

Shaken but not stirred? How earthquakes affect buildings

Make up a model as shown in either of the two photographs, depending on what materials you have to hand.



Photo 1: Model 'buildings' of different heights, using helium-filled balloons (Photo: Peter Kennett)

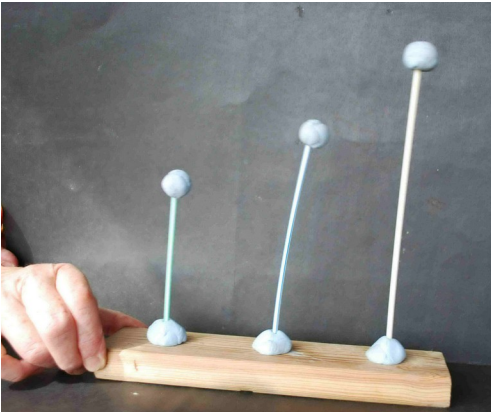


Photo 2: Blutak™ 'buildings', secured to a wooden base by more Blutak™. The middle 'building' is swaying as the base is moved backwards and forwards on the table top. (Photo: Peter Kennett)

Show the model to the pupils and ask them to say which of the three structures will sway the most when the base is shaken forwards and backwards several times on the bench. Most pupils will say that the tallest structure will sway the most, but this is not always the case. The amount of movement at the top of each column depends upon the frequency with which the base is moved – a high frequency will cause the shortest structure to sway the most, while a lower frequency causes the tallest structure to sway the

most. With practice you can find the right frequency to get any of the buildings to sway the most – so that the pupils' predictions are wrong each time!

Ask the pupils to suggest what relevance this demonstration has in the real world. Most will suggest that the model is showing what happens to buildings when they are affected by an earthquake. No doubt, pupils will relate their observations to images seen on T.V., filmed during a recent earthquake.



Damaged buildings in the Port-au-Prince neighbourhood of Bel-Air, after the 2010 Haiti earthquake. The tall block remains standing amid the ruins of lower, less well-constructed buildings.

Photo by Marcello Casal Jr/AB, licensed under the [Creative Commons Attribution 2.5 Brazil](https://creativecommons.org/licenses/by/2.5/brazil/)

Show pupils the animated cartoon on the website below, to help them to relate the model aid to a high rise building. Ask them what may not be correct about the cartoon (*Tall buildings are not necessarily the ones to collapse in an earthquake, if they have been properly constructed*).

http://upload.wikimedia.org/wikipedia/commons/b/b4/Bldg_1sss.gif

The back up

Title: Shaken but not stirred?

Subtitle: How earthquakes affect buildings

Topic: A teacher-led demonstration of the relationship between the frequency of the shaking of the 'ground' and the movement of model 'buildings' of various heights.

Age range of pupils: 14 – 18 years

Time needed to complete activity: 10 minutes

Pupil learning outcomes: Pupils can:

- observe the movement of a structure when its base is shaken;

- establish a visual relationship between the height of a structure and the frequency with which it is shaken;
- relate their observations to the damage caused by an earthquake in a built-up area.

Context: The activity can be used to help students to explore the effects of earthquakes in densely populated areas, and to dispel misconceptions about the relative safety of high rise buildings in seismically active regions.

Following up the activity:

Pupils could:

- look for a relationship between the height of structures and the frequency of vibration by timing the movement to and fro of the base and using a range of heights for their 'buildings'; *In the model shown in Photo 2, the 21cm tall structure swayed at 1.7 shakes (cycles) per second: the 17cm structure at 3.1 cycles per second and the 13 cm structure at 4.0 cycles per second.*
- investigate other materials in place of the ones shown in the photographs, using 'stalks' of different rigidity, and with different masses on top of their structures;
- carry out a web search for images of buildings which have survived/been destroyed by the same earthquake and suggest reasons for their findings;
- carry out a web search for various engineering solutions in the design of earthquake-resistant buildings.

Underlying principles:

- All buildings have a natural frequency of vibration. They shake in response to the ground being shaken by the passage of seismic waves, generated by an earthquake.
- When the natural frequency of vibration is the same as the frequency of the seismic waves, the building is said to resonate, and it is at this point that the building sways the most and so is most liable to be damaged.
- Tall buildings are not necessarily the ones at most risk from earthquake damage.
- Engineering solutions depend on calculating the natural frequency of the building and on knowing the normal range of frequencies of the relevant types of seismic waves, before designing strengthening measures etc.
- Existing buildings can sometimes be made more earthquake resistant by adding

extra struts, or flexible joints. This is termed retrofitting.

Thinking skill development:

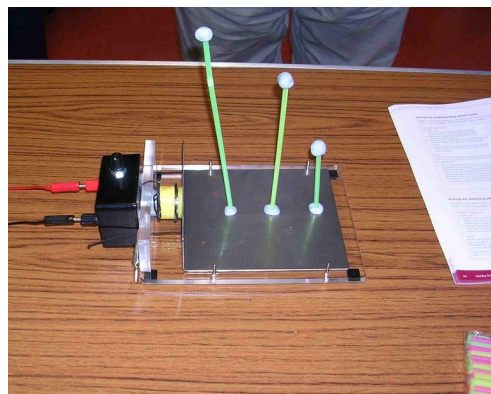
Students usually experience a cognitive conflict at the start of the activity, when the structure which they had expected to move the most does not always do so. Explaining why they were wrong involves metacognition. Linking the model to real earthquakes is a relatively simple bridging skill.

Resource list:

- a model of three 'high rise buildings', made up before the lesson. Photograph 1 shows three helium-filled balloons on 'party sticks' cut to different lengths, fixed to holes drilled in a block of wood. Photograph 2 shows three drinking straws with blobs of Blutak™ of similar mass, fixed to a wooden base with more Blutak™.

Useful links: See below. Also see the Earthlearningidea activities: '*Quake shake – will my home collapse?*', '*Surviving an earthquake*', and '*Earthquake through the window – what would you see, what would you feel?*'

Source: Based on an idea by Peter Loader, in 'Teaching Earth Sciences', Vol. 36 No. 1 2011. A more sophisticated method, using an electrically operated shaker table, is given in 'Innovations in Practical Work: Seismology', 2007, Gatsby Science Enhancement Programme, ISBN: 978-1-901351-72-9.



Model 'buildings' using an electrically operated shaker table, from the SEP kit. (Photo: Peter Kennett)

Details of publications and equipment, including a working seismograph, capable of recording real earthquakes, are given on the website: www.sep.org.uk

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