Data Article

Peak particle velocity data acquisition for monitoring blast induced earthquakes in quarry sites

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Abstract

The peak particle velocity datasets recorded during quarry blasts in the neighborhood villages and towns in Ibadan and Abeokuta were processed and analyzed in order to recommend a safe blast design for each of the quarries. The minimum peak particle velocity of 48.27 mm/s was recorded near the foundation of the nearest residence at the shot to monitored distance of 500 m. The tendency of ground vibration emanating from the quarry sites to cause damage to the structures in the nearby dwelling areas is very high. The peak particle velocity datasets recorded were not within the safe limit. Therefore the peak particle velocity that will not exceed 35 mm/s is recommended for a safe blast design.

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### Value of the data

- The data could be used as a source of information for quarry blasters to determine the relationship between the peak particle velocity and ground vibration.
- The data could be used to monitor the level of damage on structures in the neighborhood of the quarry sites.
- The data revealed Shot – Monitored distances (the distance between the shot points at the quarry sites and Building Monitored Station Points in the neighborhood of quarry sites which is very useful to quarry blasters to ensure the safety of lives and properties of residents.
- The data could serve as a measuring indicator that can be used by the Environmental protection Agency to ensure that the Peak Particle Velocity values do no exceed 50.8 mm/s recommended by the United State Bureau of Mine.

### 1. Data

The datasets presented here were recorded, using blast seismograph, during the blast induced earthquake triggered at ten quarry sites in Ibadan and Abeokuta areas, Nigeria. The data comprise peak particle velocity (longitudinal, vertical and transverse components), shot-monitored distance, charge weight and scaled distance. Of all the parameters in the datasets, the peak particle velocity dataset is the blast induced earthquake predictor. Blair [1] indicated that the peak particle velocity was strongly dependent upon the maximum charge weight in the near field and the total charge in the very far-field. On the contrary, Singh et al. [2], Singh and Vogt [3] stated that the charge weight could affect the ground vibration only at distances close to the blasts with the effects that diminish quickly with distance. And ultimately it is the charge weight that controls the ground vibration. Olofsson [4] and Persson [5] stated that the magnitude of ground vibrations depended on the quantity of explosives, characteristics of the rock, distance from the blasting site and geology of the deposits.

Pal Roy [6] carried out field investigations with blasting having charge weight varying from 0.5 to 220 t to study the influence of blast duration on ground vibrations. The results signified Charge weight (quantity of explosives) distinctively as the parameter responsible for the persistence of
ground movement. However, Zhang [7] observed that the duration of the seismic waves is directly proportional to the charge weight in a blast and inversely proportional to the distance.

The components of these datasets were considered to minimize the complaints of the residents in the neighborhood of the quarry sites. In recent years, one of the problems encountered by technical personnel who are responsible for excavation with blasting is the rightful or unjustifiable complaints of people or organizations in the neighborhood of quarry sites [8,9]. The number of these kinds of real or psychological disturbances has gradually increased with the increase in the population and urbanization. Therefore, an economical and safe blasting data should eliminate these kinds of problems at the same time. For this reason, one of the significant aspects of good blasting is safety in terms of environmental effects. One of the requirements to be met by blasting design is to determine the maximum amount of explosive per delay for a certain distance, especially in large blasts, and to be able to perform controlled blasting for the elimination of these environmental problems [10,11]. Experimental studies by explosive producers and users are being continued to determine the effects of ground vibrations and air blast induced by blasting and to be able to take necessary precautions.

Legal regulations related to this subject are being developed [12–14]. Rock blasting in urban areas creates annoying ground vibrations and also may inflict structural damage when excess quantity of explosives is used. Only about 20–30% of the energy expended, during the blasting, is utilized to fragment the rock [15]. Rock breakage process continues after the fracturing of the rock is initiated until the useful energy level becomes less than the strength of the rock [16,17]. The seismic energy released after the explosion creates a rock deformation through the particle motion. This particle motion generates ground vibrations [18,19]. The vibration problem may be minimized through the use of proper blast design techniques. The intensity of ground vibration is influenced by a number of factors such as the quantity of explosives, distance from the blast, blast geometry, etc. [20,21]. Peak particle velocity (PPV) value which is the key for the damage level prediction has been used to develop specification in several countries [22]. Particle velocity is the primary concept for investigating the damage potential of blast-induced vibrations [3].

2. Experimental design, materials and methods

The data were generated during the survey of residential buildings in the neighborhood of the quarry sites. A Global Positioning System (GPS) was used to measure Shot-Monitored distances (the distance between the shot points at the quarry sites and Building Monitored Station Points (BMSP) in the neighborhood of quarry sites). Shot-Monitored distances (D) were recorded from GPS. 3-component blast Seismographs were positioned at twenty BMSP in the dwelling areas surrounding each site. Longitudinal, vertical and transverse PPV datasets associated with the blast-induced earthquakes were recorded from the Seismograph.

Twenty PPV datasets were obtained for each site (as shown in Tables 1–10).

The patterns and protocols applied by the quarry blasters during the shots were followed in obtaining these data. For blasting operations at these sites, Ammonium Nitrate Fuel Oil (ANFO) was used as explosive. The explosives were detonated using magnadet detonator. Scaled distance (SD) data were obtained for each BMSP (as shown in Tables 1–10) using:

\[ SD = D \times W^{-0.5} \]  

Charge weight of explosive, W, tends to \( W_m \), when the quantity of explosive is maximum.

In order to establish a useful relationship between PPV and SD, as shown in Eq. (2), the PPV against SD data pairs obtained for each site was plotted using linear regression lines (Fig. 1).

\[ \log PPV = \log K - \beta \log SD \]  

\( K \) and \( \beta \) are rock energy transfer and attenuation constants of the sites determined from the log PPV versus log SD linear regression graphs.
Table 1
Datasets of ground vibration measurements and design parameters for blasting at Ladson Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^2 |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|----------------------|
|                         |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                        |
| 1                       | 300                                    | 1850                                | 110.50         | 109.45             | 108.20             | 189.46             | 6.97                   |
| 2                       | 350                                    | 1850                                | 86.25          | 85.95              | 86.15              | 149.16             | 8.14                   |
| 3                       | 400                                    | 1875                                | 70.45          | 71.25              | 69.65              | 122.17             | 9.24                   |
| 4                       | 450                                    | 1950                                | 60.20          | 60.35              | 60.10              | 104.30             | 10.20                  |
| 5                       | 500                                    | 1950                                | 50.90          | 50.20              | 49.75              | 87.10              | 11.32                  |
| 6                       | 550                                    | 1950                                | 43.70          | 43.85              | 43.15              | 75.46              | 12.46                  |
| 7                       | 600                                    | 1950                                | 39.50          | 40.50              | 38.95              | 68.68              | 13.59                  |
| 8                       | 650                                    | 1875                                | 32.35          | 32.75              | 32.45              | 56.32              | 15.01                  |
| 9                       | 700                                    | 1875                                | 28.80          | 27.50              | 28.10              | 48.74              | 16.17                  |
| 10                      | 750                                    | 1875                                | 25.75          | 24.95              | 24.85              | 43.62              | 17.32                  |
| 11                      | 800                                    | 1912.5                              | 23.60          | 22.65              | 23.85              | 40.48              | 18.29                  |
| 12                      | 850                                    | 1912.5                              | 21.45          | 21.15              | 20.95              | 36.69              | 19.44                  |
| 13                      | 900                                    | 1912.5                              | 19.55          | 19.15              | 19.85              | 33.81              | 20.58                  |
| 14                      | 950                                    | 1900                                | 17.85          | 18.95              | 17.25              | 31.23              | 21.79                  |
| 15                      | 1000                                   | 1875                                | 16.25          | 16.85              | 15.75              | 28.21              | 23.09                  |
| 16                      | 1050                                   | 2950                                | 21.65          | 20.75              | 21.15              | 36.70              | 19.33                  |
| 17                      | 1100                                   | 1800                                | 13.50          | 13.05              | 13.25              | 22.98              | 25.93                  |
| 18                      | 1150                                   | 2750                                | 17.65          | 18.75              | 17.25              | 30.99              | 21.93                  |
| 19                      | 1200                                   | 2150                                | 13.55          | 13.05              | 13.95              | 23.42              | 25.88                  |
| 20                      | 1250                                   | 2050                                | 12.20          | 11.75              | 12.55              | 21.08              | 27.61                  |

Table 2
Datasets of ground vibration measurements and design parameters for blasting at Offa Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^2 |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|----------------------|
|                         |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                        |
| 1                       | 300                                    | 1450                                | 90.85           | 90.75               | 90.25              | 156.95             | 7.88                   |
| 2                       | 350                                    | 1450                                | 71.05           | 71.30               | 70.95              | 100.94             | 9.19                   |
| 3                       | 400                                    | 1400                                | 55.75           | 55.75               | 55.08              | 96.18              | 10.69                  |
| 4                       | 450                                    | 1450                                | 47.50           | 47.40               | 47.35              | 82.13              | 11.82                  |
| 5                       | 500                                    | 1400                                | 39.05           | 39.15               | 38.95              | 67.64              | 13.36                  |
| 6                       | 550                                    | 1500                                | 35.45           | 35.55               | 35.75              | 60.63              | 14.20                  |
| 7                       | 600                                    | 1200                                | 25.70           | 25.85               | 27.45              | 45.63              | 17.32                  |
| 8                       | 650                                    | 1850                                | 32.05           | 32.00               | 32.05              | 55.48              | 15.11                  |
| 9                       | 700                                    | 1850                                | 28.40           | 28.45               | 28.35              | 49.19              | 16.27                  |
| 10                      | 750                                    | 950                                 | 14.95           | 14.90               | 14.85              | 25.81              | 24.33                  |
| 11                      | 800                                    | 1350                                | 17.80           | 17.70               | 17.85              | 30.80              | 21.77                  |
| 12                      | 850                                    | 1250                                | 15.25           | 15.20               | 15.15              | 26.33              | 24.04                  |
| 13                      | 900                                    | 1250                                | 13.95           | 13.80               | 12.95              | 23.51              | 25.46                  |
| 14                      | 950                                    | 1500                                | 14.75           | 14.85               | 14.25              | 25.32              | 24.53                  |
| 15                      | 1000                                   | 1500                                | 13.50           | 13.25               | 13.35              | 23.30              | 25.82                  |
| 16                      | 1050                                   | 1750                                | 14.25           | 13.95               | 14.05              | 24.39              | 25.10                  |
| 17                      | 1100                                   | 2350                                | 16.75           | 16.05               | 16.25              | 28.32              | 22.69                  |
| 18                      | 1150                                   | 1350                                | 10.00           | 9.85                | 10.05              | 17.26              | 31.30                  |
| 19                      | 1200                                   | 1450                                | 9.90            | 9.85                | 9.25               | 16.75              | 31.51                  |
| 20                      | 1250                                   | 2755                                | 15.50           | 15.20               | 14.95              | 26.36              | 23.81                  |
### Table 3
Datasets of ground vibration measurements and design parameters for blasting at Seed Vest Quarry.

| Data monitoring points | Shot to monitored distance (D) [metre] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^2 |
|------------------------|----------------------------------------|-------------------------------------|-------------------------------|-----------------------|
|                        |                                        |                                     | Vertical [mm/s]               |                       |
|                        |                                        |                                     | Longitudinal [mm/s]          |                       |
|                        |                                        |                                     | Transversal [mm/s]           |                       |
|                        |                                        |                                     | Vectoral Sum [mm/s]          |                       |
| 1                      | 300                                    | 1650                                | 100.75                        | 174.16                |
| 2                      | 350                                    | 1550                                | 74.90                         | 128.35                |
| 3                      | 400                                    | 1355                                | 54.30                         | 94.17                 |
| 4                      | 450                                    | 1555                                | 50.25                         | 86.63                 |
| 5                      | 500                                    | 1850                                | 48.75                         | 83.80                 |
| 6                      | 550                                    | 1900                                | 35.95                         | 62.24                 |
| 7                      | 600                                    | 1400                                | 29.15                         | 50.67                 |
| 8                      | 650                                    | 1100                                | 21.15                         | 36.17                 |
| 9                      | 700                                    | 1250                                | 20.80                         | 34.77                 |
| 10                     | 750                                    | 1500                                | 21.55                         | 36.41                 |
| 11                     | 800                                    | 1800                                | 22.45                         | 38.42                 |
| 12                     | 850                                    | 1950                                | 21.75                         | 36.85                 |
| 13                     | 900                                    | 1250                                | 13.90                         | 23.42                 |
| 14                     | 950                                    | 1250                                | 12.75                         | 21.25                 |
| 15                     | 1000                                   | 1200                                | 10.75                         | 18.62                 |
| 16                     | 1050                                   | 1950                                | 15.50                         | 26.58                 |
| 17                     | 1100                                   | 1800                                | 13.05                         | 22.73                 |
| 18                     | 1150                                   | 1800                                | 12.55                         | 21.17                 |
| 19                     | 1200                                   | 1800                                | 11.75                         | 19.44                 |
| 20                     | 1250                                   | 1950                                | 10.25                         | 18.83                 |

### Table 4
Datasets of ground vibration measurements and design parameters for blasting at Wetipp Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^2 |
|------------------------|----------------------------------------|-------------------------------------|-------------------------------|-----------------------|
|                        |                                        |                                     | Vertical [mm/s]               |                       |
|                        |                                        |                                     | Longitudinal [mm/s]          |                       |
|                        |                                        |                                     | Transversal [mm/s]           |                       |
|                        |                                        |                                     | Vectoral Sum [mm/s]          |                       |
| 1                      | 300                                    | 1600                                | 110.44                        | 191.01                |
| 2                      | 350                                    | 1450                                | 82.24                         | 142.44                |
| 3                      | 400                                    | 1850                                | 80.85                         | 140.00                |
| 4                      | 450                                    | 1700                                | 64.10                         | 86.42                 |
| 5                      | 500                                    | 1300                                | 45.30                         | 72.89                 |
| 6                      | 550                                    | 1750                                | 48.94                         | 84.74                 |
| 7                      | 600                                    | 1800                                | 64.10                         | 80.79                 |
| 8                      | 650                                    | 1800                                | 39.20                         | 68.04                 |
| 9                      | 700                                    | 1200                                | 26.24                         | 45.44                 |
| 10                     | 750                                    | 1150                                | 23.02                         | 39.85                 |
| 11                     | 800                                    | 1650                                | 27.24                         | 47.11                 |
| 12                     | 850                                    | 1050                                | 17.98                         | 30.65                 |
| 13                     | 900                                    | 1850                                | 24.95                         | 42.93                 |
| 14                     | 950                                    | 1300                                | 17.86                         | 28.87                 |
| 15                     | 1000                                   | 1950                                | 22.25                         | 38.37                 |
| 16                     | 1050                                   | 1100                                | 13.69                         | 23.55                 |
| 17                     | 1100                                   | 1250                                | 13.05                         | 24.15                 |
| 18                     | 1150                                   | 1350                                | 13.91                         | 23.80                 |
| 19                     | 1200                                   | 1500                                | 14.12                         | 24.29                 |
| 20                     | 1250                                   | 1750                                | 14.88                         | 25.74                 |
Table 5
Datasets of ground vibration measurements and design parameters for blasting at Ratcon Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance $D/W^2$ |
|------------------------|----------------------------------------|-------------------------------------|-------------------------------|--------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                      |
| 1                      | 300                                    | 1500                                | 105.61           | 104.95              | 105.24              | 182.33             | 7.75               |
| 2                      | 350                                    | 1950                                | 101.52           | 101.32              | 101.55              | 175.74             | 7.93               |
| 3                      | 400                                    | 1850                                | 77.11            | 77.00               | 69.88               | 129.45             | 9.30               |
| 4                      | 450                                    | 1100                                | 40.27            | 40.15               | 40.33               | 69.715             | 13.57              |
| 5                      | 500                                    | 1050                                | 32.28            | 31.98               | 32.17               | 55.67              | 15.43              |
| 6                      | 550                                    | 1750                                | 42.51            | 42.02               | 42.45               | 73.31              | 13.15              |
| 7                      | 600                                    | 1200                                | 26.46            | 26.39               | 26.42               | 45.77              | 17.32              |
| 8                      | 650                                    | 1400                                | 26.33            | 26.30               | 26.35               | 45.60              | 17.37              |
| 9                      | 700                                    | 1700                                | 27.39            | 27.32               | 27.43               | 47.42              | 16.98              |
| 10                     | 750                                    | 1350                                | 19.95            | 19.75               | 19.84               | 34.38              | 20.41              |
| 11                     | 800                                    | 1800                                | 22.86            | 22.84               | 22.79               | 39.54              | 18.86              |
| 12                     | 850                                    | 1300                                | 15.57            | 15.45               | 15.52               | 26.87              | 23.57              |
| 13                     | 900                                    | 1550                                | 16.42            | 16.35               | 16.40               | 28.39              | 22.86              |
| 14                     | 950                                    | 1200                                | 12.00            | 12.05               | 12.02               | 20.83              | 27.42              |
| 15                     | 1000                                   | 1950                                | 16.69            | 16.66               | 16.62               | 28.85              | 22.65              |
| 16                     | 1050                                   | 1900                                | 15.00            | 15.05               | 15.02               | 26.02              | 24.09              |
| 17                     | 1100                                   | 1100                                | 8.66             | 8.59                | 8.62                | 13.94              | 33.17              |
| 18                     | 1150                                   | 1400                                | 8.87             | 8.89                | 8.84                | 15.36              | 30.74              |
| 19                     | 1200                                   | 1550                                | 10.01            | 10.05               | 10.08               | 17.40              | 30.48              |
| 20                     | 1250                                   | 1650                                | 9.85             | 9.79                | 9.81                | 15.01              | 30.77              |

Table 6
Datasets of ground vibration measurements and design parameters for blasting at Equation Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance $D/W^2$ |
|------------------------|----------------------------------------|-------------------------------------|-------------------------------|--------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                      |
| 1                      | 300                                    | 1400                                | 114.70           | 114.75              | 114.72              | 198.71             | 8.02               |
| 2                      | 350                                    | 1250                                | 84.85            | 84.82               | 83.97               | 146.44             | 9.90               |
| 3                      | 400                                    | 1600                                | 83.63            | 82.98               | 83.45               | 144.37             | 10.00              |
| 4                      | 450                                    | 1150                                | 55.81            | 55.78               | 55.84               | 96.67              | 13.27              |
| 5                      | 500                                    | 1000                                | 43.44            | 43.41               | 43.52               | 75.27              | 15.81              |
| 6                      | 550                                    | 2050                                | 63.32            | 63.25               | 63.30               | 109.62             | 12.15              |
| 7                      | 600                                    | 1350                                | 41.48            | 41.35               | 41.44               | 71.75              | 16.33              |
| 8                      | 650                                    | 1250                                | 35.01            | 34.85               | 34.96               | 60.52              | 18.38              |
| 9                      | 700                                    | 1650                                | 38.40            | 38.38               | 34.42               | 64.28              | 17.23              |
| 10                     | 750                                    | 1250                                | 28.53            | 28.49               | 28.51               | 49.38              | 21.21              |
| 11                     | 800                                    | 1900                                | 35.10            | 35.03               | 35.06               | 60.73              | 18.35              |
| 12                     | 850                                    | 1350                                | 25.21            | 25.14               | 25.26               | 43.65              | 23.13              |
| 13                     | 900                                    | 1300                                | 22.61            | 22.63               | 22.58               | 39.16              | 24.96              |
| 14                     | 950                                    | 1700                                | 25.35            | 25.29               | 25.31               | 43.85              | 23.04              |
| 15                     | 1000                                   | 1550                                | 22.05            | 22.12               | 22.09               | 38.26              | 25.40              |
| 16                     | 1050                                   | 1650                                | 21.51            | 21.46               | 21.54               | 37.24              | 25.85              |
| 17                     | 1100                                   | 1500                                | 18.80            | 18.75               | 18.72               | 32.49              | 28.40              |
| 18                     | 1150                                   | 1250                                | 15.48            | 15.39               | 15.43               | 26.73              | 32.53              |
| 19                     | 1200                                   | 1450                                | 16.20            | 16.08               | 16.13               | 27.95              | 31.51              |
| 20                     | 1250                                   | 1750                                | 17.48            | 17.42               | 17.51               | 30.26              | 29.88              |
Table 7
Datasets of ground vibration measurements and design parameters for blasting at Verytaces Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance $D/W^2$ |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|-------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                           |
| 1                      | 300                                    | 1050                                | 142.91          | 142.94              | 142.89              | 247.53              | 9.26                      |
| 2                      | 350                                    | 1150                                | 125.71          | 125.69              | 125.74              | 217.74              | 10.32                     |
| 3                      | 400                                    | 1250                                | 112.80          | 112.72              | 112.77              | 195.31              | 11.31                     |
| 4                      | 450                                    | 1400                                | 104.95          | 104.91              | 103.89              | 181.15              | 12.03                     |
| 5                      | 500                                    | 1450                                | 94.62           | 94.58               | 94.53               | 163.81              | 13.13                     |
| 6                      | 550                                    | 1300                                | 79.28           | 79.34               | 79.38               | 137.41              | 15.25                     |
| 7                      | 600                                    | 1450                                | 76.31           | 75.95               | 76.26               | 131.94              | 17.56                     |
| 8                      | 650                                    | 1350                                | 66.56           | 66.51               | 66.62               | 115.29              | 17.69                     |
| 9                      | 700                                    | 1650                                | 68.65           | 67.93               | 68.62               | 118.47              | 17.23                     |
| 10                     | 750                                    | 1500                                | 59.83           | 59.87               | 59.68               | 103.57              | 19.36                     |
| 11                     | 800                                    | 1100                                | 46.17           | 46.10               | 46.05               | 79.86               | 24.12                     |
| 12                     | 850                                    | 1000                                | 40.63           | 40.57               | 40.53               | 70.28               | 26.88                     |
| 13                     | 900                                    | 1300                                | 44.34           | 44.39               | 44.42               | 76.87               | 24.96                     |
| 14                     | 950                                    | 1200                                | 39.68           | 39.60               | 39.65               | 68.66               | 27.42                     |
| 15                     | 1000                                   | 1700                                | 45.87           | 45.83               | 45.78               | 79.37               | 24.25                     |
| 16                     | 1050                                   | 1600                                | 41.78           | 41.66               | 41.72               | 72.26               | 26.25                     |
| 17                     | 1100                                   | 1100                                | 31.71           | 31.70               | 31.64               | 54.88               | 33.17                     |
| 18                     | 1150                                   | 1050                                | 29.27           | 29.15               | 29.21               | 50.59               | 35.49                     |
| 19                     | 1200                                   | 1350                                | 32.29           | 32.35               | 32.19               | 55.90               | 32.66                     |
| 20                     | 1250                                   | 1250                                | 29.40           | 29.34               | 29.31               | 50.84               | 35.36                     |

Table 8
Datasets of ground vibration measurements and design parameters for blasting at Phoenix Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance $D/W^2$ |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|-------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                           |
| 1                      | 300                                    | 1550                                | 79.83           | 79.80               | 79.88              | 138.28              | 7.62                      |
| 2                      | 350                                    | 1600                                | 61.13           | 61.22               | 61.18              | 105.96              | 8.75                      |
| 3                      | 400                                    | 1650                                | 48.67           | 48.53               | 48.62              | 84.19               | 9.85                      |
| 4                      | 450                                    | 1450                                | 34.23           | 34.15               | 34.20              | 59.22               | 11.82                     |
| 5                      | 500                                    | 1950                                | 37.17           | 37.32               | 37.24              | 64.51               | 11.32                     |
| 6                      | 550                                    | 1750                                | 27.86           | 27.91               | 27.83              | 48.27               | 13.15                     |
| 7                      | 600                                    | 1850                                | 20.95           | 20.87               | 20.90              | 36.21               | 15.24                     |
| 8                      | 650                                    | 1250                                | 14.59           | 14.50               | 14.63              | 25.24               | 18.38                     |
| 9                      | 700                                    | 1350                                | 13.62           | 13.57               | 13.51              | 23.50               | 19.05                     |
| 10                     | 750                                    | 1450                                | 12.77           | 12.70               | 12.82              | 22.11               | 19.70                     |
| 11                     | 800                                    | 1450                                | 11.27           | 11.22               | 11.19              | 19.45               | 21.01                     |
| 12                     | 850                                    | 1500                                | 10.36           | 10.42               | 10.39              | 18.00               | 21.95                     |
| 13                     | 900                                    | 1600                                | 9.88            | 9.75                | 9.82               | 17.00               | 22.25                     |
| 14                     | 950                                    | 1350                                | 7.55            | 7.48                | 7.61               | 13.07               | 25.86                     |
| 15                     | 1000                                   | 1250                                | 6.35            | 6.27                | 6.40               | 10.98               | 28.28                     |
| 16                     | 1050                                   | 1050                                | 4.89            | 4.81                | 4.76               | 8.35                | 32.40                     |
| 17                     | 1100                                   | 1100                                | 4.67            | 4.55                | 4.63               | 8.00                | 33.17                     |
| 18                     | 1150                                   | 1250                                | 4.85            | 4.80                | 4.78               | 8.33                | 32.53                     |
| 19                     | 1200                                   | 1600                                | 5.67            | 5.59                | 5.62               | 9.75                | 30.00                     |
| 20                     | 1250                                   | 1750                                | 5.71            | 5.76                | 5.82               | 9.98                | 29.88                     |
Table 9
Datasets of ground vibration measurements and design parameters for blasting at Associated Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^{1/2} |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|--------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                      |
| 1 300                  | 1200                                   | 106.00                              | 106.12          | 106.04          | 183.69           | 8.66                |
| 2 350                  | 1150                                   | 83.21                               | 83.12           | 83.19           | 144.06           | 10.32               |
| 3 400                  | 1800                                   | 94.28                               | 94.15           | 94.22           | 163.19           | 9.43                |
| 4 450                  | 1850                                   | 81.66                               | 81.58           | 81.52           | 141.31           | 10.46               |
| 5 500                  | 1950                                   | 73.22                               | 73.27           | 73.31           | 126.90           | 11.32               |
| 6 550                  | 1450                                   | 52.33                               | 52.26           | 52.20           | 90.52            | 14.44               |
| 7 600                  | 1350                                   | 44.18                               | 44.25           | 44.09           | 76.51            | 16.33               |
| 8 650                  | 1450                                   | 41.56                               | 41.48           | 41.61           | 71.97            | 17.07               |
| 9 700                  | 1500                                   | 38.40                               | 38.35           | 38.46           | 66.52            | 18.07               |
| 10 750                 | 1750                                   | 38.83                               | 38.79           | 38.88           | 67.26            | 17.93               |
| 11 800                 | 1650                                   | 34.11                               | 34.09           | 34.07           | 59.02            | 19.69               |
| 12 850                 | 1700                                   | 32.03                               | 32.11           | 31.98           | 55.49            | 20.62               |
| 13 900                 | 1750                                   | 30.20                               | 30.32           | 30.27           | 52.42            | 21.51               |
| 14 950                 | 1600                                   | 26.34                               | 26.25           | 26.30           | 45.55            | 23.75               |
| 15 1000                | 1850                                   | 27.13                               | 26.85           | 27.02           | 46.77            | 23.25               |
| 16 1050                | 1400                                   | 20.93                               | 20.79           | 20.84           | 36.12            | 28.06               |
| 17 1100                | 1450                                   | 20.11                               | 20.23           | 20.16           | 34.93            | 28.89               |
| 18 1150                | 1350                                   | 18.00                               | 18.19           | 18.11           | 31.35            | 31.30               |
| 19 1200                | 1800                                   | 20.70                               | 20.81           | 20.62           | 35.87            | 28.28               |
| 20 1250                | 1950                                   | 20.68                               | 20.52           | 20.60           | 35.68            | 28.31               |

Table 10
Datasets of ground vibration measurements and design parameters for blasting at United Quarry.

| Data monitoring points | Shot to monitored distance (D) [metres] | Charge weight (in 50 holes) (W) [kg] | Peak Particle velocity (mm/s) | Scaled distance D/W^{1/2} |
|------------------------|----------------------------------------|-------------------------------------|-----------------------------|--------------------------|
|                        |                                        |                                     | Vertical [mm/s] | Longitudinal [mm/s] | Transversal [mm/s] | Vectoral Sum [mm/s] |                      |
| 1 300                  | 850                                    | 83.56                               | 83.47           | 83.66           | 144.74           | 10.29               |
| 2 350                  | 750                                    | 61.96                               | 61.84           | 61.75           | 107.13           | 12.78               |
| 3 400                  | 1300                                   | 75.32                               | 75.40           | 74.28           | 129.91           | 11.09               |
| 4 450                  | 1100                                   | 57.05                               | 57.22           | 57.15           | 98.97            | 13.57               |
| 5 500                  | 650                                    | 34.31                               | 34.38           | 34.43           | 59.54            | 19.61               |
| 6 550                  | 1500                                   | 53.57                               | 53.48           | 53.65           | 92.78            | 14.20               |
| 7 600                  | 1750                                   | 52.84                               | 52.72           | 52.90           | 91.49            | 14.34               |
| 8 650                  | 950                                    | 31.04                               | 31.15           | 31.24           | 53.94            | 21.09               |
| 9 700                  | 1000                                   | 29.03                               | 29.12           | 28.86           | 50.24            | 22.14               |
| 10 750                 | 1300                                   | 31.63                               | 31.56           | 31.72           | 54.80            | 20.80               |
| 11 800                 | 950                                    | 23.31                               | 23.42           | 23.38           | 40.48            | 25.96               |
| 12 850                 | 950                                    | 21.44                               | 21.56           | 21.49           | 37.23            | 27.58               |
| 13 900                 | 1200                                   | 23.27                               | 23.08           | 23.16           | 40.13            | 25.98               |
| 14 950                 | 1550                                   | 25.77                               | 25.62           | 25.70           | 44.51            | 24.13               |
| 15 1000                | 850                                    | 15.86                               | 15.92           | 15.80           | 27.47            | 34.30               |
| 16 1050                | 1400                                   | 20.93                               | 20.85           | 20.77           | 36.11            | 28.06               |
| 17 1100                | 1400                                   | 19.63                               | 19.75           | 19.81           | 34.17            | 29.40               |
| 18 1150                | 700                                    | 11.44                               | 11.29           | 11.38           | 19.69            | 43.47               |
| 19 1200                | 1600                                   | 19.08                               | 19.22           | 18.97           | 33.07            | 30.00               |
| 20 1250                | 1000                                   | 13.04                               | 13.17           | 13.29           | 22.81            | 39.53               |
Fig. 1. Logarithmic plot of Peak Particle Velocity against Scaled Distance datasets at Five major Quarry Sites each in Ibadan and Abeokuta, Nigeria. Ibadan quarry sites are: (i) Ladson (ii) Offa (iii) Seedvest (iv) Wetipp and (v) Ratcon. Abeokuta quarry sites are: (vi) Equation, (vii) Verytaces, (viii) Phoenix, (ix) Associated and (x) United.
The maximum quantity of explosives ($W_m$) that can be detonated safely was determined using Eqs. (1) and (2).

The PPV datasets obtained from ground vibrations at all the monitored stations recorded ranged from 9.98 to 247.53 mm/s. The PPV exceeded 50.8 mm/s recommended by the United States Bureau of Mine (USBM) at 55% of BMSP. The PPV data revealed that the vibration intensities were not bearable at most of the monitored stations. The analysis of data signifies that there is a correlation between the exceeded or large PPV recorded and the cracked walls of buildings in the vicinity of quarry sites.

A combination of scaled distance and geological constants, $k$ and $\beta$ parameters obtained from the regression lines in Fig. 1, could be used to predict the exact PPV associated with the vibration intensities of the quarry sites. Combination of these parameters with the PPV could also be used to determine the maximum quantity of the explosive to be detonated that will not cause damage to the buildings and structures around the sites.

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Transparency document. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.dib.2018.04.103.

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