International Journal Multidisciplinary Science
IJML Vol 4 No. 1 February 2025 | ISSN: 2963-8119 (print), ISSN: 2963-7821 (online), Page 158-164

# APPLICATION OF BAMBOO PILES IN ATHLETIC TRACK CONSTRUCTION

**Reynold Andika Pratama[1], Ervina Yuliyanti[2], Savira Septiarini[3], Gita Puspa Artiani[4]**
[1,2,3]Civil Engineering Study Program, Faculty of Engineering and Informatics, Dian Nusantara University, Indonesia
[4]Universitas Krisnadwipayana, Indonesia

**Article History**
Received : Januari 2025
Revised : Januari 2025
Accepted : February 2025
Published : February 2025

**Corresponding author*:**
Ervina.yuliyanti@dosen.undira.ac.id

**DOI:**
https://doi.org/10.56127/ijml.v4i1.2219

**Abstract:** This study explores the application of bamboo piles as a sustainable ground improvement technique in the construction of an athletic track at the Malabar National Athletic Training Center in Pangalengan, West Java. Utilizing a qualitative case study approach, the research documents the implementation methods, technical considerations, and performance outcomes of bamboo pile foundations in addressing geotechnical challenges posed by soft clay soils and high groundwater levels. The bamboo piles, made from Gigantochloa apus, were systematically prepared, treated with borax-boric acid for durability, and installed in a triangular grid pattern to enhance soil bearing capacity and minimize settlement. The integrated foundation system, combining bamboo piles with gravel layers, drainage systems, and a synthetic track surface, met the International Association of Athletics Federations (IAAF) performance criteria, achieving a bearing capacity improvement of 180-220% and maximum settlement of 12 mm. The approach offered significant economic benefits, with 35-45% cost reductions compared to conventional concrete piles, and environmental advantages, including a 60-70% lower carbon footprint. This research underscores the viability of bamboo piles as a cost-effective, environmentally friendly solution for specialized construction, bridging traditional knowledge with modern engineering practices. Recommendations for future applications include rigorous geotechnical investigations, quality control, and long-term performance monitoring to ensure reliability.

**Keywords**: Bamboo piles, ground improvement, athletic track construction, sustainable construction, foundation engineering, geotechnical challenges, indigenous technology, Malabar National Athletic Training Center.

## INTRODUCTION

Foundation systems are critical components in civil engineering construction, providing essential support and stability for structures built above them. The selection of appropriate foundation systems depends on various factors including soil conditions, structural loads, environmental considerations, and economic constraints. In regions with challenging soil conditions, ground improvement techniques are often necessary to enhance soil bearing capacity and reduce settlement potential.

Bamboo piles represent an indigenous technology that has been utilized in various parts of Indonesia as a sustainable and cost-effective ground improvement method. This traditional technique leverages locally available materials and knowledge to address geotechnical challenges in construction projects. Despite its historical usage, the application of bamboo piles in modern construction projects, particularly in specialized facilities like athletic tracks, remains relatively undocumented in academic literature.

This study examines the application of bamboo piles in the construction of athletic tracks at the Malabar National Athletic Training Center in Pangalengan, West Java. The research focuses on the implementation methods, technical considerations, and

performance outcomes of bamboo pile applications in this specialized construction context. By documenting this case study, the research contributes to the body of knowledge on sustainable foundation technologies and their application in sports facility construction.

Understanding the practical application of bamboo piles in modern construction projects is valuable for civil engineering professionals seeking sustainable, economical, and locally appropriate solutions for ground improvement. This research bridges traditional knowledge and contemporary construction practices, offering insights into the continued relevance of indigenous technologies in modern civil engineering applications.

**Bamboo as a Construction Material**

Bamboo has been recognized as a versatile construction material with significant environmental benefits. According to Sharma et al. (2015), bamboo possesses favorable mechanical properties, including high tensile strength, flexibility, and a strength-to-weight ratio comparable to steel in certain applications. These properties make bamboo suitable for various structural applications, including foundation systems.

Research by Xiao et al. (2013) highlighted the sustainability aspects of bamboo, noting its rapid growth rate, carbon sequestration capabilities, and renewable nature. Their study emphasized bamboo's potential as an environmentally friendly alternative to conventional construction materials in appropriate applications.

**Bamboo Pile Technology**

The use of bamboo piles as a ground improvement technique has historical precedence in Southeast Asian construction practices. Janssen (2000) documented traditional bamboo pile applications in Indonesia, noting their effectiveness in improving bearing capacity in soft soil conditions. His research described the traditional methods of bamboo pile preparation, including preservation techniques to enhance durability.

Studies by Nurdiana and Umniati (2015) investigated the load-bearing capacity of bamboo pile foundations, finding that properly implemented bamboo piles can significantly improve soil bearing capacity in certain soil conditions. Their research established preliminary design parameters for bamboo pile applications in small to medium-scale construction projects.

**Ground Improvement for Athletic Facilities**

Athletic facilities, particularly running tracks, require specialized foundation systems to ensure performance, safety, and durability. According to the International Association of Athletics Federations (IAAF) guidelines (2019), athletic track foundations must provide consistent support, appropriate drainage, and minimal settlement to maintain surface integrity and performance characteristics.

Research by Mundell and McCombie (2009) examined ground improvement techniques for sports facilities, highlighting the importance of uniform support and controlled settlement in maintaining surface quality. Their work emphasized the relationship between foundation performance and the functional characteristics of athletic surfaces.

**Sustainable Construction Practices**

The integration of sustainable practices in construction has gained increasing attention in recent years. Berge (2009) advocated for the use of natural, locally available materials as a means of reducing environmental impact and enhancing project sustainability. His

research emphasized the importance of revitalizing traditional construction techniques that utilize renewable resources.

Studies by Pacheco-Torgal and Jalali (2012) examined the environmental benefits of incorporating traditional and indigenous construction methods in contemporary projects. Their research highlighted the potential for reduced carbon footprint, decreased transportation impacts, and enhanced local economic benefits through the use of locally sourced materials and techniques.

## RESEARCH METHOD

This research employed a qualitative case study approach to investigate the application of bamboo piles in athletic track construction at the Malabar National Athletic Training Center in Pangalengan, West Java. The study was conducted during a professional internship at the construction project, allowing for direct observation and documentation of bamboo pile implementation.

### Data Collection

Data collection methods included:

1. Direct field observation of bamboo pile preparation, installation, and performance
2. Documentation review of project specifications, geotechnical reports, and construction drawings
3. Semi-structured interviews with project engineers, construction managers, and skilled workers
4. Photographic documentation of construction sequences and techniques
5. Collection of soil data and bamboo pile specifications

The observation focused specifically on the following aspects of bamboo pile implementation:

1. Bamboo selection and preparation methods
2. Preservation techniques for enhancing durability
3. Installation procedures and equipment
4. Pattern and spacing configurations
5. Integration with other foundation elements
6. Quality control measures
7. Performance monitoring

### Data Analysis

The collected data was analyzed through a systematic process of categorization, comparison, and interpretation. The analysis focused on identifying the specific implementation methods employed, evaluating their effectiveness, and determining critical factors affecting bamboo pile performance. The findings were compared with established geotechnical principles and previous research on bamboo pile applications to contextualize the observations within the broader field of foundation engineering.

## RESULT AND DISCUSSION

### Site Conditions and Geotechnical Considerations

The Malabar National Athletic Training Center site presented several geotechnical challenges that influenced the decision to implement bamboo piles:

1. Soil Profile: Geotechnical investigations revealed a soil profile consisting of soft clay extending to depths of 3-4 meters, underlain by medium-dense sandy silt. The

soft clay layer exhibited low bearing capacity (approximately 50-70 kPa) and high compressibility characteristics.

2. Groundwater Conditions: Relatively high groundwater levels were encountered at depths of 1.5-2.0 meters below the surface, further complicating foundation design and construction.
3. Settlement Concerns: Preliminary calculations indicated potential for significant differential settlement under the loading conditions of the athletic track without ground improvement measures.
4. Environmental Considerations: The project's location in a rural area of West Java presented logistical challenges for transporting conventional construction materials, while offering access to local bamboo resources.

These site conditions necessitated a ground improvement approach that could enhance soil bearing capacity, reduce settlement potential, and accommodate the specific performance requirements of athletic track surfaces.

**Bamboo Pile Characteristics and Preparation**

The bamboo piles used in the project exhibited the following characteristics:

1. Species Selection: Gigantochloa apus (common name: bamboo apus) was selected for its favorable mechanical properties, local availability, and established performance in similar applications.
2. Dimensional Specifications:
   - Diameter: 8-12 cm
   - Length: 3-4 meters
   - Wall thickness: 0.8-1.2 cm
3. Preservation Treatment:
   - Borax-boric acid solution treatment (10% concentration)
   - Immersion period: 7-10 days
   - Air drying period: 14 days
4. Preparation Process:
   - Harvesting of mature bamboo (3-5 years old)
   - Removal of branches and nodes
   - Cutting to specified lengths
   - Preservation treatment
   - Drying and quality inspection

The preparation process emphasized quality control to ensure consistent mechanical properties and enhanced durability. Particular attention was paid to selecting bamboo culms with appropriate age, as younger bamboo lacks sufficient strength while older bamboo becomes brittle.

**Installation Methodology**

The bamboo pile installation followed a systematic methodology designed to maximize effectiveness while accommodating site conditions:

1. Site Preparation:
   - Clearing and grubbing of vegetation
   - Establishment of reference lines and elevation controls
   - Excavation to design elevation
2. Installation Pattern:
   - Triangular grid pattern with 60-80 cm spacing

- Staggered arrangement to maximize soil improvement effect

3. Installation Technique:
    - Pre-drilling pilot holes using manual augers
    - Insertion of bamboo piles using drop hammer (150 kg)
    - Driving to refusal or specified depth
    - Cutting of pile heads to uniform elevation
4. Quality Control Measures:
    - Verification of pile locations and spacing
    - Monitoring of driving resistance
    - Inspection of pile integrity after installation
    - Documentation of installation parameters

The installation process was conducted by local workers with experience in bamboo construction, supervised by project engineers to ensure compliance with design specifications.

**Integration with Athletic Track Structure**

The bamboo pile system was integrated with other structural elements to form a comprehensive foundation system for the athletic track:

1. Pile Cap Layer:
    - 15 cm thick compacted gravel layer placed directly above pile heads
    - Geotextile separator between gravel and overlying materials
2. Drainage System:
    - Perforated drainage pipes installed within the gravel layer
    - Slope gradient of 1% toward peripheral drainage channels
3. Base Course:
    - 20 cm thick compacted crushed stone base
    - Gradation designed for stability and drainage
4. Surface System:
    - Synthetic rubber athletic track surface
    - Installation according to IAAF specifications

This integrated system utilized the bamboo piles to transfer loads through the soft clay layer while incorporating appropriate drainage measures to maintain consistent subsurface conditions.

**Performance Evaluation**

The performance of the bamboo pile system was evaluated through several methods:

1. Settlement Monitoring:
    - Settlement plates installed at strategic locations
    - Regular elevation surveys over a six-month period
    - Maximum recorded settlement: 12 mm
    - Differential settlement: < 5 mm across 20 m spans
2. Load Testing:
    - Plate load tests conducted on improved ground
    - Bearing capacity improvement: 180-220% compared to untreated soil
    - Reduced settlement under equivalent loads
3. Surface Performance Assessment:
    - Evenness measurements using 3 m straightedge
    - Compliance with IAAF Class 2 facility requirements

- Consistent bounce and response characteristics

4. Durability Assessment:
    - Excavation of test piles after six months
    - Visual inspection for degradation
    - Moisture content measurement
    - Compression testing of extracted samples

The performance evaluation indicated that the bamboo pile system effectively improved ground conditions to meet the requirements of the athletic track facility. The observed settlement was within acceptable limits, and the surface characteristics met the specified performance criteria.

**Economic and Environmental Considerations**

The implementation of bamboo piles offered several economic and environmental advantages:

1. Cost Comparison:
    - Material cost: 40-50% lower than conventional concrete piles
    - Installation cost: 30% lower due to simpler equipment requirements
    - Overall foundation system cost: 35-45% reduction
2. Environmental Benefits:
    - Carbon footprint reduction: estimated 60-70% compared to concrete pile alternatives
    - Utilization of renewable local resources
    - Reduced transportation impacts
    - Support for local bamboo cultivation and harvesting
3. Construction Timeline:
    - Faster installation compared to conventional deep foundation systems
    - Reduced equipment mobilization requirements
    - Overall schedule advantage: approximately 3 weeks

These considerations demonstrate the potential of bamboo pile systems as economically viable and environmentally responsible alternatives to conventional ground improvement techniques in appropriate applications.

## CONCLUSION

The study of bamboo pile applications in the athletic track construction at the Malabar National Athletic Training Center revealed a successful integration of traditional technology with modern construction requirements. The bamboo pile system effectively addressed the geotechnical challenges of the site while offering economic and environmental advantages.

The key findings of this research include:

1. The effectiveness of properly prepared and installed bamboo piles in improving bearing capacity and reducing settlement in soft soil conditions
2. The importance of systematic preparation and preservation methods in ensuring bamboo pile durability
3. The successful integration of bamboo piles with conventional construction elements to create a comprehensive foundation system
4. The economic and environmental benefits of utilizing locally available, renewable materials in construction projects

These findings highlight the continued relevance of indigenous technologies in addressing contemporary engineering challenges, particularly in contexts where sustainability and local resource utilization are prioritized.

The bamboo pile system implemented in this project demonstrated satisfactory performance in meeting the specialized requirements of athletic track construction. The observed settlement characteristics and surface performance indicate that properly designed and executed bamboo pile applications can achieve the necessary technical outcomes while offering additional sustainability benefits.

For future projects considering bamboo pile applications, it is recommended to:

1. Conduct thorough geotechnical investigations to determine site suitability
2. Implement rigorous quality control in bamboo selection, preparation, and installation
3. Develop appropriate integration details with other structural elements
4. Establish monitoring programs to document long-term performance
5. Consider local expertise and material availability in system design

These recommendations can enhance the effectiveness and reliability of bamboo pile applications in appropriate construction contexts.

## REFERENCES

Berge, B. (2009). The ecology of building materials (2nd ed.). Architectural Press, Oxford.

International Association of Athletics Federations (IAAF). (2019). Track and field facilities manual. Monaco.

Janssen, J. J. A. (2000). Designing and building with bamboo. International Network for Bamboo and Rattan, Technical Report No. 20.

Mundell, C., & McCombie, P. (2009). Limit equilibrium assessment of drained bearing capacity for foundations on soft clay. Proceedings of the 17th International Conference on Soil Mechanics and Geotechnical Engineering, Alexandria, Egypt.

Nurdiana, A., & Umniati, B. S. (2015). Bearing capacity of bamboo pile foundation. Procedia Engineering, 125, 265-271.

Pacheco-Torgal, F., & Jalali, S. (2012). Earth construction: Lessons from the past for future eco-efficient construction. Construction and Building Materials, 29, 512-519.

Sharma, B., Gatóo, A., Bock, M., & Ramage, M. (2015). Engineered bamboo for structural applications. Construction and Building Materials, 81, 66-73.

Xiao, Y., Zhou, Q., & Shan, B. (2013). Design and construction of modern bamboo bridges. Journal of Bridge Engineering, 15(5), 533-541.