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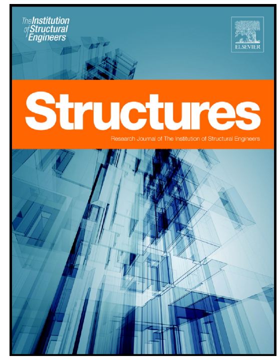

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Bar Layout and Weight Optimization of Special RC Shear Wall

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Abstract

Optimization problems can be defined and formulated with either discrete or continuous variables. This paper presents a continuous optimization method for the design of reinforced concrete shear walls, based on the concept of boundary element and with the reinforcement layout taken into consideration. Contrary to the discrete method, where algorithm must be provided with a set of previously prepared default designs, the continuous optimization algorithm generates and evaluates a wall design in each iteration. The objective function of the algorithm minimizes the cost of the wall, which depends on the reinforcement details (rebar diameter and layout) and the wall dimensions (the cost of concrete and formworking). This objective function consists of the boundary element dimensions and the reinforcement layout variables (cross-sectional area and spacing of rebars). Shear wall design requirements and restrictions are formulated as constraints in accordance with ACI318-11 provisions for special ductility. After obtaining optimal wall design for seismic loads, design details such as wall dimensions and reinforcement details are determined accordingly. The optimization is performed by the use of several metaheuristic algorithms, including PSO, FA, WOA, and CSA. The comparison of the results of continuous and discrete optimization methods show that the shear wall designs obtained by the continuous approach are less expensive and closer to the global optimum.

Keyword: **Continuous Optimization Method, Seismic Design, Metahuristic Algorithm, RC Shear Wall, Bar Layout.**

1. Introduction

With the rapid development and growing complexity of engineering optimization problems, the use of metaheuristic algorithms has become the method of choice in this regard. Metaheuristic algorithms are a family of computational method that estimate an initial solution and then improve it iteratively based on a set of rules to approach the global optimum. However, the final result of the algorithm is not guaranteed to be the optimal solution.

Many of the existing powerful algorithms are nature-inspired and population-based. One of the oldest of such algorithms is the Genetic Algorithm (GA) [1], which is inspired by biological mechanisms such as reproduction, mutation, and survival of the fittest. Other notable examples algorithms inspired by the collective and social behavior of animals include the Particle Swarm Optimization algorithm (PSO) [2], the Ant Colony Optimization algorithm (ACO) [3], and the Firefly Algorithm (FA) [4].

Researchers constantly develop new algorithms to accelerate convergence to the optimum and reduce the error of approximation for a specific set of problems. In other words, the purpose of any new algorithm is to improve solution accuracy, solving speed, or both. Notable among the algorithms introduced in recent years are the Harmony Search algorithm (HS) [5], Simulated Annealing algorithm (SA) [6], gradient evolution algorithm (GE) [7] and Heat Transfer Search algorithm (HTS) [8] developed in 2015, the Whale Optimization Algorithm (WOA) [9], Crow Search Algorithm (CSA) [10] and Water Evaporation Optimization algorithm (WEO) [11] developed in 2016, and the thermal exchange optimization [12], and Electro-Search algorithm [13] developed in 2017.

In this study, a continuous optimization method is formulated for the RC shear wall design problem. The continuous nature of the optimization method provides better flexibility than discrete method, allowing the algorithm to further approach the Best Solution. Since the results produced by the continuous method may not be real-world applicable, the method is also combined with discrete approach in order to achieve more practical results. The shear wall problem is solved by PSO, FA, WOA, CSA algorithms and the results are compared.

This paper consists of six sections. In Section 2, optimization algorithms and their formulations are described. Section 3 explains the RC shear wall design problem, cost function, problem constraints, and the wall optimization method. Section 4 provides a numerical example of the shear wall problem, and Section 5 presents a parametric study performed on that wall. Finally, the results are presented in Section 6.