Botball and Seismology: A perfect pair with STEM applications

Presented by

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## Monitoring Earthquake Damage through Frequency, Soil Displacement and Foundation Damage

## 1 Introduction:

"If one introduces the concept of energy of an earthquake then that is a theoretically derived quantity." From the seismologist who invented the Ritcher scale, Charles Ritcher; as being a part of Botball for the past two years, I have found that there is a connection between Botball and Science, to be more precise, Botball and seismology. Seismology is the study of Earthquakes. Earthquakes are a common natural disaster here in the Pacific Rim. Notable Earthquakes include the 1906 San Francisco Earthquake, the 1960 9.0+ earthquake in Chile, and the most recent, March 11, 2011 Earthquake in Japan, which had a magnitude between an 8.9-9.1! However, this natural disaster does not cause damages structure wise, but also can cause emotional damage, health problems, famine, drought, and also, damages through its frequency. Today, many seismologists are relying towards parallel robots to help protect buildings. The structures of the parallel robots are similar to the robots built in Botball. It is closely related to Botball through using a claw which is used to grab Botguy and similar to a robotic hand; along with the base of the Legobot used for this years' game, it has an arm similar to an arm trying to grab botguy from the previous years' games.

### 1.1 Frequency and Earthquakes:

Frequency plays a large role when it comes to earthquakes. Based on the  frequency, we can find the amplitude of an earthquake and know how much damage an earthquake has caused. To find the frequency of an earthquake, use the following equation:

$$\lambda=\upsilon/2\pi$$

where one the take the average wavelength from the three axes: x, y, and z and then use it to divide by 2pi or about 6.28.

# 1.2 Soil Displacement

Soil displacement; well, it's pretty self-explanatory through the name itself except it does not happen through liquefaction. Liquefaction is when the soil liquefies after an earthquake. Soil displacement and foundational damage are like plants' roots loosening their grip on the soil, hence causing an erosion. Soil Displacement is when soil shift drastically to one side. The connection between Frequency of an Earthquake and Soil Displacement depends on the velocities of the p and the s waves.

# 2 The main problem and hypothesis

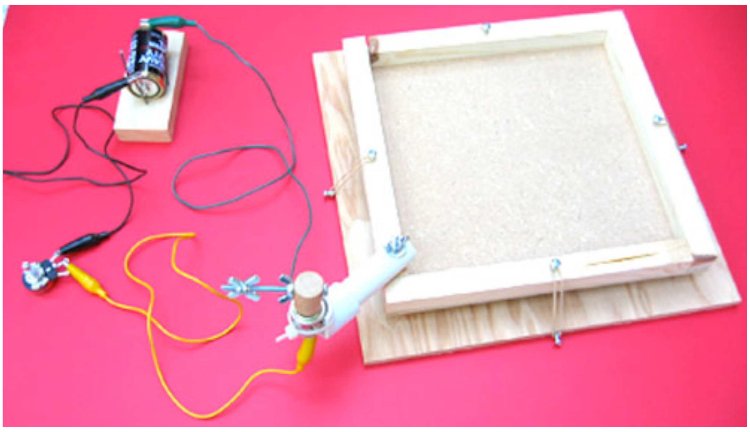
As we did more research on this topic, we wondered if there actually was a connection between the frequency, soil displacement and foundational damage caused by the earthquake. To solve this problem, we came up with a hypothesis stating as the frequency goes up, so will the soil displacement and foundational damage.

# 3 Materials used, procedures

We built our own shake table, with a motor that was more powerful from our original design, we used a laptop, a HOBO ware sensor, three buildings, three foundation types, and three soil types. We built two of our foundations with wood, nuts, bolts, and springs. One of our foundations was nothing basically and one mostly consisted of wood springs and rubber band and our last foundation consisted of nuts and bolts. Our three soil types are sand, loam, and clay. The HOBO ware device is a device that measures the seismic waves caused by the shaking, hence, this helps us find the frequency of an earthquake. Furthermore, the HOBOware sensor, operates like the SONAR sensor, where it uses the sound and vibration to record all the "Shockwaves" the shake table was creating. Two of the buildings were based on a sturdy basket to collect the fish for the fish farm, and the biofuels to place into the tower; however the third building was actually built out of legos and was based on sturdiness of the base of the robot.

We tested these buildings out by creating an earthquake through the shake table, which was timed for thirty, forty-five, and sixty seconds. As we tested this out, we attached the sensor to each building. Most of our graphs came out as we expected it to be but, we noticed that some of our graphs came out to be something we did not expect to see. We noticed that in all of our sand tests, that there was a jolt, then it was gone for a few seconds and in the last few seconds of each of the tests, there were enormous amount of shaking. The frequency that was measured on through this sensor was 100 hertz/0.01 seconds.

The Hoboware Sensor(Credits: Google Images)



The shake table(Credits: John Rajathen)

# 4 Analysis

We noticed a minimal amount of soil displacement occurring; however, we noted a large amount of foundational damage. One of our foundations was not cooperating with the buildings and the soil types. Furthermore, we noticed that there is a slight connection between the frequency and the shaking. We observed the heavier the shaking, the more waves were being created; hence, the frequency was higher. In our sand tests, minimal amount of shaking was present compared to the clay and loam tests. Also, our graphs indicated the presence of additional low frequency waves, rather than huge frequency waves from what we expected in the sand tests. For the loam soil, foundational damage was visible and our bolted foundation was not readily collaborative with our buildings and soil. Surprisingly, the bolted foundation turned out to be a poor base during the loam tests. We predicted the clay to cause more damage and it evidently did. Due to the displacement of the clay, one of our buildings fell apart. Our foundations (all of them) worked effectively with the clay and sand soils, but it also caused major soil displacement. Hence, there were many pros and cons in this project. Our frequency range for the first, second, and third buildings are as follows: 2864.82 Hz/sec, 2460 Hz/sec, and 1672 Hz/sec.

# 5 Conclusion

Based on our results and analysis, our hypothesis was correct. As mentioned in our analysis, there were many pros and cons in this project. Contrary to our expectations, the spring foundation withstood the most alterations solely based on foundational damage. Entirely judged upon soil displacement, the loam displaced a larger amount compared to sand and clay. When looking at our graphs, loam displayed less frequency; therefore, resulting in less damage. On the other hand, clay proved to be the worse, causing more foundational damage and soil displacement. If we had additional time, we would have further analysed our project and collected more data to support our hypothesis. Since this is an extensive project, we will be continuing our experiment next year in hopes of providing more useful information, in order to prevent less damage during earthquakes.

# References: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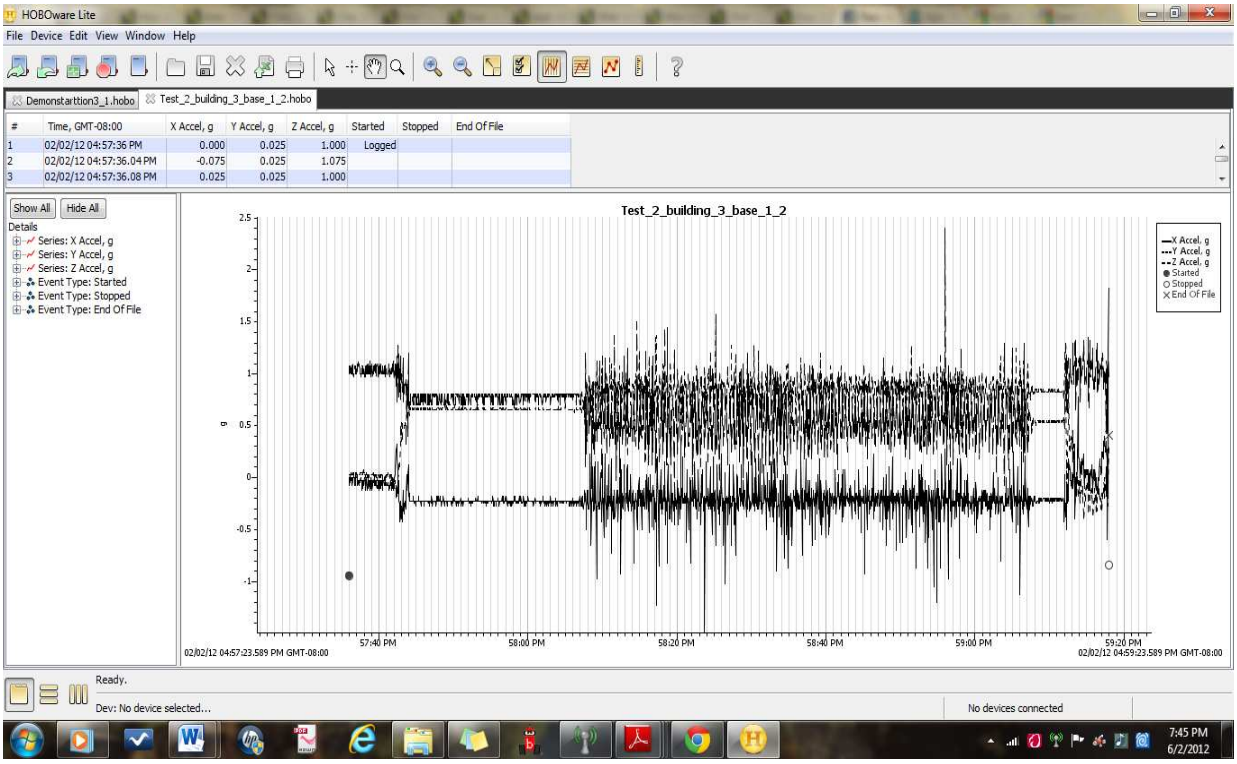


# An example of a graph and an overview of the HOBOware Software.