J. Appl. Environ. Biol. Sci., 5(10S)336-339, 2015

ISSN: 2090-4274
Journal of Applied Environmental and Biological Sciences
www.textroad.com

Optimization of Double Layer Grids Using Simulated Annealing Method Size

Mortaza Shikhpuor Jalali[1]*, Reza Taheri[2] and Motahare Afshar[3]

[1,2]MA.Technical and Soil Mechanics Laboratory of Kerman
[3]Msc student, department of civil Engineering, Graduate University of Advanced technology

Received: April 20, 2015
Accepted: June 15, 2015

ABSTRACT

In recent years, several methods have been used to optimize the structures [1-2]. Genetic algorithm, simulated annealing algorithm and ant colony algorithm are the most important available evolutionary methods in the engineering optimization different problems. In optimization problems, the main goal is usually to minimize the weight of the structure under design constraints. In this paper the simulated annealing algorithm is proposed to minimize the weight of double layer grids.
Simulated annealing algorithm is a search method that used for finding a global optimum for a complex problem. The basic idea of this method was introduced in 1953. In this process a physical system initially at a high-energy state is gradually cooled down until its minimum energy level is reached.
A square-on-square double layer grid with 221 nodes and 800 elements is presented to examine and verify the proposed optimization method.

KEY WORDS: Double layer grids, Size optimization, Simulated annealing algorithm

1. INTRODUCTION

The space frame structures, the combination of membrane and geometric form, external loads, internal forces and displacements of the structure is not located in one plane and goes beyond and spread into 3 dimensions. In fact, space frame structures ate defined to groups of structures, mainly flat grids, drum, domes, towers, grids of cables, membrane structures, constructions folding and so on.

Space frame structures have diverse and variety forms and can be utilized a variety of materials such as steel, aluminum, wood, concrete Arce, mixed materials and plastic materials reinforced with fibers of glass, and combinations of these materials in the construction space frame structures.

Using large spaces such as stadiums, factory halls, airports requires the area without middle column and separating from space frame structures, low weight and high strength and high hardness of these structures which are suitable for these areas.

Optimization space frame structures is important for weight loss of structures, in addition will be provided to savings in materials and destruction of environment, allowing free entrance to the needs of changing societies.

At the same time reduce mass in the seismic behavior of the product is desirable. Recently, there have been used various methods to optimize structures. For example, in [3] reference, an article is provided as a way of evolution strategies to optimize the size and shape of the truss structure so that the cross-section of the truss members to optimize the size and coordinates of nodes intended as shape optimization. In this paper, the size optimization of the double layer grids is presented regarding to various constraints by using simulated annealing method.

2. Express mathematical optimization problem

The main objective of this paper is to obtain a statistical search so that can be obtained optimization of space frame structures by considering factors include stress, slenderness ratio and displacement. In this paper, cross-sectional areas of members are selected as design variables [4].

3. Static constraints optimization problem

In optimal design, the double layer grids minimized affected by static factors. Structure weight (w) is minimized so that the constraint stress(g_σ), slenderness ratio (g_λ) and displacement factor (g_s) are satisfied.

$$w(\bar{A}) = P^e \sum_{k=1}^{NMB} a_k \sum_{i=1}^{Nk} L_i$$

$$\text{Subject to: } g_\sigma, g_\lambda, g_s \leq 0$$
$$\bar{A} = [a_1 \dots a_{NMG}]^T$$
$$a_k \in \bar{A}, \quad k = 10 \rightarrow NMG$$

Corresponding author: Mortaza Shikhpuor Jalali, MA. Technical and Soil Mechanics Laboratory of Kerman
email: MSHIKHPUR@YAHOO.COM

In this regard. NMG is the number of types of members, N_k the number of type k, $a_k$section level of members k have been selected from the available list of steel pipes(A), P^e members density, L_i the lenght member of i and the constraints stress, slenderness ratio expressed by the following relationship:

$$g_\sigma = \sum_k max(|\sigma_k|/\sigma_{max} - 1,0)$$

$$g_\lambda = \sum_k max(|\lambda_k|/\lambda_{max} - 1,0)$$

That $\sigma_k, \sigma_{\max}, \lambda_k, \lambda_{\max}$ are respectively the stress, allowed stress, slenderness ratio and allowed of slenderness ratio is K member of double layer grids. In this essay, the ASCE regulation [5] is used for determine amount of allowable stress factors and slenderness.

$$\sigma_{\max} = 0.6 f_y$$

$$\sigma_{\max} = \sigma_c$$

$$\sigma_c = [(1 - \frac{\lambda_k^{\ 2}}{2 \times C_c^{\ 2}}) f_y] / (\frac{5}{3} + \frac{3\lambda_k}{8C_c} - \frac{\lambda_k^{\ 3}}{8C_c^{\ 3}}) \qquad \lambda_K < C_c$$

$$\lambda_K \geq C_c \qquad \sigma_c = \frac{12\pi^2 E}{\lambda_k^{\ 2}}$$

$$C_c = \sqrt{2\pi^2 E / \mathrm{fy}}$$

4.Simulated Annealing Algorithm

Simulated Annealing algorithm is an exploratory search method that used for finding general optimal solutions for issues. In this method, First a system is heated in high temperature and then cooled slowly so that the system is in equilibrium every time. This algorithm includes the following steps [6]:

1. Cooling schedule

The first stage is placing good cooling schedule. After selecting the suitable amounts for starting acceptable possibility (p_s), ultimate acceptable possibility (p_f) and cooling periods (N_c), the cooling schedule parameters calculated as follows:

$$T_s = \frac{-1}{\ln(P_s)} T_f = \frac{-1}{\ln(P_f)} \qquad \lambda = \left[\frac{\ln(P_s)}{\ln(P_f)}\right]^{\frac{1}{N_c} - 1}$$

T_s, T_f, λ Point to the initial temperature, final temperature and coefficient of decrease temperature. The initial temperature is assumed as the current temperature $T=T_S$

2. Initial design

This step is randomly generated initial design so that the variables design are selected at random from steel sections. This design is considered as the current design and the structural analysis is performed with the initial design and objective function value is calculated.

3. Generating candidate designs and evaluating

A number of candidate designs are generated in the vicinity of the current design. This is performed as follow: a design variable is selected, the selected variable is given a small perturbation in a predefined neighborhood and finally, new design is generated. difference objective function of new design and the current design is calculated. If this amount is positive, it means that the new solution is more efficient than the current, so the new solution will replace the current solution and if it is negative, the new solution with possibility $-\frac{\Delta fitness}{T}$ replace to the current solution and it is repeated until all design variables are perturbed.

$$I'_i = I_i \mp Z_i$$

In this Eq, Z_i refers to the amount of perturbation applied to the ith design variable, and is sampled randomly within an integer neighborhood [1,nw], where nw indicates the width of neighborhood.

4. Iterations of a cooling cycle

An separate iteration in decrease temperature cycle, when all the variables design have been selected one time to produce new designs. In general, a cycle should be repeated in a certain times and then temperature reduced.

Having selected the iterations of the starting and final cooling cycles i_s, i_f , the iteration of a cooling cycle (i_c) is determined by a linear interpolation between i_c and i_f as follows:

$$ic = if + (if - is)\left(\frac{T - T_f}{T_f - T_s}\right)$$

5. Reduce Temperature

When the number of repetitions of cooling end, the temperature was reduced by a factor of temperature λ .

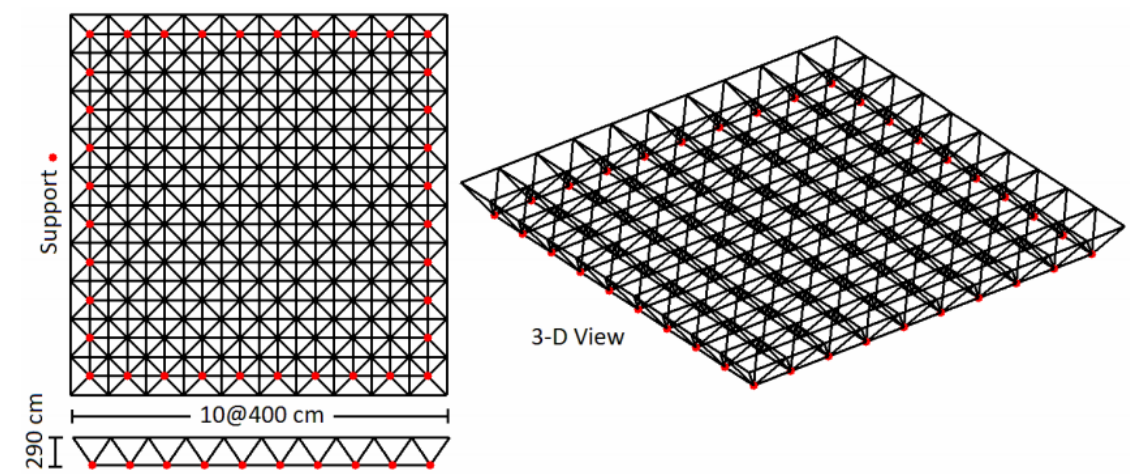
$$T^{k+1} = T^k \times \lambda$$

That the temperature T^{k+1} in k + 1 th cooling cycle and T^k temperature is in the in k th .

6. Repeat steps 3 to 5 to the maximum number of N_c to an end

Numerical example:

In order to demonstrate the effectiveness of Simulated Annealing method, a square on the square double layer grid with 221 nodes and 800 elements is considered. The assumed material is steel with a Youngs modulus and mass density of $2.1*10^6 kg/cm^2$ and $7850 kg/m^3$, respectively. The dead load on double layer grid is $180 kg/m^2$. This distributed load is assigned to the nodes of the top grid in the proportion of their load bearing area. 6 stages have been implemented cause of random nature of this method and have been reported in Table 1:



double layer grid 10*10 A

Optimum weights of structure (kg) Table1:

Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
23516	22316	21497	22614	21589	22478

6. Conclusion

Annealing of metals is one of discovery learning methods that is one of the most important evolutionary methods of optimization of engineering issues. The main aim of optimizing structures is minimize the weight of the structure according to design constraints that is used a simulated annealing algorithm to minimize the weight of double layer grids, so that the stress, slenderness ratio and displacement constraints are satisfied.

REFERENCES

1. J.S. Arora, “Optimization of structural and mechanical systems”, in: J.S. Arora (Ed.), Introduction to Optimization, World Scientific Publishing Pte. Co., Singapore, pp. 1–7,2007
2. J.S. Arora, “Methods for discrete variable structural optimization”, in: S.A. Burns (Ed.), Recent Advances in Optimal Structural Design, Technical Committee on Optimal Structural Design, ASCE, Reston, VA, pp. 1–40, 2002.
3. Ahrari, Ali, and Ali A. Atai. "Fully Stressed Design Evolution Strategy for Shape and Size Optimization of Truss Structures." Computers & Structures 123 (2013): 58-67.
4. Mashayekhi, Mostafa, et al. "Reliability-based topology optimization of double layer grids using a two-stage optimization method." Structural and Multidisciplinary Optimization 45.6 (2012): 815-833.
5. American Institute of Steel Construction, AISC Manual, 2005.
6. Hasançebi, Oğuzhan, and Fuat Erbatur. "Layout optimization of trusses using simulated annealing." Advances in Engineering Software 33.7 (2002): 681-696.