A Strip Footing 2.5 M Wide Is Loaded On The Ground Surface With A Pressure Equal To 175 Kpa. Calculate

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Understanding how to analyze and design foundations is a fundamental aspect of geotechnical engineering. When a strip footing is subjected to a specific load, engineers must determine whether the ground can safely support the load without excessive settlement or failure. In this article, we explore the detailed calculation process for a strip footing that is 2.5 meters wide and is loaded with a pressure of 175 KPa. We will delve into the concepts of bearing capacity, settlement estimation, and safety factors, providing comprehensive insights suitable for students, professionals, and enthusiasts alike.

Introduction to Strip Footings and their Significance in Foundation Engineering

Before diving into calculations, it’s essential to understand what strip footings are and their role in construction.

What is a Strip Footing?

A strip footing is a type of shallow foundation used primarily to support load-bearing walls. It distributes the load of the structure over a wider area of ground, thereby reducing the pressure exerted on the soil.

Key features of strip footings include:
- Usually rectangular in shape
- Designed to carry loads from load-bearing walls
- Commonly used in both residential and commercial buildings
- Typically placed at shallow depths

Importance of Proper Foundation Design

Foundation design ensures the stability and durability of structures by:
- Preventing excessive settlement
- Avoiding shear failure
- Ensuring even load distribution

- Protecting against potential ground failure

Parameters and Data for Calculation

To analyze the footing, we need to understand the parameters involved:
- Width of the strip footing, $B = 2.5\, \text{m}$
- Applied pressure or load intensity, $q = 175\, \text{kPa}$
- Soil properties (assumed or given):
- Cohesion, c
- Internal friction angle, ϕ
- Soil type and its bearing capacity parameters
- Depth of footing, D (if available)

Since the problem does not specify soil parameters, we'll assume typical values for a medium-cohesion soil to illustrate the calculation process.

Calculating the Total Load on the Footing

The first step is to determine the total load transmitted through the footing based on the given pressure.

Total Load Calculation

The total load Q supported by the footing can be calculated as:

$$
Q = q \times A
$$

Where:
- $q = 175\, \text{kPa}$ (pressure)
- A = area of the footing

Since the footing is 2.5 meters wide, and assuming a length L, the area $A = B \times L$.

However, for the purpose of calculation, often we analyze the load per unit length of the footing, especially since the footing is strip-shaped.

$$
Q_{\text{per unit length}} = q \times B
$$

Calculating:

$$
Q_{\text{per unit length}} = 175\, \text{kPa} \times 2.5\, \text{m} = 175\, \text{kPa} \times 2.5\, \text{m} = 437.5\, \text{kN/m}
$$

This indicates that per meter length of the footing, it supports a load of 437.5 kN.

Understanding Soil Bearing Capacity

The capacity of the ground to support the load depends on soil properties. The ultimate bearing capacity q_u can be estimated using classical theories such as Terzaghi's bearing capacity equation.

Terzaghi’s Bearing Capacity Formula

$$
q_u = c N_{c} + \sigma_{0} N_{q} + 0.5 \gamma B N_{\gamma}
$$

Where:
- c = cohesion of soil
- σ_{0} = effective vertical stress at the footing level
- γ = unit weight of soil
- N_{c}, N_{q}, N_{γ} = bearing capacity factors depending on the angle of internal friction ϕ

Assumed typical values for medium cohesive soils:
- $c = 25\, \text{kPa}$
- $\phi = 20^\circ$
- $\gamma = 18\, \text{kN/m}^3$
- Depth D = 1.5 m (assumed)

Calculating the bearing capacity factors:

$$
N_{c} = (N_{c} \text{ for } \phi) \approx 20
$$
$$
N_{q} = (N_{q} \text{ for } \phi) \approx 12
$$
$$
N_{\gamma} = (N_{\gamma} \text{ for } \phi) \approx 12

\]

Effective vertical stress:

$$
\sigma_{0} = \gamma \times D = 18\, \text{kN/m}^3 \times 1.5\, \text{m} = 27\, \text{kPa}
$$

Calculating ultimate bearing capacity:

$$
q_u = 25 \times 20 + 27 \times 12 + 0.5 \times 18 \times 2.5 \times 12
$$
$$
q_u = 500 + 324 + 0.5 \times 18 \times 2.5 \times 12
$$
$$
q_u = 500 + 324 + 0.5 \times 18 \times 30
$$
$$
q_u = 500 + 324 + 0.5 \times 540
$$
$$
q_u = 500 + 324 + 270 = 1094\, \text{kPa}
$$

Design bearing capacity (allowing for safety factors):

Applying a factor of safety (usually 3):

$$
q_{allow} = \frac{q_u}{FS} = \frac{1094}{3} \approx 365\, \text{kPa}
$$

Since the applied pressure $q = 175\, \text{kPa}$ is less than the allowable bearing capacity, the footing design appears safe regarding bearing capacity.

Settlement Analysis of the Strip Footing

Apart from bearing capacity, settlement is a critical consideration.

Estimating Settlement

Settlement S can be estimated using:

$$
S = \frac{q \times B \times (1 - \nu^2)}{E_s}
$$

Where:
- ν = Poisson's ratio (assumed 0.3)
- E_s = modulus of elasticity of soil (assumed 25 MPa for medium soil)

Calculations:

$$
S = \frac{175\, \text{kPa} \times 2.5\, \text{m} \times (1 - 0.3^2)}{25,000\, \text{kPa}}
$$
$$
S = \frac{175 \times 2.5 \times (1 - 0.09)}{25,000}
$$
$$
S = \frac{175 \times 2.5 \times 0.91}{25,000}
$$
$$
S = \frac{398.125}{25,000} \approx 0.0159\, \text{m} = 15.9\, \text{mm}
$$

The settlement of approximately 16 mm is acceptable for most construction standards, which typically allow settlements up to 25 mm.

Summary of Key Findings

- The applied pressure of 175 KPa on a 2.5-meter-wide strip footing results in a total load of 437.5 kN per meter length.
- Using Terzaghi’s bearing capacity theory, the ultimate bearing capacity of the soil is approximately 1094 KPa, with an allowable capacity of about 365 KPa considering a safety factor of 3.
- The applied pressure is well within safe limits, indicating the footing design is adequate in terms of bearing capacity.
- Estimated settlement of around 16 mm is within acceptable limits, ensuring minimal structural issues over time.
- Proper design should also consider other factors such as overturning, sliding, and local shear failure, which require detailed analysis.

Design Recommendations for Engineers

To optimize foundation safety and performance, engineers should adhere to the following guidelines:

1. Verify soil properties through geotechnical investigations before final design.
2. Apply appropriate safety factors based on soil variability and load uncertainties.
3. Ensure the footing is placed at a depth that minimizes frost action and reduces settlement.
4. Consider reinforcement and drainage provisions to enhance foundation stability.
5. Use proper construction techniques to prevent soil disturbance and ensure load transfer efficiency.

Conclusion

The analysis of a strip footing with a width of 2.5 meters subjected to a pressure of 175 KPa demonstrates that, with typical soil parameters, the foundation design is safe and efficient. The calculations confirm that the soil

Frequently Asked Questions

What is the maximum load capacity of a 2.5 m wide strip footing subjected to a pressure of 175 kPa?

The maximum load capacity is calculated by multiplying the footing area by the pressure: Load = Area × Pressure = 2.5 m × length × 175 kPa. To find the total load, the length of the footing must be known.

How do you determine the total load supported by a

strip footing that is 2.5 meters wide under a pressure of 175 kPa?

The total load is found by multiplying the footing's surface area (width × length) by the pressure. Without the length, only the load per unit length can be calculated as 2.5 m × 175 kPa.

If a strip footing is 2.5 meters wide and experiences a pressure of 175 kPa, what is the load per unit length?

The load per unit length is calculated as width × pressure = 2.5 m × 175 kPa = 437.5 kN/m.

What considerations are important when designing a strip footing with a width of 2.5 meters loaded at 175 kPa?

Design considerations include soil bearing capacity, footing size and reinforcement, load distribution, and safety factors to prevent failure or excessive settlement.

How does the pressure of 175 kPa influence the design of a 2.5 m wide strip footing?

The pressure determines the load the footing must support; it influences the footing's dimensions, reinforcement requirements, and the foundation design to ensure safe load transfer to the ground.

Additional Resources

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Introduction

In geotechnical engineering, understanding the bearing capacity of soils and the behavior of foundations under various loading conditions is fundamental to ensuring structural safety and efficiency. Among common foundation types, strip footings are widely used for load transfer in load-bearing walls and linear structures such as railways, roads, and pipelines. The scenario where a strip footing, measuring 2.5 meters in width, is subjected to a pressure of 175 kPa on the ground surface is an illustrative case that embodies core principles in foundation design and soil mechanics.

This article delves into the comprehensive analysis of this problem, aiming to calculate the ultimate bearing capacity and related parameters. We will explore the theoretical background, assumptions, and step-by-step calculations rooted in classical geotechnical methodologies. The discussion will also address factors influencing the calculation, including soil properties, footing dimensions, and safety considerations.

Background and Significance

The Role of Strip Footings in Structural Engineering

Strip footings serve as continuous foundations supporting load-bearing walls or long, linear structures. They are typically designed to distribute loads evenly across the supporting soil, minimizing settlement and preventing failure. Accurate calculation of the bearing capacity is crucial for:

- Ensuring the stability of the structure
- Preventing excessive settlement
- Optimizing foundation dimensions for cost-effectiveness
- Complying with safety standards and codes

The Challenge of Load and Soil Interaction

When a footing is loaded, it exerts pressure on the soil surface. If the applied pressure exceeds the soil's bearing capacity, failure may occur in the form of shear failure or excessive settlement. Therefore, the primary objective is to determine whether the soil can safely support the applied load and to design the footing accordingly.

Problem Statement and Data Overview

The problem involves a strip footing with the following characteristics:

- Width of footing (B): 2.5 meters
- Applied pressure on ground surface (q): 175 kPa
- Soil properties: Not explicitly provided, but typically, calculations rely on soil parameters such as cohesion (c), internal friction angle (ϕ), and unit weight (γ).

The primary goal is to compute the ultimate bearing capacity of the soil under these loading conditions and to assess whether the footing's design is safe.

Fundamental Concepts and Theoretical Framework

Bearing Capacity Theory

The classical approach to foundation bearing capacity is based on Terzaghi's ultimate bearing capacity equation, which considers the contributions of soil cohesion, internal friction, and surcharge effects.

The ultimate bearing capacity (q_u) for shallow foundations is given as:

$$q_u = c N_c + \gamma D_f N_q + 0.5 \gamma B N_\gamma$$

Where:

- c: Cohesion of soil (kPa)
- γ: Unit weight of soil (kPa/m)
- D_f: Depth of footing below ground surface (m)
- B: Width of footing (m)
- N_c, N_q, N_γ: Bearing capacity factors dependent on the soil's internal friction angle (ϕ)

Assumptions in Calculations

- The soil is homogeneous, isotropic, and elastic-perfectly plastic.
- The footing is rigid, and settlement is within permissible limits.
- The load is uniformly distributed.
- Depth of footing (D_f) is known or assumed; in many cases, D_f is taken as $B/2$ for shallow foundations.

Selection of Soil Parameters

Since the problem does not specify soil parameters, typical values or assumptions are used for illustrative purposes:

- Cohesion, c: 30 kPa (clayey soil)
- Internal friction angle, ϕ: 30°
- Unit weight, γ: 18 kN/m^3
- Depth of footing, D_f: 1.25 m (assuming $D_f = B/2$)

Step-by-Step Calculation

Step 1: Determine Bearing Capacity Factors

For $\phi = 30°$, the bearing capacity factors are:

- $N_c \approx 37.2$
- $N_q \approx 23.5$
- $N_\gamma \approx 19.7$

These values are obtained from standard tables or calculations based on the logarithmic relationships.

Step 2: Calculate Components of Ultimate Bearing Capacity

Using the assumed parameters:

- Cohesion term: $c N_c = 30 \times 37.2 = 1116$ kPa·m²
- Surcharge term: $\gamma D_f N_q = 18 \times 1.25 \times 23.5 = 18 \times 1.25 \times 23.5 = 529.125$ kPa·m²
- Friction term: $0.5 \gamma B N_\gamma = 0.5 \times 18 \times 2.5 \times 19.7 = 0.5 \times 18 \times 2.5 \times 19.7 = 443.0$ kPa·m²

Step 3: Calculate Ultimate Bearing Capacity

Summing the components:

$q_u = 1116 + 529.125 + 443.0 = 2088.125$ kPa

This is the ultimate bearing capacity (q_u).

Step 4: Calculate Allowable Bearing Capacity

Applying a factor of safety (usually between 3 and 3.5):

- For safety, select FS = 3

Allowable bearing capacity (q_a):

$q_a = q_u / FS = 2088.125 / 3 \approx 696$ kPa

Interpretation of Results

The applied pressure on the ground surface is 175 kPa, which is significantly less than the calculated allowable bearing capacity of approximately 696 kPa. This indicates:

- The footing, under the given assumptions, is capable of safely supporting the load.
- The design provides a safety margin against failure.

Factors That May Affect Actual Capacity

- Variability in soil parameters
- Settlement considerations
- Load eccentricity
- Water table effects
- Construction quality and footing embedment depth

Advanced Considerations and Practical Applications

Influence of Depth

Increasing the depth Df generally increases the surcharge component, thereby raising the ultimate bearing capacity. Conversely, shallow foundations are more susceptible to failure if soil parameters are weak.

Effect of Soil Type

Different soils necessitate different parameters:

- Sandy soils: high friction angle, low cohesion
- Clayey soils: higher cohesion, lower friction angle
- Silts: intermediate properties

Load Distribution and Structural Considerations

The uniform load assumption is idealized; actual load distributions may vary, necessitating detailed structural analysis.

Code Compliance

Designs must adhere to local codes such as Eurocode 7, AASHTO, or Indian Standards, which specify safety factors, testing procedures, and permissible settlement limits.

Conclusion

The analysis of a strip footing 2.5 meters wide subjected to a surface pressure of 175 kPa demonstrates that, with typical soil parameters, the footing is within safe bearing limits. The calculated ultimate capacity of approximately 2088 kPa and the allowable capacity of about 696 kPa provide a substantial margin of safety.

This case exemplifies the importance of accurate soil characterization and adherence to classical geotechnical principles in foundation design. It underscores that, even with simplified assumptions, fundamental calculations can guide safe and efficient foundation engineering practices.

References

- Das, B. M. (2016). Principles of Foundation Engineering. Cengage Learning.
- Bowles, J. E. (1996). Foundation Analysis and Design. McGraw-Hill.
- Terzaghi, K., Peck, R. B., & Mesri, G. (1996). Soil Mechanics in Engineering Practice. Wiley.

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Note: Actual project designs must incorporate site-specific soil
investigations, detailed load assessments, and compliance with relevant
standards.
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