The Influence of Skirt Depth and Compartments on the Load Response of Skirted Foundations in Sand

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ABSTRACT

This experimental study examines how shallow foundations with skirted designs containing internal partitions react to vertical and inclined loads at 0°, 5°, 10°, and 15° angles in sandy soil with 30% relative density. The experimental setup included Linear Variable Differential Transformers (LVDTs) for the settlement measurements, load cells for the load application, and a data logger for precise data acquisition. The research used square foundation models (10 cm × 10 cm) with steel skirts, which were tested at three skirt depths (0.5B, 1B, and 1.5B) with three internal partition configurations: no partition, two compartments, and four compartments. The results demonstrate that both the bearing capacity and settlement performance are substantially enhanced when the skirt depth increases and the number of the internal partitions increases. Under vertical load, the Bearing Capacity Ratio (BCR) increased to 4.4 from 2.18 when the skirt depth reached 1.5B for unpartitioned skirts, while two-compartment skirts achieved 5.46 at a skirt depth of 1.5B and four-compartment skirts reached 7.09 at the same depth. The Settlement Reduction Factors (SRF) at 1.5B depth were 0.92 for the unpartitioned skirts, 0.946 for two-compartment skirts, and 0.968 for four-compartment skirts. The foundation's bearing capacity decreases when the load becomes inclined, yet, the skirted foundation maintains its performance advantage. At 15°, The BCR of the four-compartment skirt increased from 3.48 at 0.5B to 4.8 at 1B and reached 6.705 at 1.5B depth, while the SRF values were 0.84, 0.87, and 0.91 respectively. The research demonstrates that the skirted foundations with internal partitions deliver superior performance in sandy soils when subjected to vertical or inclined loading, thus making them suitable for engineering projects that require resistance to both the vertical and inclined load resistance.

Keywords-skirted foundation; bearing capacity; settlement reduction; compartmentalized skirts; inclined load

I. INTRODUCTION

The construction of shallow foundations on sandy soils faces significant geotechnical difficulties because of the excessive settlement and low bearing capacity that threaten the structure safety and stability, especially under vertical or inclined loads [1]. A wide range of soil improvement methods can be deployed to handle these problems. The most frequently implemented foundation methods for strengthening the soils, decreasing the settlements, and enhancing the load-bearing capacity include the mechanical compaction, chemical grouting, geosynthetic soil reinforcement, and pile utilization [2]. The contemporary foundation solution known as skirted foundations optimizes the relationship between the foundation elements and surrounding soil materials. A shallow footing foundation has vertical plate skirts that extend into the soil around its perimeter. The extension of the skirts into the soil helps contain the lateral soil movement while changing the stress distributions, which improves the bearing capacity and reduces settlement [3, 4]. The skirted foundations entered the offshore and coastal construction market during the 1960s before their application expanded to onshore shallow foundation projects in sandy soil conditions. Scientists have extensively studied the skirt dimensions and shapes. However, few investigations have focused on how the internal compartmentalization affects the skirted foundation performance. The addition of internal partitioning that divides the skirted zone into multiple sub-regions will improve the soil confinement and optimize the load transfer mechanisms when the foundations encounter complex loading situations.

The aim of this study is to investigate experimentally how different skirt depths and internal compartment arrangements affect the bearing capacity and settlement of square shallow foundations built on dry sandy soil. The experimental tests include vertical and inclined loading tests on model footings that have skirts without internal partitions, skirts with two internal compartments, and skirts with four internal compartments. The main contribution of this research involves testing square skirted foundations with internal cross-shaped partitions under vertical and inclined loads on loose sand. Most previous research focused on the external skirt geometry or depth. Nevertheless, this study examines the internal compartmentalization, which has received limited attention in the literature.

II. BACKGROUND

Significant research has been carried out on the improvement of the behavior of foundations under eccentric, inclined, and lateral loads, especially in weak or partially saturated soils. Several methods have been employed to improve the bearing capacity, minimize the settlement, and check the soil movement, including the use of skirted foundations, soil confinement, and geogrid reinforcement. The performance of these methods is very much dependent on the soil properties, the foundation size, and the nature of the loading. Authors in [5-7] studied the effects of the eccentric loading on the foundation response. The obtained results indicated that the eccentric loading decreases the ultimate bearing capacity and increases both the displacement and tilting. However, the use of soil confinement and geogrid reinforcement helps in reducing the negative effects, and thus improves the bearing capacity and overall stability. Authors in [8-12] observed that the bearing capacity and settlement of soils are significantly improved with an increase in the length of the skirts, particularly for soils with a low relative density. Authors in [13-16] showed that the geometric shape of skirts has a significant impact on the foundation performance. The circular skirts are more effective in increasing the soil bearing capacity than the square skirts. Double-skirted foundations are better at reducing the settlement than single-skirted foundations. T-shaped skirts are more efficient than H-shaped skirts in optimization tasks, which results in a better overall performance in enhancing the foundation behavior. The performance of skirted foundations is highly dependent on the characteristics of the subgrade. Soils with a high percentage of coarse particles and a high value of friction angle show a better improvement in the bearing capacity [17, 18]. Inclined skirted foundations are used to manage the lateral movement of the soil and enhance the bearing capacity, but the slope angle should be properly selected as high slope angles decrease the efficiency [19, 20]. In [21-25] it was observed that the presence of skirts improves the bearing capacity and settlement behavior under eccentric and inclined load conditions. Authors in [26-28] investigated gypsum soils and demonstrated that the skirts increase the bearing capacity and the settlement of the soil when the Length-to-Diameter (*L/D*) ratio is between 0 and 2. However, excessive confinement at high *L/D* ratios may lead to a slight reduction in the shear strength of the soil, and hence the bearing capacity [26-28]. Thus, the skirted foundations are a suitable solution for construction on saturated gypsum soils. Authors in [29] examined the response of circular foundations with geogrid skirts subjected to vertical loads at the center and eccentric positions in poorly graded sand. The results showed that the addition of geogrid skirt, especially when coupled with horizontal reinforcement, substantially increases the bearing capacity and decreases the settlement.

Authors in [30, 31] assessed the performance of skirt-enhanced foundations. The PLAXIS 3D numerical modeling revealed that a 0.5B deep skirt foundation reduced the differential settlement by 80% while extending the safe excavation depth to 0.75B. It was exhibited that skirts effectively enhanced the ring foundation resistance to lateral deformation when subjected to unbalanced loads. It was additionally shown that advanced foundation designs play a crucial role in improving the structural stability during major construction activities. Authors in [32-37] demonstrated that piles with enlarged bases and multi-bell piles enhance the bearing capacity and decrease the settlement in sandy soils. Numerical modeling along with sub-drainage systems improves the soil stability when the saturation levels change. The use of jet-grouted piles proved superior to the conventional concrete piles because they enhanced the load transfer and minimized the deformation. The 3D numerical analysis demonstrated that higher friction angles decrease both the bearing capacity and bending moment but shorter piles lead to increased lateral displacement. The importance of the soil–structure interaction was demonstrated and the implementation of skirted foundations with internal confinement was supported.

III. EXPERIMENTAL PROGRAM

This study involves a series of tests on square foundation models (10 cm × 10 cm) with steel skirts at three depths (0.5B, 1.0B, and 1.5B) and three internal configurations (no partition, two partitions, and four partitions) to assess their impact on the bearing capacity and settlement reduction. The testing program consisted of vertical loads and inclined loads at 5°, 10°, and 15°. Relative density of 30% was utilized to model the loose sand conditions frequently encountered in natural ground, where shallow foundations experience a low bearing capacity and excessive settlement. The selected density represents unfavorable field conditions to assess the effectiveness of the skirted foundations in enhancing the soil behavior. The research investigates weak soil conditions, although higher relative densities of 50% or 70% could potentially produce better results. Future research could investigate testing under denser soil conditions. The experimental setup included a steel testing tank, skirted footing models, a loading system, and instruments for measuring the load and settlement. The testing program and configuration details are presented in Figure 1.

A. *Testing Tank*

The testing tank consisted of a 60 cm × 60 cm × 60 cm steel container, which served as the sand holding vessel. The tank had steel walls on three sides and tempered glass on one side, which provided visibility to observe the soil behavior. The rigid steel walls provided uniform boundary conditions while preventing the lateral displacement of the sand when subjected to loading. The tank received uniform sand distribution through the sand raining technique to establish a uniform relative density of 30% across all tests.

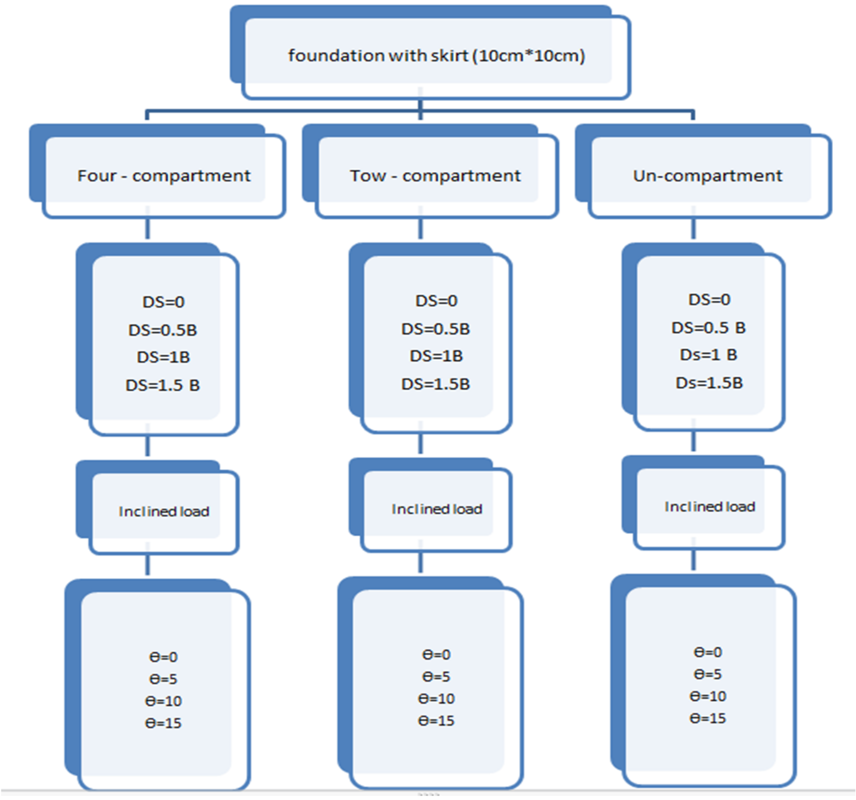

Fig. 1. Flow chart testing program.

B. *Footing and Skirt Configurations*

The footing model consisted of a 100 mm × 100 mm steel plate with 5 mm thickness. The steel skirts measured 2 mm in thickness and came in three different lengths: 5 cm, 10 cm, and 15 cm, representing 0.5B, 1.0B, and 1.5B, respectively. Three skirt configurations were used:

- The non-compartmentalized skirt consisted of a single continuous piece without any internal partitions.
- The two-compartment skirt design included a single partition that split the skirt into two equal sections.
- The four-compartment skirts consisted of two intersecting internal partitions, which created four equal compartments below the footing. Figure 2 illustrates the three skirt configurations used in the experimental program.

C. *Raining Device*

The raining device functioned to maintain a uniform relative density across the tests through its ability to control the sand drop height. The raining device consists of a 60 cm × 10 cm × 55 cm metal box, which hangs from metal wires through a manual pulley system for elevation control. The bottom gates of the box have adjustable settings, which can be operated by a side lever to manage the sand flow rates. The entire system rests on a strong metal frame, which measures 220 cm tall and 75 cm wide, to maintain stability during sand deposition. Figure 3 illustrates the design and components of the raining device used for uniform sand placement.

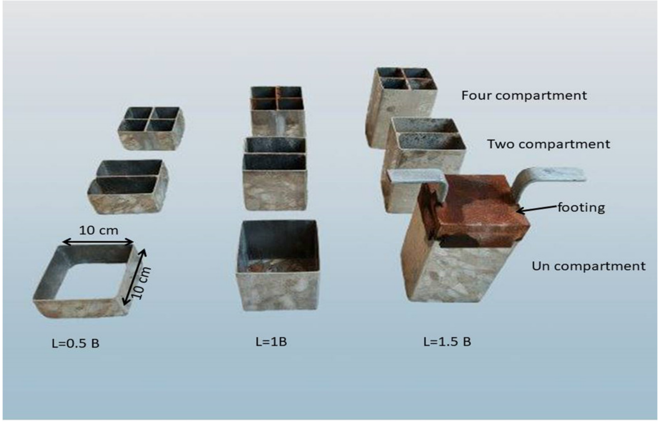

Fig. 2. Skirted foundation models showing different lengths and internal compartmentalization configurations.

D. *Loading System*

The loading device consists of heavy steel material with 4 mm thickness and dimensions of 140 cm height and 80 cm width. The loading device includes a manual hydraulic jack, which is mounted on an arc, to enable the load application at different positions on the foundation (either centrally or at an angle). A one-ton load cell is placed between the jack and the foundation base to measure the applied load with high precision. Figure 4 portrays this loading system.

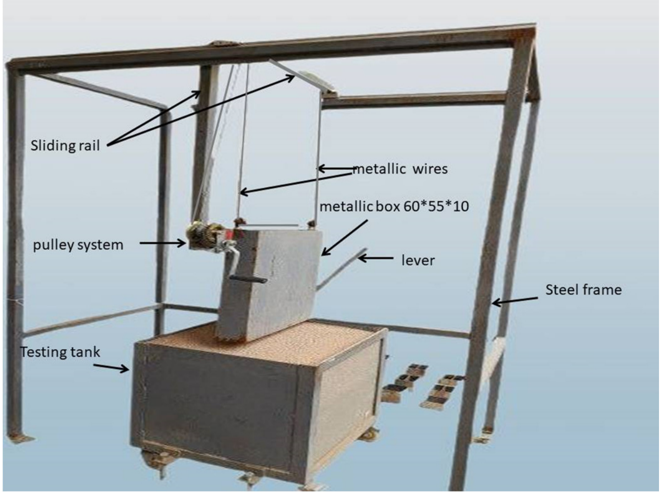

Fig. 3. Raining device for controlled sand deposition in foundation testing.

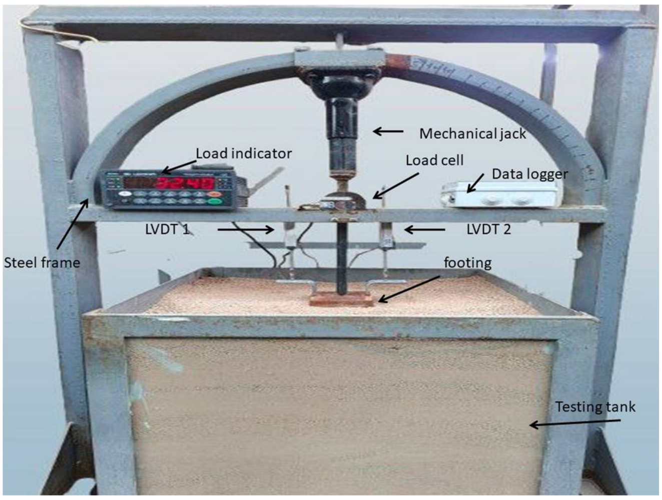

Fig. 4. Loading system for foundation testing.

E. *Instrumentation and Measurement*

- Load Measurement: A digital load indicator connected to a 1-ton capacity load cell was used to record the applied force.
- Settlement Measurement: Linear Variable Displacement Transducers (LVDTs) with a precision of 0.01 mm were placed at the corners of the footing to measure the settlement.
- Data Acquisition System: Data from the load cell and LVDTs were recorded at regular intervals to generate load-settlement curves.

F. *Properties of Sand*

The sand used in this study was sourced from Karbala Governorate. It was washed, dried, and subjected to the necessary laboratory tests to determine its properties. The results are presented in Figure 5 and Table I.

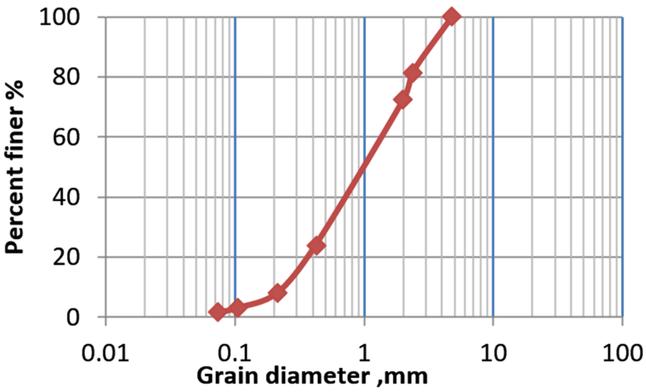

Fig. 5. Sand grain – size distribution curve.

TABLE I. SOIL PROPERTIES

Property	Value	Specifications
Specific gravity (*Gs*)	2.67	ASTM D-854
D10 (mm)	0.238	ASTM D-422
D30 (mm)	0.52	
D60 (mm)	1.37	
Coefficient of uniformity (*Cu*)	5.75	
Coefficient of curvature (*Cc*)	0.829	
Fine modulus	4.09	
Maximum dry unit weight (kN/m^3)	18	ASTM D-4253
Minimum dry unit weight (kN/m^3)	15.89	ASTM D-4254
Dry unit weight (kN/m^3) in the test of relative density=30%	16.47	
Relative density of sand during test (D_r)%	30	
The angle of internal friction $\varnothing$ at D_r=30%	32.07	ASTM D-3080
Soil classification (USCS)	(SP)	ASTM D-2487
SO3%	0.23	

IV. TESTING PROCEDURE

The purpose of this examination is to study the influence of deeper skirting and internal partition elements on the foundation settlement behavior and bearing capacity of square footings in sandy ground when subjected to vertical and inclined forces.

The soil tank preparation started by adding sand in layers with a height of 10 cm for each layer. The rain technique served to achieve the required relative density of 30% because it mimics natural soil deposition processes while producing a uniform soil sample.

Once the tank was filled, the skirt was carefully installed at the center of the tank to ensure sufficient spacing to minimize the effect of the tank walls. The interior of the skirt was then filled using the same compaction technique to ensure that the soil properties inside the skirt matched those of the surrounding soil. After fully preparing the soil, the foundation was placed directly on top of the skirt.

The loading process happened in stages with 5 kN increments at each step. The system required 2 min of waiting time for settlement stabilization following every load increment before it recorded the measurements. The system measured both the load and settlement with precise LVDT sensors, which transferred data automatically through a dedicated data acquisition system.

The study generated performance curves through plotting the applied load against the measured settlement after finishing all loading stages. The results examined different skirt models by analyzing the variations in the skirt depth along with the internal partition numbers.

The increase in the skirt depth combined with the internal partition addition will boost the foundation bearing capacity because it limits soil movements underneath the skirt structure. The distribution of loads across deeper soil depths leads to a settlement reduction. This testing method effectively replicates real-world field scenarios to obtain important data for developing foundation designs with skirts in geotechnical projects.

V. RESULTS AND DISCUSSION

A. *Effect of Skirt Depth on Bearing Capacity*

The failure load was defined as the load that caused a settlement equal to 10% of the foundation width. Authors in [33-35] used two parameters to assess the skirt effectiveness, BCR and SRF:

$$BCR = \frac{q_R}{q_{UR}} \qquad (1)$$

$$SRF \frac{S_{UR}-S_R}{S_{UR}} \qquad (2)$$

where q_R and q_{UR} are the bearing capacities before and after reinforcement, respectively, and S_{UR} and S_R are the settlements of unreinforced and reinforced soil under the same stress.

The un-skirted foundation under vertical load had a bearing capacity of 32 kPa. Adding un-compartment skirts at depths of 0.5B, 1B, and 1.5B raised the capacities to 70 kPa, 103.5 kPa, and 141.1 kPa, respectively, corresponding to BCRs of 2.18, 3.23, and 4.4, and SRFs of 0.53, 0.74, and 0.92. This confirms that increasing the skirt depth improves the confinement and shear resistance, as displayed in Figures 6-9.

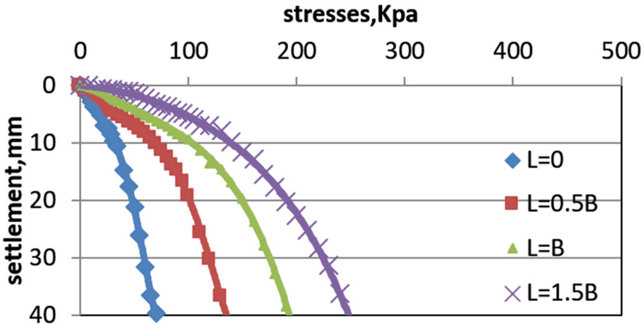

Fig. 6. Stress-settlement relationship for non-compartmentalized skirted foundation at different depths under vertical loading.

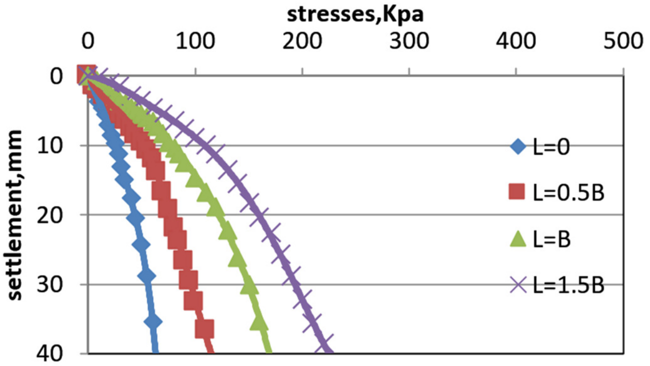

Fig. 7. Stress–settlement relationship for un-compartment skirted foundation under inclined load at 5°, with varying skirt lengths.

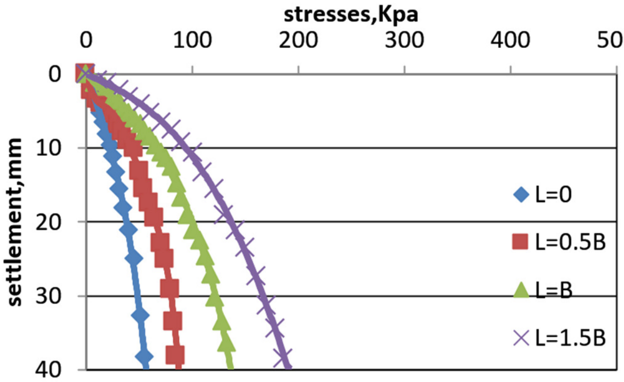

Fig. 8. Stress–settlement relationship for un-compartment skirted foundation under inclined load at 10°, with varying skirt lengths.

Under inclined loads (5°, 10°, and 15°), the bearing capacity decreased with angle due to the reduced vertical resistance. Still, deeper skirts enhanced the soil confinement, improving the performance under both vertical and inclined loads, as shown in Figures 7-9. For example, the un-skirted foundation under inclined load at 15° had a bearing capacity of 20.1 kPa. Adding un-compartment skirts at depths of 0.5B, 1B, and 1.5B raised the capacities to 35 kPa, 55 kPa, and 80 kPa, respectively, corresponding to BCRs of 1.7, 2.73, and 3.98, and SRFs of 0.45, 0.67, and 0.79.

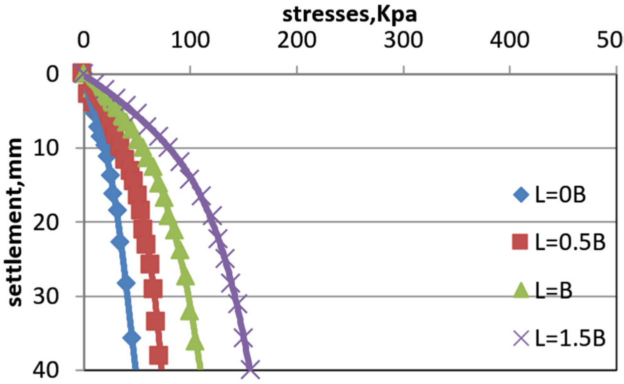

Fig. 9. Stress–settlement relationship for un-compartment skirted foundation under inclined load at 15°, with varying skirt lengths.

B. Effect of Internal Partitioning

The internal partitioning of the skirted foundation resulted in a better bearing capacity than the non-partitioned skirts. The two-partition skirt at 0.5B depth under vertical load achieved a 97.1 kPa bearing capacity with BCR=3.03 and SRF=0.818. At 1B depth it reached 136 kPa with BCR=4.25 and SRF=0.91, and at 1.5B depth it reached 175 kPa with BCR=5.46 and SRF=0.94. The four-compartment skirt produced the highest results, which included 126 kPa (BCR=3.9, SRF=0.92) at 0.5B, 169 kPa (BCR=5.28, SRF=0.95) at 1B and 227 kPa (BCR=7.09, SRF=0.96) at 1.5B. The internal partitions enhanced the soil confinement, which reduced the soil movement inside the skirt, thus leading to substantial increases in the foundation load-bearing capacity. The improvement became more significant when the skirt depth increased and the number of partitions grew. The research findings demonstrate that the skirted foundations with internal compartmentalization achieve a better bearing capacity and settlement control when used on loose sandy soils. The practicality and cost-effectiveness of skirted foundations make them suitable for field applications where shallow foundations are preferred and soil improvement is required. The installation process of the skirted systems remains simpler than that of the pile systems while requiring less depth than raft foundations. They also provide enhanced soil confinement and load transfer in weak ground conditions. Skirted foundations serve as an efficient solution for specific site conditions that include low to moderate loading and sandy profiles. Figures 10 and 11 illustrate the improvement in both the BCR and SRF with the increase in the number of compartments.

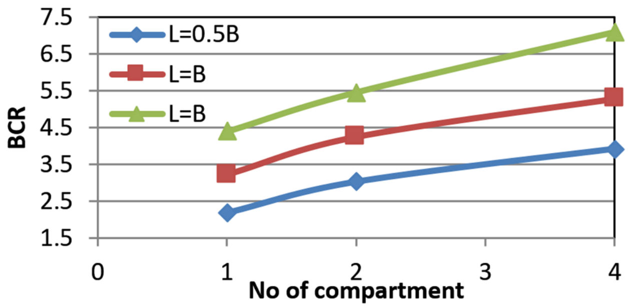

Fig. 10. BCR-number of compartment relationship under vertical load, with varying skirt lengths.

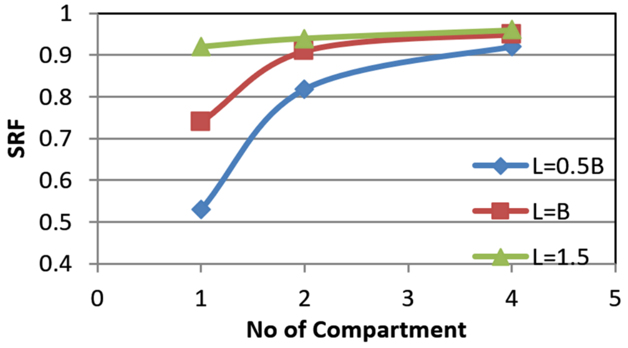

Fig. 11. SRF-number of compartment relationship under vertical load, with varying skirt lengths.

C. Effect of Inclined Load on the Performance of Skirted Shallow Foundations

The application of inclined loads led to a noticeable reduction in the bearing capacity compared to the vertical loading. The implementation of skirted foundations together with their internal compartmentalization systems proved effective for handling inclined loads. The bearing capacity reached only 25.42 kPa when testing with a 5° load inclination without using a skirt. An un-compartmented skirt installed at different depths of 0.5B, 1B, and 1.5B resulted in improved bearing capacities of 52.8 kPa (BCR=2.077, SRF=0.52), 78.125 kPa (BCR=3.07, SRF=0.71), and 110 kPa (BCR=4.32, SRF=0.88). The two internal compartments introduced to the design led to improved bearing capacities of 74 kPa at 0.5B, 105 kPa at 1B, and 135 kPa at 1.5B. The highest improvements were achieved with four internal compartments, resulting in 96 kPa, 131 kPa, and 179 kPa at 0.5B, 1B, and 1.5B depths, respectively.

The bearing capacity without a skirt dropped to 23 kPa when the load inclination reached 10°. Using a non-compartmented skirt increased this to 44 kPa (BCR=1.91, SRF=0.5) at 0.5B, 67 kPa (BCR=2.91, SRF=0.69) at 1B, and 96 kPa (BCR=4.17, SRF=0.87) at 1.5B. The two compartments enhanced the bearing capacity to 65 kPa at 0.5B, 92 kPa at 1B, and 120 kPa at 1.5B. The four-compartment configuration delivered the highest results: 84 kPa, 114 kPa, and 160 kPa at the respective depths. The bearing capacity achieved its lowest values at an inclination of 15°. The bearing capacity without a skirt was only 20.1 kPa. A non-compartmented skirt raised the values to 35 kPa (BCR=1.74, SRF=0.45) at 0.5B, 55 kPa (BCR=2.73, SRF=0.67) at 1B, and 80 kPa (BCR=3.98, SRF=0.79) at 1.5B. The two compartments yielded a better performance: 55 kPa at 0.5B, 75 kPa at 1B, and 100 kPa at 1.5B. The highest bearing capacities were achieved by using four compartments that delivered 70 kPa, 96.6 kPa, and 134.1 kPa at escalating skirt depths.

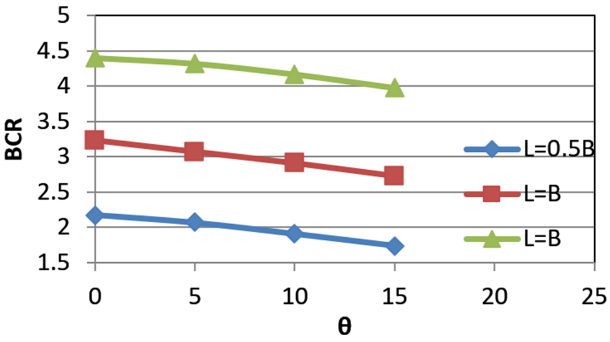

Fig. 12. Relationship between BCR and inclination angle of applied load for un-compartmented skirted foundations, with varying skirt lengths.

The skirted shallow foundations achieve better resistance against inclined loads because of their internal compartment design. The internal compartments in the skirt design reduce the lateral displacement and improve the soil confinement, which results in enhanced performance. The design of the appropriate skirts together with the internal compartments helps decrease the negative impact of the increasing load inclination on the bearing capacity. In Figures 12 and 13, the BCR and SRF values' behavior is demonstrated in relation to the changing inclination angles.

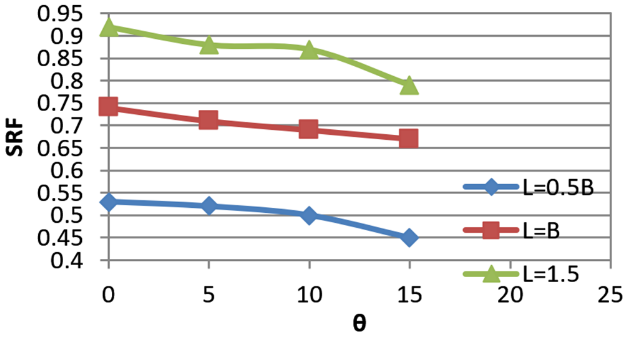

Fig. 13. Relationship between SRF and inclination angle of applied load for un-compartmented skirted foundations, with varying skirt lengths.

D. Analysis of BCR and SRF for Different Design Factors

The BCR and SRF variations are depicted in Table I, where the results for different skirt lengths (0.5B, 1B, 1.5B), internal partitioning types (no compartmentalized, two compartment, four compartment), and load inclination angles (0°, 5°, 10°, 15°) are demonstrated. The results indicate that longer skirts combined with internal partitions produce the most significant improvements in BCR particularly when the load is vertical. The highest BCR and SRF values occurred at vertical loads (0°) when four partitions were used with a 1.5B skirt length. The BCR values decreased with an increasing load inclination but the performance benefits from longer skirts and partitions continued to appear.

TABLE II. VARIATION OF BCR, AND SRF WITH SKIRT LENGTH, SKIRT TYPE, AND LOAD ANGLE

Load angle (*Θ*)	**Skirt type**	**Skirt length**	**BCR**	**SRF**
0	Un-compartmentalized	0.5B	2.18	0.532
0	Un-compartmentalized	1B	3.23	0.744
0	Un-compartmentalized	1.5B	4.4	0.921
0	Two-compartment	0.5B	3.03	0.818
0	Two-compartment	1B	4.25	0.912
0	Two-compartment	1.5B	5.46	0.946
0	Four-compartment	0.5B	3.9	0.926
0	Four-compartment	1B	5.28	0.952
0	Four-compartment	1.5B	7.09	0.968
5	Un-compartmentalized	0.5B	2.077	0.52
5	Un-compartmentalized	1B	3.07	0.71
5	Un-compartmentalized	1.5B	4.32	0.88
5	Two-compartment	0.5B	2.91	0.75
5	Two-compartment	1B	4.13	0.82
5	Two-compartment	1.5B	5.31	0.92
5	Four-compartment	0.5B	3.77	0.91
5	Four-compartment	1B	5.15	0.94
5	Four-compartment	1.5B	7.04	0.95
10	Un-compartmentalized	0.5B	1.91	0.5
10	Un-compartmentalized	1B	2.91	0.69
10	Un-compartmentalized	1.5B	4.17	0.87
10	Two-compartment	0.5B	2.82	0.718
10	Two-compartment	1B	4	0.8
10	Two-compartment	1.5B	5.21	0.88
10	Four-compartment	0.5B	3.65	0.89
10	Four-compartment	1B	4.95	0.9
10	Four-compartment	1.5B	6.95	0.93
15	Un-compartmentalized	0.5B	1.74	0.45
15	Un-compartmentalized	1B	2.73	0.67
15	Un-compartmentalized	1.5B	3.98	0.79
15	Two-compartment	0.5B	2.73	0.7
15	Two-compartment	1B	3.73	0.78
15	Two-compartment	1.5B	4.97	0.82
15	Four-compartment	0.5B	3.48	0.84
15	Four-compartment	1B	4.8	0.87
15	Four-compartment	1.5B	6.705	0.91

VI. CONCLUSION

This research adds to the existing knowledge about the skirted foundations by examining the internal compartmentalization effects on the load-bearing capabilities. The greatest amount of research has concentrated on parameters, such as skirt depth, external geometry, or skirt material, particularly under vertical loading, but few studies have examined the internal partitions or their behavior under inclined loads. The research investigates how internal cross-shaped compartments influence the bearing capacity and settlement behavior of skirted foundations when subjected to vertical and inclined loads. It is shown that the internal compartments improve the performance of the skirted foundations in loose sandy soils, thus establishing the proposed method as a promising practical solution for shallow foundation systems.

The present study examined how the skirt depth along with the internal compartmentalization affects the load-bearing capacity and settlement patterns of shallow foundations with skirts in sandy soil under vertical and inclined loading scenarios. The experimental results produced findings, which led to the following conclusions:

- The bearing capacity increased substantially when the skirt depth increased from 0.5B to 1.5B because the Bearing Capacity Ratio (BCR) values rose to 2.18 from 4.4 for the un-compartment skirts, to 3.03 from 5.46 for the two-compartment skirts, and to 3.9 from 7.09 for the four-compartment skirts. The results demonstrate that the depth augmentation directly results in better structural performance.
- The addition of the internal partitions produced substantial performance improvements at 1.5B depth because the BCR value increased from 4.4 to 5.46 when moving from un-compartment to two-compartment skirts and then increased further to 7.09 with four-compartment skirts. The analysis demonstrates that the internal partitions serve as crucial elements to enhance the foundation bearing performance.
- A 15° inclined load resulted in decreased bearing capacity at 1.5B depth, which caused the BCR to decrease from 4.4 to 3.98 in un-compartment skirts, from 5.46 to 4.97 in two-compartment skirts, and from 7.09 to 6.7 in four-compartment skirts. The four-compartment skirt design maintained most of its bearing capacity during inclined

loading because partitioning proved effective in resisting the non-vertical loads.

- The number of internal partitions enhances the settlement reduction capabilities.
- The SRF values were 0.921 for un-compartment skirts, 0.946 for two-compartment skirts, and 0.968 for four-compartment skirts at 1.5B depth under central loading conditions. The four-compartment skirt design performed better at minimizing deformations than the other configurations even though the settlement reduction efficiency decreased under a 15° inclined load.
- The skirted foundations, especially with internal compartments, improve the bearing capacity and reduce the settlement on loose sandy soils, making them a practical and cost-effective alternative to raft and pile foundations under certain site conditions.
- The skirted foundations are most effective in granular soils, but with proper design considerations they can also be used in other soil types, such as clay or gypsiferous soils. Therefore, their application can be extended to various site conditions, depending on the geotechnical and economic feasibility.
- The skirted foundations are practical for field application due to their ease of construction, cost-effectiveness, and improved load performance, especially in sandy or soft soils. Their performance can be enhanced further with internal compartmentalization, as shown in this research.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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