geotech. Geoenviron. Eng, 133 (10), 1192-1202.

[3] Consoli, N.C., Prietto, P.D.M., Ulbrich, L.A., “Influence of fiber and cement addition on behavior of sandy soil”, J. Geotech. Geoenviron. Eng, 124 (12),1211-121.

[4] Humphrey Danso., D. Brett Martinson., Muhammad Ali., John. B. Williams., “Physical, mechanical and durability properties of soil building blocks reinforced with natural fibers”, Construction and Building Materials, 101 (2015) 797–809 .

[5] Khosrow Ghavami., Romildo D. Toledo Filho., Normando P. Barbosac., “Behaviour of composite soil reinforced with natural fibres”, Cement and Concrete Composites, 21 (1999) 39-48.

[6] Qiming Chenn., MuradAbu-Farsakh.,” Ultimate bearing capacity analysis of strip footings on reinforced soil foundation”, Soils and Foundations.

[7] Sayyed Mahdi Hejazi et al., “A simple review of soil reinforcement by using natural and synthetic fibers”, Construction and Building Materials, 30 (2012) 100–116.

[8] Sung-Sik Park., “ Effect of fiber reinforcement and distribution on unconfined compressive strength of fiber reinforced cemented sand”, Geotextiles and Geomembranes, 27 (2009) 162–166.

[9] Temel Yetimoglu., Jonathan T. H. Wu., “Bearing Capacity of Rectangular Footings on Geogrid-reinforced Sand”, Journal of Geotechnical Engineering ,120:2083-2099 (1994).

[10] Younes Amini., Amir Hamidi., and Ebrahim Asghari., “Shear Strength Characteristics of an Artificially Cemented Sand-Gravel Mixture”, IACGE (2013)