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Selecting and scaling real ground motion records using harmony search algorithm

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ABSTRACT

In this study, a solution model is proposed to obtain input ground motion datasets compatible with given design spectra based on meta-heuristic harmony search algorithm. The utility of the solution model is demonstrated by generating ground motion datasets matching the Eurocode-8 design spectra for different soil types out of an extensive database of recorded motions. A total of 352 records are selected from the Pacific Earthquake Engineering Center (PEER) Strong Motion Database based on magnitude, distance, and site conditions to form the original ground motion domain. Then, the proposed harmony search based solution algorithm is applied on the pre-selected 352 time-series to obtain the ground motion record sets compatible with design spectra. The results demonstrate that the proposed HS based solution model provides an efficient way to develop input ground motion record sets that are consistent with code-based design spectra.

1. Introduction

In seismic design and seismic performance evaluation of buildings, dynamic analyses, also known as response history analyses, is becoming a common practice due to rapidly increasing computational power and the evolution of engineering software. However, it is still a challenge to obtain input ground motion acceleration records compatible with the seismic design code [1–3]. In practice, three types of ground motions are used for response history analyses, namely, artificial, simulated, and real ground motions [4–6]. The selection of ground motions used for analysis is critical consideration because the motions have significant impact on analysis results and, hence, on the design outcome. Therefore, it is important to be able to obtain an appropriate set of ground motions for an accurate estimation of the seismic structural responses based on the seismic hazard at the site where the structures are located [7].

The availability of online digital databases of strong motion recordings has increased the accessibility to real ground motions. However, depending on the conditions of the recording stations, magnitude of the source earthquake, faulting types, site soil types, overall and strong pulse duration, distance between the source of the earthquake and the recording site the ground motions can have very different spectral characteristics. In order to take into account the seismic hazard profile of the region where the analyzed structure will be situated, one has to obtain or develop ground motions that comply with a specific hazard scenario for that region as defined by the enforced design code. In newer design codes, the regional hazard characteristics are described through design spectrum, traditionally known as uniform hazard spectrum, given for a range of structural periods of interest [8–10]. As no ground motion record has the response spectrum that matches a given code-based design spectrum, one has to find a way to obtain "code-compliant" input base acceleration records that could be used in the design process. One approach is to select and scale actual, recorded ground motions available through databases to develop suite of candidate design input motions.

For scaling real ground motions, various frequency or time-domain methods can be used. Frequency-domain methods [11–14] manipulate the frequency spectrum of the ground motion records. Time-domain methods [5,15,16,17], however, manipulate only the amplitude of recorded ground motions.

Recently, Iervolino et al. [1] discussed the Eurocode-8 [8] Part 1 requirements about seismic input with respect to the best current practice. The authors also investigated to assess whether it is possible to find real record sets complying as much as possible with the Eurocode-8 requirements. In order to extend the study to bridge structures, a similar study concerning Eurocode-8 Part 2 was carried out [2]. Finally, REXEL, a software

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