Data Article

Experimental dataset for measurements of freely vibrating structures equipped with impact dampers

Mohamed Gharib

Department of Mechanical Engineering, Texas A&M University at Qatar, Education City, PO Box 23874, Doha, Qatar

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ABSTRACT

This data article comprises the experimental data during testing a vibration control technique for structural and mechanical systems which uses new passive vibrational control device called the linear particle chain impact damper (LPCID). The LPCID consists of freely moving spherical balls of different sizes arranged linearly inside a rigid container. The data were collected by taking precise measurements from a custom-designed experimental setup. The data were collected for a freely vibrating frame structure which was released from an initial position by an electromagnet. The data presented in the article will provide a path for researchers to validate the dynamic models for several types of impact dampers such as single-unit and multi-unit impact dampers. The data will also help in understanding the nonlinear behaviour of this type of impact dampers. The article also comprises data for examining the performance of the LPCID by varying the design parameters, including mass ratios, damper clearance and chain length. The article is related to research articles by Gharib and Karkoub (2017) [1].

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E-mail address: mohamed.gharib@qatar.tamu.edu

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**Specifications Table**

| Subject               | Mechanical Engineering; Civil and Structural Engineering |
|-----------------------|----------------------------------------------------------|
| Specific subject area | Free Vibration, Passive Vibrational Control, Impact Dampers |
| Type of data          | Schematics, Tables, Graphs                               |
| How data were acquired| The data were acquired with a laser displacement sensor placed on a structure. The measured signals are calibrated with a data acquisition system. |
| Data format           | Raw, Analysed, Filtered                                  |
| Parameters for data collection | Displacement time response, frequency spectrum |
| Description of data collection | The data were collected with a laser displacement sensor placed on a structure |
| Data source location  | Data obtained from the structural vibration setup in the Mechanical Engineering Department at Texas A&M University at Qatar, Education City, Doha, Qatar |
| Data accessibility    | The data are available in this article and as a supplementary file and can be found in the online version at: https://doi.org/10.1061/j.jib.2021.107003. Also, the data are available at Mendeley repository at: https://data.mendeley.com/datasets/4xd3wkmxmr/3 |
| Related research article | M. Gharib, M. Karkoub, Experimental investigation of linear particle chain impact dampers in free-vibration suppression, Journal of Structural Engineering 143(2) (2017) 04016160. https://doi.org/10.1061/(ASCE)ST.1943-541X.0001638 |

**Value of the Data**

- The data can be used to examine the efficiency of using linear particle chain impact dampers as well as conventional impact dampers for controlling structural systems under free vibrations.
- The experimental data can be used to verify mathematical models of vibrating structures without and with impact dampers.
- The data can be used in designing efficient linear particle chain, single-unit and multi-unit impact dampers, considering various damper parameters.
- The data of the experiment is of considerable interest to the mechanical and civil engineering industries.

1. **Data Description**

Impact dampers (IDs) consist of rigid containers that include freely moving spherical ball(s) constrained by the container’s boundaries. When a primary system is excited, the collision between the damper balls and the rigid boundaries exchanges the kinetic energy and the damper dissipates the kinetic energy in different forms. In general, conventional IDs can be classified as single-unit impact dampers (SUIDs) and multi-unit impact dampers (MUIDs) [1,2]. A recent type of MUID is the linear particle chain impact damper (LPCID), which has shown more efficient damping of structural vibrations than conventional IDs. Fig. 1 shows schematics for the SUID, MUID and LPCID.

This article comprises the dataset from experimental work to measure structural vibration responses with and without SUIDs, MUIDs and LPCIDs [1]. A single degree-of-freedom structural frame was used to investigate the performance of the IDs to dampen the free vibrations that

![Fig. 1. The impact dampers (a) the single-unit impact damper, (b) the multi-unit impact damper (c) the linear particle chain impact damper.](image-url)
occur from releasing the top floor of the frame from its initial position by an electromagnet and switch arrangement. The structure's displacement measurements were collected and calibrated by a high-precision laser position sensor, reflector and data acquisition system. Several IDs were fabricated with varying dimensions to investigate the effect of varying the parameters. The dataset include lists of the numerical values and material used for the experiment setup and the IDs. Detailed geometric information can be found in [1].

The experiments were conducted with a freely vibrating frame in which vibrations were induced by releasing the top floor from an arbitrary initial position by means of fixed electromagnet and switch mechanism at the same level as the top floor. The experiments were conducted with and without dampers to study and compare the response in each case. Each ID configuration is designated its nLmS values, where L refers to large balls, S refers to small balls, n is the number of large balls and m is the number of small balls. The geometric parameters that were used in the comparisons were the damper length (d), which is the size of the container; the chain length (dC), which is the sum of all diameters of the dampers; the clearance (C), which is the available space in the damper container; and the balls’ mass ratio (μB), which is the mass ratio of small to large balls.

This article is accompanied by spreadsheet files with the same name as the figure number in [1]. For example, the data for “figure x” in [1] is listed in file “Figure x Data”. The dataset is provided as supplementary material in MS Excel format (*.xlsx). This supplementary data can be found in the online version of this paper.

The supplementary material includes the dataset for the following cases:

• the displacement time response of the top floor of the undamped structure without an ID (0L0S) and with a conventional SUID (1L0S) with a damper length (d) of 200 mm, a clearance (C) of 161.9 mm, a large ball diameter DL of 38.1 mm and a small ball diameter DS of 6.35 mm.
• the comparative displacement time response of the structure without an ID (0L0S) and with a LPCID (2L1S) with the same clearance (C = 161.9) mm as the impact SUID (1L0S) and a damper length d = 256 mm.
• the response of the structure without an ID (0L0S) and with a LPCID (2L1S) with the same damper length (d = 200 mm) as the SUID (1L0S) and a clearance of 117.4 mm.
• the top envelopes to compare the time responses for all previous cases.

2. Experimental Design, Materials and Methods

The experiments were performed with the newly designed and manufactured LPCID, which was mounted on the top floor of a one-storey frame structure to dampen the free vibrations. The fabricated LPCID consisted of two solid mild steel blocks, large and small chrome steel balls, four different plastic holders for the small balls, three damper assemblies with different chain lengths and polished stainless steel circular bars to guide the small balls' holders. The single degree-of-freedom system consisted of two rectangular rigid plates (top and bottom floors) with flexible stainless steel sheets at the sides.

The top floor of the structure was released from an initial position (40 mm) by an electromagnet that held the top plate when the switch was turned on; whenever excitation was needed, the plate was released by turning the switch controlling the electromagnet off. Fig. 2 shows the components of the experiment setup. The dimensions and materials of the damper and structure are included in the supplementary material.

The displacement time response was measured by a high precision laser optical displacement sensor with the aid of a reflector directly attached at the top floor. The measured data were calibrated and filtered with a data acquisition system and a personal computer.

An additional experiment provided additional data to evaluate the performance of the LPCID versus a SUID with a large mass. The supplementary material includes the dataset for the comparative damping performance of the top floor vibrations of the frame system with a SUID or
a LPCID, both of which had a large mass. In this dataset, the LPCID (2L1S, $D_L = 38.1$ mm and $D_S = 6.35$ mm) contained three balls with a total mass of 458.71 g and the SUID (1L0S, $D_L = 5038$ mm and $d = 200$ mm) contained a large ball with a mass of 537.7 g.

Experiments were also conducted to investigate the damping efficiency of MUIDs without small balls (1L0S, 2L0S, 3L0S, 4L0S). The supplementary material includes the dataset for:

- the time response for the 1L0S, 2L0S, 3L0S and 4L0S MUID arrangements.
- the time response for the same arrangement but with a fixed ball to examine the effect of added mass versus freely moving masses.

Additional experiments were conducted to compare the damping efficiency of the LPCID versus the MUID. The supplementary material includes the dataset for the displacement time response for the LPCIDs and MUIDs with several chain lengths (2L0S, 2L1S, 3L0S, 3L2S, 4L0S and 4L3S) with $D_L = 38.1$ mm, $D_S = 6.35$ mm and $d = 200$ mm.

Experiments were also conducted for investigation into the effect of parameter variations on the dampers’ ability to control the structure’s free vibrations. The investigated parameters were the chain length, the damper mass ratio and the damper clearance. The supplementary material for these experiments includes the dataset for:

- the effect of chain length variations in various LPCID configurations (2L1S, 3L2S and 4L3S).
- the effect of damper mass ratio variations for four small balls ($D_S = 0.25$ in, 0.50 in, 0.75 in and 1.0 in) in three different LPCID arrangements (2L1S, 3L2S and 4L3S).
- the effect of damper clearance variations with three different chain lengths (150 mm, 200 mm and 250 mm) in three different LPCID arrangements (2L1S, 3L2S and 4L3S).

**Ethics Statement**

The author duly adhered to ELSEVIER ‘Ethics in publishing’ policy.
CRediT Author Statement

Mohamed Gharib: Conceptualization, Methodology, Software, Visualization, Investigation, Data curation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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Supplementary Materials

The data are available in this article and as a supplementary file and can be found in the online version at doi:10.1016/j.dib.2021.107003.

Also, the data are available at Mendeley repository at: https://data.mendeley.com/datasets/4xd3wkmxm/3.

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107003. Videos of the experimental data presented in this paper which show sample experiments are available at: https://youtube.com/playlist?list=PLZI_dQHGpH2r9RR5KG1oiltOF0u7ILV9A.

References

[1] M. Gharib, M. Karkoub, Experimental investigation of linear particle chain impact dampers in free-vibration suppression, J. Struct. Eng. 143 (2) (2017) 04016160, doi:10.1061/(ASCE)ST.1943-541X.0001638.

[2] Z. Lu, S.F. Masri, X. Lu, Particle Damping Technology Based Structural Control, Springer, 2020.