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

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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.

This Data in Brief article is an additional item directly alongside the following paper published in the Elsevier journal Communications in Nonlinear Science and Numerical Simulation: M. Claeys, J.-J.
Sinou, J.-P. Lambelin and B. Alcoverro, Multi-harmonic measurements and numerical simulations of nonlinear vibrations of a beam with non-ideal boundary conditions, Communications in Nonlinear Science and Numerical Simulation, 19(12), 4196–4212, 2014. https://doi.org/10.1016/j.cnsns.2014.04.008. © 2019 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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.
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 × 100 × 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.

### Table 1

| 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          |
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.

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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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