**ACTIVITY: Best base isolator**

**Activity idea**

In this activity, students use a physical model to investigate the effectiveness of different properties for base isolators.

By the end of this activity, students should be able to:

* understand how base isolators work
* know what properties make an effective base isolator
* carry out a simple science investigation.

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**Introduction/background**

An earthquake can cause the ground to move, sometimes violently. A building built directly on the ground will be shaken and may be heavily damaged as a result. When a building is built away (isolated) from the ground, resting on pads known as base isolators, it will only move a little or not at all during an earthquake. You can find out more about this article [How do base isolators work?](http://link.sciencelearn.org.nz/resources/1022-how-do-base-isolators-work)

Base isolators in use today are constructed from a combination of materials, each contributing a particular property. The activity described here enables students to evaluate the effectiveness of single-material base isolators and encourages them to consider the properties of those materials that make them effective or not. Students also apply their knowledge of these materials and their properties to a real-life application.

The nature of base isolators means that they have to be developed and tested using laboratory models. Find out more in the video [Testing base isolators](http://link.sciencelearn.org.nz/videos/559-testing-base-isolators). To find out if they work to protect actual buildings, they need to experience an earthquake.

The Christchurch Women’s Hospital, which is base isolated, performed very well when tested under the extreme conditions of the magnitude 6.3 earthquake in February 2011. Non-base isolated buildings around it were significantly damaged. As a result of this, the Christchurch Art Gallery is to be retrofitted with base isolators, and some new buildings are already being constructed with base isolators. The technology is also being used to protect some Wellington buildings, although of course people hope that they will never be tested.

**What you need**

For each group of students:

* Wire springs x 4 – you can make a spring by winding stiff wire around a whiteboard marker (or similar diameter object) about 16 times
* Wood or MDF block 15 cm x 15 cm, 1–2 cm thick – this is the floor of the model house
* Wood or MDF block 20 cm x 20 cm, 1–2 cm thick – this represents the ground
* House blocks (numerous) – use empty matchboxes or similar sized wooden blocks
* Isolators of different textures and properties – jelly/jubes, marshmallows, rubber stoppers or erasers, polystyrene, water in a zip-lock bag, ball bearings or marbles in a zip-lock bag
* Reusable adhesive putty
* Stopwatch
* Calculator
* Copy of the student handout [Testing base isolators](#handout)

**What to do**

1. Discuss how base isolators work and what materials are used in them. Also make sure students know how experiments are sometimes carried out using variables and controls. If necessary, explain what is meant by a control in an experiment. In this case, you want to know how a ‘normal’ building, with no base isolators, behaves in an earthquake. You will then be able to measure the effectiveness of different potential base isolators and compare them to the control.
2. Hand out copies of the student handout [Testing base isolators](#handout) and assist students to gather the materials they need and conduct the experiment.
3. Discuss the results.

**Discussion questions**

* Which, if any, of the materials behaved as predicted? Which didn’t?
* Did the second predictions improve or worsen as the trials proceeded?
* Did all groups get the same results? If not, why not? It would help to construct a class table of averages and/or final rankings to compare results.
* How could these experiments be improved?
* What other materials would you like to try, and why?

**Student handout: Testing base isolators**

1. Fill in the first two columns of the results sheet with a list of the base isolators to be tested and their basic properties.
2. In the Predictions 1 column, make predictions about how you think the different materials will perform in an experimental earthquake. You could:
* give each material a number, with 1 being the best
* assign each material to a group – best, medium or worst isolators.

1. Your experimental set-up will look something like this (viewed from the side). Make sure you can copy this structure in all later tests.

* Prepare the ‘ground’ – use the putty to attach a spring beneath each corner of the ‘ground’ wooden block. Set this structure on a firm surface, such as a table, using putty if necessary.
* Place the house ‘floor’ directly onto the centre of the ‘ground’, holding it in place with a small amount of putty.
* Use the building blocks to construct a simple hollow house structure on the ‘floor’.
1. This will be the ‘control’ test, with no base isolators.
* Push the ‘ground’ block gently from side to side to simulate earthquake motion. The force used must be strong enough to destroy the house within a short time (a few seconds) and be consistent each time it is repeated. Discuss how to achieve this. You might need to develop and try some ideas to find the most effective. Could you gradually increase shaking until the building fails, then test which isolators help the building survive the strongest shaking?
* Discuss how to measure the destruction of the house. Will you measure the time to the first block, the second block or all the blocks falling off? Is there a better measure?
1. When you have decided on your methods, time how long it takes for the house to be destroyed and record this time in column 5 of the results sheet. Repeat the measurement two more times and calculate an average. Discuss why you need to do this.
2. Now test the base isolator materials, one at a time. Before testing each new material, you can use the Predictions 2 column to record fresh predictions of effectiveness based on previous tests.
* Set up the house ‘floor’ on four (or another consistent number) of the base isolator to be tested. Use a small amount of putty to fix the base isolators to the ‘floor’ and ‘ground’. Rebuild the house in the same way as used in the control test.
* Shake the ‘ground’ to simulate an earthquake, as discussed and trialled in step 4.
* Record the results and repeat twice, then record the average of the three readings.
1. In the right-hand column of the results sheet, rank the materials based on results, with 1 being the best (i.e. longest time to house destruction).

**Results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Base isolator material** | **Properties of material** | **Predictions 1** | **Predictions 2** | **Time taken for house to fall** | **Rank the materials 1 = best (longest time)** |
| Control – no base isolators |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |
|  |  |  |  | Trial 1:Trial 2:Trial 3:Average: |  |