AVDASI 2 Dynamics Testing: Post Processing Tool

1 Basic process and methods

On running the code, the file explorer will open to open the required data file. Select the required data file and click open to run the application. It may take a few moments to open the app window:

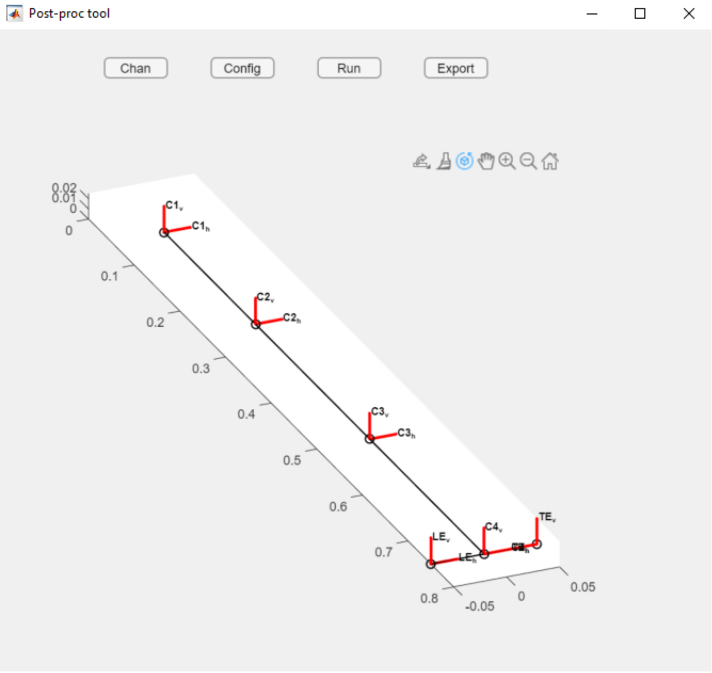


Figure 1: App window

The window shows the selected locations used to excite the structure (black 'O') and the red bars attached to these points indicates the directions in which the hammer was used at each of these points (e.g: The point C2 had two sets of impulses, vertically, C2_v and horizontally, C2_h).

The process flow of this app uses the average of the FRF's at each station and direction of excitation, between the accelerometer(s) and the inputs from repeated impulses at each point. The averaged FRF's are the passed into MATLAB's *modalfit()* functionality[1] to fit a transfer function to the averaged FRF's collected experimentally. The fitted transfer function allows the extraction of modal properties and the mode shape itself. The quality of the fit is subject to the desired user settings and the collected data. For the present purpose, you are given the option to vary 3 *modelfit()* parameters to tune (these can be set through the 'Config' button).

The individual functionalities of the app buttons and the remainder of the interactive objects are described in Section 2. Below is an example of the processing stages that may be performed using the T beam example (you may try this with the attached T-beam example, using the associated data file 'NiData_TBeamDemo.mat'):

1) View the FRFs from the repetitions at selected places but clicking the red bars showing the excitation directions at each station **Figure *2*** (a) – see section 2.1. At the same time make a note of the placement of peaks which may be of interest

[1] Refer https://uk.mathworks.com/help/signal/ref/modalfit.html for more details.

2) Using the ‘Config’ button to tune the *modalfit()* parameters (section) to obtain a refined fit. You may check the quality of the fitted model by clicking on different red bars at different stations - **Figure *2*** (b). In this example, the first three modes are of interest. For this case, a frequency range of 5-25Hz with 6 modes set through ‘**Config’.**

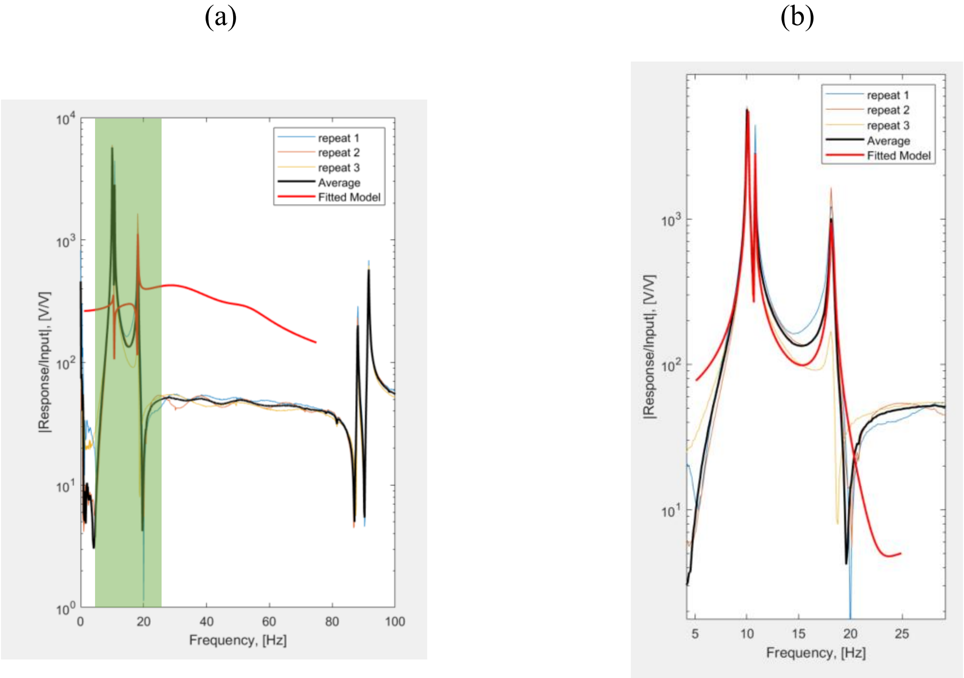


Figure 2: FRFs from case C4_v. (a) Prior to tuning fitting parameters. (b) With adjusted modalfit parameters

3) Once a satisfactory fit is obtained with the range of interest, click ‘**Run**’ and follow the process described in section 2.4. For the current case, with the tuning parameters set in stage (2), the first three modes can be identified as show in **Figure *6***. The identified modes may be recorded and saved. Repeat 2-3 if other individual or sets of peaks from different frequency ranges are of interest.
4) Click ‘Export’ to save the selected modes and the fitted FRFs. You can use your own plotting functions using the exported data.

2 Functionalities

The app has 5 interactive elements: the 4 buttons (‘**Run**’, ‘**Config**’, ‘**Chan**’, ‘**Export**’) and the clickable red bars showing the excitation directions at each station.

2.1 Clickable red-bars

Clicking on an individual red bar showing the available impact direction(s) at each station on the main app window in **Figure *1*** opens the windows shown in **Figure *3***. In the shown example, the vertical excitation bar at station C1 (‘C1_v’) was clicked, as indicated by the Figure title in **Figure *3*** (a). The window in **Figure *3*** (b) shows the number of repeats recorded at this station the selected direction, in this case the 3 repetitions were recorded. The left hand side plot on window in **Figure *3*** (a) shows the FRFs generated from each of the repetitions, the average of the selected repeats and the result of the fitting from *modalfit()* as identified by its legend. The plot on the right shows the raw hammer inputs corresponding to each of the impulses[2].

[2] For FRF computations, the only the content around the peak in the hammer input is retained, the remainder of the signal set to zero. This ensured that any spurious inputs generated by moving the hammer cable, etc during the collection period is omitted.

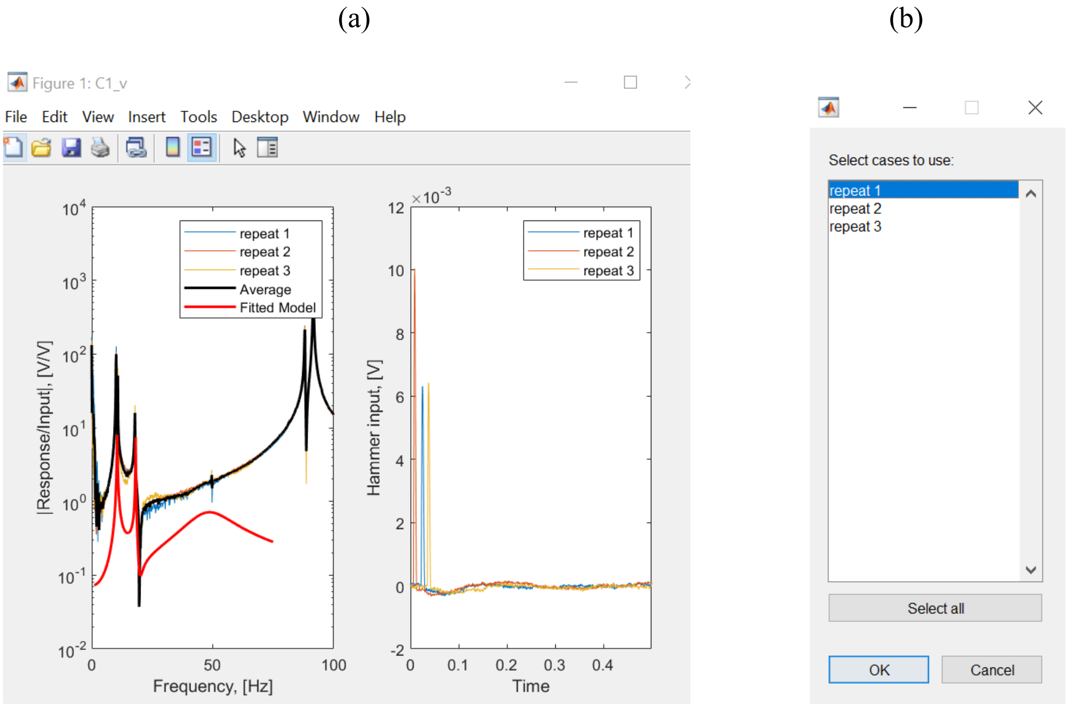


Figure 3: Windows opened on clicking a red bar indicating an excitation case. (a) Collected, averaged and fitted FRFs, (b) Tool to select repeated cases to retain for averaging

The window **Figure** ***3***(b) allows the user to select the desired set of repeats used for the averaging process (by default, it uses all of the repeats). If one of the repetitions can be identified as an outlier from **Figure** ***3***(a), the user can select all the repetitions excluding the one to be discarded and hit 'OK'. If a refined selection is made, window **Figure** ***3*** (a) will close and re-open with the updated averages. If the existing selection is to be retained, simply click 'Cancel' in **Figure** ***3***(b).

2.2 'Chan' Button

During experimentation, two sensors were used, one in the In-plane/horizontal direction (IP) and one in the Out-Of-Plane/vertical direction (OOP). Clicking on the 'Chan' button allows the user to select which combination of sensors are to be used.

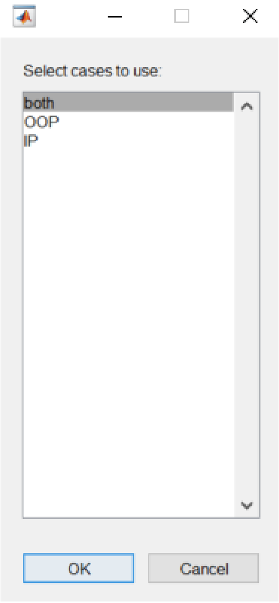


Figure 4: Window appearing on clicking 'Chan'

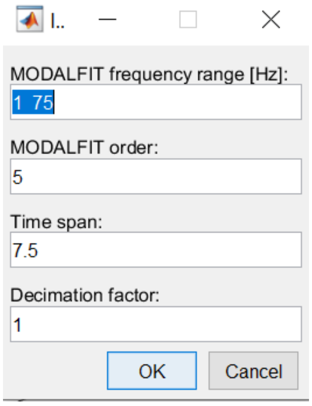
The options available on the above window are as follows:

- ‘both’: Uses the sum of the two sensors for processing, as a new quantity that is sensitive to both the vertical and horizontal motions. This is the default setting.
- ‘IP’: Uses only the output of the horizontal sensor.
- ‘OOP’: Uses only the output of the vertical sensor

The default setting is ‘both’. This is suggested if both the sensors were engaged simultaneously during the experiment as it allows meaningful mode shapes to be computed. However, if the experiment was carried out in two stages individually the corresponding setting must be selected (in these cases two data files will be provided, each engaging either the IP or the OOP sensor only).

2.3 ‘Config’ Button

The configure button allows the user to set the fitting settings used by *modalfit()* through the following window.



I..

MODALFIT frequency range [Hz]:
1 75

MODALFIT order:
5

Time span:
7.5

Decimation factor:
1

Figure 5: Window appearing on clicking 'Config'

In the above:

- **Frequency range** (1x2 input, default: 1-75Hz) defines the ranges of frequencies used for fitting the transfer function: the fitted FRF in **Figure** ***3***(a) spans this range.
- **MODALFIT order** (1x1 integer, default: 5) is a measure of the number of modes to be fitted within the selected range.
- **Time span** (1x1 input, default 7.5s) the collection time in seconds (starting from the hammer impulse) to be used for processing. The experimental data was collected for 15s after each impulse. However, for e.g in the case of damped modes with higher frequencies, the mode will decay significantly within a shorter time span and will continue to collect noise for the remaining period. The default value should be sufficient for your purpose; however the option is available to append this.

2.4 ‘Run’ Button

On clicking this button, the window shown in **Figure** ***6*** will appear. This is known as a stabilisation diagram, indication a measure of the acceptability of the solutions generated by the methods used by *modalfit()*.

For the present purpose, this process is simplified: The figure overlays the frequencies identified by *modalfit()* as **clickable black lines,** on top of the average of all FRF’s. User is simply expected to identify the lines that matches a peak, which indicates that it is a fitted mode that indicates a physical mode of the structure.

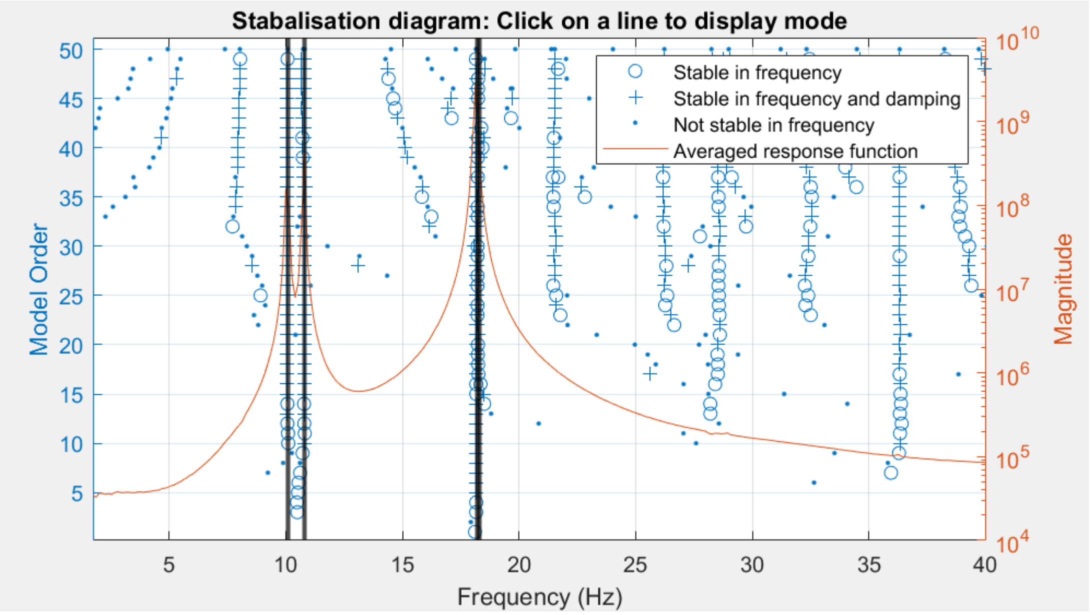
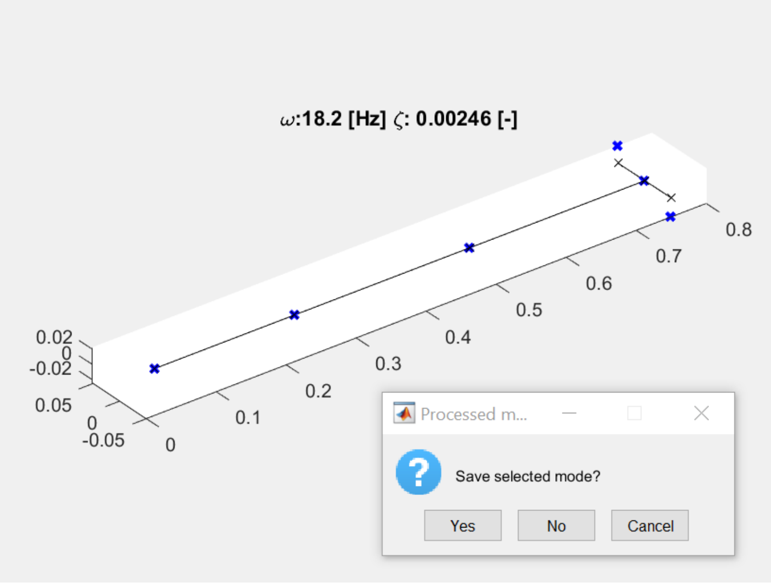


Figure 6: Stabilisation diagram appearing on clicking 'Run'

Clicking on a black line (e.g below from the one just below 20Hz) opens the following:



Save selected mode?

Figure 7: Example illustration of a mode shape and the option to save the mode on clicking a black line from Figure 6.

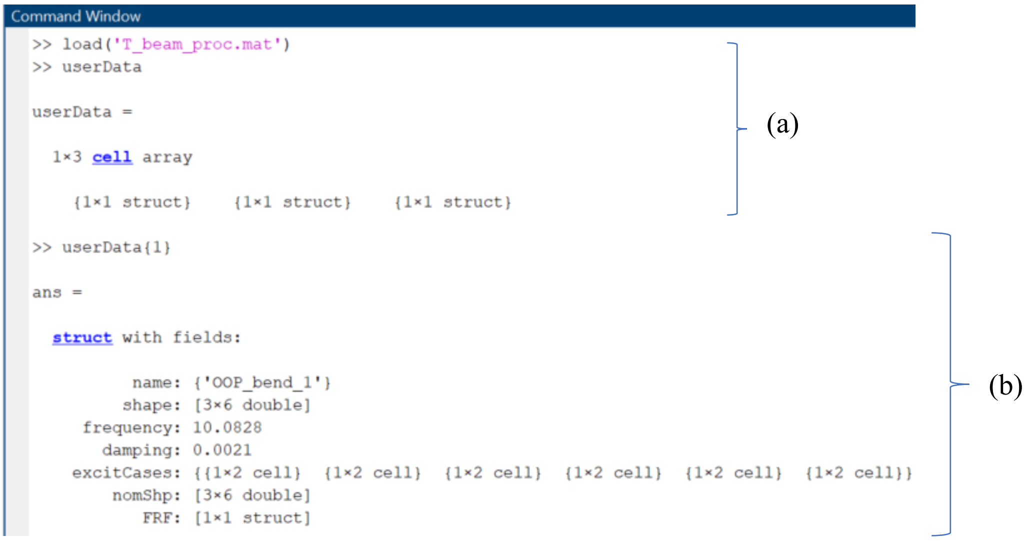
The figure shows the shapes associated with the selected mode shape (in the above case, torsion), and the modal properties. The user will be given the option to save the selected mode, if desired. If 'Yes' is selected, an option will be provided to type in an identifier/name for the mode. When saving, the fitted FRFs linked with the current settings in '**Config**' are also saved.

Note: If an excitation was not carried for a certain direction at a certain station during the experiment, this point will not show any activity in that direction when mode shapes are displayed. The available excitation directions can be checked from the red bars available at each station in the main app window in **Figure *1***.

2.5 ‘Export’ Button

This allows the selected modes to be saved as a ‘.mat’ file in a desired location. If a warning is presented on clicking ‘**Export**’, it means that the user has not selected any modes as described by the via the ‘**Run**’ button.

The saved file will have a cell array ‘**userData**’ of size 1xN, N being the number of modes named and saved by the user through ‘**Run**’. Each of these cells will have the following structure:



```
>> load('T_beam_proc.mat')
>> userData

userData =

  1×3 cell array

    {1×1 struct}    {1×1 struct}    {1×1 struct}

>> userData{1}

ans =

  struct with fields:

         name: {'OOP_bend_1'}
        shape: [3×6 double]
    frequency: 10.0828
      damping: 0.0021
   excitCases: {{1×2 cell}  {1×2 cell}  {1×2 cell}  {1×2 cell}  {1×2 cell}  {1×2 cell}}
       nomShp: [3×6 double]
          FRF: [1×1 struct]
```

Figure 8: Example of the contents in the saved data file structure

- **name:** String identifier given by the user
- **frequency**, **damping**: corresponding to the mode
- **nomShp**: Excitation locations of the structure – 3xF, F being the number of unique excitation stations and each row giving the X,Y and Z coordinates
- **excitCases**: {1xF} cell array, each cell having the identifiers associating the multiple directions of impacts performed at each unique station.
- **shape**: modal deformation for the selected mode – 3xF, same as nomShp, each column giving the displacement of at the corresponding excitation station.
- **FRF** – structured array:
    - **FRF.frqVec**: 1xn array of n frequencies in Hz.
    - **FRF.avFRF**: n x 1 x J array of the averaged experimental FRFs collected from the J excitations, evaluated at the n frequencies in **FRF.frqVec**.
    - **FRF.fit**: n x 1 x J array of the fitted FRF by *modalfit()*, corresponding to the J excitations, evaluated at the n frequencies in **FRF.frqVec**.

Note that the FRFs are stored individually for each of the modes, based on the fitting parameters set through ‘**Config**’ at the point of identification of the mode though ‘**Run**’. This is to allow for different *modalfit()* parameters to be set to identify groups of modes.