# INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
## SHORT ABSTRACT OF THESIS


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Thesis Title: Negative and zero Poisson's ratio cellular metamaterials with enhanced mechanical properties

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| Thesis Submitted to the Department/ Center | : | Mechanical Engineering |
| Date of completion of Thesis Viva-Voce Exam | : | 12th April 2024 |
| Key words for description of Thesis Work | : | Mechanical metamaterials, additive manufacturing, negative Poisson's ratio, mechanical properties |

**SHORT ABSTRACT**


Cellular metamaterials are man-made structures that have unusual mechanical properties. Lattice structures belong to a category of cellular metamaterials formed by periodic arrangement of interconnected struts or plates. With a change in the arrangement of struts, the lattice structures can be made to exhibit positive, negative, or zero Poisson's ratio. In contrast to the extensive research focusing on positive Poisson's ratio lattices, only a few studies focus on enhancing the mechanical properties of lattice structures exhibiting negative Poisson's ratio (NPR) or zero Poisson's ratio (ZPR). These negative or zero Poisson's ratio lattices can find potential applications in different industries, including automobile, defense, aerospace, bio-medical, and sports. This thesis demonstrates different techniques, such as unit cell topology modification, design of dual-phase lattices, and tapered-strut lattices to enhance the mechanical properties of the NPR and ZPR lattices. The NPR lattices made of AlSi10Mg and polyamide 12 (PA12), and the ZPR lattices made of PA12 were fabricated using two different additive manufacturing techniques. Uniaxial compression tests were performed to understand the mechanical behavior of the lattices. The mechanical properties of the metallic lattices were studied under quasi-static and high-strain rate loading conditions, while the mechanical properties of the polymeric lattices were studied under only quasi-static loading conditions. The quasi-static tests were conducted using the universal testing machine, and the high-strain rate tests were conducted using a split Hopkinson pressure bar. Finite element simulations were performed to study the deformation modes and mechanical performance of the lattice structures, which were corroborated by the experiments. The compressive strength, Young's modulus, and energy absorption ability of the proposed NPR and ZPR lattices were compared with the commonly studied NPR or ZPR lattices. Moreover, the effect of unit-cell geometric parameters of the lattices on the mechanical properties was also investigated. This thesis work demonstrated that the conventional composite rule of mixture can predict Young's modulus and Poisson's ratio of the dual-phase lattices. In addition, modifying the existing unit cells by using additional struts or by replacing uniform cross-section struts with tapered struts proved promising to enhance the mechanical properties. Zero Poisson's ratio tubular lattices were also designed, and the effect of unit-cell parameters was studied by the Design of Experiments (DoE) technique with Analysis of Variance (ANOVA). The tubular lattices were optimized for high-energy absorption or high-strength-stiffness applications.