Question Ideas

- Adhesives (experiment)
- Why did war and human conflict come and how do we avoid it? (study and analyzing)
- ***How could we use building techniques from 1000+ years ago to make buildings that are useful today?*** (my favourite!) (study/innovation)
- How do different window types affect heat in your house? (experiment)
- How can listening to music help you in sports? (experiment)

Title:

Architecture of the Past Transforming the Future

Question: How could architectural styles from 1000+ years ago be relevant and useful today in light of all the natural disasters?

Good questions to ask:

1. What material was it made out of? How could we use those materials today?
2. Is it earthquake proof?
3. What techniques were used? How could we use their techniques today?

Introduction:

In this project I will be looking into the past and researching various buildings and their styles to discover how we could use their styles today, when there are many natural disasters and other issues in our world. My method for this project is to ask three questions: “What material was it made out of?” “Is it earthquake resistant?” And, “What techniques were used?” Follow me as we delve deeper into the Architecture of the past to transform the future.

Research:

Colosseum, Rome: 70 and 72 CE

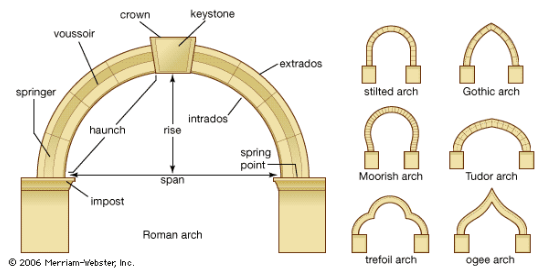
Image:

Basic Architecture

- The Colosseum was one of a few freestanding structures in that day
- The Colosseum had many trapdoors to give unexpected entrances
- The elliptical shape made sure that everyone could see the fight

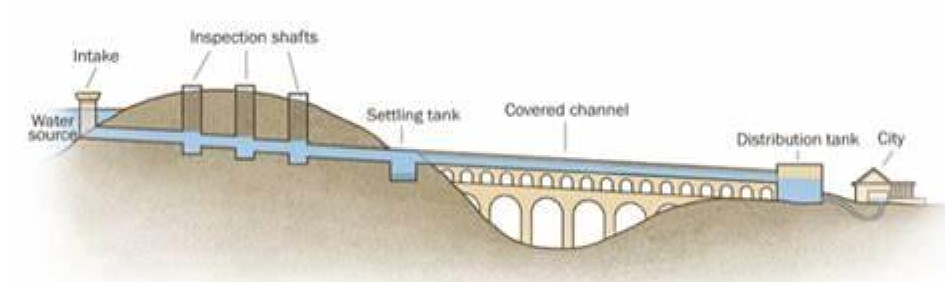
Arches

- The arches are one of the reasons the colosseum was so strong, and it inspired many more modern arches.
- Arches work so well because of the way they use gravity to their advantage. The voussoirs want to slide in on themselves toward the center of the arch. Once the keystone is in place, they are unable to do so and they end up pushing in on the keystone. The keystone is now unable to move and remains hard. Thus, under pressure, the arch gets stronger.



Aqueducts

- The aqueducts were used to transport water from the higher areas to the city. They used gravity to take the water down long paths above and below ground. As you can see, the arches were used again to make the bridges.



What materials were used?

Travertine stone and concrete.

Stone can not burn, but is something we have to excavate. 100,000 cubic meters were used in the making of the colosseum. Purely stone structures are not as liable to burn, but are pricey and often wood is used in buildings. We could, however, use stone to resist fires in BC and area. If we use stone, though, our prices will be quite a lot higher because of the excavation, transportation, and other costs associated with stone construction. It also is not very insulating. Concrete, however, is something cheaper and in some ways stronger than stone.


Travertine stone.

Is it earthquake proof?

Here's the weird part: It is pretty much so. The strange part is it does not bend, has no springy base, and does not meet the requirements of an earthquake-proof building. Recent research suggests that we could use careful patterns (called metamaterials) and use them to deflect sound waves from earthquakes, possibly saving precious buildings. The Colosseum seems to be an early version of this. No one knows for sure, but if it was really like this…

We could tweak it and use it to save buildings today.

What techniques were used?
The arch is the most notable. Several arches stand proudly, holding tons of weight and keeping it up. We can use arches today. They aren't just pretty, they are structurally sound.
(See Research:Arches above.)

The Colosseum: Final Trifold Write-up
The Colosseum was one of the few standing structures in its day, and has survived years of fights and other more creative uses. The Colosseum's defining technique was its arches, which made up the building's walls. Arches were often used because of their immense strength. They were strong because the forces acting on the bricks/voussoirs pushed inward, and once the keystone was set, strengthened the arch by doing so. The only way to destroy an arch is to smash either the keystone or one of its foundation blocks. The Colosseum and its arches were made of travertine stone, a very strong sedimentary rock that is a version of limestone. Stone is a great building material that does not burn (although it may warp), is fairly strong, and is incredibly resistant to compression, although it is not as strong when under tension. Stone was a building material that was used throughout the ages. Although the Colosseum is not built to be earthquake proof, there are theories on how it survived the amount of time that it did, such as the metamaterial theory, nothing is confirmed as of yet.

Sources- Colosseum
Colosseum | Definition, Characteristics, History, & Facts | Britannica
Architecture · Colosseum · Piranesi in Rome
24 Mind-Blowing Facts About The Roman Colosseum (PICTURES)
Arch | Types, Design & Structures | Britannica
arches in architecture and engineering
Aqueducts Move Water in the Past and Today | U.S. Geological Survey
Colosseum Water and Sewer System.
Awesome Arches | GYSTC
Stone Construction - Sustainable Build.
Seismic cloak could minimize earthquake damage – Physics World
Deflecting Earthquakes The Way Ancient Romans Did It | Hackaday
Ancient Romans may have built structures that acted like seismic invisibility cloaks

Pyramids of Giza, Egypt: 2580 BC-2560 BC

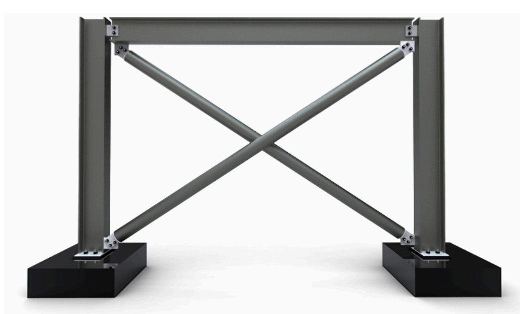
Image:

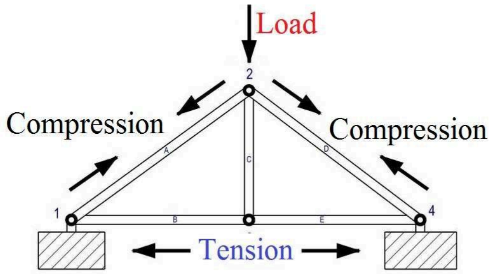
Basic Architecture

No one quite knows how it was built. The angle of the pyramids makes it that people could not have carried the heavy stone blocks, yet the winch wasn't invented yet. The most accepted theory is that a curling ramp that coiled around the building was used to build it and carry the large 2 ton blocks up the pyramid. They were placed so precisely it almost seems impossible. There is a tomb painting showing the Egyptians transporting a large statue with sleds on greased ground. In a day without cars, trucks, or winches, this would have been genius.

Triangle Strength

- Triangles are the strongest shape. Once a triangle has been made, its shape cannot be changed unless the sides are either lengthened or shortened.
- The sum of the interior angles of a triangle are always 180 degrees, no matter what.
- Each side supports the other two, meaning it can bear weight quite well
- Wide base gives triangles strength in earthquakes
- If you take a square and add 2 diagonal lines through it you get cross bracing, because you created 4 triangles out of a square





What material was it made out of?
The Pyramids of Giza were made out of limestone. Limestone is quite strong, but does absorb water and is susceptible to acid rain. Limestone may not be good for areas plagued by rain, but the desert, where rain is rare, is a perfect place to use limestone.

Is it earthquake proof?
As you can see in the video that I inserted in my sources, the pyramid points stay firm, and although the pyramid shakes, it can return to its original shape because of its points.
It also has a wide base to support it, and you cannot change the angles of a triangle without changing the length of its sides. Thus, although it is not designed with earthquakes in mind, it may be firmer than first assumed.

What techniques were used?
The pyramid shape is incredibly strong
(See Triangle Strength: Research above)

Final Trifold Write Up: Pyramids of Giza
The Pyramids of Giza are the oldest buildings I researched into, and still very strong. They were made to be tombs for the elite rulers of Egypt, but are now a tourist attraction for the people of this day. The Pyramids of Giza were made from limestone, which is a strong material but very susceptible to the effects of acid rain and it absorbs water. They didn't have the strongest earthquake proof buildings, but its large base lent it some strength against the seismic waves. The Pyramids major strength was its use of triangles in its architecture. Triangles are strong due to the fact that you cannot change the shape of a triangle without changing the length of its sides. The Pyramid was not the strongest building that I researched into, but did have quite a few qualities that we should use today.

Sources-Pyramids Of Giza
Great Pyramid of Giza - World History Encyclopedia
Pyramids of Giza | History, Location, Age, Interior, & Facts | Britannica
The Egyptian Pyramid | Smithsonian Institution
Why Is the Triangle the Strongest Shape - How This Shape Dominates Strength and Stability
Triangles are the strongest shape | Thinking about Geometry | Underground Mathematics
Pyramid casing stone.
Limestone: Characteristics, Uses And Problem | GSA.
Earthquake Simulation On Pyramid

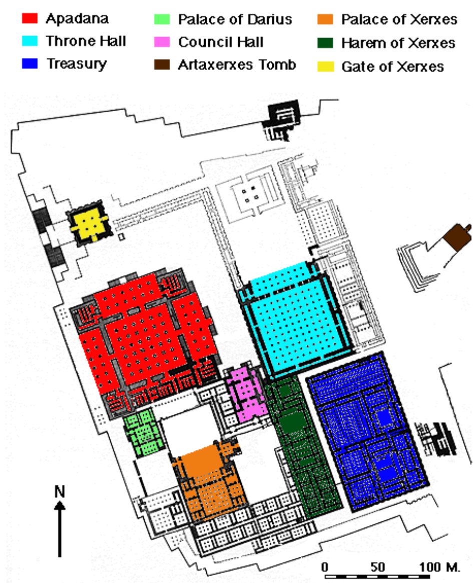
Persepolis 518 BC

Image:

Basic Architecture:

- Persepolis lost much of its beauty due to Alexander the Great looting the impressive city and burying it in its own ruins.
- Even though it was destroyed, 13 huge columns still stand in the great hall, which is also known as the apadana.

Note: Irrelevant to project. Too large a complex for specific research.



Sources-Persepolis

[Persepolis - UNESCO World Heritage Centre]

[Persepolis - Ancient City, Persian Empire, Achaemenid Dynasty | Britannica]

Göbekli Tepe

Image:

Basic Architecture:

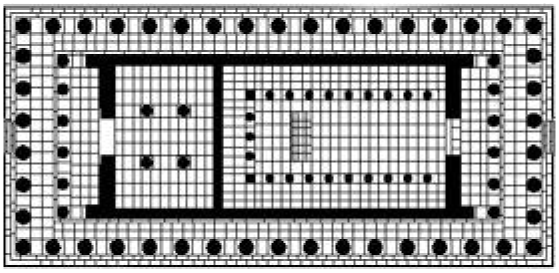
Note: Irrelevant to project. Too large a complex for specific research

Parthenon, Athens, Greece (447–432 BC)

Image:

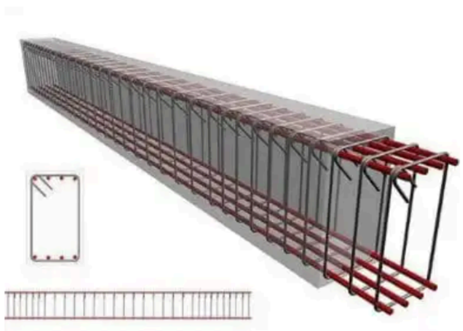
Basic Architecture:

- The Parthenon is a complex structure that is full of columns.
- The marble was placed very precisely and it survived thousands of years, but it was partially destroyed from man ripping down statues and crushing the marble. Some of it still stood, though, and the structure was salvageable.

 Floor plan of the parthenon.

Columns

- There are three basic sections of a column. The base, the shaft, and the capital.
- It is quite simply a vertical pillar that supports weight and inspires structural integrity.
- Columns are strong because of the fact that stone is better under compression.
- Columns don’t have to be filled to be strong
- Beams are under tension, columns are under compression
- Steel and concrete= an item that can withstand both tension and compression.
- If a column is just under compression, a circular column is best, but if it is under compression and tension, it should be made more like this.



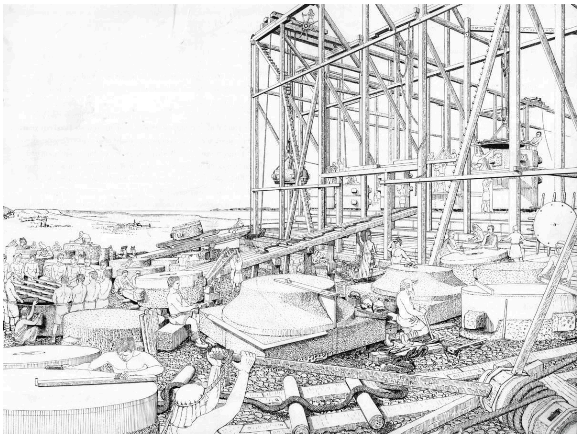
What material was it made out of?

The Parthenon was made out of white marble. Marble is quite strong except on its fault lines, but concrete is consistent.

Is it earthquake proof?

Very much so. The parthenon was built on a foundation of marble, which helped a lot. It also had lead and metal “joints” in each layer of the foundation, which allowed it to bend and absorb the seismic waves. The third help was in the fact that its columns were not just solid, but were of layers of the same crafted stone, allowing it to shift. The positioning of the columns helped as well.

What techniques were used?
The many earthquake-resistant techniques helped quite a bit, and, of course, its columns.
(See Columns:Research above)



Final Trifold Write Up: Parthenon:
The Parthenon is a Greek wonder that was built to be a temple to the goddess Athena, the Greek goddess of knowledge. It has many columns and was built out of white marble, which is a very strong stone that is often used in countertops. The most impressive part of the Parthenon lies in its extraordinary triple seismic insulation. The Parthenon is protected from earthquakes by the smooth marble plates that it lies on, the small lead joints that connect each layer, and the superimposed slices of stone that make up the columns. When an earthquake starts, the seismic energy travels through the layers of smooth marble, then it reaches the lead joints. The lead converts some of the seismic energy into thermal energy. Finally, the superimposed columns are reached. They are able to shake and still remain standing. All these factors working simultaneously protects the building from these seismic waves. The Parthenon used columns extraordinarily, and it stands strong to this day.

Sources: Parthenon
Parthenon | Definition, History, Architecture, Columns, Greece, & Facts | Britannica
Parthenon
Unlocking Mysteries of the Parthenon | History| Smithsonian Magazine
Doric Columns | Architect of the Capitol
Columns.
Column | Definition in Architecture, Styles and Shapes | Britannica
Parthenon: Triple anti-seismic protection and brilliant engineering | thestructuralengineer.info
Why has the Parthenon in Athens never been knocked down by an earthquake? - Quora
How could the Parthenon remain standing for 2,500 years without a foundation

All Sources

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Seismic cloak could minimize earthquake damage – Physics World
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Types of Foundations in Construction | BigRentz.
Persepolis - UNESCO World Heritage Centre
Persepolis - Ancient City, Persian Empire, Achaemenid Dynasty | Britannica

Notes From My Expert Meeting With Saphron Skinner-Willson

<u>Triangles</u>
Wide base give it strength in earthquakes to triangles
USE TRIANGLES
Cross Bracing
Take square, add line through middle, and another=cross bracing
<u>Metamaterials/Colosseum</u>
Arches are self supporting, so are domes
Stones were used to help it stand
No insulation
Stone is not good at tension, but can withstand pressure
Metamaterials is a small electromagnetic field that can shelter buildings. WE DON'T KNOW HOW!
<u>Columns</u>
Columns are strong because of the fact that stone is better under compression.
Columns don't have to be filled to be strong
I beams are strong, but cannot be made out of stone because they are put under tension
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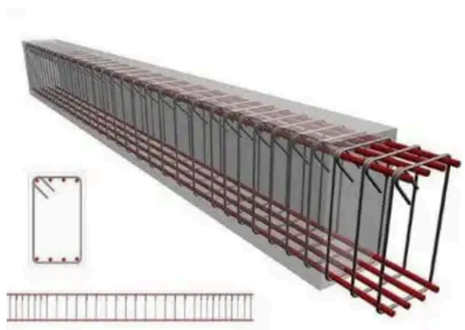


Marble is quite strong except on its fault lines, but concrete is consistent.

Analysis

Answers to the major questions:

What material should it be made out of?
As we see in all the buildings I researched into, we see stone as a material that can stand for all the years. It is not flammable, and has a strong base. Combined with the more modern steel and concrete, we can make buildings that are able to withstand high temperatures.

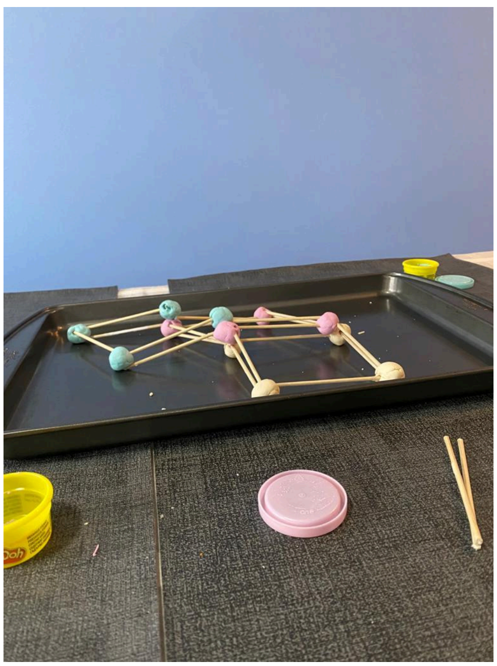
How do we make it earthquake resistant?
If we look at the Parthenon, we see the strongest of the three buildings that I researched into. It is triple enforced with the marble base, lead and iron joints, and superimposed columns made out of different “slices” of stone.

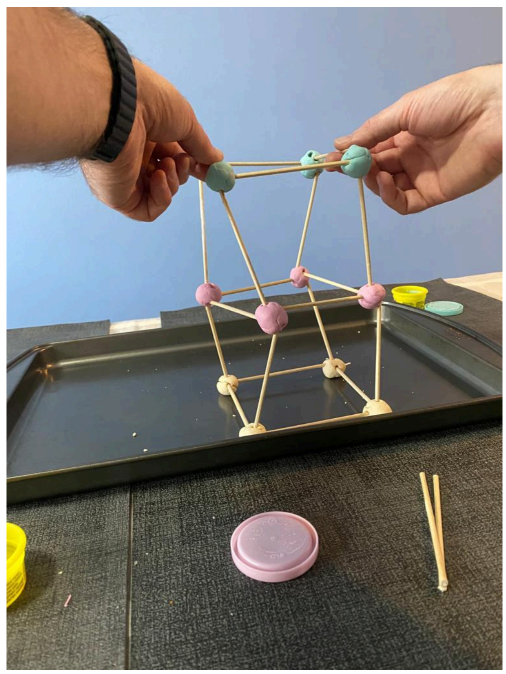
What techniques should I use?
Arches are strong, but have somewhat faded from our modern architecture. We should bring them back.

Columns are good for weight distribution. If we build them the way the Greeks did, they will still offer their protection in earthquakes.

Triangles are super strong and we can use cross bracing and other triangle elements in buildings today.

Field Testing and Application of Building Techniques on a Square Frame:

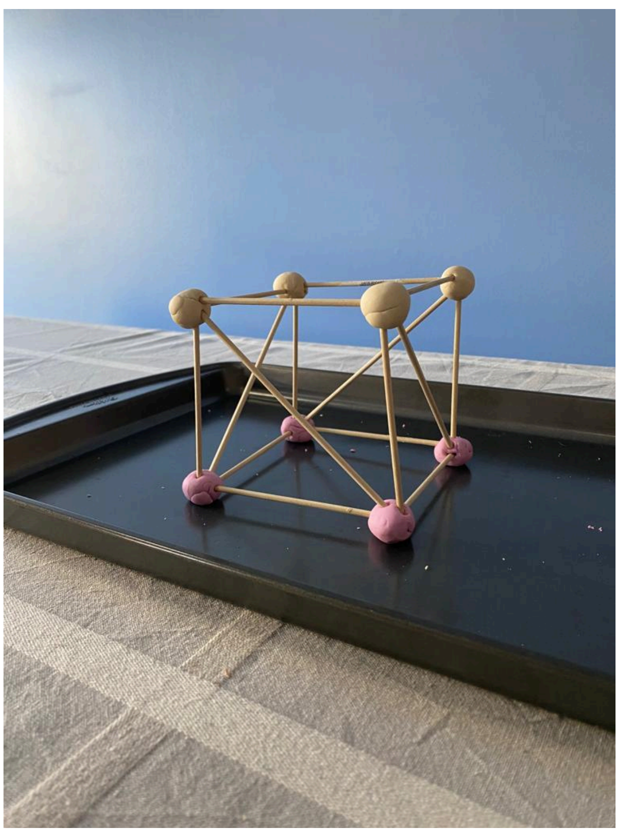




1st test: 2 story frame with no cross bracing or other additions added.

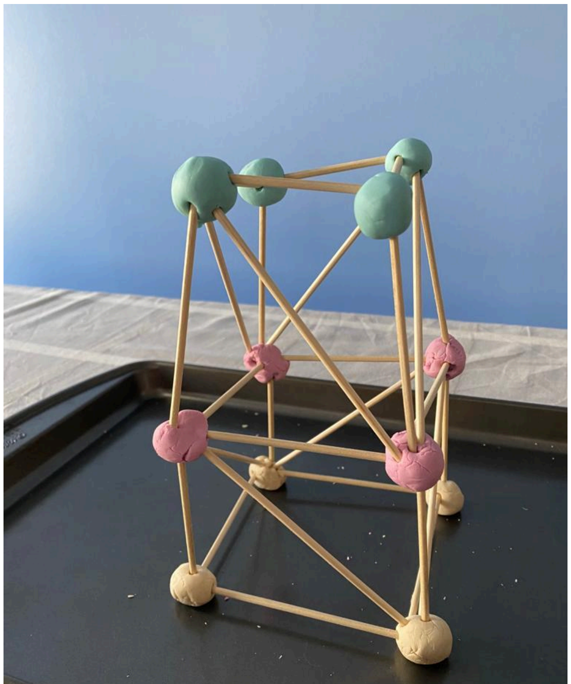
2 test: 1 story frame without cross bracing or other additions added.

Plain Square.mp4



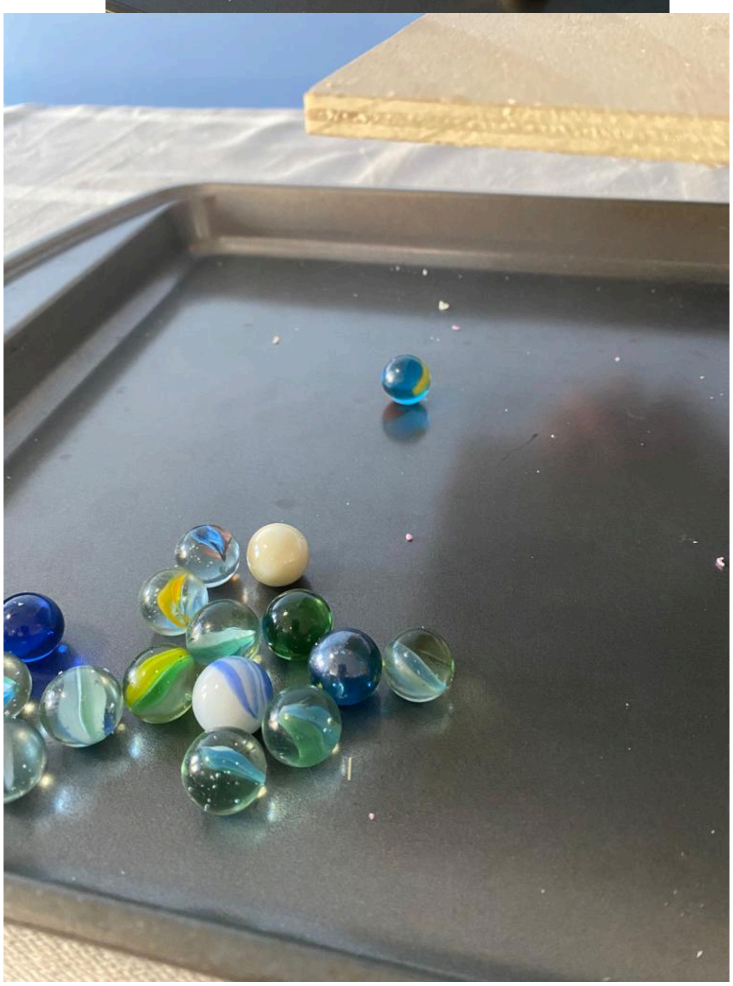
3rd test: 1 story frame with cross bracing but no other additions.

Square with cross bracing.mp4



4th test: 2 story frame with cross bracing and a lighter top.

2 story crossbracing.mp4



5th test: 2 story frame with cross bracing, lighter 2nd story, and parthenon isolation.

Final test.mp4

Conclusion

In conclusion, we can enhance the buildings of today with techniques such as columns, arches, and triangles. We can use earthquake resistant techniques that were invented thousands of years ago, such as the triple anti-seismic protection of the Parthenon, and use materials such as stone to strengthen our buildings.If I did this project again, I would expand it by looking into more and older buildings, digging deeper with my research, and asking new questions about the buildings of the past. Ultimately, the data that I have collected can be used in many ways and the building techniques that I found can be applied differently than the way that I applied it. In conclusion, we could make less disposable buildings and waste less materials if we looked back instead of forward and invented new buildings that can stand the test of time.

Other information for the Project

SCAN ME

This is a QR code to put on my trifold.

Research to help buildings

[Types of Foundations in Construction | BigRentz](#).

Printing Copies:

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The Parthenon is a Greek wonder that was built to be a temple to the goddess Athena, the Greek goddess of knowledge. It has many columns and was built out of white marble, which is a very strong stone that is often used in countertops. The most impressive part of the Parthenon lies in its extraordinary triple seismic insulation. The Parthenon is protected from earthquakes by the smooth marble plates that it lies on, the small lead joints that connect each layer, and the superimposed slices of stone that make up the columns. When an earthquake starts, the seismic energy travels through the layers of smooth marble, then it reaches the lead joints. The lead converts some of the seismic energy into thermal energy. Finally, the superimposed columns are reached. They are able to shake and still remain standing. All these factors working simultaneously protects the building from these seismic waves. The Parthenon used columns extraordinarily, and it stands strong to this day.

The Colosseum

The Colosseum was one of the few standing structures in its day, and has survived years of fights and other more creative uses. The Colosseum's defining technique was its arches, which made up the building's walls. Arches were often used because of their immense strength. They were strong because the forces acting on the bricks/voussoirs pushed inward, and once the keystone was set, strengthened the arch by doing so. The only way to destroy an arch is to smash either the keystone or one of its foundation blocks. The Colosseum and its arches were made of travertine stone, a very strong sedimentary rock that is a version of limestone. Stone is a great building material that does not burn (although it may warp), is fairly strong, and is incredibly resistant to compression, although it is not as strong when under tension. Stone was a building material that was used throughout the ages. Although the Colosseum is not built to be earthquake proof, there are theories on how it survived the amount of time that it did, such as the metamaterial theory, nothing is confirmed as of yet.

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Introduction

My project this year was inspired by the earthquakes that have been occurring all over the world, the tornadoes ripping across our land, and the fire raging through BC. When you go online and look at the repercussions of these events, you see buildings that are nothing more than rubble, nothing more than dust and ashes. But there are buildings that have proved their worth. 1000 year old buildings that are still standing. My research project is on how we can use these techniques that were invented thousands of years ago on buildings today to enhance and protect them so we have houses and skyscrapers that stand for years to come.

Method

My method for this project was to ask three questions of the buildings that I researched into, which included the Parthenon, the Colosseum, and the Pyramids of Giza. These three questions were: “What material was it made out of?”, “Is it earthquake resistant?”, and “What techniques were used?”.

Log book

SCAN ME

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In conclusion, we can enhance the buildings of today with techniques such as columns, arches, and triangles. We can use earthquake resistant techniques that were invented thousands of years ago, such as the triple anti-seismic protection of the Parthenon, and use materials such as stone to strengthen our buildings. If I did this project again, I would expand it by looking into more and older buildings, digging deeper with my research, and asking new questions about the buildings of the past. Ultimately, the data that I have collected can be used in many ways and the building techniques that I found can be applied differently than the way that I applied them. In conclusion, we could make less disposable buildings and waste less materials if we looked back instead of forward and invented new buildings that can stand the test of time.

Analysis

Answers to the major questions:

What material should it be made out of?

As we see in all the buildings I researched into, we see stone as a material that can stand for all the years. It is not flammable, and has a strong base. Combined with the more modern steel and concrete, we can make buildings that are able to withstand high temperatures.

How do we make it earthquake resistant?

If we look at the Parthenon, we see the strongest of the three buildings that I researched into.

It is triple enforced with the marble base, lead and iron joints, and superimposed columns made out of different “slices” of stone.

What techniques should I use?

Arches are strong, but have somewhat faded from our modern architecture. We should bring them back.

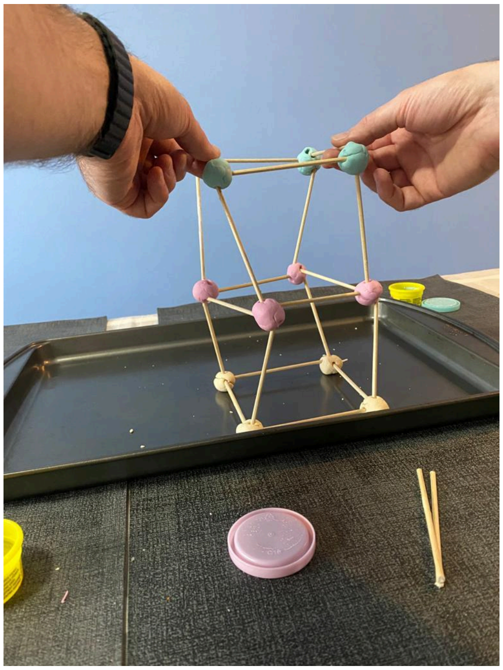
Columns are good for weight distribution. If we build them the way the Greeks did, they will still offer their protection in earthquakes.

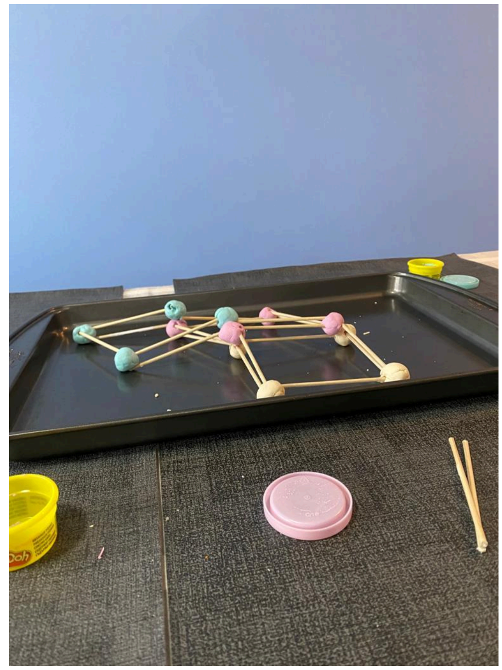
Triangles are super strong and we can use cross bracing and other triangle elements in buildings today.

Field Testing and Application Of Building Techniques on a Square Frame

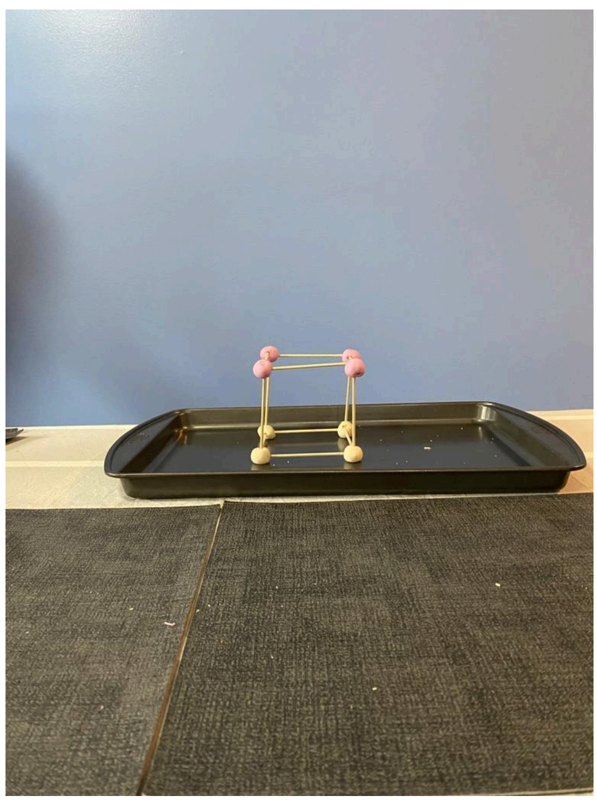
For a quick demonstration of the techniques and how they may enhance our square buildings, I completed a few tests on how our square frames may react in earthquakes with the techniques I’m investigating added onto them.

1st test:





2nd test:



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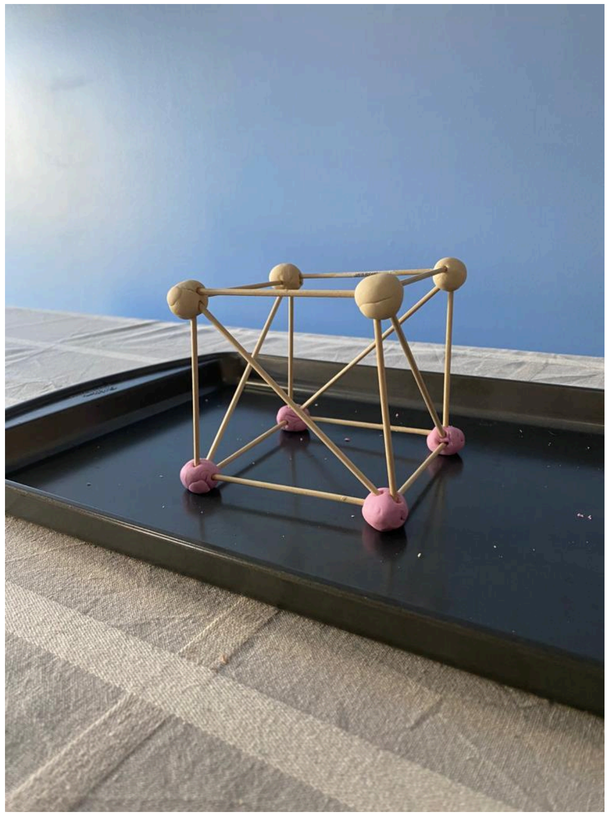
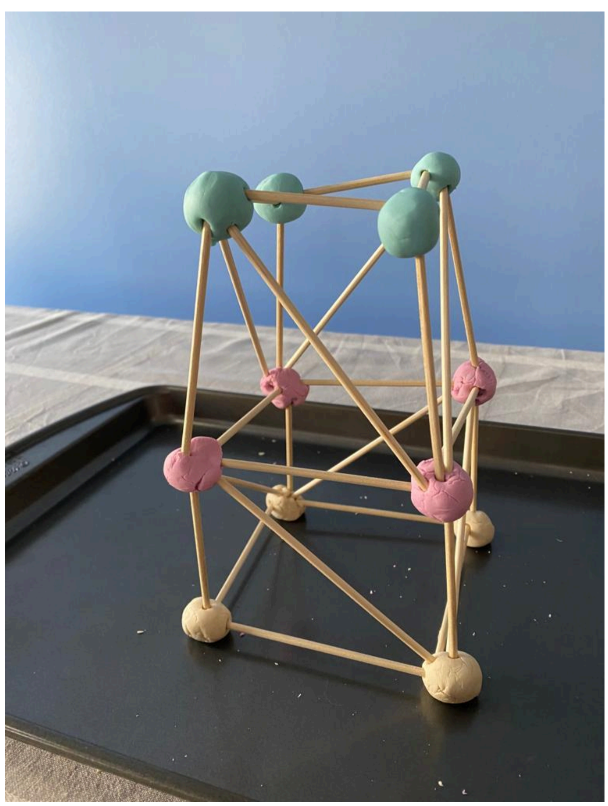
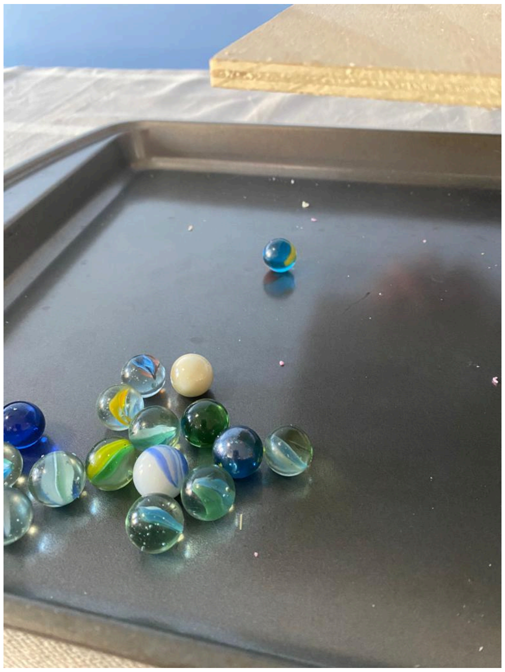
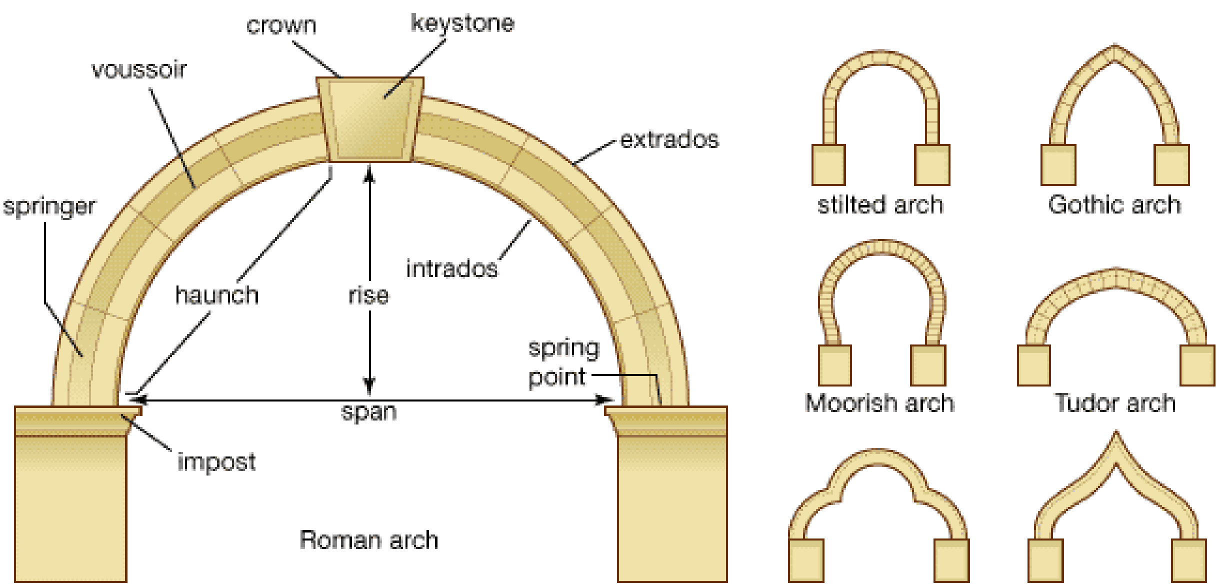


4th test:

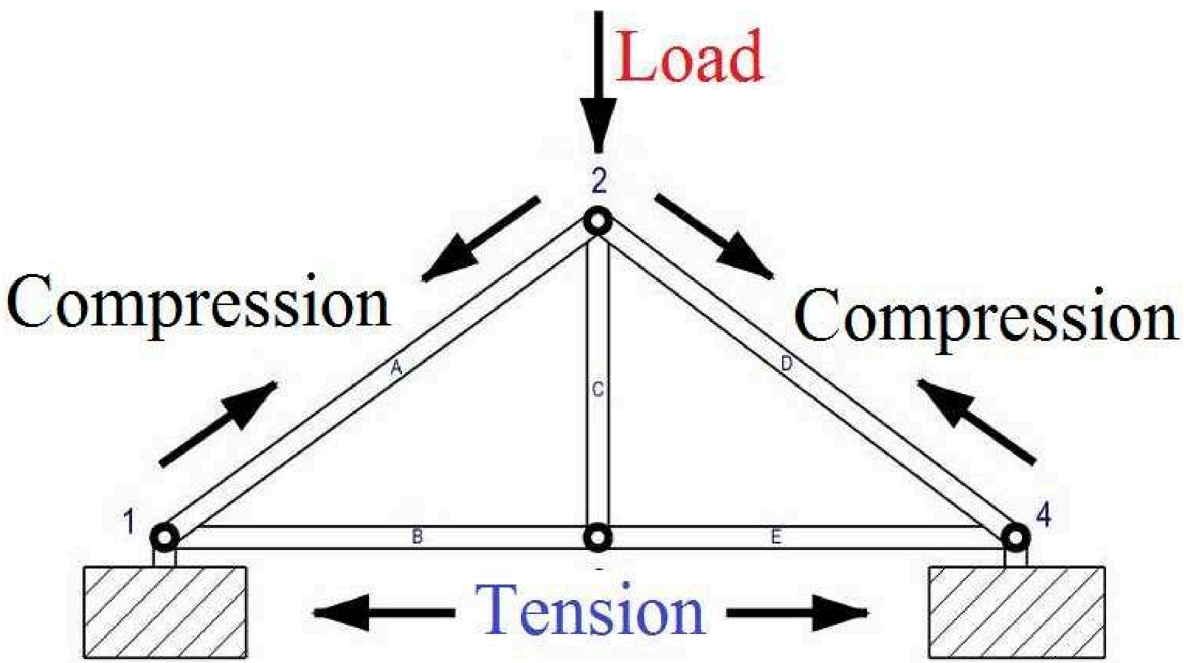


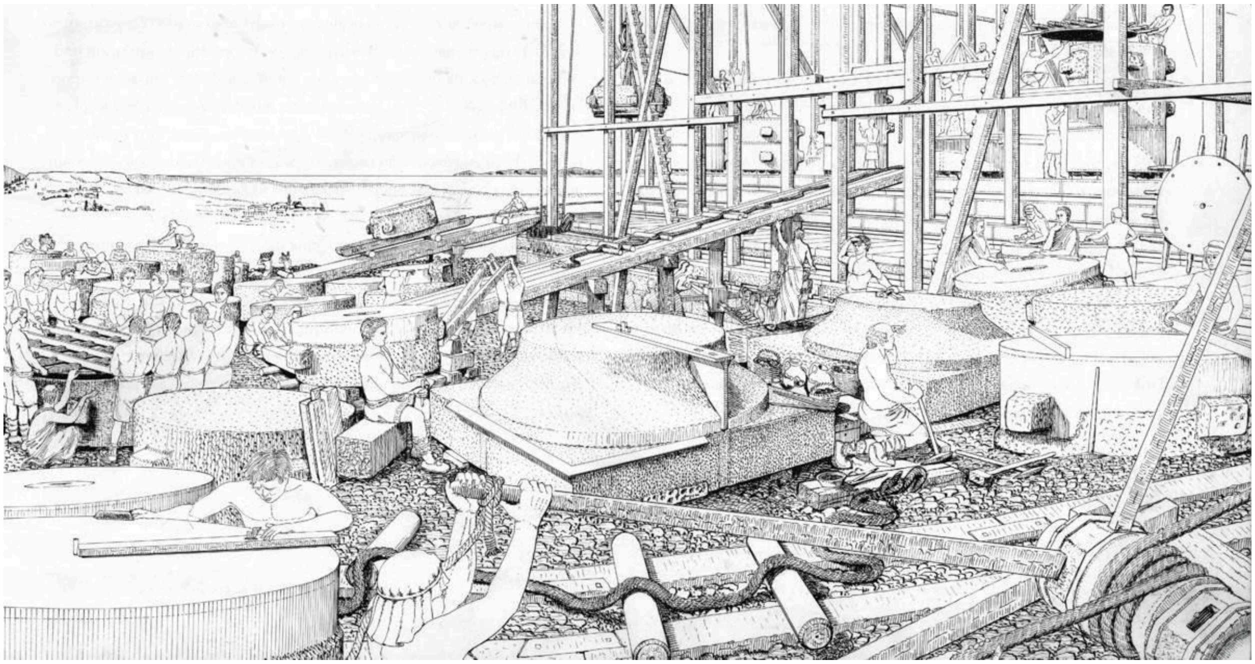
5th test:

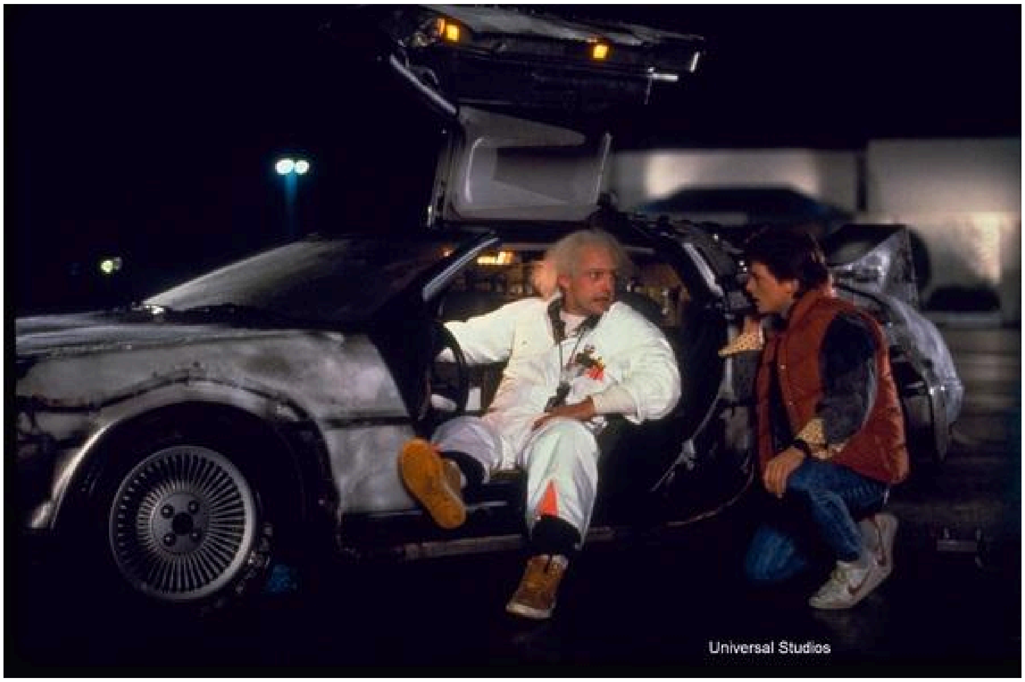




crown
keystone
voussoir
extrados
springer
intrados
haunch
rise
spring point
span
impost
Roman arch
stilted arch
Gothic arch
Moorish arch
Tudor arch
trefoil arch
ogee arch


Load
2
Compression
A
C
D
Compression
1
B
E
4
Tension

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