Chapter 6

Conclusions

In this study, an ACO algorithm for sizing optimization of structures is proposed. The ACO mimics the way ant colonies function in the real world. An ant colony is capable of finding the shortest path between its nest and a food source. This natural process of finding the shortest path is achieved by using three basic mechanisms, i.e. pheromone trail-laying, pheromone trail-following and pheromone evaporation. These three simple mechanisms comprise the ACO and can be simulated by computers. In this study, sizing optimization problems of structures are first formulated in a suitable way that fits the ACO approach. To this end, the optimization problem under consideration is transformed into a foraging problem of an ant colony. Each design solution is interpreted as a route that ants can use to walk from the colony's nest to a food source. A better design is made to be equivalent to a shorter route. In this study, to possibly improve the quality of the ACO algorithm, a greedy heuristic is also incorporated into the algorithm. The greedy heuristic simply allows ants to consider not only levels of pheromone but also sizes of structural members when they select their paths.

The proposed algorithm is used to solve sizing optimization problems of truss and frame structures. From the obtained results, it can be concluded that the greedy heuristic can generally improve the quality of the results if an appropriate degree of the greedy heuristic is employed. It can be expected that, if too high a degree of the greedy heuristic is employed, the search will simply become a greedy search and the quality of the results can be compromised. The comparison with the results obtained by a standard GA shows that, when the greedy heuristic is not used in the ACO algorithm, the results from the ACO algorithm are always better than those from the standard GA in terms of both quality and uniformity. When the greedy heuristic with an appropriate degree of the greedy heuristic is employed, the performance of the ACO algorithm becomes even better. Nevertheless, if an inappropriate degree of the greedy heuristic is used, the standard GA can outperform the proposed algorithm. Finally, for the numerical examples shown in this study, the results from the proposed algorithm are found to be better than those results reported in the literature. Since the basic concept of the ACO is simple and the proposed ACO algorithm can be easily implemented, with its excellent performance, the proposed algorithm is indeed satisfactory.

References

Abbaspour, K.C., Schulin, R. and van Genuchten, M.Th. 2001. Estimating unsaturated soil hydraulic parameters using ant colony optimization. *Advances in Water Resources* 24: 827-841.

American Institute of Steel Construction 1989. *Manual of steel construction—allowable stress design.* Ninth edition. Chicago. Illinois.

Bonabeau, E., Theraulaz, G., Deneubourg, J.-L., Aron, S. and Camazine, S. 1997. Self-organization in social insects. *Trends in Ecology & Evolution* 12(5): 188-193.

Camp, C., Pezeshk, S. and Cao, G. 1998. Optimized design of two-dimensional structures using a genetic algorithm. *Journal of Structural Engineering* 124(5): 551-559.

Dorigo, M. and Gambardella, L.M. 1997. Ant colonies for the travelling salesman problem. *BioSystems* 43: 73-81.

Dorigo, M., Caro, G.D. and Gambardella, L.M. 1999. Ant algorithms for discrete optimization. *Artificial Life* 5(2): 137-172.

Eggers, J., Feillet, D., Kehl, S., Wagner, M.O. and Yannou, B. 2003. Optimization of the keyboard arrangement problem using an Ant Colony algorithm. *European Journal of Operational Research* 148(3): 672-686.

Fu, K.-C. and Levey, G.E. 1978. Discrete frame optimization by complex-simplex procedure. *Computers and Structures* 9: 207-217.

Galante, M. 1996. Genetic algorithms as an approach to optimize real-world trusses. *International Journal for Numerical Methods in Engineering* 39: 361-382.

Goldberg, D. E. 1989. *Genetic algorithms in search, optimization, and machine learning.* Reading. Massachusetts: Addison-Wesley.

Gravel, M., Price, W.L. and Gagné, C. 2002. Scheduling continuous casting of aluminum using a multiple objective ant colony optimization metaheuristic. *European Journal of Operational Research* 143(1): 218-229.

Gutjahr, W.J. 2000. A graph-based ant system and its convergence. *Future Generation Computer Systems* 16: 873-888.

Hasançebi, O. and Erbatur, F. 2002. Layout optimisation of trusses using simulated annealing. *Advance in Engineering Software* 33: 681-696.

Jayaraman, V.K., Kulkarni, B.D., Karale, S. and Shelokar, P. 2000. Ant colony framework for optimal design and scheduling of batch plants. *Computers and Chemical Engineering* 24: 1901-1912.

Jennings, B., Brennan, R., Gustavsson, R., Feldt, R., Pitt, J., Prouskas, K. and Quantz, J. 1999. FIPA-compliant agents for real-time control of Intelligent Network traffic. *Computer Networks* 3(19): 2017-2036.

Korošec, P., Šilc, J. and Robič, B. 2004. Solving the mesh-partitioning problem with an ant-colony algorithm. *Parallel Computing* 30(5-6): 785-801.

Lagaros, N.D., Papadrakakis, M. and Kokossalakis, G. 2002. Structural optimization using evolutionary algorithms. *Computer and Structures* 80: 571-589.

Lee, Z.-J., Lee, C.-Y. and Su, S.-F. 2002. An immunity-based ant colony optimization algorithm for solving weapon–target assignment problem. *Applied Soft Computing* 2(1): 39-47.

Maniezzo, V. and Carbonaro, A. 2000. An ANTS heuristic for the frequency assignment problem. *Future Generation Computer Systems* 16(8): 927-935.

McMullen, P.R. 2001. An ant colony optimization approach to addressing a JIT sequencing problem with multiple objectives. *Artificial Intelligence in Engineering* 15: 309-317.

Nanakorn, P. and Meesomklin, K. 2001. An adaptive penalty function in genetic algorithms for structural design optimization. *Computers and Structures* 79: 2527-2539.

Papadrakakis, M., Lagaros, N.D. and Tsompanakis, Y. 1998. Structural optimization using evolution strategies and neural networks. *Comput. Methods Appl. Mech. Engrg* 156: 309-333.

Rajan, S.D. 1995. Sizing, shape, and topology design optimization of trusses using genetic algorithm. *Journal of Structural Engineering* 121(10): 1480-1487.

Rajeev, S. and Krishnamoorthy, C.S. 1992. Discrete optimization of structures using genetic algorithms. *Journal of Structural Engineering* 118(5): 1233-1249.

Sadek, E.A. 1992. Optimization of structure having general cross-sectional relationships using an optimality criterion method. *Computers and Structures* 43(5): 959-969.

Talbi, E.-G., Roux, O., Fonlupt, C. and Robillard, D. 2001. Parallel ant colonies for the quadratic assignment problem. *Future Generation Computer Systems* 17: 441-449.

Thevendran, V., Das Gupta, N.C. and Tan G.H. 1992. Minimum weight design of multi-bay multi-storey steel frames. *Computers and Structures* 43(3): 495-503.

T'kindt, V., Monmarché, N., Tercinet, F. and Laügt, D. 2001. An Ant Colony Optimization algorithm to solve a 2-machine bicriteria flowshop scheduling problem. *European Journal of Operational Research* 142(2): 250-257.

Wu, S.-J. and Chow, P.-T. 1995. Steady-state genetic algorithms for discrete optimization of trusses. *Computers and Structures* 56(6): 979-991.