Multi-Objective Optimization for Support Location of Reactor Head lifting Structure

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1. Introduction

The paper deals with support location optimization of reactor head lifting structure subjected to seismic excitation. The reactor head lifting structure is a large vertical structure used for lifting reactor head. The necessity of the horizontal supports arose to reduce excessive seismic responses of the structure excited by seismic loads. The variation of the supporting location induces the change of the seismic responses as well as of dynamic characteristics of the structure.

The finite element method(FEM) and multi-objective optimization based on genetic algorithm(GA) have been used to obtain the optimal supporting locations in terms of minimizing stresses and displacements at the same time. This paper presents the Pareto optimal sets with the specific optimal support height and distance ratio.

2. Analysis Model and Methods

In this section, the reactor head lifting structure and its applicable finite element model are described. Multi-objective GA methods and seismic analysis methods are introduced for supporting location optimization.

2.1 Description of the Structure and Model

Motives of the study began to determine the lateral supporting location of the reactor head lifting structure. The structure consists of sub-assemblies functioning to CEDM cooling, missile shielding, seismic supporting and lifting the reactor closure head. In particular, the structure should be designed considering seismic excitation. As a result, it is important to reduce the seismic loads with horizontal support system. Basically, this function is performed by 4 supports connected to the pool wall. It is believed that optimized support location contributes to decreasing the internal forces of the main structures effectively.
Based on the main load path components of structure, FE model consists of 3 vertical columns, top plate and 4 lateral supports.

2.2 Multi-Objective GA

In this paper, two objectives, stress and displacement as structural responses was optimized at the same time. Among the multi-objective optimization methods, an approach to determine the Pareto optimal solution sets is used. GA simulates the natural selection progress with a computational programming, gene, population, selection, crossover and mutation[1]. Being a population-based approach, GA are well suited to multi-objective optimization problems. This study have used multi-objective GA MATLAB program developed by A. Popov[2].

2.3 Seismic Analysis

The structural responses of the reactor head lifting structure under seismic excitation were obtained from response spectrum analysis method[3]. The modes are combined with the grouping method considering the dynamic characteristics. This is analyzed by the commercial analysis software, ANSYS[4].

2.4 Combining the Optimization and Seismic Analysis

Both the MATLAB program for the optimization and FE program for seismic analysis are combined. The interfaces of the programs are shown on the Figure 1.

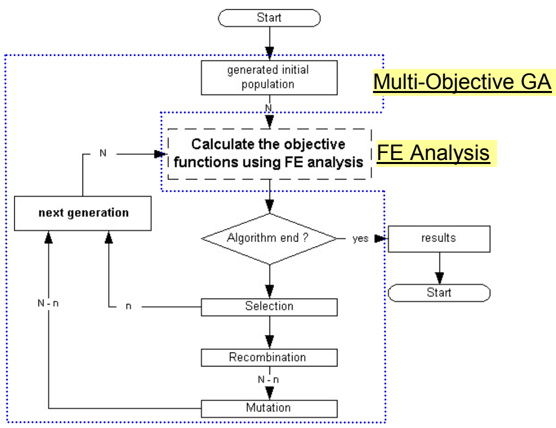

Figure 1. General scheme of the FE analysis and the multi-objective GA

3. Results of Multi-objective Optimization

The design variables are height ratio(h/L) and distance ratio(a/B) of the support end at the wall side. When the support location can be varied independently for each support, the analysis results are presented as follows.

Depending on the number of iterations, optimal results of the main column are shown on the Figure 2. Pareto curves, sets of all the points, are optimal solutions specific given support locations.

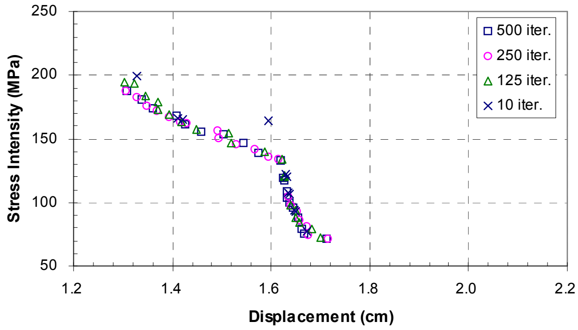

Figure 2. Pareto optimal sets depending on iterations

The Pareto optimal results occurred in the two separated region depending on height ratio shown on Figure 3. The one is above 0.9 > h/L, the other is 0.75< h/L < 0.8 so that the support heights are determined in the suggested two regions.

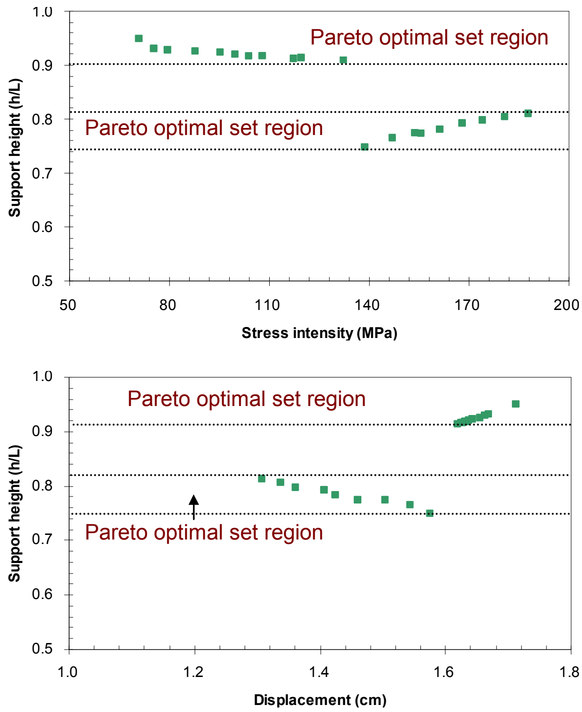

Figure 3. Stress intensities and displacements for support height variation

Stresses and displacements depending on distance ratios for 4 supports are shown on Figure 4. Many optimal sets are found in the two near areas of a/B = 0.4 and a/B = 0.8. Although the design variables of distance ratio are given 4 supports independently, it is found that two of them are closely located and others are similar to the former locations within a/B <0.2.

4. Conclusions

The support location optimization of the reactor head lifting structure under seismic excitation with multi-objective was performed using genetic algorithm and

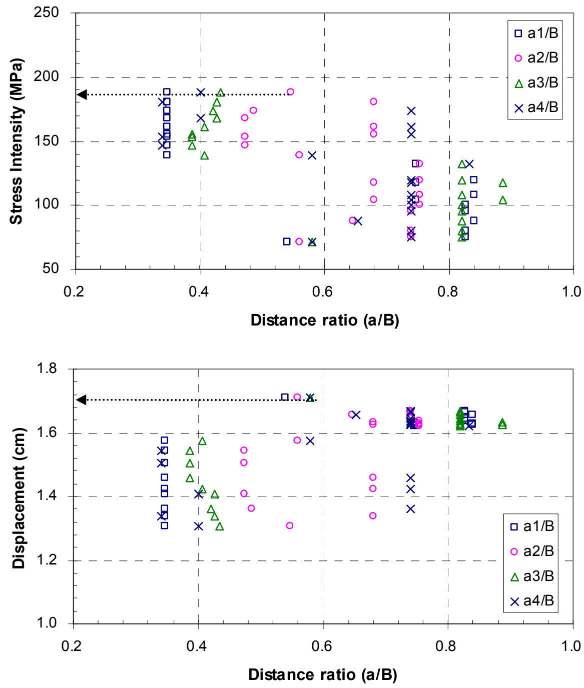

Figure 4. Stress intensities and displacements by depending on support distance ratios (a/B)

response spectrum method. The results show that integral module, multi-objective GA and FEM, leads the Pareto optimal sets at the specific support locations. In addition, this study confirms that the solution sets exists in two separate optimal height regions and distance ratio regions, in which trends of the results are founded. The study also provides many support locations having optimal sets which can be selectively applied to the structure against design restrictions.

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