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Traditional Solution for Foundations in a Lake Environment: Case of the Village Ganvié in the Republic of Benin

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ABSTRACT

The problems noted in the structures built on wooden foundation piles in a lake environment required various works to strengthen over time. This work mainly consists of the recovery of the foundation mass by micropiles due to the increase in loads on the structures, or the recovery of the foundation mass by injection, which is carried out when voids form between the ground and the wooden foundation elements. The high cost of foundation reinforcement methods led the National Agency for the Development of Tourist Heritage in Benin (ANPT) to replace the wooden foundation piles with reinforced concrete piles in the implementation of the project “reinventing the lakeside city of Ganvié”. This article presents an artisanal technology for the creation of reinforced concrete foundation piles in a lake environment. On-site examples made it possible to evaluate the performance of this artisanal implementation technique. The installation of these piles is carried out following manual drilling, followed by the installation of reinforcement and the pouring of concrete on site. The implementation of reinforced concrete foundation piles in place of the wooden ones studied in this article only impacted the infrastructure of the homes of the lakeside town of Ganvié but not the superstructure, which preserved the old traditional wooden architecture and thatched roofs. Thus, the ambition to move this city of Ganvié from the stage of a lake village to that of a floating city is very successful. This will contribute to improving the environment and living conditions of the populations and will promote economic development through tourism.

Keywords: Wooden Foundation Piles; Disorder of Foundations; Reinforcement of Foundations; Manual Drilling; Reinforced

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1. Introduction

Planet Earth was formed approximately 4.54 billion years ago. On this planet, 71% of the total surface is covered by oceans of salt water, which form the hydrosphere along with other water sources such as lakes, rivers or groundwater^[1]. There is therefore only 29% of land surface on the entire globe. The Earth is now home to millions of living species, including humans. Since the dawn of time, the latter have colonized large habitable areas in order to found civilizations and develop exchanges with their fellow human beings.

With the rise of technology and the improvement of health services, we are witnessing strong population growth on a global scale. This strong human population growth leads to the need for new living space. However, of the 29% of the available surface area, only 26.3% is habitable if we do not take into account the 1,700 to 1,800 million hectares of surface area covered by tropical forests, animal reserves and parks^[2]. This small habitable percentage of the globe is shared today between approximately 7.5 billion humans, at the rate of 1,810 hectares of more or less fertile land per human. This mathematical calculation does not reflect the reality of spatial occupation and the distribution of habitable surfaces around the globe. In addition, it does not take into account the main major trend that affects the surfaces actually available to humans.

Thus, during the International Conference on Amphibious Architecture, which was held from August 26 to 29, 2016 in Bangkok, the need to rethink amphibious cities was highlighted.

The debate therefore arises on what some call the “blue revolution”. The feasibility study shows that the “blue revolution” constitutes a very important issue. According to this study, if habitable spaces become scarce, oceans and lakes will be a response by helping to offer a high standard of living to the population while protecting ecosystems. One of the main challenges of the 21st century will therefore be to see the emergence of new sustainable cities on the waters^[3].

Faced with the multiple environmental and socio-economic upheavals that the earth is currently experiencing,

many of these cities are faced with urban changes, most of the time poorly controlled.

In Benin, we can cite the example of the lakeside towns located in the Commune of Sô-ava. These cities, sheltering the civilization of the “men of the water” (locally called Toffins or toffinus), stand out for their uniqueness. The history and way of life of these populations constitute a major tourist attraction. However, they increasingly have to face the deterioration of their urban landscape. This heritage landscape is essential to maintaining their tourist attractions, a real economic vector^[4].

Among these lakeside cities, one attracts thousands of visitors each year from the four corners of the world. This is Ganvié, a city included on the UNESCO World Heritage indicative list since 1996^[4].

Benin, a country located in West Africa, has many remarkable cultural and natural resources that offer real possibilities for its development. Recognized for its legendary hospitality, Benin fascinates visitors throughout its territory with its beaches, lakeside villages, museums, cliffs and mountain ranges, and fauna and flora reserves^[5].

Among the lakeside cities that are the cultural pride of Benin, we have Ganvié. It is located to the northwest of Lake Nokoué (**Figure 1**), at the very place where the right arm of the Sô river which constitutes the backbone of the Municipality of Sô-ava of which it is part, flows into Lake Nokoué. It is about twenty kilometers as the crow flies from Cotonou and about eight kilometers from the Calavi Tourist Station. Here, the entire life of the population takes place on the water and revolves around the water.

Nowadays, the lakeside city populated by more than thirty thousand people (37,172 inhabitants) according to the last General Population and Housing Census^[6]. It is in a state of advanced change. With the decentralization policy, it straddles two (02) of the seven (07) districts that make up the commune of Sô-ava. It includes eleven (11) villages in total.

Economically, the main activity of the populations is fishing. But overpopulation and overexploitation exert great pressure on fisheries resources, which tend to become exhausted. Faced with falling incomes and increasing unem-

ployment, a wave of change in mindset is pushing people to diversify their activities. We are witnessing a multiplication and diversification of small trades such as carpentry, tailoring and other product trades.

On a cultural level, the losses are enormous. We are witnessing the gradual disappearance of the traditional mode of housing, which gave authenticity to lakeside towns and attracted so many tourists. Crafts, closely linked to tourism, try to fill this economic-cultural void but they lack visibility. The demand for art objects is present but is not satisfied by the supply. This state of affairs is paradoxical given the enormous tourist potential of the area.

In general, numerous multidisciplinary studies have been carried out (ethnography, sanitation, architecture, urban management, construction materials, tourism, polytechnics, mechanics, renewable energy). But few of them focus on improving living and housing conditions. Populations must face the effects of demographic pressure (overexploitation of fishery resources, environmental degradation), lack of planning documents and town planning regulations (urban sprawl, lack of equipment) and poverty. (unemployment, low accessibility rates of equipment, exodus of young people, etc.).

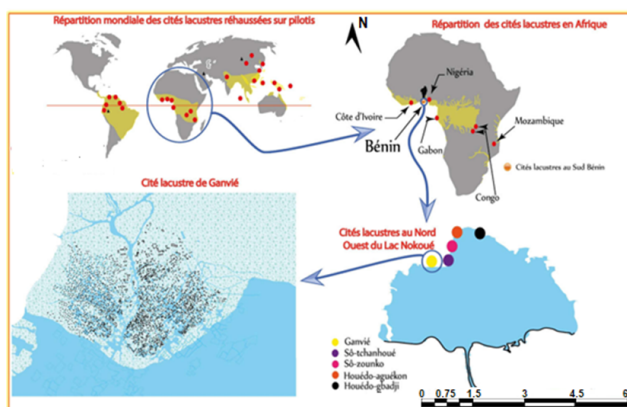


Figure 1. Location plan of the lakeside town of Ganvié.

Source: Babilas Hountondji.

The lakeside city of Ganvié, whose origins date back to the 18th century, a place of refuge for a population fleeing slave raids in order to escape a sad fate, has become a major tourist site in West Africa nicknamed the Vernice of Africa^[7]. Inscribed on the UNESCO tentative list since 1996 but not yet classified as a world heritage site, contrary to what some tourist guides suggest^[8].

It has experienced a drop in attendance rates with the

development of modern architecture on stilts (**Figure 2**), chipboard walls and tin roofs, replacing the old traditional architecture of wood and thatched roofs (**Figure 3**) for around twenty years^[5].



Figure 2. Ganvié in 2024.



Figure 3. Ganvié in 1962.

The disappearance of the old architecture of the lakeside town of Ganvié is said to be due to the type of foundation put in place (wooden piles), which does not last too long because it is subject to damage.

The problems noted in homes built on wooden foundation piles in the lakeside town of Ganvié require various works to strengthen the foundations. This work mainly consists of the recovery of the foundation mass by micropiles due to the increase in loads on the structures, or the recovery of the foundation mass by injection, which is carried out when voids form between the ground and the wooden foundation elements. The high cost of foundation reinforcement methods (construction site installation, reconnaissance by underwater diving, instrumentation and monitoring of long-term measurements) led the National Agency for the Development of Tourist Heritage in Benin (ANPT) to seek to anticipate the replacement of wooden foundation piles with reinforced concrete piles in the implementation of the

project “reinventing the lakeside city of Ganvié”, that is to say, by transforming it from the stage of a lakeside village to that of a floating city with a new housing model (**Figure 4**).

It is with the aim of finding a solution approach to the concern of the National Agency for the Development of Tourist Heritage in Benin (ANPT) above that this article was initiated.



Figure 4. Lake habitat model of the lake city reconstructed.

Source: Babilas Hountondji.

To carry out this study, our main question is formulated as follows:

Taking into account current cultural, spatial, climatic and economic characteristics, how can we qualitatively support the change in the urban environment observed in Ganvié?

From this main question, the following specific questions arise:

- What measure should be taken for sustainable urban development in Ganvié?
- What arrangements should be made to promote rational use of space?
- How can we preserve the tourist appeal of Ganvié?

The main objective of this work is to effectively and qualitatively guide the urban change underway in Ganvié while maintaining its tourist appeal. From this main objective, the following specific objectives arise, among others:

- Improve the housing environment;
- Propose arrangements aimed at rationalizing the use of space;
- Strengthen the tourist vocation of Ganvié while allowing the diversification of economic activities.

2. Materials and Methods

There are generally two drilling methods for installing foundation piles: the manual drilling method and the mech-

anized drilling method. The materials to be used therefore depend on the method chosen.

The manual drilling method is a practical and affordable solution for piles less than 40 meters deep^[9] in alluvial soils (loose materials such as clay and sand) and soft weathered rock formations (such as soft sandstones and limestones) because it allows:

- a reduction in costs: 4 to 10 times less expensive than conventional mechanized drilling at equal depth.
- better accessibility to sites due to the lightness of the equipment, isolated communities may be affected.
- local manufacturing of drilling equipment which requires less investment to start the activity.
- job creation and know-how remain available locally even after the end of the project intervention.

Different types of geological formations (soil layers) are encountered during drilling. A range of different drilling techniques have been developed to penetrate the various geological formations. Regardless of the technique used, it is necessary to (a) break or cut the formation, (b) bring the debris (soil) to the surface, and (c) if necessary, support the walls of the hole to prevent them from collapsing during driving^[9].

Each of the drilling techniques has been developed specifically for one or more types of formations (soil layers); therefore, it is sometimes possible to combine several drilling techniques to carry out a single drilling. The different drilling techniques can be classified into four main groups: Auger drilling, Percussion drilling, Mud drilling and Water jetting. A wide range of techniques deriving from these four main principles has developed throughout the world^[9].

Auger drilling

Figure 5 shows the implementation of auger drilling. It consists of a set of steel extensions that is turned by a handle. Different types of augers can be attached to the end of the extensions. The augers are turned into the ground until they fill and are then pulled out of the hole to be emptied. The auger model varies depending on the type of formation (soil type) to be drilled. Generally, above the static level, the borehole remains open without the need for support. Once in the water table, temporary pre-casing can be used to prevent the collapse of the borehole walls. The sinking continues inside this pre-casing using a water auger until the desired depth is reached. Then, the permanent casing is installed

and the temporary pre-casing is raised to the surface. Auger drilling can be used to a depth of approximately 15 to 25 meters, depending on the geology. It is a technique suitable for unconsolidated formations: Sands, silts and soft clays.



Figure 5. Auger drilling^[9].

Percussion drilling

Figure 6 shows the implementation of percussion drilling. It uses a heavy bit (or spoon) attached to a rope or cable, which is lowered into the borehole or inside a pre-casing. A tripod (or goat) is generally used to hang equipment. By moving the rope or cable up and down, the drill bit loosens and fragments the soil or consolidated rock in the drill hole, from which the debris is then extracted using the scoop. As with auger drilling, metal or PVC pre-casing can be used to prevent the hole from collapsing. Once the final casing has been installed, the pre-casing must be removed. Percussion drilling is generally used to a depth of 25 meters. It is suitable for unconsolidated and consolidated formations: Sands, silts, hard clays, soft limestone, laterite, layers containing gravels and small pebbles.



Figure 6. Percussion drilling^[9].

Mud drilling

Figure 7 shows the implementation of mud drilling. It uses the circulation of water to bring the drilled materials to the surface of the ground. The drill string is operated up and down. During the descent of the rods, the shock created by the drill bit attached to the end of the drill string loosens/fragments the soil materials and during the upward movement, the end of the drill string is closed with the hand (valve effect), thus creating a suction of the water and the debris it contains to the surface. During the next lowering movement, the hand is removed from the drill string and the water squirts into the previously dug basin next to the borehole. In this settling basin, the debris separates from the water to settle at the bottom of the basin while the excess water flows back down into the hole. The pressure of the water on the walls of the borehole prevents them from collapsing. Mud drilling (with or without rotation) can be used to a depth of approximately 35 meters. It is suitable for unconsolidated formations: Sands, silts and clays. If rotation is used (with a drill bit), it is possible to penetrate semi-consolidated formations such as hard clay, soft limestone and weathered laterite.



Figure 7. Percussion drilling^[9].

Water jetting

Figure 8 shows the implementation of water jetting. Water jetting is also based on water circulation and pressure. Unlike mud drilling, water is now injected inside the drill string and the mud (water and debris) rises along the walls of the drilling. In order to obtain sufficient water pressure, a motor pump is used. The lower end of the drilling pipe can be left simply open, or a driving tool (bit bit) can be added. The drill string can also be completely or partially rotated. A drilling fluid (additive) can be mixed with water to prevent

the collapse of the hole walls and uncontrolled loss of water through seepage. The water casting technique (with rotation) can be used up to a depth of approximately 35–45 meters. It is suitable for drilling in alluvial materials such as loosely compacted sands, silts and thin layers of soft clay.



Figure 8. Mud drilling^[9].

As part of this work, our study area, the village of Ganvié, is a lake area. Despite the fact that the survey file produced by the National Society for Testing and Research in Public Works (SNERTP) indicates the depth of the piles as 15 m, we opted for the “Water Launching” method because it took into account the large number of piles; we did not want to install a definitive/permanent casing and also the pressure of the water supplied by the motor pump on the walls of the borehole is not sufficient to prevent the latter from collapsing. Once the principle of drilling the piles was retained, this allowed us to clearly define the materials to be used as well as the appropriate methodology.

2.1. Materials

1. The work barge

Figure 9 shows the main equipment (barge) of a river works site used in the context of this work. It includes:

- a front gantry which allows its movement, and which still serves as a drilling unit.
- a hydraulic crane which allows the handling of various elements such as temporary pre-casing, molds, reinforcement, etc.
- a generator which allows the crane to move.
- a plinth which prevents equipment from falling into the water.
- a hold which allows the equipment to be contained.

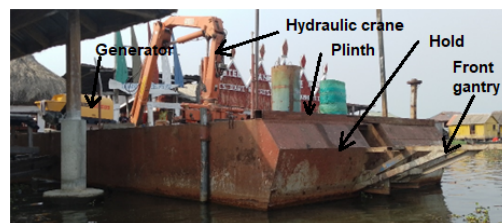


Figure 9. Work barge.

Source: Babilas Hountondji.

Other small materials are used as part of this work, namely:

2. The drilling rod

Figure 10 shows the drill rod which allows drilling to the depth indicated by the drilling file produced by the National Society for Testing and Research in Public Works (SNERTP).

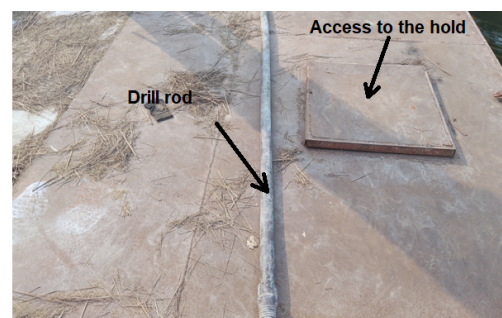


Figure 10. Drill rod and access to the hold.

Source: Babilas Hountondji.

3. The drill bit

Figure 11 shows the artisanal drill bit. Driving tool attached to the end of the drill string, it loosens/fragments the soil materials.



Figure 11. Artisanal drill bit.

Source: Babilas Hountondji.

4. Temporary pre-casing

Figure 12 shows the pre-casing. It is used to prevent the walls of the borehole from collapsing.



Figure 12. Pre-casing.

Source: Babilas Hountondji.

5. The mold

Figure 13 shows the prefabricated mold. It is used for the casting of reinforced concrete posts resting on the sole at the pile head.



Figure 13. Prefabricated mold.

Source: Babilas Hountondji.

6. The belt

Figure 14 shows the belt. It is used for the bit-drill rod assembly, completing the drill rods and completely or partially rotating the drill rod string.



Figure 14. Belt.

Source: Babilas Hountondji.

7. The motor pump

Figure 15 shows the belt. It is used to obtain sufficient water pressure.



Figure 15. Motor pump.

Source: Babilas Hountondji.

8. The L-shaped tube and the flexible tube

Figures 16 and 17 shows the flexible tube and the L-shaped tube. Two tools are assembled, the flexible tube connected to the motor pump then the L-shaped one connected to the head of the drill string to inject water into the latter to cause the mud (water and debris) to rise along the walls of the borehole.



Figure 16. Flexible tube.

Source: Babilas Hountondji.



Figure 17. L-shaped tube.

Source: Babilas Hountondji.

2.2. Method

In this part, we describe the main stages of water launching. Firstly, the operators, while on the barge, assemble the

various small pieces of equipment. These are:

- the assembly of the bit and the drill rod (**Figure 18**),
- the assembly of the flexible tube and the L-shaped tube (**Figure 19**).



Figure 18. Assembly of the bit and the drill rod.

Source: Babilas Hountondji.



Figure 19. Assembly of the flexible tube and the L-shaped tube.

Source: Babilas Hountondji.

Subsequently, in order to obtain sufficient water pressure, one of the operators positioned on the front gantry of the barge puts the motor pump fitted with flexible suction and discharge tubes into the water by keeping it running (**Figure 20**).



Figure 20. Finding water pressure.

Source: Babilas Hountondji.

Once water pressure is available and the drilling loca-

tion is identified, the drilling operation begins. The operators completely or partially rotate the drill string which gradually sinks (**Figure 21**).

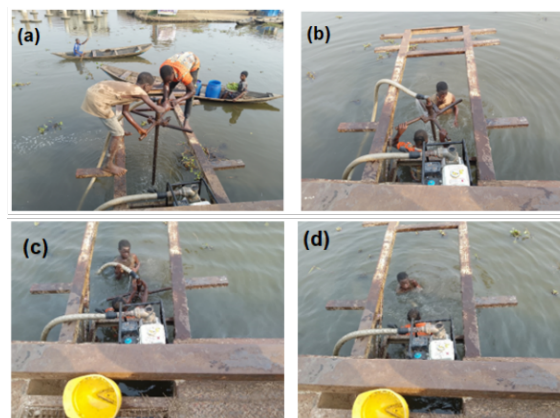


Figure 21. (a) Start of drilling; (b) Partially driven drill string; (c) Drill string almost sunk; (d) Drill string fully inserted.

Source: Babilas Hountondji.

When the desired depth is not reached, add your rods and continue the same operation until the desired depth is reached.

3. Results

During the sinking, soil samples are taken (**Figure 22**). These samples of the soils traversed help us understand what materials we have penetrated (drilled) and tell us when we have reached the final drilling depth.



Figure 22. Sample collection during the sinking.

Source: Babilas Hountondji.

Once the drilling was completed at a depth of 15 m, the reinforcements were put in place and the concreting carried out according to the plans below (**Figures 23 and 24**).

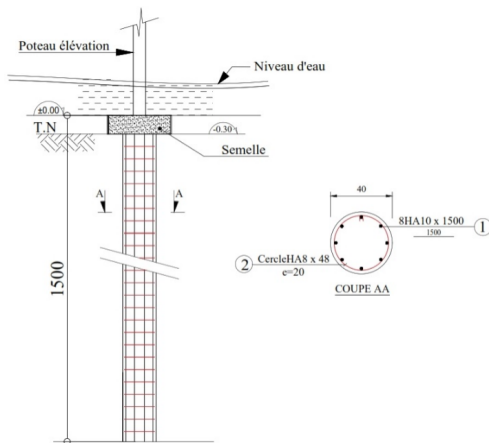


Figure 23. Pile reinforcement plan.

Source: Babilas Hountondji.

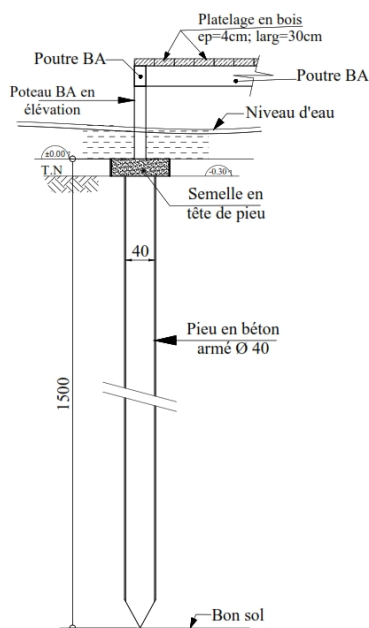


Figure 24. Pile formwork plan.

Source: Babilas Hountondji.

4. Discussion

The wood material has strong environmental advantages compared to other construction materials such as concrete and steel. The storage of carbon dioxide and the reduction of carbon emissions established from the carbon base attest to this. In today's society where the concept of sustainable development is anchored at the heart of the State's actions, wooden piles constitute an alternative solution to concrete and steel piles. The use of wooden piles nevertheless requires some precautions: the durability of the wood material which highlights that untreated wood could be sub-

ject to endogenous fungal degradation in tidal zones. The durability of wooden piles is ensured as long as they are completely and constantly submerged.

The dimensions of the wooden stakes were limited by those of the trees. The devices for joining the piles nevertheless made it possible to increase their length. Their geometry also varied depending on their use: the foundation piles were circular, while the piles used in the construction of cofferdams were squared. The wooden piles were driven into the ground using driving machines^[10]. The energy of the striking mass was transmitted to the pile via a shock wave propagating in the pile shaft. The pile was protected at the head and tip by metal reinforcements in order to limit the risk of cracking or fracturing. The protection of the pile heads with a concrete thimble, subsequently reinforced by metal reinforcements, also serves as a connection between the foundations and the upper part of the structure.

The study of construction methods for wooden pile foundations of structures and buildings showed that they had evolved over the centuries. The first uses of concrete in foundations date back to the industrial era. The fence, then the decking was successively replaced by this material. This era was also marked by a gradual decline in the use of wooden piles and the emergence of new types of piles, mainly metal piles and concrete piles.

Disorders are noted on structures based on wooden piles. In an aquatic site, they are subject to two types of water action which can be exerted on the entire structure or locally.

The action of the watercourse on all the structures causes general scouring of the foundations during periods of flooding when the high speed of the current washes away all the particles at the bottom of the watercourse. The removal and stripping of part of the foundation piles in the ground then leads to a reduction in the limit load-bearing capacity of the piles (**Figure 25**).

Intensive extraction of sediment from the river leads to a deepening of the riverbed and an increase in water velocity^[11]. It also causes a change in the grain size and a reduction in the density of the alluvium which becomes more mobile^[12-14]. The embankments of rock deposited to the right of the piles gradually slide and the sand located under the mesh washes away. The collapse of the piles results from the lateral instability of the piles stripped over a certain

height under the decking^[15].

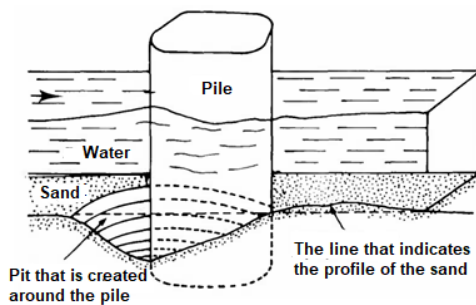


Figure 25. General scour phenomenon^[16].

The localized action of the watercourse in the vicinity of the structure mainly results in the phenomenon of local scour, different from general scour. It results from swirling movements of water at the level of the piles and consists of the formation of funnels at the base of the piles (**Figure 26**).

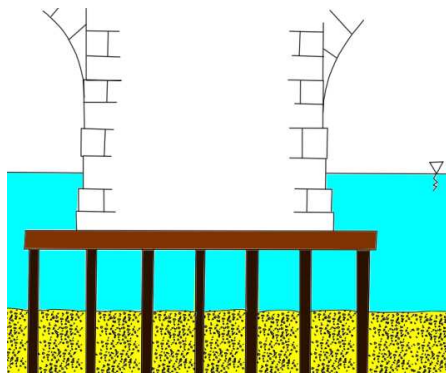


Figure 26. Local scouring of a pile in the ground^[16].

Local scour results in partial stripping of the pile heads. The structure is then weakened, but its ruin is not systematic.

Disorders observed on the structures^[17] may result from:

- the disorganization of the rock masses which collapse following the scouring of the watercourse bed at the foot of the embankment.
- cavity formation and stripping of piles. This stripping leads to a reduction in the limit lift and the resistance to lateral forces of the latter.
- the dissolution of lime from mortars with fresh water.
- the deterioration of the fence, the decking and the foundation piles which weakens the structure of the work.

There are also other causes of disorder, mainly linked to original inadequacies, acts of war, natural hazards and

lack of maintenance:

- the limit load capacities of piles evaluated from driving formulas can be overestimated. This overestimation then leads to significant settlement of the structures.
- the lack of maintenance and the poor quality of the materials constituting the piles lead to the degradation and dislocation of the masonry^[18].
- the events of war were also responsible for the ruin of numerous works.
- finally, natural hazards, such as ice jams that have occurred over the past centuries, have been the cause of numerous destructions of structures, whether or not they are based on wooden piles.

The disorders noted on structures built on wooden piles require various foundation strengthening works^[19, 20]. This work mainly consists of underpinning the foundation mass using micro piles^[21] or grout injection^[22–25] or also by injection of a low-slump mortar to densify loose and granular soils^[26–28]:

- the underpinning of the foundations by micro piles is carried out as soon as a lack of load-bearing capacity is proven^[29, 30]. It generally results in the settlement (or even overturning) of the piles^[31]. The increase in loads on the structure is generally the main cause^[32].
- the recovery of the foundation mass by injection is carried out when voids form between the ground and the wooden elements of the foundation^[33–35].

The high cost of foundation reinforcement methods (construction site installation, reconnaissance by underwater diving, instrumentation and monitoring of long-term measurements) led the National Agency for the Development of Tourist Heritage in Benin (ANPT) to replace wooden piles with concrete piles. Thus, in the implementation of the project “reinventing the lakeside city of Ganvié”, the wooden foundation piles were replaced by reinforced concrete piles.

This decision to replace wooden piles with reinforced concrete piles in the lake area is further confirmed because research has shown that in recent years, during the reconstruction of river dams on the Yonne, the wooden foundation piles were substituted for concrete piles. The Grand Port Maritime de Rouen also replaced the wooden piles in an advanced state of degradation and located under the quays with concrete piles^[36].

The reinforced concrete foundation piles instead of the wooden ones studied in this article only impacted the infrastructure of the homes of the lakeside town of Ganvié but not the superstructure which kept the old traditional wooden architecture and thatched roofs. Thus, the ambition to move this city from the stage of a lake village to that of a floating city is very successful as shown in the photos (**Figure 27a,b**) below. This will contribute to improving the environment and living conditions of the populations and will promote economic development through tourism.



Figure 27. (a) Reinforced concrete piles installed in place of wooden ones. (b) View of the constructed lake habitat model.

Source: Babilas Hountondji.

Without a doubt, the success of current habitats in lake areas gives hope for future innovations and developments. They are a solution for the future, provided they do not pollute and respect the environment and ecosystems, and also are economically accessible to as many people as possible.

5. Conclusions

The Beninese timber sector, despite strong logging potential, is poorly valued. The use of wooden piles in the construction of structures and buildings is disappearing in Benin during the 21st century and has been replaced by other pile technologies such as reinforced concrete piles. The absence of a Beninese regulatory framework relating to wooden piles, the skepticism and prejudices of construction stakeholders regarding the resistance properties of wood, the disorders observed in the structures and the high cost of methods of reinforcing them justify the absence of this type of piles in current practice in Benin.

Given the growing interest in technological advances in the field of piles, our research focused on evaluating the capabilities of reinforced concrete piles as a substitute for wooden piles. Drawing on existing literature highlighting the types and installation of wooden piles, our research aimed to

answer a question: How could reinforced concrete piles be used in place of wood without significantly modifying the architecture?

We concluded that by its great adaptability, the range of reinforced concrete foundation piles in lake areas possible applications and by the fact that it combines improvement and reinforcement of lake habitats, this solution is likely to develop in Benin then in all of West Africa. The successes achieved now and the increasing frequency of applications using it are a good indication of this. The manual drilling method, one of the fundamental bases of the solution, is put into practice thanks to adequate equipment, but above all relies on the experience, competence and seriousness of the company personnel. In order to limit the empirical nature of this, it is now necessary to deepen the understanding of the mechanisms involved to develop simpler and very profitable solutions.

The types of work described above are not very complex. However, we note that for this type of work a specific inventory is useful. Workers with experience in these types of work have a significant contribution to the progress of the work. A lot of upstream work must be done in order to be able to find an agreement with environmental services and representatives of the National Agency for the Development of Tourist Heritage in Benin (ANPT) so that the work can move forward.

Author Contributions

Writing: original draft, validation, supervision, resources, project administration, methodology, investigation, conceptualization, B.H.; writing-revision and publishing, resources, methodology, conceptualization, L.K.A.; writing-revision and editing, validation, methodology, F.d.P.C.; writing – review and editing, validation, M.P.A. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Not applicable.

Data Availability Statement

The authors agree to share their research data upon request.

Conflicts of Interest

The authors certify that there is no conflict of interest to declare.

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