TYPES OF FOUNDATIONS IN BUILDING CONSTRUCTION

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INTRODUCTION

A building usually consists of two main components, superstructure (above ground) and substructure (below ground). The foundation is known as the substructure. They guarantee that structures can resist the test of time and environmental pressures by providing crucial support and stability. Different types of foundations are used in construction to accommodate various factors such as soil properties, the type of structure being built on, and the load-bearing requirements [1]. This article will further discuss the significance of these foundations and clarify their differences.

CATEGORY OF FOUNDATION

Foundations are usually classified into two primary categories:

1.) Shallow Foundation:

Shallow foundations are constructed near to the surface of the ground and transfer weight to relatively shallow ground (often 1 to 3 metres). This kind of foundation is often used for lightweight structures such as houses, stores, guard house, small factory, etc. with a maximum load per column of not more than 50 tonnes. A medium (firm) upper stratum of soil is the minimum requirement of shallow foundations which is ideal for light structures like low-rise buildings (< 5 stories). JKR/ Mackintosh Probe test is conducted to determine soil bearing capacity [2].

N (Blows/ ft)	Consistency	Unconfined Compressive strength (Ton/Sq Ft)	Unconfined Compressive strength (kPa)	JKR or Mackintosh Probe (Blows/ft)
2	Very soft	0.00 – 0.25	0.0 – 25	0 – 10
2 – 4	Soft	0.25 – 0.50	25 - 50	10 – 20
4 - 8	Medium (firm)	0.50 – 1.00	50 – 100	20 – 40
8 - 15-	Stiff	1.00 – 2.00	100 – 200	40 – 70
15 - 30	Very stiff	2.00 – 4.00	200 – 400	70 – 100
Over 30	Hard	4.00	400	100

Cohesive Soil (Clay)

N (Blows/ ft)	Relative density	Allowable soil pressure (Ton/Sq Ft)	Allowable soil pressure (kPa)	JKR or Mackintosh Probe (Blows/ft)
0 – 4	Very loose	Not suitable	Not suitable	0 - 10
4 - 10	Loose	0.0 – 0.8	0 – 80	10 - 30
10 - 30	Medium	0.8 – 2.8	80 – 280	30 - 80
30 - 50	Dense	2.8 – 4.7	280 – 470	80 - 110
Over 50	Very dense	4.7	470	110

Cohesionless Soil (Sand)

The graph below illustrates the relationship between the no. of blows/ft of probe test and soil bearing capacity.

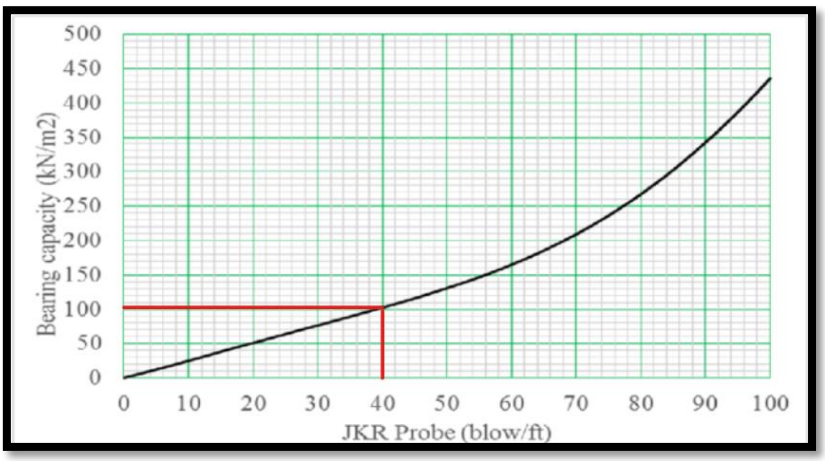
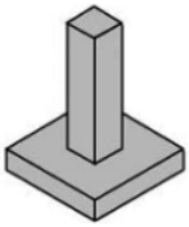
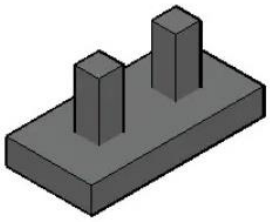
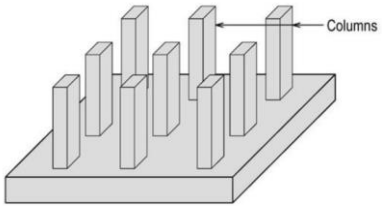
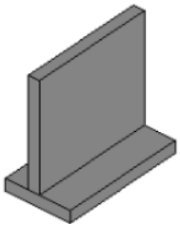


Figure 1: 40 blow/ft indicates 100 kPa of soil bearing capacity [2]

The size of the pad footing is designed to carry the structure load knowing the in-situ soil bearing capacity. Based on the in-situ soil bearing capacity, the larger the structure load exerted to the ground, the larger the size of pad footing is required, and vice versa.

Bearing Capacity of Soil (kN/m^2)	Structure Load (kN)	Size of Pad Footing (m^2)
50	100	2
100	100	1

Shallow foundations are subdivided into various types based on their shape, size, and overall design as follows [3]:

Shallow Foundation	Description
i. Pad Footing 	The most common shapes are square, rectangular, or round. Based on variables such the column load, soil-bearing capability, and any architectural concerns, the footing's shape and dimensions are chosen.
ii. Combined Footing 	To support either several columns or columns that are placed closely together, combined footings are used. Their function is to disperse the weight coming from numerous columns over a larger surface area.
iii. Raft Foundation 	Raft foundations cover the entire building footprint. They distribute the building's load over a larger area, which is beneficial in areas with weaker soil.
iv. Strip Footing 	Strip footings are extended foundation pads that support columns that are placed close to one another. These footings are made expressly to make it easier to distribute weights along a straight path.

2.) Deep Foundation:

A deep foundation is constructed deep down and disperses weight at a depth of at least three meters. The load-carrying stratum (end bearing) and frictional resistance are essential for pile stability [4].

The number of blows (N) is measured using the Standard Penetration Test (SPT). As a result, the N-value is used to determine stratigraphy, the relative density and angle of shearing resistance of cohesionless soils, and the cohesion of cohesive soils. This is done utilising geotechnical engineering ideas. The test is usually terminated at N-value of 50 unless other specific criteria is given by the engineer [5].

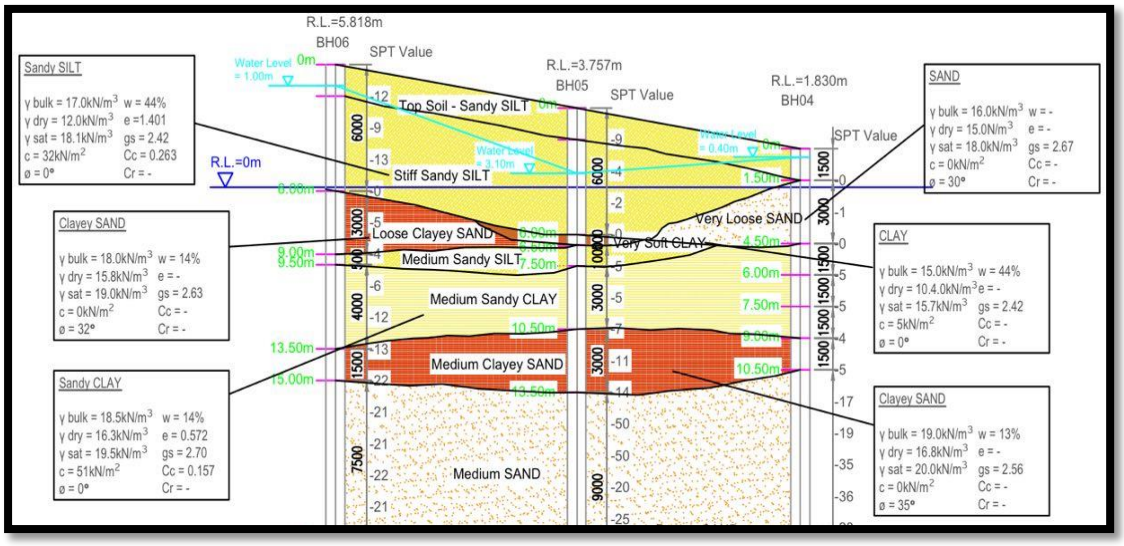
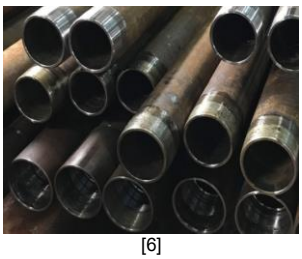


Figure 2: Example of Soil Stratigraphy

It is an ideal foundation for low-rise buildings with soft/loose upper soil stratum and heavy structures including high-rise buildings, and infrastructure (metro stations, bridges, fly-overs, etc.). Deep foundations are subdivided into various types as follows:

Deep Foundation	Description
i. Micro Piles  [6]	Micropiles are small-diameter piles that are frequently employed in places with restricted access or when foundation support is required for existing structures. They are frequently employed in tasks involving retrofitting.
ii. RC Square Piles  [7]	Segmented Reinforced Concrete Piles (RC-Piles) are constructed by assembling reinforced concrete segments of varying lengths, typically 3 meters, 4 meters, and 6 meters, with steel joint plates affixed at each end [7].

iii. Spun Piles  [8]	Spun piles are cylindrical concrete piles featuring a hollow core and prestressed reinforcement, extensively employed in construction projects like bridges and buildings. Manufactured using a spinning process, these piles consist of high-strength concrete and prestressed steel components [8].
iv. Bored Piles  [9]	Drilling a hole into the ground to the proper depth and, if necessary, reinforcing it with steel is part of the procedure. The hole is then filled with concrete to form a solid foundation. Borehole piles are used to move high loads from structures to deeper, stronger soil or rock layers under the softer surface soil layers.

CONCLUSION

In conclusion, various site-specific factors, including conditions and circumstances, determine whether shallow or deep foundation techniques should be used. While deep foundations perform well in soft/loose soils and while supporting heavy constructions, shallow foundations are favoured for stiff soils and lighter loads. A thorough soil research and careful design are needed to guarantee the foundation's overall safety and stability.

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References:
[1] Madeh Izat Hamakareem (n.d.). Foundation Selection Criteria for Buildings. The Constructor. Retrieved on 28th April 2024 from https://theconstructor.org/geotechnical/foundation-selection-criteria/6971/
[2] Mohd Fairus Yusof (2017) Correlation of JKR Probe with Undrained Shear Strength. MATEC. Retrieved on 28th April 2024 from https://www.matec-conferences.org/articles/matecconf/pdf/2017/17/matecconf_iscee2017_07009.pdf
[3] Indeed Editorial Team (2022, June 25). Foundation Types in Construction: Definition and 5 Primary Types. Indeed. Retrieved on 28th April 2024 from https://www.indeed.com/career-advice/career-development/foundations-types
[4] Hamzah M. Beakawi Al-Hashemi (2016, Jan). End Bearing Capacity of Pile Foundation. University of Bahrain. Retrieved on 28th April 2024 from https://www.researchgate.net/publication/309533940_End_Bearing_Capacity_of_Pile_Foundations
[5] PRD RIGS (2023, June 15). Standard Penetration Test (SPT) for soils – All You Need to Know. Retrieved on 28th April 2024 from https://www.linkedin.com/pulse/standard-penetration-test-spt-soils-all-you-need/
[6] John Lawrie (n.d.). Threading For Micropile. Retrieved on 28th April 2024 from https://www.johnlawriemetals.com/old/tubulars-2/micropile
[7] DUASIA PADUSEJATI (n.d.). Pile Production. Retrieved on 28th April 2024 from https://duasia.co.id/index.php/pile-production
[8] Top-Base Method (M) Sdn. Bhd. (n.d.). Pile Foundations. Retrieved on 28th April 2024 from https://topbasemethod.com/spun-piles-malaysia/
[9] Henry Drilling (n.d.). Bored Piles. Retrieved on 28th April 2024 from https://www.henrydrilling.com/bored-piles/