Workshop - Working with Multiple Subcases and Multi Discipline Optimization

AN MSC NASTRAN SOL 200 TUTORIAL

Questions? Email: christian@ the-engineering-lab.com

Optimization Problem Statement

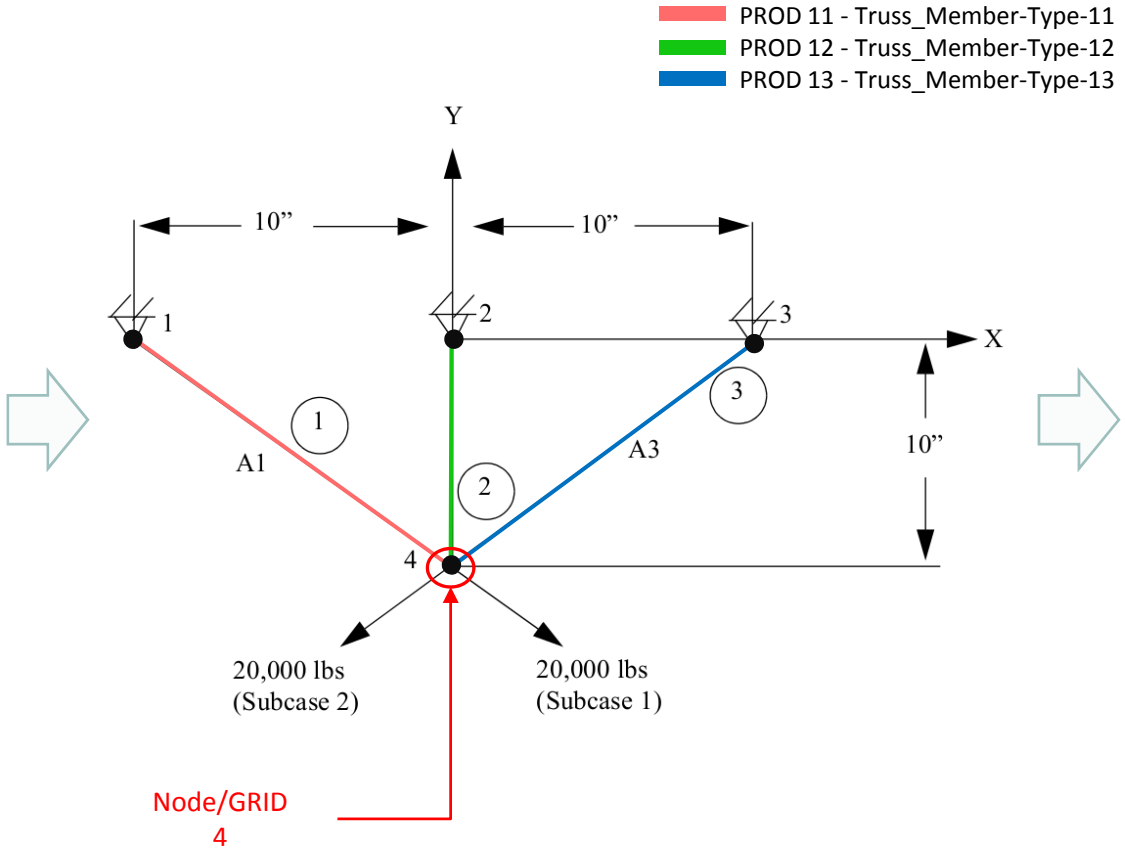
Design Variables

x1: A of PROD 11
x2: A of PROD 12
x3: A of PROD 13

.1 < x1, x2, x3 < 100.

Variable Link

x3 = x1



Design Objective

r0: Minimize weight

Design Constraints

r1: Axial stress of elements related to PROD 11, 12, 13

-15000 < r1 < 20000

r2: x and y component of displacement for node 4

-.2 < r2 < .2

r3: natural frequency of mode 1

80 Hz < r3

Optimization Problem Statement Subcase Assignment

This tutorials describes how to assign constraints across different subcases when the analysis types are different. This example deals with a multidiscipline optimization. Subcases 1 corresponds to a normal modes analysis. Subcases 2-20 correspond to statics subcases. Each subcase is assigned constraints.

	Status	Label	Response Type	Analysis Type	Description	Global Constraints	SUBCASE 1	SUBCASE 2	SUBCASE 3	SUBCASE 4	SUBCASE 5	SUBCASE 6	SUBCASE 7	SUBCASE 8	SUBCASE 9	SU
		Search	Search	Search	Search											
						Analysis Types →	Normal Modes	Statics	Statics	Statics	Statics	Statics	Statics	Statics	Statics	Sta
		r1	DISP	STATICS	T1, T2 component(s) of displacement at grid 4			☑	☑	☑	☑	☑	☑	☑	☑	
		r2	STRESS	STATICS	Stress, item code 2, of elements associated with PROD 11, 12, 13			☑	☑	☑	☑	☑	☑	☑	☑	
		r3	FREQ	MODES	Natural frequency of mode 1		☑									

Contact me

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

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Tutorial

SOL 200 Web App Capabilities

The Post-processor Web App and HDF5 Explorer are free to MSC Nastran users.

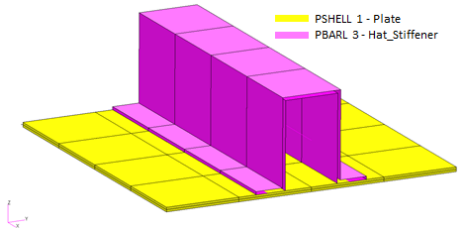
Compatibility

- Google Chrome, Mozilla Firefox or Microsoft Edge
- Windows and Red Hat Linux
- Installable on a company laptop, workstation or server. All data remains within your company.

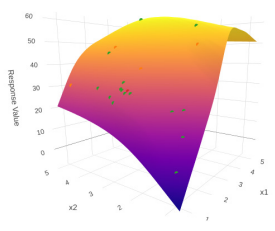
Benefits

- REAL TIME error detection. 200+ error validations.
- REALT TIME creation of bulk data entries.
- Web browser accessible
- Free Post-processor web apps
- +80 tutorials

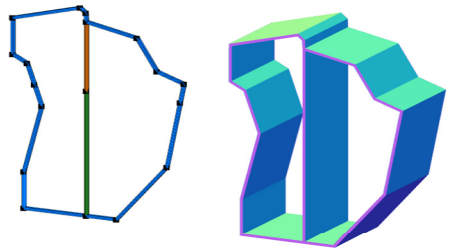
Web Apps



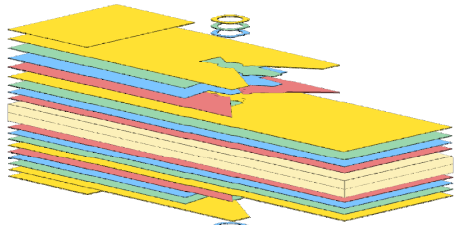
Web Apps for MSC Nastran SOL 200
Pre/post for MSC Nastran SOL 200. Support for size, topology, topometry, topography, multi-model optimization.



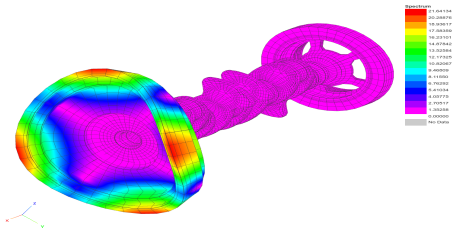
Machine Learning Web App
Bayesian Optimization for nonlinear response optimization (SOL 400)



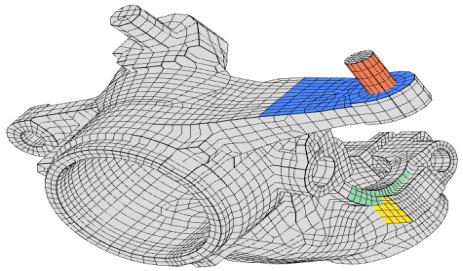
PBMSECT Web App
Generate PBMSECT and PBRSECT entries graphically



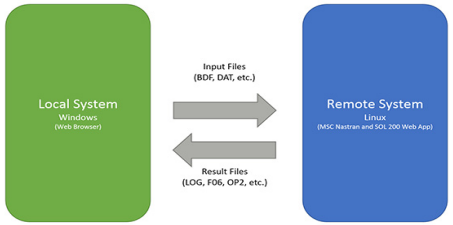
Ply Shape Optimization Web App
Optimize composite ply drop-off locations, and generate new PCOMPG entries



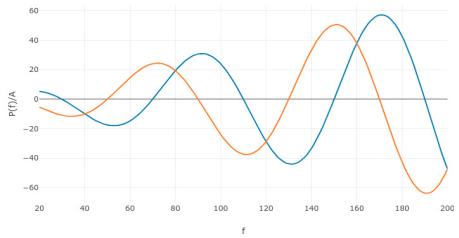
Post-processor Web App
View MSC Nastran results in a web browser on Windows and Linux



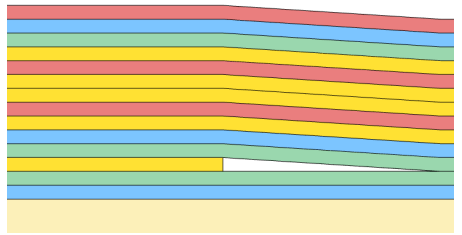
Shape Optimization Web App
Use a web application to configure and perform shape optimization.



Remote Execution Web App
Run MSC Nastran jobs on remote Linux or Windows systems available on the local network



Dynamic Loads Web App
Generate RLOAD1, RLOAD2 and DLOAD entries graphically



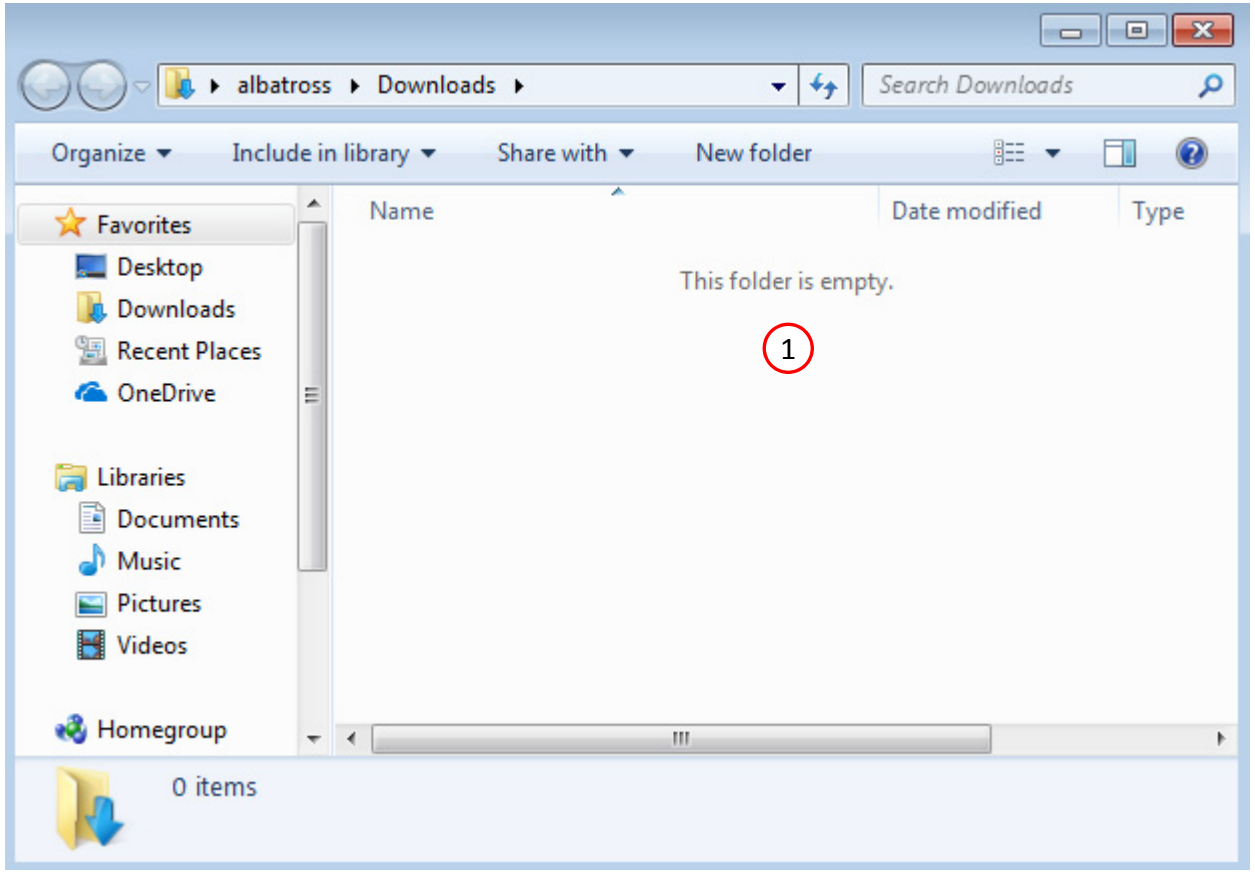
Stacking Sequence Web App
Optimize the stacking sequence of composite laminate plies

HDF5 Explorer Web App
Create graphs (XY plots) using data from the H5 file

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

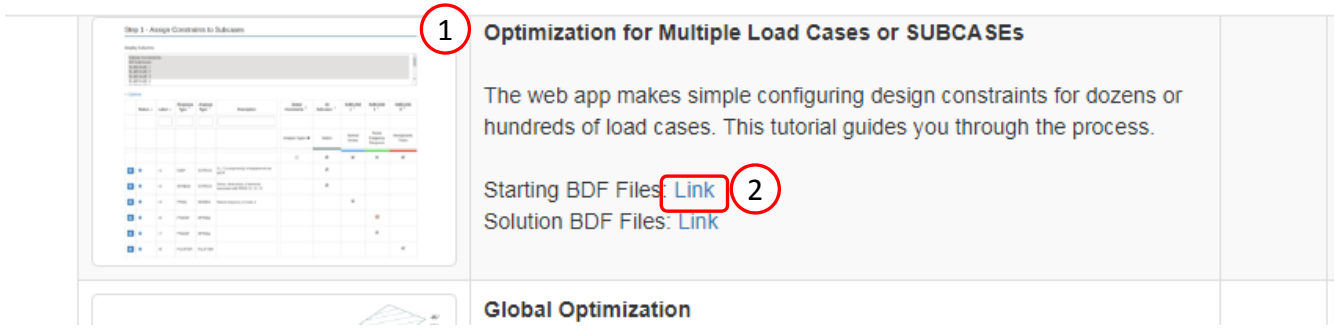
1. Click on the indicated link

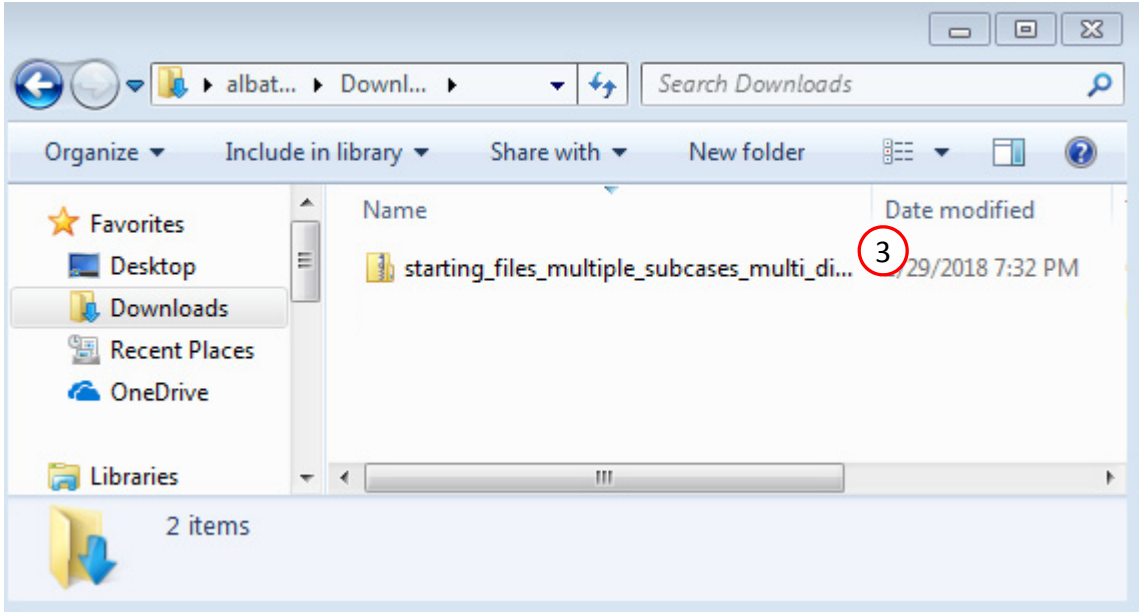
- The necessary BDF files for this tutorial are available in the Tutorials section of the User's Guide.

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.





Open the Correct Page

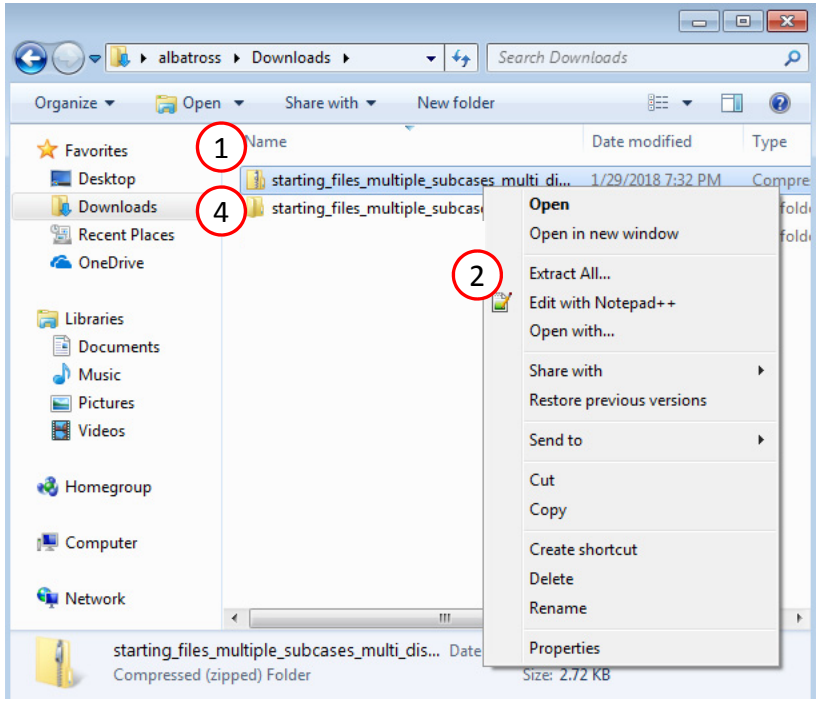
1. Click on the indicated link

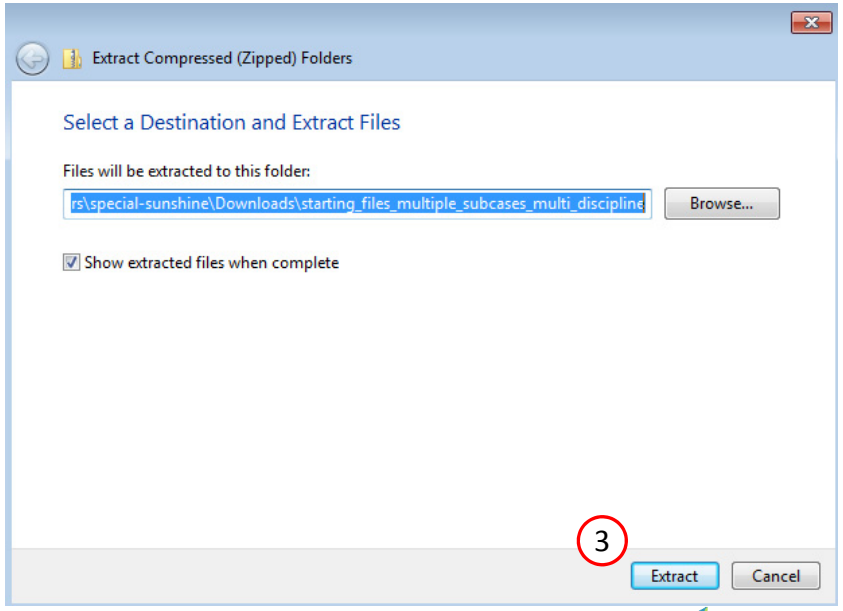
- MSC Nastran can perform many optimization types. The SOL 200 Web App includes dedicated web apps for the following:
  - Optimization for SOL 200 (Size, Topology, Topometry, Topography, Local Optimization, Sensitivity Analysis and Global Optimization)
  - Multi Model Optimization
  - Machine Learning
- The web app also features the HDF5 Explorer, a web application to extract results from the H5 file type.

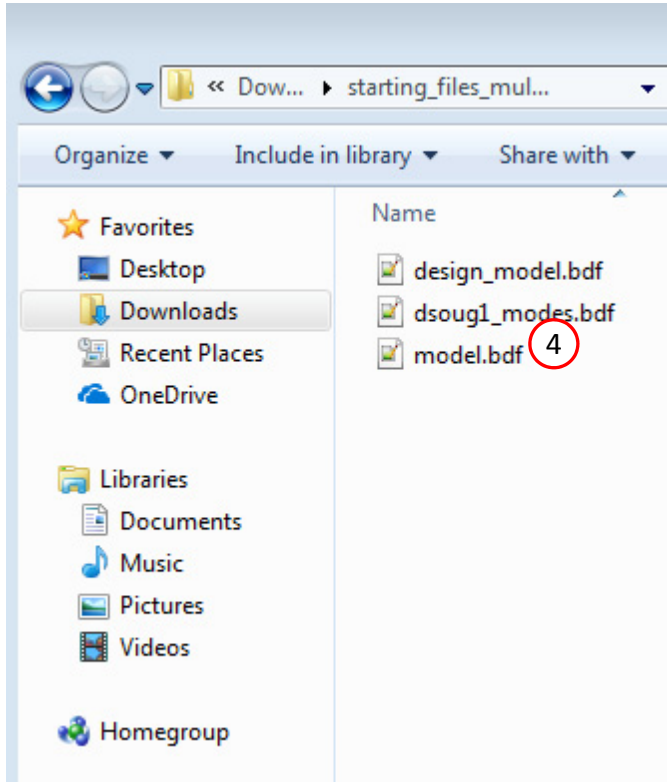
Obtain Starting Files

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.







Merge the BDF files

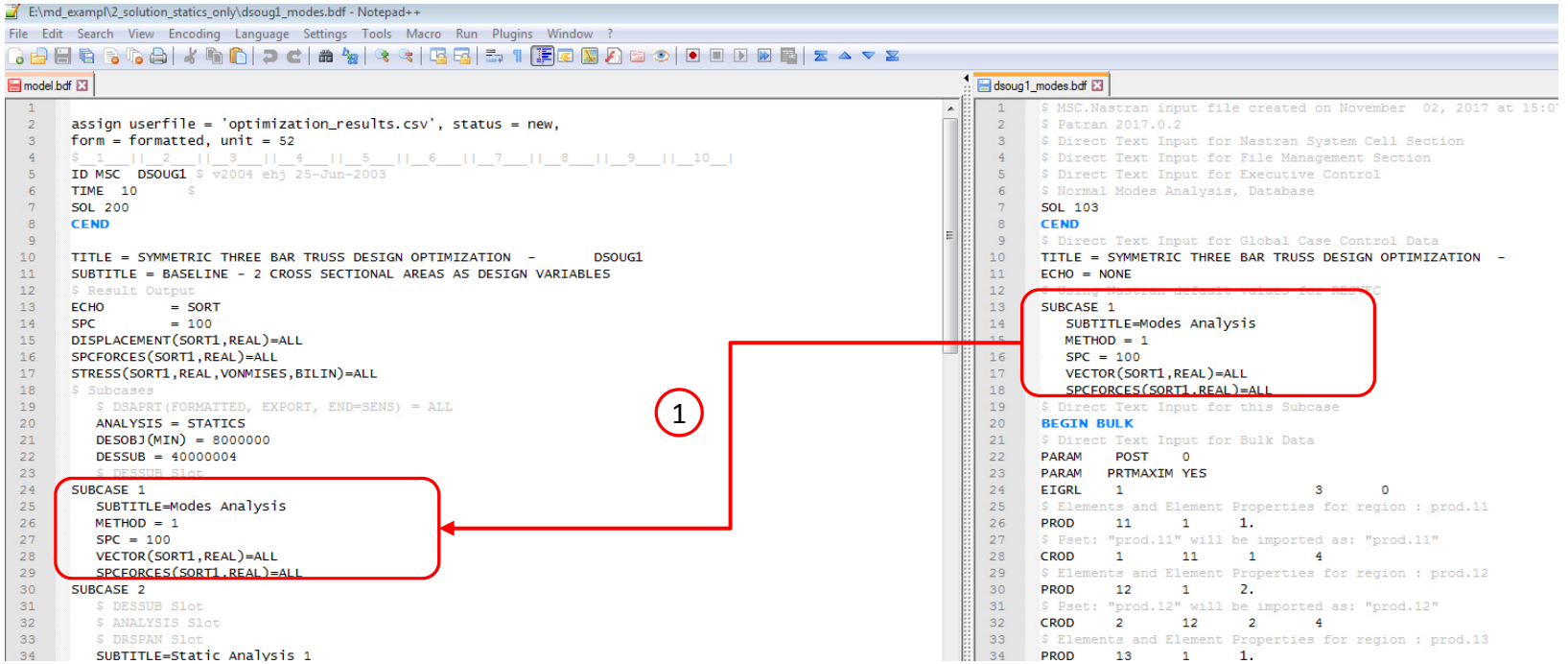
Two sets of bulk data files (BDF) have been provided.

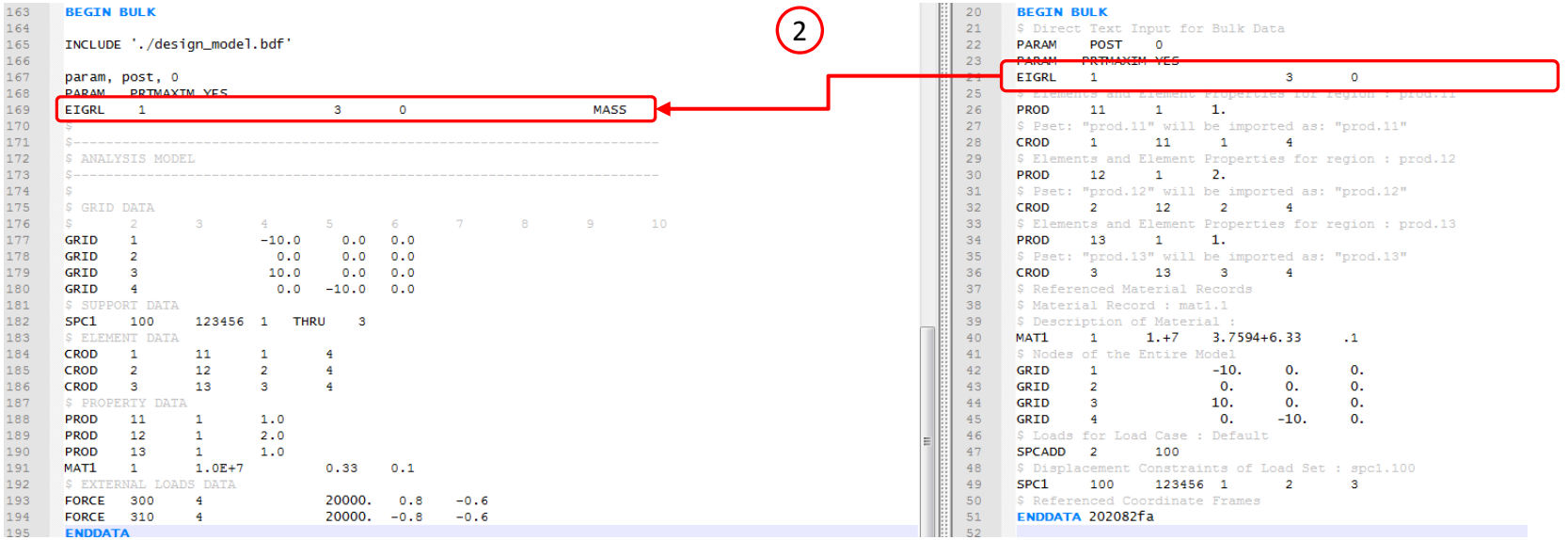
- Set 1: model.bdf and design_model.bdf
- Set 2: dsoug1_modes.bdf

The Set 1 files are configured to perform only a static analysis optimization and contains 19 load cases. The Set 2 file is the same Finite Element Model, but configured to perform an eigenvalue or normal modes analysis. The procedure below merges information from Set 2 to Set 1. Afterwards, the files of Set 1 can be modified to perform both a static and normal modes analysis for 20 subcases.

1. Open *dsoug1_modes.bdf*. Take SUBCASE 1 and move it to *model.bdf*.
2. Take the line with EIGRL at the beginning and move it to *model.bdf*
3. Save *model.bdf*

- There are 2 methods to perform multidisciplinary optimization:
  - Method 1 - Merge the necessary bulk data files and use ANALYSIS in each SUBCASE, e.g. ANALYSIS=STATICS, ANALYSIS=MODES. This method is used for this tutorial.
  - Method 2 – Use the Multi Model Optimization capability. This does not require that manual merging of files as shown on this page.

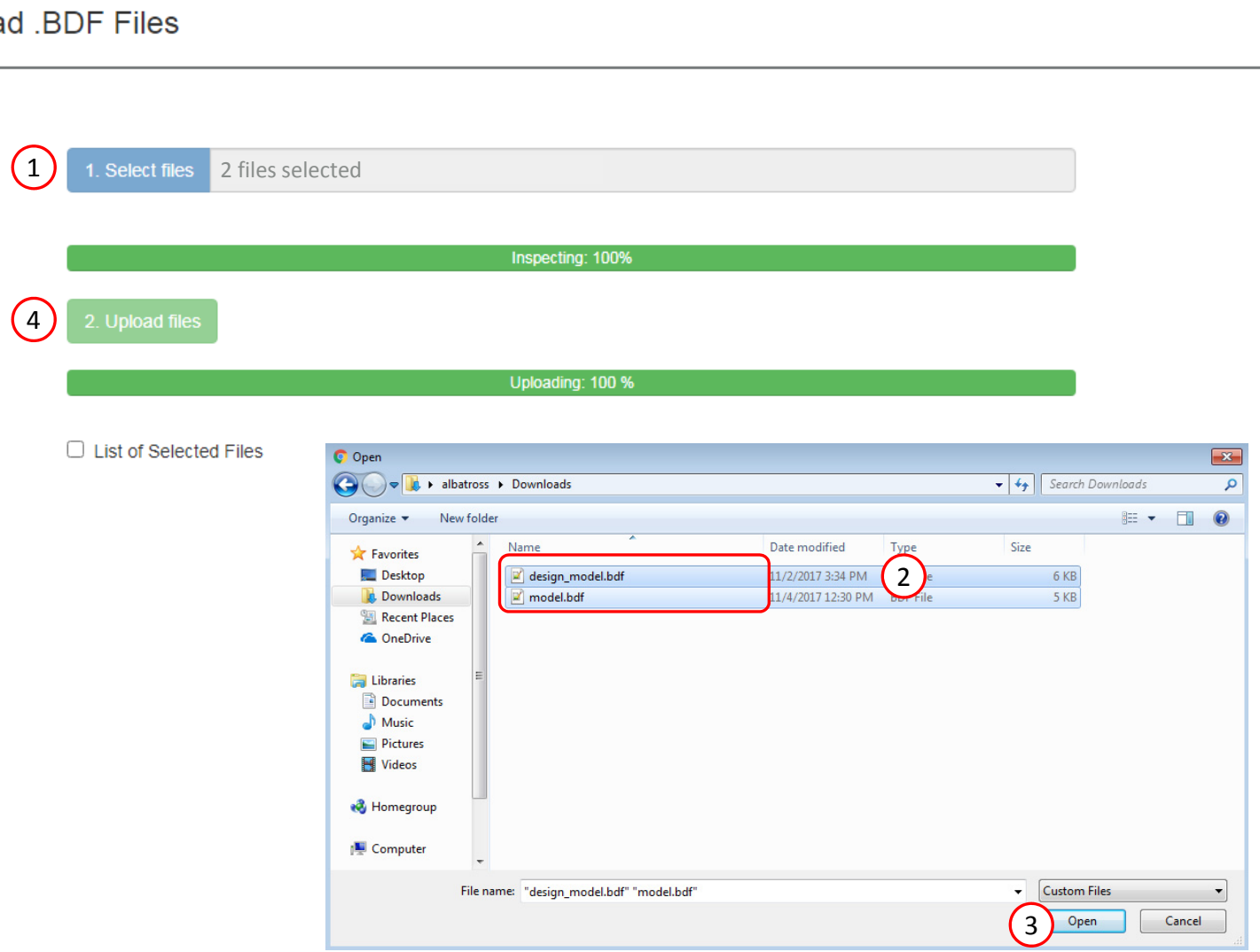




Upload BDF Files

1. Click 1. Select Files
2. Select these two files:
   - model.bdf
   - design_model.bdf
3. Click Open
4. Click Upload Files

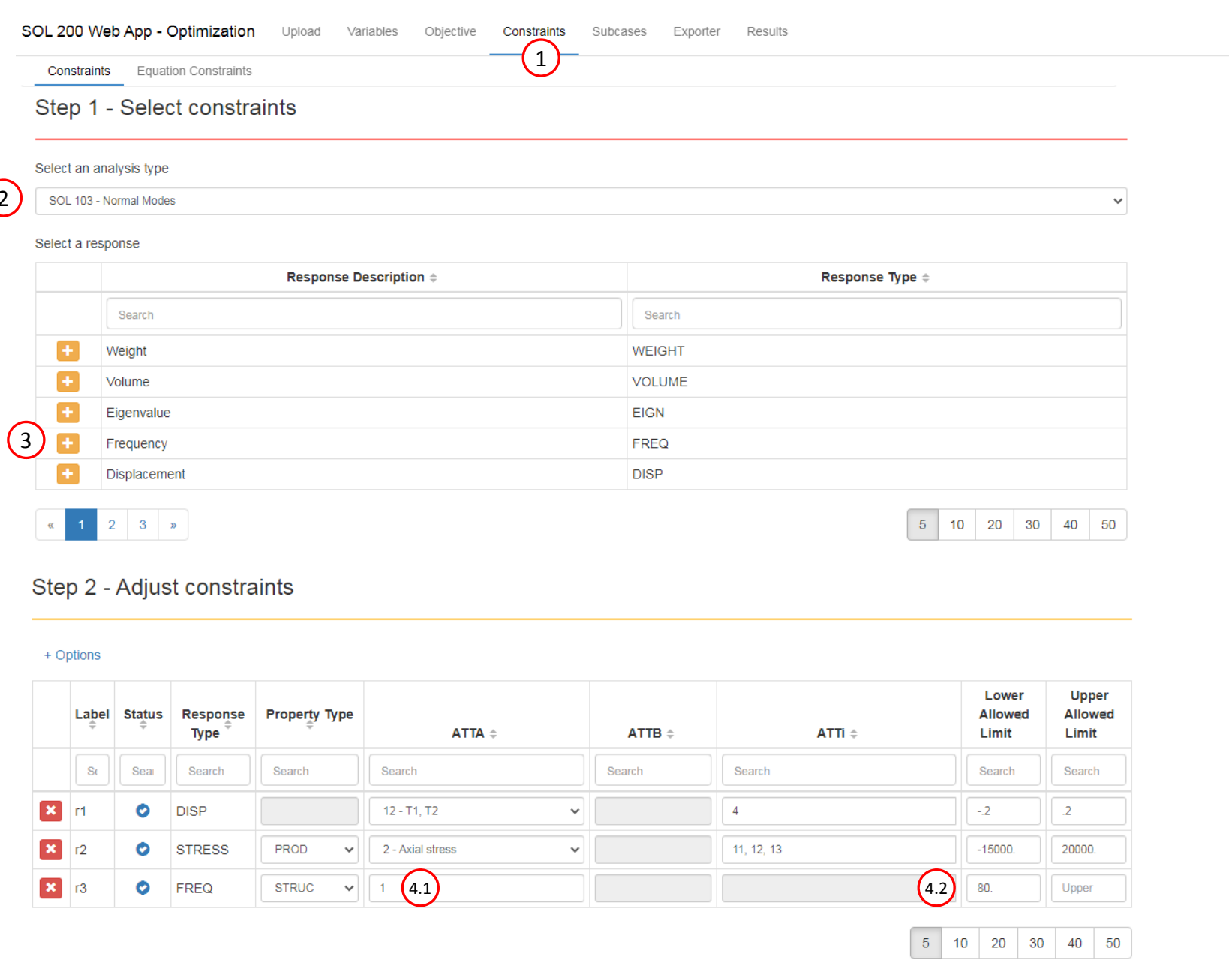
- The process starts by uploading all the necessary BDF files. The BDF files can be files of your own or files found in the Tutorials section of the User's Guide.



Create Design Constraints

1. Click Constraints
2. Set the analysis type to Normal Modes
3. Click the plus (+) icon for Frequency
4. Configure the following for constraint r1
    1. ATTA: 1 (mode 1)
    2. Lower Allowed Limit: 80. (80. Hz)

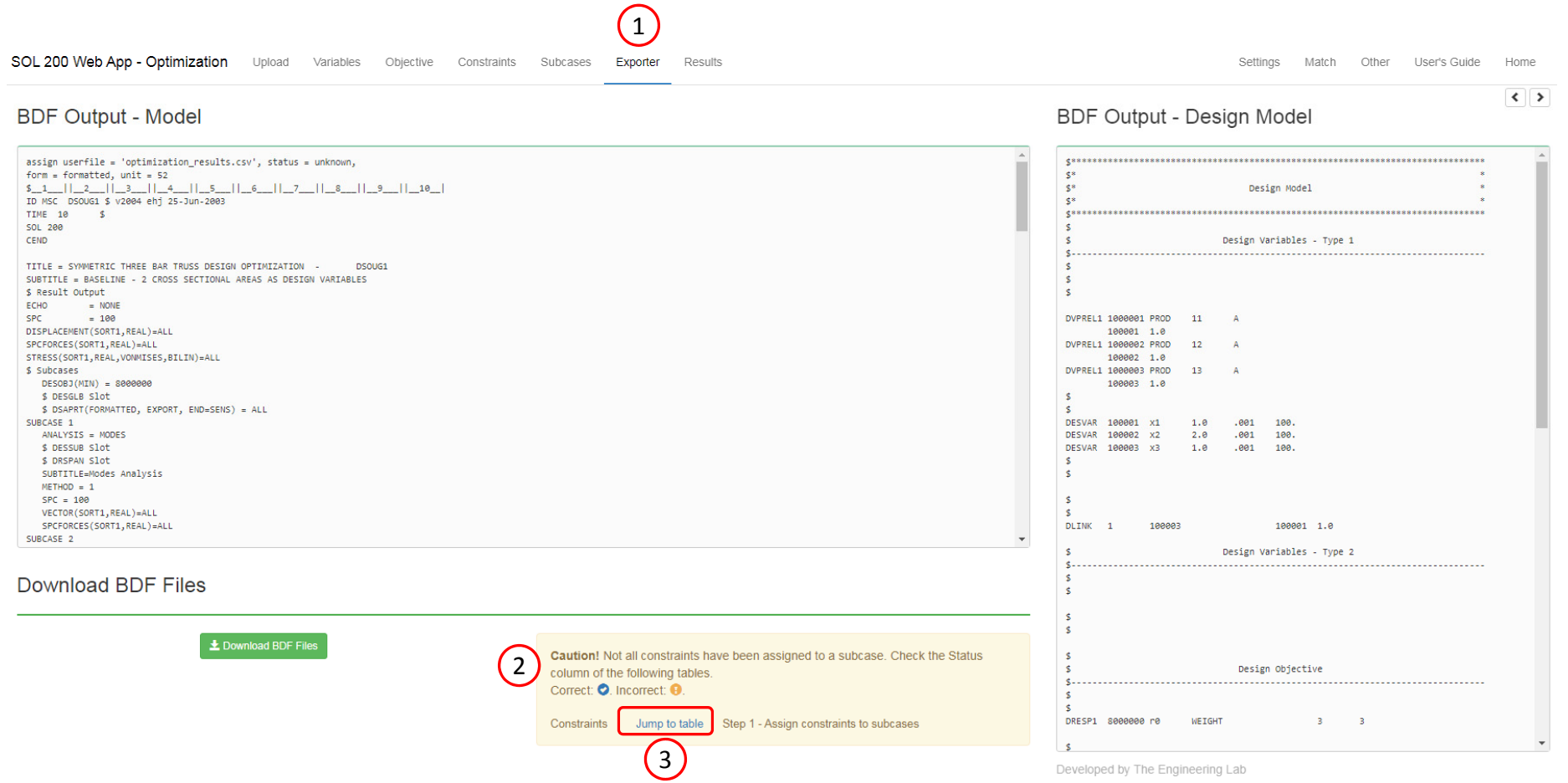
- Part of the design model has already been created. The variables, objective and constraints for a statics optimization have been configured. On this page, a new constraint for the 1st natural frequency is created. The goal is to perform both a statics and modes optimization.



Export New BDF Files

1. Click on Exporter
2. Note that a cautionary message is presented.
3. Click Jump To Table

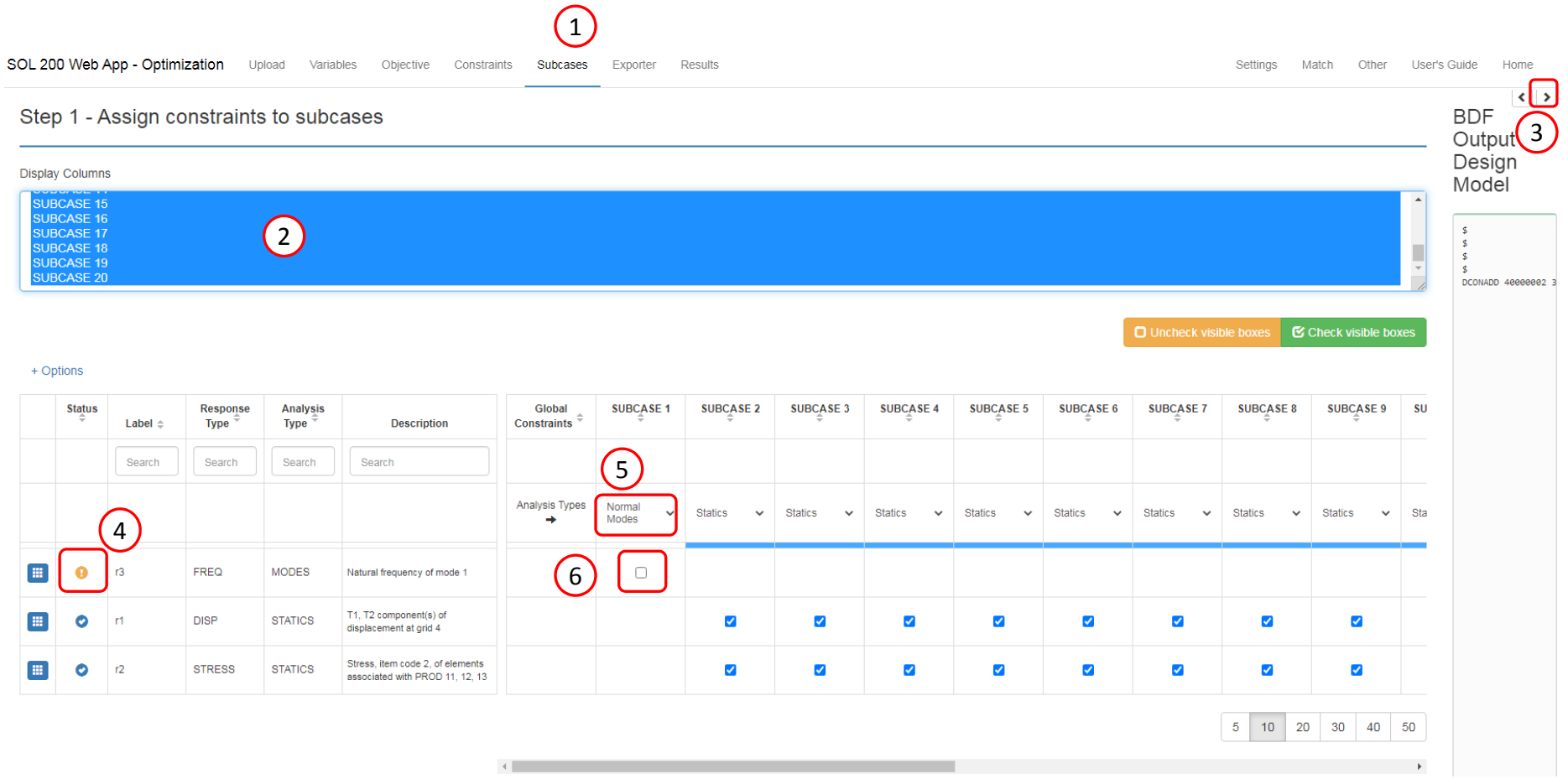
- The natural frequency constraint was just created, but a message appears indicating that the constraint was not assigned to a SUBCASE.



Assign Constraints to Load Cases (SUBCASES)

1. Click Subcases
2. Select each option in the select box (Hold down the Shift key on the keyboard and use the mouse to select multiple options)
3. Click the Right Arrow to expand the width of the table
4. Note that the r3 constraint for natural frequency has a yellow status icon, indicating that the constraint is not assigned to any subcases
5. Change the analysis type of column SUBCASE 1 to Normal Modes
6. Mark the checkbox

- A change from a yellow to blue status (=>) means the constraint is assigned to at least one column
- r3 or the natural frequency constraint is applied to SUBCASE 1



Assign Constraints to Load Cases (SUBCASES)

1. Click 2 times the Label column to sort the Label column in descending order

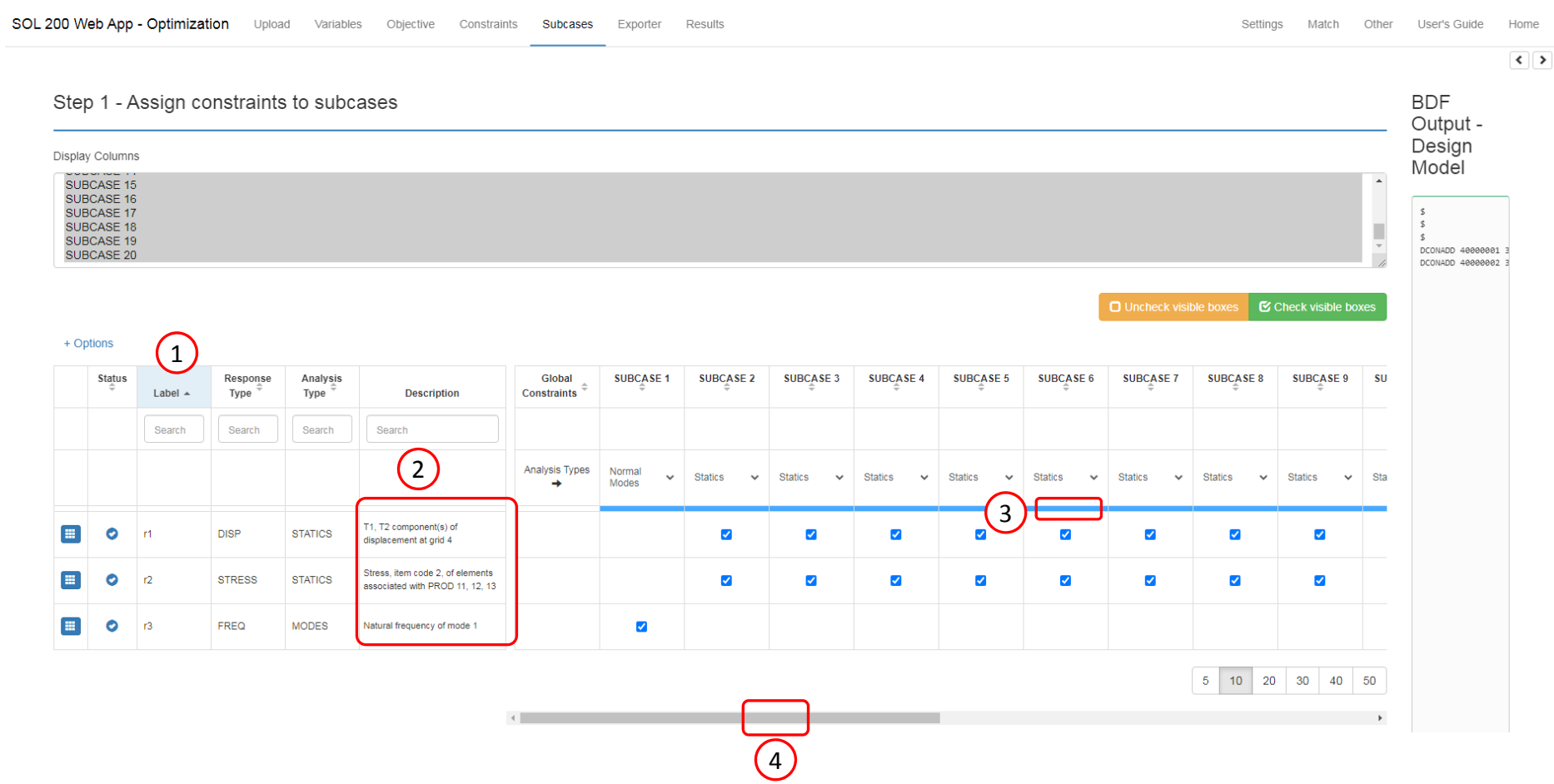
Other information

2. Descriptions of each constraint are available and can be used to confirm the constraint has been properly configured
3. The blue bar indicates at least one constraint has been applied to the column/SUBCASE
4. The horizontal scroll bar can be used to navigate across multiple SUBCASEs

- When hundreds of SUBCASEs must be configured, the following options expedite the process:

Uncheck visible boxes

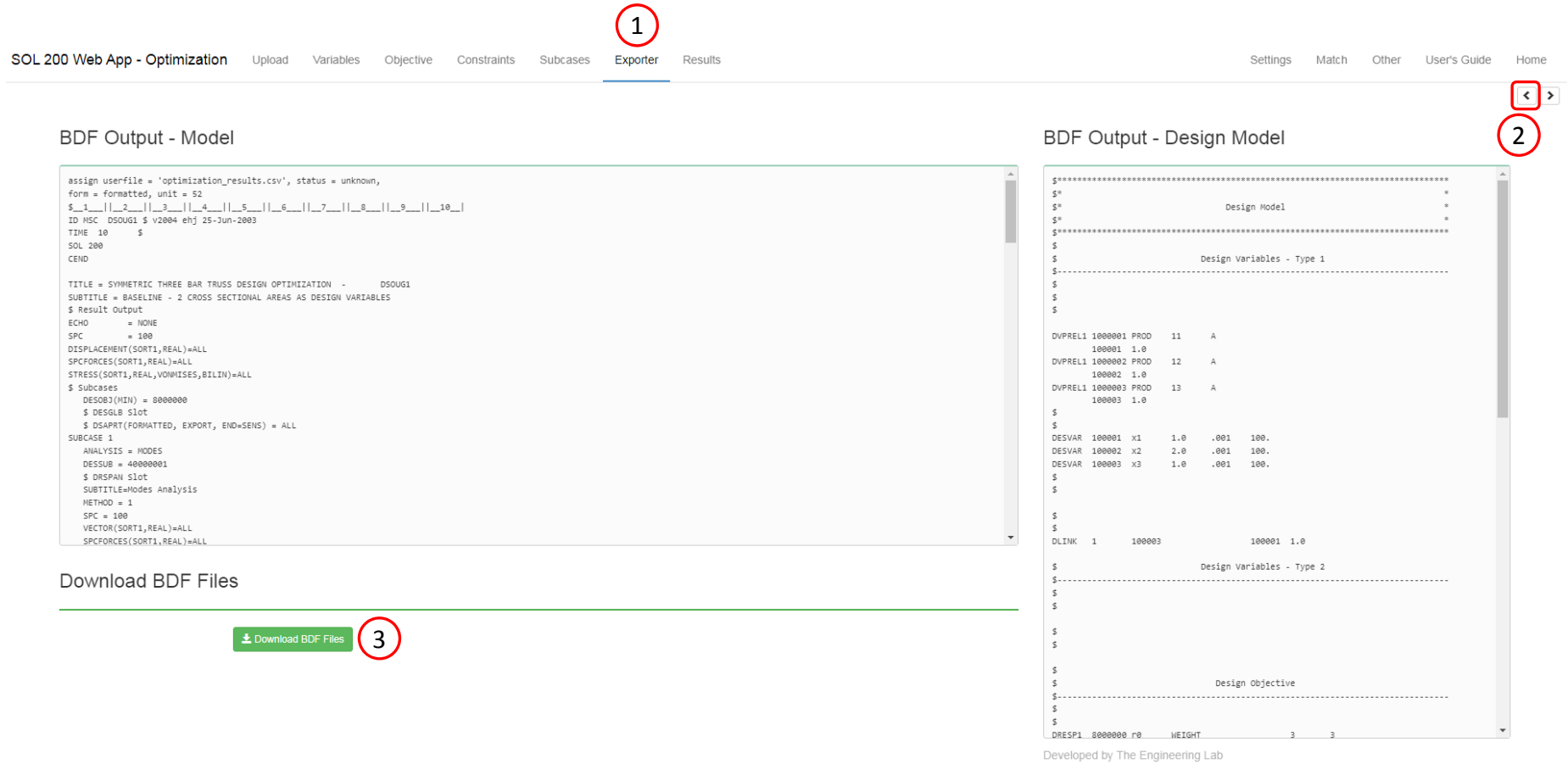
Check visible boxes



Export New BDF Files

1. Click on Exporter
2. Click the Left Arrow to expand the width of the section BDF Output – Design Model
3. Click on Download BDF Files

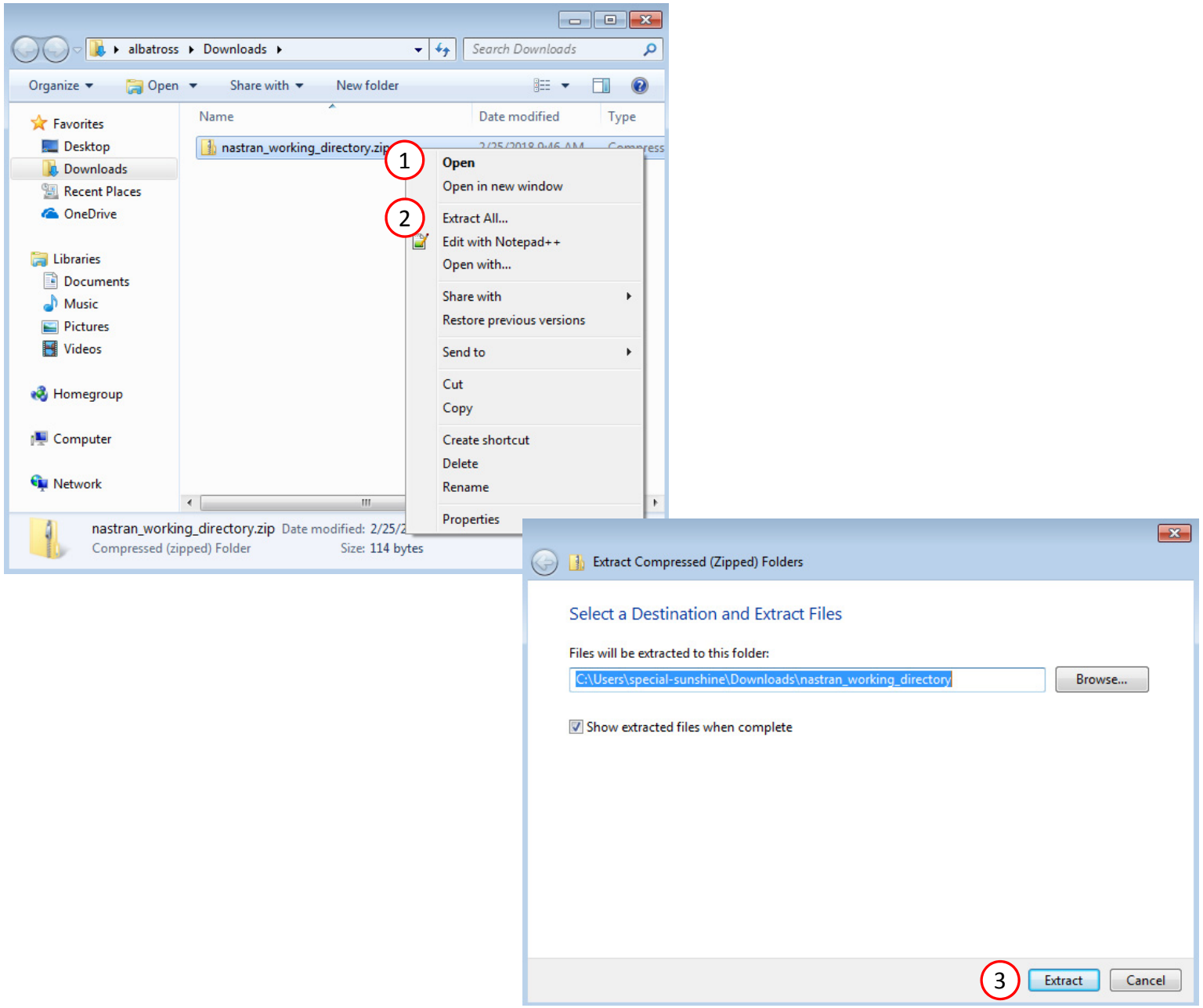
- When the download button is clicked a new file named “nastran_working_directory” is downloaded. If the file already exists in your local folder, the folder name is appended with a number, e.g. “nastran_working_directory (1).zip”



Perform the Optimization with Nastran SOL 200

1. A new .zip file has been downloaded
2. Right click on the file
3. Click Extract All
4. Click Extract on the following window

- Always extract the contents of the ZIP file to a new, empty folder.



Perform the Optimization with Nastran SOL 200

1. Inside of the new folder, double click on Start MSC Nastran
2. Click Open, Run or Allow Access on any subsequent windows
3. MSC Nastran will now start

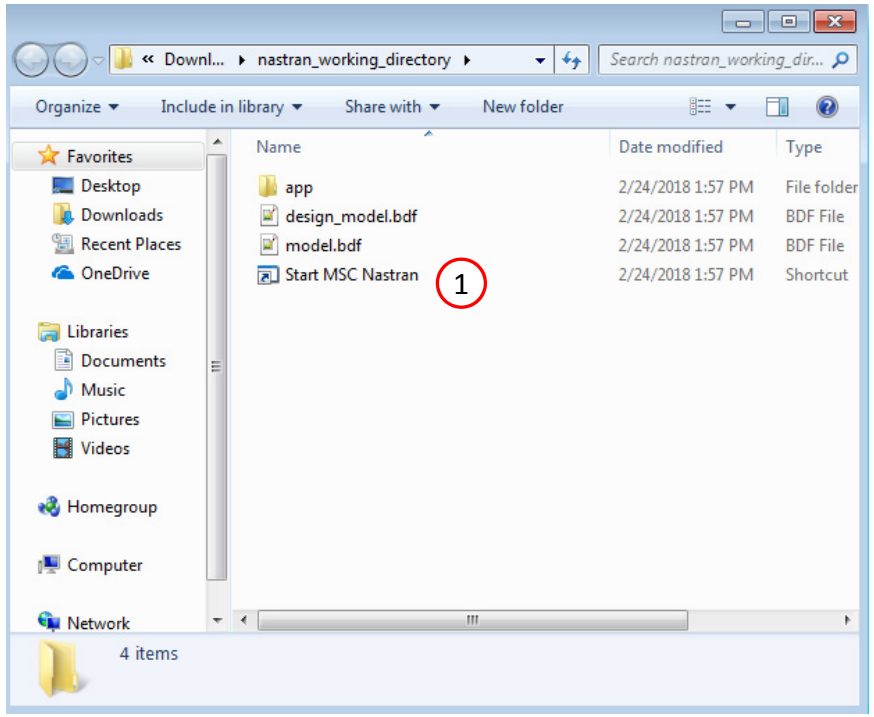
- After a successful optimization, the results will be automatically displayed as long as the following files are present: BDF, F06 and LOG.
- One can run the Nastran job on a remote machine as follows:
  1) Copy the BDF files and the INCLUDE files to a remote machine. 2) Run the MSC Nastran job on the remote machine. 3) After completion, copy the BDF, F06, LOG, H5 files to the local machine. 4) Click "Start MSC Nastran" to display the results.

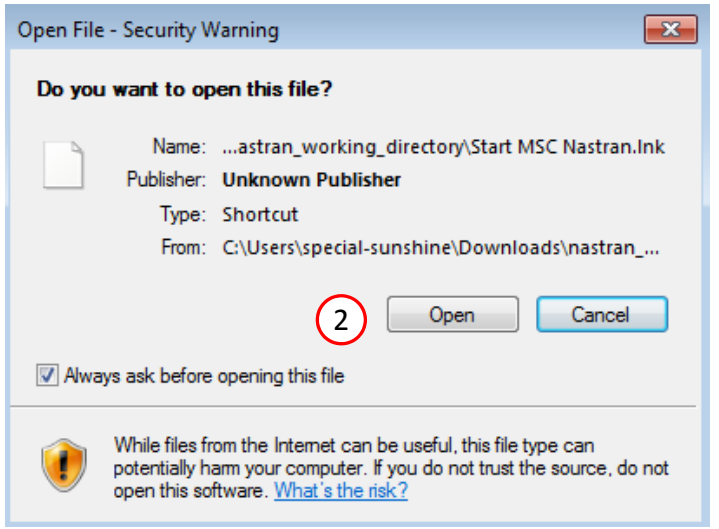
Using Linux?

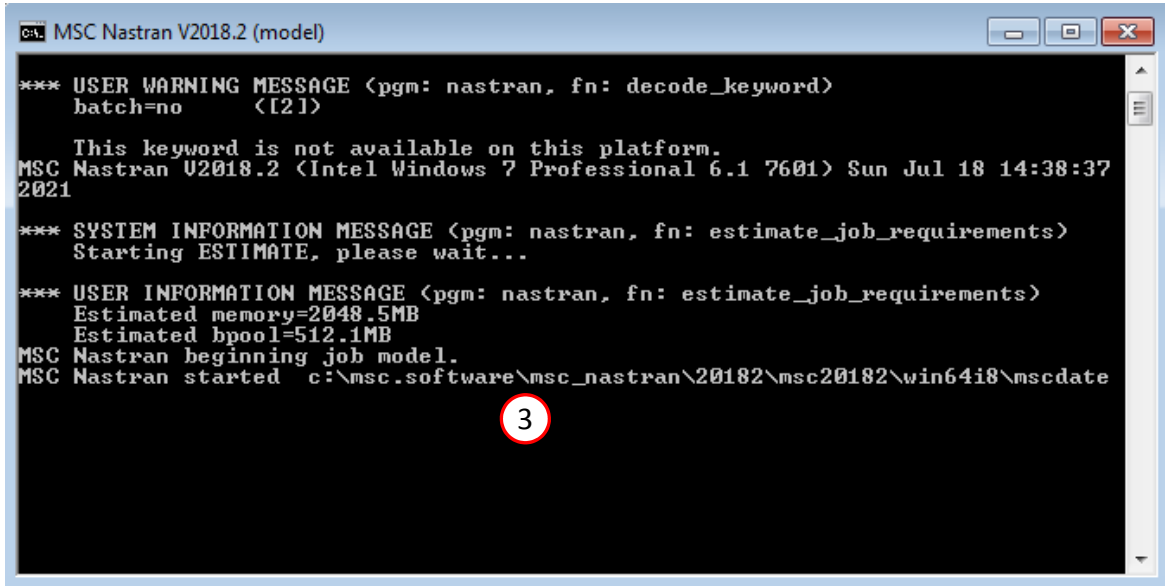
Follow these instructions:
1) Open Terminal
2) Navigate to the nastran_working_directory
cd ./nastran_working_directory
3) Use this command to start the process
./Start_MSC_Nastran.sh

In some instances, execute permission must be granted to the directory. Use this command. This command assumes you are one folder level up.

sudo chmod -R u+x ./nastran_working_directory







Status

1. While MSC Nastran is running, a status page will show the current state of MSC Nastran

- The status of the MSC Nastran job is reported on the Status page. Note that Windows 7 users will experience a delay in the status updates. All other users of Windows 10 and Red Hat Linux will see immediate status updates.

SOL 200 Web App - Status

Python MSC Nastran

Status

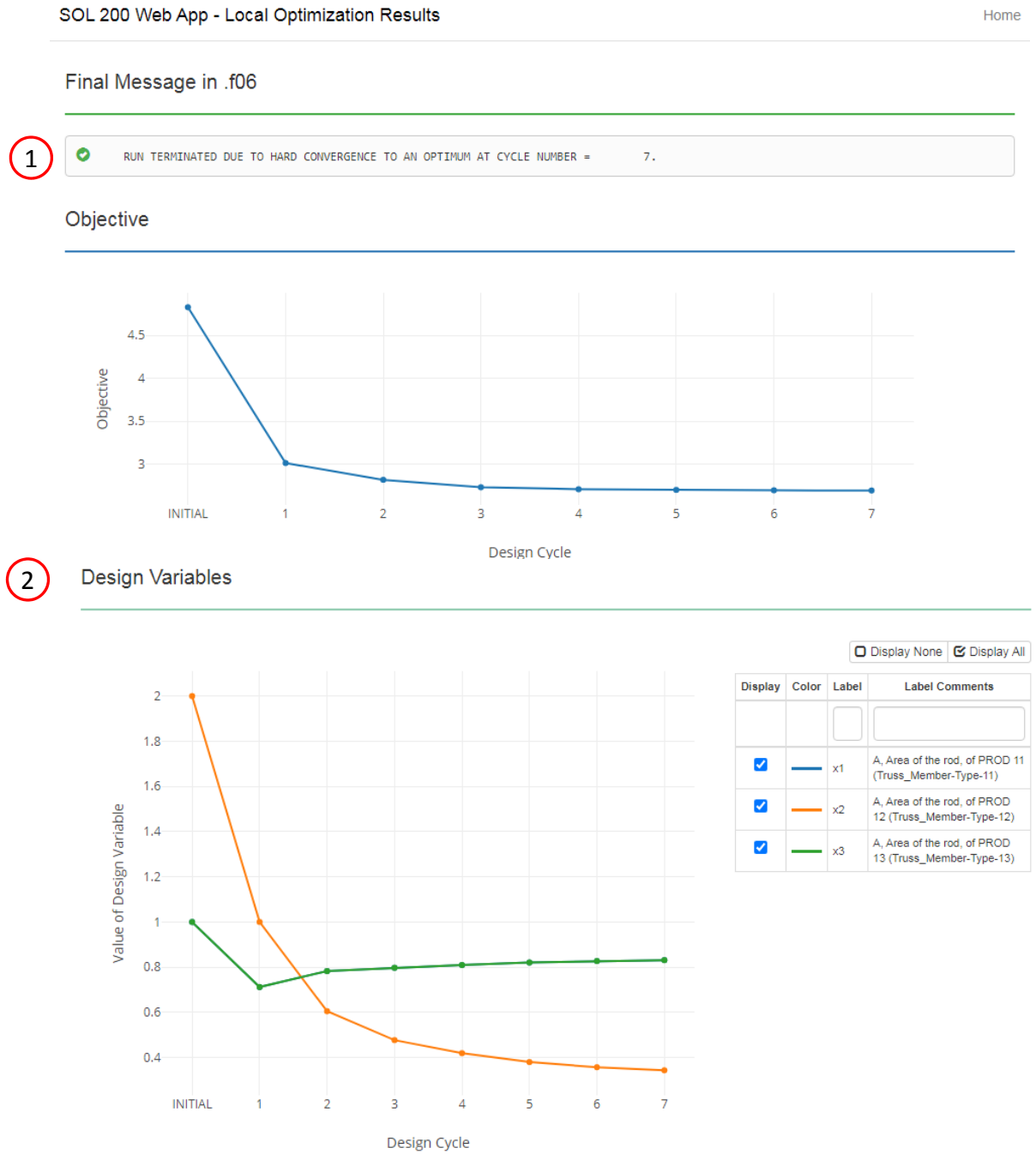
Name	Status of Job	Design Cycle	RUN TERMINATED DUE TO
model.bdf	Running	None	

Review Optimization Results

After MSC Nastran is finished, the results will be automatically uploaded.

1. Ensure the messages shown have green checkmarks. This is indication of success. Any red icons indicate challenges.
2. The final value of objective, normalized constraints (not shown) and design variables can be reviewed.

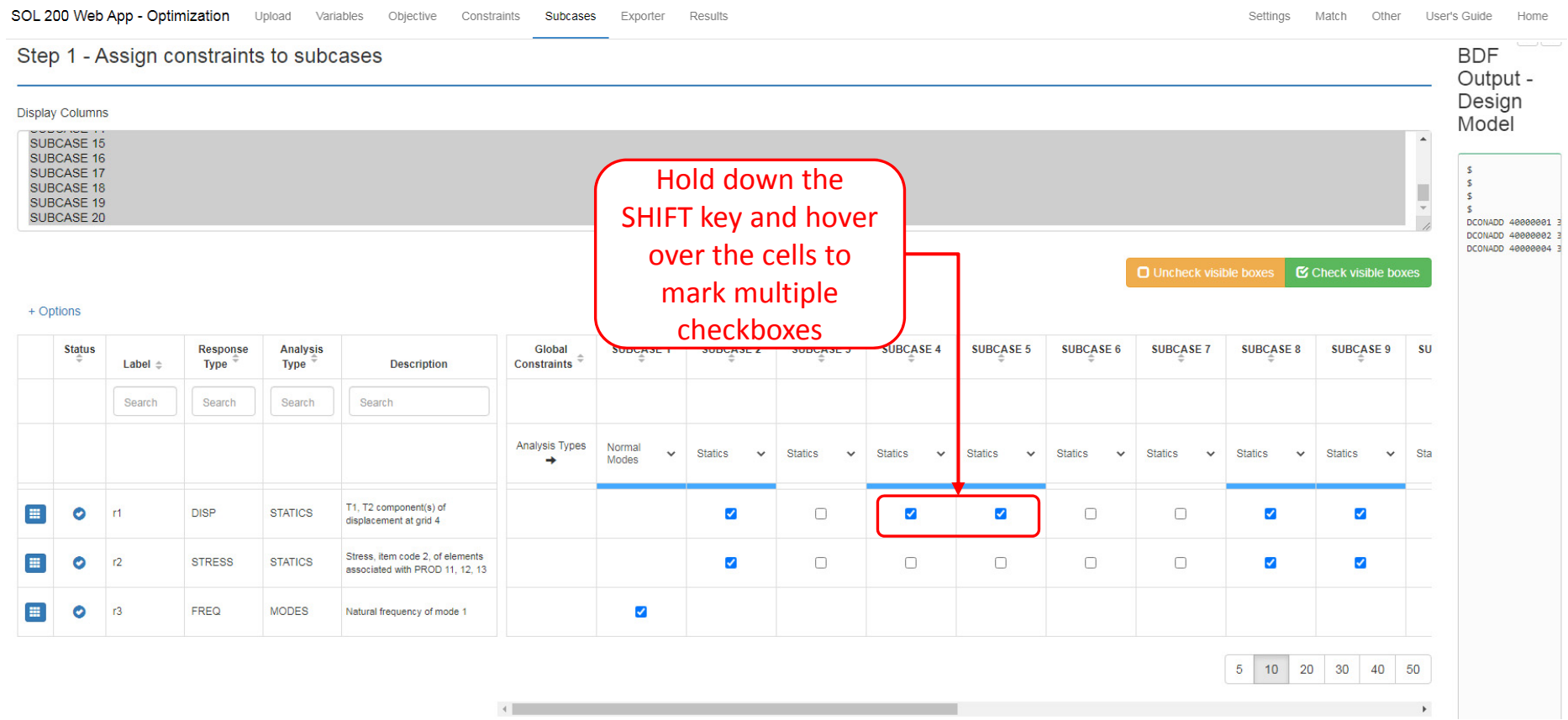
- The results shown are the outcome of a multidisciplinary optimization for both statics and modes.



Extra Information

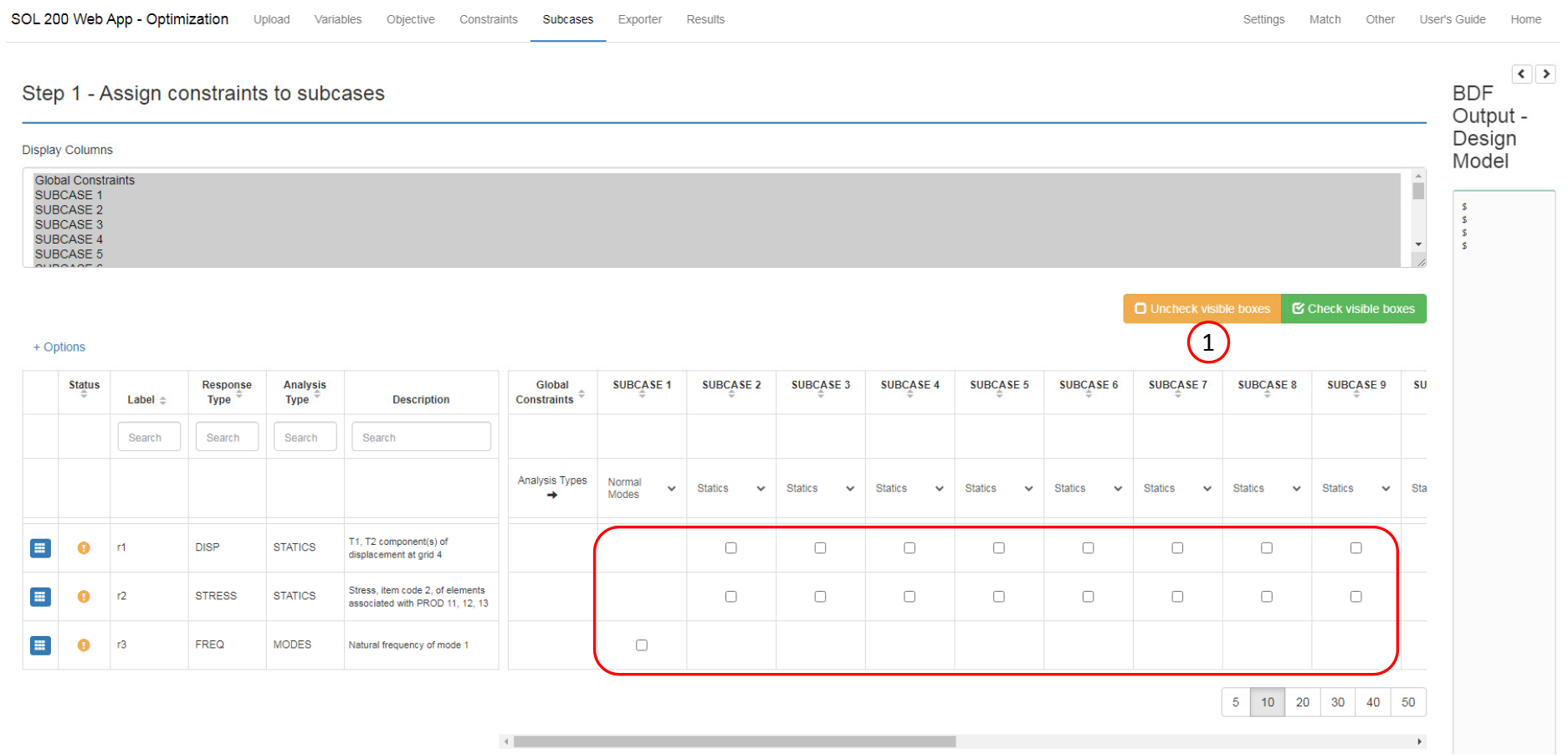
Assign Constraints to Load Cases (SUBCASES)

1. Hold down the SHIFT key on the keyboard and hover the mouse cursor over checkboxes to mark multiple checkboxes without mouse clicking frequently



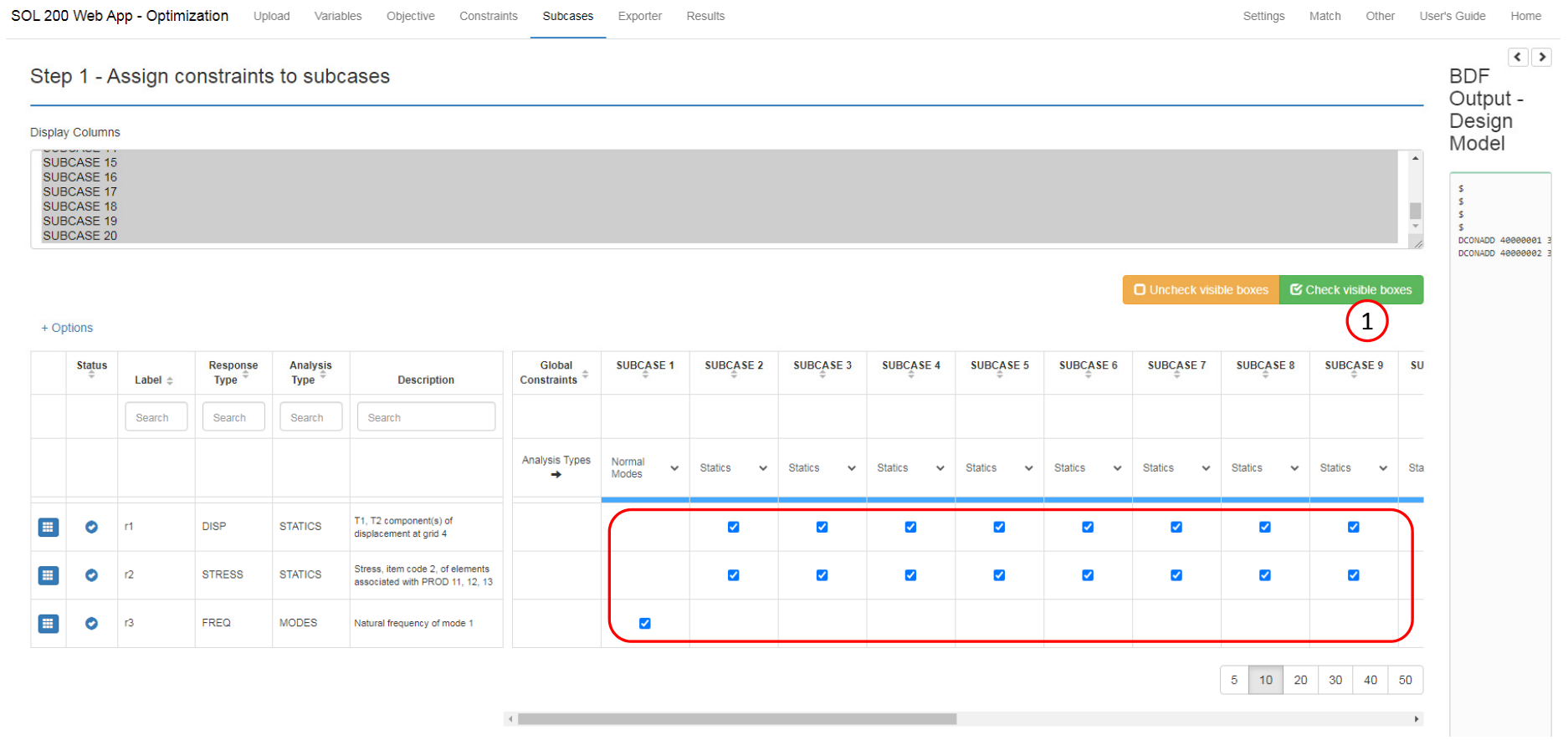
Assign Constraints to Load Cases (SUBCASES)

1. If you click Uncheck visible boxes, every visible checkbox will be unmarked



Assign Constraints to Load Cases (SUBCASES)

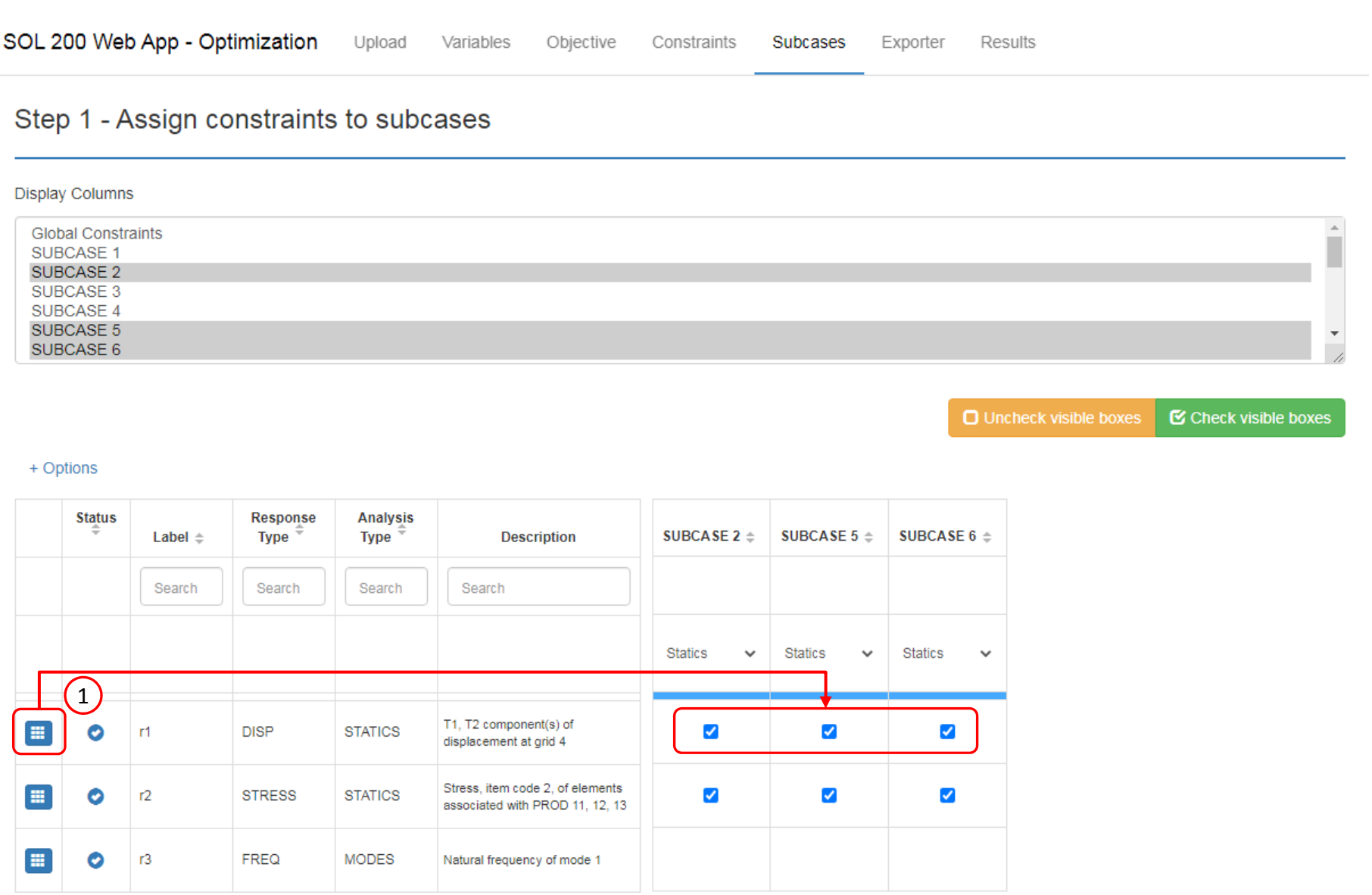
1. If you click Check visible boxes, every visible checkbox will be marked



Assign Constraints to Load Cases (SUBCASES)

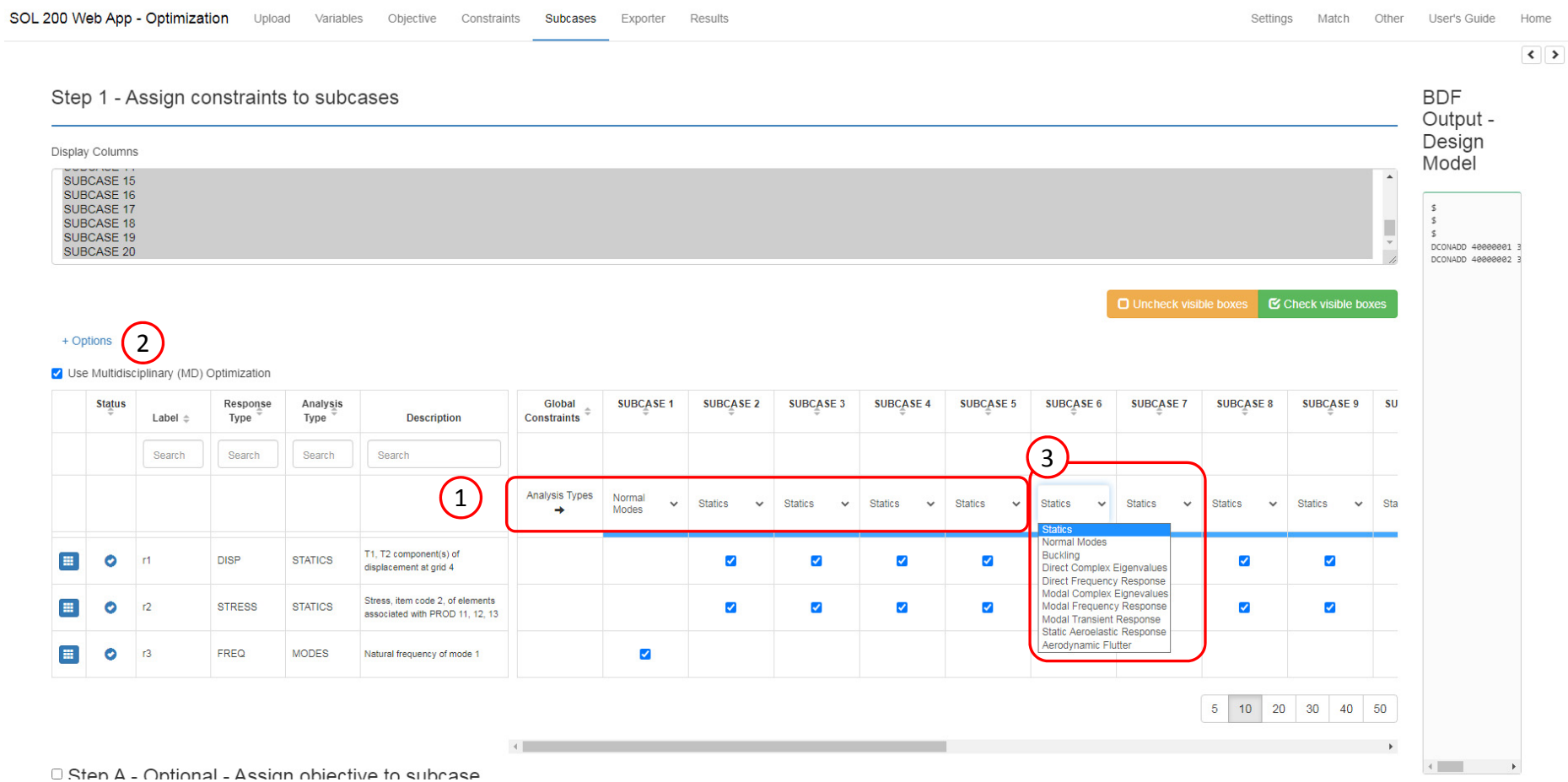
1. Click the indicated icon and the SUBCASEs in which the constraint has been assigned will be displayed.

In this example, the columns for SUBCASE 2, 5 and 6 have been displayed because the r1 constraint has been assigned to these SUBCASESs



Assign Constraints to Load Cases (SUBCASES)

1. The Analysis Type bar will be shown automatically if constraints of different analysis types are created
2. Alternatively, the Analysis Type bar can be manually turned on by clicking *+Options* , then mark the checkbox for Use Multidisciplinary (MD) Optimization
3. The analysis type for each SUBCASE can be manually changed



End of Tutorial