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Modelling and parametric study of self-centering reinforced concrete frame structures

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Abstract

The beam-column and column-base connections of the self-centering reinforced concrete frames in this paper are allowed to open at beam ends and uplift at column bases by releasing the constraints, while rubber and prestressed tendons are introduced to ensure the self-centering of the structure. The seismic performance of the self-centering frames was investigated through nonlinear numerical modelling. Analytical models using OpenSEES are developed to study the seismic performance of the self-centering frames, and a parametric study is carried out. The parameters, such as the relative beam-to-column stiffness, rubber thickness, and the prestressed tendons on the behavior of the structures are investigated. Through this study, it is recommended to use relatively strong beams, more prestressed tendons, appropriately thick rubber blocks and prestressed tendons with proper positions to ensure the seismic performance and the self-centering capability of the structure.

Keywords: self-centering frame structures; nonlinear numerical modelling; seismic performance; parametric study

1 Introduction

Recent earthquakes highlight the limitations of traditional seismic lateral resisting systems, which may experience large residual drifts and significant damage distributed throughout the system that make it difficult and costly to repair. Self-centering frame systems can protect the structure by concentrating the majority of structural damage in replaceable energy-dissipation devices, while eliminating the residual deformation [1-2]. This paper focuses on the seismic performance of reinforced concrete frame structures with self-centering beam-column and column-base connections through nonlinear numerical modelling. The self-centering reinforced concrete frame structures consists of three main components: (a) beam-column and column-base connections that remain essentially elastic and are allowed to open at beam ends and uplift at column bases by releasing the constraints (Figure 1); (b) prestressed tendons and rubber blocks that provide self-centering forces, ensuring the self-centering ability of the structure; and (c) replaceable energy dissipating devices that control the maximum displacement of the structure by dissipating input energy.

Approaches for modelling the post-tensioned precast reinforced concrete frame structures with self-centering beam-column connections were carried out during the past few decade [3-5]. In this study, analytical models using OpenSEES [6], which have been validated by shaking table tests, are used to study the seismic performance of self-centering frames, and a parametric study of self-centering reinforced concrete frame structures is

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