



Metaheuristic Optimization Algorithms and Civil Engineering

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The purpose of the using metaheuristic algorithm is to obtain an efficient and quickly solution for the related problem from the solution space which consist of the all combination of design variables. Testing all combination to find best solution takes many computational times and calculation efforts when the number of design variables are high. To overcome this difficulty the metaheuristic optimization algorithms can be preferred. Metaheuristic algorithms don't prefer to use complex mathematical explanation such as the differential equations. But they don't promise to find the best solution always for a given problem.

The civil engineering problems can be as; optimal design of two or three dimensional structures, optimal design of geotechnical structures such as foundation structures and bases, optimum design of reinforced concrete structure or building elements, time-cost optimization for project work programs, optimization of reinforced concrete structures sensitive to environmental effects (CO₂ release) and so on.

Optimization in structural engineering can be defined as the most efficient use of design variables by determining an objective function such as total weight, cost, CO₂ emission or work duration in a construction project where the project is to be carried out. Depending on the problem, the design variables can be as element dimensions, number of elements, material properties, geometry of construction, duration of business activity, or cost. It may become difficult to create a mathematical model for the calculation of the objective function by taking into account these design variables. The combination of all design variables must be tested on the mathematical model created to find the global solution of the problem. However, in the case of continuous design variables or large number of design variables, the calculation volume and the required calculation time is also increase. Therefore, the use of metaheuristic optimization algorithms is effective solution for the engineering problems. The use of materials is becoming more limited due to the decrease of material resources in every day. So, it

is a necessary to design structures with less weight or volume with the help of the using optimization technique in the construction of the engineering structures. In addition to the material, an optimization process is also needed to create an effective work schedule depending on time and cost. In other words, it is uneconomic and a long time will be required to make the projecting process without any work schedule, material and cost optimization in all processes of the engineering structures from the design to construction.

Until now, the researchers developed many metaheuristic optimization algorithms by mimicking the natural phenomena, simulated the behavior of the animal's life or imitating a classroom like TLBO [1]. The main purpose in the developing a new optimization algorithm is to find global optimal solution for an engineering problem in a short time by using the minimum number of function evaluation. Thus, the advances of the new developed algorithm is compared by using some performance criteria such as number of function evaluation, CPU time, number of run, mean and standard deviation of the value of fitness function. Some of the most popular metaheuristic optimizations are: Differential Evolution (DE) by Storm & Price [2], Simulated Annealing (SA) by Kirkpatrick [3], Big bang - big crunch (BBBC) Osman & Eksin [4], Ant Colony Optimization (ACO) by Dorigo [5], Particle Swarm Optimization (PSO) by Kennedy & Eberhart [6], Genetic Algorithms (GA) by Holland [7], Jaya by Rao [8], Harmony search (HS) by Geem et al. [9], Artificial Bee Colony (ABC) by Karaboğa & Bastürk [10], Tabu Search (TS) by Glover [11], Teaching-Learning-Based Optimization (TLBO) by Rao et al. [1], Charged System Search (CSS) by Kaveh & Talatahari [12] and Cultural Algorithm (CA) by Reynolds [13].

Using these metaheuristic algorithms different type of civil engineering problems are investigated by the researchers. In the sub-research areas such as construction management, structural analysis, hydraulic, material science, geotechnical engineering and transportation many studies have been presented to the

open literature until now. Some examples for implementing of the metaheuristic algorithms related to the different sub-research areas in civil engineering can be given as following.

Buckling load optimization of laminated plates using TLBO [14] in mechanic, Jaya algorithm to design steel grillage structure [15], prediction of berm geometry using TLBO algorithm [16] in hydraulic, optimum design of tied back retaining wall using GA [17] in geotechnic, solving traffic signal coordination under oversaturation conditions using ACO [18] in transportation and multi-objective optimization for construction time-cost tradeoff problems using PSO in construction management [19-20].

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