Why build an earthquake-resistant building?

When an earthquake strikes, as it did in Nepal in 2015, buildings are often damaged or destroyed. Many people can be injured or killed by falling rubble. Many others are made homeless. It can take a long time to rebuild their homes after the disaster.

Two years after the Nepal earthquake, less than 5% of the destroyed houses had been rebuilt. That means that 800,000 families were still forced to live in temporary shelters.

The Japanese architect, Shigeru Ban, designs earthquake-resistant buildings built largely from cardboard. The buildings are strong, lightweight, and quick to construct. They are also less likely to injure people if they fall during an earthquake.

These buildings can be used to provide temporary homes after a disaster. They can also be major buildings that remain standing for decades.

Three examples of cardboard buildings designed by Shigeru Ban for earthquake-prone areas; Rebuilding a school in China; Christchurch Cathedral, New Zealand; The Paper Dome, a temporary church in Japan.

Design brief:

You are to design a building that would withstand a major earthquake. You will need to design, build and test a small scale model that meets the following criteria:

Is quick and easy to assemble

Has a minimum height of 60 cm

Has a maximum base of 30 cm x 30 cm

Remains standing after an earthquake, as simulated by shaking a table for 10 seconds

Is constructed from the materials supplied by your teacher

Costs less than $60 to build, given the material costs listed below

Your model cannot be attached to the table in any way.

Materials:

Spaghetti ($1 per 10 cm)

Blu Tack or plasticine ($1 per gram)

Scissors or retractable craft knife

Ruler

The engineering process:

The engineering process is a sequence of steps that engineers use to help them develop and test potential solutions to challenges. Here's a quick summary of the process you need to follow.

Define the problem you need to solve. Brainstorm to generate new ideas. Research possible solutions. Design a solution. Create a prototype. Test and evaluate your prototype. Share your solution or improve your design by repeating steps 1, 2 and 3.

Question 1

It's important that what you need to achieve is very clear from the start. What are you hoping to build and why is it important?

We are hoping to build an earthquake proof building, that can withstand some level of earthquake, without sustaining large amounts of structural damage.

Question 2

Propose different ways you could design a building to resist an earthquake. Upload your sketches and notes. There are many ways that we can build buildings to help counteract an earthquake, some of these things that we can build are:

a) Bottom heavy, keep most of the weight on the ground, this reduces swaying and load on support beams.

b) Connections to the ground are very important, we need to maximise the amount of connections to the ground.

c) The building needs to be flexible, if the building is rigid and moves all on it's own and cannot copy the 'flow' of the earthquake then after a while the building will gain enough momentum to break crucial parts of the structure.

Question 3

Investigate the problem, gather data, and search for information about other ways this problem has been tackled by engineers. Summarize the information you find using notes, diagrams, photos, or videos.

We are going to infuse the structure of a pyramid, this allows our building to be cost effective but also have the most strength, including the time to build such building is going to take no time, it is simple and reliable.

Question 4

Key Question

Create a detailed design. Make sure you include: How much of each material you will need, Labelled diagrams, Written information to support your design

The design 'Plan 3 [EP] Final' is the blueprint that we have decided to use as our final model, this was from a vigorous cycle of testing the structural integrity and overall stamina of the building. Out of the three building designs the last one stood out the most, this was due to a series of complications that were solved just by the general design.

1) Twisting, the building did not twist around the center of the structure, this was the most common effect of a square based building.

2) Falling over, the building previously would fall over because it would be like a helicopter, although we cannot attach a motor with props, but we can limit the amount of Blu Tac and spaghetti to try eliminate this issue.

3) Beams snapping in the middle, even though this did not occur a lot, this was a design flaw in our first tests, this was because we had a lot of weight on one beam, our new design equally distributes weight.

Question 5

Calculate the cost of your model based on how much of each material you will use. Remember that the model needs to cost less than $60 to build.

4 x 15cm , 12 x 25cm, 1 x 10cm, 375 = $37.5 (Spaghetti), 21 = $21 (Blu Tack), A grand total of $58.5

Question 6

Use your design and materials to construct a scale model. Upload a photo or video of your completed model.

Question 7

Ask your teacher for advice with this stage. To test how well your model withstands an earthquake, it will be placed on a table. The table will be shaken for 10 seconds to simulate a quake. Record data by taking photos and videos of the testing process. Take notes on any damage to your building.

First of all, there were no breaks. Secondly, the building did not topple over, We moved the plate around vigorously at probably a magnitude 10 earthquake and the building did not even get close to capsizing. This is an extremely promising sign of the integrity of the building and how stable our design is. We can build it quickly and deconstruct it fast too, this is yet another positive of this building design.

Question 8

Evaluate the success of your design.

Fast to make, on record of sub 7 minutes 30 seconds.

The building does sway more than acceptable for a building if the earthquake waves are very long.

Works beautifully, doesn't fall over easily at all.

There is limited height of the top part of the tower, because of the base being so low the 'antenna' part cannot be too long and heavy. Otherwise, the building will capsize.

Structural integrity is excellent, the building doesn't break no matter how hard the earthquake is. (To an extent of course!)

We have used quite a bit of our money to build this, this means that we cannot sustain any major breaks in our build otherwise we would not be able to replace the spaghetti.

Question 9

Based on the testing phase, propose ways in which you could improve upon your initial design. Upload or redraw your new, improved design. Highlight any changes that you made and your reasons for making them.

Problem: Main Beam Connections not Being as strong as main spaghetti beam.

Solution: Have a small splint using leftover pieces of spaghetti to strengthen joints on the main pole of the building, when force is applied to the joints, they can pull apart or even break, with this splint we can minimise the chances of this occurring if there are large earthquakes, or excessive movement.

Question 10

Build, test and evaluate the improvements to your earthquake-resistance building design. Discuss how the changes you made impact the ability of your building to survive an earthquake.

These changes did exactly as expect, we saw no sign of breakage on the joints, there was also a lower bend rate in the main beam, this helps with height. We have made the main beam longer too, the building now exceeds 70 centimetres, way more than what is desired. This proves how sound our design is.

Question 11

Design an EPortfolio to share your design, how it works and how it solves the problem. Include a description of the process you followed to reach your final design.

Question 12

What worked well:

Teamwork, we worked together to come to conclusions for the designs, building and testing the tower, also we came together to finish our testing branch, and complete this activity.

Research, all team members worked together to find the best way of building the tower and the best design, we worked like a machine, within 30 minutes, we found a couple of promising designs. Then we tried all of the designs and make the 'perfect tower'.

Organization, we used out of school time to do all of the planning and a large portion of the tests, this is an example of perfect organisation and planning.