Royal Academy of Engineering

THIS IS ENGINEERING

ENGINEERING *IN THE* MOVIES

EARTHQUAKE PROOF

STEM

Science, Engineering and Maths Focus

INTRODUCTION

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SAN ANDREAS (2015) is a movie about an earthquake that causes devastation to Los Angeles and the San Francisco Bay Area. Earthquakes are sudden motions along breaks in the Earth's crust called faults.

The earthquake in the film is caused by the San Andreas Fault – a boundary between tectonic plates that has caused a number of earthquakes in real life, including one in October 1989 that hit San Francisco and destroyed thousands of structures and caused part of the Bay Bridge to collapse.

Plate tectonics are important features of Earth's surface and major geologic events. Eruptions result from plate movement and these can have a devastating effect on human and wildlife habitats.

CHALLENGE

- Teams of four
- 240 minutes
- 3 KS3
- Expert

MATERIALS

- Tray
- Bag of marbles
- Correx sheet
- Jitterbug kits
- Blu-Tack
- Sticky tape
- Heavy weight
- Construction kit – straws, dowel rod or KNEX
- Connectors
- Weights
- String

OVERVIEW

Design and build an earthquake-resistant structure.

Understand principles of earthquake engineering and design, including the importance of a solid foundation, wide base, symmetrical design and trusses.

TERMS & CONCEPTS

- Foundation
- Height-base ratio
- Symmetry
- Truss

WHAT ARE TECTONIC PLATES?

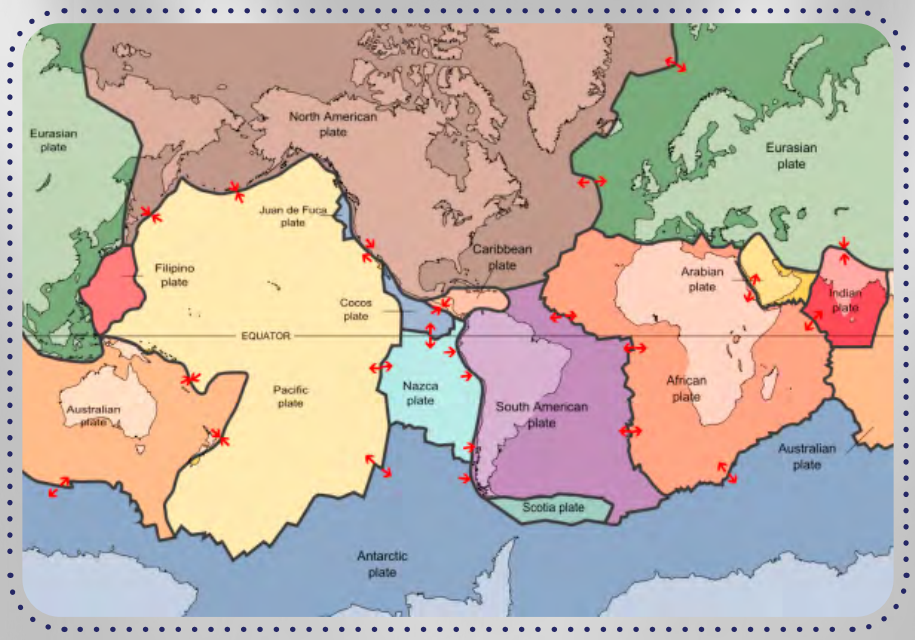
The Earth's surface is made of many plates that move very slowly, only an inch or two each year.

These enormous slabs of rock, called tectonic plates, can interact in three ways: they can spread apart, collide or slide against each other. Earthquakes can happen anywhere on Earth, but they are most likely to occur where two tectonic plates meet.

The map of Earth's tectonic plates shows earthquakes are most common at the boundaries between plates. The movement of plates relative to one another is shown with red arrows.

Engineers work hard to design and build earthquake-resistant buildings. There is no such thing as an earthquake-proof building, but engineers can figure out ways to reduce the damage and to keep people safe.

Designing earthquake-resistant buildings is extremely important in areas where earthquakes are common, such as California and Japan. One way to make buildings stronger is to use trusses and cross bracing, which make a structure stronger by using triangle shapes.



INSTRUCTIONS

In this challenge, you will work in small teams to engineer and build a structure that can withstand an earthquake.

1. Plan your structure. Should it be flexible or rigid?
2. Design your structure before constructing it. Planning through drawing is an important part of the engineering process.
3. Build and test the structures.

Place the structure on the testing platform. Start with a gentle shake of the platform. Observe how the structure moves.

Gradually increase the strength. How hard do you need to shake the building to cause it to fail? Note weak points and think about how you can improve them. Make modifications and test again.

Evaluate the success of each structure you build.

Did the structure stand on its own before testing? Did the structure withstand the first, weak earthquake?

What's the longest amount of time that the structure stood upright while the earthquakes shook it?

THE CHALLENGE

The aim is to work together in a team to design and build a two-storey structure that can withstand simulated earthquake vibrations.

You will learn team skills that are essential to all fields of science and engineering.

THE REQUIREMENTS

- Both floors of the structure must support 250 grams of weight.
- Your building must be at least 36 centimetres tall.
- A construction drawing with measurements and analysis must be submitted before earthquake testing.
- Design a way to secure the weights so that they don't fall off and so that you can add additional weights.
- To survive an earthquake test, the building must not collapse for 10 seconds after the earthquake begins. The weights must stay on the building.

THE PROCEDURE

1. Build the earthquake shake table. This can be done with a tray of marbles with a flat surface on top. Alternatively, you could use the Jitterbug kit to provide an electric shake.
2. Build your structure using the materials provided by your teacher. Attach the base of your structure to the shake table using tape or Blu-Tack.
3. Record your outcomes on the incident report.

EXTENSION

After each test, repair any damage to the structure, redesign and improve it to withstand more weight and shake.

YOUTUBE GUIDE

www.youtube.com/watch?v=6HgxiYBkh3U

INCIDENT REPORT

During construction, how did you test the strength and stability of your structure?

During construction, what strategies did you use to strengthen the weaker areas?

What are the strongest parts of your building?

What are the weakest parts of your building?

What features of the structure did you redesign to improve stability?

What further improvements would you make to the structure to make it earthquake proof?

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The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

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We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

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We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

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We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

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