Structural Dynamics Open-Ended Project

REPORT 2019

[Steady-state vibration response of a fixed-free beam subjected to base excitation ___A numerical investigation using MATLAB]

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Introduction:

This work presents some of the consequences of doing a sine-sweep base-excitation test to determine the modal parameters i.e. Natural frequency (**f_n**) & amplification factor(Q). of a fixed-free beam using FRF-curve-fit[1] which is an extension to half-power bandwidth method.

In this work:

1-Natural bending mode frequencies of a 100mm x 20mm x 5mm Aluminum beam was determined via FEA on MATLAB.

2-Sine sweep base acceleration data (accelerometer data) was generated in MATLAB.

3-Response acceleration (accelerometer data) of the system (arbitrarily assumed system) under base excitation was generated in MATLAB

4-Frequency Response Function (FRF) was generated using the base excitation and response accelerations.

5-Using FRF-Curve-fitting the modal parameters (**f_n & Q**) are estimated.

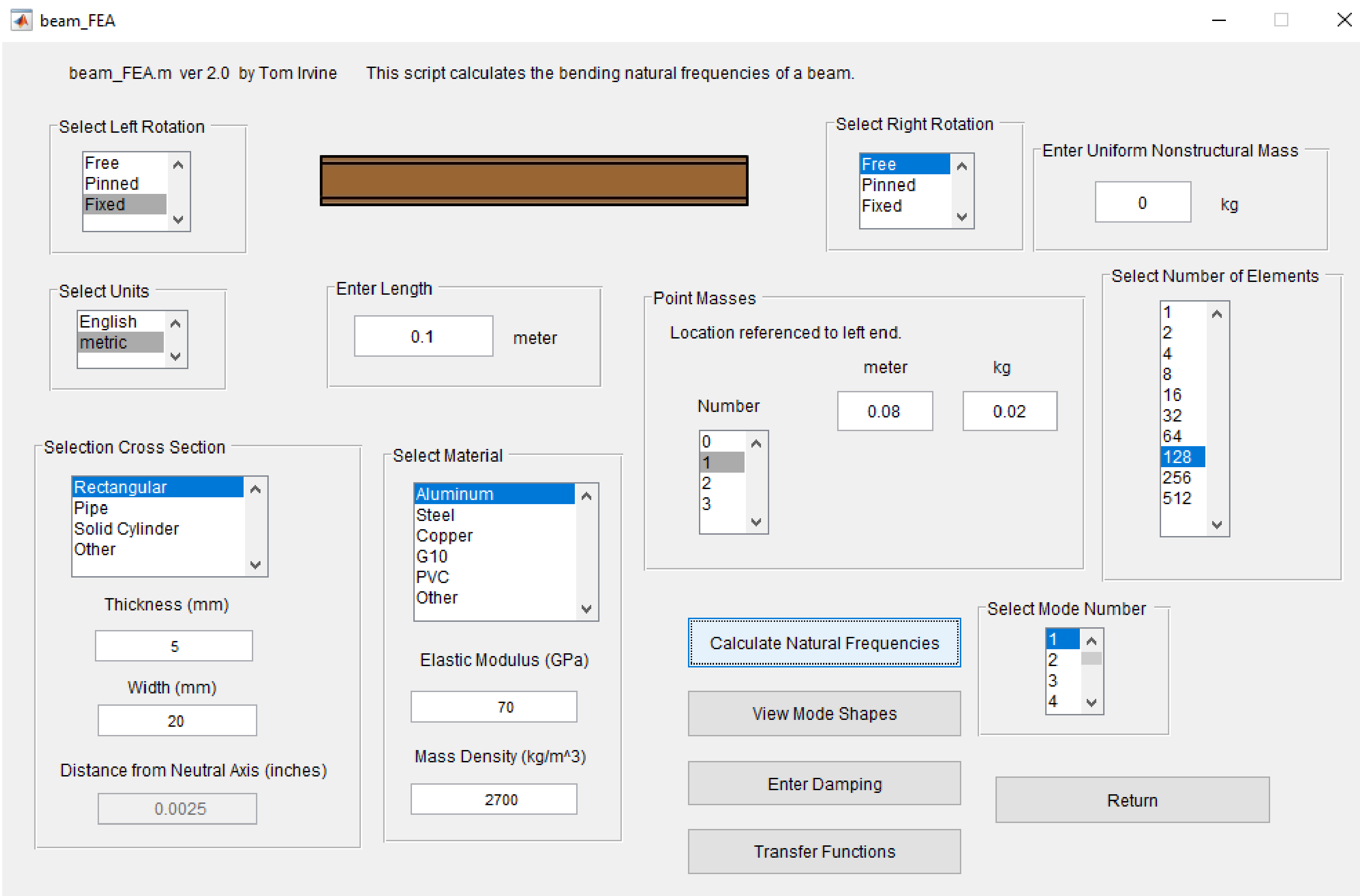
FEA of beam:

A rectangular Aluminum beam of dimensions **100mm x 20mm x 5mm** is considered for the analysis

A dummy point mass (accelerometer mass) of **20 gram** is placed 80mm to the right of the fixed end to incorporate the effect of mass of accelerometer on natural frequency.

For the Aluminum beam density is assumed to be **2700kg/m^3** and elastic modulus is assumed to be **70GPa.**

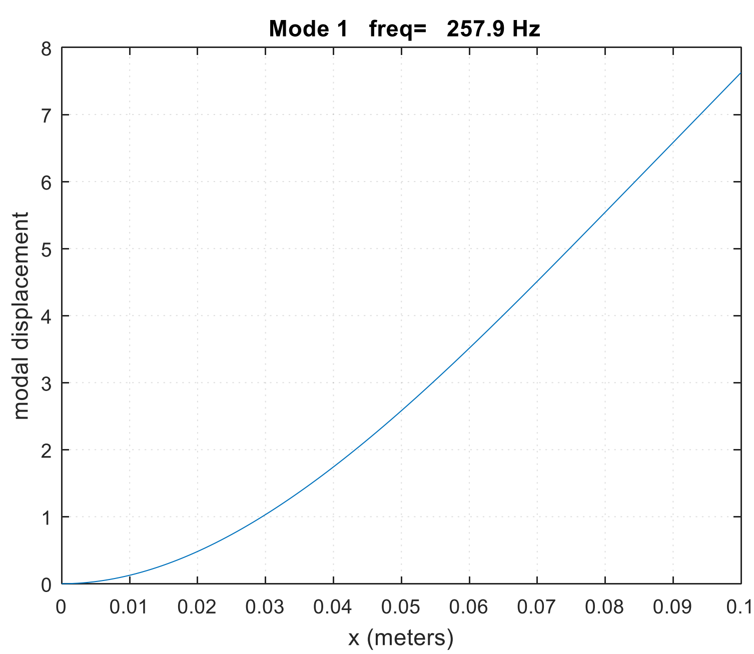
[1] FRF curve fit MATLAB GUI---by Tom Irvine (www.vibrationdata.com)



1-Snapshot of FEA GUI

Mode #	Frequency (Hz)
1	257.882
2	2572.3
3	6490.8
4	11810

2 First 4 bending modes frequencies of the beam



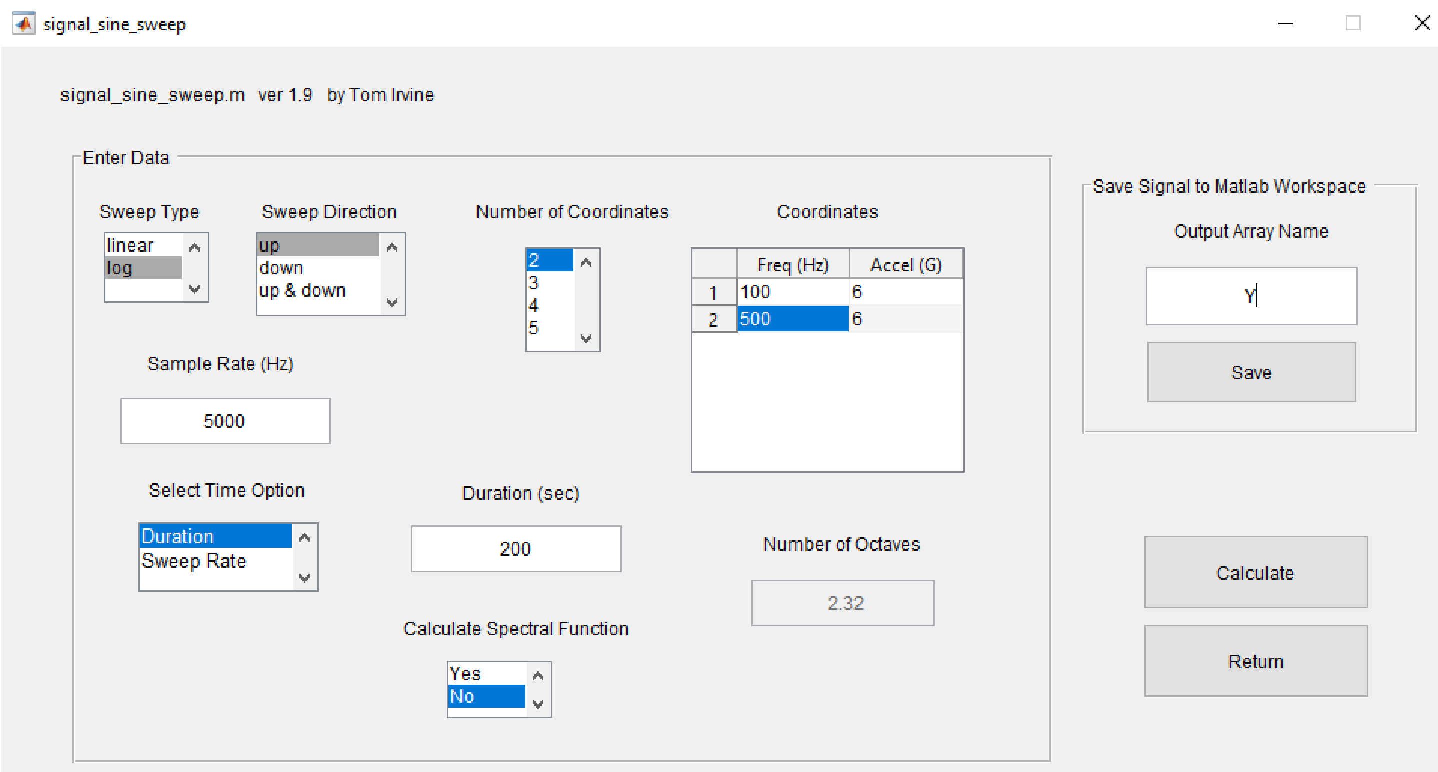
3-Mode shape of first bending mode

Base excitation:

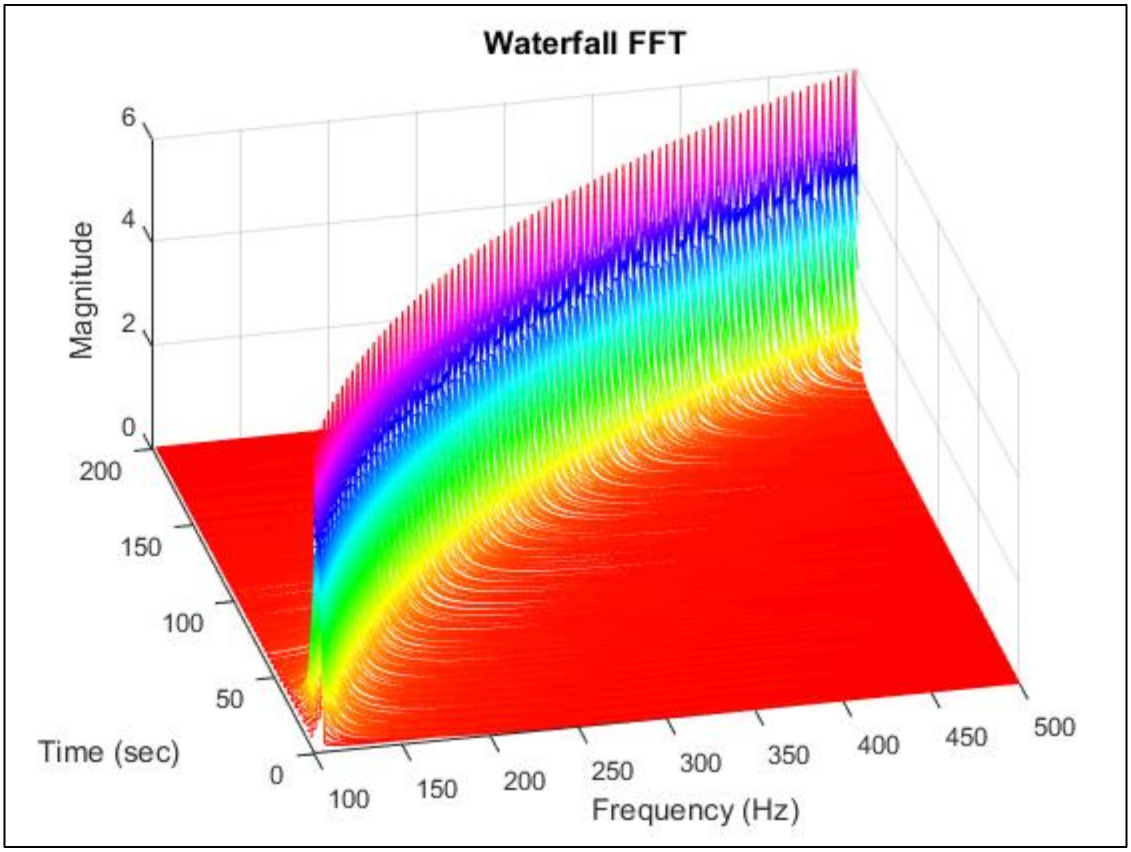
Base excitation dummy data can be generated in MATLAB to excite only the first bending mode at **257.9 Hz.**

It is decided to excite the beam from **100Hz** sweep-up to **500 Hz** in **200 seconds** at a constant acceleration magnitude of **6G.**

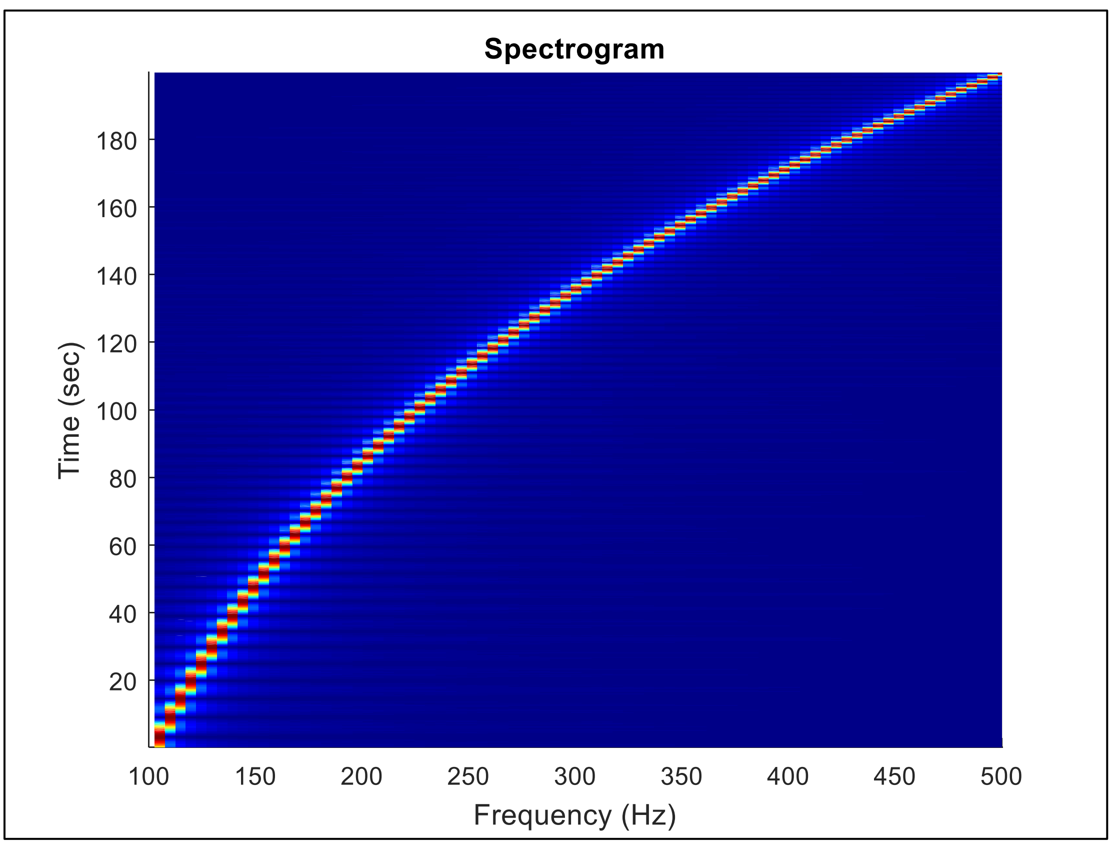
Under these conditions a dummy accelerometer data with a sampling rate of **8000samples/sec** was generated in MATLAB.



4-Snapshot of Signal generator GUI



5-Waterfall FFT of base excitation data

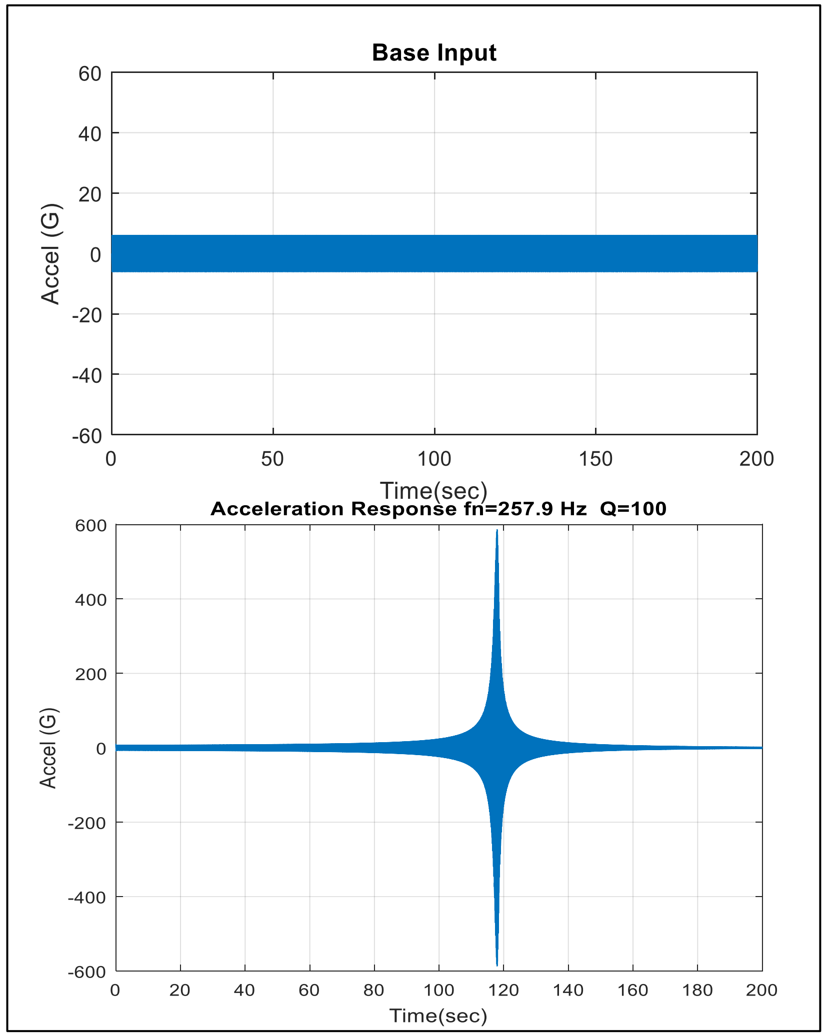


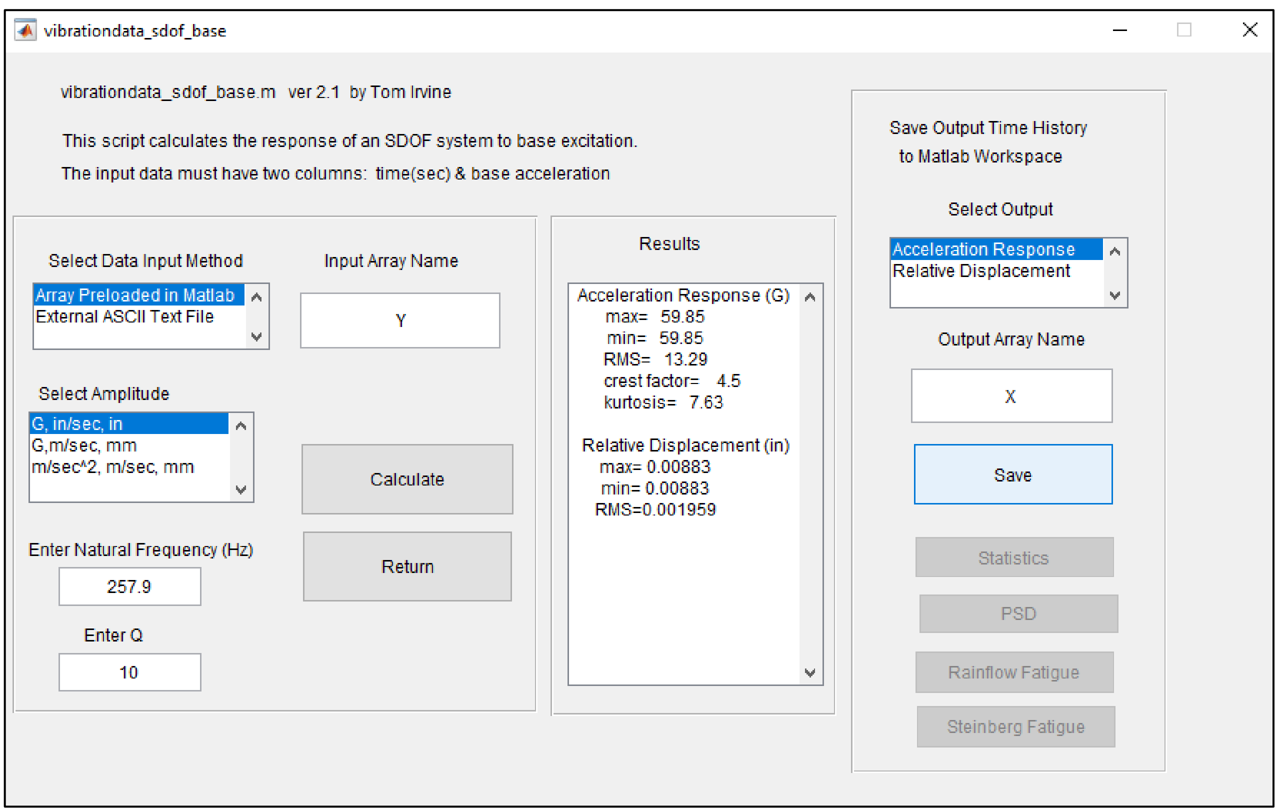
6-Spectrogram of base excitation data

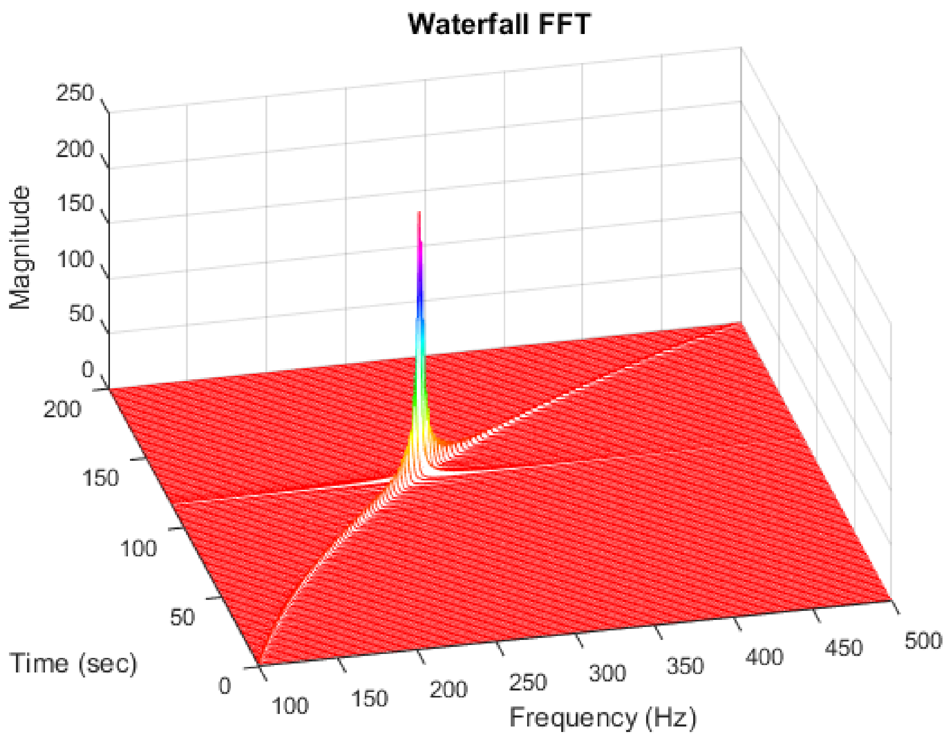
Response:

FEA of the beam has revealed that the first bending mode occurs at **257.9Hz.** Also, the beam has very well separated modes in terms of frequency, so we can have an **equivalent Single DOF system** having a natural frequency of **257.9Hz** and an arbitrarily assumed damping **loss factor η=0.01** which corresponds to a **Quality factor Q=100.**

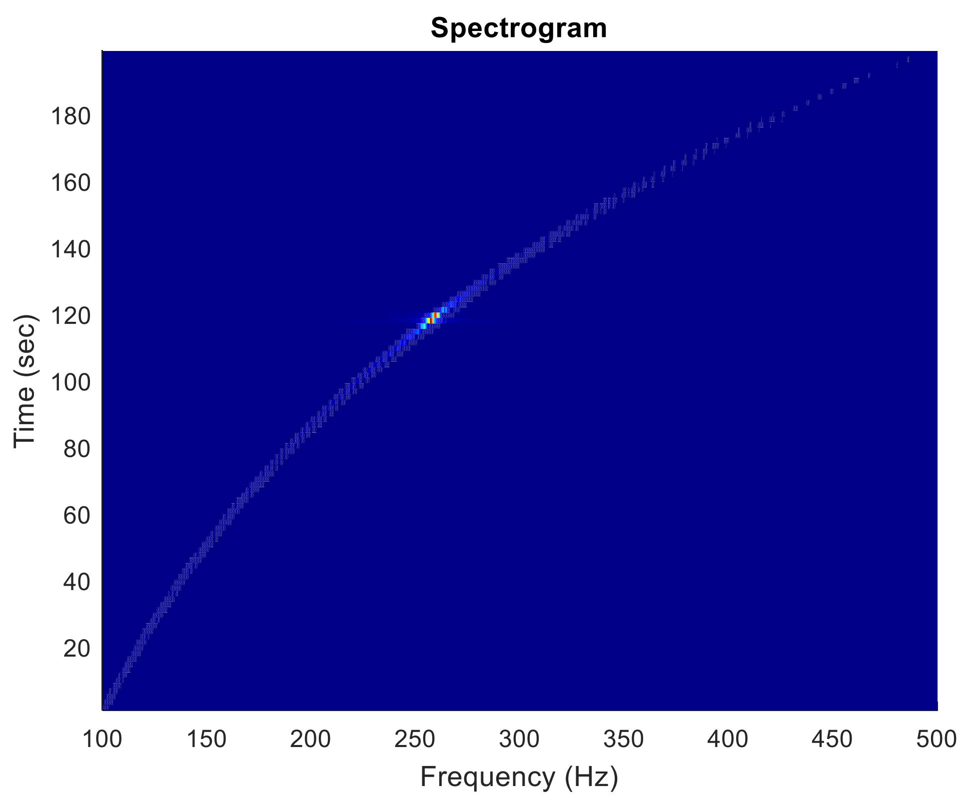
Under these conditions a SDOF response to base input was generated in MATLAB.







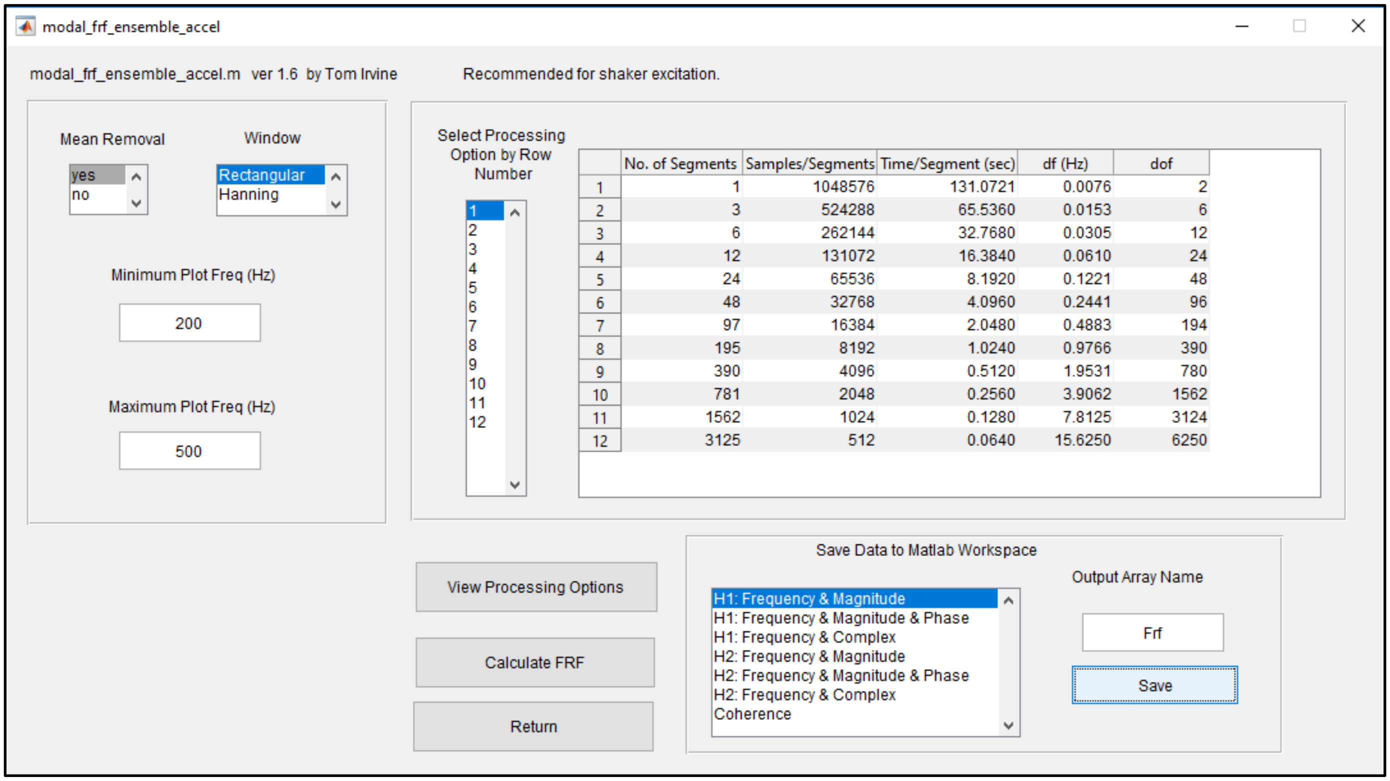
Waterfall FFT of Response Data

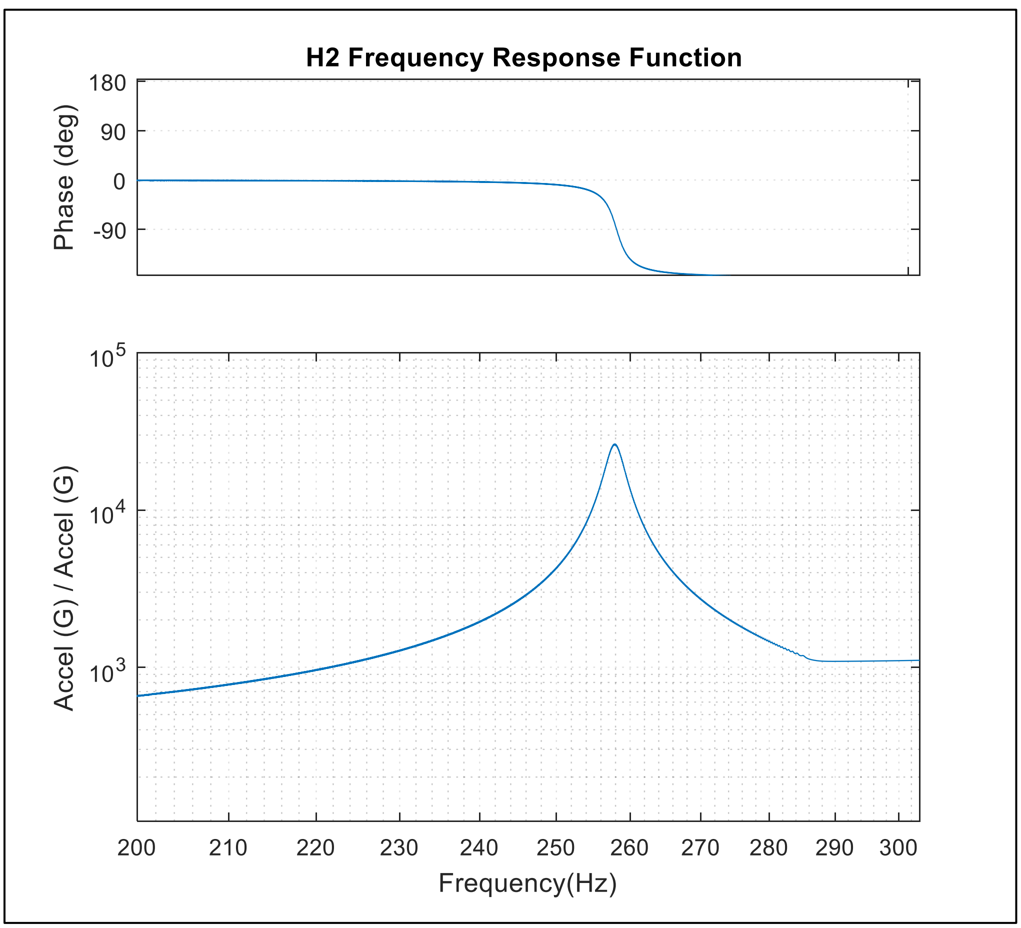


Spectrogram of Response Data

Frequency Response Function (FRF):

FRF of input and response accelerations is generated

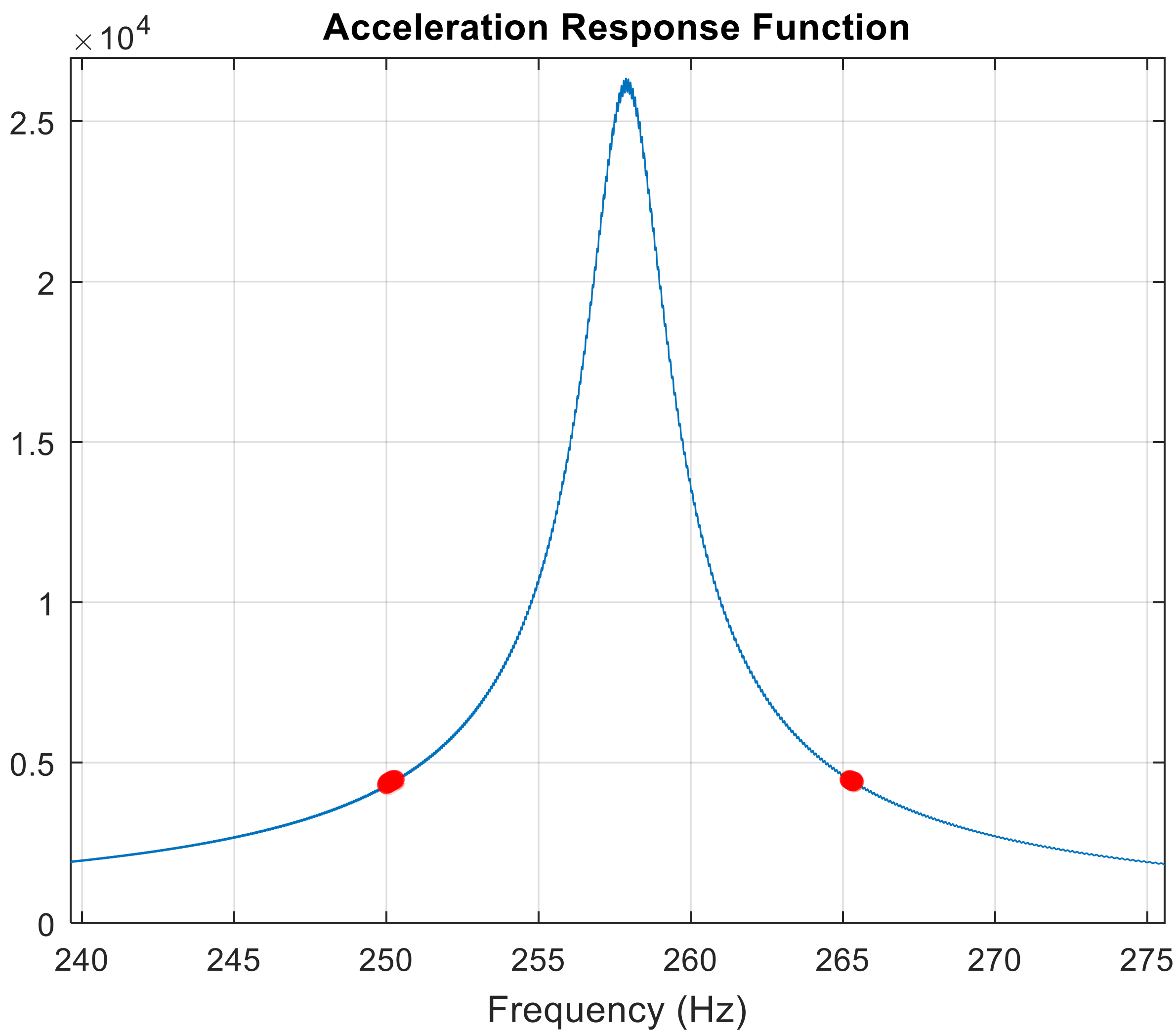




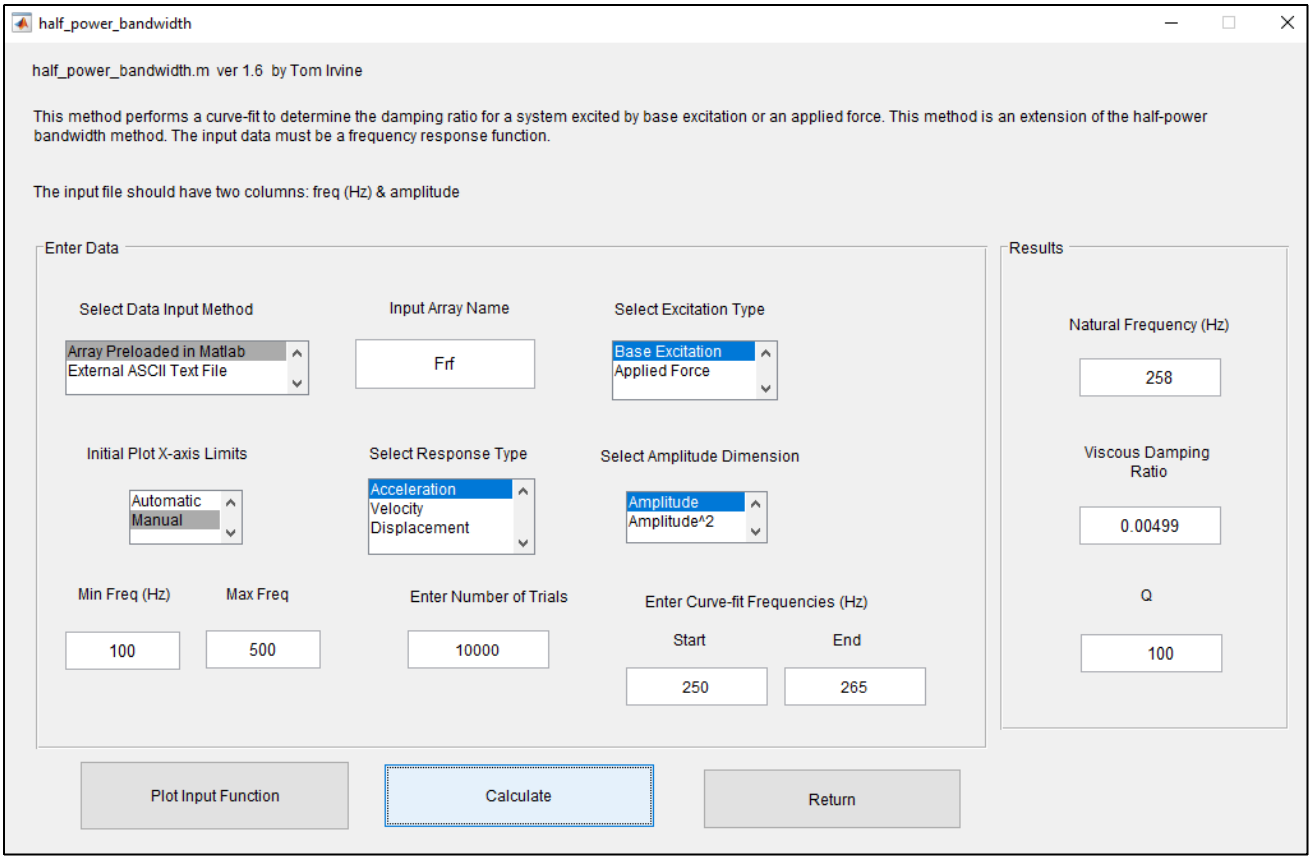
FRF Curve-fitting:

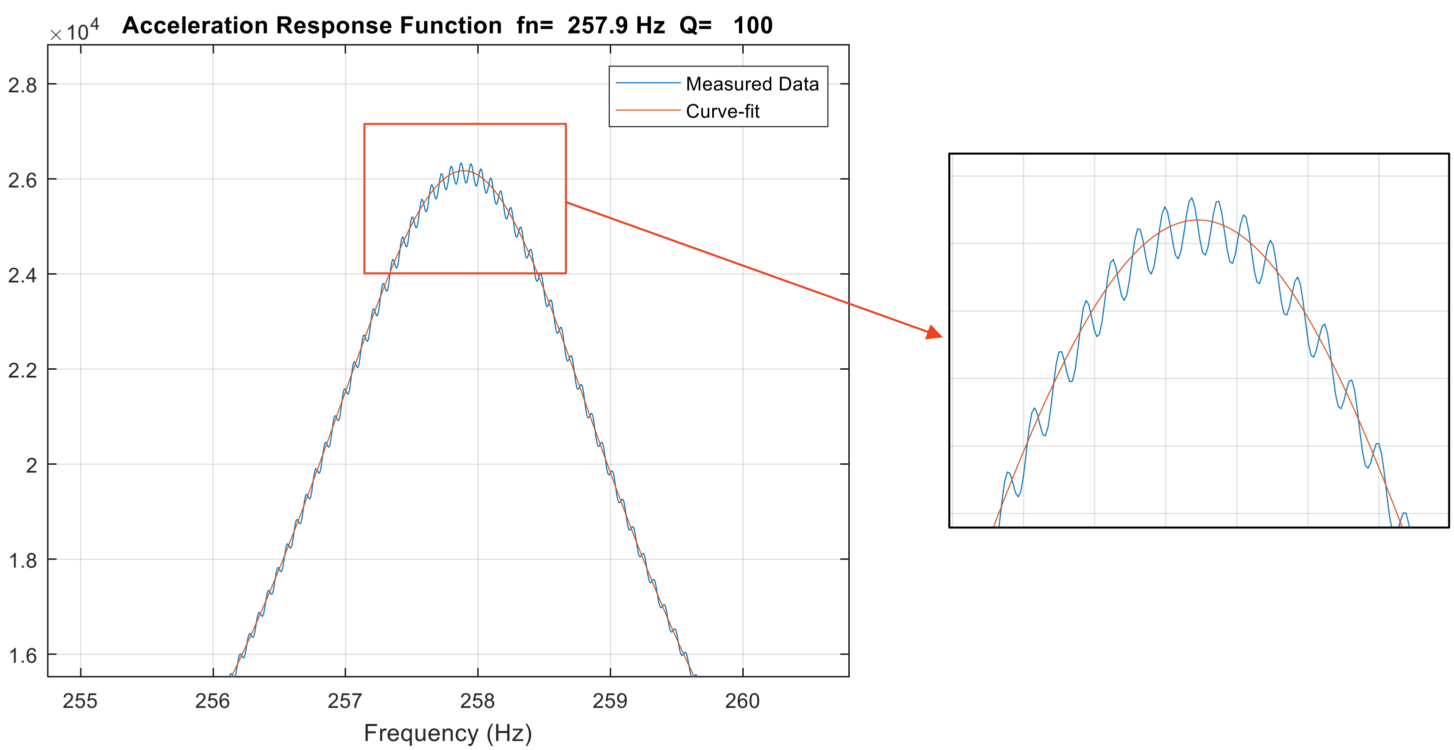
FRF Curve fitting is performed on generated FRF to estimate modal parameters

To start curve fitting we need to select two points on FRF .We have selected 250Hz & 265Hz



7-plot of FRF showing arbitrarily selected points between which curve fitting is to be performed


half_power_bandwidth
half_power_bandwidth.m ver 1.6 by Tom Irvine
This method performs a curve-fit to determine the damping ratio for a system excited by base excitation or an applied force. This method is an extension of the half-power bandwidth method. The input data must be a frequency response function.
The input file should have two columns: freq (Hz) & amplitude
Enter Data
Select Data Input Method
Array Preloaded in Matlab
External ASCII Text File
Input Array Name
Frf
Select Excitation Type
Base Excitation
Applied Force
Initial Plot X-axis Limits
Automatic
Manual
Select Response Type
Acceleration
Velocity
Displacement
Select Amplitude Dimension
Amplitude
Amplitude^2
Min Freq (Hz)
Max Freq
100
500
Enter Number of Trials
10000
Enter Curve-fit Frequencies (Hz)
Start
End
250
265
Results
Natural Frequency (Hz)
258
Viscous Damping Ratio
0.00499
Q
100
Plot Input Function
Calculate
Return


Acceleration Response Function fn= 257.9 Hz Q= 100
×10^4
2.8
2.6
2.4
2.2
2
1.8
1.6
255
256
257
258
259
260
Frequency (Hz)
Measured Data
Curve-fit

Curve fit Results:

Modal parameter	Assumed values	Estimated values	Percent error
Natural Frequency (fn)	257.9 Hz	258 Hz	0.04%
Quality factor (Q)	100	100	0%

Comments:

- Results from FRF Curve fitting technique are more reliable and accurate with very little error.
- In order to have better FRF, sample rate of accelerometer data should be high. In our case we have used 8000Hz sampling rate.
- Curve fitting technique has eliminated the possible source of error in selecting half power points.