EXTENDED ABSTRACT

Optimization of Steel Frames with Non-rismatic Members Using Genetic and Micro-genetic Algorithms

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1. Introduction

The steel frames with variable cross sections in large span bridges and industrial buildings are preferred due to economic considerations. In these frames, the distribution of internal forces depends on the assumed initial dimensions for cross sections of members. Based on the determined internal forces from initial structural analysis, ratio of the demand to capacity and the allowable story drift, section dimensions of the members are corrected. New analysis and design of the frame is performed with the dimensions for cross sections of members. Analysis and design are iterated until designed and assumed cross sections become the same. The aim of the trial and error method in assuming the initial dimensions, analyzing and designing of the structure is a safe structure design with minimum structural weight. Therefore, final plan is prepared after numerous iterations. The plan may be resulted in non-optimized design in some cases because of the large number of design restraints and variables, complicated distribution of internal forces and initial assumption. Therefore, it is necessary to devise an optimization method for designing such frames.

In the current study, the genetic and micro-genetic algorithms were used to find an optimized design with minimum weight of steel frames having variable cross sections members. The aim of these optimization methods was selection of the proper cross sections to obtain a safe design with considering the strength and serviceability criteria of building specifications. The studied frames have been built from the welded variable cross section beams with compact web and flange components.

2. Methodology

A software in Fortran language was prepared for linear analysis, optimization and design of steel moment frames with non-prismatic members by use of genetic and micro-genetic algorithms. This software is capable to use all of the genetic and micro-genetic algorithms parameters. Also, it can consider any type of loading and boundary conditions. The structure weight is regarded as the objective function and the ratio of the story drift, axial force; bending moment and member stress are the restraints. The optimum dimensions of the member sections and the haunch length of the members with variable cross sections were determined using the suggested method. Therefore, the optimum design with minimum weight was obtained by eliminating the long steps of the trial and error method for searching the optimum sections of the structures with variable cross sections. The advantages and disadvantages of both algorithms were compared together with the obtained optimum designs and the effect of elitism to reach an optimum was examined.

3. Results and discussion

The genetic and micro-genetic algorithms were converged to identical designs after 100 and 95 generations in the frame under-study (Fig. 1), respectively. As shown in Fig. 2, the convergence rate in micro-genetic algorithm is higher than genetic one. The differences between minimum and maximum weights in genetic and micro-genetic
algorithms were 7.35% and 5.27%, respectively. The use of genetic and micro-genetic algorithms with elitisms option led to decreased weight of the optimized frame.

![Fig. 1. Steel frame with variable cross section](image)

![Fig. 2. Steel frame weight as a function of generation](image)

4. Conclusions

As two efficient search methods, the genetic and micro-genetic algorithms are used for finding optimum design of steel moment frames with non-prismatic members. The results showed that the micro-genetic algorithm is preferred to genetic algorithm to find optimum design of steel frames with non-prismatic members. It has high convergence rate. This algorithm needs less population for obtaining an optimized design compared with the normal genetic algorithm. The number of required iteration steps in micro-genetic algorithm is less than the other algorithm.

A software in Fortran language was prepared using genetic and micro-genetic algorithm for optimum design of steel frames with variable cross sections. In this software, the linear elastic analysis of the structure is performed by stiffness method. In the optimization process, the stress constraints are considered in the frame members to account interaction between axial forces and bending moments. In this procedure, the weight of structure is the objective function and the story drift, stress and the interaction between the axial force and bending moment are the constraints. The optimum cross sections and the length of the haunch of members with variable cross section were determined using the suggested method.
The elitism application effect was investigated in the algorithms. The elite-oriented approach resulted in the improvement of the genetic and micro-genetic algorithm functions. The use of the elitism option in both algorithms led to the increased efficiency of the algorithms and decreased weight of the optimized frame. In these kinds of algorithms, regarding the decreased number of the new members, the convergence rate increases.