How much force is applied when a phone is dropped?

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Smartphones play an important role in our lives and have become an indispensable part of our lives. At first glance, they seem to have only advantages for us, but they also have disadvantages such as fragility and high price. There are many ways to break them, such as damage from falling, submersion in water, and failure from prolonged use. In this article, we will focus on the damage caused by falling. We investigated how the device actually falls, and created a model that resembles a smartphone to show the impact of a fall and the case that would protect it. This model was made to match the size and weight of an actual smartphone, so it can be used as a real model. Also, since we used models of the same weight, we believe that the magnitude of the impact depends on the case.

1 Background

Smartphones are now becoming an everyday necessity. However, there are some bottleneck points. Smartphones are very expensive and it is difficult to replace them frequently. Also, the screen is easily broken.For this reason, we wanted to create a smartphone case that would be resistant to cracking even if the smartphone was dropped, so we started this research.

From the previous research of Ena High School in Gifu Prefecture1), it is known that by creating a space around the object to be protected (hereinafter referred to as "crushable zone"), it is possible to protect an object when it is dropped. For example, in this previous study, we made a crumple zone with construction paper and dropped an egg on it, but it did not break. It is believed that the crushable zone absorbed the impact. In this previous study, it was the crushing of the square paper.

From this, it was assumed that the impact could be reduced by absorbing it with air cushions. It was also assumed that the main reason why the phone cracked was not the force product, which is the product of the magnitude of the force applied and its duration, but the maximum value of the impact. The reason for this is that when we continued to apply weak force to the smartphone for a long time, it did not break. The verification of this result was obtained after applying a larger amount of energy than the maximum value obtained in the actual experiment they conducted.

The next preliminary experiment was conducted to find out that smartphones usually tend to fall from where. In this experiment, a real smartphone was dropped from a height of 123.5 cm.The reason we chose 123.5 cm was because it is the height of the chest of the average Japanese male. Of course, we pulled a rug under it. The results are shown in fig.2 below. The most common result was addison the side. From this result, we decided to focus on the sides and make a structure to protect the sides.

side	screen	corner
13	5	2

fig.1Investigation of preliminary experiment. How often did the phone lard in these positions.

2 Materials and experimental methods

○materials

・woods
・clay
・rubber
・oscilloscope
・piezoelectric element
・(corrugated) cardboard

○Experimental Methods

1) Make a model of the phone out of wood. The size and weight of the model was adjusted to the IPhone 10, which is used by many people. The weight was adjusted with clay.

2) Rubber attached to smartphone model.pic.1,2,3

pic.1①no case

pic.2 ②Attach a piece of rubber 1 cm thick.

pic.3 ③A 0.5 cm cavity in 1 cm thick rubber

3) We made an experimental apparatus like the one shown in fig.2 out of cardboard so that the model would fall straight down without rotating.The piezoelectric element was placed on the floor.A smartphone model was dropped from a height of 123.5 cm, and the voltage across the piezoelectric element was measured 20 times each.

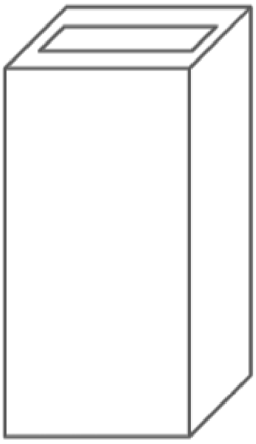
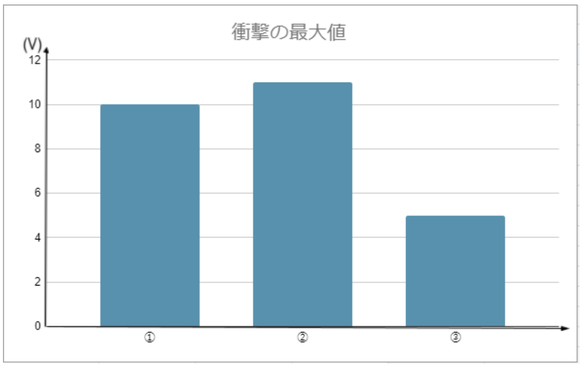


fig) 2 experimental device

3 Results and conclusion

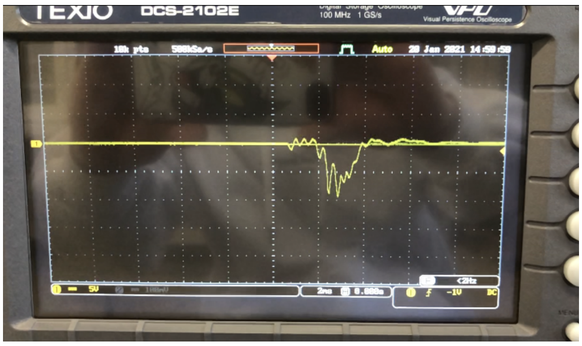
In the following, the case without any case is referred to as ①, the case with 1cm thick rubber on the drop surface is referred to as ②, and the case with 1cm thick rubber with a 0.5cm cavity is referred to as ③. The results are shown in fig. 3. The graphs show that the impact values for each case are ③<①<②. pic 4 is the graph of the waves seen on the oscilloscope when the shock value was ①,and pic 5 is the graph of the waves seen when the shock value was ③. This graph shows the time on the horizontal axis and the voltage, or the magnitude of the shock, on the vertical axis. The shape of the graph at ①is like a series of sharp needle-like waves for a short period of time. On the other hand, if we look at the graph for (3), we can see that the shape of the wave is like a gentle slope that continues for a long time. From the shape of the graph, we can see that in case①, a strong impact w



as applied to the falling object for a short time, and in case③,, a weak impact was applied to the falling object for a long time.

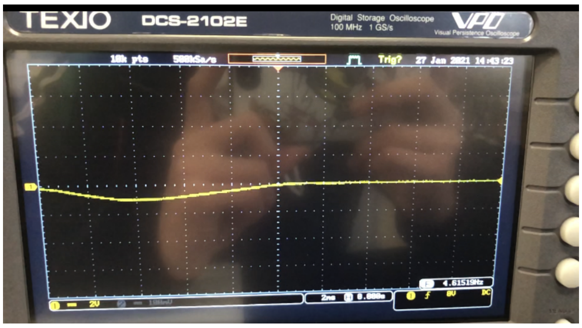
fig.3 Experimental results

The vertical axis shows the voltage (magnitude of impact) and the horizontal axis shows the falling object.
The maximum value at ① was10V
The maximum value at the time of ②was11V
The maximum value for ③ was5V.



pic 4 The fall at the time of ①.

The vertical axis shows the voltage (magnitude of the impact) and the horizontal axis shows the time.



pic.5 The fall at the time of (3)

The vertical axis shows the voltage (magnitude of the impact) and the horizontal axis shows the time. They are aligned with the values measured in case ①

From these results, it can be said that at least in case③, we were able to change the way the force was applied to the dummy from the case ③, that is, the case where we did not devise anything. As a result, the impact on the dummy was minimized, and we believe that our hypothesis was correct. Comparing the results of ①and ②,the impact value of ②was larger than that of ①, even though the rubber was removed. From this result, we can see that just adding things will only increase the total weight of the dummy, and the magnitude of the impact will increase. This suggests that we need to devise some way to absorb the shock.
Now, in this experiment, we used a case made of rubber. If we made it out of other materials, such as silicon, sponge, or other materials, how would it affect the results? Also, if we applied other mechanisms to absorb the shock, such as honeycomb structure, would the shock really be reduced in the same way? What is the extent of the reduction? Also, what is the most suitable phone case from the perspective of ease of holding the phone? Since we were only able to experiment with a small number of cases, our questions are endless. This research can be applied not only to protect phones, but also to cushions for saving lives, packs for delivering fragile items, and many other things. I sincerely hope that our juniors will take over this research, unravel our unanswered questions, and reveal the truth that will contribute to this society in some small way.

【bibliography】

○Web ページ

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