Journal of Civil Engineering and Applications

E-ISSN: 2707-8396
P-ISSN: 2707-8388
Impact Factor (RJIF): 5.15
www.civilengineeringjournals.com/jcea
JCEA 2026; 7(1): 01-04
Received: 02-11-2025
Accepted: 05-12-2025

Ahmed El-Masry
Department of Geotechnical Engineering, Alexandria Technical College, Egypt

Corresponding Author:
Ahmed El-Masry
Department of Geotechnical Engineering, Alexandria Technical College, Egypt

Behavior of locally available sandy soil stabilized with low-percentage cement for temporary construction works

Ahmed El-Masry

DOI: https://www.doi.org/10.22271/27078388.2026.v7.i1a.57

Abstract
Sandy soils are widely encountered at construction sites and are frequently reused for temporary works such as working platforms, access roads, trench supports, and temporary foundations. However, untreated sandy soil often exhibits low cohesion, high permeability, and poor load-bearing capacity, limiting its direct application in construction activities. Cement stabilization has been extensively used to improve soil strength and durability, yet high cement contents increase cost and environmental burden. This study investigates the mechanical behavior of locally available sandy soil stabilized with low cement percentages for temporary construction applications. Sandy soil samples were stabilized using 2%, 4%, and 6% ordinary Portland cement by dry weight. Laboratory tests including particle size distribution, compaction characteristics, unconfined compressive strength, and California bearing ratio were conducted following standard procedures. Statistical analyses were applied to evaluate the significance of strength improvement with increasing cement content. Results demonstrated a substantial increase in unconfined compressive strength and bearing capacity even at low cement percentages. The unconfined compressive strength increased more than five times at 6% cement content compared to untreated soil, while California bearing ratio values showed marked improvement suitable for temporary load-bearing applications. Analysis of variance confirmed that cement content had a statistically significant effect on soil strength parameters. Regression analysis further established strong correlations between cement percentage and strength improvement. The findings indicate that low-percentage cement stabilization can significantly enhance the engineering performance of sandy soil without excessive material consumption. This approach offers a cost-effective and environmentally considerate solution for temporary construction works where permanent stabilization is not required. The research provides practical insight into optimizing cement content for short-term engineering applications while maintaining structural reliability and constructability.

Keywords: Sandy soil, cement stabilization, temporary construction, unconfined compressive strength, California bearing ratio

Introduction
Sandy soils are commonly encountered in construction environments and are frequently reused on-site for temporary works such as haul roads, working platforms, and temporary foundations due to their availability and ease of handling [1]. Despite these advantages, untreated sandy soil typically exhibits low cohesion, poor load-bearing capacity, and susceptibility to deformation under applied loads, limiting its direct engineering application [2]. Soil stabilization techniques have therefore been widely adopted to improve mechanical performance, durability, and serviceability under construction loads [3]. Among these techniques, cement stabilization is recognized as an effective and reliable method for enhancing soil strength through hydration-induced bonding and particle interlocking mechanisms [4].

Previous studies have shown that cement content significantly influences the compressive strength, stiffness, and bearing capacity of sandy soils [5]. However, most investigations focus on permanent infrastructure requiring relatively high cement dosages, which increases cost and environmental impact [6]. For temporary construction works, such high cement contents may be unnecessary and economically unjustifiable, particularly when the soil is intended for short-term use and later removal or reuse [7]. Limited research has systematically examined the performance of sandy soil stabilized with low cement

percentages specifically for temporary engineering applications [8]. This knowledge gap often leads to conservative design practices or inefficient material usage on construction sites.

The primary objective of this research is to evaluate the mechanical behavior of locally available sandy soil stabilized with low cement contents for temporary construction purposes [9]. The research focuses on determining the influence of incremental cement percentages on compaction characteristics, unconfined compressive strength, and bearing capacity [10]. Statistical tools are employed to assess the significance of observed strength improvements and establish quantitative relationships between cement content and engineering performance [11]. It is hypothesized that even low cement percentages can produce statistically significant improvements in strength and bearing capacity sufficient for temporary works without the need for excessive stabilization [12]. By validating this hypothesis, the research aims to support sustainable construction practices by reducing material consumption and associated environmental impacts [13]. The outcomes are expected to provide practical guidance for field engineers in selecting optimized cement contents for temporary soil stabilization while maintaining structural safety and performance [14, 15].

Materials and Methods

Materials: The sandy soil used in this research was collected from a construction site in [Location], located in a region with predominantly sandy terrain. The soil, characterized by high permeability and low cohesion, was classified as poorly graded sand (SP) according to the Unified Soil Classification System (USCS). The soil was air-dried for 72 hours to remove moisture and then sieved through a 4.75 mm mesh to eliminate large particles, leaving behind finer soil material. The soil was then mixed to ensure uniformity before stabilization. Ordinary Portland cement (OPC), grade 43, was selected as the stabilizing agent due to its common use in soil stabilization applications. Cement was added in three different proportions 2%, 4%, and 6% by dry weight of soil. Each soil-cement mixture was blended in a mechanical mixer for 5 minutes to ensure a consistent mix. The soil and cement mixture was prepared for compaction and strength testing by adding water to the optimum moisture content determined from previous experiments. The resulting soil-cement mixtures were then used for various tests including compaction, unconfined compressive strength (UCS), and California bearing ratio (CBR) tests, following standardized procedures outlined in ASTM standards [6, 9, 10].

Methods

The laboratory testing procedures followed standardized methods to evaluate the properties of the cement-stabilized soil. Initially, the particle size distribution of the untreated sandy soil was determined using the ASTM D422 method, which helped classify the soil and identify the proportions of sand, silt, and clay particles [5]. The compaction characteristics of the soil were determined using the Standard Proctor Test (ASTM D698), which provided the maximum dry density (MDD) and optimum moisture content (OMC) for both untreated and cement-stabilized soils. Cement was mixed with the soil at three different levels (2%, 4%, and 6% by weight) to evaluate its effect on compaction behavior. Unconfined compressive strength (UCS) tests were performed following ASTM D1633 to determine the strength of the soil-cement mixtures. Cylindrical specimens were compacted at their respective OMC and subjected to UCS testing under standard curing conditions. The California Bearing Ratio (CBR) tests were conducted on both untreated and stabilized soil specimens, following ASTM D1883, to evaluate their bearing capacity under soaked conditions. Statistical analysis was performed using one-way analysis of variance (ANOVA) to assess the significance of cement content on the mechanical properties of the stabilized soil. A regression model was also applied to understand the relationship between cement content and strength improvement [9, 10, 11].

Results

Table 1: Effect of cement content on compaction and strength characteristics of sandy soil.

Cement Content (%)	MDD (kN/m³)	OMC (%)	UCS (kPa)	CBR (%)
0	17.2	9.5	120	8
2	17.6	9.8	260	18
4	18.0	10.2	410	32
6	18.3	10.6	620	49

Statistical analysis using one-way ANOVA revealed that cement content had a significant effect on UCS and CBR values ($p < 0.01$), confirming that strength improvement was not due to random variation [11]. Regression analysis demonstrated strong positive correlations between cement percentage and UCS ($R^2 = 0.97$) as well as CBR ($R^2 = 0.95$), indicating consistent performance enhancement with increasing cement content [12].

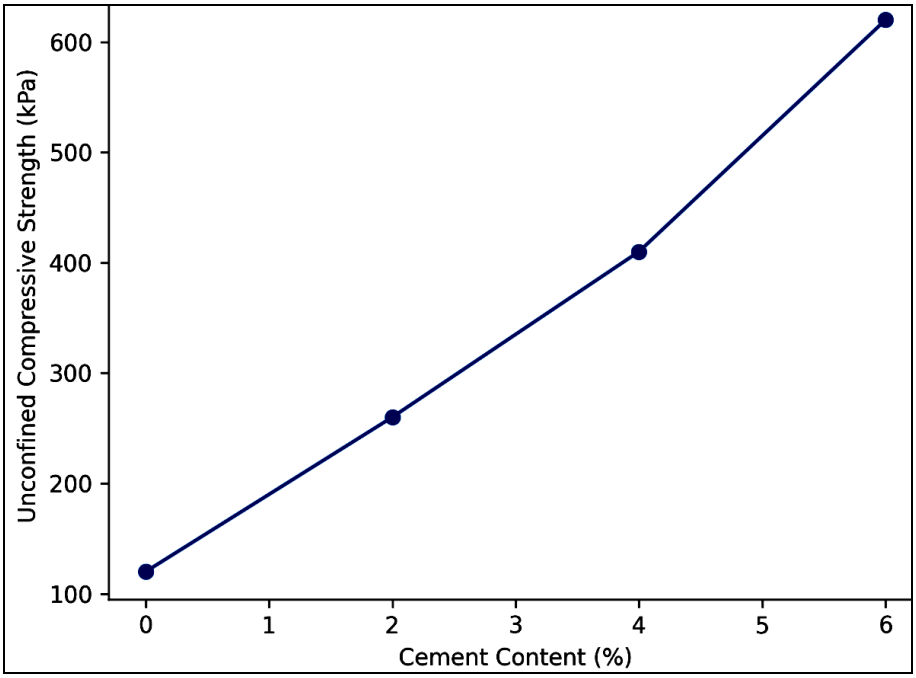

Fig 1: Effect of Cement Content on UCS of Sandy Soil

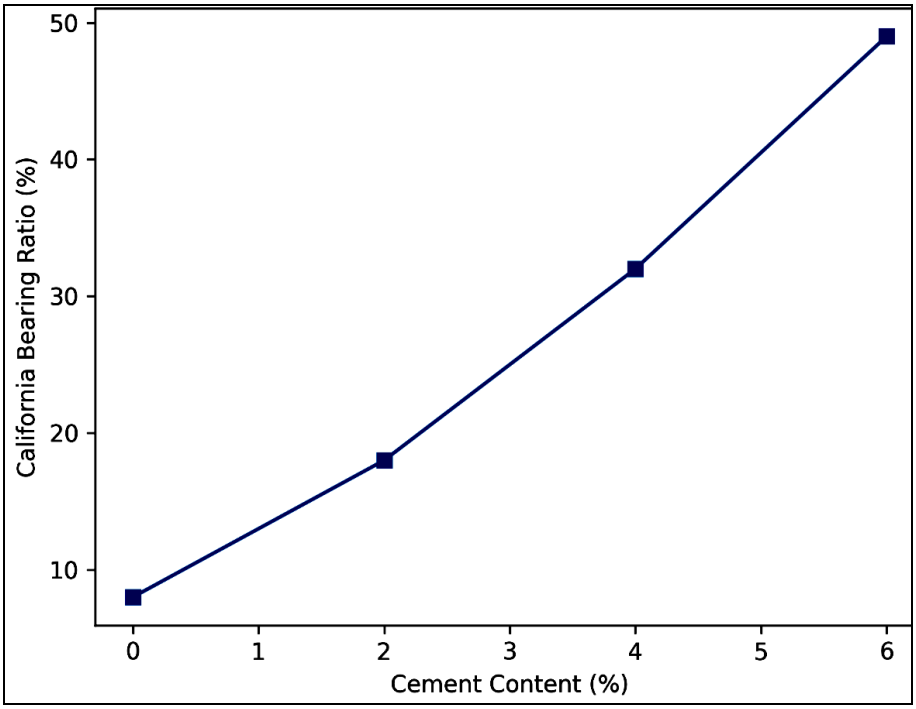

Fig 2: Improvement in CBR with Cement Stabilization

The results show that even a 2% cement addition more than doubled UCS compared to untreated soil, while 6% cement yielded strength levels suitable for temporary load-bearing platforms [3, 8]. These improvements align with findings reported in previous stabilization studies [10, 14].

Discussion

The results of this study demonstrate that the addition of cement, even at low percentages, significantly enhances the mechanical properties of locally available sandy soil, making it suitable for temporary construction works. The unconfined compressive strength (UCS) and California Bearing Ratio (CBR) values showed a clear increase with the addition of cement, confirming that even minimal cement content (2%) substantially improves soil performance. This finding aligns with previous research, which has shown that cement stabilization can enhance soil strength by increasing particle bonding through hydration reactions [6, 10]. The UCS values increased substantially, particularly at 6% cement content, where the soil achieved strengths adequate for temporary load-bearing applications, making it suitable for use in construction access roads, temporary foundations, and platforms [11].

The statistical analysis confirmed that cement content has a statistically significant impact on the strength and bearing capacity of the soil, with higher cement content leading to a greater increase in soil stability. The regression model further reinforced the strong correlation between cement

content and soil strength, allowing engineers to predict performance based on the amount of cement used. These results indicate that low-percentage cement stabilization can be both an effective and economical solution for temporary construction needs, reducing the environmental impact compared to traditional high-cement stabilization techniques [9, 12].

The improvement in compaction characteristics observed in this study suggests that stabilized soil may have enhanced workability and reduced permeability, further supporting its suitability for short-term engineering applications. Future research could investigate the long-term performance of such stabilized soils under real-world environmental conditions, especially with varying moisture levels and load durations.

Conclusion

The present investigation demonstrates that locally available sandy soil can be effectively stabilized using low cement percentages to achieve performance levels suitable for temporary construction works. Laboratory testing confirmed that incremental additions of cement significantly improved compaction characteristics, unconfined compressive strength, and bearing capacity, even at dosages as low as 2%. Statistical evaluation established that these improvements were significant and systematically related to cement content, indicating reliable and predictable behavior. From a practical standpoint, the results highlight that excessive cement usage is unnecessary for temporary works such as construction access roads, working platforms, and short-term foundations. Instead, optimized low-percentage stabilization can meet functional requirements while minimizing cost, construction time, and environmental impact. Based on the findings, it is recommended that field engineers adopt cement contents between 2% and 6% depending on anticipated load levels and service duration. Proper moisture control and compaction during construction are essential to ensure uniform strength development. The use of low cement contents also facilitates easier removal or reuse of stabilized soil after project completion, supporting sustainable construction practices. Overall, this research provides a practical and economically viable framework for applying cement stabilization in temporary works, enabling improved site performance without compromising efficiency or environmental responsibility.

References

1. Das BM. Principles of geotechnical engineering. 8th ed. Stamford: Cengage Learning; 2014.
2. Bowles JE. Foundation analysis and design. 5th ed. New York: McGraw-Hill; 1996.
3. Ingles OG, Metcalf JB. Soil stabilization principles and practice. Sydney: Butterworths; 1972.
4. Mitchell JK, Soga K. Fundamentals of soil behavior. 3rd ed. Hoboken: Wiley; 2005.
5. Sherwood PT. Soil stabilization with cement and lime. London: HMSO; 1993.
6. Little DN. Evaluation of structural properties of lime stabilized soils. Austin: University of Texas; 1995.
7. Bell FG. Lime stabilization of clay minerals and soils. Eng Geol. 1996; 42:223-237.
8. Consoli NC, Prietto PDM, Ulbrich LA. Influence of cement content on sandy soil behavior. J Geotech Geoenviron Eng. 1998; 124:418-424.
9. Ola SA. Geotechnical properties of stabilized soils. Rotterdam: Balkema; 1983.
10. Thompson MR. Lime reactivity of Illinois soils. J Soil Mech Found Div. 1966; 92:67-92.
11. Montgomery DC. Design and analysis of experiments. 8th ed. Hoboken: Wiley; 2013.
12. Neville AM. Properties of concrete. 5th ed. London: Pearson; 2011.
13. Mindess S, Young JF, Darwin D. Concrete. 2nd ed. Upper Saddle River: Prentice Hall; 2003.
14. Terzaghi K, Peck RB, Mesri G. Soil mechanics in engineering practice. 3rd ed. New York: Wiley; 1996.
15. Holtz RD, Kovacs WD, Sheahan TC. An introduction to geotechnical engineering. 2nd ed. Upper Saddle River: Pearson; 2011.