

FREQUENCY RESPONSE OPTIMIZATION OF A RECTANGULAR PLATE BASED ON HYPERWORKS

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ABSTRACT

This paper demonstrates the capability of frequency response optimization using the Optimal Structure. Initially, an existing finite element model of a flat plate is retrieved and modal frequency response analysis is performed to derive the peak magnitude. A dynamic response optimization is then performed on the same plate to obtain a new design. The new design gives an optimized material layout with a minimized peak response. Post-processing tools will be used in Hyper View to visualize ISO-Plots, magnitude, and phase of the complex displacement results.

Keywords: *Hyper works, Modal Analysis, Material Optimization, Minimized Peak Displacement*

1. INTRODUCTION

Topology optimization provides designers with a conceptual design at the primary stage in engineering design. Topology optimization satisfies both the constraints and the objective function in a given material quality and design space, and provides a global optimal result. The biggest advantage of the topology optimization is that it can accord to a known boundary conditions and load conditions to determine a reasonable structure. It can be used both for the conceptual design of new products but also for the improvement of existing products design [1-3].

Hyper Mesh as the Altair Company's flagship product is a finite element solver for mainstream high-performance pre-and post-processing software that allows engineers to analyze the performance of products in a highly interactive and visual environment. Optimal-Structure as an optimization tool is specifically for the conceptual design and the development of structural analysis [5],[11]. Optimal Structure is an optimization tool, based on the finite element method with topology optimization (topology), topography optimization (topography), shape optimization (shape) and size optimize (size), can produce a precise design concept or layout. Optimal Structure and Hyper Mesh have seamless interface, so that users can quickly and easily set problem, submit and post-processing a set of operation. This article performs topology

optimization for a rectangular plate, and achieves a better design [4], [6].

2. SETTING UP A MODAL FREQUENCY RESPONSE ANALYSIS IN HYPERMESH

Launch Hyper-Mesh, Set the User Profile and Import a File. In this section, the model is constrained at one edge. A unit vertical load will be applied acting upwards in the positive z-direction at a point on a free edge corner of the plate [7-8]. We first need to create the two load collectors SPC and unit-load.

2.1. Import the Finite Element Model

(1). Create the SPC and Unit Load Collectors.

(2). Create Constraints. The model is showed in the following figure 1.

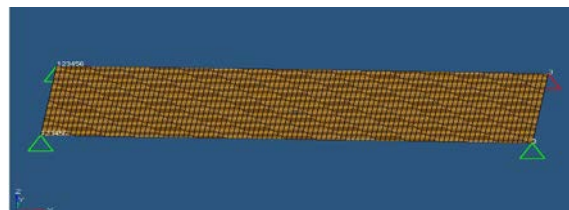


Figure 1. Finite Element Model

2.2. Setting Up Modal Analysis On The Model

(1). Create a Unit Load at a Point on the Flat Plate.

(2). Create a Frequency Range Table.

- (3). Create a Frequency Dependent Dynamic Load.
- (4). Create a Set of Frequencies to be used in the Response Solution.
- (5). Create a Load Collector EIGRL to Use as the Modal Method.
- (6). Create an OptiStruct Load step (also referred to as a subcase).
- (7). Create a Set of Nodes for Output of Results.
- (8). Create a Set of Outputs and Include Damping for Frequency Response Analysis.
- (9). Run the Analysis.

Table 1. The Iterative Data

Iterations	Node Number	Iterative Frequency	X axis displacement	Y axis displacement	Z axis displacement
1	3	2.495944E+01	1.62766E-19	1.10219E-18	9.61302E+02
2	3	5.585619E+01	4.55098E-16	-1.20475E-15	1.18101E+03
3	3	1.134379E+02	-5.58264E-14	1.61006E-13	4.09159E+02

Iterations	Node Number	Iterative Frequency	X axis displacement	Y axis displacement	Z axis displacement
1	3	2.495944E+01	1.70796E+01	2.81851E+00	3.19619E-20
2	3	5.585619E+01	2.26036E+01	2.80709E+01	-1.48944E-17
3	3	1.134379E+02	1.12154E+01	2.16275E+01	4.13857E-15

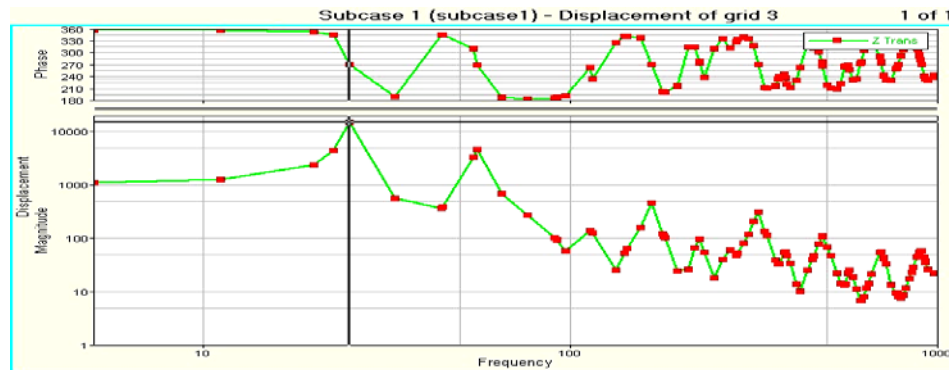


Figure 2. Frequency Response Function (Node 3, Z-Displacement)

3. POST-PROCESSING FRF RESULTS

This section describes how to view displacement results (.mvw file) in Hyper Graph and also how to understand the displacement output (.disp file) from this run. The results file (.h3d) contains only the displacement results for the three nodes specified in the node set output. Open the displacement file (.disp) using a text editor[9]. This is the first three iterative date. The concrete iterative data as is shown in table 1.

The Peak Displacement of the Baseline Model in Hyper Graph as is shown in figure 2.

4. CREATE THE DESIGN VARIABLES FOR TOPOLOGY OPTIMIZATION

A topology design space definition, plate, has been created. All elements organized into the design component collector are now included in the design space. The thickness of these shells can vary between 0.15 (base thickness defined above) and the maximum thickness defined by the T (thickness) field on the PSHELL card.

The object of this exercise is to determine where to locate ribs in the designable region. Therefore, a non-zero base thickness is defined, which is the original thickness of the shells[10]. The maximum thickness, which is defined by the T field on the

PSHELL card, should be the allowable depth of the rib.

Currently, the T field on the PSHELL card is still set to 0.15 (the original shell thickness), this needs to be changed to a higher value to create a design space where the material can be removed.

4.1. Two Responses Will Be Defined Here

- (1). Frequency Response Displacement.
- (2). Total Volume Response.

4.2. The Steps Are as Follows

- (1). Create Responses.
- (2). Create the Constraints.
- (3). Define the Objective.

(4). Run the Optimazation.

5. POST-PROCESSING THE TOPOLOGIC RESULTS

Element Density and Element Thickness results are output from OptiStruct for all iterations. This section describes how to view an ISO-Plot of the new design in Hyper View. Each element of the model is assigned a legend color, indicating the density of each element for the selected iteration. The last design iteration gives the optimized material layout.

5.1. View a Static Plot Of The Density Results

View a static plot of the density results as is shown in figure 3.

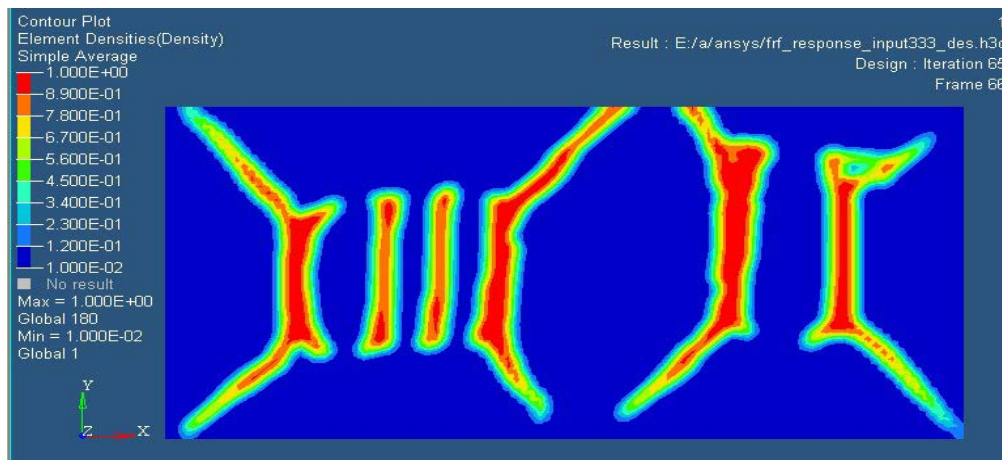


Figure 3. Contour Of The Baseline Model (Final Design Iteration)

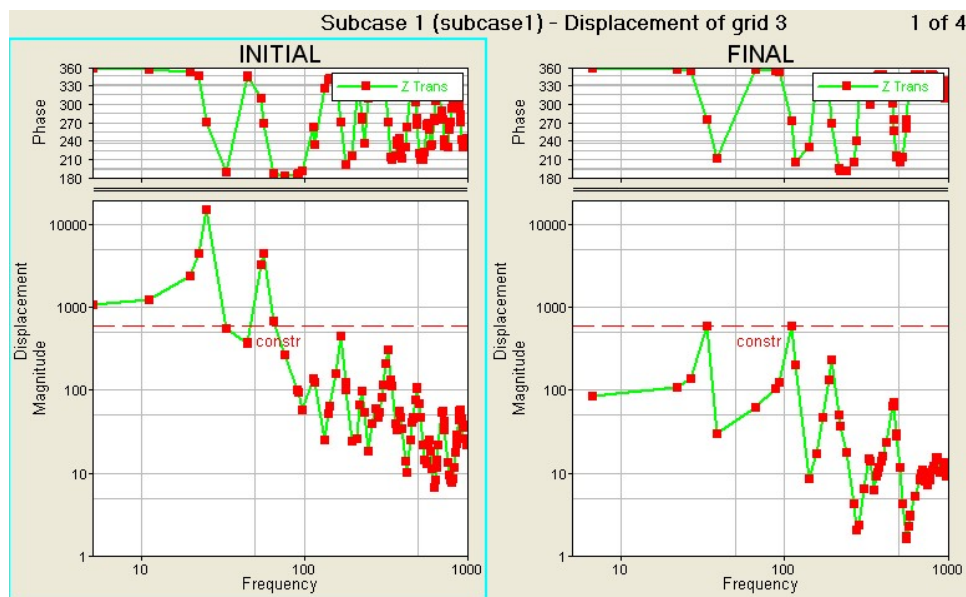


Figure 4. Frf Response For Initial And Final Design



5.2. Comparing the Results

The goal of the optimization is to minimize the size of the rectangular plate, the constraint condition is that the displacement of the peak is less than 600mm, the design variables are the density value of each unit of the design space. OptiStruct output file containing specific information on the file setup, the setup of your optimization problem, estimates for the amount of RAM and disk space required for the run, information for each optimization iteration, and compute time information.

From the Final-Chart can be seen that the optimized displacement peak is under the constraint curve, and it meets the design requirements.

Optimization of the frequency response curve control shown as is shown in figure 4.

6. CONCLUSIONS

Rectangular plate structure analysis based on the frequency response of the modal method has been performed in this paper, the material distribution ISO-Plots and phase of the complex displacement results were obtained by analyzing the following conclusions:

(1). Topology optimization design can overcome the blindness in the traditional design, on the one hand, to reduce the workload of the modeling, on the other hand improved or greatly reduce the quality of the structure on the basis of maintaining the structural performance.

(2). Topology optimization can provide structural engineering conceptual optimized design methodology to shorten the design and development cycle, improve part quality, cost savings, thereby enhancing the competitiveness of enterprises.

(3). Optimization results show that the materials meet the design requirements of the optimal distribution, reflected the topological optimization method in the mechanical parts in the process of initial design application value.

(4). Use Hyperworks of model simulation analysis can greatly reduce costly physical prototype manufacturing and test times, improve the design quality of parts and shorten the development cycle, make the research conclusion is more close to the actual situation of working device.

(5). The structural topology optimization in parts structure design of the initial stage for the designer to provide a conceptual design, the structural layout in the optimal scheme, therefore,

and size optimization and shape optimization, compared to obtain greater economic benefits.

(6). Frequency response analysis can more directly see system in broadband incentive, which aroused resonance frequency place. Combining the results of modal analysis, we can get a more profound understanding of the dynamic behavior of the system.

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