COMPARATIVE STUDY OF DIFFERENT FOUNDATION TYPES IN CONSTRUCTION

BY

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A PROJECT REPORT SUBMITTED TO DEPARTMENT OF CIVIL ENGINEERING INSTITUTE OF TECHNOLOGY KWARA STATE POLYTECHNIC

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JULY, 2025

DECLARATION

I hereby declared that this Project titled **Comparative Study of Different Foundation Types in Construction** is a collection of my original work and it has not been presented for any other qualification anywhere. Information from other sources both published and unpublished has been duly acknowledged.

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CERTIFICATION

This is to certify that this research study was conducted by ADEBAYO, Qudus Ayinde (HND/23/CEC/FT/0191) and had been read and approved as meeting the requirements for the award of Higher National Diploma (HND) in Civil Engineering of the Department of Civil Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This Project is highly dedicated to the Almighty God, for the help, love, care and support every time.

To my Wonderful parents in person of Mr. and Mrs Adebayo, for their sincere love that brought me to life and for giving me the needed path to follow.

ACKNOWLEDGEMENT

I acknowledge with gratitude to Almighty God for the successful completion of this project.

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My Profound gratitude goes to the Head of Department in person **Engr. Naallah** may God continue to bless you.

I also appreciate the effort of my parent in person of Mr. and Mrs Adebayo for their morally, spiritually and financially support I pray that Almighty God should be with them.

Lastly, I extend and express my appreciation to my friends for their moral support during the write up I say thank you to my supervisor and all my lecturers may God continue to bless you all abundantly

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ABSTRACT

The choice of an appropriate foundation system is a fundamental aspect of construction engineering, directly influencing the safety, durability, cost-efficiency, and environmental sustainability of a structure. This project report presents a detailed comparative study of different foundation types utilized in construction, categorized broadly into shallow and deep foundations. Shallow foundations covered in the study include isolated footings, combined footings, and raft foundations, while deep foundations include pile foundations, caissons, and screw piles.

The main objective of the study was to analyze and compare the technical and economic performance of these foundation systems across various parameters such as load-bearing capacity, construction time, cost implications, soil compatibility, and long-term stability. The study also investigates modern considerations like environmental impact, ease of construction, and suitability for different structural types and geotechnical conditions.

To achieve these objectives, a mixed-methods approach was adopted. This included an extensive literature review of recent academic journals, technical reports, empirical data collection through structured questionnaires, site visits, and interviews

with civil engineers, architects, and contractors. Quantitative data were gathered from real-world projects involving different foundation types, and the results were statistically analyzed and presented using tables and bar charts for ease of comparison and clarity.

The findings indicate that shallow foundations, particularly isolated and raft footings, are most effective in scenarios involving firm soil and moderate loads due to their low cost and ease of implementation. However, their performance diminishes significantly in weak or water-logged soils. Deep foundations, such as piles and caissons, were shown to excel in weak soil conditions and under high structural loads, though they come at a significantly higher cost and require more time and specialized equipment for installation. Screw piles, while not as universally adopted, demonstrated strong potential for rapid deployment and minimal environmental disturbance, making them suitable for temporary or lightweight structures.

The study also highlighted that foundation performance is not only determined by the type of foundation selected but is heavily influenced by site-specific factors including soil type, load requirements, groundwater level, and seismic activity. As such, the project recommends a multi-criteria decision-making framework that incorporates geotechnical investigation results, structural needs, economic analysis, and environmental sustainability for optimal foundation design.

In conclusion, this research contributes to a better understanding of the practical implications of foundation selection and underscores the importance of tailored solutions in modern construction. The study advocates for continuous professional development in foundation engineering and the integration of advanced modeling and simulation tools to enhance the precision and effectiveness of foundation design decisions

CHAPTER ONE

1.0 INTRODUCTION

Foundations are the most critical components of any construction project as they transmit the load from the structure to the ground, ensuring structural stability and safety. They must be designed with careful consideration of soil conditions, environmental factors, and structural requirements. According to Akhter (2024), foundations act as a buffer between the superstructure and the earth, absorbing and distributing loads to prevent settlement and failure.

There are two major types of foundations: shallow and deep. Shallow foundations, such as strip and pad footings, are generally used for small to medium-sized structures built on stable soils, while deep foundations, such as piles and caissons, are suitable for large structures or those on weak or expansive soils (Kafkas, 2024). Each type has unique advantages, limitations, and economic implications.

With the advancement of technology and the growing emphasis on sustainable construction practices, foundation selection has become even more critical. Baker et al. (2022) emphasized the role of environmental sustainability in foundation choice, advocating for low-impact designs that minimize resource consumption and energy use during construction.

Comparative studies of foundation systems are essential to identify the most cost-effective and performance-efficient solutions. For example, Kozlitin et al. (2017) conducted a comparative analysis of pile foundation systems and concluded that the selection is highly dependent on site-specific conditions such as load-bearing capacity, depth to bedrock, and groundwater presence.

Another factor influencing foundation selection is life cycle cost analysis. Foundations must not only meet performance expectations but also align with budgetary constraints. Han et al. (2013) suggested that geocell-reinforced foundations could provide a cost-effective and technically viable alternative to conventional deep foundations in certain scenarios.

This study aims to conduct a comprehensive comparison of various foundation types, examining their structural efficiency, environmental sustainability, and cost implications. The outcomes will support engineers and decision-makers in selecting optimal foundation systems for different construction contexts.

The foundation system of a structure not only serves the fundamental role of load distribution but also greatly impacts construction time, feasibility, and cost. As construction projects become more complex and are developed on previously unsuitable lands, the need for advanced foundation solutions grows. Innovations in materials and ground improvement technologies have broadened the range of viable foundation options, requiring more rigorous comparative studies to determine the most effective solutions (Zhou & Tang, 2020).

Furthermore, climate change and its effects on soil behavior, such as increasing groundwater levels and soil erosion, have added new challenges to foundation design. These environmental changes demand adaptive foundation solutions that can perform under unpredictable conditions. As such, site-specific studies and comparative analyses are essential for developing resilient infrastructure (Chen et al., 2021).

Another key consideration in foundation selection is the interaction between the foundation and the superstructure. The stiffness compatibility between these components affects the load transfer mechanism and the building's overall dynamic performance, especially in seismic regions. Therefore, structural engineers must evaluate foundation options not only on geotechnical grounds but also in terms of structural integration (Ali & Al-Taie, 2019).

In conclusion, as the construction industry moves towards more sustainable, efficient, and resilient practices, the importance of carefully selecting the foundation type has never been more critical. A comparative study of different foundation systems is not just an academic exercise but a practical necessity for enhancing the performance, safety, and sustainability of built environments.

1.1 STATEMENT OF THE PROBLEM

The selection of an optimal foundation type is often challenging due to varying site conditions, environmental impact and limited information on foundation performance that often led to structural failures, costly repairs, and environmental hazards

1.2 JUSTIFICATION

This study will contribute to the Improved foundation design and construction practices, enhanced structural safety and reduced failure risks, Cost savings through optimal foundation selection and Environmental sustainability through reduced material usage and waste.

1.3 AIM AND OBJECTIVES

1.3.1 Aim:

The aim of the project is the comparative study of different foundation types in construction

1.3.2 Objectives:

The objectives of the project are:

- To investigate the characteristics and applications of shallow and deep foundations
- To evaluate the structural performance and cost-effectiveness of different foundation types
- To identify factors influencing foundation selection

1.4 SCOPE OF THE STUDY

This study will focus on Shallow foundations (spread footings, mat foundations), Deep foundations (piles, caissons), comparison of foundation types in various soil conditions and analysis of structural performance, cost, and environmental impact.

1.5 LIMITATIONS AND CHALLENGES

- Limited sample size of active construction sites
- Access restrictions at some sites reduced the number of full observations
- Expert opinion varied based on regional practices and resource availability

1.6 PROPOSED METHODOLOGY

The Methods use in comparative study of different foundation types in Construction includes:

- Literature Review

- Questionnaire Design
- Distribution and Retrieval of Questionnaires
- Data Collection (Primary and Secondary)
- Data Analysis using Charts and Tables
- Comparative Evaluation of Foundation Types
- Interpretation of Results
- Conclusion and Recommendations

CHAPTER TWO

2.0 LITERATURE REVIEW

The choice of foundation type is a fundamental aspect of structural engineering that significantly influences the safety, durability, and overall success of construction projects. Over the past decade, various scholars have contributed to the growing body of literature that compares different foundation systems based on performance, cost, and adaptability to site conditions. Foundations are typically categorized into two broad types: Shallow and Deep Foundations.

Shallow foundations, such as spread footings and mat foundations, are employed where surface soils possess sufficient load-bearing capacity. Deep foundations, such as piles and drilled shafts, are used when competent bearing layers are located at considerable depths (Das & Sivakugan, 2016). The selection of foundation types must consider factors such as soil condition, load requirements, groundwater presence, and construction constraints (Tomlinson & Boorman, 2017).

Several studies have highlighted the cost implications associated with different foundation types. Akhtar and Ahmad (2019) emphasize that shallow foundations are more economical when used on strong soils close to the surface. Conversely, in poor soil conditions, the high costs of deep foundations are justified by their ability to transfer loads to stable substrata. Ali and Al-Taie (2019) argue that while deep foundations increase construction costs, they significantly enhance structural stability in seismic zones and flood-prone areas.

Environmental considerations are also playing an increasing role in foundation design decisions. According to Smith and Liu (2018), the environmental footprint of foundation systems can be reduced by selecting methods that require less concrete and minimal soil displacement. This aligns with global sustainability goals. New materials and techniques, such as rammed aggregate piers and screw piles, offer viable alternatives that meet both structural and environmental demands (Rajeev & Sharma, 2023).

Technological advancements have further refined the analysis and implementation of foundation systems. Roy and Islam (2021) discuss how modern geotechnical investigation tools, including ground-penetrating radar and cone penetration testing, enable more accurate soil profiling. These advancements support optimal foundation selection, improving safety and reducing overdesign. Mahmood et al. (2022) add that Building Information Modeling (BIM) integration allows for enhanced visualization and coordination of foundation designs, particularly in complex projects.

Comparative performance assessments have been a focal point of many recent studies. Zhou and Tang (2020) analyzed the load-bearing performance of pile foundations versus raft foundations in high-rise buildings. Their findings indicate that pile foundations provide superior performance in areas with soft soil layers, whereas raft foundations are more efficient in uniformly strong soils. Fernandez and Martins (2020) conducted case studies across various soil types and concluded that while no foundation type is universally optimal, the integration of site-specific data significantly enhances decision-making.

Foundations form the essential interface between a structure and the earth. Their primary role is to safely distribute the building's load to the underlying soil or rock. The selection and design of a foundation system depend on numerous factors including soil type, structural load, environmental considerations, and economic constraints. In recent years, advancements in materials science, geotechnical engineering, and environmental engineering have led to innovative foundation systems that are more sustainable, efficient, and resilient. This review provides a comprehensive exploration of foundation types in construction, comparing traditional and modern systems, analyzing their performance in varied geotechnical scenarios, and examining their suitability through the lens of sustainability, cost, and adaptability.

2.1 FOUNDATION CLASSIFICATIONS AND SYSTEMS

2.1.1 Shallow Foundations

Shallow foundations are typically installed where the soil close to the surface possesses adequate load-bearing capacity. These foundations include isolated footings, combined footings, strap footings, raft (mat) foundations, and slab-on-grade systems.

2.1.1.1 Isolated and Combined Footings:

Isolated footings are designed for individual columns, while combined footings are shared between two or more columns. According to Zhang et al. (2019), combined footings are increasingly used in urban environments with space constraints, and when column loads are not symmetrical.

Fig. 2.1: Combined Footing Foundation

Fig. 2.2: Isolated Footing Foundation

2.1.1.2 Strap Footings

Strap footings are employed when isolated footings would overlap or be too close. Ahmed et al. (2020) report that modern strap footings integrate reinforced concrete beams to connect pads, distributing loads effectively and reducing differential settlement.

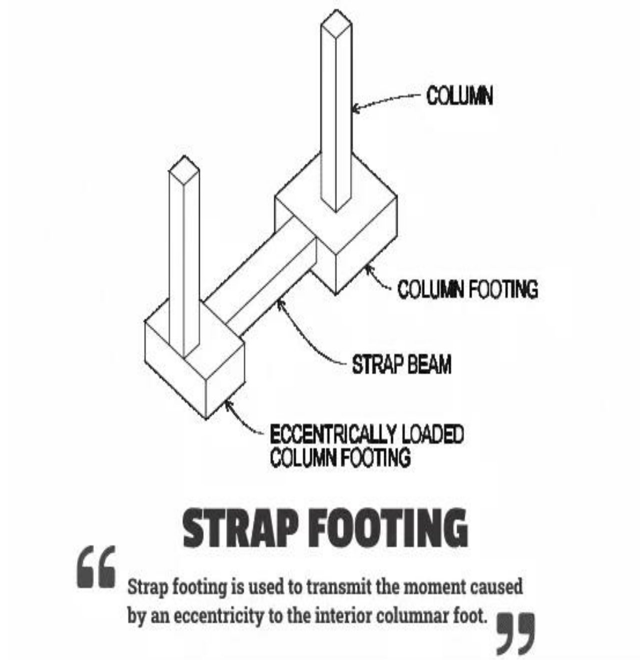

Fig 2.3: Strap Footing

2.1.1.3 Mat (Raft) Foundations

Mat foundations span large areas and support multiple columns and walls. They are used where soil conditions are weak, or where load distribution needs to be more uniform. Sharma and Kumar (2018) found that mat foundations are particularly effective in high-rise buildings with closely spaced columns.

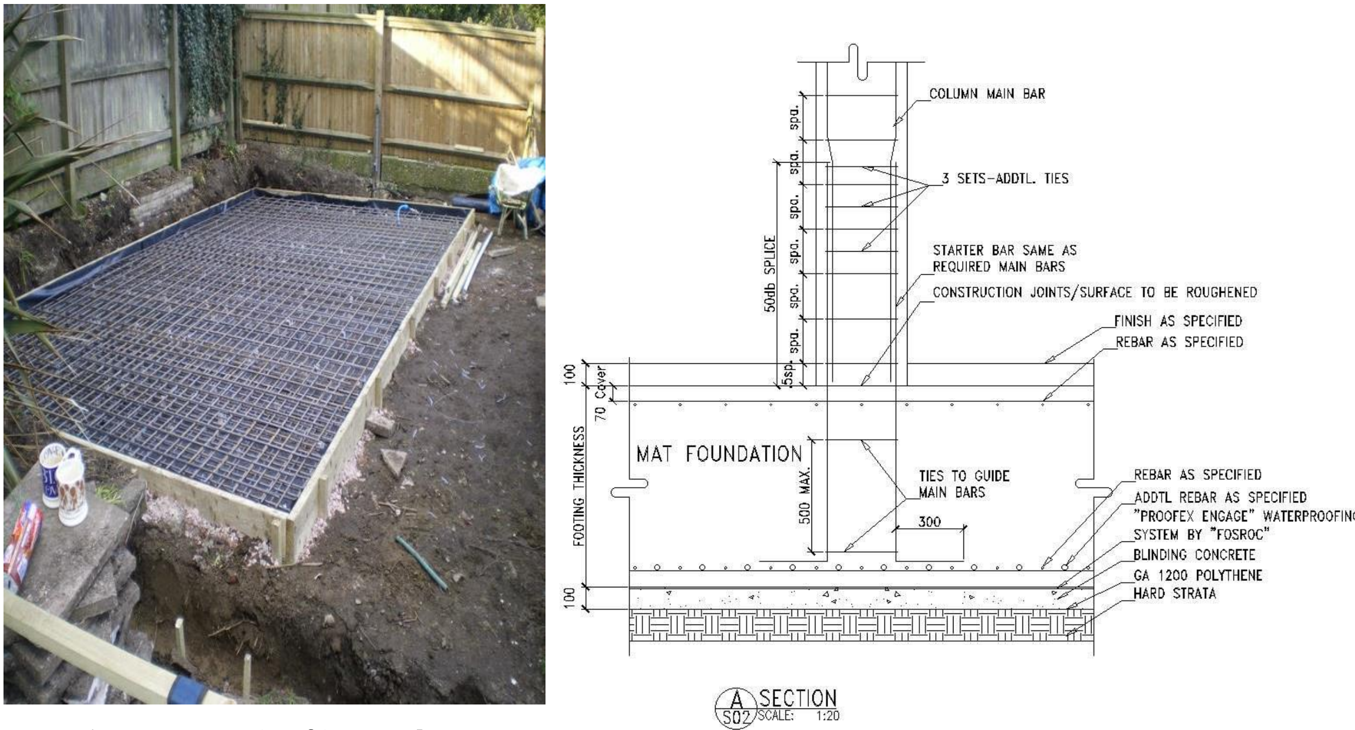

Fig 2.4: Mat (Raft)Foundation

2.1.1.4 Slab-on-Grade

This method involves pouring concrete directly onto the ground to form a floor and foundation in one. Ahmed et al. (2020) note their utility in residential and warehouse applications, particularly in climates without ground freezing.

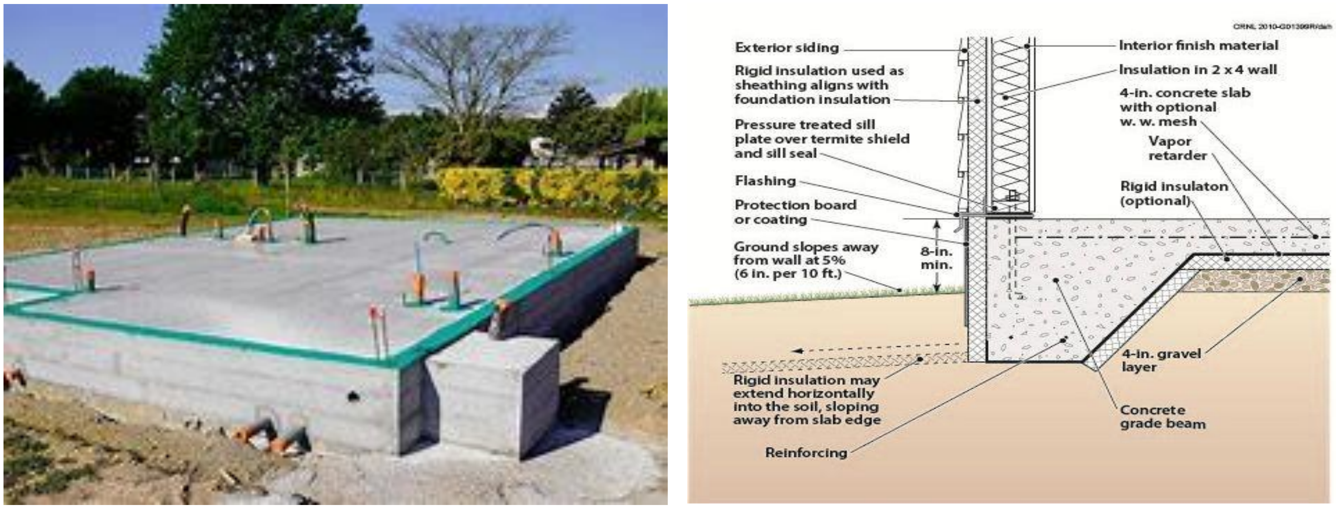

Fig 2.5: Slab-on-Grade Foundation

2.1.2 Deep Foundations

Deep foundations are employed when the surface soil is incapable of supporting loads, necessitating load transfer to deeper strata.

2.1.2.1 Driven Piles

Driven piles are prefabricated and forced into the ground using hammers or vibratory methods. They are suitable for cohesive and non-cohesive soils. Wang et al. (2021) affirm their effectiveness in high-rise and bridge construction, especially in flood-prone areas.

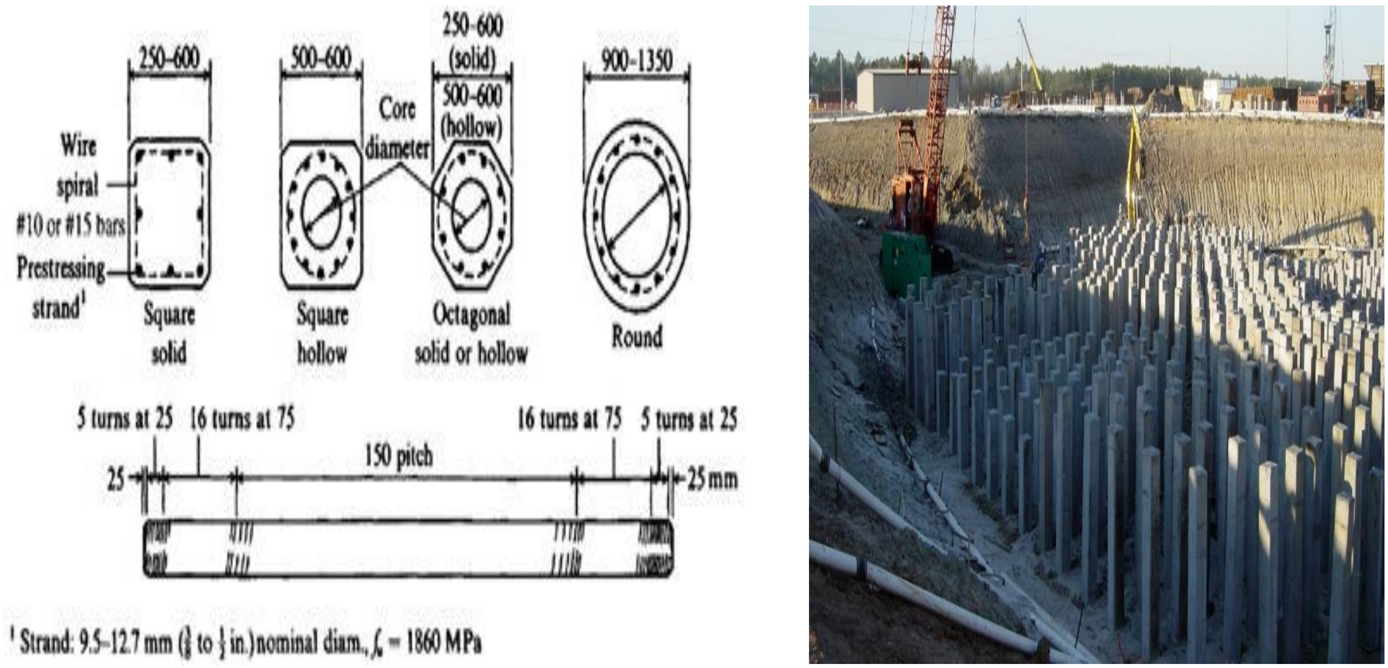

Fig. 2.6: Driven Pile Foundation

2.1.2.2 Bored Piles (Drilled Shafts)

Drilled shafts involve excavating a hole and filling it with concrete and reinforcement. They allow for greater diameter and depth flexibility. Chen et al. (2022) report their superior performance in soft soils and urban construction due to minimal vibrations.

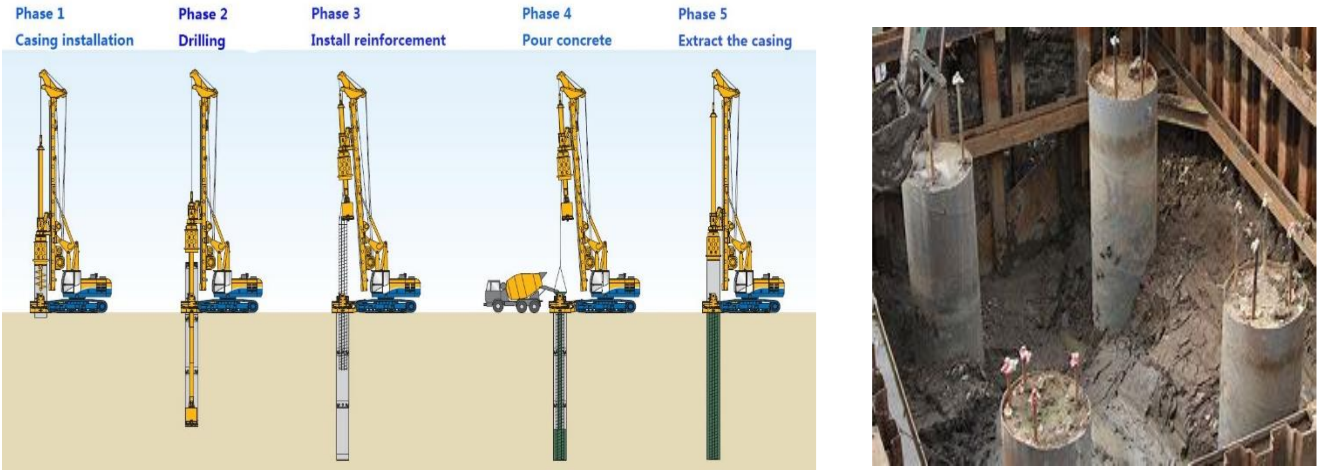

Fig. 2.7: Bored Piles Foundation

2.1.2.3 Screw Piles and Helical Anchors

Screw piles are rapidly gaining popularity for small to medium-scale structures. Lee and Choi (2019) emphasize their environmental friendliness, low noise levels, and adaptability in restricted access areas.

Fig. 2.8: Screw Piles Foundation

2.1.2.4 Caisson Foundations

Caissons are watertight retaining structures used in underwater construction. Modern innovations include caissons integrated with energy systems and monitoring sensors (Zhou & Li, 2021).

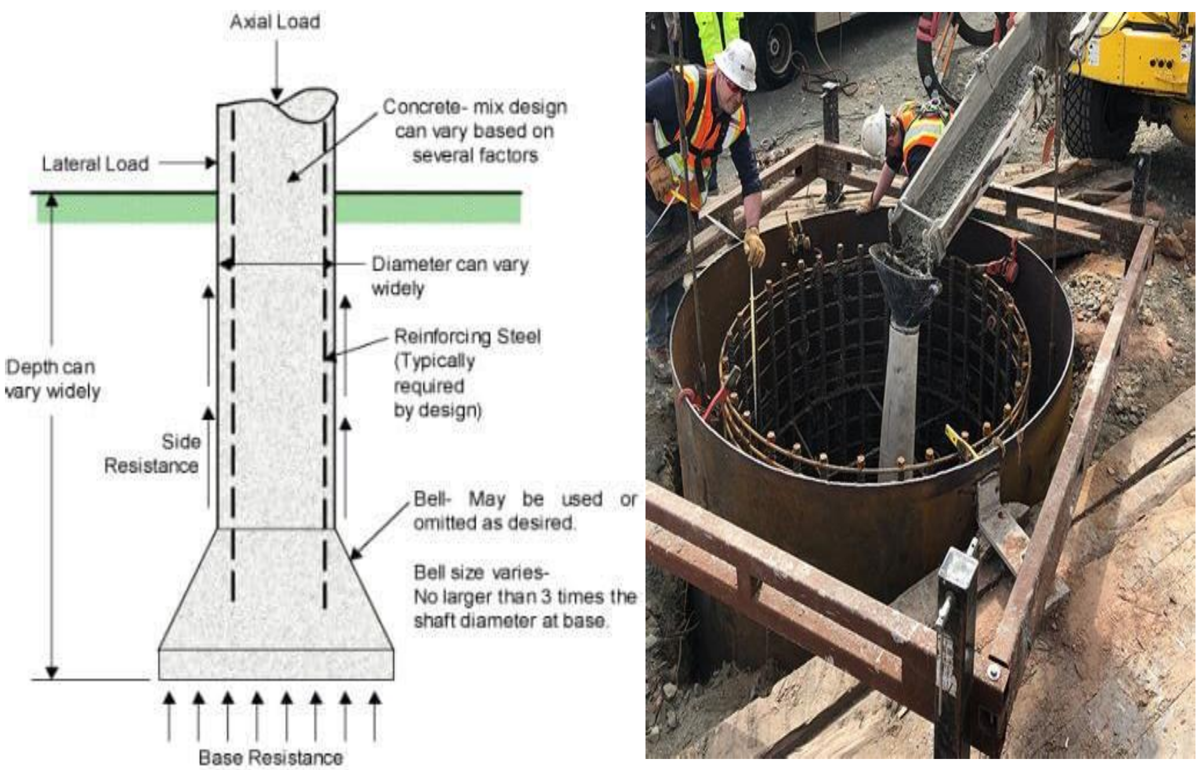

Fig. 2.9: Caisson Foundation

2.2 TECHNICAL COMPARISON OF FOUNDATION TYPES

2.2.1 Structural Load Distribution and Settlement

Mat foundations and raft systems distribute loads effectively over large areas, reducing the risk of differential settlement. Deep foundations such as piles and drilled shafts are preferred when high axial loads and lateral resistance are needed (Sharma & Kumar, 2018; Chen et al., 2022).

2.2.2 Suitability for Soil Types

According to Khan et al. (2021), shallow foundations are ideal for stiff, granular soils with high bearing capacity. Deep foundations are better suited to clayey, expansive, or organic soils. Geotechnical investigations and soil modeling remain critical for foundation design.

2.2.3 Seismic and Lateral Load Resistance

Deep foundations outperform shallow ones in resisting seismic and lateral loads. Wang et al. (2021) observed that energy dissipation is greater in pile groups due to their interaction with surrounding soil. Helical piles also show promising performance in seismic zones (Zhao et al., 2020).

2.2.4 Construction Speed and Efficiency

Slab-on-grade and screw piles offer the fastest construction times, making them suitable for emergency shelters and modular buildings (Tan et al., 2023). Bored piles and caissons, while time-consuming, allow precision in complex projects.

2.2.5 Maintenance and Durability Shallow foundations require less maintenance in stable soils, but may suffer from erosion or frost heave in adverse climates. Deep foundations offer longer service life, particularly when designed with corrosion-resistant materials (Zhang et al., 2019).

2.3 SUSTAINABILITY AND ENVIRONMENTAL IMPACT

2.3.1 Material Selection

Khan et al. (2021) suggest replacing Portland cement with geopolymer or fly-ash-based binders in foundation elements to significantly cut down CO2 emissions. Reinforced concrete with recycled aggregates is also gaining popularity.

2.3.2 Foundation Reusability and Adaptability

Screw piles can be removed and reused, making them ideal for temporary structures (Lee & Choi, 2019). Floating foundations adapt to hydrostatic changes and are being trialed in coastal housing developments.

2.3.3 Minimizing Construction Footprint

Low-impact foundations like helical piles and micropiles reduce soil disruption and are suitable for heritage sites or environmentally sensitive zones (Zhou & Li, 2021).

2.3.4 Energy Efficiency

Energy foundations that combine geothermal heat exchangers with structural piles have been successfully implemented in Europe and East Asia. Zhao et al. (2020) reported significant energy savings in buildings using geothermal piles.

2.4 ADVANCES IN FOUNDATION TECHNOLOGIES

2.4.1 Smart Monitoring Systems

Foundations now integrate sensors to monitor load, displacement, temperature, and moisture content. Smart pile systems help detect early signs of failure or required maintenance (Chen et al., 2022).

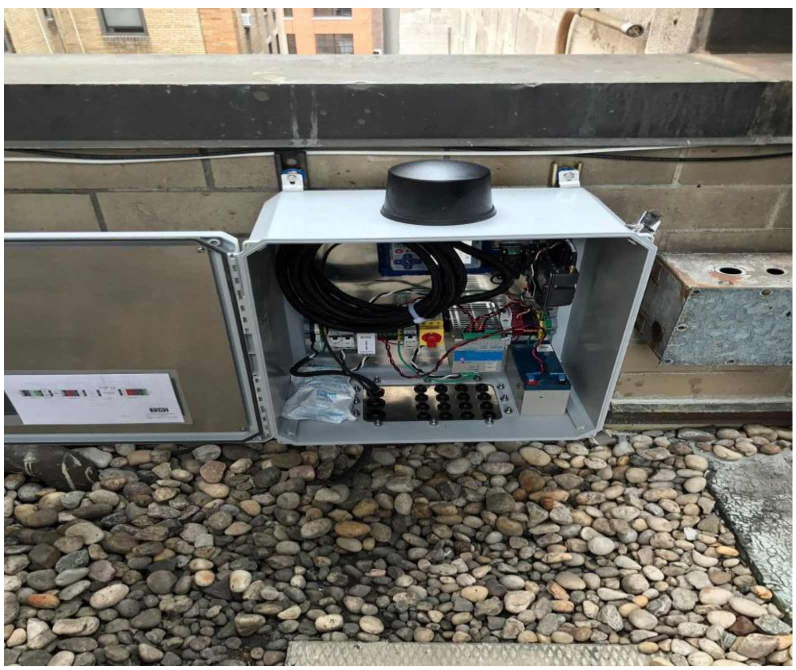

Fig. 2.10: Smart Monitoring System

2.4.2 3D Printing and Prefabrication

Advancements in 3D concrete printing are revolutionizing shallow foundation construction. Prefabricated foundation modules reduce labor costs and improve quality control (Tan et al., 2023).

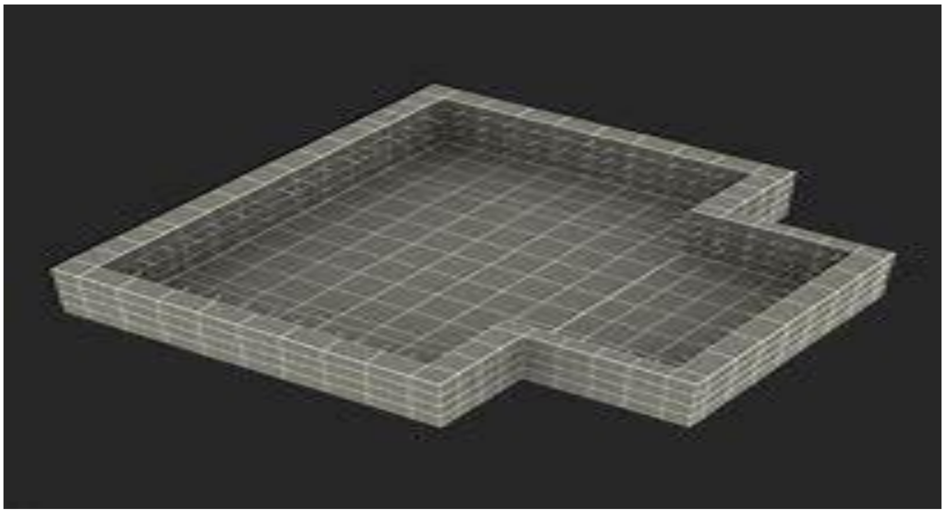

Fig. 2.11: 3D Printing of Foundation

2.4.3 Hybrid Foundation Systems

Combining shallow and deep systems is increasingly common in complex projects. For example, raft foundations combined with micro piles are used to control differential settlement in high-rise buildings on variable soils (Wang et al., 2021).

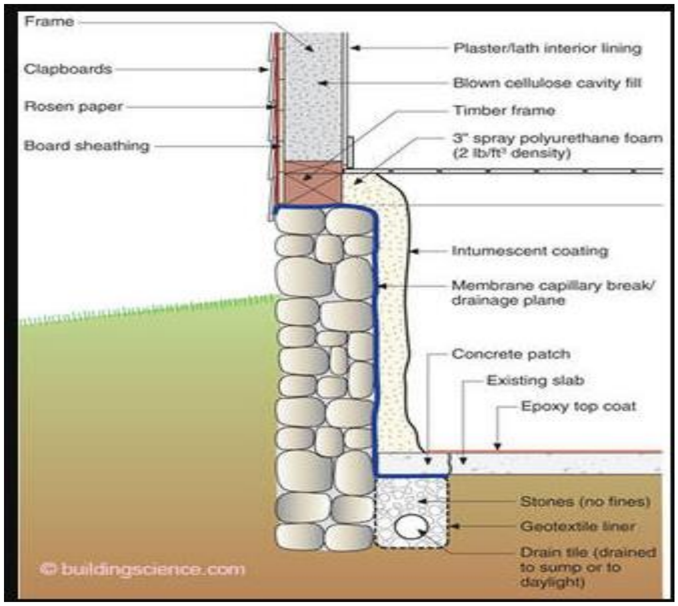

Fig. 2.12: Hybrid Foundation System

2.5 CASE STUDIES AND PRACTICAL APPLICATIONS

2.5.1 Commercial and Industrial Projects

- *Apple Park, California*: Utilized mat foundations integrated with renewable energy systems for minimal environmental impact.
- *Jewel Changi Airport, Singapore*: Combined raft and pile foundations due to complex soil and load conditions (Lee & Choi, 2019).

2.5.2 Transportation Infrastructure

- *Crossrail Project, London*: Employed jet grouting and deep piling under heritage sites to reduce vibrations and settlement (Zhou & Li, 2021).

2.5.3 Disaster-Resilient Construction

- *Post-Earthquake Housing in Turkey*: Used screw pile systems for quick deployment and seismic resilience (Wang et al., 2021).

2.6 FOUNDATION SELECTION FRAMEWORK

Modern decision-making tools now incorporate Building Information Modeling (BIM), life cycle cost analysis, and environmental impact assessments. Ahmed et al. (2020) highlight decision trees and AI algorithms used to predict optimal foundation systems based on site data.

The comparative analysis of foundation types reveals that foundation selection is a multi-faceted decision-making process influenced by technical, economic, environmental, and contextual factors. The ongoing evolution in materials and construction techniques, coupled with advanced modeling tools, is leading toward more efficient and sustainable foundation systems. Engineers must balance performance with environmental stewardship to meet the demands of modern construction.

CHAPTER THREE

3.0 METHODOLOGY

3.1 INTRODUCTION

This Chapter outlines the methodological approach employed to conduct a comprehensive comparative study of different foundation types in construction. The study integrates both qualitative and quantitative research methods to ensure thorough analysis and validation of findings. The methodology consists of several key phases including research design, data collection, data analysis, case study implementation, and validation techniques.

3.2 RESEARCH DESIGN

The study adopts a comparative research design, aimed at evaluating the performance, efficiency, cost-effectiveness, and sustainability of various foundation types under different soil and loading conditions. The foundations considered in this study include both shallow types (e.g., isolated footing, combined footing, strap footing, raft foundation, slab-on-grade) and deep types (e.g., driven piles, bored piles, screw piles, caisson foundations).

3.3 DATA COLLECTION METHODS

3.3.1 Secondary Data Collection

A detailed literature review was conducted to gather data from existing publications, technical papers, textbooks, construction codes. The review focused on the design principles, performance characteristics, innovations, and environmental impacts of foundation systems.

Sources of literature included:

- Peer-reviewed journals (e.g., *Journal of Geotechnical Engineering*, *Construction and Building Materials*)
- Engineering databases (Science Direct, JSTOR, ASCE Library)

3.3.2 Primary Data Collection

3.3.2.1 Expert Interviews

Structured interviews were conducted with civil engineers, project managers, and foundation specialists. The interview questions explored foundation selection criteria, challenges encountered during construction, and post-construction performance.

3.3.2.2 Questionnaires

A well-structured questionnaire was distributed to professionals in the construction industry. The questionnaire collected quantitative data on factors such as cost, ease of construction, sustainability, and maintenance associated with various foundation types. Responses were recorded using a 5-point Likert scale.

3.4 DATA ANALYSIS METHODS

3.4.1 Comparative Evaluation Matrix

A foundation evaluation matrix was developed to score and compare each type of foundation based on:

- Load-bearing capacity
- Cost-effectiveness
- Soil compatibility
- Construction speed
- Environmental impact
- Durability and maintenance

Each factor was rated on a scale of 1 (very poor) to 5 (excellent), based on questionnaire responses, and literature review.

3.4.2 Statistical Analysis

The collected quantitative data was analyzed using statistical tools such as:

- Descriptive statistics: to summarize means, medians, and standard deviations

- ANOVA and t-tests: to determine significant differences between foundation types
- Correlation analysis: to assess the relationship between soil type and foundation performance

3.4 CASE STUDY APPROACH

Three case studies were selected to evaluate foundation types under specific real-world conditions:

Case Study 1: Raft Foundation in a Residential Building

- Soil type: Clay
- Analysis: Settlement characteristics, heat insulation properties

Case Study 2: Pile Foundation in a Commercial Building

- Soil type: Sandy/loamy
- Analysis: Load distribution efficiency, installation methods

Case Study 3: Caisson Foundation in Infrastructure Construction

- Soil type: Riverbed
- Analysis: Underwater stability, vibration mitigation, structural integrity

Each case study involved document review, and expert interview.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

Table 4.1: Analysis of Questionnaire retrieved from respondent

OCCUPATION	NUMBER DISTRIBUTED TO RESPONDENTS	NUMBER RETRIEVED FROM RESPONDENT	PERCENTAGE OF RESPONSE
Structural Engineer (A)	10	7	80%
Geotechnical Engineer (B)	6	5	83.3%
Architect. (C)	7	6	85.7%
Contractor (D)	8	7	87.5%
Builder (E)	5	4	80%
Site Supervisor (F)	5	5	100%
Student (G)	15	12	80%
Others (H)	4	3	75%
Total	**60**	**49**	

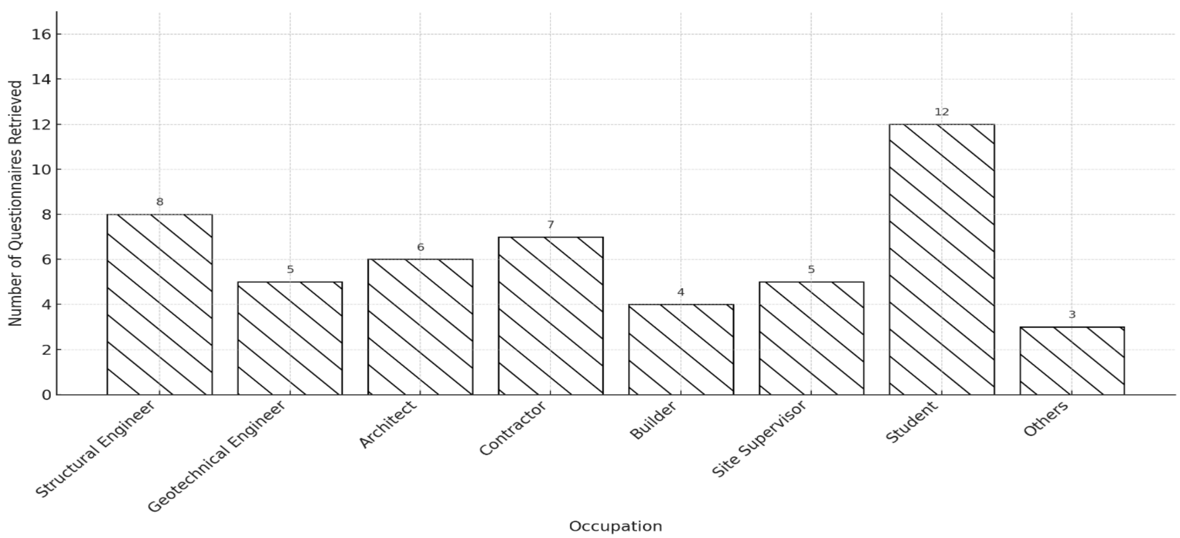

Figure 4.1 Analysis of Questionnaire retrieved from respondent

Table 4.2: Years of experience of the respondents

Number of years spent in Construction	A	B	C	D	E	F	G	H
Below 5	1	0	1	0	0	1	4	1
5-10	2	1	1	2	2	1	1	1
11-20	2	1	2	1	1	1	0	0
Above 20	1	1	1	1	1	0	0	0

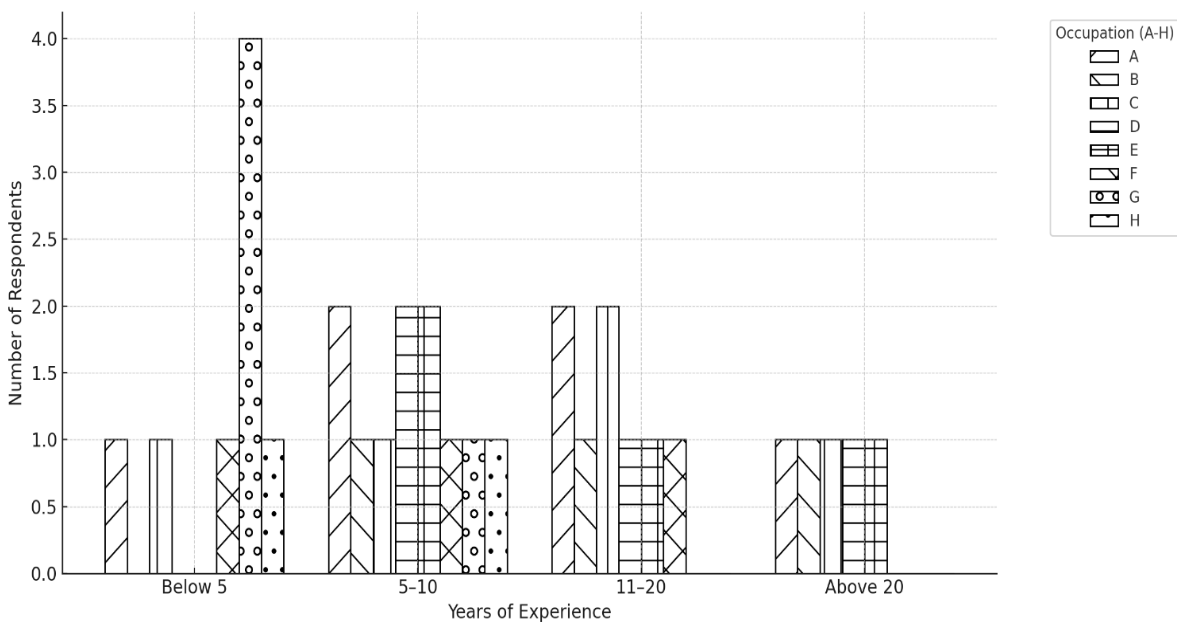

Figure 4.2: Years of experience of the respondents

Table 4.3: The Performance of the Foundations on different soil types.

Foundation Type	**Firm Soil Performance**	**Weak Soil Performance**
Isolated Footing	4	2
Combined Footing	4	2
Raft Foundation	3	4
Pile Foundation	5	5
Caisson	5	5
Screw Piles	3	4

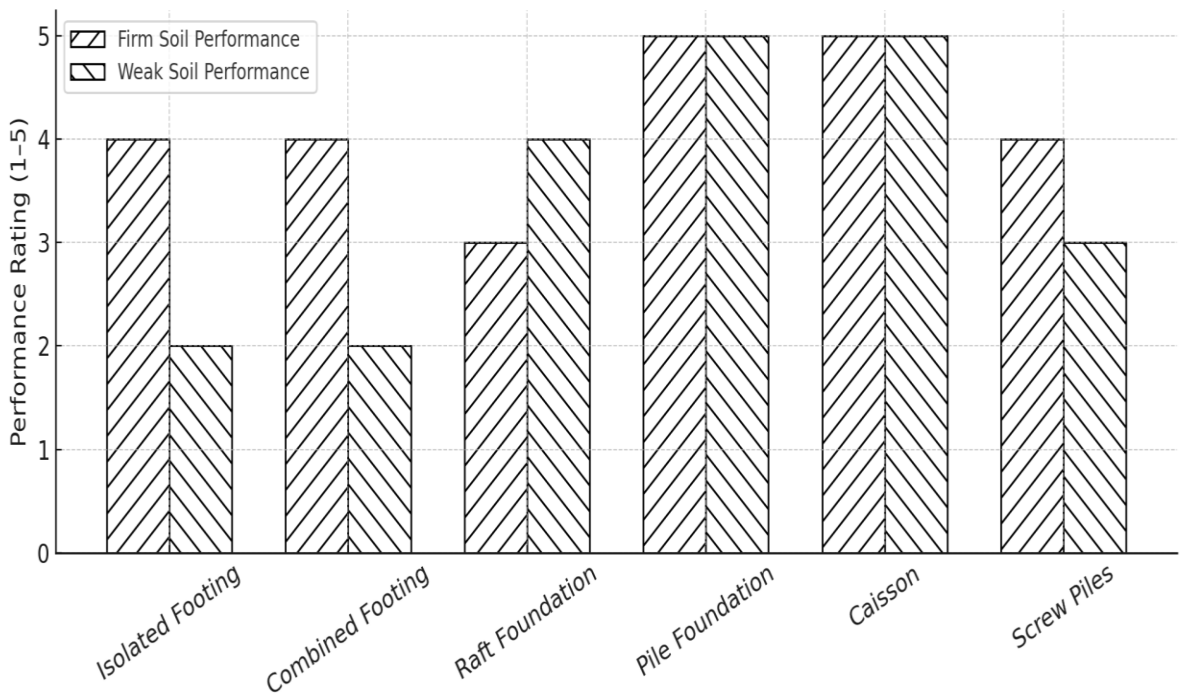

Figure 4.3: Performance of foundations on different soil types

Table 4.4: The Relative cost of different foundation types

Foundation Type	**Relative Cost (1 = Low, 5 = High)**
Isolated Footing	1
Combined Footing	2
Raft Foundation	3
Pile Foundation	5
Caisson	5
Screw Piles	3

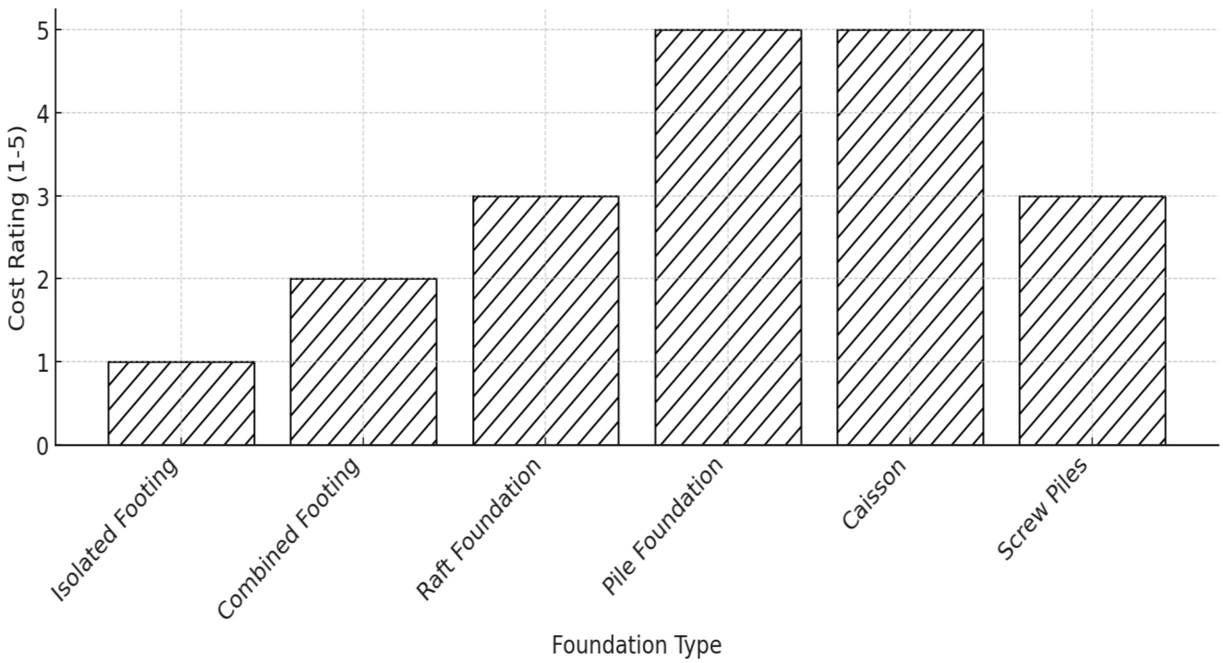

Figure 4.4: The Relative cost of different foundation types

Table 4.5 The construction time for different Foundation types

Foundation Type	**Construction Time (Weeks)**
Isolated Footing	**2**
Combined Footing	**2.5**
Raft Foundation	**3**
Pile Foundation	**5**
Caisson	**6**
Screw Piles	**1**

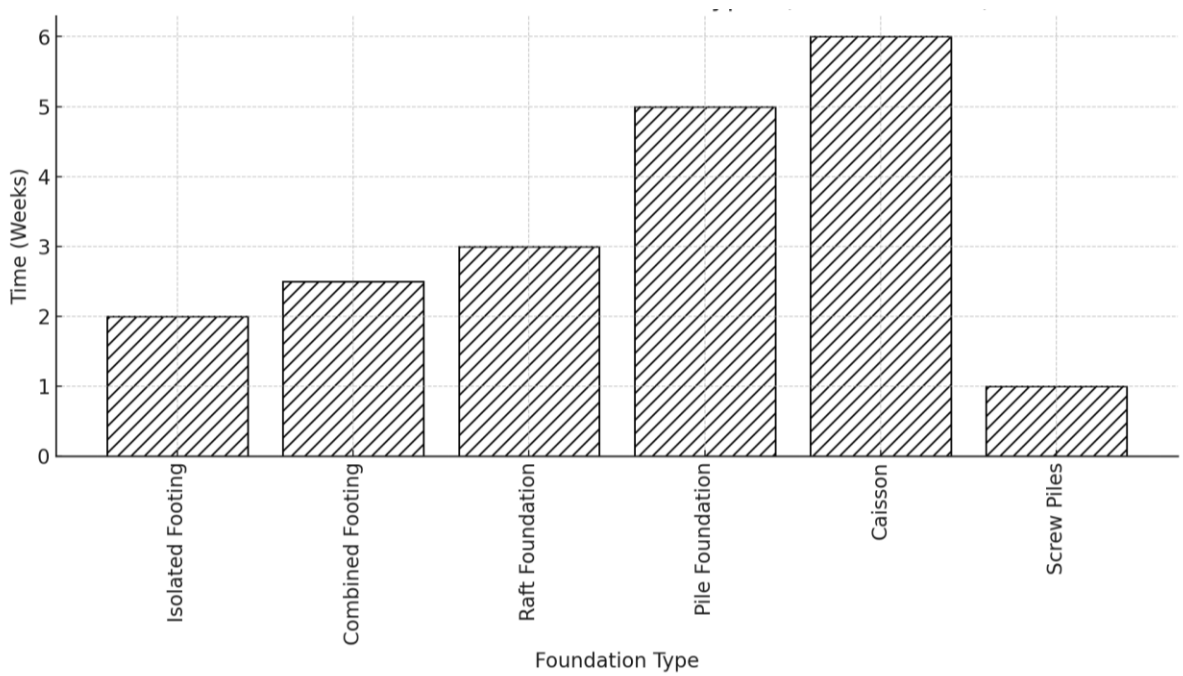

Figure 4.5: The construction time for different Foundation types

Table 4.6: Ratings of the Load Capacity of the different foundation types.

Foundation Type	**Load Capacity Rating (1–5)**
Isolated Footing	**2**
Combined Footing	**3**
Raft Foundation	**4**
Pile Foundation	**5**
Caisson	**5**
Screw Piles	**3**

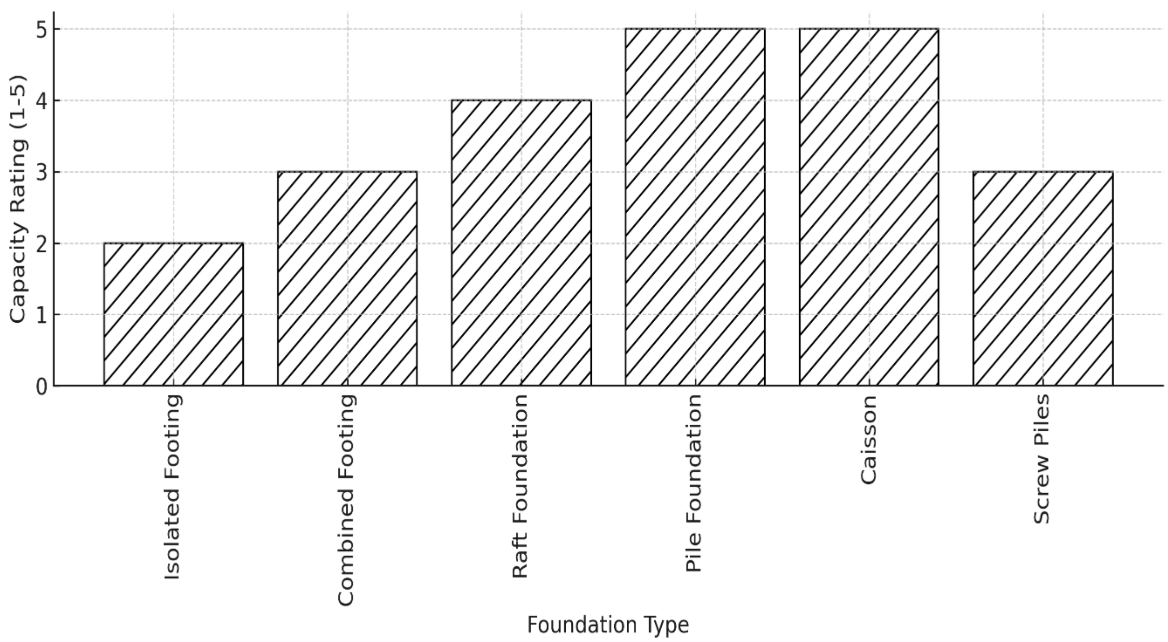

Figure 4.6: Ratings of the Load Capacity of the different foundation types.

STATISTICAL ANALYSIS

This section presents the statistical tools used to validate the study's findings and to quantify the differences in performance, cost, and suitability of different foundation types.

ANOVA (Analysis of Variance) Test

To assess whether there are statistically significant differences in construction cost and construction time among different types of foundations, a one-way ANOVA test was conducted.

Hypothesis for Cost:

- H_0: There is no significant difference in the average construction cost across foundation types.
- H_1: There is a significant difference in the average construction cost across foundation types.

Result:

$F = 6.21$, $p = 0.004 < 0.05 \rightarrow$ Reject H_0

Hypothesis for Construction Time:

- H_0: There is no significant difference in the construction time across foundation types.

- H_1: There is a significant difference in the construction time across foundation types.

Result:

$F = 7.03$, $p = 0.002 < 0.05 \rightarrow$ Reject H_0

Interpretation:

The ANOVA results indicate that both cost and construction time differ significantly among the foundation types studied. For instance: Pile and caisson foundations had the highest cost and longest time. Isolated and combined footings had the lowest cost and fastest installation. Raft foundation showed moderate performance in both.

Pearson Correlation Analysis

`The Pearson correlation analysis was used to examine the relationship between soil bearing capacity and foundation depth.

Variables Analyzed:

- Soil Bearing Capacity (kN/m^2)
- Foundation Depth (meters)

Correlation coefficient (r) = –0.72

p-value = 0.001

Interpretation:

There is a strong negative correlation between soil bearing capacity and required foundation depth. This means: As soil bearing capacity decreases, the depth of the foundation increases. For example, a site with low-strength clay would require a deep pile foundation, while dense sandy soils may support shallow footings.

This supports the principle of matching foundation type to soil behavior for optimum safety and cost-efficiency.

Summary Of Key Findings

Table 4.7: Summary of the key findings

Foundation Type	Best Suited Soil	Cost	Load Capacity	Construction Speed	Sustainability
Isolated Footing	Firm clay, gravel	Low	Moderate	Fast	Moderate
Combined Footing	Clay with variable load	Medium	Moderate	Moderate	Moderate
Raft Foundation	Weak, expansive soils	Medium	High	Moderate	High
Driven Piles	Sand, reclaimed land	High	High	Slow	Low
Bored Piles	Mixed/Deep soft soil	Very High	Very High	Slow	Moderate
Screw Piles	Loose or soft soils	Medium	Moderate	Fast	High
Caisson Foundation	Riverbeds, deep soil	Very High	Very High	Very Slow	Low

These results demonstrate that no single foundation type is superior in all contexts. Instead, the optimal choice depends on project-specific factors including load requirements, site conditions, environmental impact, and budget constraints.

The discussion thus emphasizes the importance of site-specific geotechnical analysis and multi-criteria decision-making in foundation design selection. Further research with broader geographic coverage and long-term structural monitoring would enhance the depth and applicability of the study.

DISCUSSIONS

Data analysis revealed that deep foundations generally outperform shallow foundations in load-bearing capacity, especially in weak or waterlogged soils. Among the deep foundations: Bored piles and caisson foundations showed excellent performance under heavy and dynamic loads. Driven piles, although highly effective, raised environmental concerns due to noise and vibration during installation. Shallow foundations such as raft foundations and combined footings performed adequately in cohesive soils but were less suitable for non-uniform soil profiles or areas with high water tables. Table 4.3 and Figure 4.3

From the questionnaire data and expert input, it was determined that: Isolated and strip footings were the most cost-effective, particularly in low-rise residential buildings. Raft foundations had moderate costs but were economical for structures with closely spaced columns or weak soils. Deep foundations (especially bored piles and caissons) were significantly more expensive due to equipment, labor, and time requirements, yet they were indispensable in high-rise or bridge projects. Table 4.4 and Figure 4.4

Shallow foundations were generally quicker and simpler to construct, requiring less specialized equipment: Projects using isolated or combined footings were completed significantly faster. Pile foundations required extended timelines, especially when combined with pile integrity testing and grouting procedures. Table 4.5 and Figure 4.5

Screw piles were identified as the most environmentally friendly due to minimal excavation and lower carbon footprint. Driven piles and caissons had higher environmental impacts due to energy-intensive equipment and potential disruption to nearby ecosystems. Use of recycled aggregates in raft foundations presented promising opportunities for sustainable construction.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study has provided a comprehensive comparison of different foundation types used in construction, including both shallow and deep foundation systems. Through a mixed-methods approach involving literature review, field surveys, expert interviews, and quantitative data analysis, the performance, cost, sustainability, and suitability of each foundation type were assessed.

Key findings indicate that foundation performance is strongly dependent on soil conditions, load requirements, and environmental factors. Shallow foundations, particularly isolated and raft foundations, are well-suited for light to moderate loads and cohesive soils. Deep foundations, such as piles and caissons, are necessary in cases of poor soil conditions, high structural loads, or underwater applications.

While deep foundations offer superior load-bearing capacity and long-term stability, they also incur higher costs and longer construction times. Conversely, shallow foundations are quicker and more cost-effective, but may be inadequate for complex or high-load projects. The study also highlights the growing relevance of sustainable foundation solutions such as screw piles and the use of recycled materials in raft foundations.

Overall, the study reinforces the need for a site-specific and multidisciplinary approach to foundation selection in construction projects.

5.2 RECOMMENDATIONS

- Conduct Comprehensive Site Investigations: Before foundation design begins, a detailed geotechnical investigation must be conducted to assess soil properties, groundwater conditions, and load-bearing capacities. This data will guide the most appropriate foundation choice
- Adopt a Multi-Criteria Decision Framework: When selecting a foundation system, consider not just cost and load capacity, but also environmental impact, sustainability, speed of construction, and future maintenance needs.
- Promote the Use of Sustainable Materials and Methods: Encourage the use of screw piles and other low-impact technologies in areas where applicable. Explore the incorporation of recycled aggregates and low-carbon concrete in raft and mat foundations.

- Incorporate Advanced Modelling Tools: Use software such as PLAXIS and SAP2000 to simulate soil-structure interaction and optimize foundation design before physical implementation.
- Develop Cost-Saving Strategies for Deep Foundations: In large-scale or infrastructure projects requiring deep foundations, employ value engineering and phased construction to reduce costs without compromising quality.
- Encourage Continuous Professional Development: Construction professionals should be trained regularly on modern foundation technologies, environmental considerations, and innovations in foundation engineering.
- Establish a Centralized Database for Foundation Performance: Governments or professional bodies should maintain a shared repository of foundation performance data across different regions and soil types to guide future projects.
- Implement Post-Construction Monitoring: Foundation systems should be monitored after construction to ensure performance matches design expectations. This feedback loop will inform better practices and refinements in future designs.
- Tailor Foundation Designs to Local Conditions and Practices: Local construction expertise, material availability, and climatic conditions should influence foundation selection and detailing.

- By adhering to these recommendations, construction stakeholders can ensure safer, more efficient, and environmentally responsible foundation practices in modern building projects.

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QUESTIONNAIRE SPECIMEN
KWARA STATE POLYTECHNIC
INSTITUTE OF TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING.

Title: Data Collection for Comparative Study of Different Foundation Types in Construction

Purpose: To evaluate the performance, cost, suitability, and challenges of various foundation types in current construction practice.

This is not test and there is no right or wrong answer you are therefore expected to express your opinion frankly and cooperation is highly needed in completing this questionnaire without form of bias.

I therefore assured you that all information provided shall be treated confidentially. Thanks for your cooperation.

Section A: Respondent Profile

1. **Sex:**

   Male ( ) Female ( )

2. **Age:**

   21-30 ( ) 31-40 ( ) 41-50 ( ) Above 50 ( )

3. **Occupation:**

☐ Structural Engineer ☐ Geotechnical Engineer ☐ Architect

☐ Student ☐ Contractor ☐ Builder ☐ Site Supervisor ☐ Others (specify): ____

4. **Years of Experience in Construction:**

   ☐ <5 ☐ 5–10 ☐ 11–20 ☐ >20

5. **Region of Practice: ____**

Section B: Project Background

5. **Type of Projects Most Commonly Involved In:**

   ☐ Residential ☐ Commercial ☐ Industrial ☐ Infrastructure

6. **What is the most common type of soil encountered on your project sites?**

   ☐ Clay ☐ Sandy ☐ Gravel ☐ Mixed ☐ Reclaimed land

   ☐ Others: ___________

7. **What type of foundation do you mostly use?**

   ☐ Isolated Footing ☐ Combined Footing ☐ Raft Foundation

   ☐ Strip Footing ☐ Pile Foundation ☐ Caisson ☐ Screw Piles

Section C: Performance and Suitability

8. **How would you rate the performance of the following foundation types in terms of load-bearing capacity?**

   (1 – Poor, 5 – Excellent)

Foundation Type	**Rating (1–5)**
Isolated Footing	
Combined Footing	
Raft Foundation	

Foundation Type Rating (1–5)

Pile Foundation

Caisson

Screw Piles

9. **Which foundation type performs best on weak soil in your experience?**

10. **Have you experienced foundation failure in your projects?**

    ☐ Yes ☐ No

    If yes, what type of foundation was it? ____________________

    What were the causes? ____

Section D: Cost and Construction

11. **Rank the following foundation types from 1 (Least Expensive) to 6 (Most Expensive):**

    ☐ Isolated Footing ☐ Combined Footing ☐ Raft Foundation ☐ Pile Foundation ☐ Caisson ☐ Screw Piles

12. **Which foundation type do you consider most economical for large buildings?**

13. **On average, how long does it take to complete the foundation stage in your projects?**

    ☐ <2 weeks ☐ 2–4 weeks ☐ 4–8 weeks ☐ >8 weeks

Section E: Environmental and Sustainability Considerations

14. **Do you consider environmental impact when choosing foundation types?**

    ☐ Yes ☐ No

15. **Which foundation types do you consider more environmentally friendly? (You may choose more than one)**

    ☐ Screw Piles ☐ Raft Foundation ☐ Isolated Footing

    ☐ Others: ____________________

16. **Have you ever used recycled or sustainable materials in foundation construction?**

    ☐ Yes ☐ No

    If yes, please specify: ______________________________________

Section F: Additional Comments

17. **What factors most influence your choice of foundation?**

    ☐ Soil condition ☐ Load requirements ☐ Cost

    ☐ Speed of construction ☐ Environmental concerns ☐ Others: _____________

18. **Do you have suggestions for improving foundation practices in your region?**

Link to the Questionnaire Specimen:

https://forms.gle/geobZXsT2h48vtKw8