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"Undergraduates' Digital Engagement Towards Global Ingenuity"

2nd Edition

Organiser :

Department of Built Environment Studies and Technology, College of Built Environment, UiTM Perak Branch

Co-organiser :

INSPIRED 2024. Office of Research, Industrial Linkages, Community & Alumni (PJIMA), UiTM Perak Branch

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SEISMIFLEX JOINT SYSTEM FOR PRECAST CONCRETE WALL PANEL

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Abstract
In Malaysia, the widespread use of Industrialized Building Systems (IBS), particularly precast construction, is prevalent. However, the country faces a growing concern regarding seismic events, as recent minor earthquakes have caused slight structural damage. This highlights the need for early preventive measures, especially as seismic activities appear to be increasing. This study aims to maximize earthquake resistance during seismic events to prevent post-earthquake damage to the low-rise building. The research methodology includes comprehensive document reviews, iterative idea generation sessions, and sophisticated 3D simulation modelling using Sketchup software with findings expected to offer practical recommendations for application. The predicted outcomes include advancements in the understanding of seismic resilience in low-rise construction. Ethical considerations guide the process of the research, ensuring integrity and confidentiality. This research seeks to innovate and elevate the standards of seismic resistance in precast concrete construction, potentially offering commercial applications for enhanced building safety.

Keywords: *Industrialized Building System (IBS), Seismic Jointing System, Earthquake Resistance, Low-Rise Building, Precast Concrete.*

1. INTRODUCTION

This paper focuses on developing and simulating an innovative seismic jointing system called SeismiFlex Joint System tailored for precast concrete wall panels to enhance earthquake resistance. The primary objective is to improve the safety of the building on earthquake resistance. The study addresses the gap in research on the interaction of seismic jointing systems with surrounding structures in precast load-bearing constructions and the lack of existing systems which focus on post-earthquake repairability (Guan et al., 2023; Liu et al., 2023; Masrom & Hamid, 2020). Literature highlights varying seismic risks across Malaysia, from low to moderate in most regions on the Sunda Plate to higher risks in Sabah due to its proximity to the South China Sea and past seismic events like the 2015 Ranau earthquake (The Sun, 2023; Tongkul, 2021). Existing jointing technologies such as PRW-TSD, seismic expansion joints, pop-up seismic floors, and others reveal both strengths and challenges, like connection strength issues and water leakage. Methodologically, the study employs a design thinking framework involving document review, idea generation, and 3D simulation to propose and test novel jointing systems. Anticipated outcomes include enhanced seismic resilience for precast structures, providing crucial insights for seismic-prone areas. Recommendations focus on targeting markets with similar seismic conditions, conducting comprehensive literature reviews, and integrating user feedback for commercial viability in construction sectors vulnerable to seismic risks.

2. MATERIALS AND METHODS

The study adopts a descriptive and simulative research design to develop a SeismiFlex Joint System for precast concrete wall panels. The methodology comprises three phases: document review, idea generation, and 3D simulation. The document review thoroughly assessed academic publications, industry reports, and conference proceedings regarding existing seismic jointing systems and their performance, material properties suitable for a new seismic jointing system, and seismic design considerations for precast concrete buildings. The idea generation sessions utilized brainstorming, mind mapping, and information from previous research initiatives, which were incorporated to generate feasible, cost-effective solutions that enhance seismic resilience. Proposed designs were then simulated using advanced 3D simulation software to replicate the expected model, allowing for a complete assessment of its shape, functionality, and performance features in a simulated environment.

The SeismiFlex Joint System integrates flexible elastomeric elements for multi-directional seismic movement, features a concealed design to maintain architectural aesthetics, utilizes reliable adhesive application for secure panel attachment, and employs a composition of high-grade aluminium and synthetic membrane for durability and resilience. Assembly occurs off-site and is detailed in Figure 2.1, facilitating efficient installation during precast concrete panel erection. Data analysis employs a design thinking framework to extract insights from document reviews, brainstorming sessions, and simulation results, effectively guiding the project's development and addressing technological requirements.

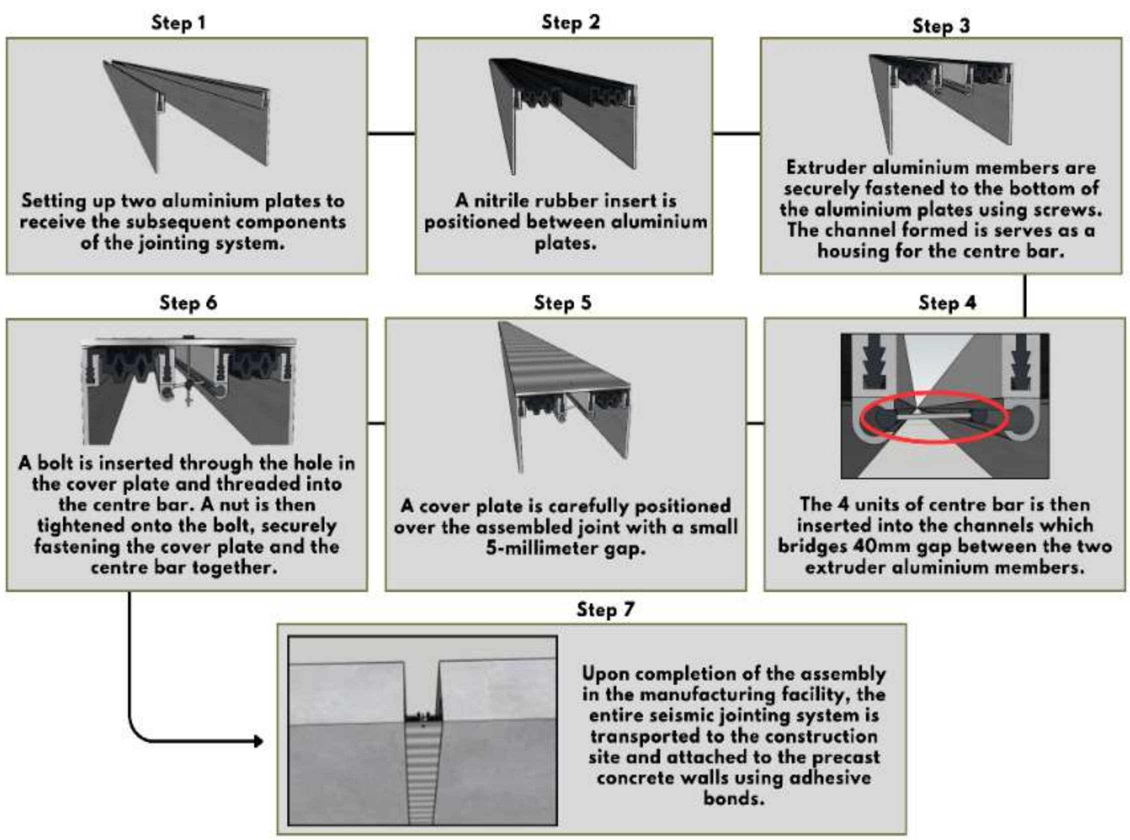

Figure 2.1 Assembly procedure of SeismiFlex Joint System

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3. RESULTS AND DISCUSSION

The results and discussion of this study focus on identifying issues and challenges concerning earthquake resistance in existing seismic jointing systems. The research thoroughly explores existing problems related to earthquake resilience in current jointing systems through comprehensive literature review methods such as document review. This groundwork serves as the basis for answering research objective 1:to identify the issues and problems of seismic jointing systems regarding earthquake resistance and research objective 2: to innovate the seismic jointing system of precast construction to improve the safety of the building during the earthquake event. Operational procedures illustrate how the SeismiFlex Joint System facilitates movement in various directions (horizontal, vertical, and rotational) of precast concrete panels during seismic events, as depicted in Figure 3.1.

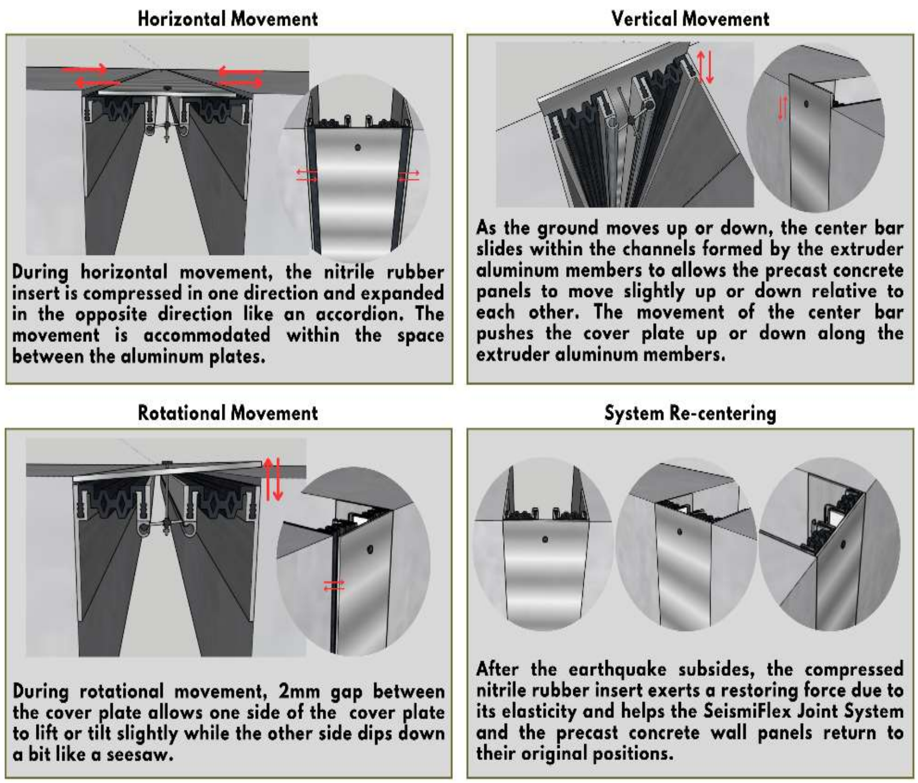

Figure 3.1 Operational procedure of SeismiFlex Joint System.

The SeismiFlex Joint System demonstrates performance characteristics such as dissipating seismic energy effectively, enhancing fire resistance and waterproofing using aluminium and synthetic rubber materials, and featuring a designed mechanism that allows controlled movement across different axes. The installation efficiency is underscored by a straightforward glue application method, simplifying attachment to precast concrete wall panels without complex processes. Moreover, the system is aesthetically integrated into the panels, preserving the modern architectural aesthetics of buildings. Regarding marketability potential, the SeismiFlex Joint System offers significant advantages. It facilitates seamless integration into building designs, ensuring compliance with safety regulations and optimizing overall structural performance, thus appealing to architects and engineers. For construction firms and contractors, using prefabricated elements enhances efficiency, reduces costs, and guarantees compliance with seismic requirements.

Building owners and developers benefit from its ability to enhance property value through superior earthquake resistance, lower maintenance costs, and the incorporation of premium safety features. These attributes collectively position the SeismiFlex Joint System as a compelling innovation in seismic jointing technology for the construction industry.

4. PERFORMANCE COMPARISON OF SEISMIFLEX JOINT SYSTEM WITH THE EXISTING JOINTING SYSTEM.

The performance comparisons with existing technologies, such as the PRS-TSD System, Seismic Expansion Joint, and Pop-up Seismic Floor System, are presented in Table 4.1.

Table 4.1 Overall specifications comparison between existing product and SeismiFlex Joint System.

Specifications	PRW-TSD System	Seismic Expansion Joint	Pop-up Seismic Floor System	SeismiFlex Joint System
Size (mm)	360 x 240 x 8	140 x 20 to 190 x 30	200 x 50	150 x 50
Material	Steel plates	Aluminium side plates and nitriles insert	Aluminium side plates and nitriles insert	Aluminium side plates and nitriles insert
Gaps up to (mm)	10	20 to 60	100	150 to 300
Moving mechanism	Vertical only	Horizontal only	Vertical and Horizontal	Vertical, Horizontal, & Rotational
Movement capacities (mm)	± 3	± 3/ ± 7/ ± 10	± 100	± 3 to ± 10
Installation Process	Bold and Nut	Bold and Nut	Bold and Nut	Adhesive Bonding
Aesthetic Integration	Visible	Visible	Visible	Invisible

5. CONCLUSION

In conclusion, this paper introduces a novel seismic jointing method to enhance the durability of precast concrete panels during seismic events. Addressing the critical need for improved earthquake-resistant construction in Malaysia, the research achieved significant insights into materials, dimensions, and assembly techniques essential for the system's efficacy. Through comprehensive methods, including document review, idea generation, and 3D simulation modelling, the study integrated aluminium plates, nitrile rubber inserts, and extruded elements to develop a durable structure capable of absorbing seismic energy and minimizing damage. 3D simulation software was crucial in refining the design to meet rigorous performance standards across various seismic conditions. The key findings emphasized the system's capacity to enhance building safety, improve construction efficiency, and reduce long-term maintenance costs by enabling controlled movement during earthquakes. This technology supports Sustainable Development Goals (SDG) 9 and 11 by prolonging structure lifespans and mitigating immediate risks to residents. Moving forward, validating the system's effectiveness through practical applications and continual refinement based on user feedback are not just recommended — they are essential. Future research should incorporate extensive user feedback and detailed case studies from construction sites that implement the seismic jointing system. For example, testimonies and qualitative feedback from engineers, contractors, and building owners can be gathered to evaluate the system's effectiveness, ease of installation, and influence on structural resilience.

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