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Gravity Dam Shape Optimization Using Simulated Annealing

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Abstract

This paper presents the shape optimization of gravity dam subject to static loadings and restraints. The structural system is discretized by the finite element method. The shape optimization of a concrete gravity dam is posed with the goal of minimum volume of concrete for which the stresses and maximum safety against overturning and sliding are considered as the constraints. The structure is designed for the load combinations which make the maximum effects. The optimization is achieved using a heuristic search algorithm called the Simulated Annealing (SA) algorithm. Just in the same manner the atoms find their way to build a perfect crystal structure through random movements, by mimicking the physical phenomena, SA finds the global optimum through a search within randomly generated configurations.

A comparison study was conducted to evaluate the efficiency of the SA against the Sequential Quadratic Programming (SQP) optimization method. The results show that SA can outperform SQP in providing desirable solutions to the shape optimization of gravity dam structure. Finally, conclusions are presented.

Keywords: Simulated Annealing, Optimization, Concrete Dam, Finite Element, SQP

1. INTRODUCTION

In general, dams are designed by trial and error, that is, an initial scheme is proposed and then analyzed. If it satisfied the demands of the design specifications, the scheme is adopted. Otherwise, the shape of the dam is modified and reanalyzed. The shape obtained in this way is feasible but not necessary optimal or even acceptable. Moreover, the time for design is rather long.

The design of dams is fundamentally a configuration optimization problem, where the external geometry of the structure is to be determined. The optimal design problem may be stated in a mathematical programming form with geometric design variables.

Sequential Quadratic Programming (SQP) method has been applied by Simoes [1,2] to the shape optimization of solid gravity dams. In this case, a two-dimensional finite element model was used. In the present paper, dam optimization is achieved both by a stochastic search algorithm called Simulated Annealing (SA) and by SQP and comparisons between these methods are presented

2. SIMULATED ANNEALING ALGORITHM

In the early 1950's**,** Metropolis proposed an algorithm for use in Monte Carlo simulations, typically for the behavior of systems in thermal equilibrium at fixed temperature. Later, Kirkpatrick et al. [3], using the Metropolis algorithm in conjunction with an annealing schedule of declining temperatures, developed an efficient approach for studying the Ising spin glass problem [4] which they named Simulated Annealing. However, it took almost thirty years before Kirkpatrick et al. independently viewed the approach simply as a heuristic to an iterative improvement technique for the combinatorial optimization

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