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Building Skyscrapers

Key words

- Engineering
- Environmental sciences
- Forces
- Earthquakes

The science behind

Introduction

In this experiment, we tried to build a strong structure of at least 2 levels, that can withstand the simulation of an earthquake, using straws, paper clips and tape.

Forces

In physics, a **force** is the cause that makes it possible to alter the state of motion or the rest of a body or that makes it possible to deform it. The concept can refer to the ability to move something, exert resistance or support weight. Therefore, physical force is a quantity that can influence **the shape and motion of material elements.** Forces can be said to affect **bodies that have a certain mass**.

Force is, therefore, a physical phenomenon that can change **the speed of motion, movement, and structure** (deformation) of a body, depending on the given point of application, direction and intensity. For example, dragging, pushing, or pulling an object involves applying a force that can change its resting state and velocity or deform its structure. Similarly, force is a measurable vector quantity that is represented by the letter 'F', and its unit of measurement in the International System is Newton 'N', named after Isaac Newton.

In his second law of motion, he described how force is related to mass and body acceleration.

For example, the greater the mass, the greater the force exerted on the object to achieve motion or change.

The force is calculated using the following formula: **F = m · a.**

F: the force required to move a body or object (in the International System, it is calculated in Newton). **M**: mass of a body (in the International System, it is calculated in kilograms). **A**: acceleration unit (in the International System is calculated in metres per second squared m / s2).

Seismic activity

- What is it, how to measure it,…

The seismic risk is an indicator, the result of a mathematical-engineering analysis, which makes it possible to **assess the effects in terms of the damage that a seismic event may cause** in a given area.

The calculation considers the time interval of the earthquake, the probability of occurrence and the degree of intensity.

In detail, seismic risk depends on the interaction of 3 factors:

- Hazard (P)
- Vulnerability (V)
- Exposure (E)

The **hazard** is the probability of an earthquake with a magnitude (intensity) more significant than the set peak threshold. It is a value representing the seismicity (frequency and strength of earthquakes) of a given area and depends solely on the physical characteristics of the territory.

Exposure indicates the possibility of an area suffering damage in economics, lives, and cultural heritage.

Vulnerability indicates a building's susceptibility to damage and collapse. This figure depends on several factors, such as inadequate design and construction, poor materials, and poor or inadequate maintenance. However, it is clear that the greater the vulnerability, the greater the likelihood that the building will be damaged or even collapse during an earthquake.

Changing the **seismic hazard** is not possible, let alone reducing exposure to seismic risk. However, vulnerability remains the only parameter on which it is possible to act through prevention interventions to secure so-called 'vulnerable' buildings.

Basic engineering technique

- Construction terms
- Stiffness of triangle, strong shapes
- Weight distribution

Geometry and architecture are two disciplines that are fundamentally linked. One of the most recognised geometric shapes is the **triangle**. Triangles are **practical tools** for architecture and are used in the **design of buildings** and other structures as they **provide strength and stability**.

When building materials are used to form a triangle, the design has a large base. The apex of the top can **handle the weight** because the energy is distributed throughout the triangle. This is why many residential houses have winches that provide a strong structure. The triangle has been in use in architecture for more years than other common shapes such as the dome, arch, cylinder and even precedes the wheel. The strongest are equilateral and isosceles triangles; their **symmetry** helps **distribute weight**.

The **equilateral triangle** is the most common triangle used in architecture. An equilateral triangle has three congruent sides and angles of 60 degrees at each grade. The length of the sides varies. A typical example of equilateral triangles in architecture is the complex of the pyramids of Giza in Egypt. Each of the four triangular sides that form the pyramids are equilateral triangle.

Isosceles triangles, which have two equal sides, are also found in architecture worldwide, especially in modern pyramid architecture. Isosceles were used in the architecture of the East Building in the National Gallery of Art in Washington, D.C. The Flatiron Building in New York City is one of the world's pioneering skyscrapers. This building was built on a triangular block in Manhattan, giving it a triangular shape, more specifically, of an isosceles triangle. It has been maintained for over 100 years, demonstrating the strength of triangular

Earthquake

- Scale, sizing, testing, etc.

The **intensity of earthquakes** is measured using **two scales** that correspond to the effects of the earthquake on the territory (**Mercalli scale**) and the energy released by the earthquake (**Richter magnitude**). The two scales are sometimes confused but measure very different volumes. The Mercalli scale, initially proposed by Giuseppe Mercalli in 1902, has been modified and known as the MCS (Mercalli, Cancani, Sieberg) scale. It is based on the visible effects on things, land, and the phenomena people feel.

However, the **Mercalli scale** is linked to subjective estimates and factors not strictly related to the earthquake and is insufficient for determining the energy developed by the earthquake. The intensity attributed to an earthquake based on this scale is unreliable because the damage varies greatly depending on the distance from the epicentre, the nature of the terrain, the density of human settlements and the type of materials used in the construction of buildings.

The **Richter scale**, devised in 1935 by Charles Richter (1900-1985) of the California Institute of Technology, is an earthquake classification scale that indicates the energy released by an earthquake based on the amplitude of seismic waves recorded by a seismograph.

An earthquake that generates a wave amplitude of 1 μm (1 micrometre equals 10^{-6} m) on the seismogram at 100 km from the epicentre is assigned magnitude M = 0; an earthquake that causes a wave amplitude of 10 μm is assigned magnitude M = 1 and so on up to M = 9.

Every day life

Katmandu 2015 earthquake

- What happened, engineering of buildings, etc.

On 25 April 2015, Nepal was hit by a **violent seismic event** of local magnitude 7.8 with an epicentre about 34 km east-southeast of Lamjung, which caused more than 8 000 deaths and severe damage in Nepal. It is the most violent seismic event to hit this area since 1934 when an 8.0 magnitude earthquake killed about 10,600 people.

Several **centuries-old buildings**, including the Dharahara Tower, rebuilt after the 1934 earthquake and located in Kathmandu's Durbar Square and part of the UNESCO World Heritage Site, were destroyed. The destruction of the city of Kathmandu was facilitated by the fact that the town was built on a prehistoric lake. The soil, consisting of soft sediments, was quickly traversed by seismic waves, which thus caused more tremors and more damage.

The earthquake that struck Kathmandu was predicted down to the details of its possible damage. Nepal lies on the border between the Indian and Eurasian plates, where the world's highest mountains bear witness to the violence of the collision, which occurs at a rate of 5 cm per year. **The seismic vulnerability of buildings** was still a known and worrying factor. Nepal has been carrying out public awareness campaigns and other risk reduction initiatives in recent years, albeit with limited financial means. Some organisations dedicated to risk reduction, such as the National Society for Earthquake Technology, questioned how much had been done to improve buildings and educate the population on how to behave in an earthquake.

The earthquake and the extensive damage it caused highlighted **the fragility of the buildings**, many of which are old or **ancient constructions**, certainly not earthquake-proof and not in accordance with current national standards. But the earthquake also highlighted aspects of inequity within Nepalese society due to geographical, economic and gender-related factors. The poorer rural areas suffered much heavier damage than the cities, as the construction characteristics and consistency of rural buildings have always been poor.

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