# Overturning of Freestanding Cylindrical Structures under Pulse-like Ground Motions

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## Abstract

This paper focuses on predicting the seismic overturning of freestanding cylindrical structures. Idealized cylinders of different sizes and slenderness are excited by synthetic pulse-like ground motions. A total of 245000 results are summarized in the form of the overturning spectrum. The obtained spectrum, however, shows large motion-to-motion variability. To reduce the variability, the support vector machine (SVM) algorithm is employed subsequently. Three geometry-related parameters of cylinders and twenty-five intensity measures characterizing ground motions are selected as candidate features. Using the minimum Redundancy Maximum Relevance (mRMR) algorithm and forward stepwise feature selection method, the optimal SVM model is determined by which model makes the least false-negative misclassification cases, that is, wrongly predicting actual overturning as non-overturning.

**Keywords:** freestanding cylinder; overturning spectrum; pulse-like ground motion; support vector machine.

## 1 Introduction

Past earthquakes have shown the great seismic performance of freestanding structures, such as classical columns [1] and storage tanks [2]. During earthquakes, these structures uplift and rock at the base, limiting the inertia forces imposed on themselves. Nowadays, rocking is widely recognized as a seismic isolation technique and has been exploited in designing new structures. However, it has been reported by accumulated studies that freestanding structures are vulnerable to overturning, especially when subjected to pulse-like ground motions [3].

Since Housner [4] first published the seminal work on the dynamics of a freestanding rigid block, the overturning behaviour of rocking blocks subjected to earthquake waves [5] has been systematically investigated. Nevertheless, it should be noted that these studies investigate the overturning in two dimensions (2D). Recently, several studies have shown that for freestanding structures, the three-dimensional (3D) effect on their seismic overturning is significant[6]. This effect is more pronounced for irregular non-structural components, such as museum artifacts [7] and unanchored equipment [8]. Vassiliou [6] analytically investigated the overturning behaviour of 3D cylinders subjected to an ensemble of ground motions with identical statistics properties. Later, the overturning behaviour was emphasized on a 3D podium, a slab supported by four rocking columns [9]. The results show large motion-to-motion variability of the obtained overturning spectra. Compared with the aforementioned 2D overturning, the 3D overturning of freestanding structures is more sensitive to the parameters that define it and, thus, more difficult to predict.

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