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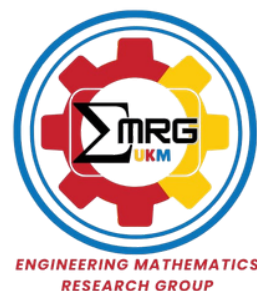
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WELCOME NOTE

Dr. Azli Arifin

Chair of iVCCCEM2026

Computational & Experimental Mechanics Research Group
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It is with great pleasure that we present the compilations of extended abstract of all presenter at iVCCCEM 2026. This volume brings together scholarly contributions from academics, industry professionals, and researchers, showcasing the latest advances, challenges, and innovations in computational and experimental mechanics. The synergy between computational simulation and experimental approaches forms the foundation of numerous technological breakthroughs and continues to play a vital role in addressing complex real-world engineering problems.

The theme of this volume, Bridging Theory and Practice: Adaptation to Machine Learning and AI, reflects the increasing importance of interdisciplinary collaboration in advancing engineering research and innovation. Computational and experimental mechanics continue to evolve through the integration of emerging technologies such as artificial intelligence, machine learning, data analytics, and automation. The contributions presented in this compilation demonstrate how these technologies are transforming engineering analysis, modelling, optimization, and decision-making, while strengthening the connection between theoretical developments and practical applications.

This volume features a diverse collection of high-quality research papers that highlight both methodological advancements and practical engineering solutions. From computational techniques and numerical modelling to experimental validation and data-driven engineering applications, the published works illustrate the transformative role of mathematics, computation, and experimental investigation in shaping the future of engineering and technology.

On behalf of the Editorial Board and the Organizing Committee, we extend our sincere appreciation to all authors, reviewers, editorial members, and supporting institutions whose dedication and commitment have made this publication possible.

We hope that this volume will serve as a valuable reference for researchers, educators, practitioners, and students, inspiring further collaboration, innovation, and scientific discovery in computational and experimental mechanics. We trust that the knowledge presented herein will contribute meaningfully to the continued advancement of research and engineering practice.



WELCOME NOTE

Assoc. Prof. Dr. Zulkifli Mohd Nopiah

Chair of EMARC 2026

**Engineering Mathematics Research Group
Faculty of Engineering and Built Environment
Universiti Kebangsaan Malaysia**

It is our great pleasure to present the EMaRC2026, marking the inaugural publication of the Engineering Mathematics Research Group, Universiti Kebangsaan Malaysia (UKM). This volume represents an important milestone in bringing together high-quality scholarly contributions from researchers, academicians, and industry practitioners who share a common interest in advancing the field of engineering mathematics.

Bridging Theory and Practice: Engineering Mathematics in the Real World, highlights the essential role of mathematical sciences in addressing contemporary engineering challenges. As engineering continues to evolve through the adoption of artificial intelligence, machine learning, data analytics, digital technologies, and advanced computational methods, engineering mathematics remains a fundamental discipline that connects theoretical principles with practical engineering solutions.

The papers presented in this volume reflect the breadth and diversity of current research in engineering mathematics. They encompass a wide range of topics, including mathematical modelling, computational mathematics, numerical analysis, optimization, statistical methods, data-driven engineering, and interdisciplinary applications. Collectively, these contributions demonstrate how mathematical approaches continue to drive innovation, improve decision-making, and support the development of sustainable engineering solutions for modern society.

These publication symbolizes our commitment to fostering research excellence, promoting interdisciplinary collaboration, and strengthening academic and industrial partnerships. We hope that this collection will serve as a valuable source of knowledge, encouraging future research and inspiring new collaborations within the engineering mathematics community.

The Editorial Board extends its sincere appreciation to all authors for sharing their valuable research, to the reviewers for their constructive evaluations, and to the organizing committee and supporting institutions for their dedication and commitment in making this publication possible.

We trust that the research presented in this volume will provide meaningful insights, stimulate further discussion, and contribute to the continued advancement of engineering mathematics for the benefit of both academia and industry.

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Investigation of Fracture Mechanics of an Additive Manufacturing Femur Bone for Prosthesis Application

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ABSTRACT

Femur fractures often require prosthetic replacement to restore mobility and structural stability. The femur is the largest and the strongest bone in human body which plays an important role in supporting body weight and enabling mobility. However, osteoporosis among elderly or high-impact trauma are common causes of femur fractures. The objective of this study is to design and fabricate a femur bone via 3D printing using PLA material and to perform a mechanical testing on the specimen under different loading condition. Thus, a suitable lattice structure of femur bone implants which is manufactured using additive manufacturing is identified. Finite Element Analysis (FEA) simulation is applied to analyze the stress distributions. Additive manufacturing offers significant for developing personalized, affordable and anatomical accurate prosthetic components. These findings demonstrate that mechanical testing and finite element approach successfully identify critical stress concentration regions along the femoral fracture, with the 1.3 mm strut honeycomb configuration demonstrating more favorable distributions under both standing and walking conditions. These outcomes provide valuable insight into the structural behavior of porous lattice implants, contributing towards the advancement of personalized and anatomical accurate femur bone prosthetic development.

Keywords: Finite Element Simulation, Additive Manufacturing, Polylactic Acid (PLA), Lattice Structure, Prosthetic Implants

INTRODUCTION

The femur bone is the largest and strongest bone in the human body, serving as the primary load-bearing structure. Femoral fractures commonly caused by high-impact trauma or degenerative conditions such as osteoporosis often require prosthetic replacement or total hip arthroplasty (THA) [1]. Traditional metallic femoral prostheses, although widely used, suffer from critical complications including stress shielding, bone resorption and aseptic loosening due to the significant stiffness mismatch between metallic implants and natural bone [2]. Furthermore, the lack of anatomical customization and poor load transfer characteristics often result in discomfort, mechanical failure and reduce long-term implant performance.

Additive manufacturing enables the fabrication of personalized and anatomically accurate femur prosthetics with honeycomb lattice structures that better replicate the mechanical and structural characteristics of natural bone. The lattice structure is introduced to reduce stiffness, improve load transfer, and better mimic the internal architecture of natural bone [3]. However, the mechanical performance and fracture behavior of additive

manufactured femur prosthesis remain insufficiently understood, as existing research focuses largely on general mechanical properties rather than fracture initiation and propagation within 3D-printed femoral structures. Therefore, the first objective is to design and simulate a femur bone prosthetic model using finite element method and to perform experimental testing on prosthetic specimen and the second objective is to analyze the fracture behavior of the honeycomb lattice structured femur prosthetic under physiological standing and walking loading conditions.

RESULTS AND DISCUSSION

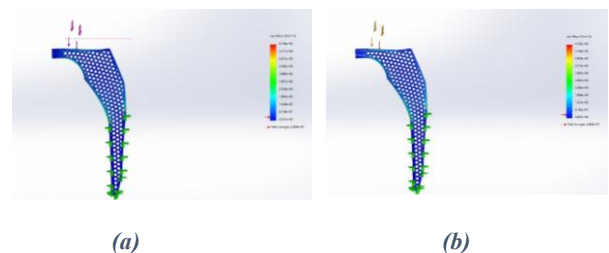


Fig. 1 Von Mises Stress of 1.3mm strut design at (a) standing load of 1600N (b) walking load at 1925N

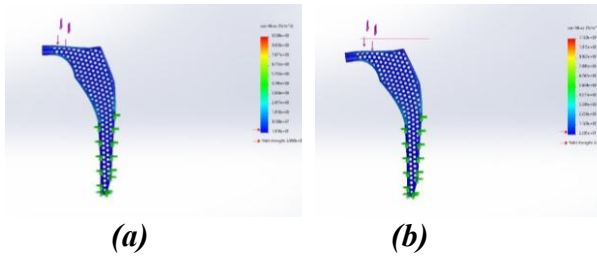


Fig. 2 Von Mises Stress of 1.8mm strut design at (a) standing load of 1600N (b) walking load at 1925N

Table 1 Von Mises Cross-Load Comparison

Strut size (mm)	Stress at 1600N (MPa)	Stress at 1925N (MPa)	Difference (%)
1.3	614.6	616.2	0.26
1.8	958.9	1128	17.6

As shown in Table 1, the increase in applied load from 1600N to 1925N [4] produced markedly different stress responses in the two configurations. In the 1.3 mm strut design, the maximum Von Mises stress has increased by 0.26% from 614.6 MPa to 616.2 MPa. Once this boundary zone reaches its stress threshold under 1600N load, the additional force introduced 1925N is redistributed throughout the internal lattice body by the smaller strut size without significantly elevating the peak stress value at any single location. This self-limiting behavior is a direct consequence of the higher strut and nodal density associated with the unit cell, which provides more redistribution pathways to absorb and disperse the additional load increment.

In contrast, the 1.8mm strut design exhibited an increased in stress value of 17.6% under the same load increment from 958.9 MPa to 1128 MPa. This stress accumulation indicates that the 1.8 mm strut size does not benefit from the same load redistribution mechanism observed in the 1.3 mm configuration. The larger unit cell provides fewer intermediate nodal connections across the volume, leaving fewer redistribution pathways available to absorb the additional load. As a result, the increased force introduced at 1925N is concentrated more directly at the existing nodal junctions, producing a stress increase closely proportional to the load increase. This behavior confirms that the structural disadvantage of the coarser lattice becomes progressively more severe as load magnitude increases, and that the performance gap between the two configurations would be expected to increase further under different load conditions exceeding the 1925N walking scenario. The divergence in load-response behavior between the two designs has important practical implications for prosthetic performance under real-load conditions. Under such conditions, a design that exhibits stress saturation behavior, as demonstrated by the 1.3mm configuration, is inherently more robust than one that accumulates stress proportionally with load.

CONCLUSION

This study investigated the structural performance of two lattice femur prosthetic configurations with the strut size of 1.3 mm and 1.8 mm and a fixed pore size of 3 mm through finite element approach. The Von Mises stress analysis demonstrated that the 1.3 mm strut configuration consistently recorded lower maximum stress value than the 1.8 mm design under different loading conditions. The configurations which exceeded the PLA yield strength, are mechanically unsuitable for clinical prosthetic applications. Nevertheless, the consistent stress value advantage of the 1.3 mm strut size model across all load conditions proves it as the structurally superior lattice configuration for the femur prosthetic application.

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