Hybrid force-displacement-based design methods for self-centering wall structures

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Abstract
Self-centering wall structures (SCWs) are well developed resilient structures and are being gradually implemented in practical engineering. Direct displacement-based design (DDBD) method is commonly adopted for seismic design of SCWs due to its predictable displacement pattern. However, practical engineers are more familiar with the present force-based design (FBD) methods rather than DDBD. To make the design procedure more acceptable to engineers and so promote SCWs in real practice, three design methods were proposed in this study, including a force-based design method using empirical formula, an iterative force-based method and a hybrid force-displacement-based design method (HBD). FBD by empirical formula discussed the applicability of existing empirical formular of structural periods in several codes for SCWs. In iterative FBD, the initial prestress is iterated to determine scant stiffness and the structural period so that SCWs can be designed in accordance with its constitutive relationships. HBD is carried out by comparing the resistance of the structure under the target displacement with the earthquake demand according to the deformation mode of the SCWs. Compared with the existing DDBD methods, the proposed design methods can simplify the design process in engineering applications while keep the design outcomes consistent with DDBD, so that proved to be reasonable. In addition, the three proposed methods can also meet the requirements of the four-level seismic fortifications from the current Chinese seismic code GB 50011-2010 (2016). It solves the problem that the existing force-based method is inapplicable when the deformation of SCWs is large and also avoids using displacement spectrum during design. The recommended design methods could be a reference for engineers to design SCWs in engineering practices.

Keywords: self-centering wall structure, displacement-based design, force-based design, hybrid force-displacement-based design, four-level seismic fortifications monitoring

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