EXPERIMENTAL STUDY OF VARIOUS SHAPED ISOLATED FOOTINGS UNDER MONOTONIC AND INCREMENTAL CYCLIC LOADING ON BLACK COTTON SOIL

Niraj Gupta[1], Pravin Patel[2], Mrs. Komal Bedi[3]

[1]Student, M.Tech. Structural Engineering, Alpine Institute of Technology Ujjain, MP, India
[2]Consultant Civil Engineer, Vistara Consultant ,Indore MP, India
[3]H.O.D. Dept. of Civil Engineering, Alpine Institute of Technology Ujjain, MP, India

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Abstract - *Bearing capacity and settlement are the two major criteria for designing of foundation. Also it is not always subjected to monotonic loading but it is also subjected to cyclic loading. The examples are lifts, bridges foundation, machine foundation, offshore structure, wind waves etc. In this experimental work an attempt has been made to study the behavior of six various shaped footing specimens. For this purpose the area of footing specimens was taken same as 150cm² and dimension are fixed accordingly. They are studied under black cotton soil. Monotonic and cyclic loading tests were conducted on all the six specimens and load intensity–settlement curves are plotted.*

It is concluded after studying the load intensity-settlement behavior that square footing shows least settlement while triangular footing shows maximum settlement at same loading intensity. Elastic rebound curve are also studied from the load intensity – settlement curves. Experimentally it is found that square footing shows better performance while triangular footing shows poor behavior.

Key Words*: *Black Cotton Soil, Elastic Rebound, Footings, Incremental Cyclic Loading, Settlement,

1. Introduction

The Bearing capacity of soil plays a major role in design of footings. As footings are used in a variety of fields such as wall foundations, offshore platforms, bridges, machinery foundations etc. the nature of load transmitted also varies. The load transmitted to the soil causes the settlement of soil. The settlement of soil varies with nature of loading such as static loading, dynamic loading, cyclic loading, repeated loading etc. When structures are subjected to cyclic loadings, the footing might fail at loads much smaller than the failure load for static condition which in turn will give rise to the collapse of structures. The method of foundation design requires that they must possess sufficient safety against failure and settlement must be kept within the tolerable limits. The shape of footing also play an important role in design of footing. Two different shaped footing may show different settlement on same soil subjected to same loading condition.

1.1 Aim of study

The load settlement behavior of footings of rectangular, circular and square shapes is well known. In the present study an attempt is made to compare the Load-settlement behavior of six different shaped footings namely rectangular, circular, square, hexagonal, triangular and octagonal footing under monotonic and incremental cyclic loading on black cotton soil.

The study is carried out using black cotton soil as strata. In this artificial field test the density and moisture content of the soil were kept same as existing in the field. Load intensity -settlement curves under monotonic and incremental cyclic loading are plotted and studied.

1.2 Experimental Program

A. **Test specimens**:- Six footing specimens having different shape and same surface area (150cm²) with plate thickness equal to 8 mm have been used.

B. **Soil Used**: Each specimen has been tested on black cotton soil. Density of black cotton soil is kept equal to 14 KN/m³.

Table -1: Sample Table format

S No.	Shape Of footing	Size(in cm)
1	Circular	Dia 13.8 cm
2	Triangular	Each Side of 18.16 cm
3	Square	12.3 cm X 12.3 cm
4	Rectangular	15 cm X10 cm
5	Hexagonal	7.6 cm Each
6	Octagonal	5.3 cm Each Side

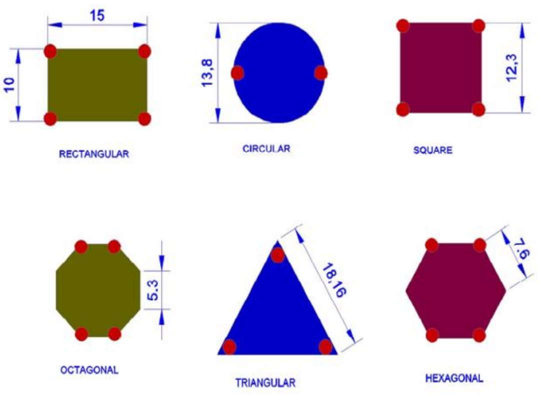

Fig -1: Dimension of all footings model in cm

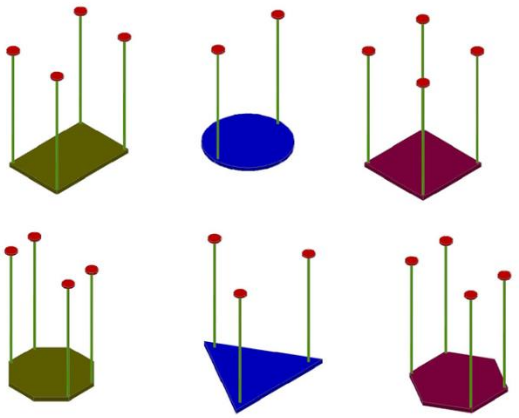

Fig -2: Details of footing model

Fig -3: Actual photograph of all footing model in cm

1.3 Instrumentation

The footing specimens are tested under monotonic and incremental cyclic loading, load being applied axially at centre of footing. A load cell is used to apply load while settlements are measured using dial gauges. The loading arrangement and instrumentation is as follows:

- Loading Arrangement: The loading arrangement consisted of a tank, reaction frame, hydraulic jack, load cell and digital load indicator. Tank of size 125 cm x 75 cm x 45 cm was filled with soil. The load was applied manually by hydraulic jack. The reaction frame was fitted to the tank keeping center of frame vertically above the center of tank. The loading arrangement is shown in Fig 4.
- Load meter and Load Cell: Load cell is pressure transducers of capacity 20KN used to record load applied. The load cell was connected to load meter to measure the load applied.
- Dial Gauges and LVDT: Dial gauges that can measure upto 25mm with least count of 0.01mm were used.

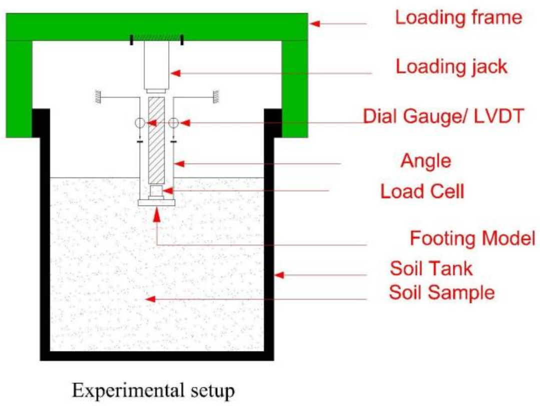

Fig -3: Experimental Setup

1.4 Test Procedures

A. Testing Under Monotonic Loading: The testing under monotonic loading has been carried out as follows:

1) The soil sample taken from the field was filled up to a height of 40cm in three layers. The bottom and middle layer having thickness 15cm each and a top layer of 10 cm. Each layer is compacted to achieve field density.
2) The footing specimen placed centrally and load was applied vertically through hydraulic jack.
3) The load was applied at an increment of 50kgs.
4) The rate of loading was kept 1kg/sec.
5) Readings of the dial gauge were noted at each increment of load. The load intensity was kept constant for 90 sec or reading in dial gauge becomes stable.
6) After each testing the soil was again disturbed and then again compacted for next specimen. The same procedure has been followed for all the six footing specimen.

B. Testing Under Cyclic Loading: The testing under monotonic loading has been carried out as follows:

1) The maximum load obtained from monotonic test was divided in equal parts of 50kg for applying cyclic loading.

2) The rate of loading and unloading was selected as 1kg /sec. The cyclic loading time history is shown below in Fig 5.

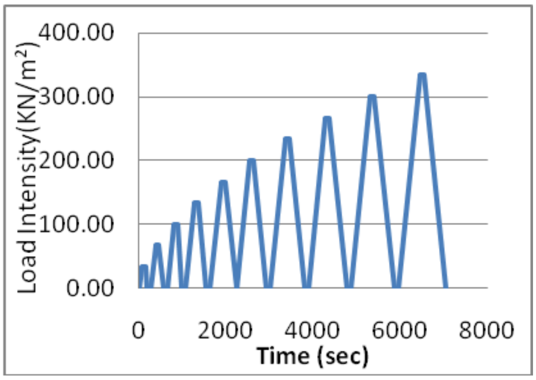

Fig -5: Time History curve for cyclic incremental loading

3). The load was released to zero so that soil can rebound and then again soil was reloaded up to next cycle.

4). The readings were taken at an interval of 25kgs for more accurate results.

5).After each testing soil was disturbed and again compacted up to field density.

1.5 RESULT

A) Test Result:- The study has been carried out on six different shaped footing as described above. The Load Intensity - Settlement behavior of these footings obtained under black cotton soil has been presented in the form of Load Intensity vs Settlement curve under monotonic and cyclic loading from Fig.6 to Fig.13.

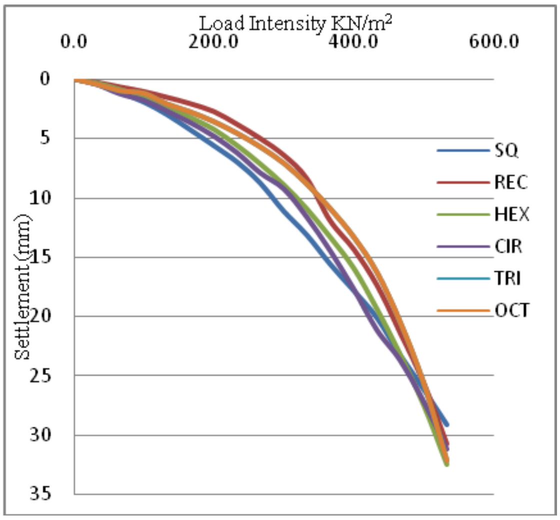

Fig -6: shows comparison of Load Intensity v/s Settlement curve of various shaped footings on black cotton soil subjected to monotonic loading.

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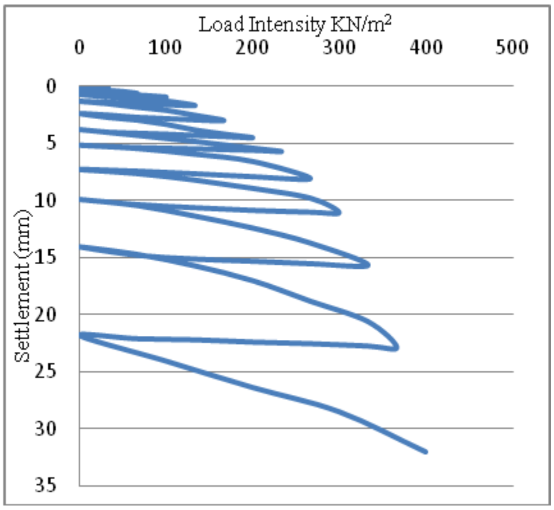

Fig -7: Load Intensity vs Settlement curve for square shaped footing on black cotton soil subjected to incremental cyclic loading.

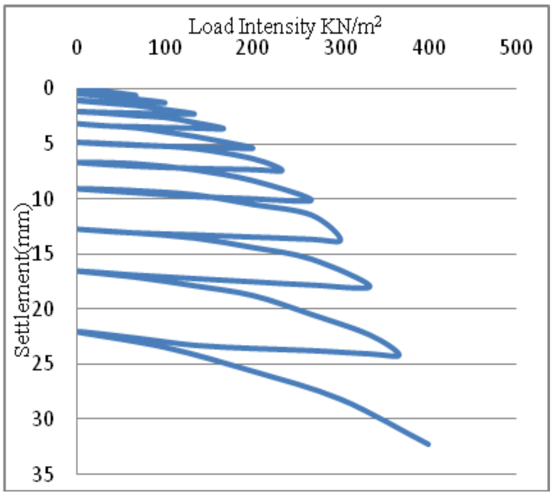

Fig -8: Load Intensity vs Settlement curve for rectangular shaped footing on black cotton soil subjected to incremental cyclic loading.

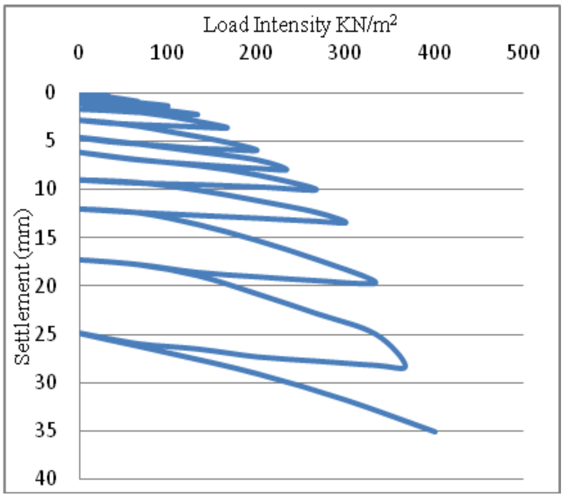

Fig -9: Load Intensity vs Settlement curve for circular shaped footing on black cotton soil subjected to incremental cyclic loading.

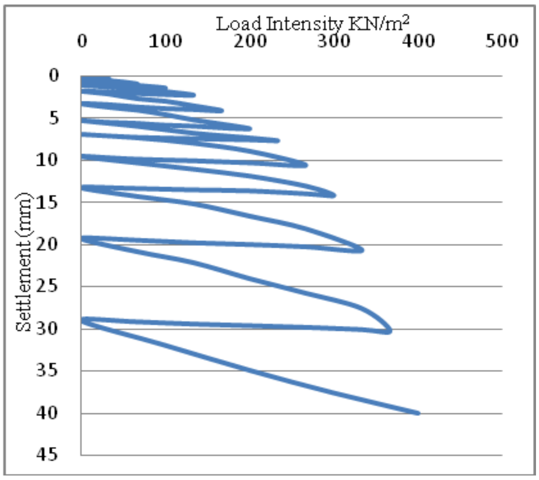

Fig -10: Load Intensity vs Settlement curve for octagonal shaped footing on black cotton soil subjected to incremental cyclic loading.

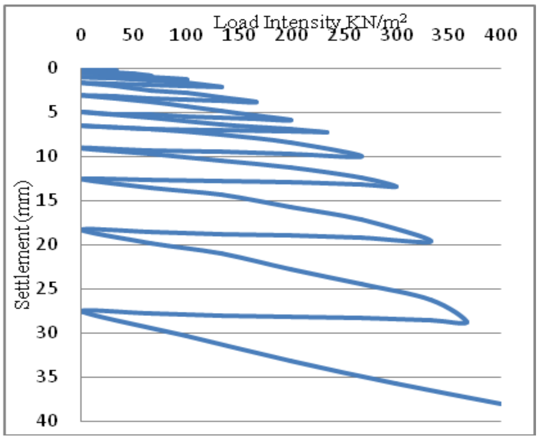

Fig -11: Load Intensity vs Settlement curve for hexagonal shaped footing on black cotton soil subjected to incremental cyclic loading.

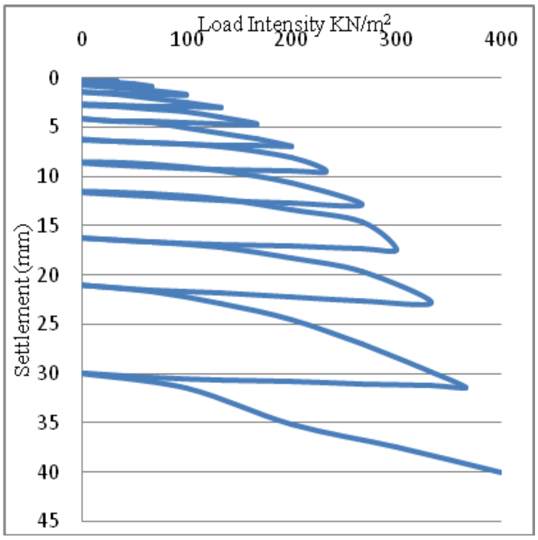

Fig -12: Load Intensity vs Settlement curve for triangular shaped footing on black cotton soil subjected to incremental cyclic loading.

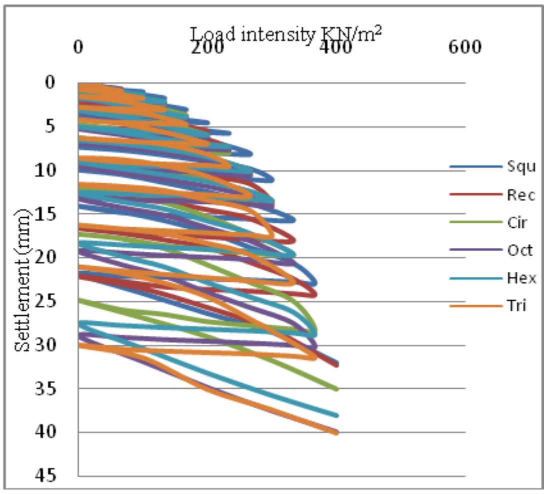

Fig -13: Comparison of Load Intensity vs Settlement curve for all six footings on black cotton soil subjected to incremental cyclic loading.

1.6 DISCUSSION

A). Monotonic Loading: From Fig.6 for monotonic loading it can be seen that settlement at a given load intensity, 533KN/m²(800kg), is maximum for triangular shaped footing while it is minimum for square footing.

B). Cyclic Loading: The same behavior of settlement at a given load intensity, 400KN/m² (600kg) is observed from a comparative load intensity v/s settlement curve of various footings subjected to incremental cyclic loading as shown in Fig.13. Triangular footing shows maximum settlement while that of square footing shows minimum settlement.

C). Elastic Rebound: From the readings taken during unloading of specimen subjected to incremental cyclic loading, elastic rebound curve are plotted for various shaped footings and a comparison is made for elastic rebound of all footings as shown below in Fig.14

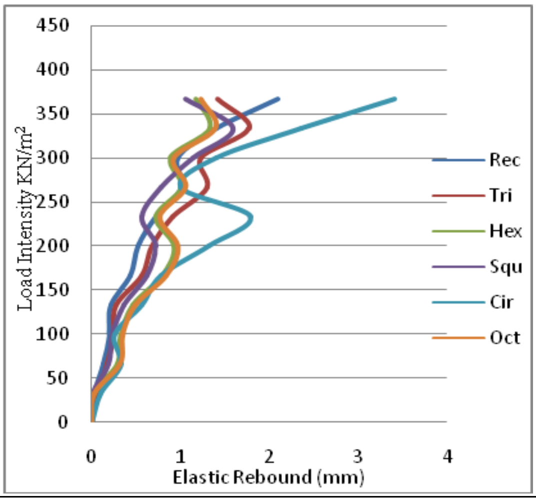

Fig -14: Elastic Rebound Curve

1.7 CONCLUSIONS

A. Monotonic Loading: Settlements in all the six footings when subjected to monotonic loading and their comparison with square footing at load intensity of 533KN/m^2(800kg) is shown in Table 2 below.

TABLE 2

Footing	Settlement (mm)	% inc.wrt to square footing
Square	29.13	-
Rectangular	30.74	5.52
Circular	31.21	7.14
Octagonal	32.15	10.36
Hexagonal	32.45	11.39
Triangular	33.63	15.4

B. Cyclic Loading: Settlements in all the six footings when subjected to incremental cyclic loading and their comparison with square footing is shown in Table 3 below.

TABLE 3

Footing	settlement (mm)	% inc. wrt to square footing
Square	31.97	-
Rectangular	32.30	1.03
Circular	35.03	9.5
Octagonal	39.96	24.99
Hexagonal	38.06	19.04
Triangular	40.08	25.36

C. Settlement: Settlement was more in triangular footing as compared to other footings at same load intensity under monotonic and incremental cyclic loading.

D. Elastic rebound curve: From elastic rebound curve it is observed that the elastic rebound is more in circular footing as compared to other footing.

E. Hence from the above study it can be concluded that square shape is better and triangular shape is least suitable for footing.

1.8 REFERENCES

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