Arching Patterns in Three Dimensions of Sand Under Vertically Vibrated

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Abstract

This research studied the arching patterns of sand in 3D under vertical vibration by considering the vibration conditions such as frequency, amplitude and the dimensionless vibration acceleration. In addition, the mechanism of the system from video recording and object tracking was analyzed. It was found that the frequency and amplitude of the vibrator were set in vertically.Cymatics was described the science of wave phenomena of vibration wave forces.In this experiment the source of sound was connected via a wave driver to the acrylic plate with fine sand strewn on it. Found that, the arching patterns were observed using square plates for frequency 150-180 Hz (grille pattern) and lower 100-140 Hz (corner pattern) and higher octaves 200-250 Hz (concave square pattern). However, the arching patterns are dependent on the dimensions of the plate, and it may be noted that these are kept constant and not varied while conducting the experiments.The variation was consistent. When the frequency was increased, the amplitude decreased. It demonstrated that the lower the system vibration was, the lower the amplitude would be. The Arching patterns of sand depended on the frequency, amplitude and the dimensionless vibration acceleration divided into 3 types: corner, grille and concave square.

Keywords: Archingpatterns, Sand, Vertical vibration, Thedimensionless vibration acceleration

Introduction

Granular materials consist of a number of solid granular material and the gap between the granular materials. Liquid such as water or air can run through the gap. The circle material is considered to be one of the interesting mechanisms to study because they have been used in many industrial processes such as sand, plastic beads, and pelleted. This kind of materials are held together only because of gravity. This shows liquidity property of the material. Therefore, it is unusual as it has both solid and liquid property. (Jaeger & Nagel, 1992) When this kind of material is vibrated or shaken, there are many interesting phenomena occurred which are arching, heaping, segregation, surface waves, convection, and others. (Sinnott & Cleary, 2009)The dynamics of granular materials which are the property of flowing and sedimentation and these are important processes in many industries such as chemical industry, pharmaceutical industry, food and agriculture, civil engineering, mechanical engineering, chemical engineering, physics, applied mathematics, and astronomy. Cymatics was described the science of wave phenomena of vibration wave forces. In this experiment the source of sound was connected via a wave driver to the acrylic plate with fine sand strewn on it. The sound vibrations cause the plate to vibrate at the same frequency, which causes movement of the sand particles to form patterns of the sound generated. The study of wave phenomena is also called cymatics. Sound vibrations can come in contact physically through the body and have an effect on our consciousness at the mental, emotional and spiritual levels (Meera, 2018). For this reason, it requires the knowledge in natural physics such as the arching of sand, sand and land erosion. Therefore, it leads to the new study focusing on the nature of small materials that are moving constantly. (Goldman, Shattuck, Moon, Swift, & Swinney, 2003) Thus, I am interested in experimenting arching patterns in three dimensions of sand under vertical vibration on acrylic plate (Aoki, Akiyama, Maki, & Watanabe, 1996). The arching patterns under vertical vibration is when the sand combines on the acrylic plate (Gallas, Herrmann, & Sokolowski, 1992); other factors are considered such as the factors of frequencies, amplitude, and dimensionless vibration acceleration. (Eshuis, Weele, Meer, Bos, & Lohse, 2007) Video records and tracker version 4.92 were used to analyze the mechanism. I hope that this research project will be useful and be a guideline to develop knowledge regarding granular material and the application of it for students, lecturers, researcher, and people are interested in this issue.

Methods and Materials

This research is to study the arching patterns of sand on a square acrylic plate under vertical vibration. To study the results of arching patterns in three dimensions of sand under vertically vibrated. (Bizon, Shattuck, Swift, McCormick, & Swinney, 1998) I have invented the tool to conduct this experiment which was a speaker of 40 watt and acrylic plate in the size of 0.1 cm in thickness, 18 cm in length, and 18 cm in width. The experiment was divided into two phases. The details are as follow:

1) To study parameter adjustment of the vertical vibration. Digital function generator was used to identify the proper frequency to use in this experiment. After that, sand and other materials used in the experiment were prepared as shown in Figure 1. To study the arching of the sand, amplitude in the speaker in each frequency was identified. It was identified by tracking the vibration of the acrylic plate using Tracker version 4.92. The amplitude was calculated based in the following equation:

$$A = \frac{|y_{max} - y_{min}|}{2} \quad (1)$$

When A is the amplitude of the vibration, Ymax is the maximum period of vertical vibration and Ymin is the minimum period of vertical vibration.

2) To study the patterns of arching sand under vertical vibration from calculating $\Gamma=$ the dimensionless vibration acceleration based on the following equation:

$$\Gamma = \frac{A\omega^2}{g} = \frac{A(4\pi^2 f^2)}{g} \quad (2)$$

When $\Gamma=$ dimensionless vibration acceleration,f is the frequency of the vibration (Hz) and g is the gravity acceleration.The experimental were used the signal generator to connected to the Digital function generator. The acrylic plate (square) is fitted at its centre on the sound vibrations (speaker), to be able to vibrate freely upon excitation. (see the images in figure 1)

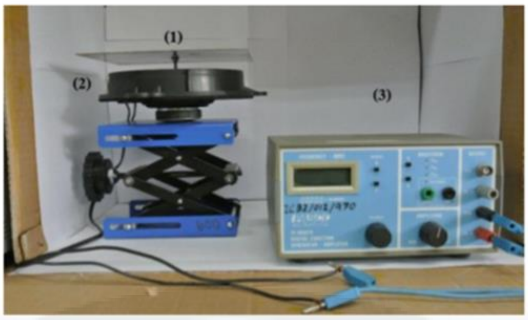

Figure 1 demonstrated the installed equipment consisting of (1) acrylic plate (2) speaker (3) Digital function generator

The fine sand particles was sprinkled on the metal plate. The desired frequency is set on the signal source and the volume gradually increased, to find the vibration 'Chladni' patterns being formed on the acrylic plate by the movement of the sand towards the regions of the nodes and forming the respective patterns (see the images in figure 3, 4 and 5).

Results

The arching patterns of three dimensions sand under vertical vibration was studied in two phases. 1) The first phase was to study parameter adjustment of the vertical vibration. Digital function generator connected to vertical vibration was used to identify the proper frequency to use in this experiment. The proper frequency used in the experiment was ranged between $100 \leq f \leq 250$Hz. Therefore, the amplitude was raged between $1.0 \leq A \leq 4.0$mm when the frequency was increased, the amplitude was decreased (Zhang, Wang, Liu, Wu, & Zhan, 2014) as shown in Figure 2. It was found that the frequency and the amplitude used to set the vertical vibration were inverse variation which was when frequency increased, the amplitude dropped. The proper frequency used in the experiment was ranged between $100 \leq f \leq 250$Hz. (Cross & Hohenberg, 1993) The amplitude was the change of the size in vertical axis between the highest point to the lowest point. This was calculated by tracking the acrylic plate using Tracker version 4.9. It resulted in the arching patterns of sand shown in Figure 3. The arching patterns of the sand on acrylic plate that were the clearest to observe was in the frequency range of 100-180 Hz. It was corner pattern. Moreover, in Figure 4, the arching patterns of the sand on acrylic plate that were the clearest to observe was in the frequency range of 150-180 Hz known as grille pattern. Furthermore, in Figure 5, the arching patterns of the sand on acrylic plate that were the clearest to observe was in the frequency range of 150-180 Hz known as concave square pattern. This was because the frequency and the amplitude triggered the arching pattern of the sand in each frequency.

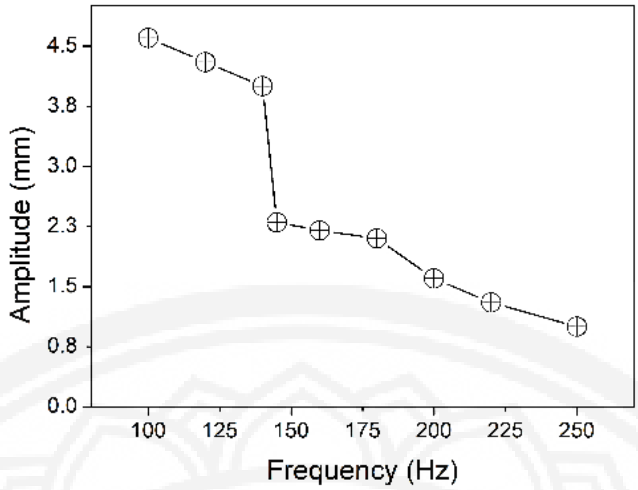

Figure 2 demonstrated the relation between frequency and amplitude used to set vertical vibration discussion

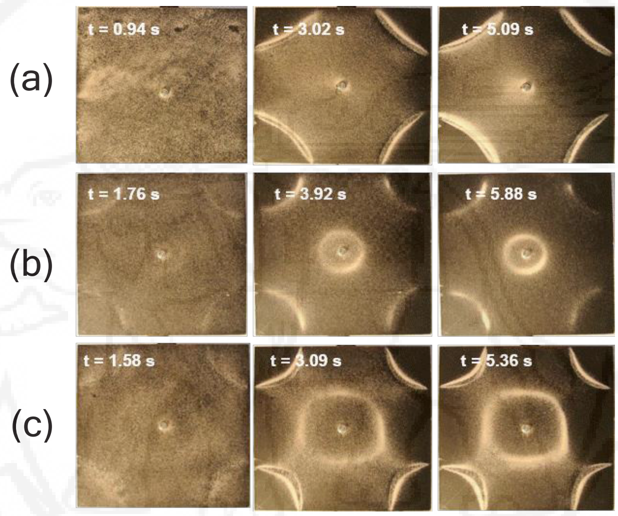

Figure 3 demonstrated the arching pattern of the sand known as corner pattern with different frequencies which were (a)f=100Hz,A=4.0mm(b)f=120Hz,A=4.0mm(c)f=140Hz,A=4.0mm

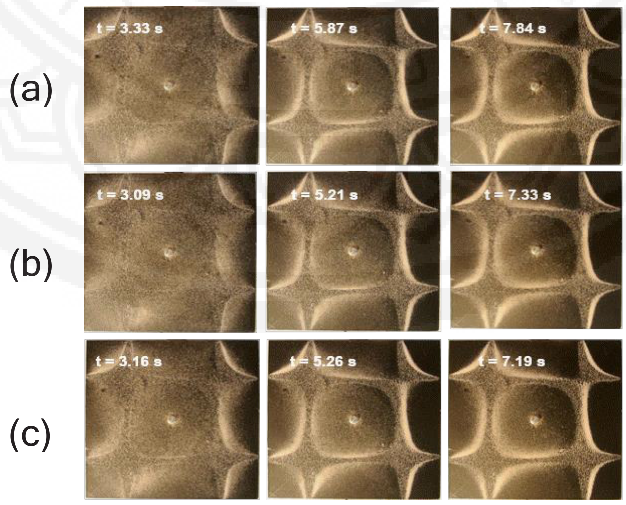

Figure 4 demonstrated the arching pattern of the sand known as grille pattern with different frequencies which were (a)f=150Hz,A=2.0mm(b)f=160Hz,A=2.0mm(c)f=180Hz,A=2.0mm

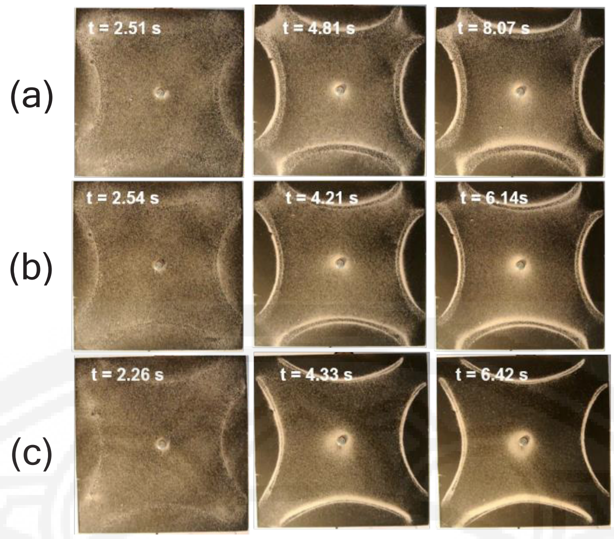

Figure 5 demonstrated the arching pattern of the sand known as concave square pattern with different frequencies which were (a) f = 200 Hz, A = 1.0 mm (b) f = 225 Hz, A = 1.0 mm (c) f = 250 Hz, A = 1.0 mm

2) The second phase was to study the arching patterns of the sand under vertical vibration. According to the study of vertical vibrator, it was known that. The ability of the vibrator was ranged in $100 \leq f \leq 250$ Hz in order to calculate the acceleration of the system by tracking the acrylic plate using Tracker version 4.92. The acceleration of the vibration was ranged in $18.8g \leq \Gamma \leq 32.1g$ as shown in figure 6.

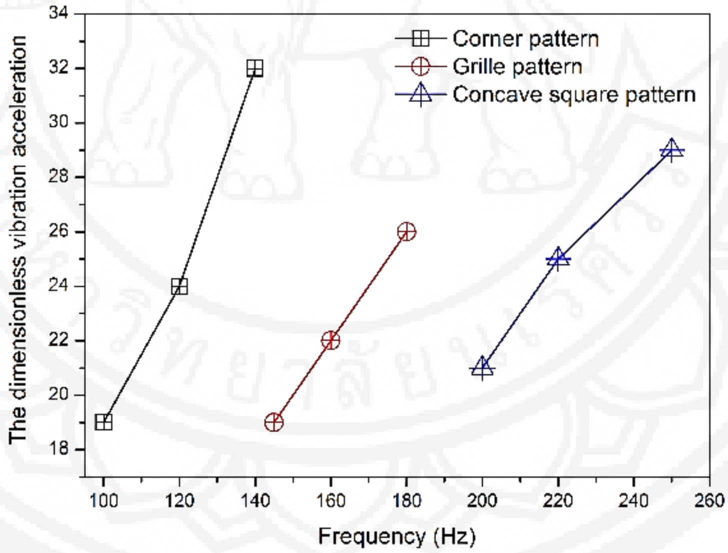

Figure 6 demonstrated the arching patterns of sand between frequency and dimensionless vibration acceleration (Γ)

According to Figure 6, it can be seen that the ranges of the frequency and the dimensionless vibration acceleration were divided into 3 groups. As the dimensionless vibration depended on frequency and the amplitude, it showed that the dimensionless vibration of the sand arching patterns was in the frequency range of 100-140 Hz resulting in corner pattern, the frequency range of 150-180 Hz resulting in grille pattern and the frequency range of 200-250 Hz resulting in concave square pattern. The most obvious pattern was observed in the frequency range between 150-180 Hz. From this experiment, we were trials using less frequencies range ($100 \leq f \leq 250$). The arching patterns were observed using square plates for frequency 150-180 Hz (grille pattern) and lower 100-140 Hz (corner pattern) and higher octaves 200-250 Hz (concave square pattern). Meera (2018) used frequencies range ($110 \leq f \leq 440$), which each frequency were a consistent form consistency of arching pattern at frequency range (150-180 Hz). But, the different arching patterns were observed using square plates for frequency 440 Hz and lower/higher octaves (consonant notes). So that, consistent of the patterns are dependent on the dimensions of the plate, and it may be noted that these are kept constant and not varied while conducting the experiments.

Conclusion and Suggestions

According to the mentioned experiment to study the vertical vibration, it was found that the frequency and amplitude was inverse variation when the frequency was $100 \leq f \leq 250$Hz and the amplitude was $1.0 \leq A \leq 4.0$ mm. It was calculated by tracking the acrylic plate using Tracker version 4.92. This resulted in the arching patterns of sand on acrylic sheet. Furthermore, the study of sand arching under vertical vibration when the ability of the frequency was in $100 \leq f \leq 250$ led to the decrease of the amplitude. To calculate the acceleration of the vibration from tracking the acrylic plate by using Tracker version 4.92, it was found that the acceleration of the vibration was in the range causing the change of sand arching patterns that depended on the change of the frequency. The amplitude and the dimensionless vibration acceleration were divided into corner pattern in frequencies 150-180 Hz, grille pattern in frequencies 200-250 Hz, and concave square pattern. When the dimensionless vibration acceleration was increased, the sand arching pattern was seen more clearly. The results from this experiment can be applied to industries related to arching of the materials and be able to know the results of the sand patterns in each size. It can also be applied to mathematic simulation in order to examine advanced dynamics system.

In studies, cymatics also developed a theory that molecules inside each cell of our body can be positively affected by sound vibration. The vibrations can work via the chakras the energy system, the endocrine system, generating a healing effect from a subtle level through to the physical, mental and emotional levels. This paves the way for possibility of further research in this area of healing and therapy for improving our health and well-being (Meera, 2018).

Acknowledgments

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