INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Programme of Study : Ph.D.

Thesis Title: Advancing the Understanding of Sandwich Structures through Mechanical Behaviour Modelling and Failure Analysis of FSSW-Joined Honeycomb Core

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Thesis Submitted to the Department/ Center : Mechanical Department

Date of completion of Thesis Viva-Voce Exam : 17-03-2025

Key words for description of Thesis Work : Sandwich structure, Honeycomb, Homogenization, CZM, FSSW, MMB

SHORT ABSTRACT

The modern automotive industry is increasingly focused on addressing global energy and environmental challenges by developing lightweight vehicles, particularly electric cars, whose performance and range are heavily influenced by weight. Sandwich structures, especially those with honeycomb cores, have gained prominence due to their lightweight nature, high bending stiffness, energy absorption, and strength. These structures are highly customizable, offering superior mechanical and crash-worthiness properties. However, joining these components effectively remains a critical challenge. Traditional methods like adhesive bonding (AB) and mechanical fastening have limitations, such as sensitivity to environmental conditions, stress concentrations, and added weight. Additive manufacturing (AM) offers potential but faces material and cost barriers.

Friction Stir Spot Welding (FSSW) has emerged as a promising, energy-efficient, and eco-friendly alternative, particularly for joining aluminum and polymer sandwich sheets. However, FSSW alone often results in interfacial bonding, extruding the polymer layer and limiting mechanical performance. Hybrid bonding (HB), which combines adhesive bonding and welding, has shown potential in enhancing joint strength and reducing stress concentrations. Despite progress, research on spot welding sandwich sheets, especially those with honeycomb cores, remains limited, with most studies focusing on weld-only, adhesive-only, or hybrid bonds.

This thesis aims to address this gap by exploring hybrid joints (FSSW+AB) for honeycomb core sandwich structures, with the goal of improving mechanical properties, durability, and overall performance. Key objectives include understanding FSSW parameters, analyzing fabrication processes, developing equivalent models for honeycomb cores and cohesive layers, and investigating failure behavior using cohesive zone modeling (CZM). Mechanical performance is evaluated through lap shear, peel, three-point bending, and mixed-mode bending tests, with results compared to numerical simulations using Abaqus®. By advancing hybrid joining techniques, this research seeks to contribute to the development of more efficient, reliable, and environmentally friendly vehicles, aligning with the automotive industry's goals of energy conservation and pollution reduction.