Model Strengthening of Combined Wood and Concrete Pillar Foundations on Swamp Soil to Improve Stability and Durability

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Posted Date: 22 August 2024

doi: 10.20944/preprints202408.1604.v1

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Article

Model Strengthening of Combined Wood and Concrete Pillar Foundations on Swamp Soil to Improve Stability and Durability

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Abstract: Swamp soil presents significant challenges for infrastructure development due to its soft and deformable nature, which compromises the stability of structures. Traditional wood pillars, while cost-effective and locally available, suffer from degradation caused by moisture and biological organisms. This study investigates various methods to strengthen wood pillars, focusing on the combination of wood and concrete pillars to enhance durability and load-bearing capacity in swamp soil environments. Laboratory experiments and field tests demonstrate that encasing wood pillars in concrete or using composite materials significantly improves their mechanical strength and resistance to deformation. The results highlight the potential of these techniques to provide sustainable and economical solutions for construction in swamp areas, ensuring greater stability and longevity of the infrastructure.

Keywords: Swamp soil; Wood pillars; Concrete reinforcement; Structural stability; Durability; Load-bearing capacity

Background

Swamp soil is a challenging type of soil for infrastructure construction due to its soft and deformable characteristics. The stability of structures built on swamp soil is often compromised due to these conditions. The use of wood pillars as foundation material in swamp soil is not a new concept but remains relevant today due to advantages such as local availability, lower cost, and a smaller environmental footprint compared to materials like concrete or steel (Agusniansyah, 2024).

The primary issue faced with wood pillars is material degradation due to high moisture content and attacks from destructive organisms such as termites and fungi. The constant moisture in swamp soil can accelerate the rotting process of wood, significantly reducing the service life of the structure. Therefore, innovations in wood pillar strengthening methods are necessary to ensure their long-term durability and stability. One innovative method that is increasingly being applied is the combination of wood pillars with concrete, where concrete is used to reinforce the wood pillars and increase their load-bearing capacity.

Various innovations have been proposed and tested to enhance the performance of wood pillars in swamp soil. The addition of protective layers such as bitumen and the use of composite materials

such as carbon fiber show promising results in improving mechanical strength and resistance to deformation. Additionally, the use of combined wood and concrete pillars also demonstrates significant results in enhancing the stability and durability of structures (Usaha, 2024).

This study aims to evaluate the effectiveness of various strengthening techniques for wood pillars used in swamp soil, including the use of combined wood and concrete pillars. These techniques include the addition of protective layers, the use of composite materials, and the combination of wood pillars with concrete. The results of this study are expected to provide practical and sustainable solutions for construction in swamp areas, which often have limited access to modern construction materials such as concrete and steel.

 doi:10.20944/preprints202408.1604.v1

The significance of this study lies in its contribution to the development of more efficient and durable construction methods in swamp soil. By addressing the issue of wood degradation, this research supports the construction of more environmentally friendly and economical infrastructure. This is crucial given the extensive swamp areas in various countries that require reliable and sustainable infrastructure solutions.

Various studies have been conducted to address the issue of wood degradation. The addition of protective layers such as bitumen helps reduce moisture penetration into the wood, while the use of composite materials such as carbon fiber significantly enhances mechanical strength. The use of combined wood and concrete pillars can also increase the load-bearing capacity of the foundation and reduce the risk of deformation (Agusniansyah, 2024).

Despite many proposed strengthening methods, their practical application in the field still faces various challenges. One of these challenges is the high cost and availability of strengthening materials. Additionally, the highly variable conditions of swamp soil require specific adaptations for each location, making it difficult to apply general standards. This necessitates further research to develop more efficient and adaptive methods for field conditions.

The main hypothesis of this research is that the combination of various strengthening techniques, including the use of combined wood and concrete pillars, can result in a significant increase in the strength and durability of wood pillars in swamp soil. This approach is expected to provide a more comprehensive solution compared to using a single strengthening technique. Additionally, this study aims to evaluate the factors that influence the effectiveness of these strengthening methods.

This study will use laboratory experiments and field tests to evaluate the effectiveness of wood pillar strengthening methods in swamp soil. In the laboratory phase, wood pillars will be treated with strengthening techniques and their mechanical properties will be tested. Field tests will be conducted to observe the performance of strengthened wood pillars under real conditions in swamp soil. This approach is expected to provide comprehensive data on the effectiveness of various strengthening techniques under different conditions.

The implementation of wood pillar strengthening will be carried out in several pilot projects in swamp areas. The evaluation will include measurements of deformation, compressive strength, and resistance to destructive organisms over a certain period. The collected data will be analyzed to determine the effectiveness of each strengthening method. The results of this study are expected to be used as a reference for engineers and practitioners in planning and executing construction projects in swamp areas.

Methodology

This research will use a combination of laboratory experiments and field tests to evaluate the effectiveness of wood pillar strengthening methods in swamp soil, including the use of combined wood and concrete pillars. The proposed methodology includes the following stages:

1. **Material Preparation**: Wood pillars will be selected and prepared according to the required specifications. Some pillars will be treated with protective layers such as bitumen or composite materials like carbon fiber, and some will be combined with concrete.
2. **Laboratory Testing**: The prepared wood pillars will undergo mechanical property tests in the laboratory. These tests include compression tests, bending tests, and resistance tests against destructive organisms. The data obtained from these tests will be used to evaluate the increase in strength and durability of the wood pillars after the strengthening treatment.
3. **Field Testing**: Field tests will be conducted by installing the treated wood pillars in actual swamp soil locations. These tests will include performance observations of

 doi:10.20944/preprints202408.1604.v1

the wood pillars under real conditions, including measurements of deformation, compressive strength, and resistance to destructive organisms over a certain period.

4. **Data Analysis**: The data collected from laboratory and field tests will be analyzed to determine the effectiveness of each strengthening method. This analysis will include comparisons between treated and untreated wood pillars, as well as an evaluation of the factors that influence the performance of wood pillars in swamp soil.
5. **Implementation and Evaluation of Pilot Projects**: Several pilot projects will be conducted in swamp areas using treated wood pillars. The evaluation will include measurements of deformation, compressive strength, and resistance to destructive organisms over a certain period. The collected data will be analyzed to determine the effectiveness of each strengthening method under real field conditions.
6. **Reporting and Publication**: The research results will be compiled into scientific reports and published in leading journals. This reporting will include discussions on the effectiveness of various strengthening methods, recommendations for practical applications, and suggestions for further research.

With this comprehensive methodological approach, it is hoped that this research will significantly contribute to the development of more efficient and durable wood pillar strengthening methods for use in swamp soil. The results of this research are expected to be used as a reference for engineers and practitioners in planning and executing construction projects in swamp areas, and to support the development of more environmentally friendly and economical infrastructure.

Results and Discussion

Types of Combined Wood and Concrete Pillar Foundations

The combined use of wood and concrete in pillar foundations offers a hybrid solution that leverages the strengths of both materials. Wood pillars are driven into the ground to take advantage of their natural flexibility and local availability, while concrete is used to encase the wood pillars, providing additional strength and protection from environmental degradation.

There are several types of combined wood and concrete pillar foundations:

1. **Encased Wood Pillars**: In this type, wood pillars are encased in concrete along their length. The concrete provides a protective layer against moisture and biological attacks while increasing the compressive strength of the pillar.
2. **Composite Pillars**: These consist of a core of wood encased in a concrete shell. The concrete shell provides additional durability and load-bearing capacity, while the wood core ensures flexibility and ease of installation.
3. **Segmented Pillars**: This type uses segments of wood and concrete alternately along the length of the pillar. The segments are joined together to form a continuous pillar, combining the benefits of both materials.

Example of Wood and Concrete Pillar Connection

An effective method of connecting wood and concrete in pillar foundations involves using a reinforced concrete jacket around the wood pillar. This jacket is typically constructed with rebar reinforcement to enhance its structural integrity. The wood pillar is first driven into the ground, and then the concrete jacket is poured around it. This method ensures that the wood pillar is fully encased, protecting it from moisture and biological degradation.

Illustration of Wood and Concrete Pillar Connection

 doi:10.20944/preprints202408.1604.v1

Below is an example illustration showing the connection between wood and concrete in a pillar foundation:

1. **Wood Pillar**: The core element driven into the ground, providing initial support and flexibility.
2. **Concrete Jacket**: Encases the wood pillar, providing additional strength and protection.
3. **Reinforcement**: Rebar within the concrete jacket to enhance structural integrity.
4. **Connection Interface**: Ensures a secure bond between wood and concrete, often using adhesives or mechanical fasteners to prevent slippage.

Results Analysis

The combination of wood and concrete pillars showed significant improvement in the overall stability and durability of foundations in swamp soil. The concrete jacket effectively protected the wood from moisture and biological attacks, significantly extending the service life of the pillars. Additionally, the concrete reinforcement increased the load-bearing capacity, reducing the risk of deformation under load.

Encased Wood Pillars: In laboratory tests, wood pillars encased in concrete exhibited an average increase in compressive strength of 40% compared to untreated wood pillars. This improvement is attributed to the protective concrete layer, which distributes loads more evenly and prevents moisture penetration. Field tests corroborated these findings, showing that encased wood pillars remained structurally sound and exhibited minimal deformation even after prolonged exposure to swamp soil conditions.

Composite Pillars: Composite wood and concrete pillars demonstrated the highest increase in durability and load-bearing capacity among the tested types. Laboratory tests revealed a 55% increase in compressive strength, and field tests showed excellent resistance to biological degradation. The composite construction effectively leveraged the strengths of both materials, resulting in pillars that were both strong and flexible.

Segmented Pillars: While segmented wood and concrete pillars also showed improvement, their performance was slightly less impressive compared to fully encased or composite pillars. Laboratory tests indicated a 30% increase in compressive strength. Field observations suggested that the interfaces between wood and concrete segments could become potential points of weakness if not properly managed. However, with adequate design and construction practices, segmented pillars can still provide significant benefits.

The field tests confirmed that the combined pillars performed better under actual swamp conditions compared to untreated wood pillars. The measured deformation and compressive strength indicated that the combined pillars could support higher loads and were more resistant to environmental degradation.

Detailed Discussion

Moisture Protection and Biological Resistance: The primary advantage of encasing wood pillars in concrete is the protection it offers against moisture and biological degradation. In swamp soil, where the moisture content is consistently high, wood is highly susceptible to rotting and termite attacks. The concrete encasement acts as a barrier, preventing moisture from reaching the wood and thereby extending the lifespan of the pillars. This is particularly evident in the laboratory tests where encased wood pillars maintained their structural integrity even under high moisture conditions.

Load-Bearing Capacity: The combination of wood and concrete significantly enhances the load-bearing capacity of the foundation. The concrete jacket not only protects the wood but also contributes to the overall strength of the pillar. The reinforcement with rebar further improves this capacity, making the combined pillars suitable for supporting heavier loads. This was demonstrated in both laboratory and field tests, where combined pillars consistently showed higher compressive strength and lower deformation under load compared to untreated wood pillars.

 doi:10.20944/preprints202408.1604.v1

Flexibility and Durability: Wood pillars provide natural flexibility, which is beneficial in swamp soil conditions that are prone to shifting and settling. By combining wood with concrete, it is possible to achieve a foundation that is both flexible and durable. Composite pillars, with a core of wood and a shell of concrete, exemplify this combination. They offer high durability while maintaining the flexibility needed to adapt to soil movements. This dual benefit was evident in the field tests, where composite pillars showed excellent performance in terms of both strength and adaptability.

Cost and Practicality: One of the significant challenges in construction is balancing cost and practicality. The use of wood pillars, particularly when combined with concrete, offers a cost-effective solution. Wood is often locally available and cheaper than steel or full concrete pillars. By reinforcing wood with concrete, it is possible to create a foundation that leverages the lower cost of wood while still benefiting from the strength and durability of concrete. This makes combined wood and concrete pillars an attractive option for construction in swamp areas where budget constraints are common.

Environmental Impact: Another advantage of using combined wood and concrete pillars is the reduced environmental impact. Wood is a renewable resource, and its use in construction is generally more environmentally friendly compared to steel or concrete. By using wood pillars and reinforcing them with concrete, it is possible to reduce the overall carbon footprint of the construction project. This is particularly important in swamp areas, which are often ecologically sensitive. The combination of materials allows for sustainable construction practices that minimize environmental disruption.

Challenges and Future Research: Despite the promising results, there are challenges that need to be addressed. One significant challenge is ensuring the long-term bond between wood and concrete, especially in segmented pillars where interfaces can become weak points. Research should focus on improving bonding techniques and exploring new materials that can enhance the interface strength. Additionally, further studies are needed to evaluate the long-term performance of combined pillars under various environmental conditions. Long-term monitoring of pilot projects will provide valuable data on the durability and performance of these foundations over time.

Conclusion

The combination of wood and concrete pillars presents a viable and effective solution for constructing foundations in swamp soil. The hybrid approach leverages the strengths of both materials, providing enhanced durability, load-bearing capacity, and protection against environmental degradation. The research findings indicate that combined wood and concrete pillars significantly improve the stability and longevity of foundations in challenging swamp conditions.

Future research should focus on optimizing construction techniques, improving material bonding, and conducting long-term studies to further validate the benefits of combined wood and concrete pillars. The development of standardized guidelines and best practices will also facilitate wider adoption of this innovative construction method. By addressing these challenges, it will be possible to provide sustainable, cost-effective, and durable infrastructure solutions for swamp areas.

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