Data in Brief 38 (2021) 107377

Contents lists available at ScienceDirect

Data in Brief

journal homepage: www.elsevier.com/locate/dib

Data Article

Acceleration time history dataset for a 3D miniature model of a shear building with structural damage

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A R T I C L E I N F O

Article history:
Received 22 April 2021
Revised 10 August 2021
Accepted 14 September 2021
Available online 16 September 2021

Keywords:
System identification
Damage detection
Shear building
Acceleration time history
Modal parameters
Non-destructive testing
Vibration-based techniques
Structural health monitoring

A B S T R A C T

The dynamics of short-to-medium height frame buildings closely resembles with a shear building. The vibrational response from a shear building model will help to understand and carry out a detailed study over the behaviour of these buildings. This data article provides acceleration time history response from a laboratory-based small-scaled (scale 1:20) three-dimensional six-storey shear building model. The article presents model specification, its assembly and experimental set-up for acquiring these data. The dataset contains free vibrational responses from the structure under both undamaged and damaged conditions. This laboratory model and corresponding experimental data are a valuable asset for the researchers working on analytical and numerical model generation, particularly in the field of structural health monitoring, in order to experimentally verify their newly developed methodologies for damage identification. The authors have provided this data to assist and contribute so as to benefit the state-of-the-art. All the datasets can be accessed via the repository link provided in the specification table. The article also provides a complete model assembly and experimentation video to its readers for a better insight into the data acquisition steps.

DOI of original article: 10.1016/j.istruc.2020.11.033
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https://doi.org/10.1016/j.dib.2021.107377

Specifications Table

Subject	Civil engineering, Structural engineering
Specific subject area	Structural health monitoring, Damage detection, Shear building laboratory model, vibration-based technique
Type of data	Table Graph Figure
How data were acquired	Vibrational responses of the floors in the form of horizontal acceleration time history were recorded with accelerometers, processed with a data acquisition system, and converted to digital data using a software, specifications of which have been presented in Table 2.
Data format	Raw
Parameters for data collection	All the tests were carried out in an ambient laboratory environmental condition. Patna district in the state of Bihar, India has Cwa (Köppen) climate condition with an average temperature of 32.4 °C in summer and 17.2 °C in winter.
Description of data collection	The experimental set-up comprises of laboratory-based small-scaled (scale 1:20) three-dimensional six-storey shear building model with sensors installed at each floor level. The structure was snapped back; allowed to vibrate freely after giving some initial displacement. The datasets contain acceleration time histories for undamaged and damaged structures. A total of twenty-five datasets for undamaged and damaged structures each are given in the Mendeley public repository. The datasets have been named in a suitable format as follows: **SB16SEPUNR_** and **SB17SEPDMR_**, where **SB**- Shear building, **16SEP**- 16th of September, **UN**- Undamaged, **DM**- Damaged, **R_** - Reading Nos. A video file describing the model assembling and the experiment has also been provided in the Mendeley public repository.
Data source location	Structural health monitoring laboratory, Block VI, Department of Civil and Environmental engineering, Indian Institute of Technology, Patna, Bihar, India Coordinates: 25.5357 °N, 84.8512 °E
Data accessibility	The data associated with this article and the video file describing the model assembling and the experiment can be accessed in the Mendeley public repository. Repository name: Mendeley Data Data identification number: 10.17632/snmz587nvb.2 Direct URL to data: http://dx.doi.org/10.17632/snmz587nvb.2
Related research article	K. Anjneya and K. Roy, Response surface-based structural damage identification using dynamic responses, Structures 29 (2021), 1047-1058, https://doi.org/10.1016/j.istruc.2020.11.033.

Value of the Data

- The paper presents a comprehensive laboratory testing data for vibration-based structural health monitoring of a shear building, to which short-to-medium height frame buildings closely resemble. This will help the researchers to suitably design a simulation model to study the global structural behaviours.
- The data represents the response of the shear building under two conditions, namely, undamaged and damaged conditions, which can be beneficial for analytical and numerical model calibration. The data can be utilized to verify any newly developed methodologies, thus benefiting the state-of-the-art.

- The experimental test recordings can be used for further model generation and developments for cutting-edge damage identification methodologies. It is also beneficial for the problems involving the generation of damping models in the structural vibrations.
- The data can be explicitly used for verifying the damage quantification capabilities of any damage quantification parameters.

1. Data Description

A free-vibration test of the laboratory-based six-storey shear building model [1,2] was carried out in the laboratory environment to capture its vibrational response. The experimental data consist of acceleration time histories for both damaged and undamaged cases. The damaged acceleration time histories correspond to a damage severity of 51.7% at fourth storey as marked in Fig. 1(a). This was achieved by replacing the columns between the third and fourth floors. The vibrational response of the structure was recorded with DeltaTron piezoelectric accelerometers, specifications of which have been provided in Table 2. A total of six numbers accelerometers were installed at the centre of each floor oriented in the direction of vibration (parallel to side A in Fig. 1(a)).

These accelerometers were connected to a data acquisition system through SubMiniature version (SMA) cables. The digital data were acquired through Pulse Labshop [3] and Pulse reflex [4] softwares, at a sampling interval of 24E-5 s. These acceleration time history data can be used to extract the modal parameters (namely, frequency and mode shape) of the structure using frequency domain decomposition (FDD) [5] or fast Fourier transformation (FFT) [6].

The acceleration time history data obtained from this experiment can be accessed from Mendeley public repository through the link in the '**Data accessibility**' section of the specification table. The data on Mendeley contains two folders named, "Undamaged dataset 16th September", "Damaged dataset 17th September", and one video file showing the detailed data acquisition procedure. Each of these folders contains a total of twenty-five acceleration time history datasets for undamaged and damaged structures, respectively. The datasets have been named in a suitable format, detail of which has been provided in the '**Description of data collection**' section in the specification table.

2. Experimental Design, Materials and Methods

The experimental setup for carrying out the vibration testing of the shear building model has been developed in the structural health monitoring laboratory at the Department of Civil and Environmental Engineering, IIT Patna, India. The experimental set up consists of a small-scaled six-storey three-dimensional model with geometrical scale of 1:20 [7]. The complete schematic diagram of the experimental model with dimensions have been shown in Figs. 1–6. The complete experimental setup has been shown in Fig. 7. The main objective to conduct this test was to obtain the acceleration time history response of the undamaged and damaged models. The time history data from the damaged structure corresponds to a damage severity of 51.7% at the fourth storey.

It will help the researchers working in the field of structural health monitoring (SHM) to verify their newly developed methodologies in damage identification capabilities. The data is also helpful for numerical and analytical model calibration. It is also beneficial for the problem involving the development of damping models in the structural vibrations.

The subsequent sections provide the model description along with the detail of experiments carried out to obtain the free vibrational response from the laboratory shear building model.

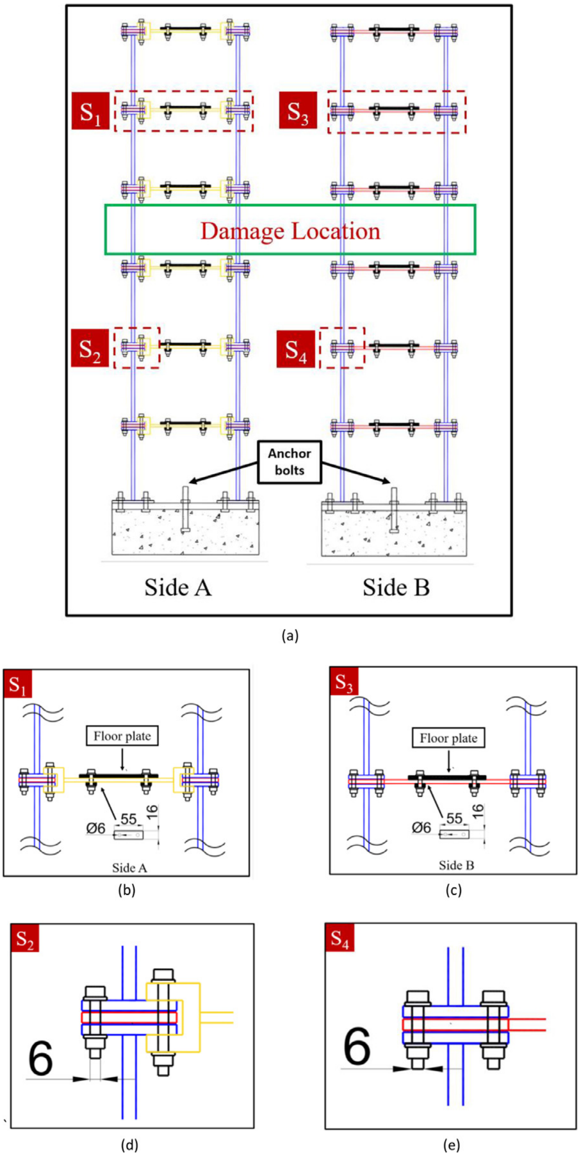


Fig. 1. Schematic diagram of the six-storey shear building (a) side views, (b) floor connections with plate connectors (Side A), (c) floor connections with plate connectors (Side B), (d) column to beam connection (Side A), (e) column to beam connection Side B.

2.1. Model description

The shear building model is designed in such a way that it can be dismantled into its components. Columns and beams with smaller cross-sectional members of same length can be used to introduce damage at any desired location. The whole structure along with its components and connections have been shown in Fig. 8. The schematic diagrams of the whole structure are shown in Fig. 1(a) where both the faces of the model are shown, marked as side A and side

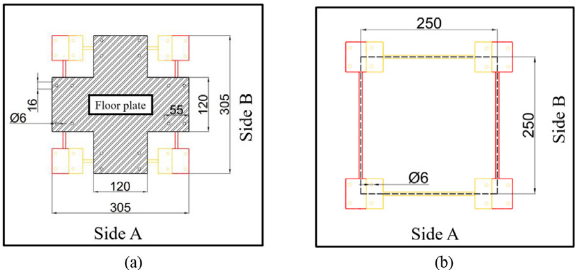


Fig. 2. Top plan view of the building model (a) with floor plate, (b) without floor plate.

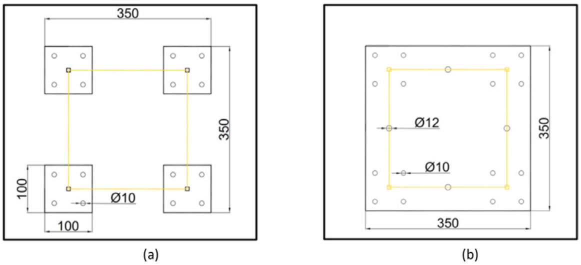


Fig. 3. (a) Bottom floor plan view (b) Bottom plate.

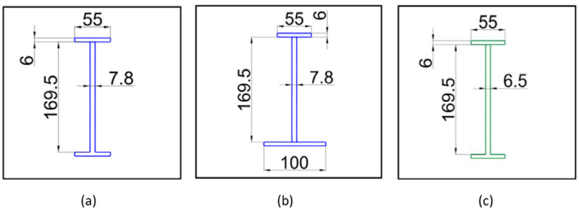


Fig. 4. Dimensions of the (a) storey column, (b) bottom storey column, (c) damaged column.

B. Fig. 1(b) and (c) shows the detailed floor connections of the sections as marked in Fig. 1(a) as S_1, S_3, respectively. Similarly, zoomed images of beam to column connections are shown in Fig. 1(d) and Fig. 1(e), respectively.

Fig. 2 shows the top view of the model with and without floor plates for better clarity. The corresponding dimensions of its components have also been shown in the diagram. The bottom storey columns of the model are connected to a mild steel plate that is fixed to the concrete block through anchor bolts. The plan view at the top of the bottom plate is shown in Fig. 3(a), while the bottom plate is shown in Fig. 3(b).

The columns at all stories are the same (Fig. 4(a)) except for the bottom storey which is wider at its base (Fig. 4(b)). The dimension of the damaged column is shown in Fig. 4(c). There are two types of beams namely, Type X and Type Y, that have been used in the model as shown in Figs. 5 and 6, respectively. These correspond to side A and side B as shown in Fig. 1.

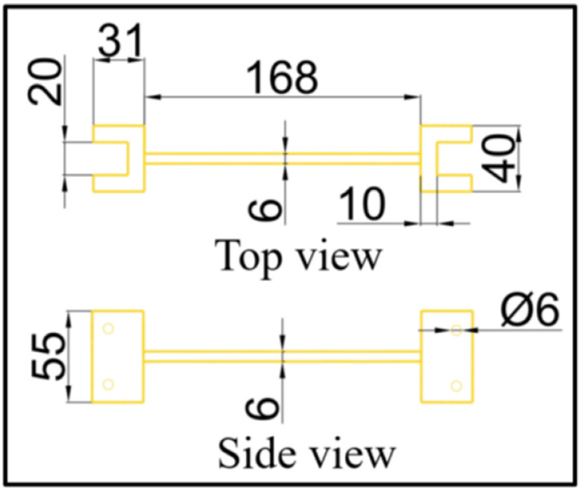


Fig. 5. Floor beam Type X, Side A.

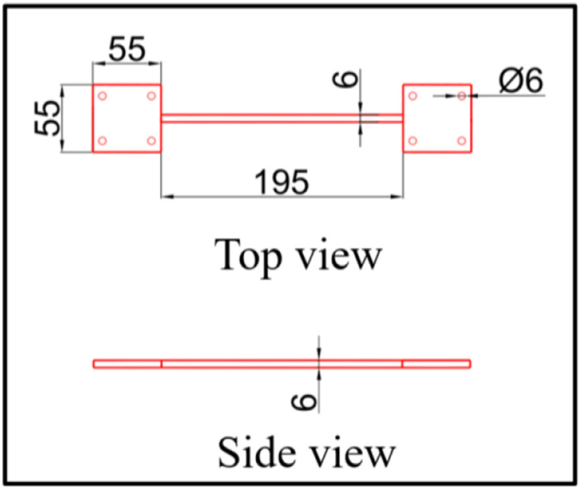


Fig. 6. Floor beam Type Y, Side B.

The model is made up of mild steel with Young's modulus, $E = 210$ GPa, Poisson's ratio, $\mu = 0.3$ and mass density, $\rho = 7.85$ g/cm^3. The model is fixed at its base to a concrete block, 350 mm × 350 mm × 250 mm in dimension. The dimensions of its various components are as follows:

Height of storey: 187.5 mm
Total height: 1125 mm
Beam cross-section: 6 mm × 6 mm
Column cross-section: (a) Undamaged: 7.8 mm × 7.8 mm, (b) Damaged: 6.5 mm × 6.5 mm
Dimension of floor: 250 mm × 250 mm

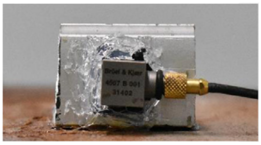
A cross-sectional schematic diagram of the beam and column have been shown in Figs. 4–6.

Table 1
Mass assigned at each floor [7]*.

Sl. No.	Floor level	Mass of plate (kg)	Mass (kg)
1	6th	2.26	7.80
2	5th	2.25	8.04
3	4th	2.16	7.95
4	3rd	2.25	8.04
5	2nd	2.27	8.06
6	1st	2.26	8.05

* Adapted from Structures, Vol. 29, Kumar Anjneya and Koushik Roy, "Response surface-based structural damage identification using dynamic responses," pp. 1047–1058, © 2021, with permission from Elsevier.

Table 2
Equipment specifications and other details.

Sl. No.	Equipment	Company name	Specifications	Picture
1.	Accelerometer	Brüel & Kjær	**Type 4507-B-001** Temperature = -54 - 121 °C Weight = 4.8 gram Sensitivity = 1 mV/ms^{-2} Residual Noise Level in Spec Freq Range (rms) ± = 800 µg Resonance frequency = 18 kHz Maximum Shock Level (± peak) = 5000 g	
2.	Data Acquisition Modules	Brüel & Kjær	**Type 3053-B-120** Included Front Panel = UA-2107-120 LAN interface Channels = 12 general-purpose input Connectors = SMB Frequency Range = 0 to 25.6 kHz Supported Signal types = Direct voltage, CCLD, charge‡	
3.	**Software**			
	Pulse Labshop and Pulse reflex	Brüel & Kjær	Used for analysis and processing of time data and spectra, FFT and modal analysis, Multi-channel analysis noise and vibration analysis using several analysers and multiple frequencies.	

The mass distribution for the model is given in Table 1 [7]. The total mass at each floor consists of the mass of the floor plates, corresponding floor beams and contributions from the columns.

2.2. Instrumentation for data acquisition

The dynamic response of the structure was recorded with Brüel and Kjær's DeltaTron piezoelectric accelerometers (Table 2) Type 4507 B 001. Accelerometers were connected with a data acquisition system using SubMiniature version (SMA) cables. The specifications of each of these equipment have been shown in Table 2.

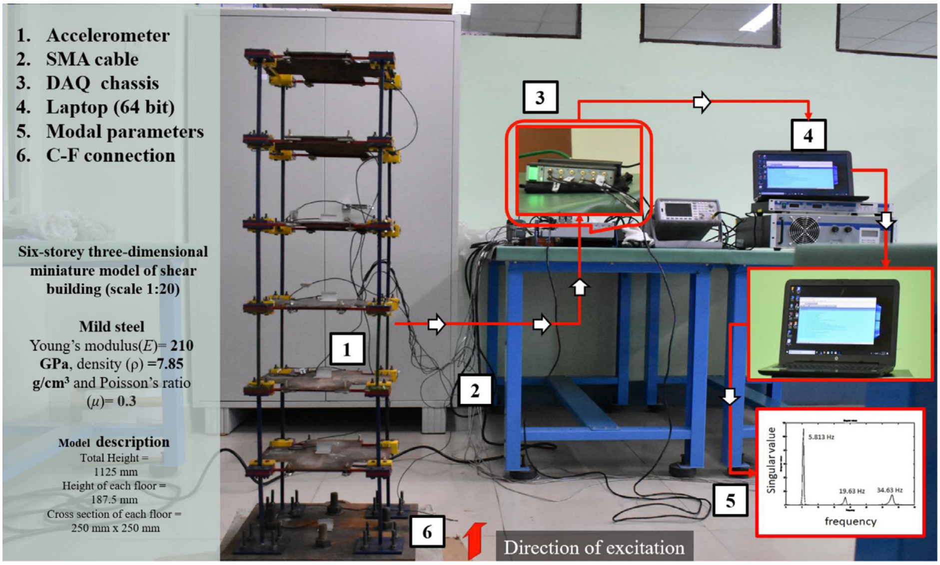


Fig. 7. Experimental setup for obtaining the dynamic response of the shear building model (Modified from [7]).

The digital data was acquired with Pulse Labshop and Pulse reflex software (Table 2) at a sampling interval of 0.00024s.

2.3. Experimental program

A total of six accelerometers was installed at each floor to acquire the structure's dynamic response. These accelerometers were installed on the L- sections fixed at the centre of each floor plates to capture the data in the direction of vibration. All accelerometers were installed in the same direction. The model was snapped back, i.e., it was allowed to vibrate freely after giving some initial displacement. The complete experimental setup has been shown in Fig. 7. A short video showing the model assembly and experimentation have been provided with this article and can be accessed via the link given in the data accessibility section.

For the undamaged structure, the columns at all the floors have a cross-section of 7.8 mm $\times$ 7.8 mm and corresponding acceleration time history data are provided with this article. The columns at fourth storey i.e., between the third and fourth floors were replaced with the columns having a cross-section of 6.5 mm $\times$ 6.5 mm to study the vibrational response of the damaged structure This corresponds to a damage severity of 51.7% and corresponding acceleration time histories data have also been provided with this data article.

Researchers interested in finding the modal parameters (frequencies and mode shapes) can carry out the FDD of these data. The representative acceleration time history plots for the data named, **SB16SEPDMR1** and **SB17SEPDMR1** (available in the Mendeley repository) corresponding to 5th storey are shown in Fig. 9. Also, the FDD plots, showing singular values of the spectral density matrix of accelerations vs frequencies for these two datasets have been shown in Fig. 10 for reference.

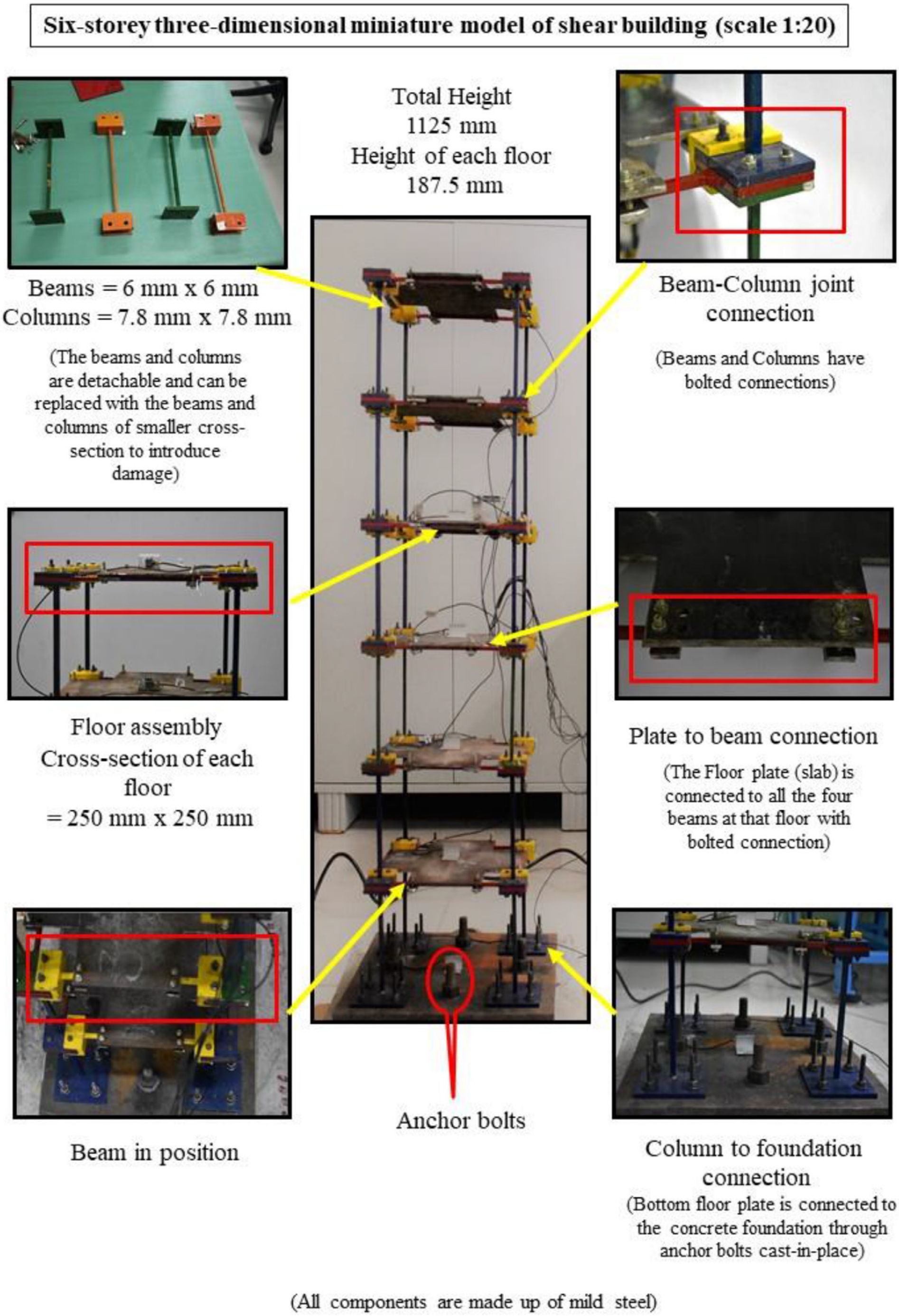


Fig 8. Model assembly, its components and connections (Modified from [7]).

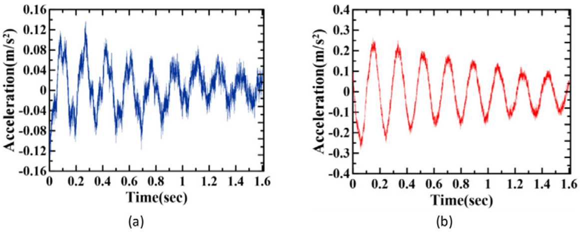


Fig. 9. A representative acceleration time history plot for 5th Storey: (a) undamaged structure, (b) damaged structure.

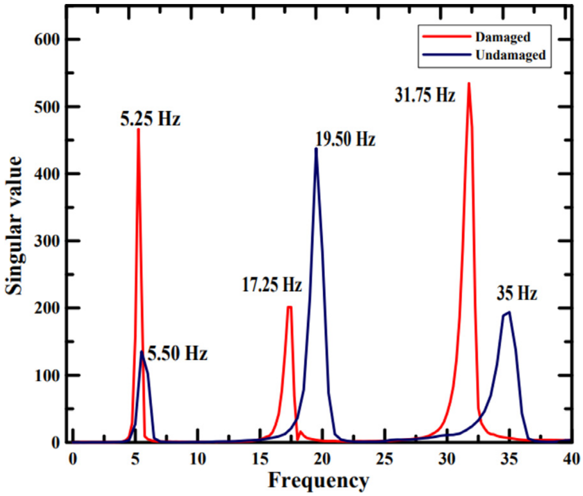


Fig. 10. A representative FDD plot showing the singular values of the spectral density matrix of accelerations vs first three modal frequencies of the laboratory model of shear building.

Ethics Statement

All the individuals and organisations involved have been given due credits and suitably acknowledged.

Declaration of Competing Interest

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

Data Availability

Acceleration time history data for experimental shear building model (Kumar Anjneya and KoushikRoy) (Original data) (Mendeley Data).

CRediT Author Statement

Kumar Anjneya: Methodology, Data curation, Software, Investigation, Validation, Writing – original draft; **Koushik Roy:** Supervision, Writing – review & editing.

Acknowledgements

The authors would like to thank the Ministry of Education (MoE), the government of India, for their financial support. The valuable advice of Dr. Vaibhav Singhal is gratefully acknowledged. The authors would also like to thank Mr. Eshwar Kuncham for assisting in video shooting of the model assembly and experimentation. Thanks also go to Md. Arif Faridi for his practical support.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.dib.2021.107377.

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