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The Foundations in Construction a General and Comprehensive Study from an Engineering and Historical Perspective

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Abstract

The bottom base of the structure is the very uppermost part because it connects the superstructure of the body to the ground. This bottom base is known as the foundation. In this paper we will discuss and analyze the types of foundations used in the construction industry, there is a design and also in alternative materials that we can use as foundation materials in construction that can make it more solid, durable and environmentally friendly. It is critical to build a stable base that maintains the superstructure in all climatic conditions without collapsing or deteriorating the concrete structure. If any unsuitable material is used for the foundation of the structure, the high risk is the collapse of the structure. Different types of foundation base are used in different types of structural structures, each with a unique design and specific configuration that makes a particular structure more durable and stable. A different type of foundation is used in cottages and high-rise buildings. This study presents the use of foundations for the superstructure, and appropriate design, and we will discuss more precisely about how to make the foundation foundation environmentally friendly, cost-effective for the structural building, and make it more durable and strong to withstand natural and environmental disasters.

Keywords:
Building Foundation, Construction Foundation, Foundation Engineering.

1. Introduction

Foundation engineering is an important branch of geotechnical engineering that applies soil mechanics, structural engineering, and project service requirements to the design and construction of foundations for onshore and offshore structures. Foundation engineering can be achieved as a technical approach rather than a routine procedure because well-designed and built foundations continue to perform efficiently during the life of the project. The main task and objective of the foundation engineer is to create a technically sound, practicable, and economical design of the foundation system to support the infrastructure.

Foundation systems are structural units that transfer various combinations of loads from the superstructure to the underlying soil or rock. Foundation units may bear loads individually or through the contribution of other elements such as basement walls, floors, slabs, etc.

2. Literature Review

2.1 Comprehensive Study of the Mechanical and Durability Properties of High-Performance Concrete Materials for Grouting Underwater Foundations of Offshore Wind Turbines:

With the increasing importance of offshore wind turbines, a critical issue in their construction is the high-performance concrete (HPC) used for grouting underwater foundations, as such materials must be better able to withstand the extremes of the surrounding natural environment. This study produced and tested 12 concrete sample types by varying the water/binder ratio (0.28 and 0.30), the replacement ratios for fly ash (0%, 10%, and 20%) and silica fume (0% and 10%), as substitutes for cement, with ground granulated blast-furnace slag at a fixed proportion of 30%. The workability of fresh HPC is discussed with setting time, slump, and V-funnel flow properties. The hardened mechanical properties of the samples were tested at 1, 7, 28, 56, and 91 days, and durability tests were performed at 28, 56, and 91 days. Our results show that both fly ash (at 20%) and silica fume (at 10%) are required for effective filling of interstices and better pozzolanic reactions over time to produce HPC that is durable enough to withstand acid sulfate and chloride ion attacks, and we recommend this admixture for the best proportioning of HPC suitable for constructing offshore wind turbine foundations under the harsh underwater conditions of the Taiwan Bank. We established a model to predict a durability parameter (i.e., chloride permeability) of a sample using another mechanical property (i.e., compressive strength), or vice versa, using the observable relationship between them. This concept can be generalized to other pairs of parameters and across different parametric categories, and the regression model will make future experiments

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less laborious and time-consuming. This paper traces the development of the craft and science of foundation engineering in the UK during the last 100 years drawing mainly on papers published in The Structural Engineer.

Figure 1. Building Foundation in Construction

2.2 Analytical Calculation of Critical Anchoring Length of Steel Bar and GFRP Antifloating Anchors in Rock Foundation:

Antifloating anchors are widely used during the construction of slab foundations to prevent uplift. However, existing methods for calculating the critical length of these anchors have limited capabilities and therefore require further research. As the mechanisms which govern the displacement and stability of antifloating anchors are closely related to those of piles subject to uplift, a simplified anchor model has been developed based on existing concentric thin-walled cylinder shear transfer models used for pile design. Analytical expressions for the critical length of the steel bar and GFRP (glass fiber reinforced polymer) antifloating anchors in rock are derived accordingly before demonstrating the validity of the method through engineering examples. The research results show that when the length of an antifloating anchor is less than a critical length, shear slip failure occurs between the anchor and surrounding material due to excessive shear stress. When the length of an anchor approaches the critical length, the shear stress gradually decreases to the undisturbed state. If the anchor length is larger than the critical length, the uplift loads are safely transferred to the ground without causing failure. The ratio of elastic modulus between the anchor and rock mass was found to be positively correlated with the critical anchoring length. Because the elastic modulus of GFRP bars is lower than that of steel bars, the critical anchoring length of GFRP bars is greater than that of steel bars under the same anchor-to-rock modulus ratio (Ea/Es). The results show that the proposed calculation method for the critical length of antifloating anchors appears valid and could provide a theoretical basis for the design of antifloating anchors after further refinement.

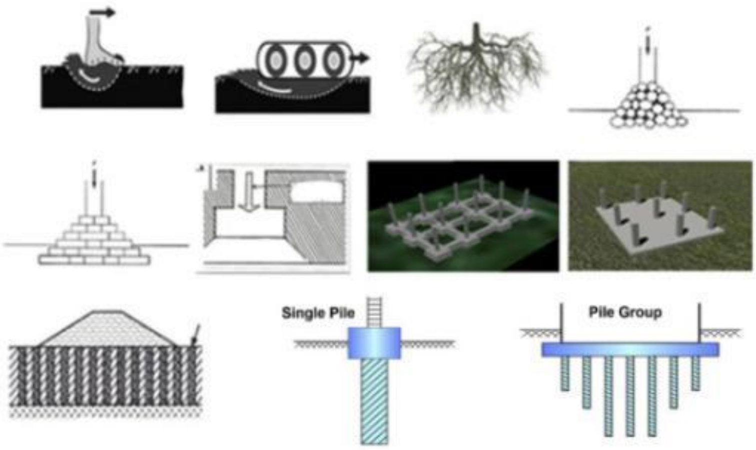

Figure 2. Various elements acting as foundation systems.

2.3. Historical and Engineering View on Foundations of Construction

The foundation is the concrete structural base that stands on the ground and supports the rest of the building. Therefore, some concrete foundation design must include extensive study of the land under the

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foundation as well as the constructive design and materials used in the foundation itself (American Concrete Institute).

The foundations are designed so that the loads imposed by the building are transferred uniformly to the contact surface to transmit and carry the wind to the ground. The net bearing capacity coming into the soil shall not exceed the bearing capacity of the soil. The design of the foundation must also take into account the stability expected from the building to ensure that all movements are controlled and standardized to prevent damage to the concrete structure. The overall design and land characteristics must be studied to determine potentially beneficial construction strategies (Malabi Eberhardt et al. 2020).

Foundation building is one of the oldest human activities, as foundations provide support for structures by transferring their load to the layers of soil or rock beneath them. Over 12,000 years ago, Neolithic Switzerland built homes on tall wooden piles, keeping people high above dangerous animals and hostile neighbors. A few thousand years later, the Babylonians raised their footprints on reed mats, and the ancient Egyptians supported the pyramids on stone blocks that rested on the bedrock. In ancient Rome foundation engineering really took a leap forward, with rules set and concretely used that chart the history of modern building elements in the UK We take a look at how foundation engineering has changed over the past century.

Building history embraces many other fields such as structural engineering, civil engineering, city growth and population growth who are close relatives of the branches of technology and history to investigate building preservation and record their achievements. These fields allow it to be used to analyze modern or the most recent and prehistoric constructions, such as the structures, building and materials. The foundations are designed so that the loads imposed by the building are transferred uniformly to the contact surface to transmit and carry the wind to the ground. The net bearing capacity coming into the soil shall not exceed the bearing capacity of the soil. The design of the foundation must also take into account the stability expected from the building to ensure that all movements are controlled and standardized to prevent damage to the concrete structure. The overall design and land characteristics must be studied to determine potentially beneficial construction strategies. The outline and design of shallow and deep foundation construction are analyzed, designed and built, as well as the methods used in other countries are discussed. Presents the main methods used by geotechnical and structural engineers, and the necessary precautions in the planning and design of concrete infrastructure (Office 2006).

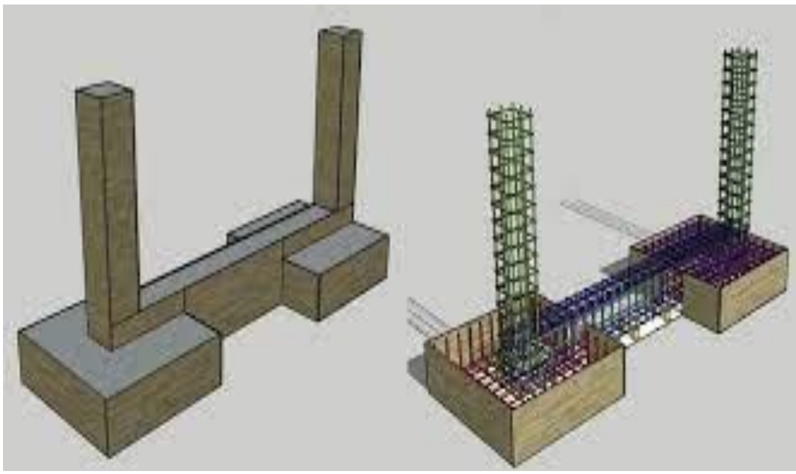

Figure 3. View on foundations of construction

3. Methodology

3.1. Research Method

There are a variety of methods for determining the bearing capacity of guard foundations on soils. Typical unpolished shear strength and values are also given for different types of materials. The assumed stresses allowed are usually based on empirical correlations and are intended to be used without much testing and design evaluation and quantitative analysis will be used. A preliminary estimate of the permissible bearing pressure can be obtained on the basis of soil descriptions. Other methods involve correlating bearing stresses with internal field test results, such as the tip value and resistance.

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3.2 Research Design and Sample for the Topic of the Research and its Theories:

$$q_u = \frac{Q_u}{B_f'L_f'} = c'\, N_c\, \zeta_{cs}\, \zeta_{ci}\, \zeta_{ct}\, \zeta_{cg} + 0.5\, B_f'\, \gamma_s'\, N_\gamma\, \zeta_{\gamma s}\, \zeta_{\gamma i}\, \zeta_{\gamma t}\, \zeta_{\gamma g} + q\, N_q\, \zeta_{qs}\, \zeta_{qi}\, \zeta_{qt}\, \zeta_{qg}$$

where N_c, N_γ, N_q = general bearing capacity factors which determine the capacity of a long strip footing acting on the surface of a soil in a homogenous half-space

Q_u = ultimate resistance against bearing capacity failure
q_u = ultimate bearing capacity of foundation
q = overburden pressure at the level of foundation base
c' = effective cohesion of soil
γ_s' = effective unit weight of the soil
B_f = least dimension of footing
L_f = longer dimension of footing
B_f' = $B_f - 2e_B$
L_f' = $L_f - 2e_L$
e_L = eccentricity of load along L direction
e_B = eccentricity of load along B direction
$\zeta_{cs}, \zeta_{\gamma s}, \zeta_{qs}$ = influence factors for shape of shallow foundation
$\zeta_{ci}, \zeta_{\gamma i}, \zeta_{qi}$ = influence factors for inclination of load
$\zeta_{cg}, \zeta_{\gamma g}, \zeta_{qg}$ = influence factors for ground surface
$\zeta_{ct}, \zeta_{\gamma t}, \zeta_{qt}$ = influence factors for tilting of foundation base

Figure 4.the generalized loading and geometric parameters for the design of shallow foundation

In selecting φ ' value for foundation design, attention should be given to the stress-dependency of the strength envelope of soils.

Kimmerling (2002) suggested using the actual dimensions, Bf and L f, to compute the influence factors for shape of shallow foundation. The equations for computing shape factors given in Figure 4.III.2 use the full dimensions of a shallow foundation.

3.2. Method of data collection

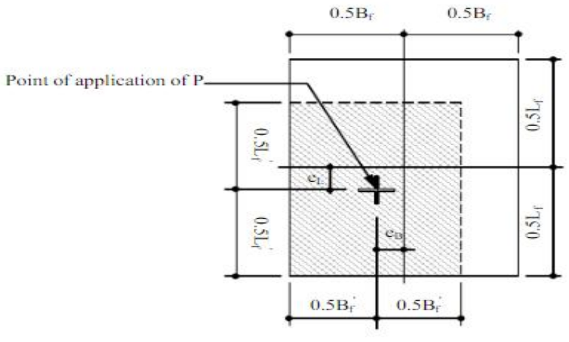

Figure 5. Force Acting on a Spread Foundation

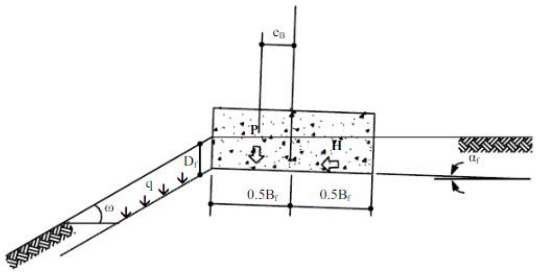

Figure 6. Effective Dimensions of Foundation Base

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3.3. Method of data analysis:

The presence of geological features such as weak strata or discontinuities can lead to failure mechanisms different from those assumed to derive the equation. An approximate method for determining the final bearing capacity of a foundation is given near the slope top. Therefore, the presence of geological features, especially weak soil layers, should be checked in investigations floor.

The final bearing capacity can be obtained by linear interpolation between the value of the foundation resting at the edge of the slope and the following equation can be used to estimate the final bearing capacity of the foundation on the top of the slope and the evaluation of the bearing capacity should take into account the geological characteristics of the land.

$$Sc = \frac{C\alpha}{1 + eo} \, Ho \log \frac{ts}{tp}$$

Where:

Sc = secondary consolidation
Cα = secondary compression index
eo = initial void ratio
Ho = thickness of soils subject to secondary consolidation
Tp = time when primary consolidation completes
ts = time for which secondary consolidation is allowed

4. General Analysis:

Foundation is suitable when the underlying soil has a low bearing capacity or large differential settlements are expected. It is also suitable for land with pockets of loose and soft soil. The advantage of a cellular raft is that it can reduce the overall weight of the foundation and therefore the net pressure applied to the ground. The cell raft must be provided with sufficient rigidity to reduce differential flattening. In some cases, the raft foundation is designed as a cellular structure where deep hollow boxes are formed in the concrete slab.

Where qnet = net ground bearing pressure
δp = settlement of the test plate
Is = shape factor
b = width of the test plate
νs = Poisson's ratio of the soil
Es = Young's modulus of soil

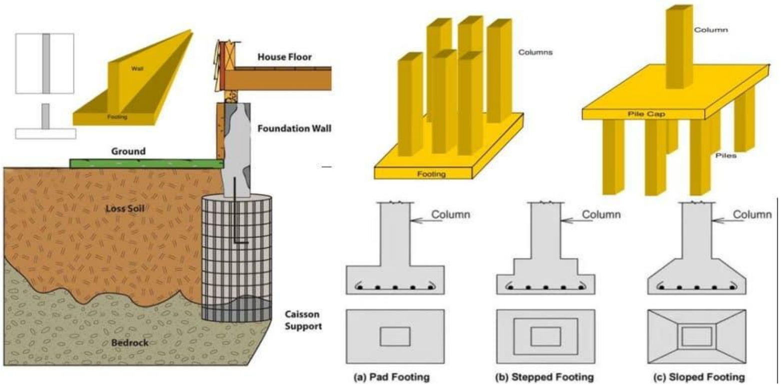

Figure 7. Types of Foundation

The method for extrapolating plate loading test results to estimate the settlement of a full-size footing on granular soils is not standardized. The increase of stress in soils due to foundation load can be calculated by assuming an angle of stress dispersion from the base of a shallow foundation. This angle may be approximated as a ratio of 2 (vertical) to 1 (horizontal) (Bowles 1992). The settlement of the foundation can then be computed by calculating the vertical compressive strains caused by the stress increases in individual layers and summing the compression of the layers.

4.1. The reason for the global trend of connected rather than separate foundations:

4.1.1 Connected foundations

Is an effective structural type of foundation that can improve the sustainability of electrical transmission towers in soft soils to serve as a resilient energy supply system. In this study, the performance of electrical transmission towers reinforced with connected beams was investigated using a series of field load tests. Model

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transmission tower structures were manufactured and adopted into the tests. Based on the load capacity mobilization and failure mechanism, a criterion to define the load carrying capacity for connected foundation was proposed. It was found that the performance of connected foundation varies with the mechanical property of connection beam.

The load capacity and differential settlement increased and decreased, respectively, with increasing connection beam stiffness. Such effect of connection beam was more pronounced as the height of load application point or tower height increases. Based on the load test results, a design model was proposed that can be used to evaluate the sustainable performance and load carrying capacity of connected foundations. Field load tests with prototype transmission tower structure models were conducted to check and confirm the performance of connected foundation and the proposed design method.

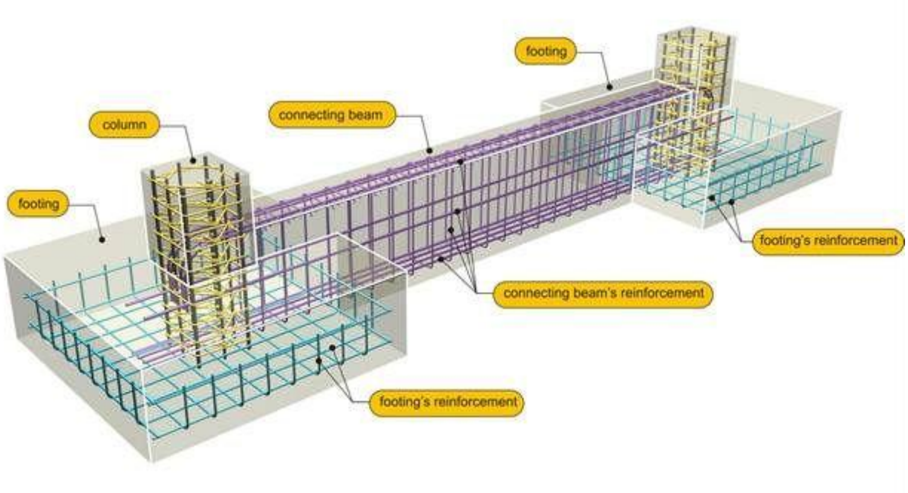

Figure 8. Connected foundations

4.1.2 Unconnected foundations

The piled raft foundations are an economical solution as well as a settlement reducer in the construction of high-rise buildings. Unconnected piled raft foundation is an innovative technique where a cushion separates the pile and raft. The cushion takes the load transferred from the raft and safely distributes over the piles beneath.

This article analyses the seismic behaviour of connected and unconnected piled raft foundation of a multistorey building using ANSYS software based on the finite element method. An 8 m × 8 m × 1 m raft and 0.4 m × 0.4 m square concrete piles with depth of 12 m resting on a very soft clay stratum were modelled. The soil block of 16 m × 16 m plan dimension with a depth of 16 m was provided with transmitting boundaries at all lateral edges with properties corresponding to shear wave velocity of clay (150 m/s) and was analysed for the response under the ground motion corresponding to El Centro 1940 earthquake.

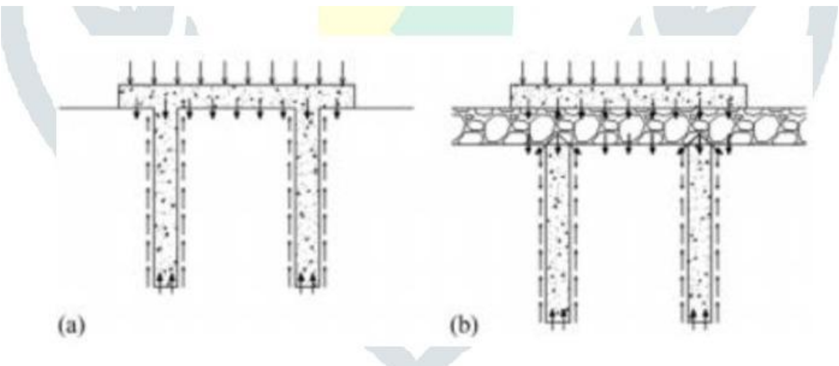

Figure 9. Unconnected foundations

4.2. Engineering influences in the future on the foundations of all kinds and the extent to which this will affect the quality of construction in the future:

The world is changing faster than ever. Just think of one of the world major trends shake up the construction industry: the world's population urban areas are increasing by 200,000 people per day, all of them need affordable cost housing as well as social infrastructure, transportation and utilities. In a confrontation such challenges, the industry is almost under an ethical obligation to transform that it the shift will have transformative effects elsewhere: on the broader society.

5. Summary and Conclusions:

This paper identified the following three-stage process for
Design of foundations for tall buildings:

1. An initial design stage, which initially provides basis for the development of foundation concepts and the cost.
2. The detailed design stage in which some previous studies are done and the foundations are selected and the concept is analyzed and incremental improvements are made to the layout and details of the foundation system. It is recommended that this stage be done collaboratively with the structural designer, such as the concrete structure.
3. The final design stage, in which both the concrete foundation analysis is done and the parameters used in the analysis are completed.

6. Acknowledgement

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