

ANALYSIS OF MACHINE-INDUCED FLOOR VIBRATIONS IN BUILDINGS USING EXPERIMENTAL AND NUMERICAL APPROACHES

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Machine-induced floor vibrations in buildings pose significant challenges to structural integrity and occupant comfort, necessitating effective mitigation strategies. The overall purpose of this study is to analyse the dynamic response of structural elements under machine-induced vibrations and evaluate various techniques to mitigate these vibrations. This research addresses the problem of excessive vibrations caused by harmonic and periodic dynamic loads from machinery, which can lead to structural issues such as cracking, fatigue, and loss of bearing capacity, as well as discomfort for building occupants.

This research employs a comprehensive methodology, combining experimental, numerical, and field investigations. An experimental setup involving a steel plate subjected to impact loading was used to measure vibration characteristics, including Peak Particle Velocity (PPV) and frequency. Finite Element (FE) models were developed using SAP2000 software and validated against experimental and field data to simulate vibration behaviour. Field measurements were conducted at two case study sites: a research lab in the selected factory building, where treadmill-induced vibrations disrupted motion-capture equipment, and a pump house, where pump operations caused localised vibrations in concrete platforms.

Key findings reveal that structural parameters such as slab thickness and span length significantly influence vibration response. Thinner slabs and longer spans amplify vibrations, while thicker slabs reduce PPV. The results obtained from the FE models showed strong correlation with experimental results, with most errors below 5%, confirming the validity and reliability of the numerical simulations. Field data highlighted the localised nature of vibrations, with PPV values reaching 4.674 m/s in the factory building and frequencies up to 13.49 Hz in the pumphouse. The study also identified resonance risks when structural natural frequencies align with machinery operating frequencies.

Principal conclusions emphasise the importance of conducting early-stage dynamic analysis in design to avoid resonant conditions and the need for structural modifications, such as increasing stiffness or optimising spans, to mitigate vibrations. The research underscores the practical significance of integrating experimental and numerical approaches for accurate vibration assessment and mitigation. Recommendations include adopting design codes that prioritise vibration serviceability limits and exploring retrofitting strategies for existing structures.

This study contributes to the field by providing empirical insights into vibration control, thereby bridging the gap between theoretical models and real-world applications. Its findings are vital for ensuring the safety, durability, and functionality of buildings subjected to dynamic loads, benefiting both structural engineers and designers.

Keywords: Floor vibration mitigation, Dynamic structural response, Finite element analysis, Machine-induced vibrations, Peak particle velocity

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