Eng. & Tech. Journal , Vol. 31 , Part (A),No. 20 , 2013

1st International Conference for Geotechnical Engineering and Transportation ICGTE in2415/4/2013

Experimental Study on the Behavior of Skirted Foundation Rested on Soft Clayey Soils

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ABSTRACT

The purpose of this study is to investigate the behavior of skirted strip model footing founded on beds of soft clays and to evaluate the improvement values in bearing capacity. A series of laboratory model tests were conducted to determine the optimal vertical capacities of skirted foundation within different skirted embedded depth (D/B) ratio (embedded depth to footing width) ranged between (0.0-2.5). The results of model tests based on the load-settlement behavior, revealed that the insertion of skirt structure into the soft clayey soil has a clear increasing the magnitude of bearing capacity with increasing (D/B) ratio according to the lateral confining pressure as compared with the soft clay state without lateral confining (D/B = 0). As a principal part in this study is to knowledge the adequate skirts embedment depth for improvement the ultimate bearing capacity value. It is found that the appropriate skirted embedded depth as the skirt depth to foundation width of 0.5 (D/B=0.5).

Key words: Skirted Foundation; Strip Footing; Bearing Capacity

دراسة تجريبية لتصرف الأسس المحاطة بجدران داخل التربة وتستقر على تربة طينية رخوة

الخلاصة

ان الغرض من هذه الدراسة هو لتحديد قيم زيادة قابلية تحمل باساس شريطي محاط بجدران عميقة داخل التربة الطينية الرخوة المحملة .تم اجراء عدد من الفحوصات المختبرية لتحديد خواص التربة المستخدمة في البحث واجراء عدد من الفحوصات لنموذج الاساس باعماق غرز مختلفة

https://doi.org/10.30684/etj.31.20A.14

حسب نسبة (D/B) تتراوح من (0 الى 2.5). أوضحت نتائج فحوصات النموذج التي كانت على شكل علاقة بين الحمل والهبوط وجود زيادة في قابلية تحمل التربة بزيادة نسبة (D/B)والضغط المحصور ا لمتولد من اساس التنورة وان افضل نسبة (D/B) كانت عندما عمق التنورة الى عرض الاساس يساوي 0.5 (D/B=0.5).

INTRODUCTION

In recent years, the civil engineering professionals have adopted the practice of improvement of soil by reinforcement, compaction, grouting etc. In view of this, the requirement for in situ treatment of soil foundation to improve its bearing capacity has risen markedly. The soil confinement is one of such methods of improving soil capacity (Vinod et al., 2007).

Skirted foundations consist of a footing with vertical skirts around the circumference (and sometimes internally) which penetrate the soil vertically and thus constrain its lateral movement beneath the footing. During vertical loadings, the soil beneath the footing is fully constrained, and so the load is transferred to the depth of the skirt tips where the soil is stronger, thereby increasing its bearing capacity (Bransby and Randolph,1999). Engineers often face the challenge of designing skirted foundations in cases where a soft, highly compressive marine deposit is encountered in such a way as to satisfy bearing- capacity requirements while minimizing the embedment depth and dimensions of the foundation due to cost considerations (Micic et. al. 2003). Skirted foundations and anchors have proven to be competitive alternatives to more traditional foundation solutions like piles and drag anchors in various types of soils and for a wide range of fixed and floating offshore platforms (Knut et. al., 1999). Skirted foundations are favored over conventional pile foundations due to economic benefits arising from simpler construction methods and lower installation cost (Hugo and Gourvence, 2008).The application of skirted foundations can be used in various soil conditions ranging from soft clay to dense sand. Several researchers were achieved to evaluate the skirt structure role in improvement the bearing capacity and settlement characters of different soil types and all of these studies demonstrated the successful application of skirted to foundations system. (AL-Aghbari, and A.Mohamedzein, 2004).

TESTING PROGRAM

Foundation Model

Foundation model is divided into two parts; strip model footing and the skirted structure. A mild steel plate of 4 cm width, 20 cm length and 2 cm in thickness was employed to simulate the proposed shallow strip model footing. The structural skirted introduced here to embracing the shallow foundation model was acted via utilizing a jacket made from rigid steel plate with a length of 20 cm, 4 cm width and 0.3 cm in thickness. It is fixed to the edges of steel strip footing with the auxiliary of four screw bolts. The steel jacket was holed vertically at equal spacing to get different (D/B) ratios as shown in plate (1).Various skirted (D/B ratios) were take into consideration via conversion the location of the screw bolts.

Loading System

The laboratory tests were conducted within a steel plate soil box with dimensions of 50 cm long by 30 cm wide by 30cm deep. Assembly of loading frame was used to apply vertical static load, the loading assembly as shown in Plate (2).Congenial static load test was implemented in present study. The loading increments were conducted according to ASTM D1194, 1987. The loading rod was attached to the shallow footing at a pin point to avoid any eccentricity. Two dial gauges having 0.01mm sensitivity were used to measure the vertical displacement.

Plate (1) Steel jacket for skirt.

Plate (2) Loading frame assembly.

Preparation of Soil Bed

Table (1) summarizes the physical properties of the clayey soil used in present study. Prior to the stage of preparation the soft soil bed, unconfined compression tests were conducted using different water contents in order to specify the actual water content needed for preparation soft soil. Several trials were made and typical (w_c) for undrained shear strength of 10kN/m^2 which predetermined for soft clay was presented as in Figure (1). Then the soil box filled with the soft prepared clay by hand in three successive layers, each layer was impacted slightly using a special wooden stick to dismiss any entrapped air and each layer was spread evenly. The box mobilize soft soil up to 25cm high to conform to the maximum skirt depth, (D/B=2.5).Then the soft soil surface was covered with a polyethylene sheet and left for 24hrs.to insure the uniform distribution water and soil skeleton.

Table (1) Properties of the soil used.

Soil Property		value
Liquid limit	L.L (%)	41
Plastic limit	P.L (%)	18.5
Plasticity index	P.I (%)	22.5
Undrained shear strength	Cu (kN/m^2)	10
Water content	wc (%)	26%
Specific gravity	GS	2.71
Classification of clay based on (USCS)		CL
Saturated Unit Weight	(kN/m^3)	15.3

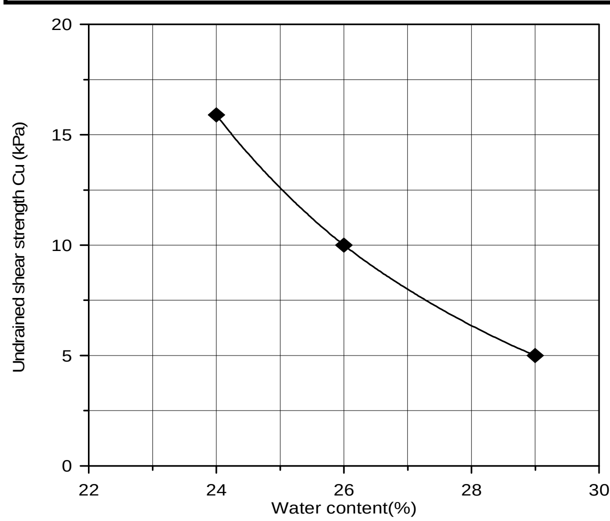

Figure (1) Variation of undrained shear strength versus water content for remolded clay after 24 hrs.

A total of six model tests have been conducted. The original test performed utilizing a conventional footing with out skirted and used as a reference case to make a comparison with the other tests performed through conjunction the skirted with the foundation. The phases of the loading process as revealed in Plate (3).

Plate (3) Assembly of loading model of skirt foundation and dial gages .

PRESENTATION AND DISSCUSSION OF TEST RESUITS

Definition of failure:

Stress-settlement curves have been revealed the behavior of skirted foundation rested on soft clayey soil. The normal foundation case without skirted that employed as a reference case by which a comparative study can be done. Ultimate bearing capacities at failure detected to show the variation in soft clay bearing capacities due to existence skirted structure. The load–settlement measurement continuous beyond failure point and followed by unloading stages. Failure commonly pointed as the q_{ult} recorded by 10% of foundation width (Terzaghi & Peck 1967) . Figures 2 and 3 deduced that the q_{ult} at failure are (25, 46, 49, 53, 57, and 62) kPa for cases of D/B ratio of (0.0, 0.5, 1.0, 1.5, 2.0, and 2.5) respectively. It is represented a comparative figures summarized the vertical bearing capacities for various cases considered.

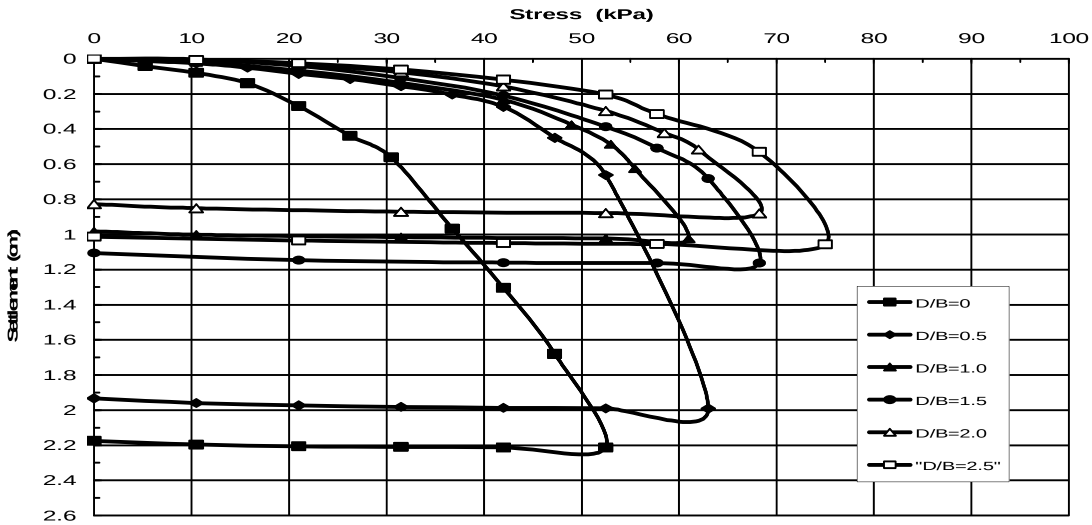

Figure (2) Stress- settlement relationship with rebound settlements for various skirted depth.

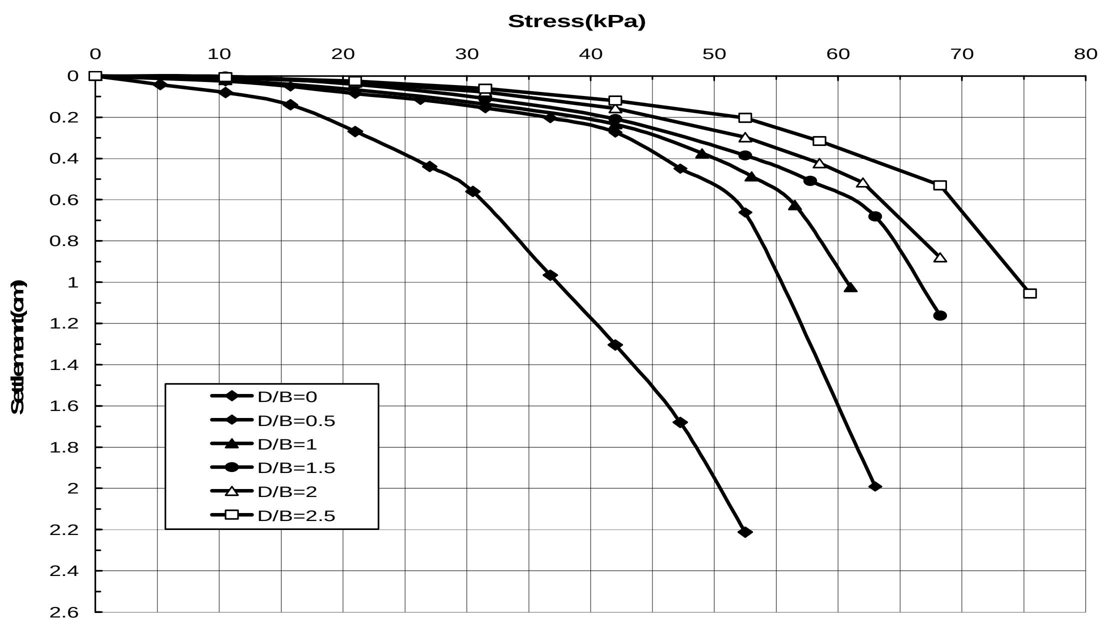

Figure (3) Stress vs. settlement for different skirted depth ratio.

The term of bearing capacity ratio (B.C.R) which defines as the ratio of the vertical capacity of treated soil to untreated at failure used as guide to evaluate the improvement capacity as a consequence to the present of a skirt. From these values of BCR,it can be beholder the utility of skirted structure system .The BCR versus skirt depth was illustrated in Figure (4).

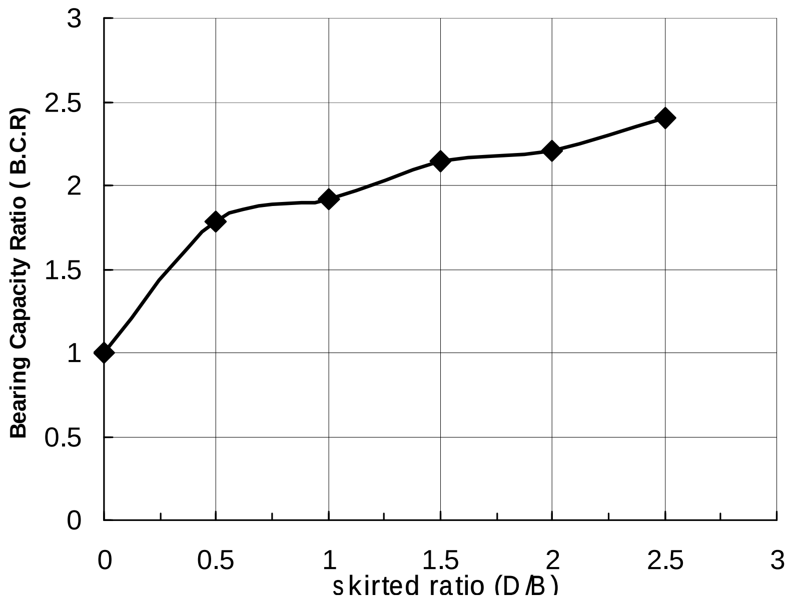

Figure (4) Effect of embedded ratio vs. depth ratio.

A sudden valuable improvement in q_{ult} was realized as the skirted enter to a limited depth ratio at D/B=0.5, an improvement in q_{ult} of about 80% was achieved. As well as an obvious constitutive increment in q_{ult} about 14% occurred when the skirted penetrated the soil down to D/B=1. It is clear that, the increment in q_{ult} is resumed at the large penetration ratio (i.e. at D/B=2, 2.5), in this case the extra increase in load failure occurred relative to previous case of depth ratio =1.5, respecting to basic foundation case of (D/B=0).

The failure pattern of untreated case shown in Plate 4, it is classified as a punching shear failure.

In the current study, it can be justification the discrepancy in collected results depending upon it the above explication, since the principal notion is that the skirt restricts the soil beneath the shallow foundation laterally and dilation the spreading of applied load within the confined zone only, a meaningful increment in failure load was achieved. The extra increment in the skirted embedded length leads to increase the confinement of soft soil beneath the foundation.

Plate (4) the model after test at basic case.

CONCLUSIONS

An effort was made to evaluate the improvement in soft clay bearing capacity with a skirted foundation system. Skirted foundation depth was selected to be a chief factor study in present research through considers different depth ratios of skirted foundation. Substantial increment in bearing capacity at failure was observed due to inclusion skirted structure in addition to determine a serviceable skirted structure depth based on the result of load-settlement relationship by consideration the skirt foundation capacity and construction cost. It was found that the best embedded depth when (D/B=0.5). The entire details of test results besides the image of failure pattern for the basic case were compiled. A precious increases in $(q_{ult})_f$ were receive due to employment of a skirted structure system yet, the degree of improvement in bearing capacity begin to decrease with the increasing in the skirt embedded depth further than (D/B=1).

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