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NUMERICAL MODELLING OF IN-PLANE SEISMIC BEHAVIOUR OF CFS DRYWALL PARTITION WALLS AND FAÇADES

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Abstract

The assessment of the behaviour of cold-formed steel (CFS) drywall partitions under in-plane seismic loading remains a critical area of study for evaluating how non-structural elements influence the seismic performance of buildings, particularly in the context of performance-based earthquake design requirements.
In the last years, many tests have been performed all over the world, but numerical modelling is quite unexplored. This study provides the main outcomes available in the state-of-the-art on numerical modelling conducted on in-plane quasi-static reversed cyclic tests performed on various partition walls and façades constructed using LWS framing. The primary objective is to analyse the influence of different construction details on the seismic behaviour observed in the tests, as well as to evaluate the impact of non-structural architectural components on the global seismic response across various building typologies.

Keywords: non-structural elements, drywall partition walls, façades, state-of-the-art, numerical modelling, seismic behaviour.

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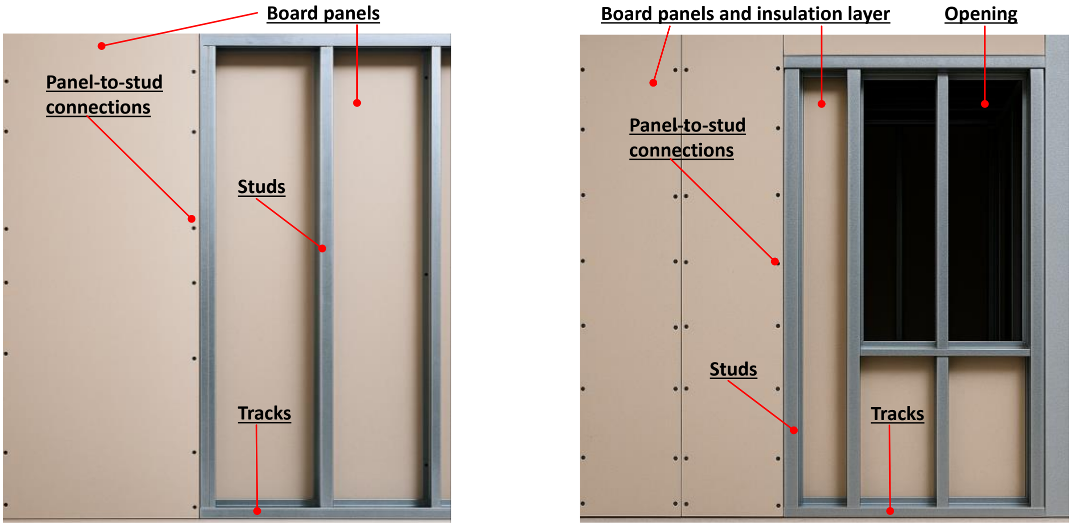
1 INTRODUCTION

The use of Cold-Formed Steel (CFS) in building construction has grown significantly over the past decades, particularly in lightweight framed systems for non-structural components such as drywall partitions and façade elements. While these systems were originally conceived as non-load-bearing, experimental evidence and post-earthquake surveys have demonstrated that they can exhibit a substantial influence on a building's seismic response. Their contribution becomes particularly relevant when assessing in-plane behaviour, where deformation compatibility, energy dissipation, and damage concentration may affect both performance and safety. As a result, the development of accurate numerical models for predicting the in-plane seismic response of CFS drywall systems has become a critical area of research.

CFS partition walls and façades are typically composed of a light steel stud framing system with attached board panels on one or both sides (Fig. 1). The main differences among partition walls and façades consist in the function, location and, insulation layer presence: partition walls divide interior spaces, are located inside the building and generally do not present insulation layer; whereas façades protect the structure from weather, provide thermal/acoustic insulation, and contribute to aesthetics, are the outer shell of the building and generally present insulation layer. Their seismic performance is governed by the complex interaction among various elements, including screw fasteners, sheathing panels, frame connections, and the progressive degradation of materials. The resulting in-plane response is inherently nonlinear, characterized by stiffness degradation, strength deterioration, pinching, and significant hysteresis, all of which must be properly captured in numerical simulations.



a) Partition wall b) Façade

Figure 1: Typical CFS Drywall Partition Wall (a) and Façade (b)

2 EXPERIMENTAL TESTS AND NUMERICAL MODELLING APPROACHES AND CHALLENGES

In a wider framework of efforts to improve the seismic behaviour of steel structures [1-4], several experimental and numerical studies were conducted to investigate the seismic response of drywall partition walls and façades with CFS framing. Recent relevant experimental studies devoted to evaluate the in-plane seismic response of drywall partition walls consisted in dynamic or quasi-static cyclic loading tests on full-scale or scaled specimens with different surroundings, geometry and construction details [5-11]. For the façades, instead, the state of the art is limited to three experimental campaigns, in which shaking-table tests [12, 13] and quasi-static reversed cyclic tests were conducted [14].

Results highlighted that even non-structural CFS drywall systems can contribute to global stiffness and energy dissipation under cyclic loading. The response is strongly influenced by sheathing type, screw spacing, edge details, and the presence of openings.

These experimental results provide essential benchmarks for calibrating and validating numerical models capable to predict the in-plane seismic behaviour of drywall partition walls and façades and their effect on the global behaviour of the building.

Numerical modelling strategies for CFS drywall walls under in-plane seismic loading are generally classified into three categories:

- Micro-modelling involves a detailed representation of each component, such as the gypsum panels, steel studs, and fasteners. Nonlinear material models and contact algorithms are used to simulate connection behaviour and interface debonding. While these models provide high-fidelity results, they are computationally intensive and more suited for research-level investigations than for design practice;
- Meso-modelling approaches reduce computational demand by grouping elements into sub-assemblies. This approach balances accuracy and efficiency and is suitable for simulating full-scale wall behaviour, as demonstrated by Rahmanishamsi et al. [15], and for evaluating the impact of non-structural architectural components on global seismic behaviour, according to Campiche et al. [16].
- Macro-modelling treats the entire wall system as an equivalent shear panel with predefined hysteretic behaviour. Multilinear, bilinear, or pinching hysteresis models are employed to capture the global force–displacement response [17, 18, 19, 20]. These models are particularly useful for integration into whole-building simulations using platforms such as OpenSees [21].

Table 1 summarizes numerical studies on single walls or the effect of drywall partition walls and façades on the global behaviour of the building.

Despite advances in numerical modelling, several challenges persist, as fastener nonlinearity, board material degradation, environmental effects and coupled in-plane/out-of-plane response. Moreover, integrating detailed wall models into full structural models is still computationally demanding, particularly for dynamic analyses.

Authors	**Global structural typology/ Surroundings**	**NS components considered**	**Numerical modelling approach**
Rahmanishamsi et al.[15]	Concrete surrounding	Partition walls	Meso-modelling
Campiche et al.[16]	CFS sheathing-braced frame	Finishing materials, internal counter walls and partition walls	Meso-modelling
De Matteis [18]	MRF	Cladding walls	Macro-modelling
Shakeel et al.[19]	Concrete surrounding	Partition walls	Macro-modelling
Shin et al.[20]	Concrete surrounding	Partition walls	Macro-modelling
Poursadrollah et al. [17]	MRF	Partition walls	Macro-modelling

Table 1: State-of-the art of numerical modelling of CFS drywall architectural non-structural components

3 ANALYSIS OF RESULTS AND DISCUSSION

From the available studies on the literature, the impact of drywall partition walls and façades on the global seismic performance of two structural systems were analysed: Moment-Resisting Frames (MRFs) and Cold-Formed Steel (CFS) structures. For MRFs, results were derived from studies evaluating the role of lightweight steel partitions and façades under cyclic and dynamic loads, showing improvements in both stiffness and energy dissipation capacities [17,18]. In the case of CFS systems, data were based on recent shake-table experiments and calibrated numerical models, which demonstrated a significant contribution of non-structural components to lateral stiffness and drift reduction [12, 13, 16].

The impact of drywall partition walls and façades on the global seismic performance was represented in Fig.2, in which each bar represents a percentage change in performance metrics relative to the bare structure, across key parameters such as initial stiffness, lateral strength, energy dissipation, inter-storey drift, and residual drift. The data distinguishes between experimental and numerical findings and between structures with and without non-structural components. The comparison highlights that while both systems benefit from the inclusion of partitions and façades, the magnitude of improvement depends on the structural typology, component configuration, and modelling approach. In the case of Moment-Resisting Frame (MRF) structures, the combined inclusion of drywall partition walls and façades leads to notable improvements in global seismic performance. Specifically, the initial stiffness increases by approximately 20%—with a rise of 21% observed in experimental results and 23% in numerical analyses. The lateral strength is enhanced by around 10% (10% experimentally, 12% numerically), while energy dissipation capacity improves significantly, with an increase of approximately 35% (32% experimental, 40% numerical). Additionally, a reduction in inter-storey drift of about 21% is recorded (20% experimental, 22% numerical), along with a decrease in residual drift of approximately 25% (24% experimental, 27% numerical).

For Cold-Formed Steel (CFS) structures, which are inherently lighter and less stiff than MRFs, the influence of drywall partition walls and façades on seismic response is even more pronounced, resulting in greater enhancements in overall structural performance under seismic loading. In fact, the initial stiffness increases by approximately 33%—with a rise of 32% observed in experimental results and 35% in numerical analyses. The lateral strength is enhanced by around 22% (20% experimentally, 23% numerically), while energy dissipation capacity improves significantly, with an increase of approximately 40% (38% experimental, 42% numerical). Additionally, a reduction in inter-storey drift of about 36% is recorded (35% experimental, 38% numerical), along with a decrease in residual drift of approximately 41% (40% experimental, 42% numerical).

4 CONCLUSIONS

This study has provided a comprehensive overview of the current state of research concerning the numerical modelling of drywall partition walls and façades with cold-formed steel (CFS) framing, focusing on their in-plane seismic behaviour and impact on the global seismic performance of buildings. A detailed comparison between Moment-Resisting Frames (MRFs) and CFS structures has been conducted, supported by both experimental and numerical evidence. Drywall partition walls and façades, although traditionally classified as non-structural elements, can significantly influence the seismic performance of structural systems, particularly when subjected to in-plane seismic actions.

For MRF structures, the inclusion of both partition walls and façades results in:

- An average increase in initial stiffness of 20%,
- An improvement in lateral strength of approximately 10%,
- An enhancement in energy dissipation capacity of 35%,

- A reduction in inter-storey drift by about 21%, and
- A 25% decrease in residual drift, showing their potential to mitigate structural and non-structural damage during seismic events.

For CFS structures, the impact is even more significant due to their lower inherent stiffness and mass. The inclusion of drywall components leads to:

- A 33% increase in initial stiffness,
- A 22% improvement in lateral strength,
- A 40% enhancement in energy dissipation,
- A 36% reduction in inter-storey drift, and
- A 41% reduction in residual drift, confirming their effectiveness in improving both structural performance and post-earthquake reparability.

Numerical modelling approaches for CFS drywall systems vary in complexity and fidelity, ranging from micro-modelling for high-accuracy simulations, to macro-modelling suitable for integration into whole-building seismic analyses. Despite recent advancements, modelling challenges persist, especially regarding connection behaviour, material degradation, and the coupling between in-plane and out-of-plane responses.

Continued research is necessary to develop more efficient and reliable numerical tools that can capture the nonlinear behaviour of these systems and facilitate their inclusion in performance-based seismic design frameworks.

In conclusion, drywall partition walls and façades should no longer be treated merely as architectural features but rather as integral components that can contribute positively to the seismic resilience of both traditional and lightweight steel-framed structures.

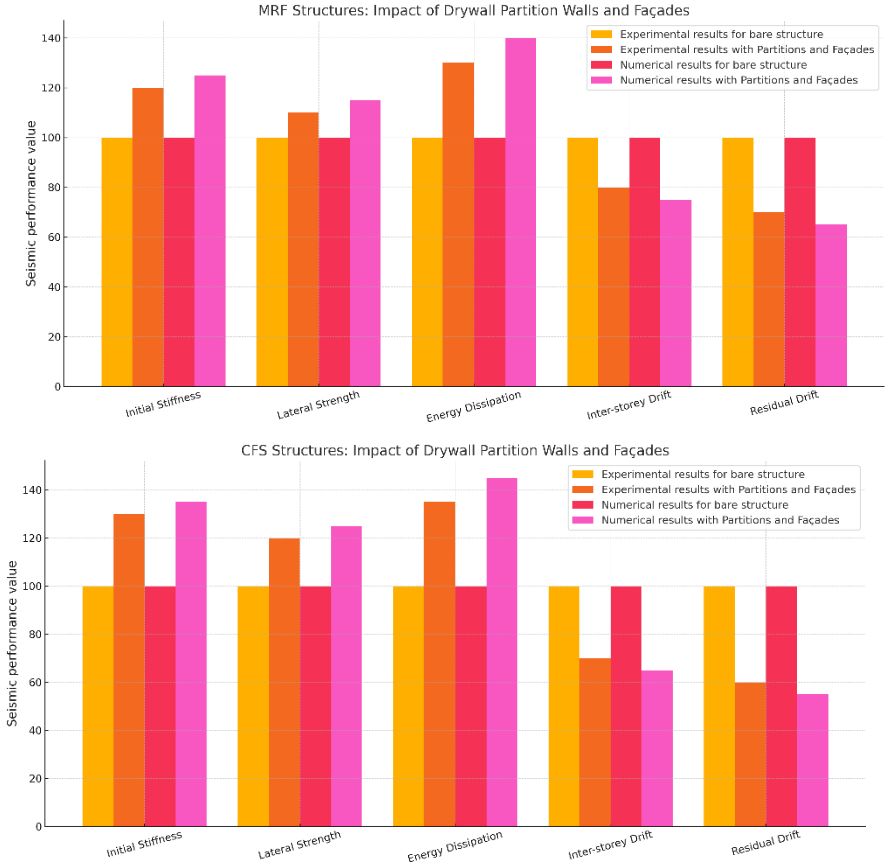


Figure 2: Analysis of experimental and numerical impact of drywall partition walls and façades on global seismic behaviour

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