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Topic of Research: Dynamic Response of High-Rise Prefabricated Modular B

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Findings

This research establishes the structural feasibility, seismic reliability, and practical applicability of prefabricated modular buildings (PMBs) in the Indian context through a multi-scale investigation involving decision frameworks, global modelling, dynamic analysis, and connection-level design. The study confirms that PMBs designed using Indian Standard steel sections and codal provisions can achieve structural performance comparable to conventional steel buildings, including under seismic loading.

A systematic hybrid AHP–TOPSIS decision-making framework is developed for modular joint selection, addressing a key uncertainty in modular construction. Analytical modelling and validation against international literature indicate acceptable deviations in critical response parameters, confirming the structural reliability of the proposed modular framework. Dynamic analyses further demonstrate that modular buildings with both rigid and semi-rigid inter-modular connections exhibit satisfactory seismic behaviour and performance trends comparable to conventional steel frames. At the connection level, a codally compliant Indian joint design achieves a balanced combination of strength, stiffness, ductility, and fabrication economy when benchmarked against AISC and Eurocode provisions.

Overall, the findings indicate that the primary constraints to modular construction in India stem from the lack of explicit codal guidance rather than structural inadequacy.

- **Modular Joint Selection Framework**
  - A hybrid AHP–TOPSIS approach effectively prioritizes intra- and inter-modular joint types.
  - Structural performance and constructability criteria are systematically integrated.
  - Connections are confirmed as the most critical elements governing modular system behaviour.
- **Structural Modelling and Codal Validation**

    - A 6-storey modular building designed using Indian steel sections satisfies IS 875 and IS 1893 requirements.
    - Key parameters—axial capacity, base shear, time period, inter-storey drift, and roof displacement—show deviations within 4–18% of reported literature.
    - Results validate the proposed analytical modelling approach.
- **Seismic Performance of High-Rise Modular Buildings**
    - Twelve-storey modular buildings with rigid and semi-rigid inter-modular joints demonstrate stable seismic response.
    - Modal, response spectrum, and time history analyses show behaviour comparable to a conventional steel building.
    - Displacement and acceleration responses confirm suitability for seismic regions in India.
- **Influence of Connection Rigidity**
    - Semi-rigid inter-modular joints increase flexibility without compromising global safety.
    - Rigid intra-modular joints ensure adequate stiffness and load transfer.
    - Connection rigidity significantly influences dynamic response and must be considered in design.
- **Connection-Level Design and Benchmarking**
    - An IS 800:2007-based rigid bolted joint satisfies strength and deformation limits.
    - Benchmarking indicates:
        - Eurocode joint: slightly higher stiffness,
        - AISC joint: marginally higher ductility,
        - Indian joint: optimal balance of safety, economy, and constructability.
    - Indian codal provisions are adequate for modular joint design when applied appropriately.
- **Implications and Contributions**
    - Modular buildings can be safely designed using existing Indian codes despite the absence of modular-specific provisions.
    - The study provides a validated analytical framework, a rational joint selection methodology, and evidence of seismic equivalence with conventional steel buildings.
    - The findings support modular construction as a sustainable, rapid, and economically viable solution for India’s urban infrastructure.