A Study on Settlement behavior of sandy soil reinforced with steel fiber

A Dissertation submitted in partial fulfillment of the requirement for the
Award of degree of

Master of Technology
In
Geotechnical Engineering

By

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CANDIDATE'S DECLARATION

I do hereby certify that the work presented is the report entitled "**A Study on settlement behavior of sandy soil reinforced with steel fiber**" in the partialfulfilment of the requirement for the award of thedegree of "Master of Technology" in Geotechnical Engineering submitted in the Department of Civil Engineering, Delhi Technological University, is an authentic record of my own work carried out under the supervision of Prof. A.K Gupta, Department of Civil Engineering. I have not submitted the matter embodied in the report for the award of any other degree or diploma to any other institution.

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CERTIFICATE

This is to certify that above statement made by the candidate is correct to the best of my knowledge.

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ABSTRACT

In this technical study deliberate about the load settlement response from plate (circular) load test put through on a 65cm diameter and 50cm height circular tank fill from compacted sandy soil mix with different percentage of steel fiber for a particular depth ratio and without reinforcement. The plate load test on the reinforced soil was performed at different pressures and show detectable strong response than compare the same test on non-reinforced soil. By the help of plate load test we can analyze the bearing capacity ratio of soil due to the steel fiber mix in soil .The load settlement curves for sandy soil reinforced with steel fiber in different quantity (0.25%, 0.5%, 0.75%, 1%), as well as on the same soil without the reinforcement have been produced. By comparing the load settlement curves, it is clearly observed that fiber reinforcement improved the behavior of the compacted soil and that bearing capacity ratio increasing with increase the percentage of steel fiber. Here one thing also observed that how bearing capacity ratio changes with H/D ratio. Where H=height of reinforced zone from plate level and D=Diameter of plate.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations

Symbol	Title
KN	Kilo newton
mm	millimeter
Kg	kilogram
Φ	Angle of internal friction
C	cohesion
C_u	coefficient of uniformity
C_c	coefficient of curvature
D_{60}	Diameter corresponding to 60% finer in the gradation analysis
D_{10}	Diameter corresponding to 10% finer in the gradation analysis
D_{30}	Diameter corresponding to 30% finer in the gradation analysis
G	specific gravity
BCR	Bearing capacity ratio
H/D	depth ratio

Chapter 1

Introduction

1.1GENERAL

In Present days soil cover a very large and important area in civil engineering. We can say geotechnical or soil engineering is a bull's-eye of civil engineering. All types of structure constructed in civil engineering finally transfer its total load on soil because of this reason study of soil is very important. The properties of soil like strength, bearing ability of soil, permeability of soil, shear strength, settlement etc. vary from type to type so it is very essential to know and analyze various properties of different types of soil so that according to the type of soil we can build a structure on it without collapse. But sometimes soil is not enough strong to take the load of structure due to this its fail. In this situation we require some improvement method on soil for example-heavy compaction, stabilization, reinforcement by geotextile, grouting etc. Generally soils are formed by weathering action of rocks. This weathering action occurs due to mechanical disintegration or chemical decomposition. After this soil is transported from one place to other place by different transported agent like wind, water, air, gravity etc. According to the transported agent we classify the soil for example-soil transported by air are- aeoline soil, loess soil, soil transported by water are-lacustrine deposits, marine deposits, alluvial deposits etc.

In hilly region large size of rocks present in the soil but as well as we come high altitude to low altitude the size of rocks decrease due to mechanical action i.e. weathering of gravels. Due to this soils like gravel, sand are available in northern region of India in abundance. These soils have large size particle due to this the surface area of these soil are less compare to clayey soil. Due to less surface area the cohesion between particles of soil are negligible and voids size are large. These voids are fill from water and air. The permeability of these soils is so high because it follows single grained structure. As well as loads are occurs on these soils the expulsion of air start which is known as compaction and after expulsion of air water start flow through voids of soil due to high permeability so these soil have more settlement property. This settlement causes difficulty for construction on the soil and also cause weak load bearing capacity of these soil. In our project we are work on improvement the settlement of this type of soil by help of steel fiber. In this project we perform plate load test carried on a circular tank to analyze settlement of sandy soil. Plate load test is also useful for analyze the bearing limit of soil which can be used for the selection of type of footing. The soil beneath the structure can fail due to two reasons one is shear failure and second is settlement failure. Its settlement must remain in permissible limit. We all know that sandy soils have large settlement compare to clayey soil due to expulsion of air from its voids under heavy load. So for overcome of this character of sand we mix steel fibers in different percentage and compare these in this project. To evaluate the influence of steel fiber on settlement behavior soil the circular tank filled with sandy soil (with or without steel fibers) in five layers and each layer compacted 50 number of blows by 2.5 kg weight of hammer and then plate load test was perform using model circular footing. Hence the extensive literature explaining experimental studies associated with this issue has been done.

1.2 Steel fibers

Steel fibers are cutting wire pieces of mild steel which have uniform size. It is the composition of various elements. Composition may include carbon(C), Silicon(Si), manganese(Mn), phosphorus(P), sulfur(S) and other elements.

1.2.1 USE OF STEEL FIBRES

a) By comparing the load settlement curves, it is clearly observed that fiber reinforcement improved the behavior of the compacted soil.

b) Steel fibers have high tensile strength, flexural strength toughness value and fatigue strength due to this strength, life-span and maintenance cost of material enhance.

c) Steel fibers have good tensile strength so it gives higher resistance to cracking.

Table 1.1 Advantages of steel fibers as a reinforced

FEATURES	BENEFITS
By Increasing flexural toughness of soil mixing with steel fibers	We can Increase load bearing capacity of soil
It gives good post crack performance its mean material give good strength after cracking if it mix.	Due to this feature of steel fiber composite material safe from sudden failure and load retaining capacity of material increase without failure
Because it have high toughness and fatigue strength due to this the impact and abrasion resistance of material increased.	Maintenance cost in any construction is a big issue and this feature of steel fiber give the advantage on this.

1.3Scope of project

The Scope of this project is-

- A circular tank of mild steel of diameter 65 cm and height 50 cm fabricated in steel workshop located near samayapur badly metro station New Delhi.
- Different types of test like sieve analysis, pycnometer test done for find out the basic properties of coarse sand.
- For find out the effect of steel fibers on settlement behavior of sand performed plate load test behind the rock lab of DTU collage.
- Select 14 cm diameter plate as a model of circular footing.
- The test perform for 0.5%, 1%, 1.5% and 2% quantity of steel fibers and for 0.5 and 1 values of depth ratio (H/D).
- To compare the results prepared graph by the help of record data book.
- In last conclude the result.

1.4Thesis Outline

Chapter 1 Detail introduction of type of soil used and use of steel fiber for decrease the settlement.

Chapter 2 includes the study of past research on steel fibers and soil i.e. literature review which are very helpful for present project work.

Chapter 3 provides the information of material and equipment used in the project and give some idea about setup of the project that were used. It also include the test methods which are performed in complete project work.

Chapter 4 Show the result of project in the format of graphs and tables. Here discussion on these results are also mention.

Chapter 5 this is the last chapter in which conclude the result of research work.

Chapter 2

Literature Review

In this chapter recent work done by the different researchers on this issue is review and presented. Foundation designs must be adequate to both the strength and serviceability criteria. The soil below the foundations must have appropriate bearing capacity value so as to carry the load of the super structure without having considerable settlements or gets failed in shear. The cracks are made in the soil mass upon reaching a particular stress condition.

NiloC.Consoli (2003): In his study he evaluates the benefits of steel fiber in the area of settlement of sandy soil. He used two steel plate load tests (0.3m diameter, 25 mm thick) to find out load settlement response of compacted sandy soil, reinforced with or without steel fibers. He also shows how the shear strength value c and **ϕ** changes due to the effect of steel fiber.

N.Ameta (2009): In this paper a study has been done on how nylon fiber upgrade the properties like bearing capacity and shear strength of coarse sand by the help of a laboratory experiment. In this experiment, A square plate load test has been carried on square tank filled with coarse sand with or without nylon fibers. They added nylon fibers in different amount 0.5%, 1%, 1.5% and 2% in coarse sand soil and compared the settlement behaviors of each case. They also check the effect of H/B ratio on bearing capacity of soil. Here H= height of reinforced soil and B= width of square footing.

Sayidk M K (2009): In this paper they performed standard proctor test, Un-soaked CBR and UCC test on black cotton soil which is reinforced by sisal fiber in different percentages. They work on black cotton soil. Doing a construction and experimental work on black cotton soil is very difficult because it have an expansive property so researcher work on it.

PitiSukontasukkul(2011) In this study they work on flexural performance of deep soil cement pile was performed for increasing the flexibility of these piles. They use steel fibers and polypropylene fiber in different percentages. Flexibility test on these column was performed and come to the conclusion that polypropylene fiber gave excellent performance in flexural strength compare to steel fiber.

B.fatahi (2012): In this technical note he studied the effect of three type of fibers- steel, recycled carpet and polypropylene on cement stabilized soil. They prepared specimens of soil with different cement content and three different percentages of fiber content was adopted for experimental work. They showed the influence of different fibers in mechanical behavior of cement mixed clayey soil.

HeshamM.Eldesouky(2015): In this paper they investigate how randomly distributed steel fiber can be used to increase the shear strength and dilation characteristics of sandy soil. To find this they used 108 specimens and checked volumetric change behaviors of fiber reinforced sand by the help of direct shear test. They also studied the difference between dry loose sand and compacted unreinforced moist sand.

Abdul Ahad (2015): In this paper researchers studied the application of steel fiber in increasing the life period, strength and overall cost of road construction. The researcher evaluates all advantages and disadvantages of steel fiber use in construction of road. They studied life cycle assessment (LCA) and life cycle cost analysis (LCCA) of new pavement system steel fiber reinforced roller compacted concrete (SFR-RCC). They check how steel fibers use in subgrade soil to decrease the thickness of pavement without effecting the vehicles riding on its.

Antonio A.S.Correia (2017): This paper describe how the mechanical behavior of soft soil like Un confined compressive strength (UCS), Flexural strength(FS), Split tensile strength(STS), Direct tensile strength(DTS) change due to the effect of binder and fiber quantity. In each test, Two types of samples are prepared, one with steel fiber and second is without steel fibers. Steel fibers changes the compressive strength, flexural strength, and tensile strength of the soil. Because soils are mostly strong in compressive strength but weak in tensile strength so researcher defines how we can increase these strength with the help of steel fiber. In some cases such as- Deep mixing column (DMC) work under horizontal load, In case of earthquake we require high flexural and tensile strength.

Chapter 3

Materials & Methods

3.1 Material and Equipment used

The material and equipment used in this project are detailed one by one according to the importance in project.

3.1.1Coarse sand

The Coarse sand is taken from the DTU which passed through 4.75 mm IS sieve and retain 75 micron sieve. The sand should be free from upper vegetative layer and other organic material so it have dried in oven for 24 hours.

Fig.3.1: Coarse sand

3.1.2 Steel fibers

Steel fibers are used for enhance mechanical behavior of soft soil such as –Un confined compressive strength(UCS), direct tensile strength(DTS),Split tensile strength (STS) and flexural strength(FS) tests.

Fig. 3.2: Steel fiber

3.1.3 Mild Steel circular tank

It was fabricated by the steel workshop. The size of Box was designed on the basis of IS code and according to the past researches. According to IS 1888:1982 the diameter of tank should be five times the breadth of test plate so that complete failure zone can be generate without any disturbances of sides of the box. So we adopt diameter of the tank is equal to 65cm and the diameter of the plate is 14cm. The tests were performed behind the rock lab of DTU.

Fig.3.3. M.S steel circular tank of dia. 65cm

3.1.4 M.S Circular Steel Plate

A Circular steel Plate of mild steel was made by the steel workshop. This plate work as a model of circular footing rest on sandy soil. The Diameter of circular plate used is 14cm and 7mm thick.

Fig.3.4: M.S circular steel plate of size 140mm

3.1.5 Dial Gauge

In this project we use two dial gauges which can measure settlement of the range of 0.001mm. These dial gauges were place on the both sides of plates and the average of the both gauges reading we record in our record book.

Fig 3.5: Dial gauge

3.1.6 Hydraulic Jack and Test setup

The hydraulic jack used in the test is taken from the concrete laboratory of Delhi Technological University and is of 100KN capacity. The base diameter of the jack is 11.5cm. It was placed upside down for this project over circular plate. A truss frame which is located behind rock lab in DTU collage use as a reaction frame in this project.

Fig 3.6 Hydraulic jack and Test setup

Fig 3.7 Reaction truss

3.2 Experiments Performed

In this project there are following test performed-

3.2.1. Properties of Coarse sand

The various properties of coarse sand are following-

3.2.1.1 Specific Gravity

It find out by using pycnometer method as per IS 2720 part 3.In this method we have taken four weight here we explain four one by one-

M_1=weight of empty flask in dry condition

M_2=weight of flask filled with moist soil

M_3=weight of flask filled with soil and water up to the top of flask after shaking it so that entrapped air should be removed from it.

M_4=weight the flask when it is full with water only.

Then By applying this formula we can find out specific gravity of soil

Specific Gravity (G) = $M_2 – M_1 / (M_2 – M_1) – (M_3 – M_4)$

Fig. 3.8: Pycnometer used for the determination of specific gravity

3.2.1.2 Sieve Analysis

Sieve analysis is a method use for particle size distribution of coarse soil like sand. We use IS 2720 part 4 for sieve analysis process. In this method the sieves are designated either by its size (in mm or µm) or the sieves are designated by IS sieve No. Here IS sieve no. represents no. of square openings per inch of length. Greater the sieve number show smaller is the size opening. Before starting the sieve analysis the soil sample should be dried, lumps are broken if necessary then sample should be passed through the series of sieves by shaking. An electronic shaker can be used for shaking arrange sieves. This shaker shake the sieves 10 to 15 minutes. Larger size particles of soil retain on the upper sieves and smaller size particles passed through the sieves.

By Help of weighing machine we can weigh the particles retained on the sieve. In last a graph is plotted on a semi-log paper in which % finer is taken on Y-axis (In arithmetic scale) and Diameter/Size of soil is taken on X-axis (log scale). The result of the test will be discussed in next chapter.

Fig. 3.9: Sieve shaking of coarse sand

3.2.1.3 Direct Shear Test

For find out the shear parameters of cohesion less soil as per **IS 2720: Part 13**. In this test samples of container size prepared. The samples put in the container and shear it at rate of 1.25mm/min at normal stress of 50kPa, 100kPa and 150kPa. Different samples are fail in this test in different normal stress from where we can draw different Mohr's circles and find out the shear parameter c and ϕ.

Fig.3.10: Direct Shear apparatus

3.2.2. Plate Load Test

It is a field test which is use for find out the ultimate bearing capacity of soil and settlement under any static load. For find out the result in different percentage of steel fiber load settlement characteristics of coarse sand, model load tests were performed as per **IS 1888:1982**. In model load tests first circular tank filled from sand without reinforcement and then it's filled with steel fiber in different depth ratio and different percentage (0.5%, 1%, 1.5% and 2%). First we have taken depth ratio (H/B) is equal to 0.5 and after that it have taken equal to 1. Each time the sand were filled up to tank mouth and a circular plate of diameter 14 cm put on its. After that a hydraulic jack and 2 dial gauge fitted on the plate. The static load applied on the plate by hydraulic jack by reaction technique starting from 2KN to 22KN in the intervals of 2KN. Each time the 250Kg soil filled in $0.166m^3$ volume of tank in five layers and compacted each layer with 2.5kg of hammer for 50 times. Here we can say the density of sand is $15KN/m^3$. The data recorded in record book. After this by the help of record book we can draw load settlement curve and then can find out bearing capacity of coarse sand in each case. By the help of load settlement curves we can find out bearing capacity of soil in each case and last we can define how bearing capacity ratio is change with depth (H/D) ratio and percentage of steel.

Bearing capacity ratio (BCR) $=\frac{Bearing\ capacity\ of\ reinforced\ soil}{Bearing\ capacity\ of\ unreinforced\ soil}$

Fig 3.11 Plate load test

Chapter 4

Results And Discussion

4.1 Properties of coarse sand

Different types of properties of the coarse sand is find out by performing different tests in laboratory. Results of these tests are following with discussion-

4.1.1 Grain size distribution of coarse sand

In laboratory we performed sieve analysis for find out the size of particle present in the soil and the results of this test are shown following-

Table- 4.1: Gradation values for coarse sand

Sieve Size(mm)	Weight retained (gm)	% weight retained	% cumulative weight retained	% finer
4.75	0	0	0	100
2.36	10	0.5	0.5	99.5
1.18	28	1.4	1.9	98.1
0,600	25	1.25	3.15	96.85
0,425	14	0.7	3.85	96.15
0.212	1151	57.55	61.4	38.6
0.150	287	14.35	75.75	24.25
0.075	459	22.95	98.7	1.3
Pan	26	1.3	100	0

From the gradation curve we can find out
D_{10}=0.103
D_{30}=0.176
D_{60}=0.290

From above data we can easily find out the value of coefficient of uniformity and coefficient of curvature which are very useful for find out type of soil. The all properties of coarse sand are shown in following table.

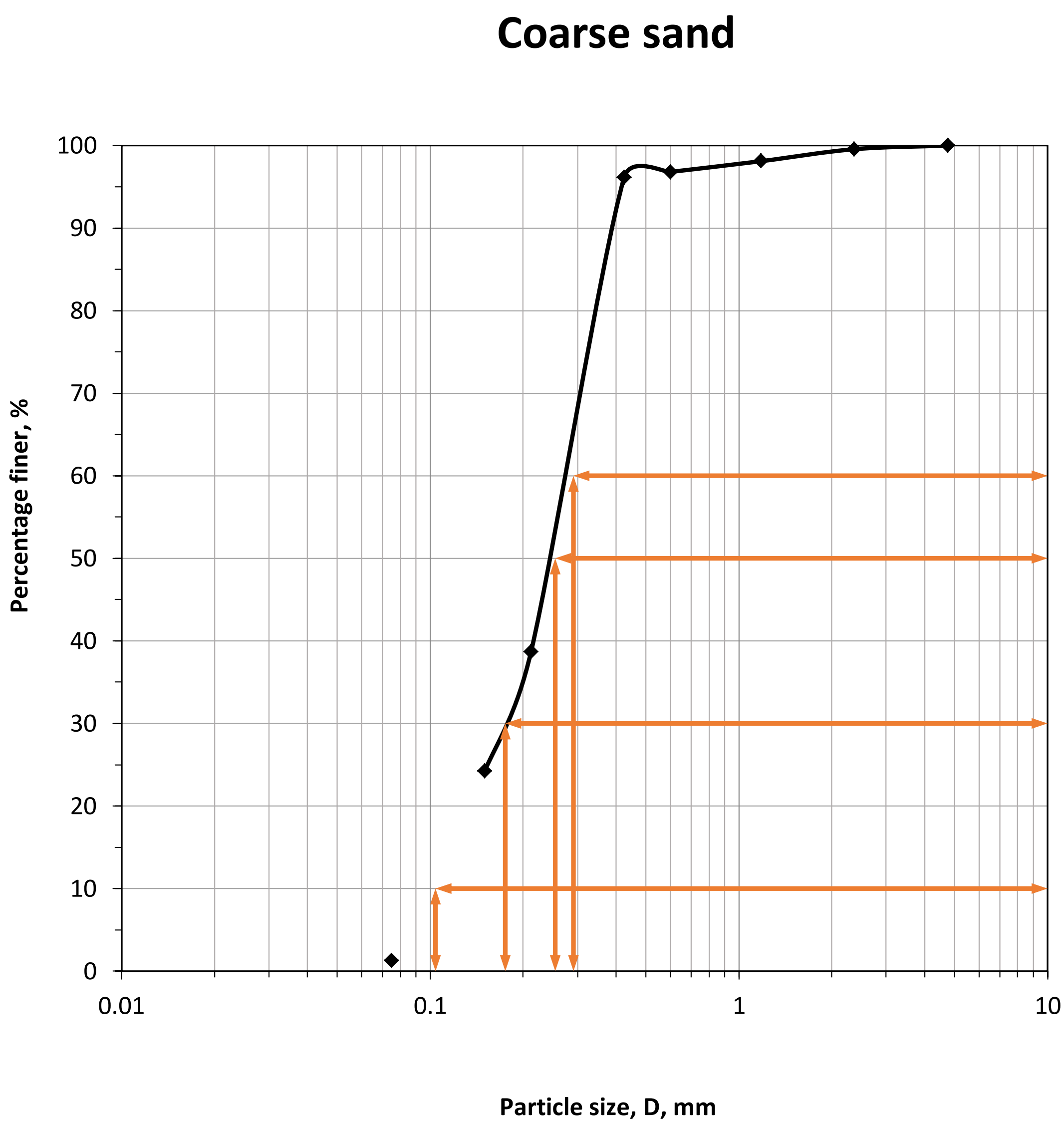

Fig-4.1 Gradation curve for Coarse sand

Table-4.2: Basic properties of coarse sand

Properties	Coarse Sand
Specific gravity	2.597
Colour	Light brown
D_{50} mm	0.255
D_{10} mm	0.103
D_{60} mm	0.290
D_{30} mm	0.176
Uniformity coefficient, C_U	2.815
Coefficient of curvature, C_C	1.037
Classification	SP
Angle of internal Friction	41.1°

4.2 Properties of Steel fiber

In this test we have taken steel fiber (cold drawn type from mild steel wire for general engineering purpose according to ASTM A820/A820M-06) from vinayak industries khasara No.112, sitabari, tank road Jaipur-302011.The properties of these fibers given by the manufacturer are following-

Table-4.3 MECHNICAL PROPERTIES

Size of diameter	0.55mm
Length	30mm
Tensile strength	1187MPa
Tolerance in length and dia.	10% + or -
Aspect ratio	0.0183

Table-4.4 CHEMICAL PROPERTIES

CHEMICAL COMPOSITION OF MILD STEEL WIRE	IN %
C	0.059
Mn	0,0391
Si	0.088
P	0.011
S	0.016

4.3 Load vs settlement curves –

The main results and discussion of thesis are start from this point one by one-

4.3.1 Load vs settlement curve for sand without reinforcement

Table 4.5 Load settlement values for sand without reinforcement

Load(kN)	Settlement(mm)
0	0
2	1.64
4	3.214
6	4.687
8	5.957
10	8.497
12	9.69
14	10.629
16	11.645
18	12.356
20	13.169
22	13.804

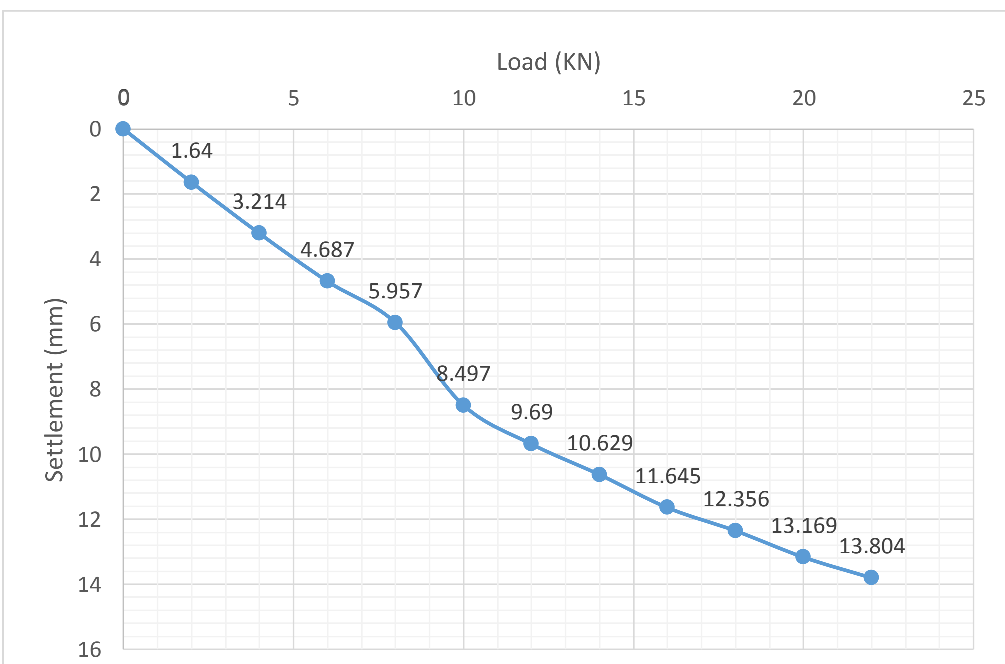

Fig: 4.2 Load vs settlement curves for sand without reinforcement

4.3.2 Load vs settlement curve for H/D=0.5 with 0.5% steel fiber-

Table 4.6 Load settlement values for H/D=0.5 with 0.5% steel fiber

Load(kN)	Settlement(mm)
0	0
2	1.386
4	3.291
6	5.069
8	6.339
10	8.675
12	9.64
14	10.351
16	10.986
18	11.748
20	12.459
22	13.094

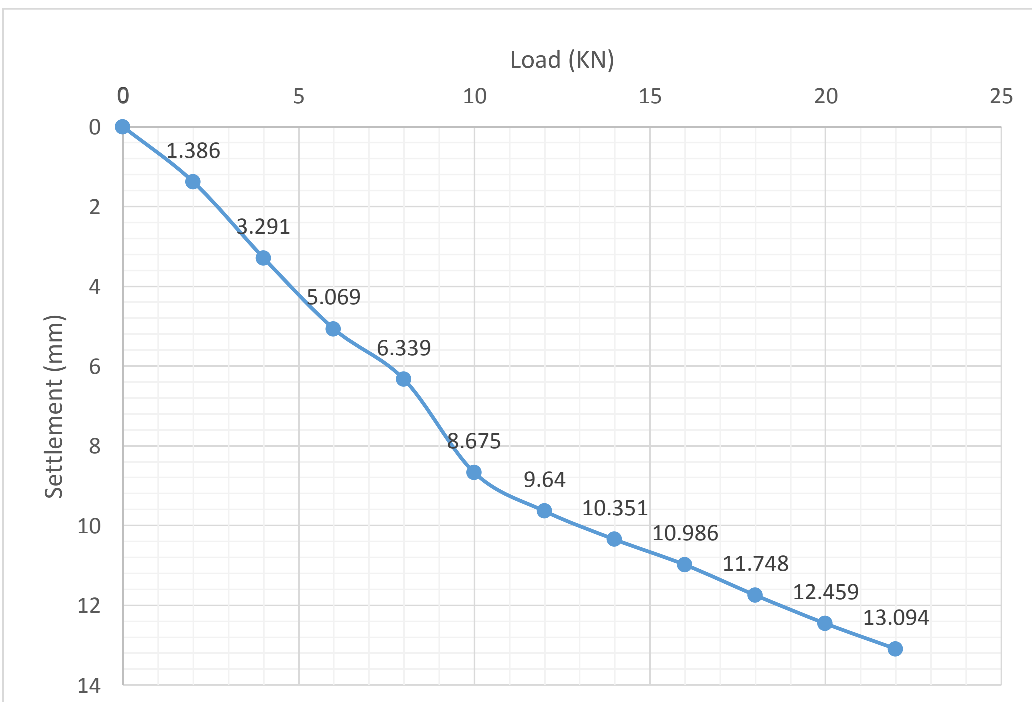

Fig:4.3. Load vs settlement curves for H/D=0.5 with 0.5% steel fiber

4.3.3 Load vs settlement curve for H/D=0.5 with 1% steel fiber-

Table 4.7 Load settlement values for H/D=0.5 with 1% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0.878
4	2.529
6	3.926
8	5.45
10	7.482
12	8.498
14	9.26
16	10.047
18	10.707
20	11.418
22	11.926

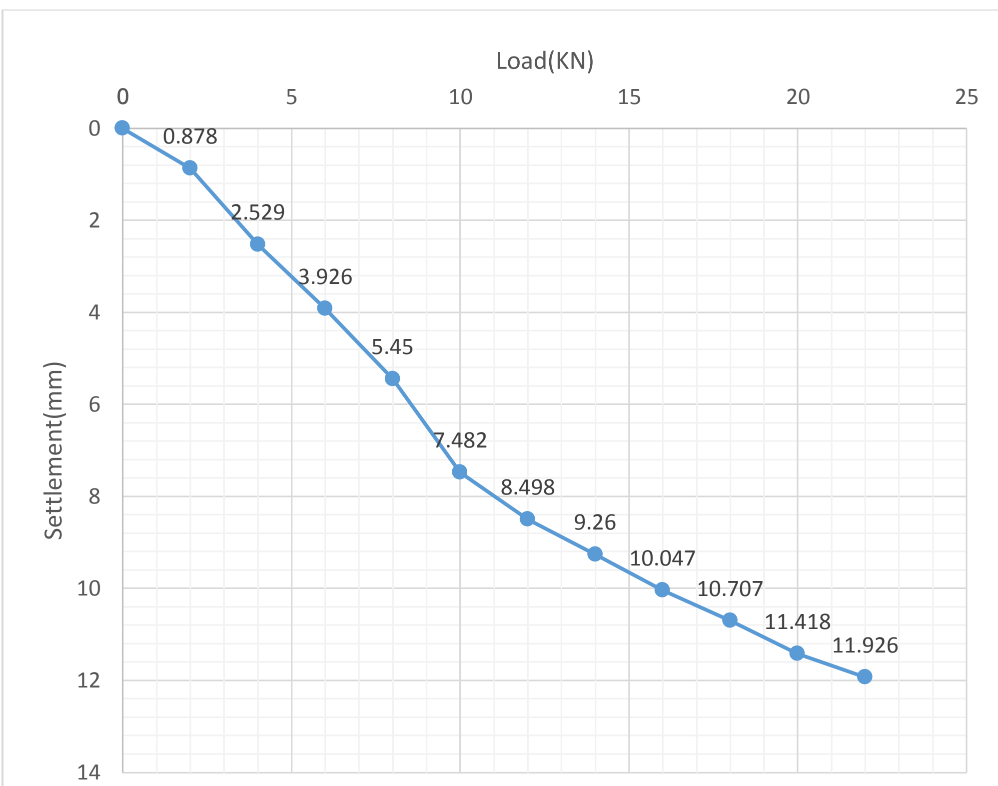

Fig:4.4. Load vs settlement curves for H/D=0.5 with 1% steel fiber

4.3.4 Load vs settlement curve for H/D=0.5 with 1.5% steel fiber-

Table 4.8 Load settlement values for H/D=0.5 with 1.5% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0.37
4	1.894
6	3.164
8	4.688
10	7.024
12	7.913
14	8.802
16	9.564
18	10.275
20	10.91
22	11.468

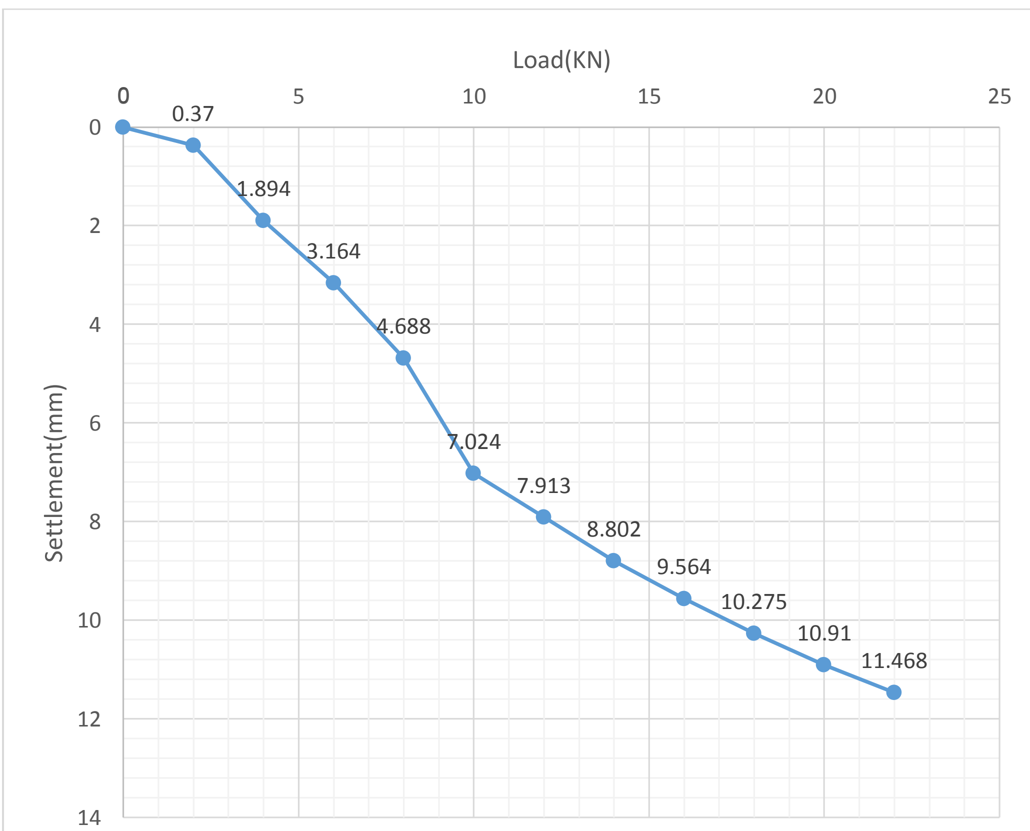

Fig: 4.5. Load vs settlement curves for H/D=0.5 with 1.5% steel fiber

4.3.5 Load vs settlement curve for H/D=0.5 with 2% steel fiber

Table 4.9 Load settlement values for H/D=0.5 with 2% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0.243
4	1.513
6	2.783
8	3.545
10	5.831
12	6.669
14	7.354
16	8.116
18	8.928
20	9.6138
22	10.502

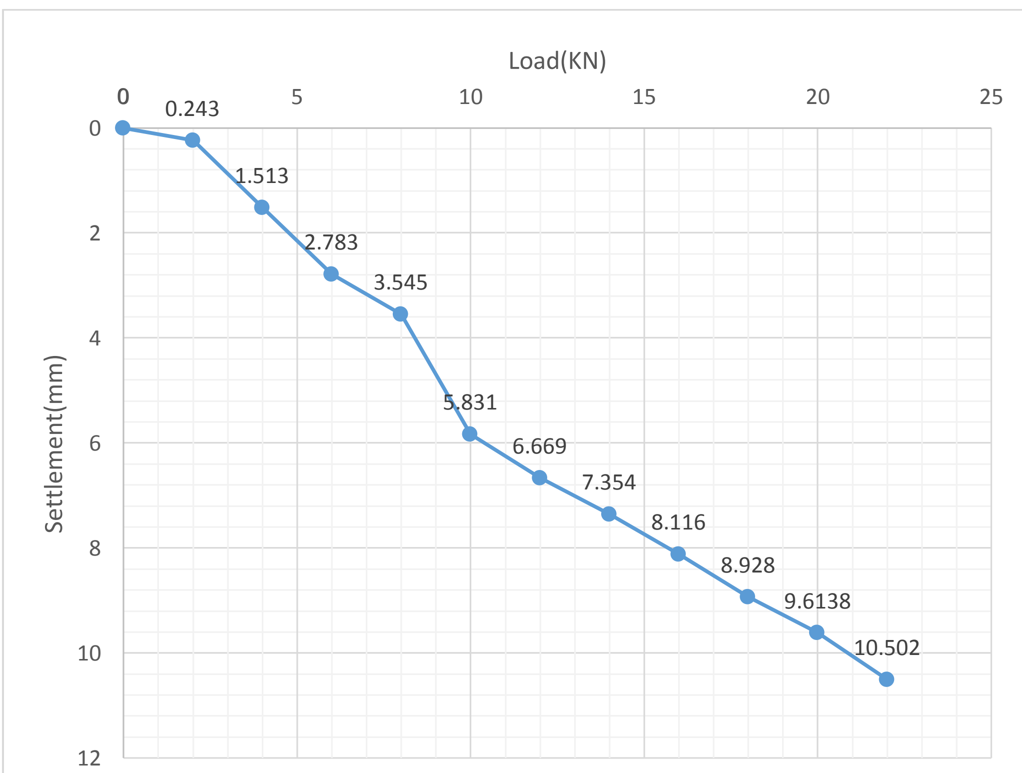

Fig: 4.6. Load vs settlement curves for H/D=0.5 with 2% steel fiber

4.3.6 Load vs settlement curves for H/D=1 with 0.5% steel fiber

Table 4.10 Load settlement values for H/D=1 with 0.5% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0.29
4	0.35
6	0.497
8	1.208
10	2.986
12	3.596
14	4.358
16	4.993
18	5.755
20	6.5676
22	7.3804

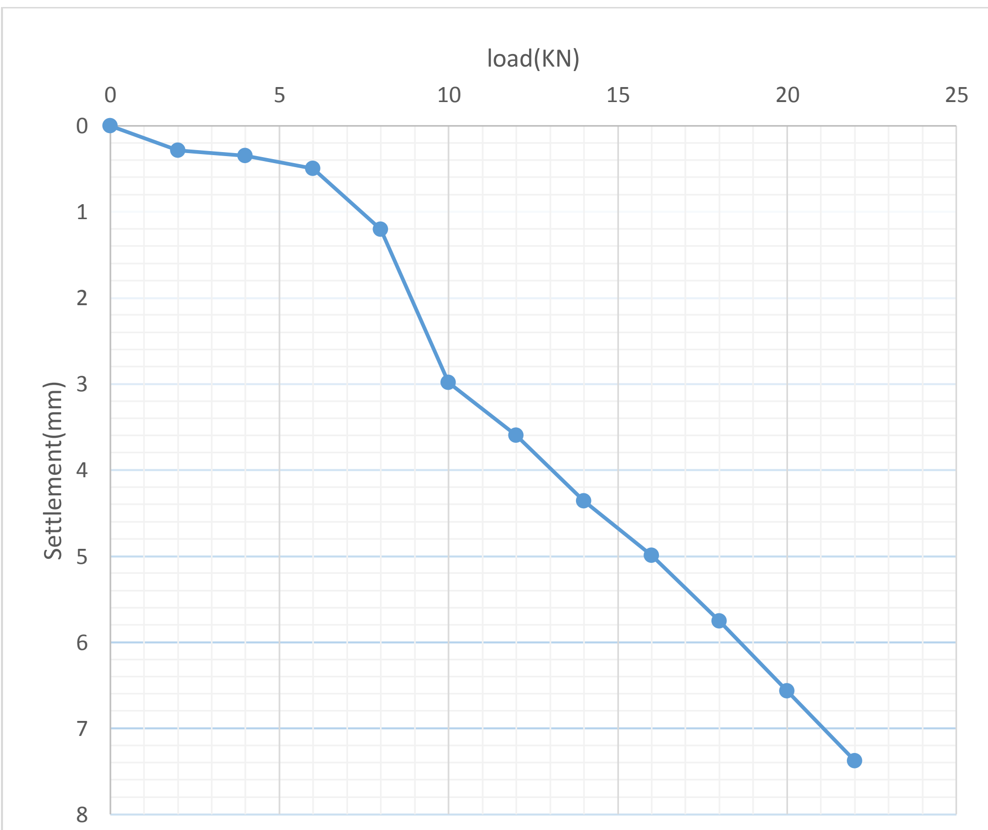

Fig: 4.7. Load vs settlement curves for H/D=1 with 0.5% steel fiber

4.3.7 Load vs settlement curves for H/D=1 with 1% steel fiber-

Table 4.11 Load settlement values for H/D=1 with 1% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0
4	0.497
6	1.202
8	1.7162
10	3.443
12	3.951
14	4.332
16	4.967
18	5.475
20	6.033
22	6.668

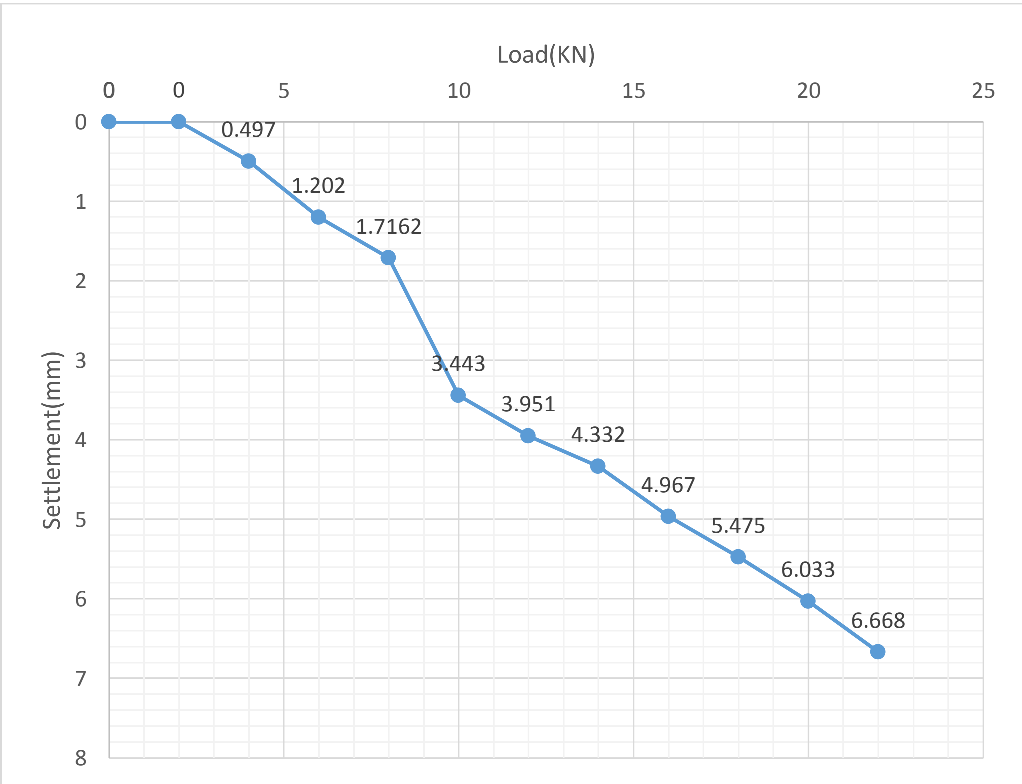

Fig: 4.8. Load vs settlement curves for H/D=1 with 1% steel fiber

4.3.8 Load vs settlement curves for H/D=1 with 1.5% steel fiber-

Table 4.12 Load settlement values for H/D=1 with 1.5% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0
4	0
6	0.44
8	0.9542
10	2.985
12	3.366
14	3.874
16	4.484
18	5.043
20	5.525
22	6.21

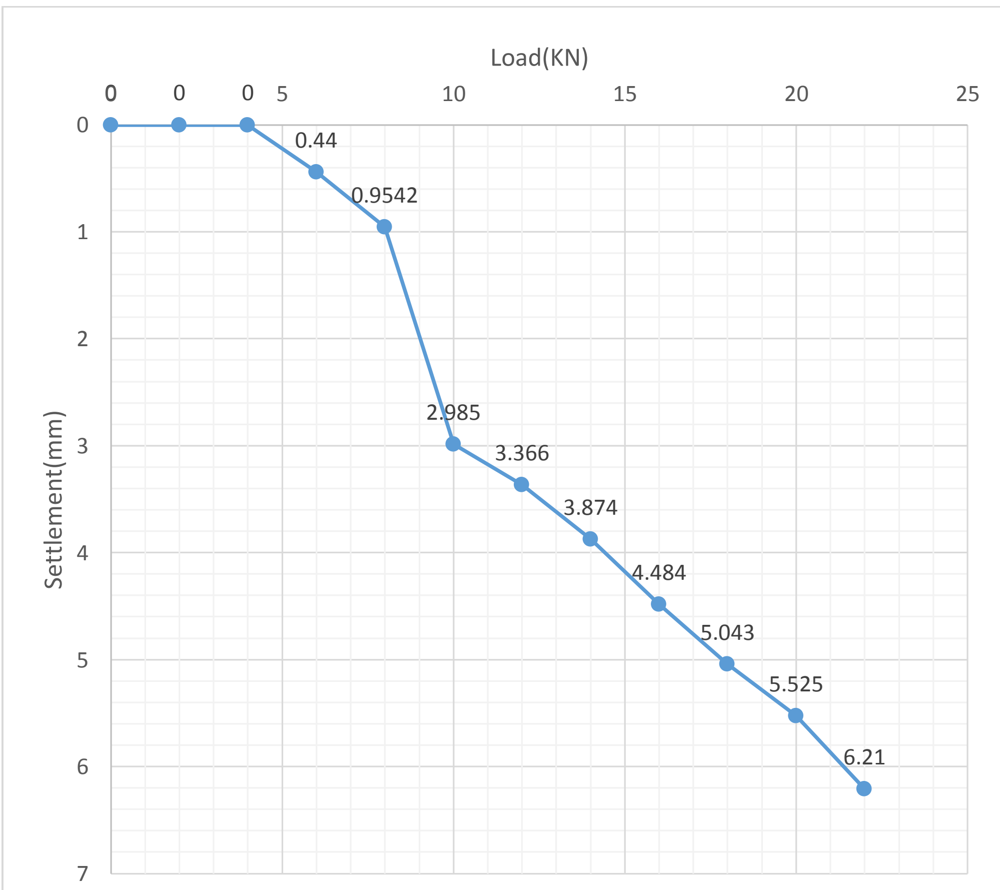

Fig: 4.9. Load vs settlement curves for H/D=1 with 1.5% steel fiber

4.3.9 Load vs settlement curves for H/D=1 with 2% steel fiber-

Table 4.13 Load settlement values for H/D=1 with 2% steel fiber

Load(kN)	Settlement(mm)
0	0
2	0
4	0
6	0.059
8	0.188
10	1.792
12	2.122
14	2.426
16	3.036
18	3.696
20	4.2288
22	5.244

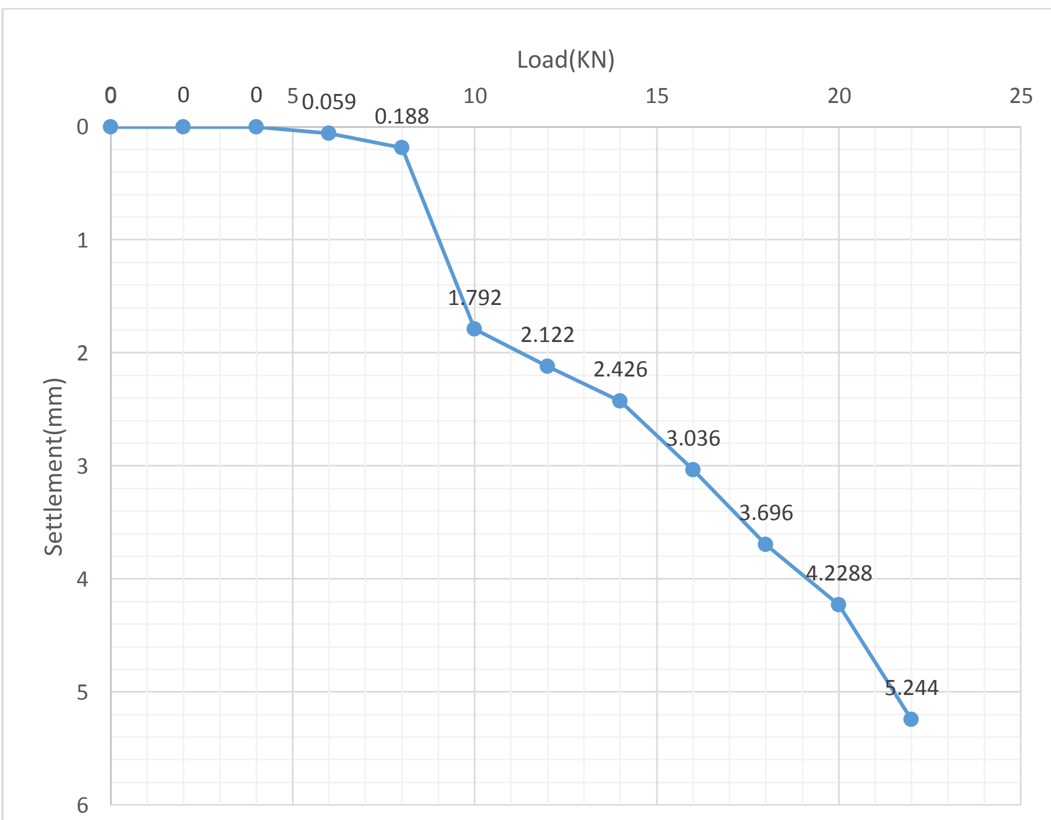

Fig: 4.10. Load vs settlement curves for H/D=1 with 2% steel fiber

4.3.10 Comparison graph For H/D=0.5 with different percentage of steel fiber-

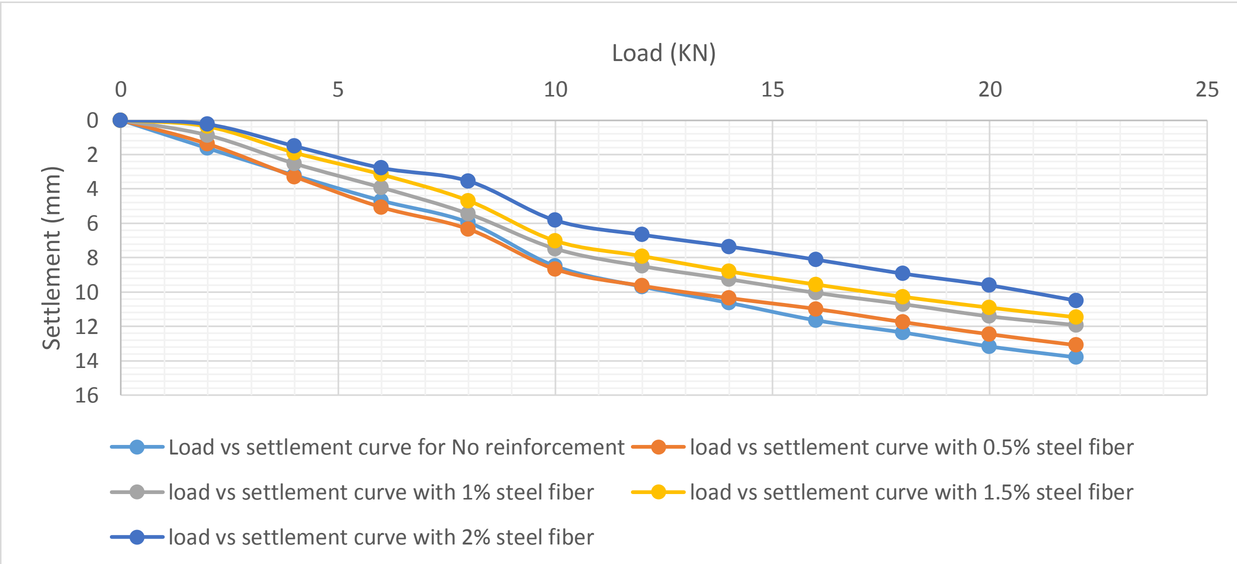

Fig: 4.11.Comparison Load vs settlement curves for H/D=0.5 with different percentage of steel fiber

4.3.11 Comparison graph For H/D=0.5 with different percentage of steel fiber in log scale-

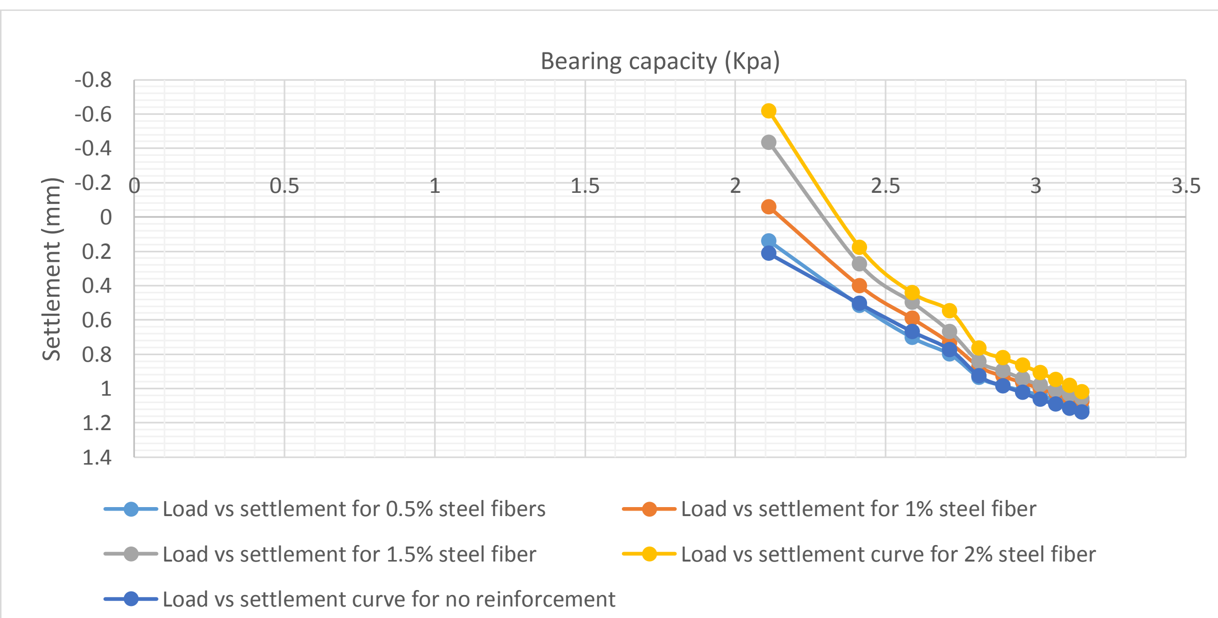

Fig: 4.12.Comparison Load vs Bearing capacity curves for H/D=0.5 with different percentage of steel fiber in log scale

4.3.12 Comparison graph For H/D=1 with different percentage of steel fiber –

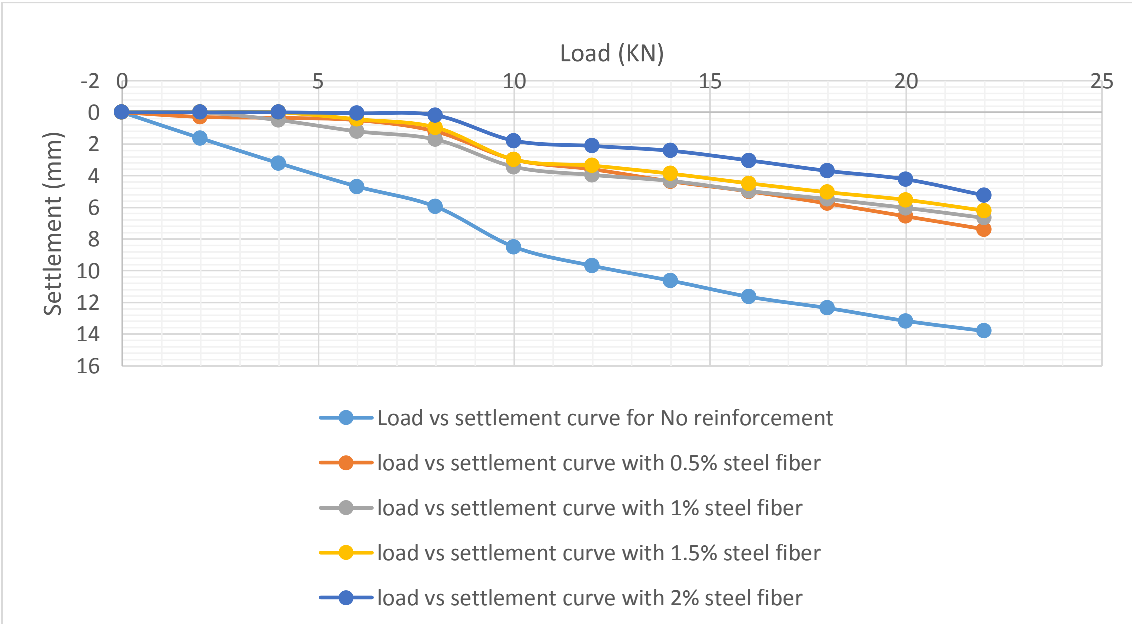

Fig: 4.13.Comparison Load vs settlement curves for H/D=1 with different percentage of steel fiber

4.3.13 Comparison graph For H/D=1 with different percentage of steel fiber in log scale-

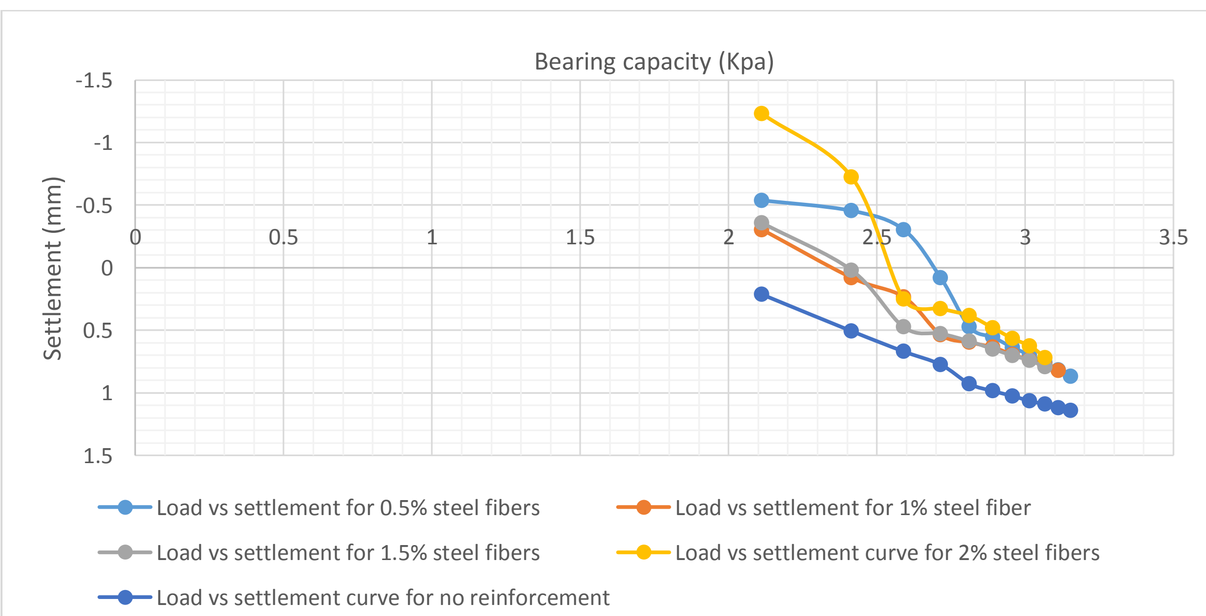

Fig: 4.14.Comparison Load vs Bearing capacity curves for H/D=1 with different percentage of steel fiber in log scale

4.3.14Variation in Bearing capacity ratio (BCR) with different percentage of steel fiber for two different depth ratio(H/D)-

Table 4.14 Variation in BCR with different % of steel fibers

Steel fiber(%)	BCR(H/D=0.5)	BCR(H/D=1)
0.5	1.05	1.25
1	1.09	1.12
1.5	1.202	1.29
2	1.23	1.32

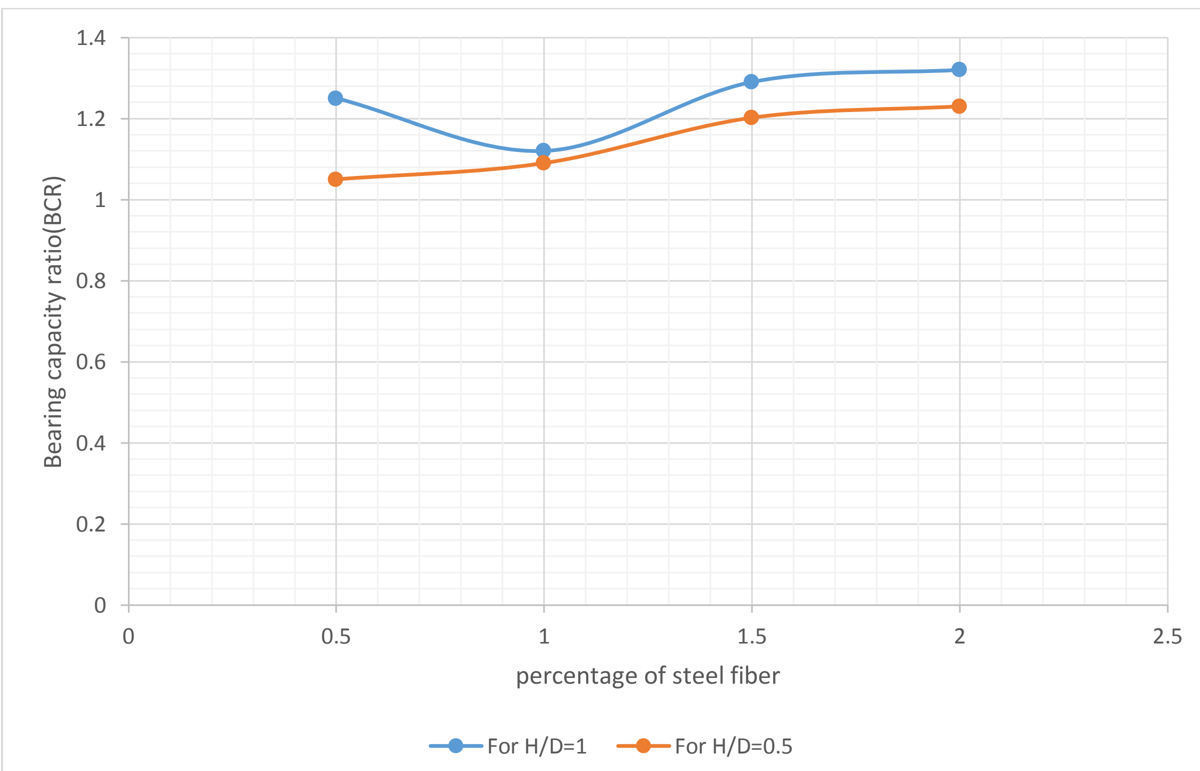

Fig: 4.15.Variation in BCR with different % of steel fiber for different depth ratio (H/D)

4.3.15 Variation in Bearing capacity ratio (BCR) with different depth ratio(H/D) for different percentage of steel fiber-

Table 4.15 Variation in BCR for different percentage of Steel fiber(SF) with different depth ratio

Depth ratio(H/D)	BCR(0.5%SF)	BCR(1% SF)	BCR(1.5%SF)	BCR(2% SF)
5	1.05	1.09	1.202	1.23
10	1.25	1.12	1.29	1.32

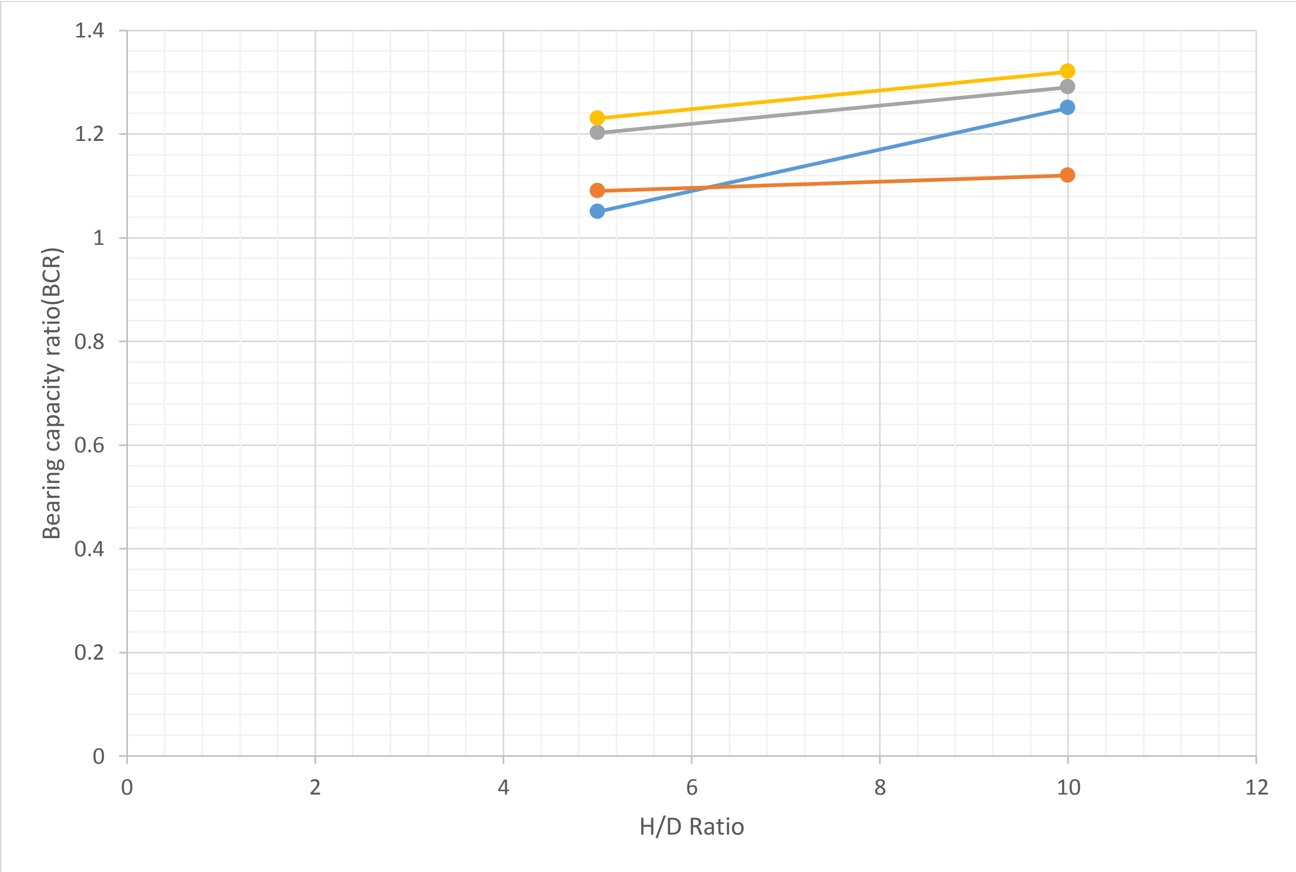

Fig: 4.16.Variation in BCR for different percentage of Steel fiber (SF) with different depth ratio (H/D)

4.3.16-Discussion

The following points come in mind after notice the results and graphs of plate load test-

1. It is observed in each graph that as well as the load increases the settlement is also increases.
2. In both depth ratio the settlement for a particular load will decrease if we increase the percentage of steel fiber.
3. A heavy change or gap also seen in settlement behavior of non-reinforced and reinforced soil by the graph.
4. From log graph between bearing capacity and settlement we can find out clear failure point.
5. For find out the bearing capacity ratio we use formula bearing capacity of reinforced soil divided by bearing capacity of unreinforced soil. These values find out from log-log graph.
6. In general if percentage of steel fiber increase bearing capacity of soil will also increase.
7. Here we mix four different percentage of steel fiber 0.5%, 1%, 1.5% and 3% in two depth ratio (H/D) 0.5 and 1.
8. In each case of different percentage of steel fiber we observed from comparison graph that settlement decrease due to the increment in steel fiber percentage. It occurs due to the stabilization of soil with fibers.
9. If we compare both depth ratio (H/B) 0.5 and 1 in same percentage of steel fiber then we observed that settlement decrease with increasing depth ratio (H/B). But here we have taken only less value of depth ratio (H/B) because for high value the effect of pressure bulb of shallow foundation does not work due to this the use of steel fibers on high depth will not be optimum.

Chapter 5

Conclusion

The conclusion of this research work are define in following point-

1. From fig15 it observed that with increase in percentage of steel fiber in the range of 0.5% to 1% bearing capacity ratio (BCR) increase with mild slope for the case of depth ratio (H/D) is equal to 0.5.
2. After 1% of steel fibers bearing capacity ratio (BCR) increase sharply up to 1.5% of steel fibers with same slope in both cases of depth ratio (H/D). After 1.5% quantity of steel fiber the increment slope of bearing capacity ratio (BCR) decrease. Its mean cost of construction will be effected if we increase quantity of fibers after 1.5%.
3. So from above two points it observed that 1% to 1.5% quantity of steel fibers are optimum in both case of reinforced zone.
4. From fig 16 we can see that as well as percentage of steel fiber increases bearing capacity ratio (BCR) increase with depth ratio (H/D) ratio.
5. But here it can see that in case of 0.5% of steel fibers the graph of bearing capacity ratio (BCR) vs. depth ratio (H/D) increases with steep slope as compare to 1%, 1.5% and 2% case of steel fibers.
6. From graph, 1.5% and 2% give high bearing capacity ratio (BCR) with depth ratio (H/D) as compare to remaining case of steel fibers.
7. So from point 4, 5 and 6 we can say 0.5% quantity of steel fiber show optimum result in this case but 1.5% and 2% quantity of steel fibers show high values of bearing capacity ratio (BCR) which are also optimum. But slope of 1.5% and 2% quantity of steel fibers for this graph are same.
8. From above points we can give conclusion that the range of 1 to 1.5% quantity of steel fibers show optimum result in any depth ratio (H/D) or reinforced zone case under pressure bulb of foundation.

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