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EXTENDED ABSTRACT

Layout Optimization of Outrigger Braced System in Steel Tall Structures Using Meta- Heuristic Algorithms

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1. Introduction

As the height of building increases, requirements of structural stiffness and stability become more important than the strength criterion. Each tall structure basically behaves like a vertical cantilever under lateral loads and the outrigger-braced system is a favorable system in tall structures (Taranath, 1998). This type of structure has a central core connected to outer columns by outrigger trusses or strong girders. The position of outrigger-braced system has a significant impact on the structural efficiency. Therefore, determining the position of outrigger braces is an important part of design process; it is mainly done experimentally and does not lead to good economic results. In this study, the particle swarm optimization (PSO), modified dolphin echolocation (MDE), Enhanced colliding bodies optimization (ECBO) and grey wolf optimization (GWO) algorithms are utilized to determine the optimum position of outrigger-braced systems in tall steel structures.

2. Methodology

In this study that the optimization is mainly aimed to reduce the structural weight and the constraint functions calculated in accordance with the type of element and problem, including stress, max displacement, drift and construction constrasints. The investigated structures are 5-bay 24-story (328-member) and 36-story (492-member) frames in which the bays are 15ft in length, the ground floor is 15ft in height and floors are 12ft in height. The seismic load on the frames is calculated and applied according to the ASCE/SEI-7 (2016).

OpenSees (2016) open-source software is employed for finite element modeling of the structures and Matlab (2015) software is used to implement optimization algorithms and other necessary computations.

In the both structures, an outrigger brace is fixed on the top floor. In the 24-story structure, the second brace can be moved between the upper and lower stories of the 12th floor. In the 36-story structure, the second and third braces can be moved between the upper and lower stories of the 12th floor and 24th floor, respectively, to achieve the optimum solution.

3. Results and discussion

The optimization results obtained by the algorithms for 24-story frame indicate that the optimum position of outrigger-braced system is determined on the 12th floor and the best structural weight is obtained by MDE algorithm. Fig. 1. shows the convergence curves of the algorithms and the inter-story drift profiles of the optimum structures found by the algorithms. It is clear that the convergence rate for the MDE algorithm is better than that of the other algorithms and the drift constraint is an active constraint in the optimization process, especially at the top stories.

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In the case of 36-story frame, the results of optimization demonstrate that the optimum position of outrigger-braced system is on the 11th and 23th floors and the best design is obtained by the MDE algorithm. The convergence rate of algorithms and the inter-story drift profiles of the optimum structures found by the algorithms are depicted in Fig. 2. It can be observed that the MDE has the best convergence rate among all the algorithms. In addition, the comparison of the inter-story drifts and the stress ratios of columns indicate that for the best design obtained by MDE the stress ratio constraints of columns dominate the optimal design.

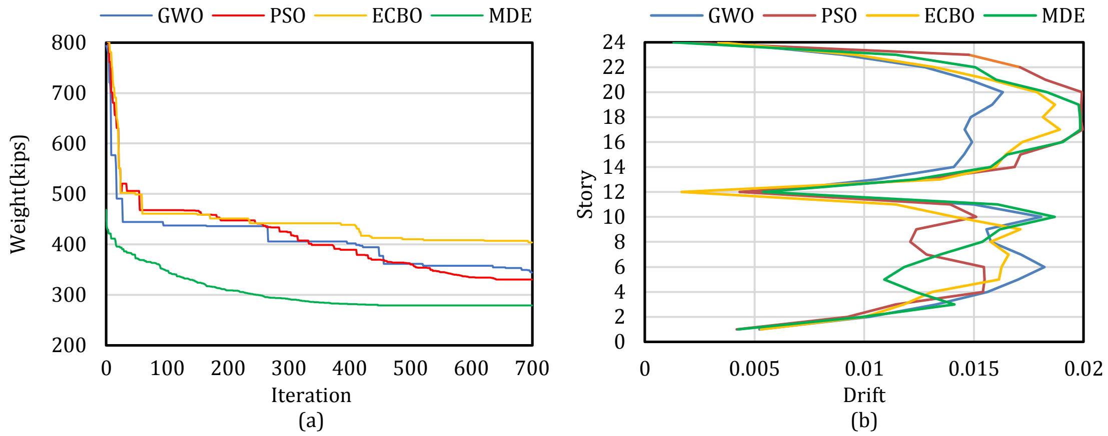

Fig. 1. 24-story frame: a) Convergence histories, b) Inter-story drift profiles

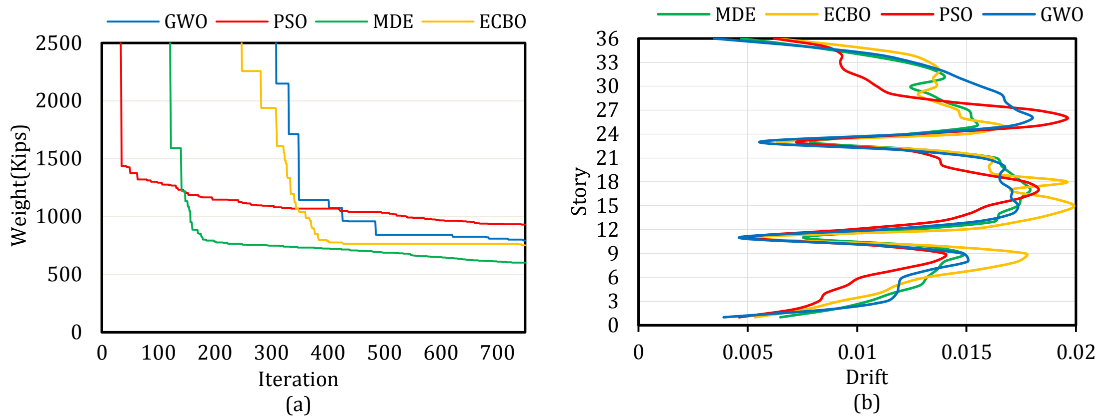

Fig. 2. 36-story frame: a) Convergence histories, b) Inter-story drift profiles

4. Conclusions

Results of this study demonstrate the proper performance of MDE algorithm in comparison with the other three metaheuristics and reveal the importance of position of outrigger-braced system in achieving the optimum structures. It is necessary to conduct an optimization process based on the seismic performance and considering nonlinear behavior of structures to obtain more realistic designs.

5. References

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