Earthquake Building Challenge

These workshop notes are designed for use along with the accompanying slides which contain explanatory images etc.

Year Group: S1-S3

Length: ~50 minutes [25 minutes introduction, 15 minutes building time, 10 minutes testing]

Set-up Time: 5-10 minutes

Room requirements: A classroom space with desks, ideally with one clear table for testing the buildings – otherwise a group can be moved for the testing.

Summary:

Students investigate the processes that create earthquakes and look at the way the energy release travels as a series of different waves, then consider the way earth movements are monitored - for example using seismometers. Pupils then work in small groups to design and build a structure which is tested to see it if would withstand a moderate earthquake

Equipment:

- Slinkies (optional)
- Chopping boards
- KNEX sticks, paper drinking straws or spaghetti
- Blu-tac (or marshmallows/gummy sweets if using spaghetti)
- Earthquake table[1]
- Spare elastic bands

[1] alternatively, test the structures by simply shaking the boards on which they are built

Content:

Earthquakes happen as a result of Earth movements that are controlled by plate tectonics and occur mainly (but not exclusively) at plate boundaries. The release of energy during an earthquake causes vibrations which are felt as a shaking of the ground.

Plate tectonics – the movement of the pieces of Earth's crust – occurs because of convection in the mantle (animation) and results in several different types of plate boundary. The most destructive earthquakes commonly occur at either conservative (transform) boundaries where two plates are sliding past each other, or destructive (convergent) boundaries where subduction is occurring. Probably the most famous example of an earthquake prone zone is the San Andreas transform fault which runs down the west coast of California/USA.

During an earthquake, energy is dispersed as a series of **seismic waves**.

Body waves travel through the earth. There are two types:

Compressional (**P wave**) – energy moving in a straight line, compressions and extensions.

DEMO: Take slinky in pairs, each hold an end at the edges of the table. Count 6 coils in from one end, pull these straight back towards the hand holding the nearest end still, release. Observe the movement of the slinky.

ANNIMATION: dots are moving back and forth, but not side to side … energy is transferred from left to right but particles themselves don't move that far.

Earthquakes

Shear (**S wave**) – How does it move, what happens to movement longer it goes on for.

DEMO: Same set up as before, in pairs with slinky, count 6 coils, except this time pull this coil out to one side and release. Observe what happens to energy over time – slows down, losing energy.

ANNIMATION: dots are moving side to side – in the animation energy is maintained but actually slows

P and S waves move differently, therefore travel at different speeds … which wave moves faster? Pupils will most often get this wrong and say S wave so it is worth reframing the question – "walking to the back of the room in straight line vs wavy line, which will get there quicker?" (straight line, P wave travels faster than S wave).

Surface waves, as the name suggests, travel along the surface of the planet (motion more complex, therefore unable to easily demonstrate using slinkies).

ANNIMATIONS: show the deformation in material near the surface, but not at deeper levels … movement is like a water wave, except backwards.

Videos: Surface waves – destructive wave, shakes ground, movement of ground is up and down but rolling, like an ocean wave.

Destroys pavements and infrastructure, energy concentrated at the surface.

Seismographs – as shown – are used to measure and record earthquakes. The typical pattern (shown) demonstrates the difference in speed of the two waves as P wave is shown to arrive first. The difference in speed is useful in finding the epicentre of an earthquake – the time between the two waves arriving at a location can be used in the speed = distance/time equation to calculate the distance that the waves have travelled. With several monitoring stations, the distance from each can be compared to triangulate the origin of the signal.

[Seismometer: All stand up still. Walk slowly on the spot = P wave. Walk harder = S wave. Run hard on the spot = surface wave. Stop = delay period. All jump at same time = aftershock. Try to replicate the perfect seismograph.]

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Building challenge introduction;

If you were in the middle of an empty field during an earthquake, would you survive? Yes, probably! Buildings are what makes earthquakes dangerous. The destruction and falling debris.

Unfortunately, a high number of people live in areas that are prone to earthquakes – so it's important to consider strength when building in these zones. Solid, deep foundations are important, for example the Sky Tower in New Zealand was designed with foundations extending 12m underground so that it can withstand an 8.0 magnitude earthquake located within a 20km.

Shape is also important - *which building is strongest of the three on the screen?* Pyramidal one, then the shorter one, then the tall one. A low centre of gravity makes buildings more stable (like bending your knees on a skateboard), and triangles are very strong shape.

Make a rectangle with fingers - easy to flatten.

Make a triangle with fingers (thumbs alongside each other) - very hard to flatten.

PROBLEM: pyramid means lost space – inefficient (cost, growing population).

Earthquakes

Good examples of shape and efficient design;

Transamerica Pyramid, San Francisco - built as pyramid but lifts put in to additional 'wings' built on the side, also uses multiple triangle-shapes in construction and foundations. In 1989, a 6.9-magnitude earthquake roughly 60 miles away caused the building to shake for more than a minute, with the top story swaying almost a foot from side to side, but the building was completely undamaged.

Torre Mayor, Mexico City - considered one of the strongest buildings on Earth in terms of earthquake resistance, Torre Mayor is designed to withstand a 8.5-magnitude earthquake. The design includes 96 'dampers' which work like car shock absorbers, meaning the tower can withstand earthquake forces nearly four times as efficiently as a conventionally damped building. In 2003, a 7.6-magnitude earthquake shook the city and not only did the building survive undamaged, those inside didn't even realise there had been a tremor!

DESIGN YOUR OWN EARTHQUAKE PROOF BUILDING!

10-15 minutes to build – for a challenge don't allow pyramid shapes, encourage at least two floors …

Construct the building on the mat/chopping board so it can be easily moved to the earthquake test zone.

Test on earthquake table (or a system of shaking the mats/chopping boards to which the designs are secured) for 10 seconds – any debris could kill a passer-by so building fails safety test if even one beam falls.

Tallest, most secure building wins the challenge.