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Integrated Metaheuristic Differential Evolution Optimization Algorithm and Pseudo Static Analysis of Concrete Gravity Dam

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Abstract

A differential evolution-algorithm-based optimum design method is presented for concrete gravity dams under stability, principal stress, and sliding constraints. A gravity dam is a large scale hydraulic structure providing its stability based on weight of concrete volume. Hence, optimization of dam cross-section leads to an economic and low cost structure. For this aim, a general dam section is reconstructed with seven proper horizontal and vertical geometric parameters which take into account all possible cross section shapes. Weight of dam is considered as goal function and the optimization problem of geometric parameters is solved using DE algorithm. The DE algorithm written as a MATLAB code are applied to Four benchmark gravity dams including Middle Fork, Richard, Pine Flat, and Friant. The comparison of DE optimum solutions with real dimension of dams and another optimization method in literature shows the performance of the DE algorithm. In mentioned benchmark dams, there are 26.82%, 30.11%, 25.31%, and 20.93% of weight reduction Compared to real values, respectively. Also, optimization results of DE algorithm are compared with literatures. The comparison shows 3.55%, 5.1%, 19.13% and 12.14% reduction of weight compared to GA and PSOD algorithms, respectively.

Keywords: Gravity Dam; Optimization; Metaheuristic Algorithms; Differential Evolution.

1. Introduction

Optimum design can be defined as the best acceptable design, based on a predetermined criterion of qualitative merit. The importance of designing structures with minimum weight was first considered by the aerospace industries in which the design of the plane is controlled majorly by weight than cost. In other industries related to civil engineering, cost may have the first importance even though the weight of system impresses its cost and function. So, optimization issue plays a great role in the ideal world. Existing optimization methods can be generally classified as analytical and numerical approaches. In Analytical approaches, the optimal point of continuous and differentiable goal function is determined using differential calculus. Due to nonlinear, discontinuous and non-differentiable goal function of real problems with various design constraints, analytical optimization may not be effective in civil engineering. Whilst the numerical approaches, especially metaheuristic algorithms, show high acceptability for solving complex and nonlinear design problems in civil engineering.

Various old and famous metaheuristic algorithms such as genetic algorithm [1-4], genetic programming [5-7], ant colony optimization [8-10], bat algorithm [11-13], and particle swarm optimization [14-16] are introduced in literature of civil engineering studies. Recently, new metaheuristic algorithms are developed by researchers for example Big bang big crunch algorithm by [17], Charged System Search by [18], ray optimization by [19], and flower pollination algorithm by [20]. The metaheuristic algorithms in civil engineering problems and their recent applications are presented by [21].

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