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Pile Foundation and Installation Methods in Nigeria

Taiye Elisha Adejumo

Research Fellow, Department of Geotechnics and Environmental Engineering, Faculty of Civil Engineering; Belorussian National Technical University, Minsk, Belarus
corresp. Author: elisha4exploit@yahoo.com

I. L. Boiko

Associate Professor, Department of Geotechnics and Environmental Engineering, Faculty of Civil Engineering; Belorussian National Technical University Minsk, Belarus; boykoil@tut.by

ABSTRACT

This paper presents a handy compendium and general overview of the state of pile foundation works in Nigeria which may hardly be found in any single volume or write up. It furnishes with a brief history of pile foundation construction in Nigeria, types of pile in use as well as installation methods mostly employed in pilling work for the construction of houses, bridges, roads, exploration platforms, ports, assembly plants, transmission tower bases and other projects, especially on weak soils in Nigeria. Depending on the terrain, use and finance, wooden piles, steel piles, reinforced concrete piles or combination piles known as composite piles have been used to supports various structures especially where the firm bedrock is far below the ground and/or water level. Installation techniques in use include driving, boring, jetting, jacking and screwing.

KEYWORDS: Pile foundations, installation methods, construction, weak soils, Nigeria

INTRODUCTION

Pile foundations (especially wooden piles) have been used in traditional constructions along river banks and coastal areas in Nigeria even before the first officially documented Carter Bridge built in Lagos in 1901. However, application of piles became more prominent towards the ends of 1960s and early 1970s, when many firms from Europe used it for the construction of houses, bridges, roads, exploration platforms, ports, assembly plants, transmission tower bases and other constructions especially on weak soils with difficult engineering-geological conditions where other foundation types becomes unsuitable.

In 1740 Christopher Polhem invented pile driving equipment which resembled today's pile

driving mechanism. Steel piles have been used since 1800 AD and concrete piles since about 1900 AD. The industrial revolution brought about important changes to pile driving system through the invention of steam and diesel driven machines. Pile foundation, which is an example of deep foundations, are usually installed with sophisticated machineries especially in large scale constructions. Today there are many advanced techniques of pile installation (Ascalew and Smith, 2007).

The arrival of English colonists followed-up by, German, Italian and French ones gave a new dimension on the implementation of pile driving in particular, with the construction of more complex and heavier buildings and structures that needed a more rationalized scientific approach (Lezin et al., 2009). Several structures were constructed on pile foundations mainly by colonial /foreign companies that used non-qualified local laborers (FMWHD, 1982).

Historically, the Carter Bridge, Lagos - Nigeria, built in 1901, was originally built by the British colonial government before Nigeria's independence in 1960. After independence, the bridge was dismantled, redesigned and rebuilt in the late 1970s (FMWHD, 1982). Many other bridges built on pile foundations include: Niger Bridge, Onitsha (1965), Eko Bridge, Lagos (1965), the third mainland bridge, Lagos (1990). Several of these bridges and other constructions were erected on difficult terrains in Lagos, Abuja and other parts of the country as documented by (FMWHD, 1982). Although some of these records are inconsistent and inadequately insufficient. In Nigeria, pile foundations have been used to support structures built on weak soils, which are found in many parts of Nigeria, as described by (Ola, 19987; Adesunloye, 1987; Chukwueze, 1991; Ige and Ogunsanwo, 2009; Omange et al., 1988 and Sadiku, 1985). A simplified soil groups in Nigeria is shown in fig.1. Some selected major foreign firms involved in pilling and pile foundation constructions of some projects amongst several others are shown in Table 1.

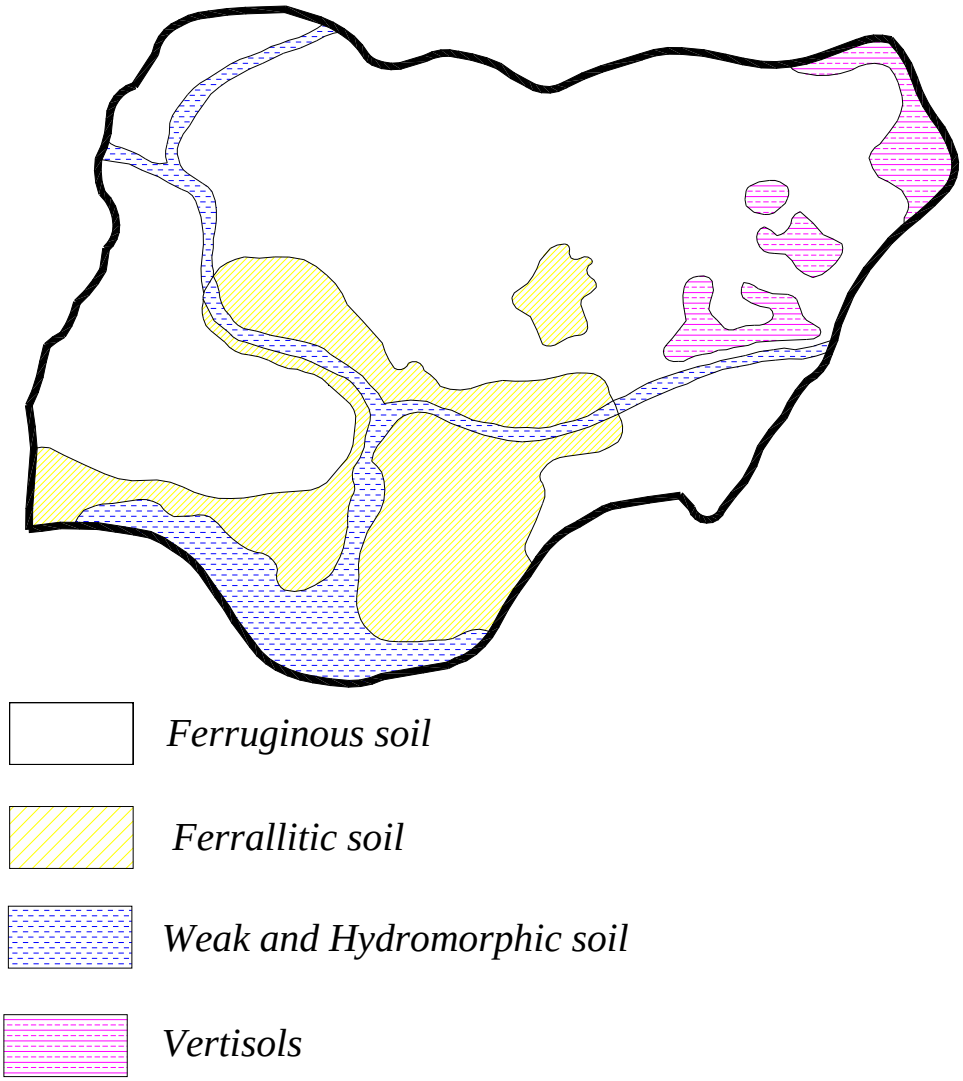

Figure 1: Simplified soil groups in Nigeria

Table 1: Some Foreign firms involved in piling works and selected projects

Structure/Project	Year of construction	Company's root/partner	Year of incorporation	Method of installation
2nd Mainland bridge (Eko bridge), Lagos	1965	JULIUS BERGER (Germany)	1890	Driven piles
Nicon Noga Hilton, Tower, Abuja	1987	BNL BOUYGUES Ltd (Czech Republic)	1952	Bored piles
QIT Building terminal, Eket	1990	CUSTAIN W/A (United Kingdom)	1984	Driven piles
Wudil-Tamburawa water supply, Kano	1997	STRABAG (Arab Contractors)	1982	Bored piles
Gurara water project	2001	SALINI Ltd (Italy)	1936	Driven / Bored piles
Oil& Gas production, South/East Nigeria	2008	AMEC (Canada)	1975	Driven / Bored piles
Dualization of East-West road	2008	REYNOLD RCC (Israel)	1984	Driven / Bored piles
Road project in Taraba	2010	PW Nigeria Ltd (Ireland/Nigeria)	1974	Driven / Bored piles
Ikeja City Mall, Lagos	2010	CAPPA D'ALBERTO (Italy)	1932	Bored piles
Abuja-Abaji road	2011	DANTATA &SAWOE (Nigeria/Germany)	1975	Driven / Bored piles

PILE FOUNDATIONS IN NIGERIA

Types of Pile foundations in Nigeria

The type of pile depends upon a wide variety of factors, including soil type, corrosion, local availability and cost, contractor preference, and the load bearing requirements of the foundation. Piles are classified by use, installation, material, and type of displacement. Piles may also be classified according to installation techniques (UFC 3-220-0216, 2004).

In Nigeria, with respect to load transmission and functional behaviour piles are classified as *End bearing piles* (bearing piles), *friction piles* (cohesion piles) and combination of end bearing and cohesion piles. With respect to type of material, pile could be classified as *Timber piles, Steel piles, Concrete pile or Composite piles.* With respect to effects on the soil, pile could be classified simply as *driven piles* or *bored piles.* (Fig.2a &2b)

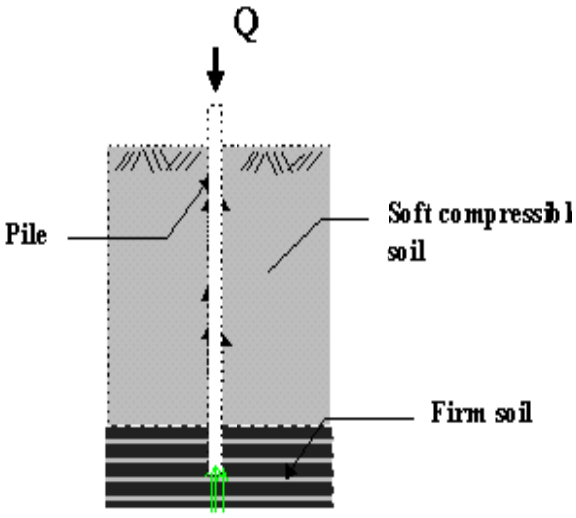

Figure 2a: End bearing pile

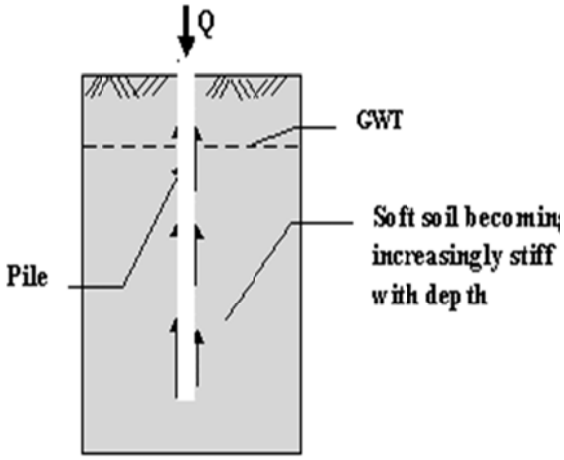

Figure 2b: Frictional or cohesion pile

Pile Foundations Installation Methods

The type of pile influences the method selected for installation. For example, impact hammers may not be able to drive timber or closed-end pipe piles into firm ground without damage to the pile, and assisted installation may be required (UFC 3-220-0216, 2004). The specific pile construction method depends on the soil condition, the ground water elevations, site conditions and the length of the pile (Bilfinger Berger, 2012).

(a) Driven Piles installation

Piles are installed or driven into the ground by a rig which supports the leads, raises the pile, and operates the hammer. Rigs are usually manufactured, but in the field they may be assembled, that is, constructed with available materials. Modern commercial rigs use vibratory drivers while most older and expedient rigs use impact hammers. The intent is the same, i.e. to drive the pile into the ground (strata). Pile-driving rigs are mounted in different ways, depending on their use. This includes railway, barge, skid, crawler, and truck-mounted drivers. Specialized machines are available for driving piles. Most pile driving operations are performed using a steel-frame, skid-mounted pile driver or power cranes, crawlers, or truck-mounted units, with standard pile-driving attachment (UFC 3-220-0216, 2004). The attachments available include adapters for connecting the leads to the top of the crane boom leads and a catwalk or lead braces used to connect the foot of the leads to the base of the boom. The leads and catwalk assembly support drop hammers weighing up to 3,000 pounds (1.5tons) and diesel hammers weighing up to 13,000 pounds (6.5tons). (Fig.3)

There are three impact hammers used for pile-driving: *the drop hammer*, *the pneumatic or steam hammer*, and *the diesel hammer*. Drop hammers and diesel hammers are standard engineering equipments. *Vibratory drivers/extractors* are not classified as hammers and do not require pile caps for protection against impact stresses. They are clamped to the pile to vibrate as a unit. Vibratory drivers are a recent development in pile-driving equipment. They are used in large scale pile constructions. The majority of modern pile vibrators runs at frequencies, ranging typically between 20 to 40 Hz. In the case of vibratory pile installation it is important to avoid

resonance in the ground or at adjacent structures or structural elements as this can cause inconvenience or damage. At high vibration frequencies (usually higher than 30 Hz), this problem can be avoided as neither the exposed length of the pile nor the soil will be in resonance. Noise emissions levels are usually low (UFC 3-220-0216, 2004).

(b) Bored Piles installation

Large bored piles are used as foundation elements to carry concentrated building loads into deeper, more stable soil layers. Bored piles can be easily adapted to the various load and soil requirements due to the large variety in diameter and construction techniques. Single pile diameter can vary between 30 and 300 cm. It can be constructed in all kinds of soil conditions.

In contrast to driven piles, bored piles enable the immediate In-situ evaluation of drilled soil layers to revise foundation length due to changed soil conditions. Construction methods of bored piles can be categorized as;

(i) The bored ***holed stabilization*** process of fully cased, partial cased, uncased and fluid stabilized excavation

(ii) The ***casing installation method***– either by driving the casing with a free fall hammer or weight, vibrating the casing, pneumatic installation or hydraulic installation with the help of a rotary drive, an oscillator or rotator.

(iii) The ***excavation method*** – either by grab excavation, rotary drilling, airlifting, and flush boring. Combinations of air-lifting and reversed circulation drilling can drill bore holes up to 150 m depth efficiently, depending on soil conditions (Bilfinger Berger, 2012).

PILE INSTALLATION EQUIPMENT

Pile installation equipments mostly used by foreign contractors (Table 1) in Nigeria include among others DSB 1/3.5 Nordmeyer Rig, SOILMEC SM-305 , LIEBHERR HS 855 HD, CAT 345 CL UDH, KOMATSU PC-300, MANITOWOC 4100 WS1, CASAGRANDE C-8, FUNDEX F14, DELMAG D22, BAUER BG 45, NEXOMA 900T, DAVEL KENT T170 as well as other models of these equipment.

INSTALLATION TECHNOLOGY/ SKILL TRANSFER PROBLEMS

Pilling works in Nigeria are mostly executed by foreign construction firms owing to high skill expertise required, and particularly due to the fact that most of the machineries and pile installation equipment are imported from Europe and America or Canada. These firms bring their equipment to Nigeria along with personnel to operate, maintain and service them. However, there is little improvement in skill, but not technology transfer. At least a good number of Nigerian workers now serve as intermediate artisans, welders, work men, surveyors, plant operators and other low skill jobs, but much ground need be covered as indigenous trained personnel are meant to work behind the foreign experts with little practical experience gained in the real pile installation techniques. This is consequently visible in the more than one century domination in pilling works in Nigeria by foreign construction firms since 1901 when the first bridge was built

in Lagos by the British government.

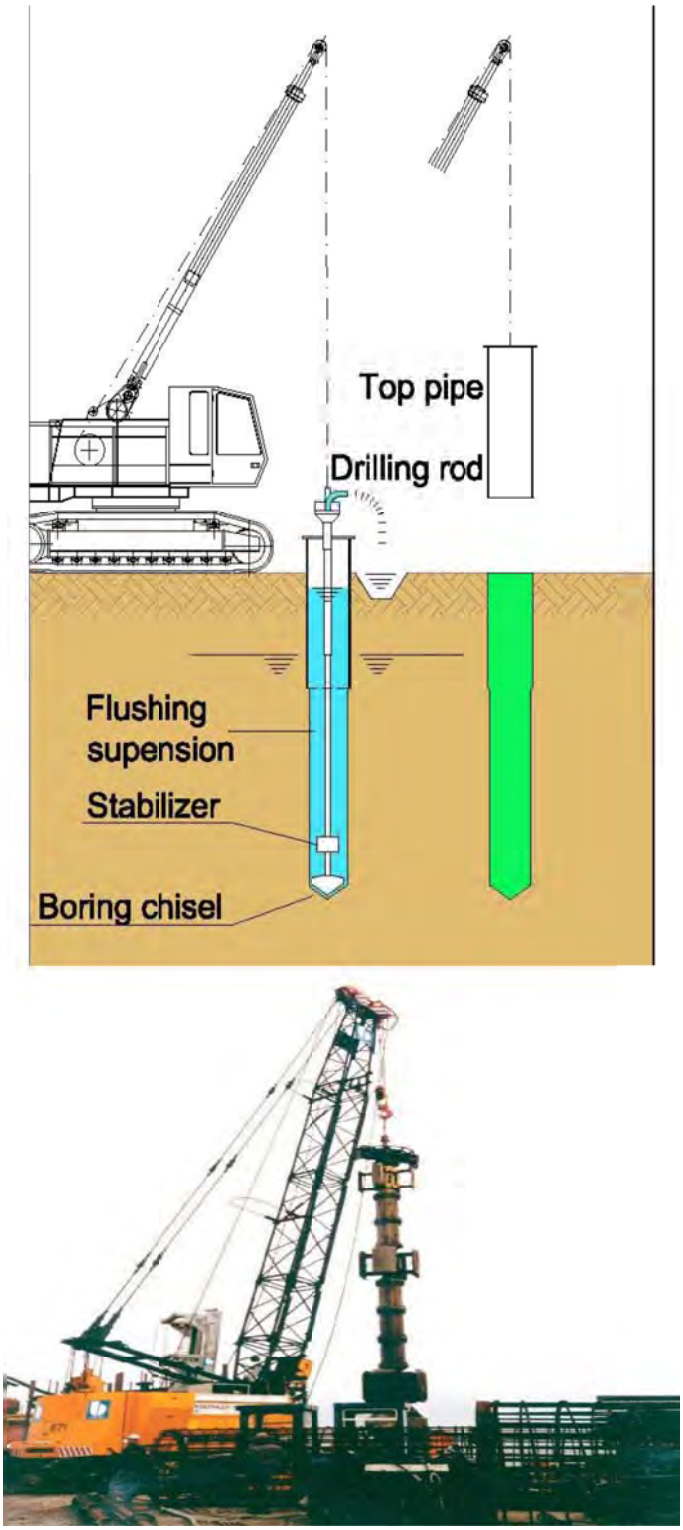

Figure 3: A multi- purpose pile installation Rig

CONCLUSIONS

- The state of pile foundations construction in different territories underlain by weak soils across Nigeria has been reviewed.
- Base on purpose, soil condition, cost and experience, wooden/timber piles, concrete piles (mostly reinforced), steel piles and composite piles have been and are still being used in Nigeria.
- Depending on the type of structure, soil conditions, expertise and finance, methods of pile foundation installation widely used in Nigeria include; driving, boring, jacking, screwing, jetting or a combination of any of these.
- Pile foundations constructions in Nigeria are mostly executed by foreign construction firms from Europe, America or Canada, which brings pile installation equipments from their countries with little knowledge transfer to indigenous workers and partners.

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