Kanazawa Izumigaoka High School 01

The Most Annoying Sound in School
~Analysis of the Noise Made by Chalks on a Blackboard~

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Abstract

Blackboards and chalks are familiar things for students. When we wrote on blackboards with chalks, sometimes we got a high-pitched noise which made us uncomfortable. We thought we could make school life comfortable by eliminating this noise. We researched the frequency of the sound by using a smartphone app which divides the sound into frequencies. We found the noise did not occur with short chalks. We found that they made a higher frequency than long chalks did. We speculated the physical surface characteristics have something to do with this phenomenon. We tried to find the way to eliminate the noise.

1. Purpose and Background

According to previous research[1], this sound is related to the Stick-Slip phenomenon. This phenomenon is that when we rub A: an object against B: another object, they make kinetic friction and static friction alternately. This makes a high-pitched noise. For example, the sound of a violin[2] , or a car suddenly braking[3]. We could find few research which was related to this noise, so we conducted our research. These were our purposes.

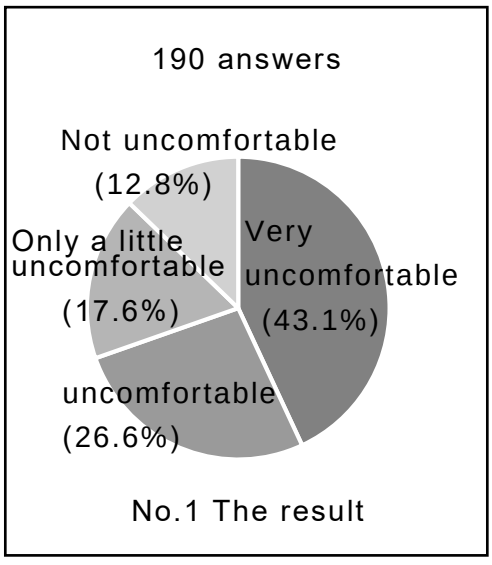
・To reveal the characteristics of the noise and occurrence conditions.
・To find ways to avoid generating it.
※We defined the annoying sound as a high-pitched noise made by chalks and a blackboard.

2. Questionnaire

We conducted a questionnaire to know the ratio of people in Izumigaoka high school who feel uncomfortable hearing the sound. We got 190 answers (No.1).

The results showed 87.2% of the people felt uncomfortable. 43.1% of those people felt very uncomfortable.

※We used Google Form.
※We calculated the answer to two significant figures.



No.1 The result

3. Experiment to study chalks' length and frequencies

[1]Purpose

To learn characteristics of the noise.

[2]Experiment1

[2]-1Hypothesis

Chalks' length is related to the noise frequencies.

[2]-2Method

(a)We measured the length to three significant figures using a caliper.

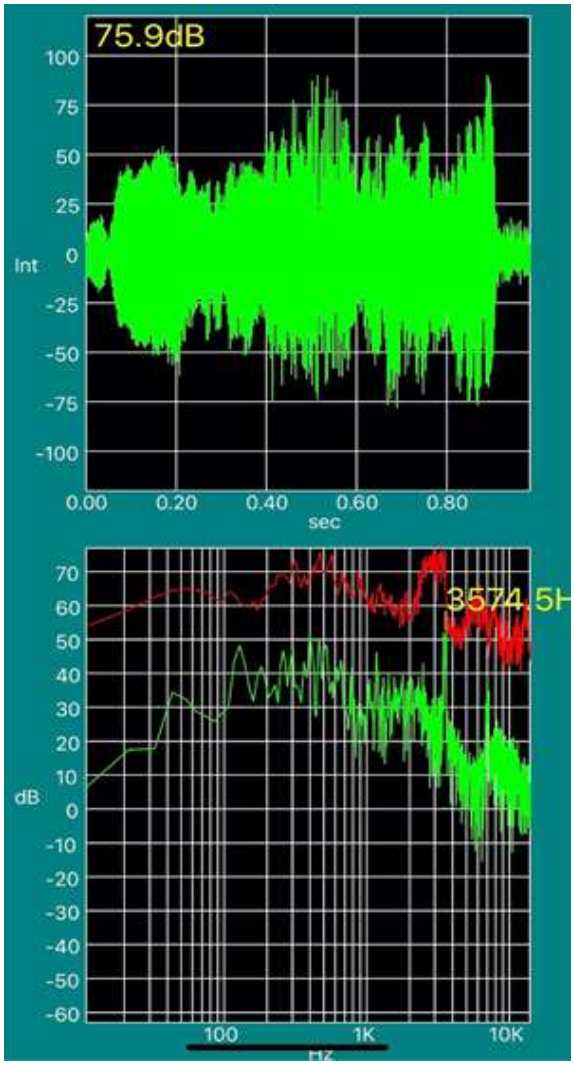
(b)We made the noise using chalks and a blackboard and measured how loud the sound was by smartphone app "FFTWave"(dB).

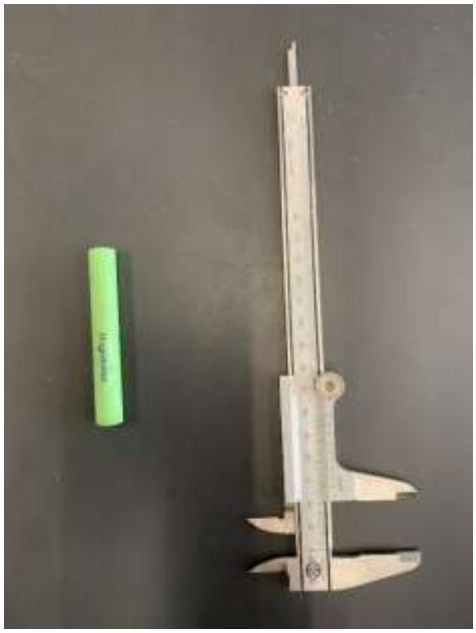
(c)We recorded different length chalks' frequencies. We used "Microsoft"'s "Excel" and make scatter charts.

※Our chalks are "Hagoromo POLY" made by "Hagoromobungu".

※Our caliper is "One-touch clamp caliper KSM15FF" made by "Nakamura Seisakusyo(KANON)" (No.2)

※"FFTWave" is "E.N.Software"'s app. It can transform a noise and show up to 4 frequencies right away. (No.3)





↑No.2 A chalk (left) and a caliper (right)

←No.3 This is a screen shot of using FFTWave. (Up is dB, Down is Hz)

[2]-3 Result

The shorter the chalk's length is, the higher the frequency is. We defined the frequency as f and the chalk's length as L. We got this formula.

$f(L - L_0) = 158(\text{const.})$

$L_0 = 0.0201\text{m}(\text{const.})$

[3]Experiment2

[3]-1 Hypothesis

The noise consists of multiple frequencies. The frequencies are involved in the chalk's length.

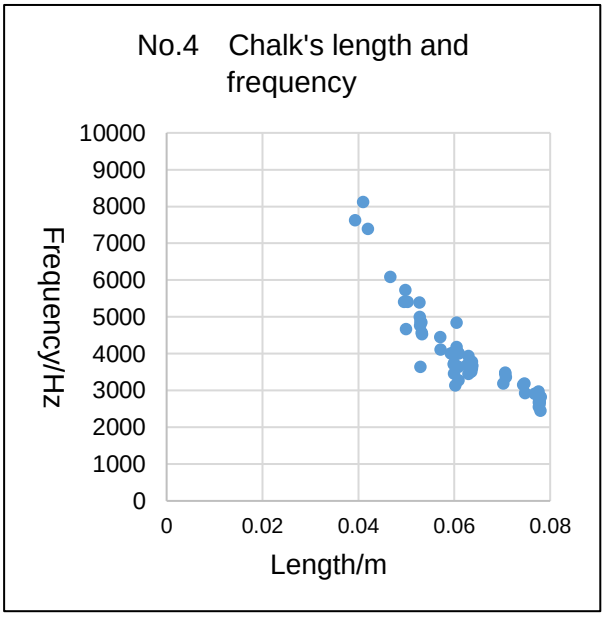
[3]-2 Method

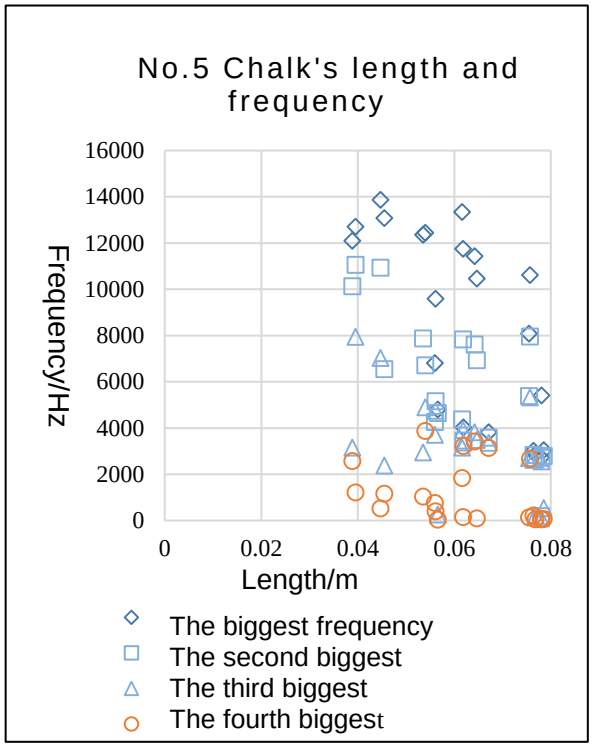
It is the same as experiment1. However, we recorded four frequencies.

[3]-3 Result

We created a graph. (No.5)

We could not find a relationship because this data is complex.





[4]Experiment3

[4]-1 Hypothesis

It is the same as experiment 2.

[4]-2 Method

It was the same as experiment1. However, we measured only the two frequencies which had the loudest volume and the second loudest volume.

[4]-3 Result

We created a graph. (No.6)

The shorter the length of the chalk is, the higher frequencies become. We created a formula.

$f(L - L_0) = 147 \cdots ①$ (The biggest volume)

$f(L - L_0) = 263 \cdots ②$ (The second biggest volume)

In ① showed $L_0 = 0.0263$m.

In ② showed $L_0 = 0.0265$m.

[5]Examination

(1)We speculated that the chalks were resonating. We had two reasons.

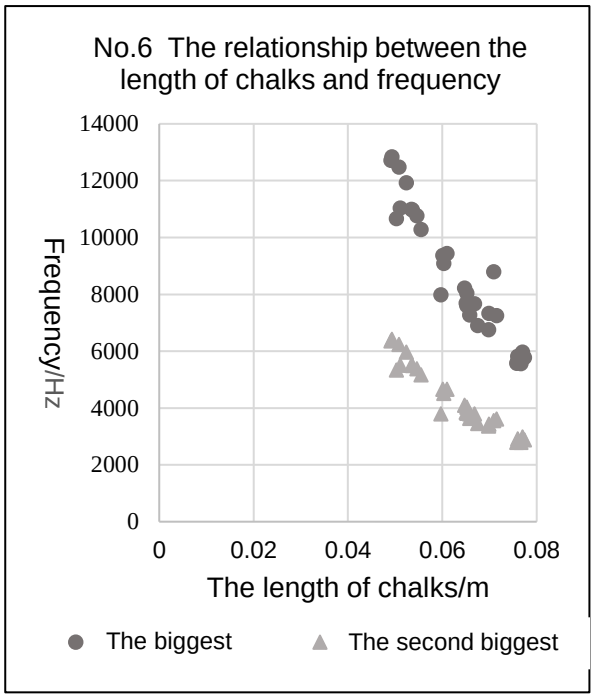
First, the frequencies were in inverse proportion to the length of chalks subtracted a constant number.

Second, the frequency of the second loudest sound was twice as high as that of the loudest sound.

※Resonance is a phenomenon that occurs when a second object vibrates at its natural frequency due to the vibration from a first object. The resulting vibration of the second object has a larger amplitude.

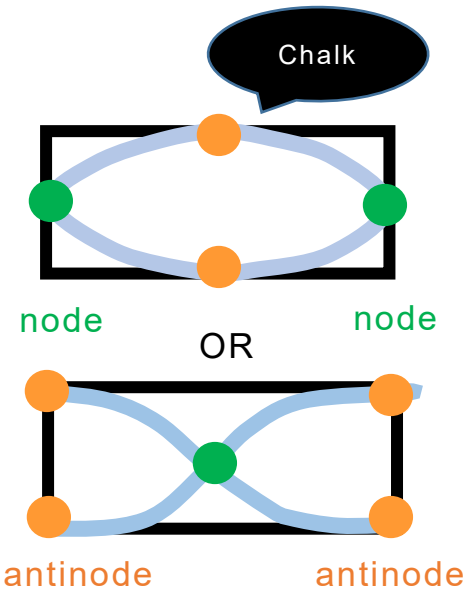
The node is the point in a standing wave that remains still at all times (zero displacement or amplitude).

The antinode (loop) is a point in a standing wave (midpoint between 2 nodes) where the largest displacement takes place.

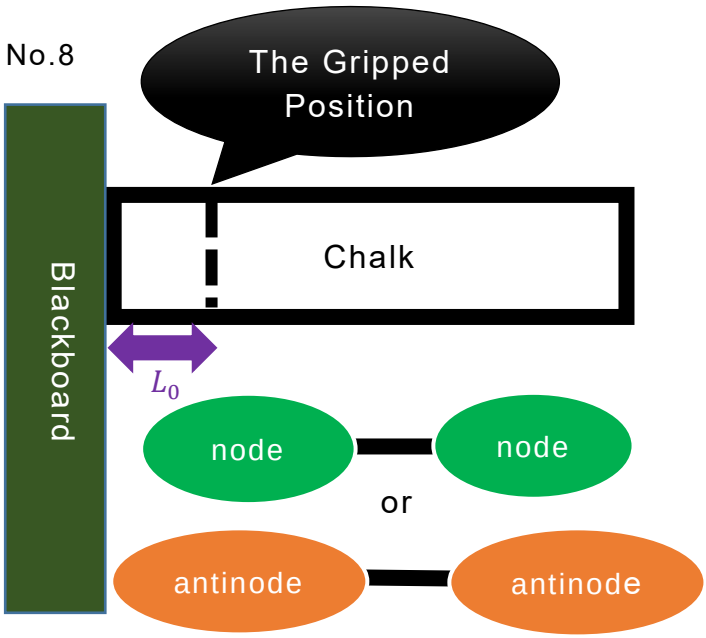


(2)We considered the wave of the sound was a longitudinal wave or transverse wave. If the wave of the sound was transverse, formula ①,②'s L_0 showed the distance between the contact area of chalks against a blackboard and the position to hold. In addition, we considered that this length was proportional to the frequencies. In experiment 3, we presumed both of the chalk's ends were nodes or antinodes because we found an overtone.

No.7



No.8



No.7 and No.8 are examples of a standing wave which may pass through chalk.

(3)We speculated that the length of chalks got shorter, the frequencies became higher. In addition, the frequencies were not annoying because they were over audible range.

Therefore, from the figure of experiment1, we found the length could make the highest frequency we can hear. It was 28.0mm. It was difficult for us to write with it.

(4)In each experiment, we could not make the noise when the chalks' length was under 40.0mm.

In examination (3), it was not because the frequencies became higher than those of the audible range. We considered that it was because it was difficult to keep the chalk's position and the period of changing static friction to kinetic friction.

4. Method to not make the annoying sound

[1]Transform the existing chalk

[1]-1 Purpose

In the experiment 1~4, we found that we can avoid generating the annoying sound by using chalks which are shorter than 40.0mm. However, it is difficult for us to hold short chalks, so we have to use a chalk holder to use them. Based on the experimental results, we discussed the form of longer chalks with which we can avoid generating the annoying sound.

[1]-2 Method

We transformed chalks into the following 4 kinds. Afterwards we researched whether we can avoid generating the annoying sound or not.

※We used "Hagoromo POLY" made by "Hagoromobungu" as the existing chalks.

《Form》

(a) Sharpened diagonally (maximum of the length: 78.0mm, minimum of the length: 38.0mm) (No. 9)

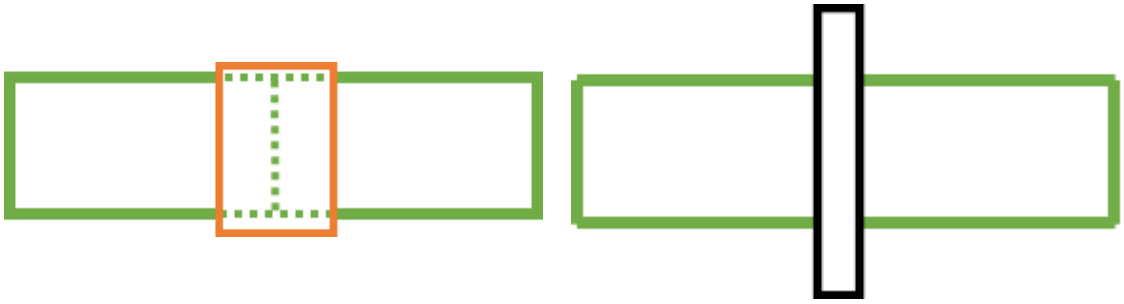
(b) Cut in half (39.0mm) and attached with paste (No. 10)

(c) Cut in half (39.0mm) and connected by cellophane tape (No.11)

(d) Cut in half (39.0mm) and attached with paste. There is a piece of paper between the two pieces. (No.12)

No. 9

No. 10



No. 11　　No.12

※We used glue “GLUE STICKS” made by “Tombow Pencil Co.,Ltd”.
※We used “Adhesive Tape” made by “NICHIBAN CO.,LTD.”
※We used “EXCELPRO RECYCLED PAPER” made by “APP JAPAN LIMITED”.

[1]-3 Result

(a) Sharpened diagonally
The annoying sound happened as usual
(b) Cut in half and attached with glue
The annoying sound happened, but the sound was small
(c) Cut in half and connected by cellophane tape
The annoying sound hardly happened
(d) Cut in half and attached with glue and a piece of paper
The annoying sound did not happen

[1]-4 Examination

According to (a), it was difficult to reduce the annoying sound using the longer chalks.
According to (b) ~ (d), we can reduce the annoying sound by connecting two pieces of chalk. This is because we can make a space between them and prevent standing waves from being made.
We speculated that (d) did not make the annoying sound because each section was absolutely separated by paper.
From the above, we believed that we could reduce the annoying sound by connecting short two pieces of the chalks made of a different material.

[2]Making the new shaped chalks

We concluded that we could avoid generating the annoying sound by using short chalks. So, we tried to make new shaped short chalks on our own that would not make the annoying sound and we can write easily.

(A)Preliminary experiment

(A)-1 Purpose

To check what materials are good for making the best chalk.

(A)-2 Method

We made chalks with 4 kinds of materials.
・Calcium carbonate (chalk powder +weak flour as thickener)
・Calcium sulfate (plaster)

・Paper clay
・Chalk powder
<<How to make>>
[Calcium carbonate]
We mixed calcium carbonate, flour, and hot water 1:1:1 and then poured it into a mold.
[Calcium sulfate]
We mixed 1.3kg chalk powder and 1.0L water and then poured it into a mold.
[Paper clay]
We arranged the shape.
[Chalk powder]
We mixed the powder and water (60% mass of the powder) and then poured it into a mold.
※We used a straw as a mold.
We dried them for a week and wrote with them.

(A)-3 Result

・Calcium carbonate broke and we could not use it as chalk.
・Calcium sulfate was soft and fragile.
The chalks were quickly consumed.
・We could not write words smoothly with the paper clay chalks.
・Chalks made from the chalk powder had a lot of cracks. We could write words smoothly like with common chalks.

(A)-4 Examination

We speculated that calcium carbonate was not a proper material for chalks because it did not harden.
We speculated that it is hard to use calcium sulfate because calks from it were so fragile.
It was difficult to make ideal shaped chalks from the chalk powder because they had a lot of cracks.
Then we adopted paper clay as the material of the chalks.

(B) Making the chalks from paper clay

(B)-1 Purpose

To make the short chalks that we can use easily and for a long time.

(B)-2 Method

We made 5 kinds of chalks and evaluated the simplicity of writing.
(a)Column like chalks
(b)The shape of a tetrapod
(c)Regular tetrahedron that has recessed sides
(d)Flat triangle
(e)Cube that has recessed sides
※We chose shapes that have many corners to write narrow lines.

(B)-3 Result

No. 13 (a),(b),(c),(d),(e)

(B)-4 Examination

When we made short and easy-to-write chalks, it was important to make them fit our hands. So we speculated that (b) was the best structure. But writing with them was not as easy as writing with the common chalks.

[3]Changing the surface physical property

(A) Changing the surface physical property of the ready-made chalks

(A)-1 Purpose

We believed that the physical surface property of a blackboard and chalks could have something to do with the annoying sound. And we speculated that chalk's unevenness on surface causes the annoying sound (from references [4)5)]). So we changed the surface physical property.

(A)-2 Method

We changed the surface physical property by using water and oil. The liquids' depth was 3.0mm.

(a) We immersed chalks in water and in oil.
(b) We left them for 5 minutes.
(c) We took them out and left them for 9 days (figure 14).
(d) We rubbed a blackboard with each chalk 100 times and counted the number of the annoying sound occurrences.

※The tip of chalk immersed in oil was covered in oil and we could not write on the blackboard. So we cut 10.0mm off each chalk.

No. 14 (The left chalk was immersed in water and the right one was immersed in oil)

(A)-3 Result

No.15: Result	water	oil
The number of the annoying sound occurrences	81	6

·The oil-soaked chalk made the annoying sound less often than the water-soaked chalk.

·We could write words with the oil-soaked chalk more smoothly than the water-soaked chalk. And the words' color written with the oil-soaked chalk was lighter than those written with the water-soaked chalk.

·It was more difficult to erase the words written with the oil-soaked chalk than to erase the words written with the water-soaked chalk.

(A)-4 Examination

Oil was useful to reduce making the annoying sound.

We believed that this was because the surface of the chalk was smoothed and the friction was reduced.

(B)Making the oil containing chalks

(B)-1 Purpose

Making oil-soaked chalks to reduce the annoying sound.

(B)-2 Method

We made chalks which contained 15g chalk powder, 12g water and 9 kinds of amount of oil (0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0g).

(B)-3 Result

All of them broke while they dried. The oil-soaked chalks were soft and we

could not use them.

(B)-4 Examination

We speculated that the chalks broke because they did not have enough thickener and the chalks were soft because the chalks contained too much oil.

5. Future tasks

We did experiments focusing on chalks' length, shape, and surface physical property as a condition to not make the annoying sound. We want to focus on some conditions such as the force we press the chalks against a blackboard, the velocity and the direction.

In addition, we want to change the way to make chalks. We could not make various shaped chalks using the existing chalks and add oil into chalks well. So we have to improve the technique to reproduce the experiments.

Moreover, we discussed the chalks this time, but we want to discuss the blackboard's conditions,too.

6. Acknowledgements

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7. References

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