Data Article

Dataset of multi-harmonic measurements for the experimental CEA-beam benchmark structure

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ARTICLE INFO

ABSTRACT

This data article comprises post-processed data to investigate the non-linear dynamic behavior of the CEA-beam benchmark structure that is a clamped−clamped steel beam with non-ideal boundary conditions. Experiments have been performed on the CEA-CESTA laboratory.

The data provided include output measurements for the nonlinear dynamic behavior of the CEA-beam (i.e. the displacement amplitudes for each harmonic component at the middle of the beam), as well as the complete input acceleration signal harmonics amplitude.

All the results from this data will help researchers and engineers in proper analysis of the nonlinearities of the clamped−clamped beam and the effect of the non-ideal input signal and advanced understanding of links between different excitation signal and the multi-harmonic responses of the CEA-beam. One of the main original contribution is to share the data sets to give the opportunity to researchers for testing and validating analytical or numerical models of a nonlinear beam with non-ideal boundary conditions and subjected to low and high levels of excitation signal.

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Specifications Table

Subject area	*Mechanical engineering*
More specific subject area	*Structural vibration, multi-harmonic response measurements nonlinearity and large displacements, beam system with non-ideal boundary conditions*
Type of data	*Tables, figure, *.mat files and ASCII files*
How data was acquired	*All the dynamic signal generation and acquisition are performed via the data acquisition platform LMS TestLab from Siemens that control the timing, synchronization, and data transfer between the Sensor-Based Input/Output modules and the external host*
Data format	*Post-processed data*
Experimental factors	*Investigation of nonlinear vibration and multi-harmonic response of the CEA-beam during a swept-sine experiment*
Experimental features	*The data give accelerations of the CEA-beam structure on a frequency band [90;130] Hz for three levels of deterministic excitation*
Data source location	*Data obtained from the CEA/CESTA laboratory, CS60001, 15 avenue des Salinières, 33116 Le Barp, France*
Data accessibility	*The data are available in this article as a supplementary file*
Related research article	*"Multi-harmonic measurements and numerical simulations of nonlinear vibrations of a beam with non-ideal boundary conditions" published in* Communications in Nonlinear Science and Numerical Simulation. https://doi.org/10.1016/j.cnsns.2014.04.008hal-01010776

Value of the Data
- The data are useful for researchers and industrial in understanding of the nonlinear bending behavior for large deflections of a beam around the primary resonance.
- The database provides multi-harmonic response measurements (1st, 2nd, 3rd, 4th and 5th harmonic components) for the experimental CEA-beam benchmark structure.
- The dataset can be used to undertake links between multi-harmonic inputs and outputs for a simple nonlinear mechanical system.
- The dataset provide experiments for various levels of excitation signal.
- The database gives the opportunity to researchers to validate analytical and numerical models for the prediction of the nonlinear dynamic behavior of a clamped−clamped steel beam with non-ideal boundary conditions.
- The measurements may vary from an experiment to another. The dataset presented here is the one used in the article [1]. A later study focused on the model uncertainties and their use in nonlinear simulations [2].

1. Data

This dataset is provided as supplementary data in a Matlab format and ASCII format.

The data are provided as follows: "case_level2.mat", "case_level4.mat" and "case_level6.mat" ("case_level2.txt", "case_level4.txt" and "case_level6.txt", respectively) give all the input and output harmonics for the three levels of excitation signal at 2 m s^{-2}, 4 m s^{-2} and 6 m s^{-2} in the Matlab format (ASCII format, respectively). Each column describes a channel output or input measurement produced for a specific acquisition frequency given in the first column of each case. Descriptions of the columns headings are provided in Table 1.

Table 1
Description of the dataset.

Column	Signal	Quantity	Unit
1	Input	Frequency	Hz
2	Input	1st harmonic	m s^{-2}
3	Input	2nd harmonic	m s^{-2}
4	Input	3rd harmonic	m s^{-2}
5	Input	4th harmonic	m s^{-2}
6	Input	5th harmonic	m s^{-2}
7	Output	1st harmonic	m
8	Output	2nd harmonic	m
9	Output	3rd harmonic	m
10	Output	4th harmonic	m
11	Output	5th harmonic	m

For the output signal, the acceleration amplitudes have been translated into displacement amplitudes for each harmonic component.

2. Experimental design, materials, and methods

The CEA-beam benchmark structure consists of a beam and two blocks made from a single piece of steel. The technical drawing of the CEA-beam benchmark structure is given in Fig. 1. All the physical parameters are also given in Table 2. This CEA-beam is bonded to a heavy steel block of dimension $100 \times 100 \times 85$ mm.

The system is instrumented with 3 three-dimensional accelerometers as depicted in Fig. 2. Two accelerometers (denoted P1 and P2) are positioned on the two massive ends of the CEA-beam and the third accelerometer (denoted A1) is at the middle of the CEA-beam. Each signal is denoted by the sensor name (P1, P2 or A1) followed by the direction of the measurement. The entrance signal 1/2(P1Z + P2Z) corresponds the shaker's feedback control signal. The measurement of the CEA-beam output is provided by the accelerometer A1. The output data provided corresponds to the response signal at the middle of the beam, in the reference frame of the heavy block, that is A1Z-1/2(P1Z + P2Z). In other words, it corresponds to the specific vertical displacement of the CEA-beam by subtracting the vertical displacement undergone by the heavy block.

The following paragraph briefly describes the experimental protocol. The vibrator is piloted with a logarithmic swept sine signal. For each level of excitation signal an increasing and decreasing swept sine signal is performed to capture as best as possible the nonlinear dynamic behavior around the first resonance (i.e. the potential hardening effect due to large deflections of the beam). For each experimental test, the frequency evolves quite slowly (0.1 octave/min in the interval near the resonance) to consider the response as stationary. Raw output and input data are post-processed by using an evolutionary updating algorithm (Covariance Matrix Adaptation Evolution Strategy), coupled with highly selective filters, in order to extract the fundamental frequency and the harmonic amplitudes of both the output and input signals. The overall experimental process and the description of the signal analysis tool are fully explained in [1].

Fig. 3 displays the experimental measurements provided from the dataset. All results from these post-processed records are analyzed and discussed in [1] for characterization of the nonlinear bending behavior for large deflections of a beam around the primary resonance. To be noted that only the 1st, 2nd, and 3rd harmonic components have been shown in [1]. The 4th and 5th harmonic components correspond to new results provided in the dataset for the interested reader.
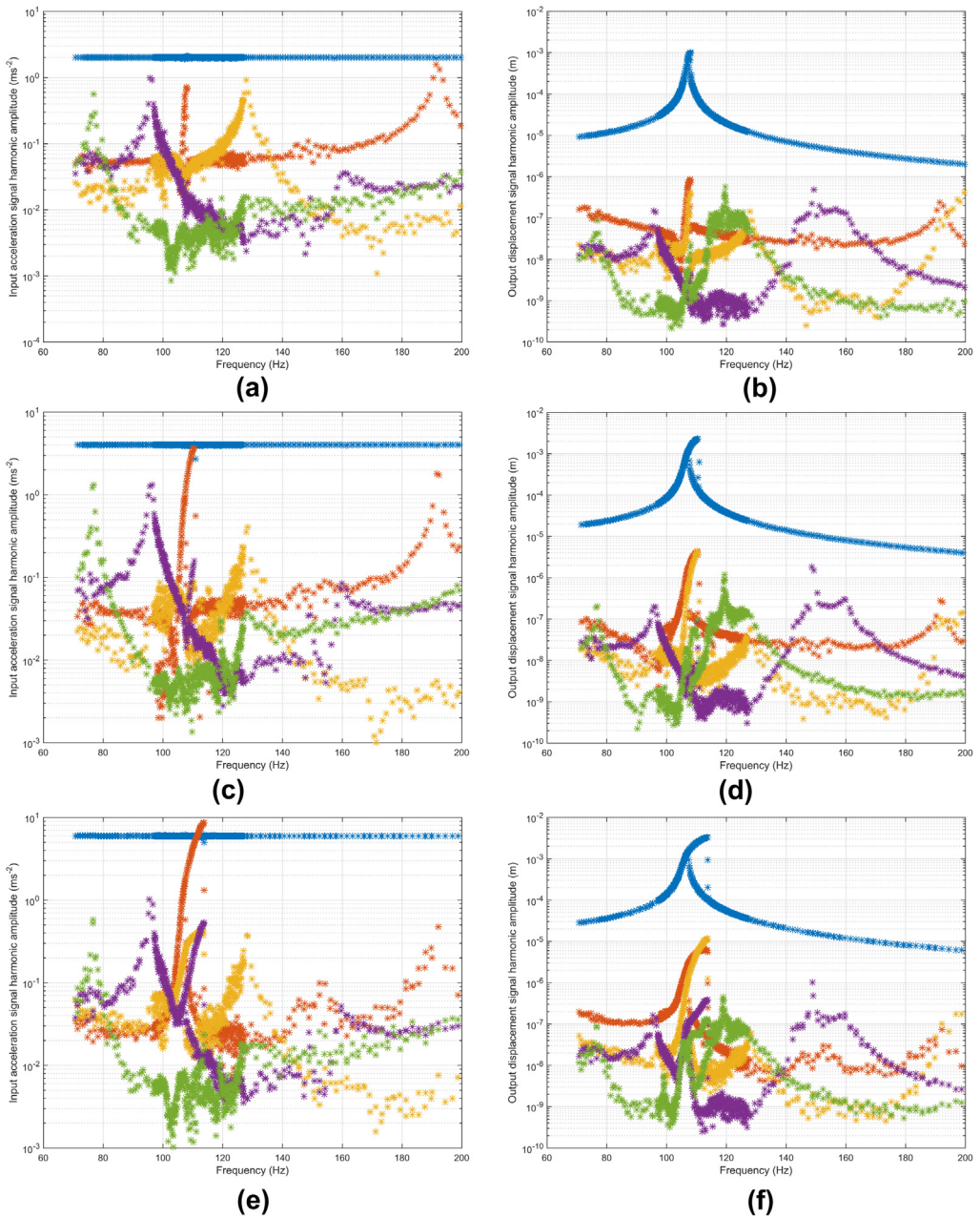
Fig. 1. Technical drawing of the benchmark CEA-beam.

Table 2
Physical parameters of the CEA-beam.

Parameter	Unit	Value
length	mm	470
thickness	mm	5
width	mm	20
Young modulus	GPa	210
density	kg/m³	7800
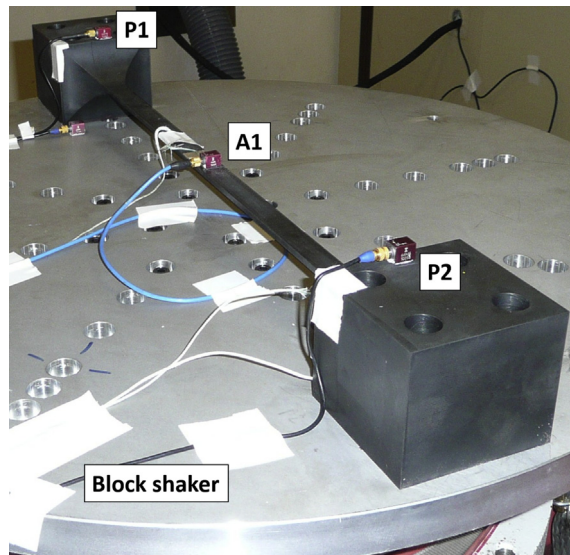
Fig. 2. Experimental CEA-beam with the three accelerometers.

Fig. 3. Post-processed data provided - inputs (a,c,e) and outputs (b,d,f) signals at the three excitation levels: 2 m s^{-2} (a,b), 4 m s^{-2} (c,d) and 6 m s^{-2} (e,f) (blue = 1st harmonic, orange = 2nd harmonic, yellow = 3rd harmonic, purple = 4th harmonic and green = 5th harmonic).

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.dib.2019.104563.

References

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[2] T. Roncen, J.-J. Sinou, J.-P. Lambelin, Non-linear vibrations of a beam with non-ideal boundary conditions and uncertainties – Modeling, numerical simulations and experiments, Mech. Syst. Signal Process. 110 (2018) 165–179.