UNIVERSITI TEKNOLOGI MARA

SEISMIC PERFORMANCE OF ROCKING WALL-FLOOR PLANK CONNECTION IN PRECAST LOAD-BEARING STRUCTURES SUBJECTED TO LATERAL CYCLIC LOAD

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ABSTRACT

The severe damage of the precast concrete wall structures recorded in past earthquakes has led to the innovation of the rocking wall concept, which can demonstrate free or minimum damage aftershock of an earthquake. Currently, the application of this innovative structural system has been limited to precast frame structures but lacks in load-bearing structure applications. Thus, this study attempts to extend further the application of rocking walls to the load-bearing structure. The research study generally involves proposing a precast connection, experimental works, analytical formulation and computer analysis using finite element software, which can be managed in four phases. In the first phase, an improvised detail of a semi-rigid connection between the precast rocking wall and the precast floor was proposed for the load-bearing structure prototype. The second phase involves experimental work. A half-scale structural assemblage (consisting of precast rocking-wall and floor plank structures) was prepared and tested under quasi-static out-of-plane lateral cyclic load. The third phase involves the establishment of an analytical formulation for moment-rotation analysis and subsequently validated with the experimental result. Besides that, the sub-assemblage specimen's finite element modelling (FEM) was mutually established in this phase. This FEM investigated the sub-assemblage specimen responses to quasi-static in-plane lateral cyclic load. The fourth phase outlines the conclusions, design recommendations and future possible research. Experimental results demonstrate that the out-of-plane strength of the proposed connection survives without collapse under maximum considered earthquake (MCE). The rocking wall experienced minor damage, while the damaged cracks in the floor plank were unavoidable. There was a good agreement between the analytical formulation for moment-rotation analysis of the proposed connection compared to the experimental result with a percentage difference of less than 10%. The cyclic analyses from the FEM reveal that the base shear and energy dissipation capacity of in-plane loading was larger than that of out-of-plane loading. The in-plane base shear using the proposed semi-rigid connection does not exceed 20% when the surrounding floor plank is incorporated into the rocking wall. Incorporating the floor plank structures into the rocking wall has influenced the initial design calculation, which signifies that the rocking wall system must consider the effect of the surrounding structure in the design calculation. Formation of the intended gap openings in the proposed connection under lateral cyclic drift has improved the seismic performance of precast wall-floor plank connection in load-bearing structures as significant plastic hinge damage in the floor plank was successfully prevented.

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CHAPTER 1
INTRODUCTION

1.1 Background of the Study

Construction of multi-storey buildings is a common practice in large urban areas with a high concentration of population density and limited land. Multi-storey buildings having deep underground structures have been constructed in many cities, which allow for the effective use of land. The continuous development and increasing population in urban areas led to extensive use of the concrete load-bearing structures concept for multi-storey residential buildings. In this respect, the rapid urbanisation process has led to a change in the construction scenario worldwide. Conventional construction has shifted towards the precast system due to tremendous pressure on the industry to deliver faster construction. The load-bearing structures can be designed and constructed using cellular or large panels (tilt-up panels). The load-bearing structures are particularly efficient for residential sectors such as apartments, hotels, student residences, key-worker accommodation prisons and military barracks. Usually, load-bearing structures are constructed using an Industrial building system (IBS) whereby most structural elements are factory-made, and the in-situ elements are minimised as possible. High-rise residential buildings commonly adopt the load-bearing structure system instead of the frame system due to repetitive and simple construction techniques in achieving economical and speedy construction. The load-bearing structure system comprises wall and floor panels arranged and connected to form a complete box structure without a separate framework, as shown in Figure 1.1.

Figure 1.1 Example of the Cellular Building

(Source: Outinord International Ltd) https://outinord.net/