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Study of Interference of Strip Footing using PLAXIS-2D

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Abstract: Many a times the columns in a structure need to be closely spaced to meet the architectural and functional requirements. This leads to the overlapping of stressed zones and may change the behavior of system of footings placed closely. In the present study, the interference of two strip footings is investigated. The footing resting on three soil mediums namely soft clay(C-soil), sandy clay(C-Ø soil) and medium sand (Ø-soil) is considered. The behavior of individual footing on each medium is first established. In case of interference study, the two footing are considered to be at same level but at different depths represented by depth ratio D/B and at different spicing represented by spacing ratio S/B. The effect of interference when two footing are at different levels is also studied and presented. The analysis is carried out for static loading conditions by applying incremental uniformly distributed loads till failure for different loading sequences, depths and spacing. The analysis is carried out using PLAXIS-2D, a modern finite element tool for geotechnical analysis and presented.

Key words: Interference, strip footing, PLAXIS-2D

I. INTRODUCTION

The foundation transmits the load of the structure safely to the ground, without undergoing any shear failure or excessive settlement. Many a times, it is inevitable to place footings at a closer spacing. In such cases the combined action of two footings is quite different as compared to that of single a footing. Closeness of the footings causes the interference of stressed zones and thus modifies the load-settlement behavior, bearing capacity and settlement. In the present study, the interference of two strip footings is studied. Three soil mediums viz., soft clay(C-soil), sandy clay(C-Ø soil) and medium sand (Ø-soil) are considered for analysis. The influence of an interfering footing at same depth or different depths is recorded and presented.

II. METHODOLOGY AND MODELING

PLAXIS-2D, finite element software for geotechnical analysis is used in the present analysis. The problem is modeled in PLAXIS-2D as plane strain problem since the length of the footing is more compared to its width. Footing is modeled as rough footing having width B=2m laid at depth D from surface. Clear spacing between two interacting footings is represented as S. The depth of the footing is represented by depth ratio D/B and proximity of footings is represented by spacing ratio S/B. A 15 node triangular element is adopted in modeling soil medium. The 2D soil model geometry of 40 m width and 40 m depth is adopted. Soil model is fixed at the bottom and roller supported at the side boundaries and uniformly distributed load is applied on the strip footing till failure. The following depth, spacing and load cases are considered for the analysis.

The load settlement behavior of an isolated strip footing resting on a given soil medium at different depths (D/B ratio 0-1.0) is obtained by loading the footing gradually, in increments of 25 kN/m^2, till failure.

Load settlement behavior of two strip footings, loaded simultaneously and spaced at S/B ratio of 0 to 4.0 and at different D/B ratio are analyzed. In simultaneous loading case, the load on two footings is applied simultaneously in increments of 25 kN/m^2, till failure.

Load settlement behavior of two footings – one representing an existing footing, which is loaded at safe ultimate load intensity and second – an interfering footing placed at spacing ratio of 0 to 4 and loaded gradually till the failure , is analyzed. This loading case is referred as varying load case. In this case the two footing are at same depths. The system of footings at various D/B ratios and on different soil medium is analyzed.

Load settlement behavior of two footings – one representing an existing footing, at D/B ratio of 1.0 and loaded at safe ultimate load intensity and second – an interfering footing placed at depth ratio of 0 to 1 and loaded gradually till the failure , is analyzed. This loading case is referred as varying depth case. In this case the two footing are at different depths and spacing ratios of 1 to 4 on different soil mediums.

The properties soil medium and footing characteristics are enumerated in Table 1and Table 2.Typical soil model with deformed mesh and the vertical displacement contours are shown in Fig.1 and Fig. 2 respectively.

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Table.1.MATERIAL PROPERTIES OF SOFT CLAY

PARAMETER	VALUE
Material model	Mohr-coloumb
Material type	Drained
Unsaturated unit weight(γ_{unsat})in kN/m^3	15.56
Saturated unit weight (γ_{sat}) in kN/m^3	19.45
Young's modulus (E) in kN/m^2	5500
Poission's ratio (µ)	0.42
Cohesion (c) in kN/m^2	30
Angle of internal friction(Ø)	1°

Table.2.MATERIAL PROPERTIES OF SANDY CLAY

PARAMETER	VALUE
Material model	Mohr-coloumb
Material type	Drained
Unsaturated unit weight(γ_{unsat})in kN/m^3	17
Saturated unit weight (γ_{sat}) in kN/m^3	20
Young's modulus (E) in kN/m^2	50000
Poission's ratio (µ)	0.3
Cohesion (c) in kN/m^2	5
Angle of internal friction(Ø)	21°

Table.3.MATERIAL PROPERTIES OF MEDIUM SAND

PARAMETER	VALUE
Material model	Mohr-coloumb
Material type	Drained
Unsaturated unit weight(γ_{unsat})in kN/m^3	16
Saturated unit weight (γ_{sat}) in kN/m^3	17.12
Young's modulus (E) in kN/m^2	40000
Poission's ratio (µ)	0.3
Cohesion (c) in kN/m^2	1
Angle of internal friction(Ø)	30°

Table.4.CHARACTERISTICS OF FOOTING

PARAMETER	VALUE
Width of footing (B) in mm	2000
Axial stiffness (EA) in kN/m	4.472 x 10^7
Flexural stiffness (EI) in kN/m^2-m	4.65 x 10^5
Equivalent thickness of plate (d) in mm	0.353
Weight of footing (w)kN/m/m	25
Poission's ratio(µ)	0.3

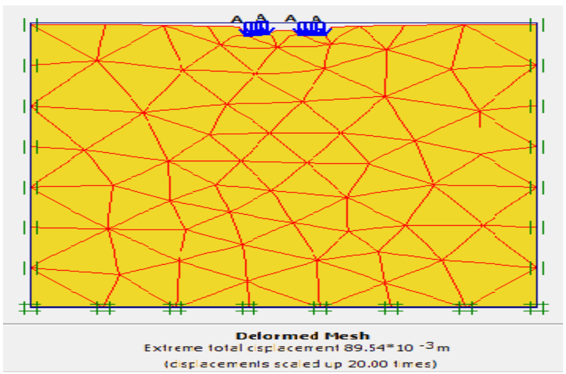

Fig.1 Deformed meshes showing total displacement for footings for simultaneous loading case.

III. RESULTS AND DISCUSSIONS

A. Simultaneous loading case

Figures 3 to 5 show the variation of failure loads for two footings loaded simultaneously and resting on soft clay, sandy clay and medium sand respectively.

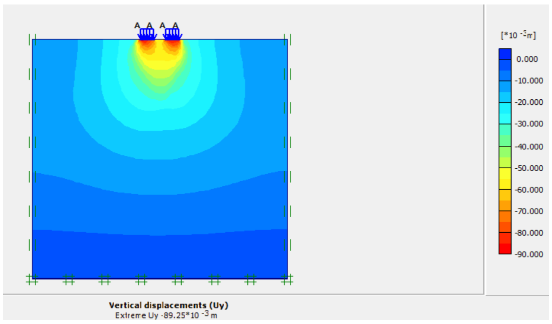

Fig.2 Vertical displacement (settlement) for simultaneous loading case

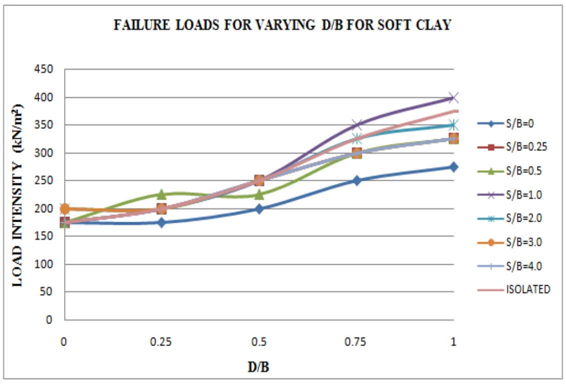

Fig.3 Failure loads for footings on soft clay

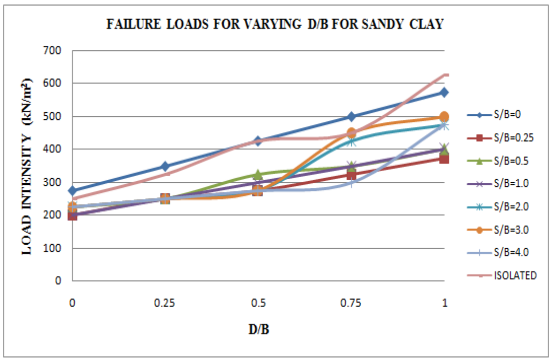

Fig.4 Failure loads for footings on sandy clay

Fig.6 and Fig.7 indicate the failure loads for three soils under consideration for surface footings and footings at D/B ratio of 1.0 respectively. For surface footings failure of the system of footings is imminent up to a spacing ratio of 1.0 in all the soils. For the footings at depth the failure of the system of footings on soft clay and sandy clay is imminent up to spacing ratio of 2.0 after which failure loads are almost constant. Though the failure loads for footings on medium sand are higher compared to those on other soils, but failure loads are observed to be minimum after spacing ratio of 2.0.

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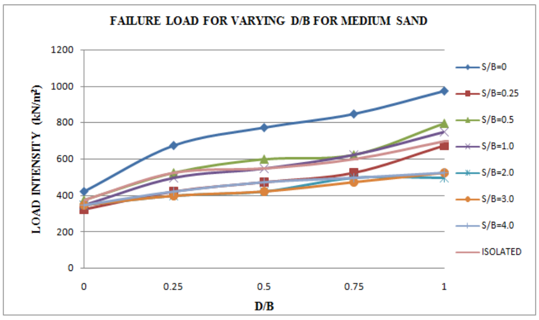

Fig.5 Failure loads for footings on medium sand

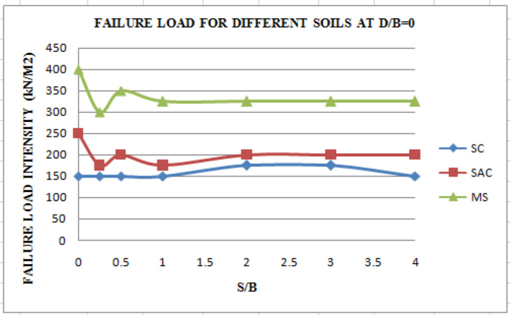

Fig.6 Failure loads for footings at D/B=0

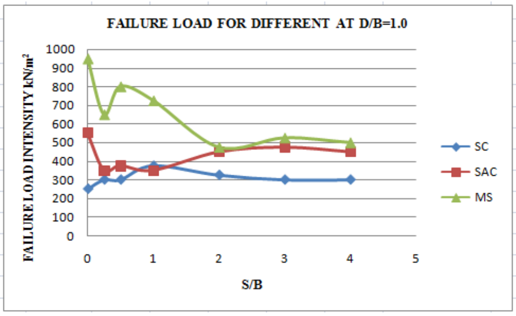

Fig.7 Failure loads for footings at D/B=1.0

B. Varying load case

Figures 8 to 10 show the variation of failure loads for two footings under varying load case and resting on soft clay, sandy clay and medium sand respectively.Fig.11 and Fig.12 indicate the failure loads for three soils under consideration for surface footings and footings at D/B ratio of 1.0 respectively. For surface footings failure of the system of footings is imminent up to a spacing ratio of 1.0 in all the soils. For the footings at depth the failure of the system of footings on soft clay is imminent up to spacing ratio of 0.5 after which failure loads are almost constant.

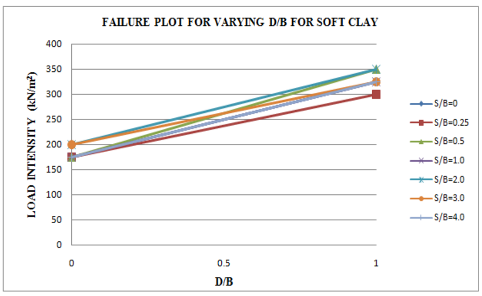

Fig.8 Failure loads for footings on soft clay

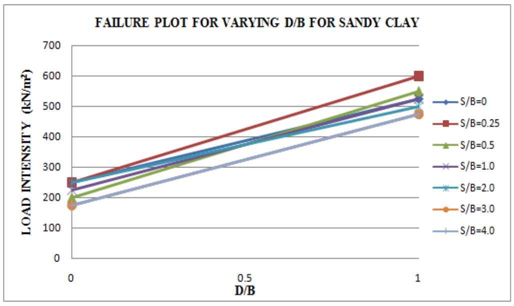

Fig.9 Failure loads for footings on sandy clay

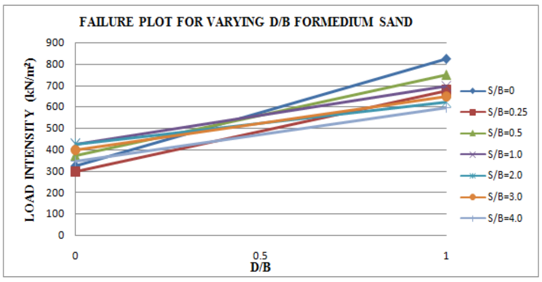

Fig.10 Failure loads for footings on medium sand

Though the failure loads for footings on sandy clay and medium sand are higher compared to soft clay, their failure loads are minimum after spacing ratio of 2.0.

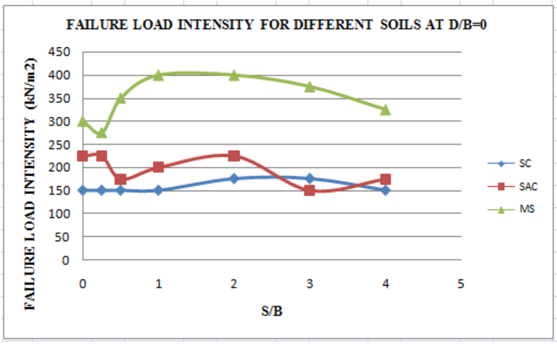

Fig.11 Failure loads for footings at D/B=0

C. Varying depth case

Fig.13 shows the failure loads for the system of footings resting on soft clay, where one footing, at D/B=1,is loaded at its ultimate value and the interfering footing, loaded gradually till failure is at the surface. For the similar situation on sandy clay and medium sand, the failure load variations are shown in Fig.14 and Fig.15 respectively.

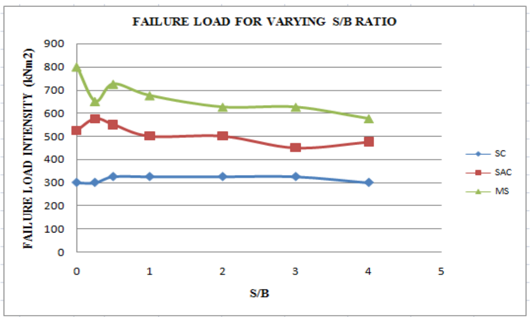

Fig.12. Failure loads for footings at D/B=1.0

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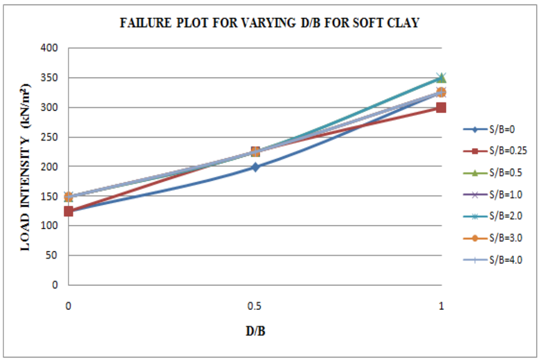

Fig.13 Failure loads for footings on soft clay

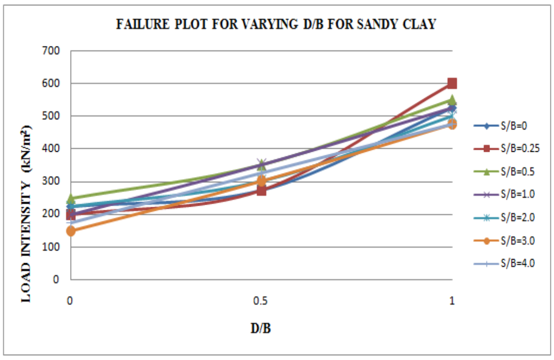

Fig.14 Failure loads for footings on sandy clay

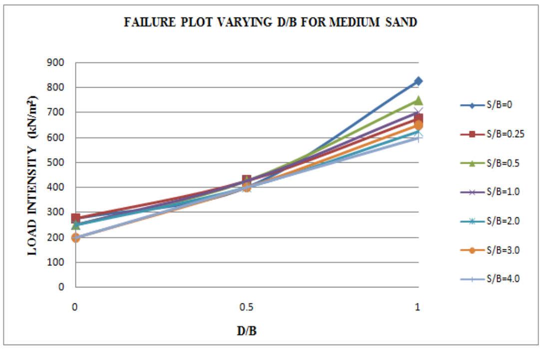

Fig.15 Failure loads for footings on medium sand

The variation of the failure loads for varying S/B ratios when one of the footing is at D/B=1 and the interfering footing at surface level and at D/B=1 and loaded gradually, for three soil mediums under consideration is represented in Fig. 16 and Fig.17.

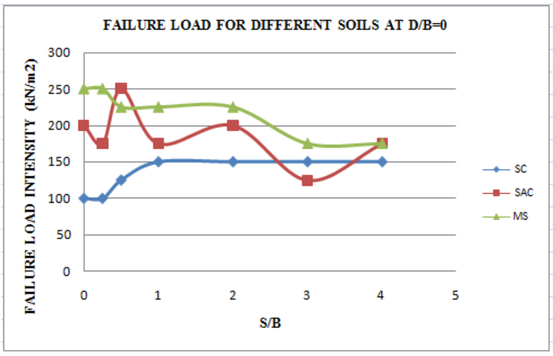

Fig.16 Failure loads for footings at D/B=0

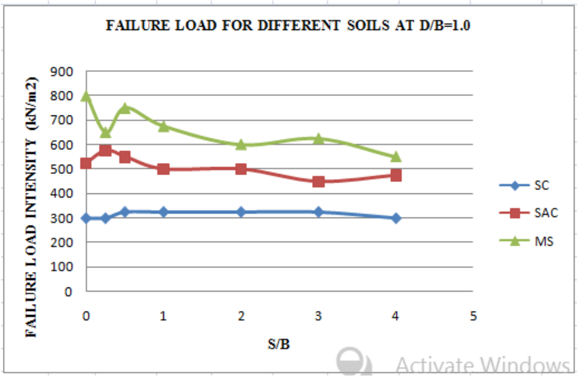

Fig.17 Failure loads for footings at D/B=1.0

IV.COMPARISON OF FAILURE LOADS FOR SIMULTANEOUS LOADING AND VARYING LOAD CASES

IV. The variation in the failure loads of system of two footings, at D/B=1 and resting on soft clay, sandy clay and medium sand, subjected to two loading patterns, i.e., simultaneous loading and varying loading are presented respectively from Fig.18.

V.

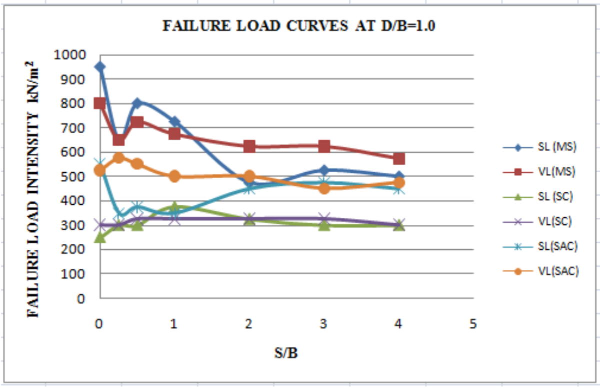

Fig.18. Comparison of failure loads for simultaneous and varying load cases for footings on soft clay, sandy clay& medium sand.

VI.

V. NOTATIONS

SC – Soft Clay
SAC – Sandy Clay
MS – Medium Sand
SL – Simultanous Loading
VL- Varying Loading

VI. CONCLUSIONS

• It is inferred that the ultimate failure intensity depends on both the proximity and the embedment depth of two interfering footing.
• The critical failure load increases with the type of soils from C-soils to Ø-soils.
• The interference of the footing is more and the failure loads are less when spacing ratio is closer than 2.0 for soft clay and sandy clay, when loaded simultaneously.

- For spacing ratios less than 0.5, the interference of the footings at depth is more and the failure loads are less for soft clays. The effect of interference sandy clay and medium sandy are felt at spacing ratios higher than 2.0, when subjected to varying loading.
- For simultaneous loading the failure load intensity increases with depth of embedment of footing irrespective of S/B ratio for all the three soil mediums considered.
- The failure loads for varying load case or simultaneous loading case become critical or decisive depending upon the S/B ratio or proximity of the interfering footing for soft soil medium.
- For footings on soft clays the failure loads are in a close range after S/B=2.0 irrespective of type of loading.
- The failure loads for varying load case are observed to be more than the failure loads of the simultaneous loading case up to S/B =2.5 for sandy clay.
- For footings on sandy clays the failure loads are in a close range after S/B=2.5 irrespective of type of loading.
- The failure loads for varying load case are observed to be more than the failure loads of the simultaneous loading case after S/B =1.0 and vice versa up to S/B=1.0, for medium sand.

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BIOGRAPHIES

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