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Comparative Assessment of Presumptive and Field-Based Soil Bearing Capacity in Cabanatuan City, Philippines

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ABSTRACT: This research presents a geotechnical comparative screening between theoretical and empirical soil bearing capacities across 13 selected data nodes in Cabanatuan City. Utilizing the Philippine Geoportal database for initial soil classification, the study identified a subsurface dominated by Fine Sand and various Loams, reflecting the alluvial depositional history of the Pampanga River Basin. Theoretical baselines were established using IBC 2024 presumptive allowable bearing capacities, yielding a constrained range of 71.82 kPa to 95.76 kPa. Conversely, site-specific Standard Penetration Test (SPT) data from available DPWH borehole logs were analyzed. Using empirical correlations to derive allowable bearing capacities (q_{field}) from N-values, results revealed a highly heterogeneous subsurface ranging from 45 kPa to 225 kPa. While the IBC framework was conservative in 62% of locations, field-based values in 5 out of 13 sampled sites exhibited lower field-based values than the corresponding IBC presumptive values. This indicates potentially unconservative assumptions in specific zones if presumptive values are utilized without site-specific verification. The study concludes that international codes provide a necessary administrative baseline but cannot fully capture the observed 180 KPa variation among the investigated samples. Consequently, site-specific geotechnical investigations remain indispensable for ensuring structural integrity and design optimization in complex alluvial environments.

KEYWORDS: Geotechnical Engineering, Soil Bearing Capacity, IBC 2024, Cabanatuan City, GIS Mapping, DPWH Borehole Logs

I. INTRODUCTION

Cabanatuan City is continuously growing as one of the key urban centers in Central Luzon. From being largely agricultural in the past, the city is now experiencing steady commercial and infrastructure development. Because of its accessible location and expanding economy, more buildings and projects are being established in built-up environments across the city. With this rapid growth, it becomes increasingly important to ensure that these structures are built on safe and stable ground.

One of the most important considerations in construction is the soil's bearing capacity, or its ability to support the weight of a structure. This factor plays a major role in foundation design and overall structural safety. However, soil conditions in Cabanatuan City are not uniform. Since the area is largely composed of alluvial deposits, soil strength can vary significantly from one location to another. If these variations are not properly assessed, they may lead to problems such as uneven settlement or structural damage over time.

To estimate soil bearing capacity, engineers commonly use two approaches: presumptive values provided in design codes and site-specific field investigations. In this study, the International Building Code (IBC) 2024 is adopted as the primary reference standard for assigning presumptive values. While these values establish a standardized administrative baseline and legal minimum for foundation pressures, they are based on broad classifications that may not adequately capture localized soil variability found in local urban environments.

Because of the different methodologies behind these two approaches, it is important to understand how presumptive values align with actual field data, especially in a developing area like Cabanatuan City. Modern tools such as geospatial mapping make it easier to analyze soil conditions across multiple locations. By combining available data and presenting them visually, engineers can better understand how soil bearing capacity varies and identify areas that may require further investigation.

In line with this, the study focuses on the comparative assessment of presumptive and field-based soil bearing capacity in selected areas of Cabanatuan City. By analyzing and comparing these methods, the research aims to provide clearer insights into soil conditions and support safer, more informed construction practices.

1.1 Background of the Study

Cabanatuan City, located in the heart of Nueva Ecija, is recognized as one of the most progressive urban centers in Central Luzon. As a major hub for trade and services, its strategic position along key road networks has enabled continuous urban expansion. Over time, this growth has transformed large portions of land, previously dominated by agricultural use, into built-up environments to accommodate a population that reached more than 327,000 as of recent census data.

With this rapid urbanization, the demand for safe and stable construction sites has significantly increased. However, Cabanatuan City is situated within a predominantly alluvial plain, where soil conditions vary widely depending on location and composition. These variations directly affect shallow soil bearing capacity, which is a critical factor in civil engineering design. This capacity determines the ability of the ground to support structural loads without excessive settlement or failure. In areas with weak or compressible soils, improper assessment may lead to structural damage, such as cracks or foundation failure. Therefore, performing a preliminary assessment of the city's subsurface is essential for the longevity of infrastructure projects.

The continuous conversion of agricultural lands into residential and commercial zones introduces additional challenges, as soils once suitable for farming are not always ideal for supporting heavy structures. The increasing number of buildings in the city highlights the importance of conducting systematic soil evaluation. Previous studies in the Philippines emphasize that mapping soil properties provides engineers with valuable information about subsurface conditions and helps guide appropriate foundation design. Such data-driven approaches reduce uncertainties in land development.

In this context, the preliminary assessment of shallow soil bearing capacity becomes a valuable tool for urban planning. By utilizing secondary data, such as soil type classifications from the Philippine Geoportal, and correlating them with prescriptive values from the 2024 International Building Code (IBC), it is possible to generate spatial representations of soil strength. Furthermore, verifying these estimates against empirical borehole data from the DPWH allows for a more localized understanding of selected subsurface conditions within the city's geotechnical landscape.

1.2 Statement of the Problem

This study aims to assess and compare soil bearing capacity estimates derived from code-based presumptive values and available field measurements in Cabanatuan City. Specifically, it seeks to answer the following questions:

1. What are the dominant soil types in Cabanatuan City based on available GIS soil data?
2. What are the corresponding presumptive allowable soil bearing capacity values based on IBC 2024 for these soil types?
3. How can these values be spatially represented to produce a preliminary soil bearing capacity map?
4. What are the soil bearing capacity values obtained from DPWH data at selected barangays?
5. How do the IBC-based presumptive values compare with the available DPWH field measurements?
6. What differences can be observed between code-based estimates and field-based values, and what factors may explain these differences?

1.3 Objectives of the Study

The primary goal of this study is to evaluate the reliability of code-based soil bearing capacity estimates by comparing them against actual field data within Cabanatuan City. The specific objectives are:

1. To identify and classify the dominant soil types across Cabanatuan City using Geographic Information System (GIS) soil data.
2. To determine the presumptive allowable soil bearing capacity values for the identified soil types in accordance with the International Building Code (IBC) 2024 standards.
3. To develop a preliminary spatial soil bearing capacity map of the city by integrating IBC presumptive values into a GIS framework.
4. To extract and tabulate actual soil bearing capacity values from Department of Public Works and Highways (DPWH) borehole and field test data at selected barangays.
5. To perform a comparative analysis between the IBC-based presumptive values and the DPWH field measurements to determine the observed differences or variance.
6. To analyze possible geotechnical factors that may contribute to discrepancies between code-based estimates and localized field-derived values.

1.4 Significance of the Study

This study focuses on the comparative assessment of presumptive and field-based soil bearing capacity in selected areas of Cabanatuan City, a rapidly developing urban center where agricultural lands are continuously being converted into residential, commercial, and infrastructure developments. As the city grows, the need for reliable information about ground conditions becomes more important to ensure that structures are built safely and appropriately.

By comparing presumptive values (based on design codes) and field-based results (from actual soil investigations), this study aims to highlight how much difference exists between the two approaches. The findings may help clarify whether commonly used code-based assumptions are sufficient or if site-specific data is necessary for more accurate and safer design decisions.

For Local Government Units and Urban Planners

This study may serve as a useful reference in land-use planning and development control. It can help identify areas where soil conditions may require closer evaluation before approving construction projects, supporting safer and more informed urban development decisions.

For Civil Engineers and Construction Professionals

The results of this study may help engineers better understand the reliability of presumptive soil bearing capacity values compared to field-based data. This can support improved foundation design, help reduce preliminary design uncertainties, and help prevent structural problems such as settlement or failure caused by inaccurate soil assumptions.

For Developers and Investors

This research may provide helpful preliminary insights when evaluating potential construction sites. Understanding the differences between estimated and actual soil capacity can assist in making more informed decisions and reducing risks related to unexpected ground conditions.

For Future Researchers

This study may serve as a reference for future geotechnical research, especially those focusing on soil bearing capacity, geospatial analysis, or comparative studies between design code values and field measurements in other urban areas.

For the Community

Ultimately, this study contributes to promoting safer construction practices. By improving understanding of soil conditions, it indirectly supports safer housing, stronger infrastructure, and more sustainable urban growth within the city.

1.5 Scope and Delimitations of the Study

This research is designed as a preliminary geotechnical screening of shallow soil bearing capacity within the administrative boundaries of Cabanatuan City. This preliminary investigation evaluates the utility of publicly accessible soil mapping data from the Philippine Geoportal as a baseline for initial engineering assessments. By correlating identified soil classifications, specifically Fine Sand, Loam, Silt Loam, and Clay Loam, with the presumptive standards of the International Building Code (IBC) 2024, the study seeks to examine the comparative relationship between theoretical design prescriptions and localized empirical reference data.

The empirical scope of this study is defined by the availability of geotechnical records from the Department of Public Works and Highways (DPWH). Comparative analysis is limited to thirteen (13) specific project locations where both digital soil mapping and verified borehole data intersect, focusing exclusively on shallow foundation systems at a standardized depth of 1.5 meters. These borehole records serve as the localized empirical reference for the study, utilizing Standard Penetration Test (SPT) N-values to derive field-based allowable bearing capacities.

The results of this study are based on discrete data nodes and should be interpreted strictly as a preliminary screening assessment rather than a representative model for the entire City's subsurface. Because site-specific field measurements exhibited a 180 kPa variance across the selected nodes, properties can vary significantly within short distances due to stratification and localized disturbances.

Furthermore, this research relies solely on secondary historical data and does not include new field investigations, borehole drilling, or laboratory testing. Consequently, these findings serve as a pre-feasibility tool and are not a substitute for the site-specific geotechnical investigations required for final structural design or actual construction projects.

1.6 Conceptual Framework

The conceptual framework of this study is structured around the critical interaction between theoretical geotechnical prescriptions and localized empirical evidence. It operates on the premise that while international building codes provide a necessary safety baseline, their generalized nature may not fully account for the specific numerical variations found in a localized environment. The framework is organized into three progressive stages: the theoretical baseline, the empirical benchmark, and the comparative synthesis.

In the first stage, the theoretical baseline is established using the 2024 International Building Code (IBC) and Philippine Geoportal maps. This represents a macro-scale approach where presumptive values are assigned based on identified soil textures. These values are inherently conservative and generalized, intended to serve as a technical minimum when site-specific subsurface data is unavailable.

The second stage incorporates field-derived geotechnical measurements, which consists of site-specific field measurements. Unlike the broad classifications of the IBC, these points represent the micro-scale reality of the subsurface. In this framework, the data extracted from Department of Public Works and Highways (DPWH) borehole logs are treated as discrete, site-specific reference nodes. By focusing on these localized measurements, the framework maintains methodological rigor, acknowledging that borehole data is a point-specific measurement of actual subsurface conditions.

The final stage is the Comparative Assessment. This is where the two data streams intersect to determine the Margin of Conservatism. By analyzing the data variance, the numerical gap between the narrow IBC range and the 180 kPa variance observed in field results, the study evaluates the reliability of the building code in a local context. Ultimately, the framework shifts the research focus from simple mapping to a high-level evaluation of the safety and efficiency of structural design standards in the study area.

INPUT

1. IBC 2024 Presumptive Tables: Standardized load-bearing values converted from psf to kPa.
2. Geoportal Soil Maps: Administrative soil series and textural classifications.
3. DPWH Borehole Records: Localized field reference points (SPT N-values) from 13 barangays.

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PROCESS

GIS Spatial Integration: Mapping Geoportal soil zones (Fine Sand, Loam, etc.) across the city.

Bearing Capacity Calculation: Correlating N-values to derive empirical safe bearing capacity $(qfield)$.

Quantitative Computation: Calculating the Difference (Δ) and Ratio (R) between datasets.

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OUTPUT

Preliminary Screening Maps: Visual thematic representations of city-wide soil strength.

Point-to-Zone Comparison: A side-by-side evaluation of theoretical vs. field performance.

Analysis of Code Reliability: Identifying zones where code assumptions are conservative or risky.

II. REVIEW OF RELATED LITERATURE

Geotechnical properties are inherently complex attributes resulting from disparate sources of uncertainty, including measurement error and transformation uncertainty. In alluvial and moisture-sensitive environments, soil properties exhibit significant spatial variability, which is concisely modeled through the "scale of fluctuation." This inherent heterogeneity explains why localized field reference points often reveal a wide data variance, such as the 180 kPa range observed in this research, that macro-scale mapping tools and administrative soil maps cannot fully capture (Phoon & Kulhawy, 1999).

International standards, including the 2024 International Building Code (IBC) and ASCE 7-22, provide presumptive allowable bearing capacities as conservative baselines for preliminary structural design. These codes are designed to ensure a technical "safety floor" when site-specific subsurface data is unavailable. However, contemporary research indicates that while GIS-based thematic maps are valuable for initial planning and desk reviews, they rely on generalized soil textures and must be validated against empirical field data (Rahman, 2025). The use of the Standard Penetration Test (SPT) remains the primary empirical method for determining the allowable bearing capacity in fine-grained and sandy soils, serving as the benchmark for code reliability.

The application of presumptive values requires a critical understanding of the "Margin of Safety" intended by code authors. Studies evaluating the reliability of building code tables often find that while they are generally conservative for uniform soils, they may not fully represent localized weaker subsurface zones in areas with complex stratification (Paikowsky et al., 2010). This lack of sensitivity to local subsurface anomalies justifies the necessity of localized empirical references to identify whether a specific region’s soil profile falls within the "safe" range assumed by the IBC or represents an unconservative risk.

The bearing capacity of a shallow foundation is not a static value but is critically influenced by hydrological conditions. According to Terzaghi’s Effective Stress Principle, the total stress in a soil mass is opposed by the pore-water pressure, or neutral stress (Rodríguez et al., 2023). A rise in the groundwater table reduces the effective confining stress, leading to a direct decrease in the soil's ultimate bearing pressure (Chen et al., 2022). This fluid-solid interaction is a primary driver of the data variance identified in residential areas, where fluctuating water levels can soften the foundation and significantly reduce shear strength compared to theoretical code predictions.

Modern geotechnical engineering frequently utilizes SPT N-values as the most straightforward and time-efficient tool for analyzing soil consistency at various depths (Rahman, 2025). While theoretical equations provide semi-empirical relations for safe bearing capacity, designers often adopt conservative values to account for potential experimental and environmental variables. The integration of localized empirical references from borehole records allows for a precise evaluation of the "Margin of Conservatism" present in administrative building codes, identifying whether these standards are sufficiently conservative for the local subsurface.

III.METHODOLOGY

3.1 Research Design

This study utilizes a descriptive-comparative quantitative research design to evaluate the reliability of standardized building codes against empirical geotechnical data. The design is structured to identify the numerical variance between the regional baseline (theoretical) and point-specific (empirical) datasets.

The descriptive component of the design involves the systematic characterization of soil textures based on digital mapping from the Philippine Geoportal and the derivation of presumptive bearing capacities from the IBC 2024. This provides a standardized numerical profile of the study area's theoretical subsurface strength.

The comparative component involves a side-by-side analysis of these theoretical values against field-based results derived from DPWH borehole records. By utilizing a comparative framework, the research quantifies the "Margin of Conservatism" and identifies specific zones where code-based assessments may be unconservative. This design ensures that the identified 180 kPa variance is analyzed using quantitative comparative methods, rather than through generalized qualitative observations.

3.2 Research Locale

The investigation is situated within the administrative boundaries of Cabanatuan City, Nueva Ecija, a strategic urban and economic center in Central Luzon. Geographically, the locale is positioned within the Pampanga River Basin, characterized by a predominantly level topography. From a geotechnical perspective, the area serves as a primary depositional environment where the subsurface is characterized by significant soil stratification.

According to the Bureau of Soils and Water Management (BSWM, 2023), the geological foundation of the region is predominantly composed of Quaternary Alluvium, consisting of unconsolidated deposits of silt, sand, and gravel. These deposits exhibit substantial numerical variability in their engineering properties across the study area. This characteristic is the primary factor in the observed data variance between theoretical building codes and empirical field measurements.

The selection of this locale is based on its rapid infrastructure development and the diverse range of soil textures identified in archival geotechnical records. By utilizing thirteen (13) point-specific data nodes across the city’s various districts, the study quantifies the discrepancy between the presumptive allowable bearing capacities of the IBC 2024 and the actual subsurface performance as recorded in verified DPWH borehole logs.

3.3 Data Sources

To facilitate a robust comparative assessment of soil bearing capacities, this study integrates two distinct data streams: theoretical "top-down" estimates and localized empirical measurements.

3.3.1 Soil Data

The research utilizes digital soil classification layers sourced from the Philippine Geoportal, the national data clearinghouse managed by the National Mapping and Resource Information Authority (NAMRIA). This dataset categorizes land units into specific soil series and textural classes based on morphological and geological characteristics. These classifications serve as the primary input for determining presumptive allowable bearing capacity values (qa). in accordance with the 2024 International Building Code (IBC).

3.3.1.1 Soil Data from the Philippine Geoportal

The Philippine Geoportal datasets provide macro-scale spatial coverage for the entire administrative boundary of Cabanatuan City. These layers classify land into textural categories such as silty clay and sandy loam, which act as the baseline for assigning theoretical bearing capacities.

By processing this data within a Geographic Information System (GIS), the study delineates broad soil zones across the city's alluvial landscape. This creates a continuous surface model essential for the preliminary geotechnical assessment of the region.

3.3.2 IBC 2024 Presumptive Values

The 2024 International Building Code (IBC), particularly Table 1806.2 on Presumptive Load-Bearing Values, is utilized to assign presumptive allowable bearing capacities (q_{IBC}) corresponding to the soil classifications identified from the Philippine Geoportal. The table provides standardized presumptive values for different soil groups, representing conservative allowable foundation pressures commonly used in engineering practice when site-specific geotechnical investigations are unavailable.

Since the IBC values are originally expressed in pounds per square foot (psf), they are converted into the International System of Units (SI), specifically kilopascals (kPa), to maintain consistency with Philippine engineering standards and Department of Public Works and Highways (DPWH) reporting formats. The conversion factor applied in this study is:

$$1 \text{ psf} \approx 0.04788 \text{ kPa}$$

3.3.3 DPWH Geotechnical Records

The empirical component of this study relies on verified geotechnical data extracted from the Department of Public Works and Highways (DPWH) investigation reports. To ensure methodological consistency and avoid conflicting derivations, the study primarily utilized the final allowable bearing capacity values reported in official DPWH borehole records. These values serve as the point-specific empirical benchmark against which the building code is evaluated.

It is acknowledged that, where applicable, these values were originally derived by DPWH using established empirical correlations based on Standard Penetration Test (SPT) N-values. These correlations are specifically adapted for the soil stratification found within the depositional environment of Cabanatuan City. By adopting the official reported values rather than performing independent recalculations, the research maintains alignment with the certified engineering standards used for local infrastructure projects. This approach ensures that the identified 180 kPa variance reflects the discrepancy between generalized administrative codes and the specialized field results recognized by national authorities.

3.3.4 DPWH Soil Bearing Capacity Data

The field-derived allowable bearing capacity values (q_{field}) used in this study were obtained from verified Department of Public Works and Highways (DPWH) geotechnical investigation reports. To maintain consistency between datasets, only soil data corresponding to a shallow foundation depth of 1.5 meters were extracted from the available borehole records.

The study utilized data from thirteen (13) selected barangays where verified DPWH borehole logs were available. These locations served as discrete comparison nodes for evaluating field-derived allowable bearing capacities against the presumptive allowable bearing capacities derived from the Philippine Geoportal soil classifications and the 2024 International Building Code (IBC). The field-based comparison was limited to these selected barangays and should not be interpreted as representative of the entirety of Cabanatuan City.

Where allowable bearing capacity values were directly reported in the borehole logs, the documented values were adopted for analysis. In cases where only Standard Penetration Test (SPT) N-values and soil descriptions were available, the corresponding allowable bearing capacities were interpreted using established empirical geotechnical correlations commonly applied in shallow foundation analysis. Due to limitations associated with historical records, detailed correction procedures for groundwater conditions, overburden pressure, and dilatancy effects were not uniformly available for all datasets. For records where allowable bearing capacity values were inferred from SPT N-values rather than directly reported, the specific empirical correlation or reference standard applied should be explicitly identified to improve methodological reproducibility and transparency.

The study primarily relied on the final allowable bearing capacity values documented within official DPWH records rather than independently redeveloping geotechnical design correlations. Consequently, the research focuses on comparative evaluation between code-prescribed presumptive values and localized field-derived values rather than recalculating theoretical bearing capacities from raw SPT datasets.

It is important to recognize that DPWH borehole records represent point-specific subsurface conditions only at the exact investigation coordinates. Therefore, the analysis was intentionally limited to node-based comparison without spatial interpolation to maintain methodological and geotechnical defensibility.

3.4 Data Processing

The collected datasets from the Philippine Geoportal, the 2024 International Building Code (IBC), and the Department of Public Works and Highways (DPWH) were systematically processed to establish a comparative framework between presumptive and field-derived allowable bearing capacities. Geographic Information System (GIS) tools were utilized for spatial organization, visualization, and comparison of the geotechnical datasets.

3.4.2 Assignment of Soil Bearing Capacity (SBC) Values

This stage involves correlating qualitative soil information with quantitative engineering standards. The soil series and textural classifications identified from the Philippine Geoportal are systematically matched with the corresponding categories listed in IBC 2024 Table 1806.2. For example, soil deposits classified as “Silty Sand” are assigned the corresponding presumptive bearing capacity specified by the code.

Through this process, theoretical Soil Bearing Capacity (SBC) values are established for each mapped soil unit, forming the baseline for subsequent comparative analysis between theoretical and empirical datasets.

3.4.3 Map Generation

After assigning the SBC values, a thematic map is generated using Geographic Information System (GIS) software. The map illustrates the spatial distribution of theoretical soil bearing capacities across Cabanatuan City based solely on IBC presumptive values.

By integrating SBC attributes with digitized soil boundaries, the study produces a color-coded visualization representing the expected soil strength across different areas of the city. This thematic representation serves as the theoretical subsurface model of Cabanatuan City and highlights zones with varying presumptive bearing capacities.

3.4.4 Extraction and Tabulation of DPWH Values

The final processing step involves the isolation of empirical field data for the 13 selected barangays through the following procedures:

1. **Location Identification:** The precise coordinates of DPWH borehole sites were plotted within the GIS environment to ensure they aligned with the mapped soil zones.
2. **Data Extraction:** Safe Bearing Capacity (SBC) values specifically corresponding to the 1.5-meter depth were extracted from the borehole logs to maintain depth-consistency across the study.
3. **Data Derivation:** The safe bearing capacity values (qfield) were extracted directly from the verified geotechnical investigation reports provided by the DPWH. These values represent the final engineering output as reported in the official borehole logs, which were derived from Standard Penetration Test (SPT) N-values using established empirical correlations appropriate for the region's soil consistency. While N-values are subject to environmental corrections, this study utilizes the final reported safe bearing capacity to represent the localized "ground truth" used in actual government infrastructure projects.
4. **Tabulation:** The extracted data was organized into a master comparison table. This table lists the barangay, the mapped soil type, the IBC-based presumptive allowable bearing capacity (q_{IBC}), and the corresponding DPWH safe bearing capacity (q_{field}) to facilitate the statistical and comparative analysis.

3.5 Data Analysis (Comparative Analysis)

The final phase of the methodology involves a systematic comparative analysis to quantify the relationship between theoretical code-prescribed values and empirical field measurements. This analysis aims to identify the “gap” between generalized engineering standards and localized subsurface conditions across Cabanatuan City.

3.5.1 The Comparative Matrix

The primary analytical tool used in this study is the Comparative Matrix. This table compares the standardized values obtained from the IBC 2024 (Table 1806.2) with the site-specific DPWH field results gathered from the 13 established data nodes. These locations were selected based on the availability and accessibility of verified DPWH borehole records. Through this comparison, a side-by-side evaluation of the "presumptive" and "actual" soil performance is achieved.

3.5.2 Quantitative Computations

To evaluate the reliability and conservatism of international building standards under the local geotechnical conditions of the Pampanga River Basin, two mathematical computations are performed for each study location.

Computation of Difference (Δ)

The absolute variance is calculated to determine the magnitude of discrepancy between the field-measured soil bearing capacity and the code-prescribed value.

$$\Delta = q_{\text{field}} - q_{\text{IBC}}$$

Significance:

A positive difference indicates that the code-prescribed value is conservative, meaning the actual soil strength is greater than the assumed design value. Conversely, a negative difference identifies locations where field-measured values are lower than the presumptive estimates, suggesting that the code may overestimate the actual soil strength in those particular areas.

Computation of Ratio (R)

The ratio is calculated to determine Comparative Ratio (R), which provides a normalized measure of the margin of safety or conservatism between empirical and theoretical values.

$$\boldsymbol{R = \frac{q_{\text{field}}}{q_{\text{IBC}}}}$$

Significance:

A ratio equal to 1.0 indicates numerical equivalence between presumptive and field-derived values between the field-measured data and the code-prescribed value. A ratio less than 1.0 signifies potentially unconservative conditions where site-specific geotechnical investigation becomes particularly important to verify the actual soil performance and reduce possible foundation risks. Meanwhile, a ratio greater than 1.0 quantifies the degree of conservatism or overdesign present in the code for a specific soil zone.

3.5.3 Synthesis and Interpretative Analysis

The numerical results obtained from the Comparative Matrix are analyzed to identify spatial trends and geological correlations. This stage includes the following:

- **Identifying Critical Zones:** Determining barangays where the ratio (R) falls significantly below 1.0, indicating high-risk areas for preliminary foundation design.
- **Assessing Mapping Reliability:** Evaluating whether specific Geoportal soil classifications consistently differ from the field results, thereby assessing the reliability of macro-scale mapping for civil engineering applications.
- **Geotechnical Implications:** Discussing how the observed variations support the necessity of site-specific borehole investigations rather than relying solely on presumptive code values within the heterogeneous alluvial plains of Cabanatuan City.

3.6 Limitations of the Study

While this research provides a critical evaluation of soil bearing capacity variance, several inherent constraints must be acknowledged to contextualize the findings. The following limitations define the scope and boundaries of the analytical results:

3.6.1 Constraints on Spatial Interpolation

The study does not attempt to perform spatial interpolation or generate a continuous bearing capacity surface map across the entire city. Due to the high degree of soil heterogeneity in the alluvial deposits of the Pampanga River Basin, mathematical interpolation between data points would lack the necessary precision for engineering applications. Consequently, the findings are strictly site-specific to the thirteen identified nodes and should not be used to predict soil behavior in adjacent areas without localized testing.

3.6.2 Scope of Empirical Data

The empirical foundation of this research is limited to the thirteen (13) available borehole data points provided by the Department of Public Works and Highways (DPWH). While these points offer significant insight into the city’s subsurface profile, they do not represent the entirety of Cabanatuan City’s diverse geological landscape. The density of the data points is constrained by the availability of historical records, which may limit the ability to identify micro-scale soil variations in barangays where no DPWH records currently exist.

3.6.3 Nature of Presumptive IBC Values

The values utilized from the International Building Code (IBC) 2024 are, by definition, presumptive and intentionally conservative. These values are designed as a "baseline" for preliminary design in the absence of field data and do not account for localized factors such as groundwater fluctuations, seasonal saturation, or specific mineralogical compositions unique to Philippine alluvial plains. Therefore, a high variance ratio$\boldsymbol{q_{field}}$ (R > 1.0) is expected as a result of the code’s built-in safety buffers.

3.6.4 Absence of Direct Field Validation

This research relies exclusively on secondary data from existing borehole logs and established mapping portals. No independent primary field testing, such as fresh Standard Penetration Tests (SPT) or laboratory soil analysis, was conducted as part of this study. The analysis assumes the accuracy and methodological consistency of the historical DPWH records and the Geoportal classifications as they existed at the time of data collection. Consequently, any recent changes in soil conditions due to land development or environmental shifts are not reflected in this analysis

IV. RESULTS AND DISCUSSION

4.1 Soil Type Distribution and Characteristics

The soil distribution map of Cabanatuan City illustrates observable spatial variation of four dominant soil types: clay loam, fine sand, loam, and silt loam. These soil classes were delineated based on GIS processing of soil dataset overlays and administrative boundaries of the city. The resulting map shows that soil distribution is not uniform, reflecting the influence of natural depositional processes and river systems typical of an alluvial plain.

Fine sand is primarily observed in narrow, elongated bands in the western-central corridor, indicating fluvial deposits. Clay loam is highly concentrated in the western and southwestern portions, while silt loam dominates the eastern and northeastern areas, covering a large continuous land area

4.1.1 Physical and Engineering Properties

The identified soil types exhibit distinct engineering behaviors that significantly affect land development and foundation suitability. Fine sand zones are generally well-drained and exhibit low cohesion, making them may be more favorable for shallow foundations under proper geotechnical verification under appropriate engineering evaluation, provided proper compaction is achieved.

In contrast, clay loam areas tend to exhibit potentially higher plasticity behavior and water retention, which may result in settlement and reduced bearing performance under structural loads. Silt loam, covering a large portion of the eastern area, may also exhibit compressibility and reduced shear strength when saturated, requiring careful evaluation for heavy infrastructure development.

Table 4.1.2: Summary of Soil Classifications

The physical and mechanical properties of the soil types found in Cabanatuan City directly dictate their performance as foundation materials. The following table summarizes the technical characteristics of the four dominant soil classifications identified within the study's 13 barangays.

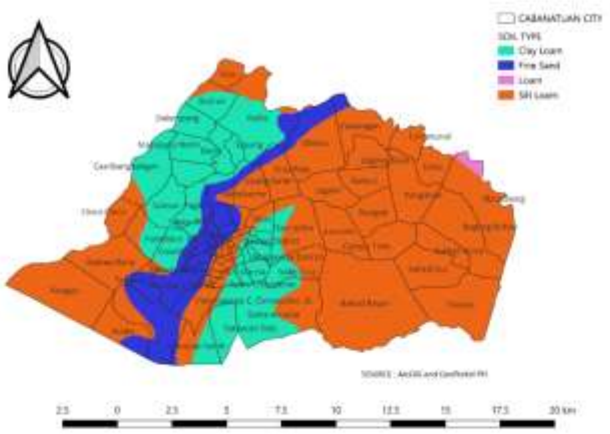
Soil Type	Location	Physical Properties	Engineering Significance
Fine Sand	San Josef Norte, San Josef Sur, Cabu, Caalibangbangan, Pangatian, Valle Cruz	Coarse to medium-grained; Well-drained; Non-cohesive	High friction angles; minimal settlement; generally suitable for shallow foundations under appropriate engineering evaluation.
Loam	Balite, Aduas Centro, Aduas Norte, Aduas Sur, Bagong Buhay, Bagong Sikat, Dicarma, Fatima, Isla, Kalikid Norte, Kalikid Sur, Matadero, Mayapyap Norte, Mayapyap Sur, San Juan Poblacion, Sapang	Medium-textured; balanced silt/sand mix; Well-drained	Low compressibility; stable for moderate loading; immediate settlement characteristics.
Silt Loam	Camp Tinio, Valdefuente, Sumacab Este, Sumacab Norte, Sumacab Sur, San Isidro, Padre Burgos, Padre Crisostomo, Bitas, Buliran, Calawagan, Caridad, Caudillo, Cinco-Cinco, Communal, Cruz Roja, Dalampang, Macatbong, Pagas, Palagay, Patalac, Polilio, Pula, Samon, Santa Arcadia, Villa Ofelia-Caridad	Medium-textured; Stiff to Hard consistency	Moderate cohesion; strength is highly sensitive to moisture changes and saturation.
Clay Loam	Pamaldan, Vijandre District, Barrera District, Bakero, Bakod Bayan, Bangad, Bantug Bulalo, Bantug Norte, Barlis, Bernardo District, Bonifacio District, Daang Sarile, Dimasalang, Dionisio S. Garcia, General Luna, Hermogenes C. Concepcion, Sr., Ibabao Bana, Imelda District, Kapitan Pepe, Lagare, Lourdes, M. S. Garcia, Mabini Extension, Mabini Homesite, Magsaysay District, Magsaysay South, Maria Theresa, Melojavilla, Nabao, Obrero, Quezon District, Rizdelis, San Roque Norte, San Roque Sur, Sanbermicristi, Sangitan, Sangitan East, Santo Niño, Talipapa, Zulueta District	Fine-textured; Cohesive; Very Stiff to Hard	Potentially higher plasticity behavior; potential for long-term consolidation settlement; high expansion/shrinkage potential.

Table 4.1.2 Soil Classification, Physical Properties, and Distribution in Cabanatuan City

4.1.3 Spatial Analysis and Mapping

he spatial distribution of these soil types across the study area is visually represented in the map below (Figure 1). The observed heterogeneity emphasizes the need for site-specific geotechnical assessments, particularly in areas where fluvial deposits meet older compacted clay soils.

Figure 4.1.3 Spatial Distribution of Soil Types in Cabanatuan City.



CLICK HERE

4.2 IBC-Based Soil Bearing Capacity (SBC) Map

This section presents the spatial distribution of the theoretical soil bearing capacities across Cabanatuan City. These values represent the "presumptive" load-bearing pressures derived by cross-referencing the Geoportal soil classifications with the **IBC 2024 Table 1806.2** standards.

4.2.1 Prescriptive Value Conversion

To translate the international standard into the local metric context, the prescriptive values provided in pounds per square foot (psf) were converted to kilopascals (kPa). The table below details the mathematical conversion used to establish the IBC-based baseline for each identified soil type.

Soil Type	Prescriptive Value (psf)	Conversion Computation	Estimated Capacity (kPa)
Fine Sand	2000	2000 × 0.04788	95.76
Loam	2000	2000 × 0.04788	95.76
Clay Loam	1500	1500 × 0.04788	71.82
Silt Loam	1500	1500 × 0.04788	71.82
kPa=psf×0.04788			

Table 4.2.1 Prescriptive Value Conversion

4.2.2 Mapping of Theoretical SBC Distribution

Using the values derived in the conversion process, a thematic map was generated to visualize the city-wide distribution of allowable foundation pressures. This map serves as the theoretical baseline for the study.

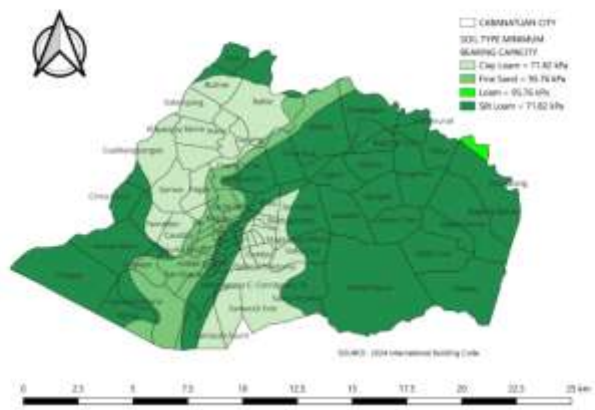


Figure 4.2. Theoretical SBC Distribution Map based on IBC 2024 Standards

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4.2.3 Analysis of Value Ranges (71.82 kPa to 95.76 kPa)

The theoretical bearing capacities within the study area fall into a narrow range, specifically between 71.82 kPa and 95.76 kPa. This concentration of values highlights the relatively uniform categorization of alluvial soils at the macro-scale:

- **95.76 kPa (High-End Presumptive Range):** Assigned to zones classified as Fine Sand and Loam. Under the IBC 2024, these granular or balanced-texture soils are assumed to have higher internal friction and better drainage, allowing for a higher prescriptive load-bearing capacity. These zones primarily follow the central diagonal corridor of the city.
- **71.82 kPa (Low-End Presumptive Range):** Corresponds to Silt Loam and Clay Loam zones. The code assigns a lower capacity to these areas due to the inherent engineering risks associated with fine-grained soils, such as moisture sensitivity, higher plasticity, and the potential for long-term consolidation settlement. These values dominate the eastern and western floodplains.

4.2.4 Significance of the Baseline

The narrowness of this range, spanning only ~24 kPa, reflects the generalized nature of building codes. While this provides a safe starting point for preliminary design, it assumes a level of geological consistency that may not exist in a dynamic river basin. This theoretical baseline will be compared against actual field results in Section 4.3 to evaluate its real-world accuracy.

4.3 DPWH Empirical Data Presentation

This section presents the empirical field measurements derived from the Department of Public Works and Highways (DPWH) geotechnical records. Unlike theoretical presumptive values, these figures are based on site-specific Standard Penetration Tests (SPT), providing a localized view of the subsurface conditions at a standard foundation depth of 1.5 meters.

4.3.1 Geotechnical Parameters from Borehole Logs

The empirical data used for this study is rooted in the physical resistance of the soil, quantified by the N-value. The N-value represents the number of blows required to drive a standard sampler into the soil and serves as the primary indicator for determining soil consistency and calculating the Safe Bearing Capacity (q_{field}).

Barangay	Soil Type (USCS)	N-Value	Consistency	Empirical Allowable Bearing Capacity (q_{field})
Aduas Sur	Silty Clay (CH)	19	Very Stiff	70 kPa
Balite	Silty Sand (SM)	8	Loose	45 kPa
Barrera District	Clayey Sand (SC-SM)	15	Medium Dense	75 kPa
Cabu	Silty Clay (CH)	22	Very Stiff	100 kPa
Camp Tinio	Poorly Graded Sand (SP)	26	Medium Dense	75 kPa
Padre Burgos	Clayey Silt (MH)	16	Very Stiff	225 kPa
Pamaldan	Silty Clay (CH)	14	Stiff	65 kPa
San Isidro	Clayey Silt (MH)	6	Soft to Firm	50 kPa
San Josef Norte	Silty Clay (CH)	11	Stiff	50 kPa
San Josef Sur	Poorly Graded Sand (SP-SM)	17	Medium Dense	125 kPa
Sumacab Este	Silty Clay (CH)	18	Very Stiff	70 kPa
Valdefuente	Clayey Silt (MH)	12	Stiff	200 kPa
Vijandre District	Silty Clay (CH)	11	Stiff	140 kPa

Table 4.3. Technical Soil Properties from DPWH Borehole Records

4.3.2 Spatial Mapping of Empirical Data

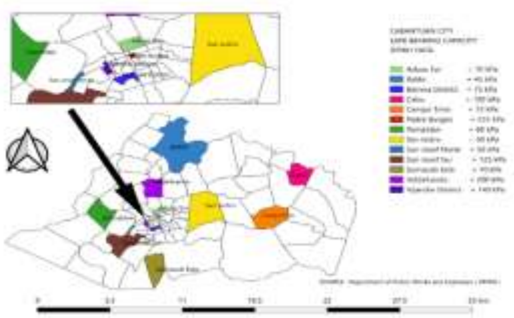

Figure 4.3. Spatial Distribution of Empirical Soil Bearing Capacity (DPWH Data).
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4.3.3 Analysis of Empirical Results and Consistency

The updated empirical dataset highlights the high degree of **numerical variability** in Cabanatuan City. The reported capacities range from a minimum of 45 kPa in Balite to a maximum of 225 kPa in Padre Burgos, resulting in a significant total variance of 180 kPa.

- **Relationship between N-Value and Strength:** The data reveals that SPT N-values alone may not directly correspond to allowable bearing capacity because derived values are influenced by soil type, groundwater conditions, correction factors, and interpretation methodology. with bearing capacity in alluvial soils. For instance, Camp Tinio exhibits a relatively high N-value of 26, typically associated with "medium dense" or "stiff" soil, but a Safe Bearing Capacity (q_{field}) of only 75 kPa. This discrepancy may be influenced by a combination of factors, including soil gradation, groundwater conditions at the time of boring, or possible differences in empirical interpretation methods used in the original reports.

This finding highlights a critical geotechnical principle: N-values alone do not provide a complete profile of soil stability, as the transition to allowable pressure is subject to various correction factors that must be accounted for in site-specific investigations.

- **Consistency Variations:** The physical state of the soil across the city varies drastically, ranging from "Loose/Soft" to "Very Stiff/Medium Dense." This broad spectrum confirms that presumptive values based purely on surface mapping are insufficient for structural engineering safety.
- **Significance of USCS Classifications:** The dominance of CH (Silty Clay) and MH (Clayey Silt) confirms that the city sits on fine-grained deposits. These soil types exhibit potentially higher plasticity behavior, making the site-specific SPT data critical for ensuring foundation stability.

4.4 Comparison of IBC and DPWH Values

This section presents the core comparative analysis between the theoretical presumptive values of the IBC 2024 and the empirical field measurements from the DPWH. By calculating the numerical variance and the factor of ratio, the research identifies the specific geographic zones where the building code remains conservative and where it presents a potential structural risk.

4.4.1 Comparative Matrix of Soil Bearing Capacities

The table below consolidates the theoretical and empirical data points for all thirteen (13) barangays. The Difference is calculated as ($q_{field} - q_{IBC}$), while the Ratio is established as

$$R = \frac{q_{field}}{q_{IBC}}$$

Barangay	IBC Value (q_{pres})	DPWH Value (q_{field})	Difference (Δ)	Ratio (R)
Aduas Sur	95.76 kPa	70 kPa	-25.76	0.73
Balite	95.76 kPa	45 kPa	-50.76	0.47
Barrera District	71.82 kPa	75 kPa	+3.18	1.04

Cabu	95.76 kPa	100 kPa	+4.24	1.04
Camp Tinio	71.82 kPa	75 kPa	+3.18	1.04
Padre Burgos	71.82 kPa	225 kPa	+153.18	3.13
Pamaldan	71.82 kPa	65 kPa	-6.82	0.91
San Isidro	71.82 kPa	50 kPa	-21.82	0.70
San Josef Norte	95.76 kPa	50 kPa	-45.76	0.52
San Josef Sur	95.76 kPa	125 kPa	+29.24	1.31
Sumacab Este	71.82 kPa	70 kPa	-1.82	0.97
Valdefuente	71.82 kPa	200 kPa	+128.18	2.78
Vijandre District	71.82 kPa	140 kPa	+68.18	1.95

Table 4.4. Comparative Matrix between IBC 2024 and DPWH Field Data

4.4.2 Discussion of Findings

This section interprets the numerical outcomes of the Comparative Matrix, focusing on the reliability and economic efficiency of the building code within the study area.

1. Observed Comparative Trends Between Empirical and Presumptive Values

($q_{field} > q_{IBC}$)

The comparative analysis reveals that in the majority of the study sites (8 out of 13 barangays), the localized field measurements exceed the IBC presumptive values. This trend confirms that the IBC 2024 maintains a generally conservative posture when applied to the alluvial soils of Cabanatuan City. In these instances, the margin of conservatism is positive, ensuring that structures designed using only code-presumptive values would likely possess a higher factor of safety than theoretically required.

2. Magnitude of Difference and Engineering Efficiency

The magnitude of the difference varies across the city, highlighting significant soil heterogeneity.

Significant Variance: In areas like Padre Burgos and Valdefuente, field values substantially exceed presumptive code values than the IBC baseline. While safe, such a large gap suggests that relying solely on the IBC may contribute to conservative foundation sizing and increased material usage.

* Unconservative Conditions: Conversely, in approximately 38% of the sites (5 out of 13), field values are lower than the IBC presumptive values. This is most notable in Balite and San Josef Norte, where the soil provides only 47% to 52% of the strength assumed by the code.

4.4.3 Conclusion of the Core Analysis

The contrast in magnitudes, ranging from a +153.18 kPa surplus to a -50.76 kPa deficit, demonstrates that the IBC presumptive values may not uniformly represent conditions across the investigated locations. This discrepancy indicates that the degree of conservatism of the IBC values varies significantly across the investigated locations, making site-specific SPT analysis an indispensable requirement for local structural integrity. The findings indicate that generalized code-based presumptive values may not fully capture localized subsurface variability within heterogeneous alluvial environments.

4.5 Analysis of Differences

The discrepancies identified in the Comparative Matrix (Section 4.4) are not merely mathematical anomalies but are rooted in the complex geological and environmental conditions of Cabanatuan City. This section analyzes the primary factors contributing to the variance between theoretical code values and localized field measurements.

4.5.1 Discussion of Soil Bearing Capacity Variance

The analysis of the thirteen (13) point-specific data nodes reveals a significant discrepancy between the building code and field observations. The recorded 180 kPa variance highlights the limitations of utilizing a regional baseline for areas characterized by complex soil stratification. Specifically, the erratic fluctuations in the allowable bearing capacity across short horizontal distances are a characteristic signature of the subsurface environment, which may be associated with fluvial depositional patterns typical of the Pampanga River Basin

Rather than a uniform soil mass, the data suggests a highly variable depositional environment. The higher-than-expected capacities in certain nodes likely stem from lenses of dense sand or gravel, while the lower capacities coincide with unconsolidated silt layers. This numerical variability underscores why the IBC 2024 presumptive values, while providing a conservative safety floor, often fail to capture the actual empirical strength of alluvial deposits. Consequently, the observed "gap" in the Comparative Matrix confirms that regional mapping serves best as a pre-feasibility tool rather than a final design parameter.

4.5.2 Soil Variability and Heterogeneity

The primary driver of the recorded variance is the significant soil heterogeneity inherent in the Pampanga River Basin. As an alluvial plain, the subsurface is composed of layers deposited by shifting river channels over millennia.

While the IBC assumes a uniform soil mass based on broad surface classifications, the borehole logs reveal interbedded layers of silt, sand, and clay that change significantly within a few meters of depth. This vertical and horizontal variability explains why two sites with the same Geoportal classification can exhibit a difference in bearing capacity of over 100 kPa. Ultimately, this demonstrates that presumptive values based purely on surface mapping may not fully capture localized subsurface variability required for final structural design.

4.5.3 Degree of Natural Compaction and Consolidation

The presumptive values provided by the IBC are intended to represent average subsurface conditions and therefore do not fully account for the specific geological stress history and consolidation characteristics of localized soil deposits.

Highly Consolidated Deposits.

Barangays such as Valdefuente and Padre Burgos exhibit high Standard Penetration Test (SPT) N-values and corresponding soil bearing capacities exceeding 200 kPa. These results indicate the presence of highly consolidated or over-consolidated soil deposits. Such layers may have undergone substantial natural compaction caused by historical geological loading, prolonged sediment accumulation, or repeated ancient flood cycles. Consequently, these deposits possess structural densities and strengths that generalized building code assumptions cannot accurately predict.

Loose Deposits.

In contrast, areas such as Balite exhibit relatively low SPT values

$$N = 8$$

indicating that the soil remains in a comparatively loose state. This condition is likely associated with recent alluvial deposition or insufficient natural consolidation. As a result, the field-measured bearing capacities in these areas fall below the presumptive values assumed by the IBC, producing negative differences in the comparative analysis.

4.5.4 Influence of Moisture and Groundwater Levels

Cabanatuan City is characterized by relatively high groundwater levels and periodic seasonal flooding, both of which significantly influence the engineering behavior of fine-grained soils, particularly CH and MH soil classifications.

The Saturation Factor

The presence of groundwater reduces the effective stress within the soil mass, thereby decreasing its shear strength and overall bearing capacity. The IBC 2024 presumptive values are generally intended for well-drained soil conditions; however, actual field conditions in flood-prone areas often differ substantially from these assumptions.

Localized measurements obtained from areas such as San Isidro demonstrate the softening effects of moisture saturation on silty and clayey soils. This reduction in soil strength contributes directly to the unconservative conditions observed in locations with negative comparative differences.

$$\Delta = q_{\text{field}} - q_{\text{IBC}}$$

These findings highlight the importance of considering seasonal groundwater fluctuations and moisture conditions during foundation design and geotechnical evaluation.

4.5.5 Local Geology: Influence of Local Alluvial Geology on Bearing Capacity Variability

The geology of Cabanatuan City is predominantly composed of Quaternary Alluvium, consisting of sedimentary deposits formed through repeated riverine and floodplain processes. The comparative analysis demonstrates that IBC presumptive values should be applied cautiously in highly heterogeneous alluvial environments and should be supplemented with site-specific geotechnical investigation whenever possible.

Although the code provides an adequate safety margin in many sectors, the substantial variation observed among the 13 investigated data nodes confirms that a single generalized presumptive value cannot fully represent the complexity of the city’s subsurface conditions.

In some areas, the high conservatism of the code may result in excessive foundation design and increased construction costs. In other locations, dependence solely on minimum code values may produce unconservative assumptions that could compromise structural safety.

These discrepancies reinforce the necessity of integrating broad geospatial soil mapping with detailed site-specific Standard Penetration Test (SPT) analysis. Such technical synthesis allows preliminary planning through regional soil classification while ensuring final structural integrity through localized empirical investigation.

The Advantage: In many parts of the city, the presence of volcanic fragments and mineral-rich sediments from the nearby Sierra Madre mountains provides a robust mineral matrix, resulting in the "Surplus" strengths $(\boldsymbol{q_{field} > q_{IBC}})$ seen in the majority of the sites.

The Risk: In other sectors, the river has deposited organic-rich "muck" or highly plastic clays. The IBC is a global code and does not account for these specific local geological "pockets," which results in the safety gaps identified in the southern sectors.

4.5.6 The Inherently Conservative Nature of the IBC

Finally, the difference is influenced by the "Safety-First" philosophy of international building codes. The IBC 2024 is intentionally designed to be conservative to prevent structural failure in the absence of a professional geotechnical report.

Economic Trade-off: By setting the presumptive values at a lower "floor" (71–95 kPa), the code ensures safety for most generic cases. However, as this study shows, this conservatism leads to a magnitude of difference as high as 153 kPa. While this ensures the building won't sink, it results in an potential economic inefficiency, where developers are forced to pay for significantly more concrete and reinforcement than the actual soil strength requires.

4.6 Engineering Interpretation

The data and comparisons established in this study provide a dual perspective on structural foundation design in Cabanatuan City. This interpretation bridges the gap between administrative compliance (the IBC) and geotechnical reality (the DPWH).

4.6.1 The IBC as a Conservative Baseline

The presumptive allowable bearing capacity established by the IBC 2024 serves as a geotechnical safety floor. In an engineering context, these values act as a generalized safety buffer designed to provide a baseline when site-specific empirical allowable bearing capacity (q_{field}) data is unavailable. The IBC values for Cabanatuan remain within a narrow 24 kPa range, functioning as this administrative floor to prevent structural instability in the absence of field records.

- **Risk Mitigation:** The code is designed to assume a conservative scenario for a given soil classification. The IBC values for Cabanatuan stay within a tight 24 kPa range, acting as a generalized safety buffer meant to provide a baseline when no field data is available.
- **Administrative Utility:** For architects and engineers in the preliminary planning phase, the IBC provides a standardized metric to estimate initial foundation sizes. However, as shown by the 153 kPa surplus in areas like Padre Burgos, using this baseline as a final design value may potentially result in conservative foundation sizing and increased material usage.

4.6.2 The DPWH as the Localized Condition

The DPWH field data represents the localized field conditions. Unlike the generalized building code, these values account for the unique, site-specific depositional history of Cabanatuan City.

- Sensitivity to Local Anomalies: The field data identifies localized conditions that a macro-scale code cannot detect, such as in Balite (R=0.47). In these areas, the DPWH data provides additional site-specific context to the IBC, identifying zones where the soil provides lower strength than presumptive estimates.

Optimization of Resources: In cases where $(\boldsymbol{q_{field} > q_{IBC}})$ the DPWH data allows for "Value Engineering." By recognizing that the local soil is significantly stronger than the code assumes (as seen in the 200+kPa values in Valdefuente), engineers can design more efficient foundation systems while maintaining a high factor of safety.

4.7 Implications for Practice

The findings of this comparative study offer critical guidance for civil engineers, urban planners, and developers operating within Cabanatuan City. The significant variance between the IBC presumptive values and localized field measurements suggests that a site-specific approach is necessary for final foundation design.

4.7.1 Role in Preliminary Planning and Feasibility

The IBC-based mapping remains a valuable tool for the initial stages of project development:

- **Zoning and Site Selection:** The theoretical IBC map serves as an effective "first-look" instrument. Developers can use it to estimate general suitability and predict preliminary project parameters during the feasibility phase.
- **Macro-Scale Risk Assessment:** Planners can utilize the presumptive baseline to identify broad areas where soil types (such as Clay Loams) are likely to require more complex foundation types.

4.7.2 The Importance of Site Investigation

The most vital implication of this research is that presumptive values are not a substitute for field testing. Given the observed variance, the following practices are recommended:

- **Risk Mitigation for High-Density Projects**: For medium-to-high-rise residential and commercial buildings, site-specific Standard Penetration Tests (SPT) are highly important. Relying solely on the IBC in areas like Balite or San Josef Norte may not fully reflect localized soil behavior in certain investigated locations, as the actual soil strength observed was lower than the code-prescribed minimum.
- **Economic Optimization:** In zones of high conservatism (where R > 1.0), such as Padre Burgos, a site investigation can lead to more efficient material usage. By proving the soil is stronger than the code assumes (225 kPa vs. 71.82 kPa), engineers can optimize footing sizes without compromising safety.
- **Validating Geoportal Data:** Because macro-scale maps cannot account for localized "lenses" of soft clay or dense sand, the Borehole Log remains the most reliable site-specific reference available in this study for safe engineering in a dynamic alluvial basin.

4.8 Limitations of the Findings

While the comparative analysis provides a robust framework, these limitations must be acknowledged to prevent over-generalization:

- **Sparse Data Density:** The empirical foundation is restricted to 13 data nodes. There are "white spaces" between these nodes where subsurface conditions remain unknown; high-strength values in one barangay cannot be assumed to apply to adjacent areas without documentation.
- **Absence of Spatial Interpolation:** This research deliberately avoids mathematical interpolation. Because alluvial soil is inherently heterogeneous, soil properties can change abruptly. The maps provided are thematic representations of points and zones, not continuous predictive surfaces.
- **Lack of Direct Field Validation:** All empirical values are derived from secondary historical data. Factors such as recent urban development or changes in groundwater may have altered the current state of the soil compared to the original log dates.
- **Methodological Scope:** Findings are tailored specifically for shallow foundation systems at a 1.5-meter depth. These results should not be applied to deep foundation design (e.g., piles)

V. SUMMARY, CONCLUSIONS, RECOMMENDATON

5.1 Summary of Findings

This research conducted a systematic comparative analysis between theoretical and empirical soil bearing capacities within the urban landscape of Cabanatuan City. The investigation began by identifying the primary soil types across thirteen representative data nodes using the Philippine Geoportal database, which classified the area into Fine Sand, Loam, Silt Loam, and Clay Loam. These classifications reflect the city's position within the alluvial Pampanga River Basin and served as the basis for subsequent modeling.

Following this classification, IBC values were assigned using the presumptive standards of the International Building Code 2024. This theoretical baseline produced a narrow range of allowable pressures, specifically between 71.82 kPa and 95.76 kPa. This small variance highlights the generalized nature of international standards, which tend to categorize soil types into broad, uniform groups for administrative simplicity.

To provide a real-world contrast, DPWH values were analyzed. These empirical figures, derived from site-specific Standard Penetration Tests (SPT) found in historical borehole logs, revealed a much broader spectrum of soil strength than the theoretical model predicted. The field-measured capacities ranged from a minimum of 45 kPa to a maximum of 225 kPa, with N-values fluctuating between 6 and 26, reflecting a subsurface environment that ranges from "Soft" to "Very Stiff/Medium Dense" consistency.

The key comparison trends highlighted a significant numerical variability between the two datasets. While the IBC values remained relatively flat, the field data exhibited a range of 180 kPa. The core analysis showed that while the IBC maintained a conservative posture in approximately 62% of the locations, the remaining 38% of the investigated sites may not fully reflect localized soil behavior, as localized measurements were lower than the code-prescribed minimum. This emphasizes the critical importance of site-specific data in a dynamic alluvial environment.

5.2 Conclusions

The systematic comparison between the International Building Code (IBC 2024) and DPWH empirical data reveals three primary conclusions regarding the geotechnical environment of Cabanatuan City:

1. Localized Limitations of Presumptive Standards: The IBC presumptive values occupy a narrow range of approximately 24 kPa, assuming a level of geological uniformity that is not supported by field observations. The actual 180 kPa variance recorded across the 13 investigated nodes indicates thata generalized code cannot capture the soil stratification typical of a dynamic river basin.

2. Divergent Safety Margins: While the IBC maintains a conservative posture in the majority of cases (62%), it simultaneously presents potential risks in nearly 38% of the locations where q_{IBC} exceeds q_{field}. This confirms that the code acts as a reliable administrative "safety floor" in some sectors but may overestimate soil strength in others, particularly in areas of recent deposition or high moisture saturation.

3. The Necessity of Site-Specific Data: The research indicates that macro-scale soil mapping is an effective tool for preliminary zoning and pre-feasibility planning. However, due to the high numerical variability found in the subsurface, localized field investigations remain essential for final structural foundation design.

5.3 Recommendations

Based on the findings of this comparative study, the following actions are recommended to improve the safety and economic efficiency of structural design in Cabanatuan City:

1. **Strongly Recommended Site-Specific Field Testing:** For the final foundation design of all medium-to-high-rise structures, it is highly recommended to conduct site-specific geotechnical investigations. Relying solely on presumptive values from the IBC is insufficient for ensuring structural integrity in highly stratified alluvial environments.
2. **Expanded Data Coverage:** To improve the reliability of regional soil strength models, future researchers and local agencies should expand borehole data coverage within Cabanatuan City. Increasing the number of data nodes beyond the 13 barangays investigated in this study will help identify additional "pockets" of soft soil or dense sand.
3. **Digital Geotechnical Infrastructure:** Local government units and urban planners should work toward developing localized GIS-based geotechnical databases. Integrating empirical SPT data into a centralized Geographic Information System will allow for more accurate preliminary risk assessments and urban zoning.
4. **Multivariate Analysis:** Future spatial analyses should integrate additional field-derived parameters, such as groundwater depth, plasticity index (Atterberg limits), and consolidation tests. Adding these variables will provide a more comprehensive profile of the city's subsurface than N-values alone.

VI. ACKNOWLEDGEMENT

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