# Innovation of Wooden Pile Foundation Model for Housing Development on Swampy Land

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## Abstract

This study examines the latest innovation in wooden pile foundation models using a combination of wood and concrete materials for house construction on swampy land. The focus of the research is on developing joints and materials that enhance the load-bearing capacity and stability of building structures on swampy terrain. The methods used include field observations, laboratory experiments, and descriptive analysis. The results show that the combination of wood and concrete in foundation piles can increase structural strength, reduce deformation, and extend the service life of buildings. The new joint techniques developed in this research are effective in improving structural integrity and minimizing the negative impacts of soft soil conditions. The conclusion emphasizes the importance of material innovation and joint techniques in construction on swampy land, providing practical guidance for construction practitioners and researchers in this field.

Keywords:

wood pilllar foundation, wood and concrete combination, swampy soil, jointing technique, Banjarmasin

## Introduction

### Background

Banjarmasin, known as the "City of a Thousand Rivers," has unique geographical conditions with extensive swampy land. The swampy soil in Banjarmasin has different characteristics compared to typical soil, often featuring high water content and low load-bearing capacity, making it challenging for building construction. According to Afni et al. (2016), using concrete as an alternative to traditional ulin wood foundations for buildings on soft soil in Banjarmasin has been considered to address these challenges.

Kayu galam (Melaleuca cajuputi Powell) is the primary choice for house foundations in Banjarmasin’s swampy areas due to its abundant availability and adaptability to wet environments. Galam wood has advantages in water resistance and slower weathering compared to other woods. However, the constant wet conditions of swampy soil can eventually cause the wood to degrade. As noted by Ma’ruf et al. (2023), galam wood has high potential as

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substructure construction material but requires additional reinforcement to improve its service life and stability.

The limitations in load-bearing capacity and service life of galam wood have led to the search for more innovative solutions. One approach being explored is the combination of wood and concrete materials. Aleksandr and Kulikov (2018) found that combining wood and concrete can enhance the structural strength and stability of foundations on wet land, merging the benefits of both materials while mitigating their weaknesses when used alone.

Research by Bettiol et al. (2016) indicated that structural damage in small-pile foundations made of wood can be reduced by using numerical analysis to identify weak points and reinforcing them with concrete. This approach shows that combining materials can offer a more durable and stable solution for construction on swampy land.

This research aims to develop a wooden pile foundation model combining wood and concrete materials and identify optimal joint techniques to enhance foundation stability and load-bearing capacity on swampy land. The research methods include field observations, laboratory experiments, and descriptive analysis. Field observations were conducted to gather data on land conditions and the use of wooden piles in Banjarmasin. Laboratory experiments aimed to test the strength and stability of the wood and concrete material combination. Descriptive analysis was used to formulate an optimal foundation design model based on the collected data.

This research is relevant as it provides practical and innovative solutions to construction challenges on swampy land. By developing a stronger and more durable wooden pile foundation model, this research can support the development of safer and more sustainable infrastructure in difficult soil conditions. According to Klaassen et al. (2016), non-destructive approaches to evaluating the expected lifespan of wooden foundations can be part of this solution, ensuring that reinforced wooden foundations last longer in harsh environments.

Additionally, this research is expected to make a significant contribution to the advancement of knowledge in civil engineering and architecture. Innovations in foundation design and joint techniques can open new opportunities for further research and the development of more advanced construction technologies. As indicated by Ma'ruf et al. (2019), alternative foundation behavior on alluvial soil in Central Borneo can serve as a guideline for similar approaches in this research, providing additional insights into how alternative materials and innovative techniques can be applied in swampy environments.

**Importance of Innovation in Swamp Land Construction**

The swampy soil conditions in Banjarmasin require a specialized approach to foundation construction to ensure the stability and safety of building structures. Elam and Björdal (2020) note that the stability of wooden foundation piles in urban environments exposed to construction work can be significantly affected, highlighting the importance of innovation in

techniques and materials. Using galam wood as a foundation material has long been practiced in Banjarmasin due to its abundant availability and adaptability to swamp conditions. However, the main

drawback of galam wood is its rapid degradation due to continuously wet soil conditions, necessitating innovation in its use.

One promising approach is the combination of wood and concrete materials. Chen et al. (2020) found that reinforcing hollow wooden columns with CFRP can enhance structural strength and resistance to harsh environmental conditions. Using concrete as a coating or additional component on wooden piles can improve compressive strength and resistance to harsh environmental conditions. Laboratory test results show that this material combination can increase load capacity and the service life of the foundation. The material combination also reduces the risk of weathering and wood degradation due to constant water exposure.

The developed joint techniques involve using steel plates and bolts to connect wood and concrete piles. These joints are proven effective in enhancing structural integrity and reducing deformation in foundation piles. Using steel plates adds strength to the joint, while bolts ensure that the wood and concrete piles remain firmly and stably connected. Test results show that this joint technique can withstand greater loads and has better resistance to harsh environmental conditions compared to traditional joint techniques.

This research concludes that innovation in galam piling techniques can improve the stability and durability of foundations on swampy land. Combining wood and concrete materials effectively increases structural strength and the service life of the foundation. The developed joint techniques also provide significant improvements in structural integrity and resistance to harsh environmental conditions. The proposed foundation design model can serve as a practical guide for construction practitioners and engineers in designing and building foundations on swampy land. This research also opens opportunities for further research and the development of more advanced construction technologies in the future.

**Environmental Impact on Wooden Foundation Stability**

Environmental factors, especially continuously wet conditions and water exposure, significantly affect the stability and service life of wooden foundations. Miha et al. (2021) assessed wooden foundation piles after 125 years of service, showing that continuous wet conditions can lead to significant degradation. Therefore, additional protection and material reinforcement are essential to ensure long-term stability. Using concrete as a coating or additional component on wooden piles can provide additional protection against this degradation, significantly extending the foundation's service life.

Research by Fadai et al. (2012) shows that cement-bonded wood composite panels have high potential as construction materials for multi-story buildings. This indicates that material combinations can provide a more durable and stable solution for construction on swampy land. By leveraging the compressive strength of concrete and the flexibility of wood, this material combination can produce a more stable and durable foundation.

**Research Methodology**

## Research Design

This study uses a combined approach of field research and laboratory experiments. The research design involves several stages:

1. **Field Observation**:
    - Observations were made to identify the conditions of swampy soil in Banjarmasin and the methods of wooden pile driving used. Data collected include soil types, wood types used, and the piling techniques applied.
2. **Laboratory Experiments**:
    - Laboratory experiments were conducted to test the strength and stability of the wood and concrete material combination. Laboratory tests include compressive strength, tensile strength, and resistance to harsh environmental conditions.
3. **Descriptive Analysis**:
    - Data obtained from field observations and laboratory experiments were descriptively analyzed to formulate an optimal wooden pile foundation design model. The analysis includes comparing traditional wooden piles and wood-concrete combination piles and identifying the most effective joint techniques.

#### Data Collection Procedure

Data were collected through several stages:

1. **Field Observation**:
    - Observations were made at various locations in Banjarmasin to collect data on soil conditions and wooden pile driving methods. Data collected include soil types, water levels, wood types used, piling techniques, and environmental conditions.
2. **Laboratory Experiments**:
    - Laboratory experiments were conducted in a civil engineering laboratory to test the strength and stability of wood-concrete combination piles. Laboratory tests include compressive strength, tensile strength, and resistance to harsh environmental conditions.
3. **Interviews with Practitioners**:
    - Interviews were conducted with construction practitioners and engineers in Banjarmasin to gain additional information on wooden pile driving methods and challenges faced in building on swampy land.

#### Data Analysis

The collected data were analyzed both qualitatively and quantitatively. The analysis includes:

1. **Strength and Stability Comparison**:
    - A comparison was made between traditional wooden piles and wood-concrete combination piles. The analysis includes compressive strength, tensile strength, and resistance to harsh environmental conditions.
2. **Joint Technique Identification**:

    - Joint techniques used in wood-concrete combination piles were analyzed to determine the most effective method. The analysis includes joint types, materials used, and installation techniques.
3. **Foundation Design Model**:
    - Based on the analysis results, an optimal wooden pile foundation design model with concrete combination was formulated. The design model includes material specifications, installation techniques, and implementation procedures.

## Results

#### Land Conditions in Banjarmasin

Observations show that the swampy soil conditions in Banjarmasin are highly variable, with different water levels. Swampy soil generally has low load-bearing capacity and is prone to deformation, necessitating innovative foundation techniques. These conditions require a specialized approach to foundation construction to ensure structural stability and safety. Using galam wood as a foundation material has long been practiced due to its abundant availability and adaptability to swamp conditions. However, the primary weakness of galam wood is its rapid degradation due to continuously wet soil conditions, necessitating innovation in its use.

#### Traditional Galam Piling Techniques

Traditional galam piling techniques involve driving galam wood piles into the swampy soil until they reach a more stable soil layer. This method has been widely used but has limitations in terms of load-bearing capacity and service life. The main challenges faced in this technique include:

- Rapid degradation of wood due to constant water exposure.
- Limited load-bearing capacity, making it unsuitable for larger or heavier structures.
- Difficulty in ensuring uniformity and stability of driven piles.

#### Innovation in Wood and Concrete Combination Piles

This research developed a new model of wooden pile foundations by combining wood and concrete materials. The results show that this combination effectively increases the structural strength and service life of the foundation. Laboratory tests indicate that wood-concrete combination piles have higher compressive strength, tensile strength, and resistance to harsh environmental conditions compared to traditional wooden piles. The combination also reduces the risk of weathering and wood degradation due to constant water exposure.

#### Effective Joint Techniques

The developed joint techniques involve using steel plates and bolts to connect wood and concrete piles. These joints have been proven effective in enhancing structural integrity and reducing deformation in foundation piles. Test results show that this joint technique can withstand greater loads and has better resistance to harsh environmental conditions compared to traditional joint

techniques. The use of steel plates adds strength to the joint, while bolts ensure that the wood and concrete piles remain firmly and stably connected.

## Discussion

The research results indicate that innovation in galam piling techniques can improve the stability and durability of foundations on swampy land. The combination of wood and concrete materials effectively increases the structural strength and service life of the foundation. The developed joint techniques also provide significant improvements in structural integrity and resistance to harsh environmental conditions. These findings support the hypothesis that material innovation and joint techniques are essential for successful construction on swampy land.

#### Practical Implications

The proposed foundation design model can serve as a practical guide for construction practitioners and engineers in designing and building foundations on swampy land. This model offers a more robust and durable solution for overcoming the challenges posed by swampy soil conditions. By leveraging the benefits of both wood and concrete materials, the foundation design can achieve greater stability and longevity. The joint techniques developed in this research also provide practical solutions for ensuring the integrity and stability of wood-concrete combination piles.

#### Future Research Opportunities

This research opens opportunities for further research and the development of more advanced construction technologies in the future. Future research can focus on optimizing material combinations, improving joint techniques, and exploring new materials that can further enhance foundation stability and durability. Additionally, long-term field studies can be conducted to evaluate the performance of the proposed foundation design model in real-world conditions.

## Conclusion

In conclusion, the innovation of wooden pile foundation models using a combination of wood and concrete materials provides a viable solution for constructing buildings on swampy land. The combination of these materials significantly enhances the structural strength, stability, and service life of foundations. The joint techniques developed in this research further contribute to the overall effectiveness of the foundation design. The proposed model offers practical guidance for construction practitioners and engineers, ensuring safer and more sustainable infrastructure development in challenging soil conditions.

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