Workshop - Responses in Design Model

AN MSC NASTRAN SOL 200 TUTORIAL
Responses in Design Model

Below are examples of responses:

- The stress of a beam
- The displacement at a node
- The weight of a structure

During an optimization, each design cycle typically produces an Improved Design. See the image to the right.

A Structural Analysis is performed on the Improved Design and a new set of outputs or Responses, such as displacements, stresses, etc., are generated.

Simplified workflow of MSC Nastran Optimization procedure
Responses in Design Model

The Responses at the end of each design cycle are reported in the .f06 file.

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The Responses App allows the upload of .f06 and displays the data from the Responses in Design Model section.

### Nastran SOL 200 Web App - Responses

<table>
<thead>
<tr>
<th>Design Cycle</th>
<th>Subcase</th>
<th>Label</th>
<th>Response Type</th>
<th>Normalized Constraint</th>
<th>Lower Bound</th>
<th>Value</th>
<th>Upper Bound</th>
<th>Normalized Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>INITIAL</td>
<td>0</td>
<td>r0</td>
<td>WEIGHT</td>
<td>N/A</td>
<td>4.8254E+03</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INITIAL</td>
<td>1</td>
<td>r2</td>
<td>STRESS</td>
<td>N/A</td>
<td>1.3530E+04</td>
<td>2.0000E+04</td>
<td>-3.2350E-01**</td>
<td></td>
</tr>
<tr>
<td>INITIAL</td>
<td>1</td>
<td>r2</td>
<td>STRESS</td>
<td>-3.9351E-01</td>
<td>-1.5000E+04</td>
<td>-9.0973E+03</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>INITIAL</td>
<td>2</td>
<td>r2</td>
<td>STRESS</td>
<td>-3.9351E-01</td>
<td>-1.5000E+04</td>
<td>-9.0973E+03</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>INITIAL</td>
<td>2</td>
<td>r2</td>
<td>STRESS</td>
<td>N/A</td>
<td>1.3530E+04</td>
<td>2.0000E+04</td>
<td>-3.2350E-01**</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>r0</td>
<td>WEIGHT</td>
<td>N/A</td>
<td>3.0136E+00</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>r2</td>
<td>STRESS</td>
<td>N/A</td>
<td>1.9833E+04</td>
<td>2.0000E+04</td>
<td>-5.8502E-03**</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>r2</td>
<td>STRESS</td>
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<td>-1.5000E+04</td>
<td>-1.1901E+04</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>r2</td>
<td>STRESS</td>
<td>-2.0660E-01</td>
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<td>-5.8502E-03**</td>
<td></td>
</tr>
</tbody>
</table>

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Optimization Problem Statement

Design Variables

- x1: T of PSHELL 1
- x2: T of PSHELL 2
- x3: T of PSHELL 3
- x4: T of PSHELL 4
- x5: T of PSHELL 5
- x6: T of PSHELL 6
- x7: T of PSHELL 7
- x8: T of PSHELL 8
- x9: T of PSHELL 9
- x10: T of PSHELL 10

0.01 < xi < 1.0

Design Objective

S0: Minimize the root sum of squares for displacement magnitudes at node 1110 for forcing frequencies 20Hz - 200 Hz

\[ \min \Phi = \sqrt{\sum_{i=20}^{200} (u_{1110}^i)^2} \]

Design Constraints

- r1: Volume
  
  
  \[ 7.99 < r1 < 8.01 \]

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- Nastran SOL 200 training
- Nastran SOL 200 questions
- Structural optimization questions
- Access to the MSC Nastran SOL 200 Web App

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Before Starting

1. Ensure the Downloads directory is empty in order to prevent confusion with other files.

- Throughout this workshop, you will be working with multiple file types and directories such as:
  - .bdf/.dat
  - nastran_working_directory
  - .f06, .log, .pch, .h5, etc.
- To minimize confusion with files and folders, it is encouraged to start with a clean directory.
Go to the User’s Guide

1. Click on the indicated link

• The necessary BDF files for this tutorial are available in the Tutorials section of the User’s Guide.
Obtain Starting Files

1. Find the indicated example
2. Click Link
3. The starting file has been downloaded

- When starting the procedure, all the necessary BDF files must be collected together.
Obtain Starting Files

1. Right click on the zip file
2. Select Extract All...
3. Click Extract
4. The starting files are now available in a folder

- This example is using a previously created design model. The design model is a model that has been converted to SOL 200 and contains bulk data entries describing the optimization problem statement, e.g. variables, objective and constraints.
MSC Nastran SOL 200 Web App

Select an optimization type to begin

The web app also features the HDF5 Explorer, a web application to extract results from the H5 file type.

MSC Nastran can perform many optimization types. The MSC Nastran SOL 200 Web App includes dedicated web apps for the following:

- Size and Topometry Optimization
- Topology Optimization
- Global Optimization
- Multi Model Optimization

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Open the Responses App

1. Click Results.
2. Click Responses (.f06).

The Results section contains links to numerous other web applications designed for specific applications. For example, if sensitivity analysis is performed, the Sensitivities App can display the results.

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Upload .f06

A new page is open to the Responses App.

1. Select the model .f06 file found in the folder.
2. Click Upload.
3. The responses found in the .f06 file are shown in the table.

- Once the F06 file is uploaded, the responses of each design cycle are available in the table. The table can be sorted and filtered.
- In the F06 file and at each design cycle, there is a section titled "RESPONSES IN DESIGN MODEL." The responses from this section are the ones in the table shown in the Responses App.
Upload .f06

Before continuing, consider the following.

1. A section is found titled “DESIGN CONSTRAINTS ON RESPONSES.” The reader may be tempted to consider the indicated value as the actual value of the constraint. This value is NOT the actual value of the constraint. The value shown is the normalized constraint for either the lower or upper bound of the constraint.

2. The actual value of the constraint or other responses is reported in the section RESPONSES IN DESIGN MODEL.

   • As shown in the following pages, the Responses app organizes and displays this information in a single table.

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1. The Local Optimization Results App, a separate app, can be used to display the Normalized Constraints plot.

2. In the Response App, click Maximum constraint for each design cycle.

3. The table is updated. Each row represents a point in the Normalized Constraints plot.

- Each design cycle has a leading constraint that is near or is violated. The Normalized Constraints plot shows the normalized constraint value of the leading constraint for each design cycle.
- For a more complicate design model, the leading constraint may vary for each design cycle, e.g. the leading constraint of design cycle 1 may be a displacement, but for the next cycle stress is the leading constraint.

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Normalized Constraints

1. In this example, the Response Type of each row is Volume.
2. For the INITIAL design cycle, the volume is 8.
3. For Design Cycle 5, the volume is 7.99.

• The actual value of the response or constraint is reported in the Value column. Since the constraint has both a lower and upper bound, there are 2 normalized constraints, one for each bound.
Show More Information

1. Click Reset view.
2. Type 6 as shown, this will filter the table so only responses from Design Cycle 6 are shown.
3. Click the Show More Information button and additional columns will be shown, e.g. GRID ID., COMPONENT NO., FREQUENCY.
4. The 7th row is read as follows: For GRID or node 1110, the 3rd component (z direction), at forcing frequency 25Hz has a displacement value of .6948.

Note that a single label, e.g. s0, can be associated with multiple responses. For example, s0 represents 180 frequency displacement values, one for each forcing frequency and there are 180 forcing frequencies.

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Labels

1. Note that in the Size Web App, a separate web app, the objective was set to minimize S0 or the Root Sum of Squares for all the displacements of GRID or node 1110, 3rd component (z direction), across all the forcing frequencies.

2. The same label S0 is shown in the Responses App.

- The capitalization of the label matters in the web app. In the Size app, the label is S0, where the letter s is upper case. The Responses app displays s0, where the letter s is lower case. The RSS option was used for S0, so all the s0 values are used to compute the RSS value.
MSC Nastran computes the value of $S_0$ as follows:

1. For each forcing frequency, determine the corresponding displacement value. Each of these values are be labeled ‘$s_0$.’

2. Take all the displacements and compute the Root Sum of Squares (RSS). The RSS value is ‘$S_0$.’ Note the difference in capitalization. To view the $S_0$ value
   1. Click 10 in the pagination bar to display at most 10 rows.
   2. Navigate to page 19.
   3. The RSS value is reported as 11.558.

When looking through the table, the final RSS value for $S_0$ is found.
Labels

A plot of the displacement vs forcing frequencies and the corresponding RSS value is shown to better communicate the point made on the previous slide.

- A separate HDF5 Explorer that comes with the Nastran SOL 200 Web App is capable of creating the frequency response XY plots.

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Approximate Model or Structural Analysis

Each design cycle produces two sets of results:

- Results from the Approximate Model
- Results from the Structural Analysis.

The Responses App never reports responses from the Approximate Model.

A look at the .f06 file and for Design Cycle 3 shows two columns: INPUT VALUE and OUTPUT VALUE.

1. **INPUT VALUE** is the structural analysis value based on the design of the previous design cycle, in this case design cycle 2. This value is reported in the Responses App and is tagged as originating from design cycle 2.

2. **OUTPUT VALUE** is the approximate value from the current design cycle. This value is never reported in the Responses App.

Note that the INITIAL and FINAL design cycles only have one VALUE column. These values are reported as is by the Responses App.
Another Example

The title of this example is ‘Automated Structural Optimization of a Stiffened Plate with MSC Nastran SOL 200/Design Optimization’ and can be found in the Tutorials section of the User’s Guide.

1. Like before, download the solution files, extract the .f06 file, upload the file to the Responses App and click Maximum constraint for each design cycle.

2. Click on the Show More Information button.

3. In the Responses Web App, for r3 and for design cycle 3, the Improved Design has a von Mises stress of 25133 PSI for element 3 and is violating its upper bound of 25000 PSI.

4. In the Size Web App, for r3, the response type is STRESS, the component is 9 - von Mises of z1, and has an upper bound of 25000. This is similar to what is shown in the Size App. Note that ATTi is 1 which indicates r3 applies to any element associated to PSHELL ID 1.

- The label r3 when configured corresponds to the von Mises stress of any element associated with PSHELL 1. Since PSHELL 1 has 16 elements associated, r3 corresponds to 16 von Mises stress values.
- When viewing r3 in the Responses app, use the Show More Information button to display the ELEMENT ID column. This makes differentiating the responses simpler.

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Another Example

1. Note that r3 appears multiple times.

2. The element column reveals that r3 is associated with different elements. According to the ELEMENT ID column, elements 15 and 3 are associated with r3.

3. Each design cycle can have a different constraint that is controlling or the limiting factor in the design cycle. Below is a summary of these constraints. The Normalized Constraints plot is also shown.

1. INITIAL Design - The maximum stress of the beam cross section (Component 7) of element 34. Value: 20902 PSI. Constraint satisfied.
2. Design Cycle 1 - The displacement, z component, of node 10302 (not shown). Value: .0165 inches. Constraint violated.

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End of Tutorial