Experimental Study of Various Shaped Isolated Footings under Monotonic and Incremental Cyclic Loading on Yellow Soil

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Abstract- The work in this study explores the load-settlement behavior of the six different shaped footing (Square, circular, rectangular, hexagonal, octagonal and triangular) specimens under monotonic and incremental cyclic loading. For this purpose, footing specimens of surface area 150cm^2 with plate thickness 8mm was taken and choosing their dimension accordingly. They are studied under yellow soil. Monotonic and cyclic loading are two parameters for designing the foundation. Therefore monotonic and cyclic loading tests were conducted on all the specimens and load intensity v/s settlement curves are plotted. For this, a tank of size 125cm x 75cm x 45cm was filled up to 40cm in 4 layers of 10 cm by yellow soil. By applying same load, settlement is noted and curves are drawn Plotted curves gives comparative results of six footing specimens for monotonic and incremental cyclic loading. Square footing specimen shows lesser settlement and triangular footing specimen shows higher settlement while other specimens give intermediate settlement. Means the load carrying capacity of square footing specimen is higher than the other specimens.

I. INTRODUCTION

One of the most fundamental and important problems in the field of civil engineering is prediction of bearing capacity and settlement of foundation of building and other structures. The load transmitted to the soil causes the settlement of soil. As footings are used in a variety of fields, nature of load transmitted also varies. By limiting the total settlement, differential settlements the structures are ensured to be safe .The settlement of footing due to load transmitted to the soil must be within 50mm for structural safety purpose. Settlements depend upon various factors such as bearing capacity, soil, particle size, area and shape of the footing and so on. Out of this, on shape factor, extensive experimental and theoretical studies on square or equivalent shaped footings are carried out but there is no literature on other shaped footings like hexagonal. So the present study, comparatively evaluated the effect of shape factor of footing on settlement of footing. Square and Hexagonal footing specimens are tested under different types of soil like yellow soil, black cotton soil, sandy soil under monotonic and cyclic loading. Two different shaped footing may show different settlement on same soil with same loading condition.

It is an important aspect in the design of foundations to understand the behavior of underlying soil when they are subjected to cyclic loading condition.

The design of footing should be such that-

1) The soil below does not fail in shear.
2) The settlement is within the safe limits.
3) Free from effect of seasonal volume changes.

A footing may settle due to following reasons:-

- The static loading.
- Repeated loading.
- The vibration produced by machine foundation.
- The vibration produced by heavily loaded vehicle.
- Liquefaction
- The shape of load settlement curves are highly influenced by density, moisture content and type of soil.

II. OBJECTIVES OF STUDY

Experimental work is performed to study following objectives-

- To compare the settlements of six different shaped footing specimens under monotonic and incremental cyclic loading on yellow soil.
- To evaluate the shape effect of footing specimens on settlement for same loading condition.
- To study the load intensity-settlement behavior of different shaped footing specimens under monotonic and incremental cyclic loading

III. EXPERIMENTAL PROGRAMME

In this experimental work six different shaped footing specimens with same cross sectional area is tested under monotonic and incremental cyclic loading on sandy soil.

- The footing specimens are circular, triangular, rectangular, square, hexagonal and octagonal in shape.
- To account the applied load a load meter and a load cell is used.
- Loading, unloading and reloading was done manually.
- Settlements were recorded using dial gauges at appropriate positions.
- The density and moisture content was kept same as existing on the field.
- Load Intensity-settlement curves are plotted to study the effect of shape of footing on settlement of soil for monotonic and incremental cyclic loading.

TEST SPECIMEN

Six different shaped footing specimens having same surface area (150cm^2) with plate thickness equal to 8 mm have been used. For the study the details of test specimens are given in table-1

Table-1 Details of test specimens

S. No.	Shape of footing	Size (cm)
1	Circular	Diameter 13.8
2	Triangular	Each side 18.16
3	Square	12.3 X 12.3
4	Rectangular	15 X 10
5	Hexagonal	Each side 7.6
6	Octagonal	Each side 5.3

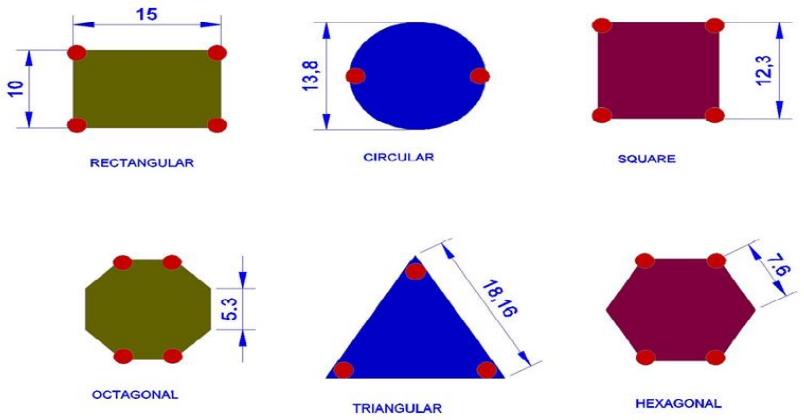

FIG. 1 DIMENSION OF FOOTING SPECIMENS IN MM

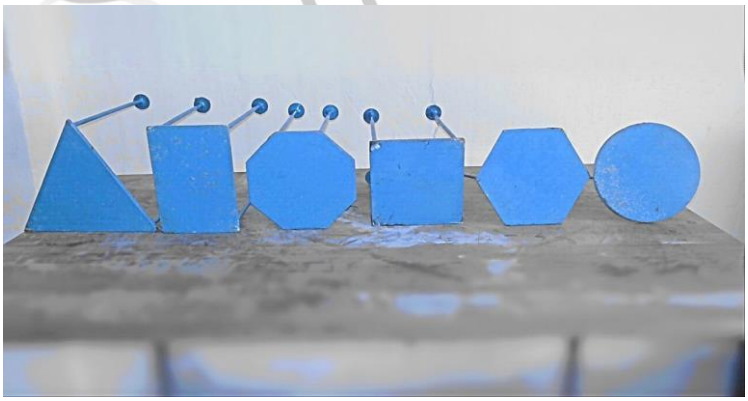

FIG. 2 ACTUAL PHOTOGRAPH OF FOOTING SPECIMENS

IV. INSTRUMENTATION

The footing specimens are tested under monotonic and incremental cyclic loading, load was applied axially at center 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-

- ***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 applied load.

- ***Dial gauges***

Dial gauges are fixed at appropriate position to measure the deflection. It can measure up to 25mm with least count of 0.01mm.

- ***LVDT***

The linear variable differential transformer (LVDT) also called differential transformer is a type of electrical transformer used for measuring linear displacement has been used to record settlement.

V. LOADING ARRANGEMENT

The loading arrangement consisted of a soil filled tank, reaction frame, jack, load cell, digital load indicator and dial gauges. A tank of size 125cm X 75cm X 45cm was filled with yellow soil. Total height of fill was kept as 40cm. It was filled and compacted keeping density equal to field density. The soil was leveled and footing specimen was placed in the soil keeping the center of specimen in line with the center of the reaction frame. The specimen was also leveled. The jack was placed on the specimens and the load cell was inserted between jack and reaction frame. Dial gauges were fitted at opposite points on the specimens. The loading arrangement is shown in Figure -2

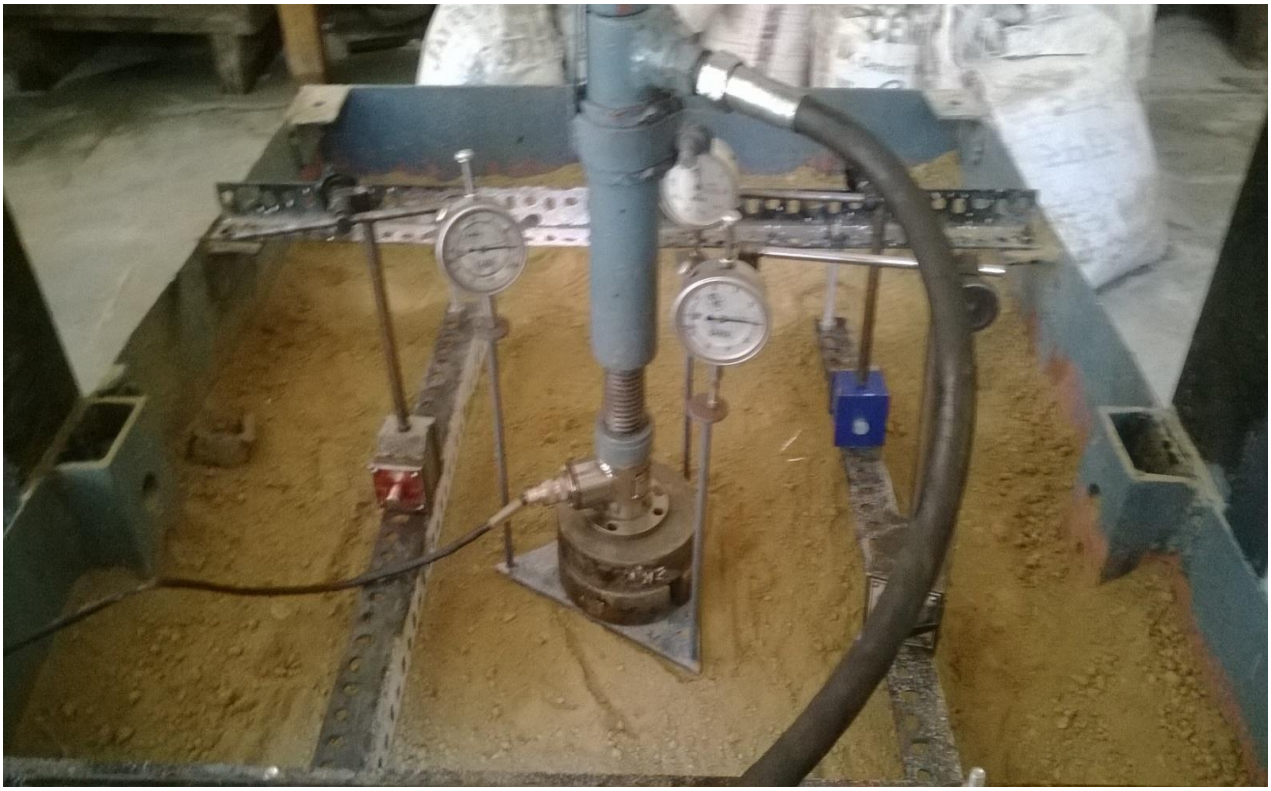

FIG.3 ACTUAL PHOTOGRAPH OF SETUP

VI. TEST PROCEDURE

Testing under monotonic loading-

1. The soil sample is filled up to a height of 40cm in two bottom layer of 15cm and a top layer of 10cm. by compacting it to achieve field density.
2. The footing specimen is placed centrally and load is applied vertically through hydraulic jack.
3. The load is applied at an increment of 50kn till soil fails or 50mm settlement occur.
4. The rate of loading is kept 1kn/sec.
5. Readings of the dial gauges were recorded at each increment of load. The load intensity is kept constant for 90 sec or reading in dial gauge becomes stable.
6. After each testing the soil is again disturbed and then again compacted for next specimen. The same procedure is followed for both Hexagonal and Square footing models and for different soils.

Testing under incremental cyclic loading-

1. The maximum load obtained from monotonic test is divided in equal parts of 50kn/m^2 for applying cyclic loading.
2. The rate of loading and unloading is selected as 1kn/sec.
3. The entire load is removed so that soil can rebound and then again soil is reloaded up to next cycle.
4. The readings were taken at an interval of 25kn/m^2 for more accurate results.

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

VII. TEST RESULT

The study had been carried out on six different shaped footing as described above. The load Intensity – settlement behavior of these footings obtained under yellow soil has been presented in the form of load intensity-settlement curve under monotonic and incremental cyclic loading.

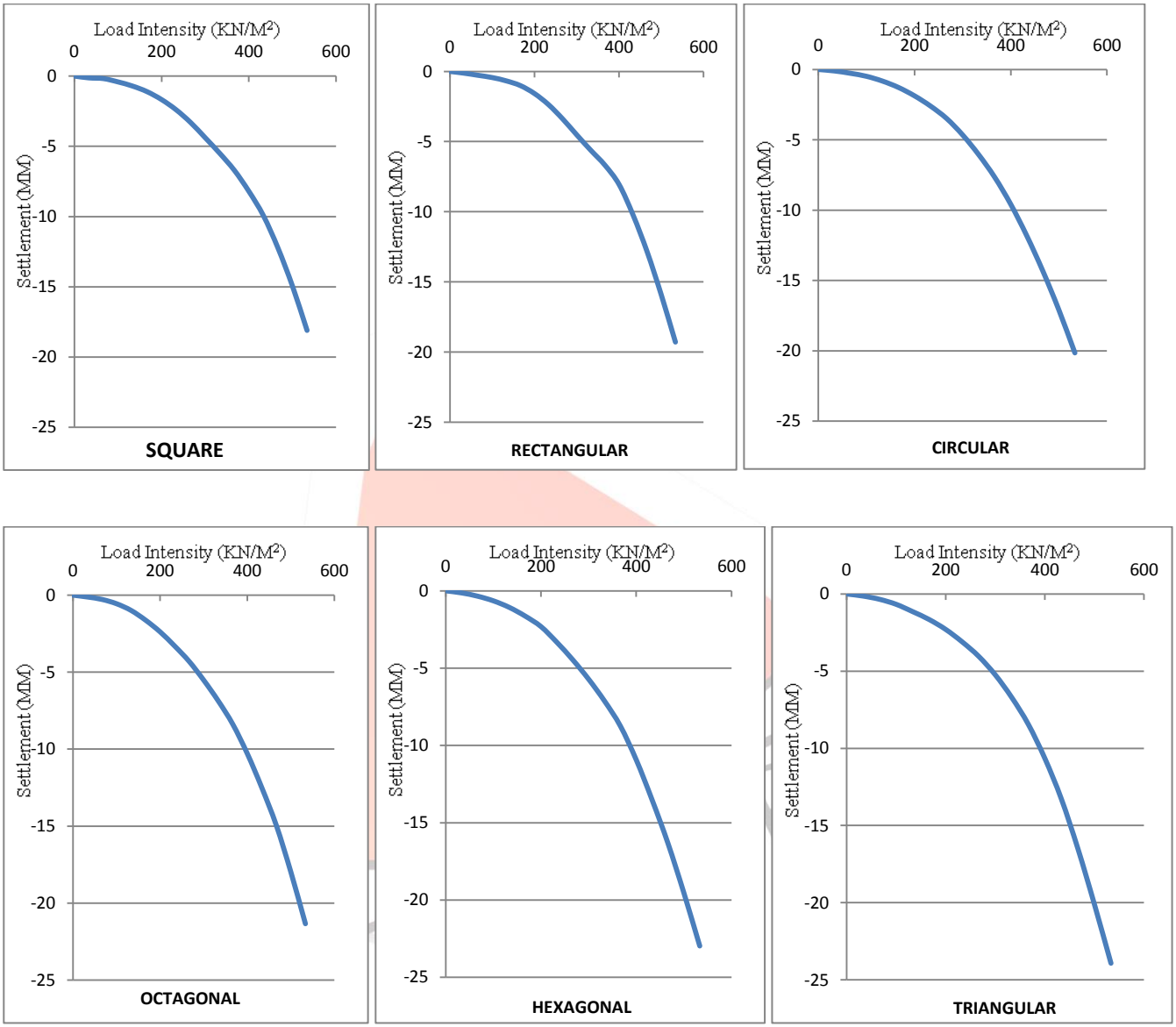

FIG.4 LOAD INTENSITY V/S SETTLEMENT CURVE FOR VARIOUS SHAPED ISOLATED FOOTING UNDER MONOTONIC LOADING

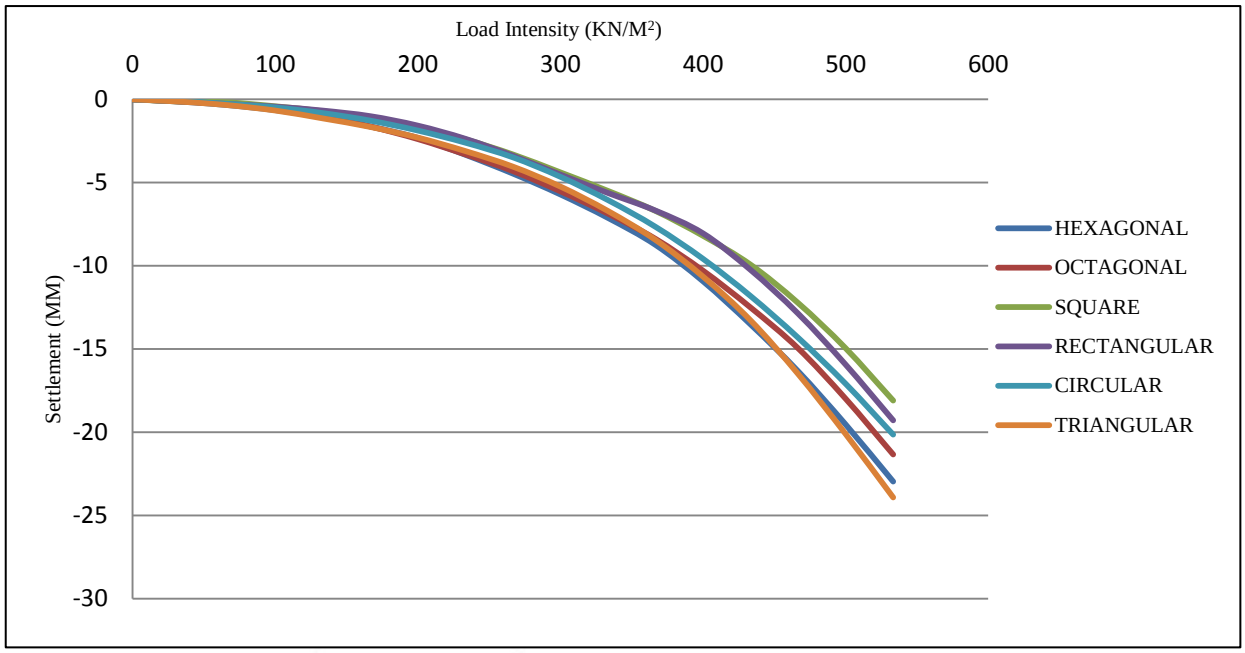

FIG.5 LOAD INTENSITY V/S SETTLEMENT COMPARATIVE CURVES FOR ALL 6 SPECIMENS FOR MONOTONIC LOADING

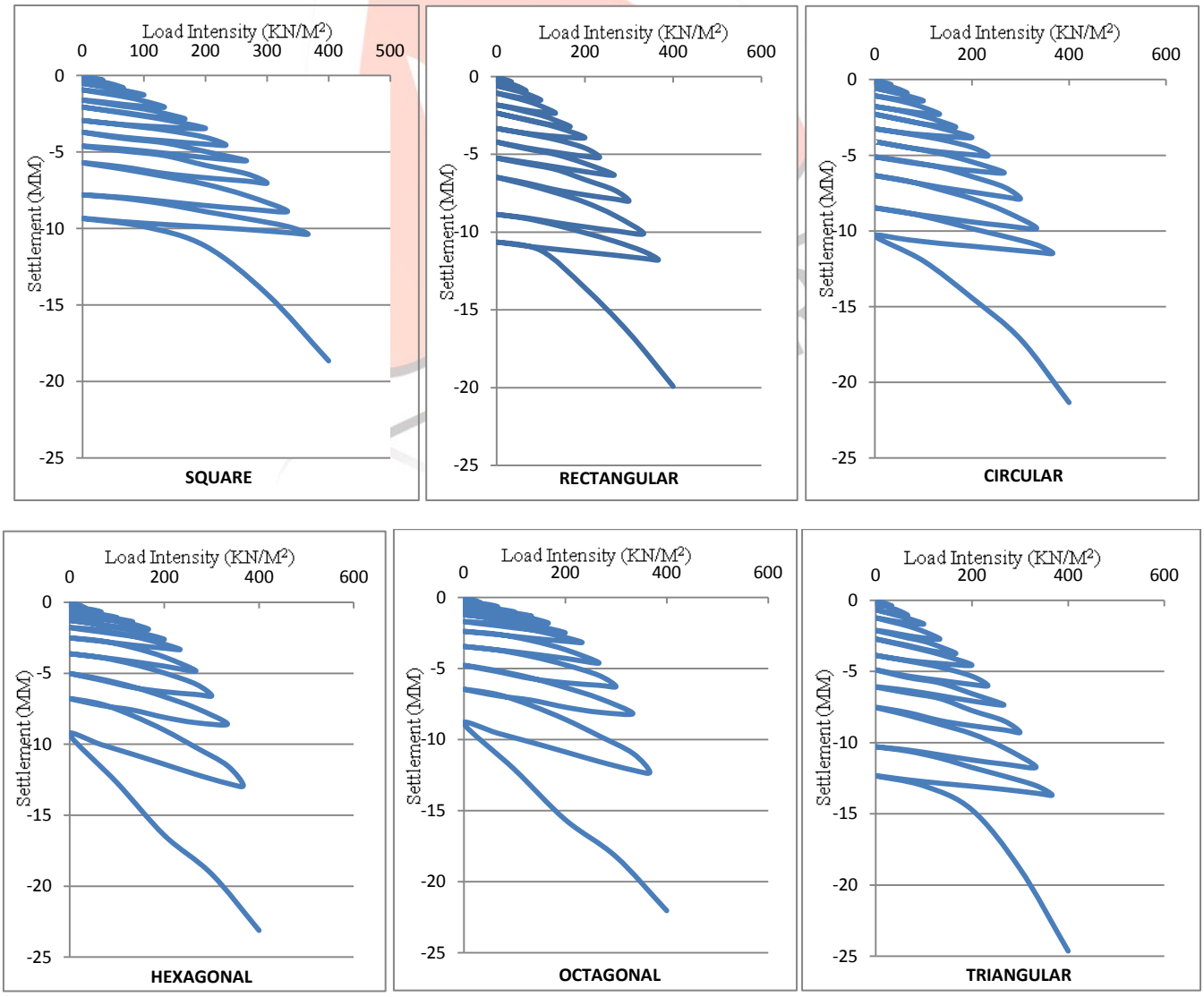

FIG.6 LOAD INTENSITY V/S SETTLEMENT CURVE FOR VARIOUS SHAPED ISOLATED FOOTING UNDER CYCLIC LOADING

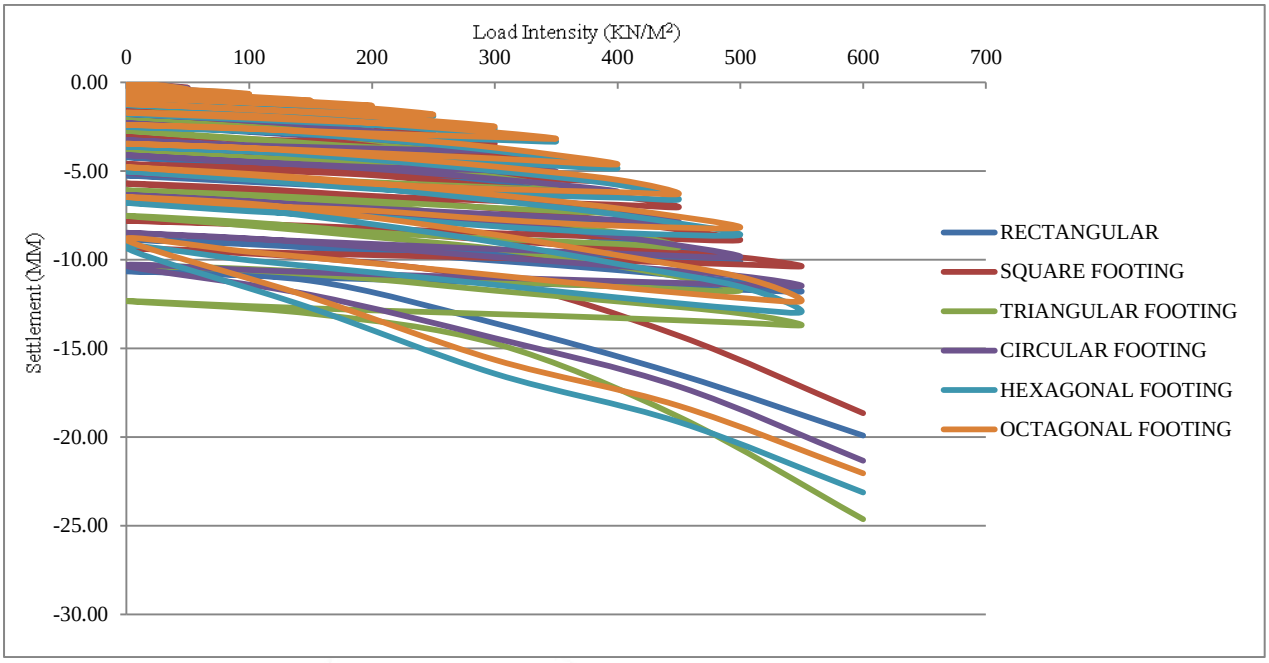

FIG7. LOAD INTENSITY V/S SETTLEMENT COMPARATIVE CURVES FOR ALL 6 SPECIMENS FOR CYCLIC LOADING

VIII. DISCUSSION

Monotonic loading

Load intensity-settlement curve shape is similar for all types of footings considered. From graph it can be seen that initial path is linear and then it becomes parabolic.

- ***Settlement***

The settlement for triangular footing is more pronounced than other footings. In yellow soil, settlement recorded at 533kn/m^2 for triangular footing specimen 29.92mm which is maximum and for square footing it is 18.10mm which is minimum at same load intensity.

Incremental cyclic loading

Load intensity-settlement curve in case of incremental cyclic loading, the loading curve for each cycle is parallel to previous curve. The unloading curves also trace curve parallel to previous unloading curves. Reloading curve crosses the unloading curves. The loop forms in this loading are similar for each type of footing considered. At higher load intensity the loop tends to enlarge as settlements increases. For comparison the settlements are found at 400kn/m^2. Settlement in case of incremental cyclic loading, triangular footing when compared with other footing specimens shows poor behavior. The settlement in triangular footing is much higher as compared to other specimens. The settlement recorded at 400kn/m^2 for triangular footing is 24.63mm which is maximum where as settlement for square footing is 18.65mm which is minimum.

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