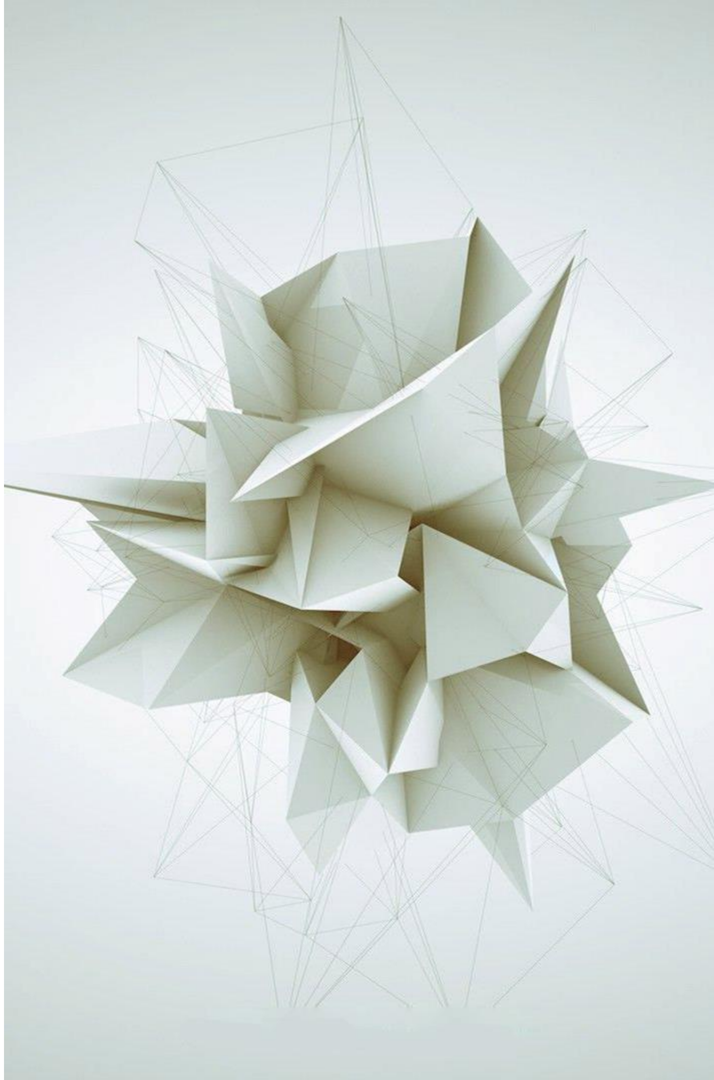
Topological Interlocking: Life Beyond The Plane

HELLO!

I am Andres Bejarano

Interested in Computer Graphics and Geometry. Currently working on interlocking configurations under supervision of professor **Christoph Hoffmann**

“Geometry Wallpaper”, from http://hdw.eweb4.com/wallpapers/7777/



In this presentation:

- What is Topological Interlocking?
- Why is it relevant?
- How can it be extended to 3D?

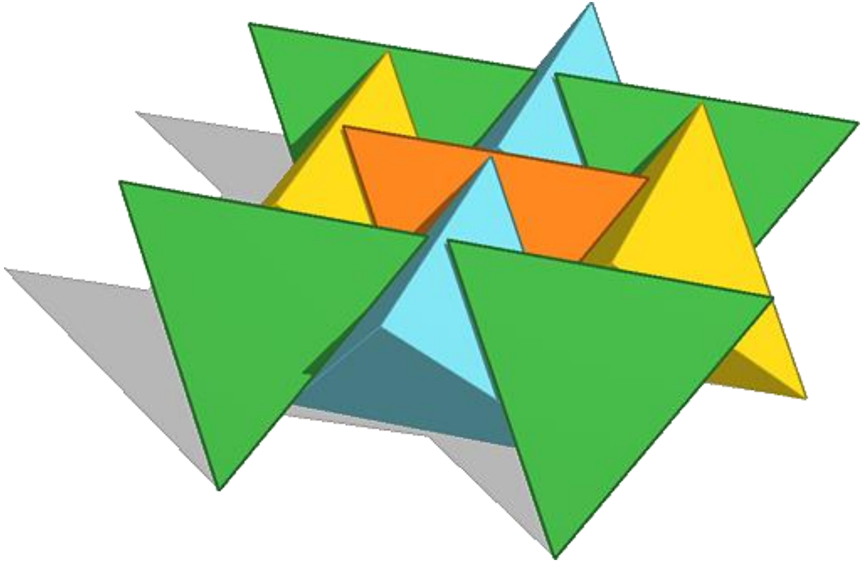
1.

What is Topological Interlocking

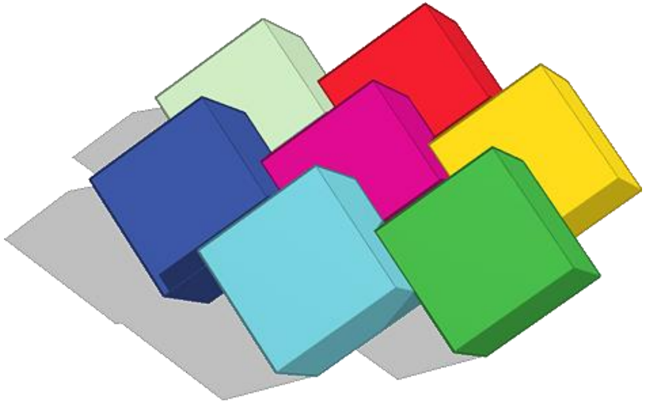
Everything you need to know in a nutshell

“**Topological Interlocking** is a structural organization for which the building blocks are locked in their positions by purely geometrical constraints.”

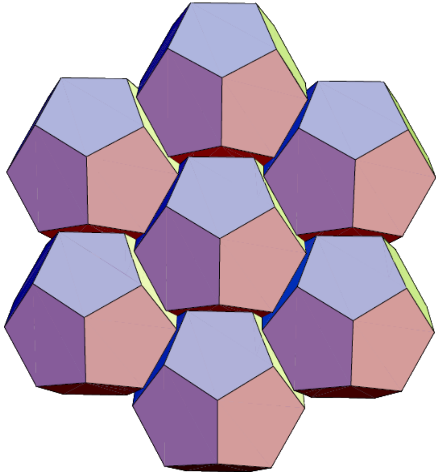
(Dyskin, 2003)

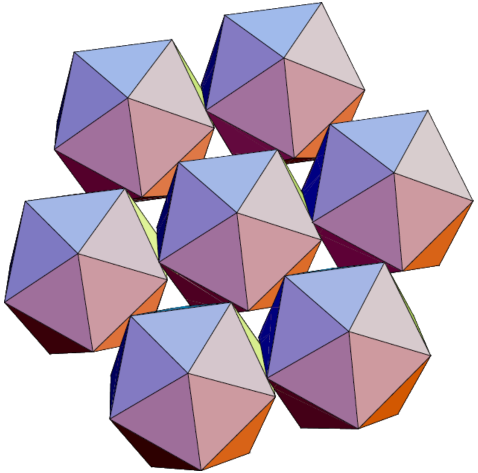


Here’s one using **tetrahedra**



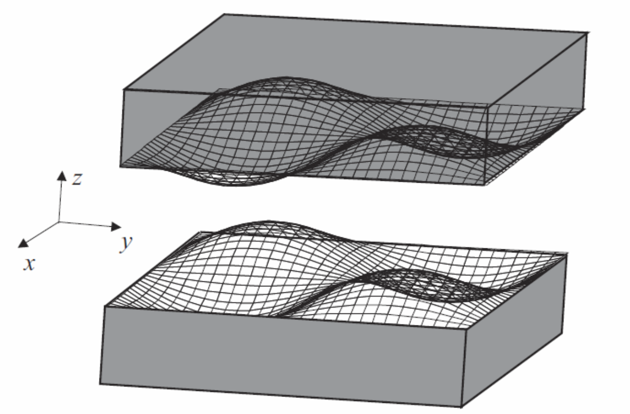
It also works with **hexahedra** and **octahedra**

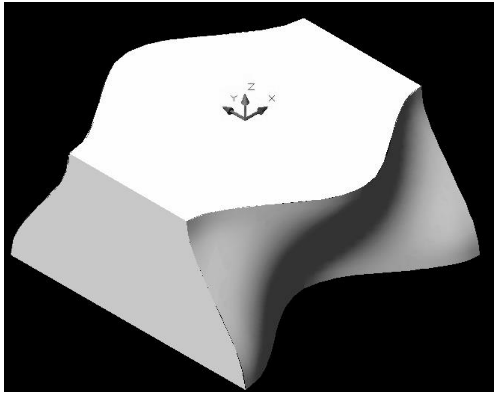




And of course, **dodecahedra** and **icosahedra** can be used too

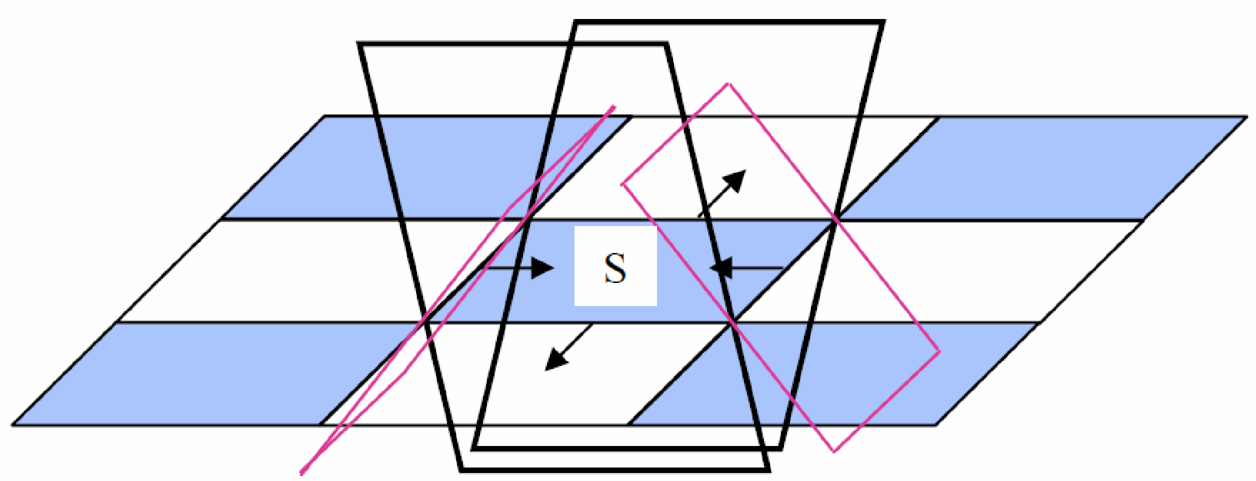
(Kanel-Belov, 2008)





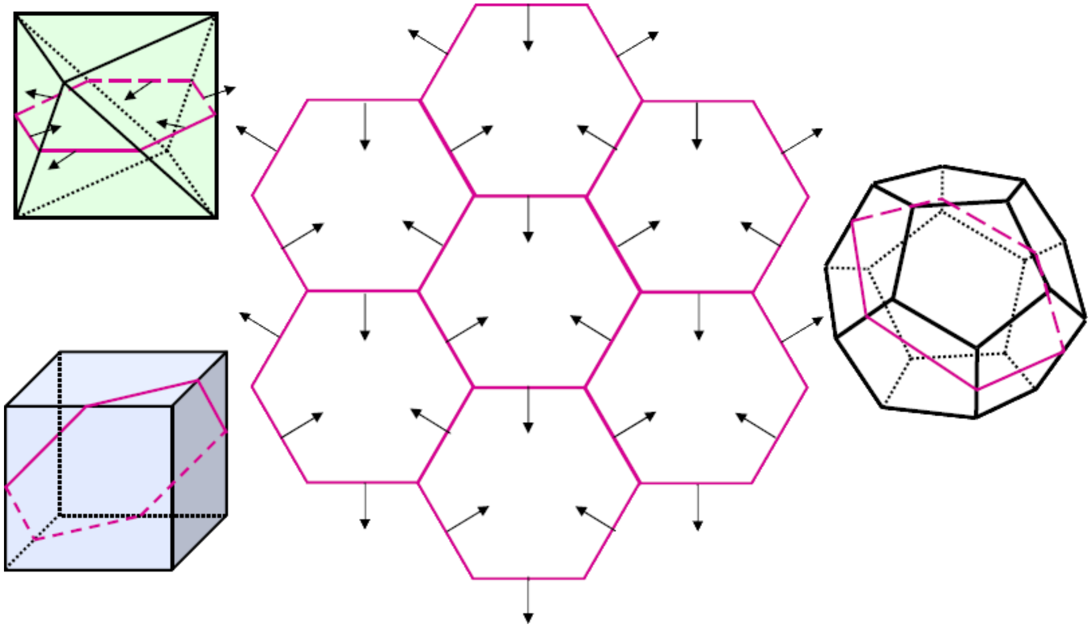
Convexity is not mandatory. Introducing the **Osteomorphic Brick**

(Dyskin, 2003)



For tetrahedra all we need is a **Chessboard**

(Kanel-Belov, 2008)



For the other solids* use a

Honeycomb Pattern

(Kanel-Belov, 2008)

* Icosahedra doesn't fit here

2.

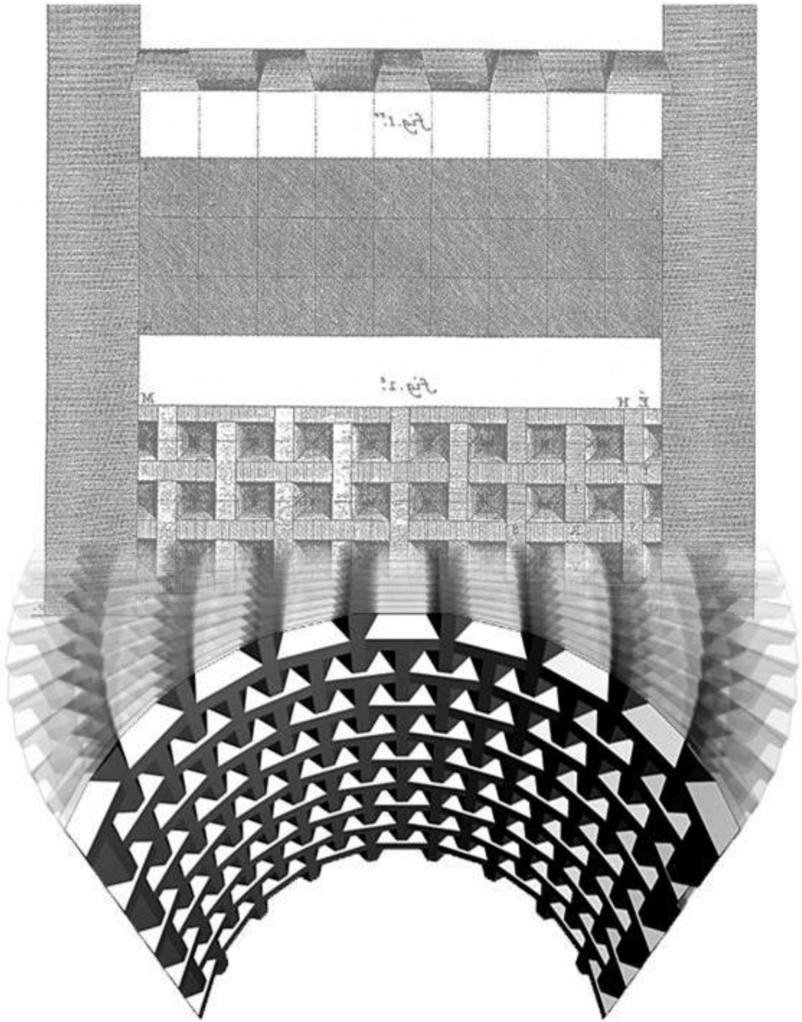
Why is it relevant?

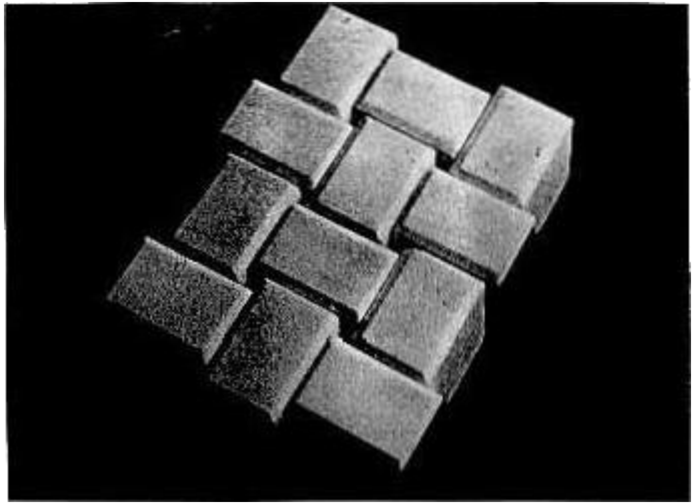
Its is more useful than you thought it would

Since 1699 it’s being used for

Flat Vault Design

(Brocato, 2012)

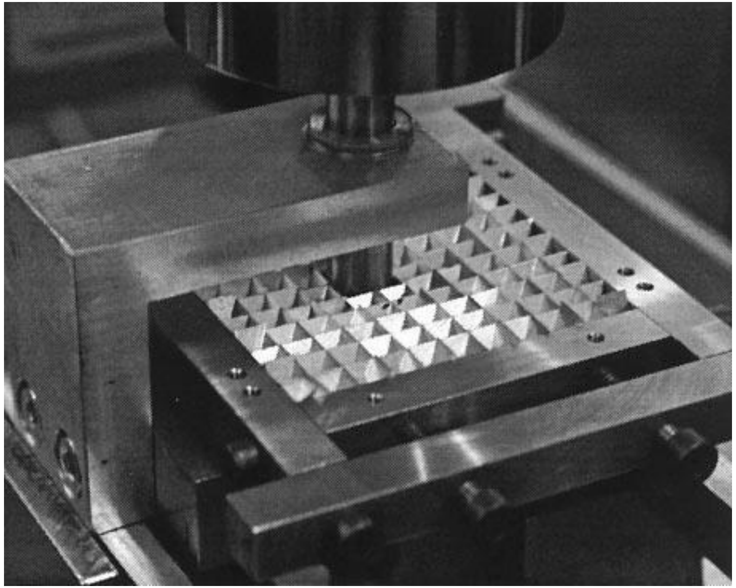




In 1984 it was considered for

Interlocking Paving

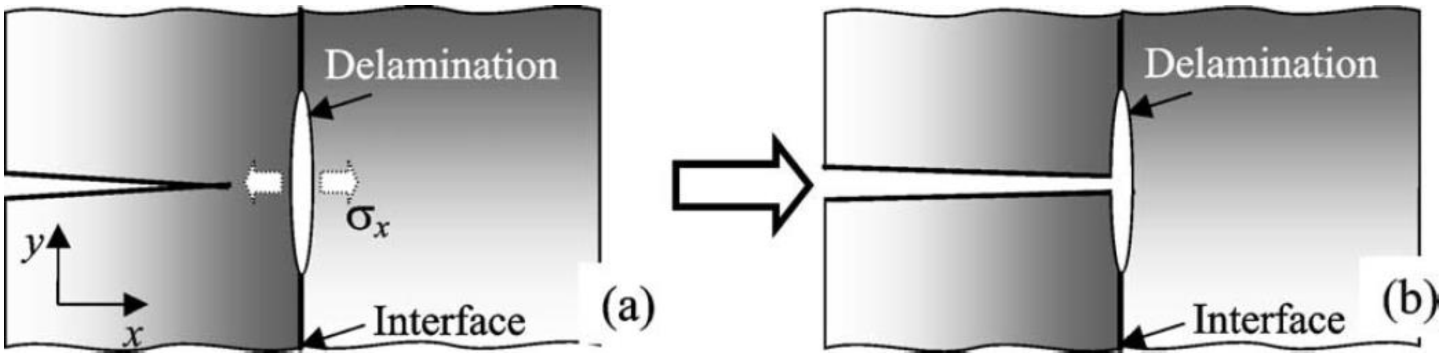
(Glickman, 1984)



In 2001 it was found it has very good

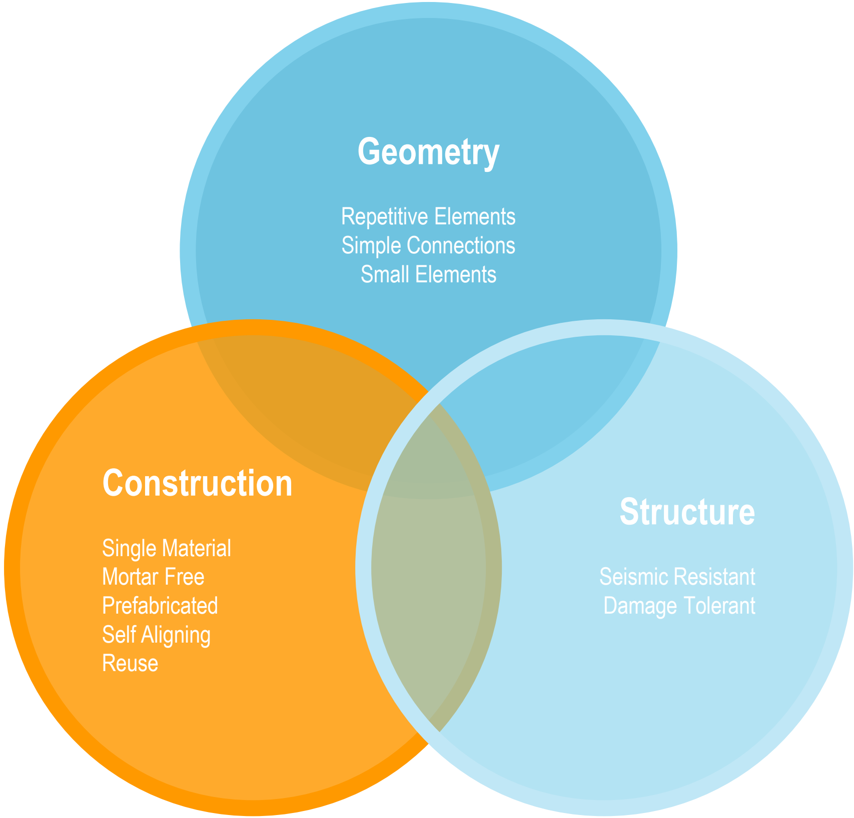
Resistance Properties

(Dyskin, 2001)



Prevents
Crack Propagation

(Dyskin, 2003)



It’s good for

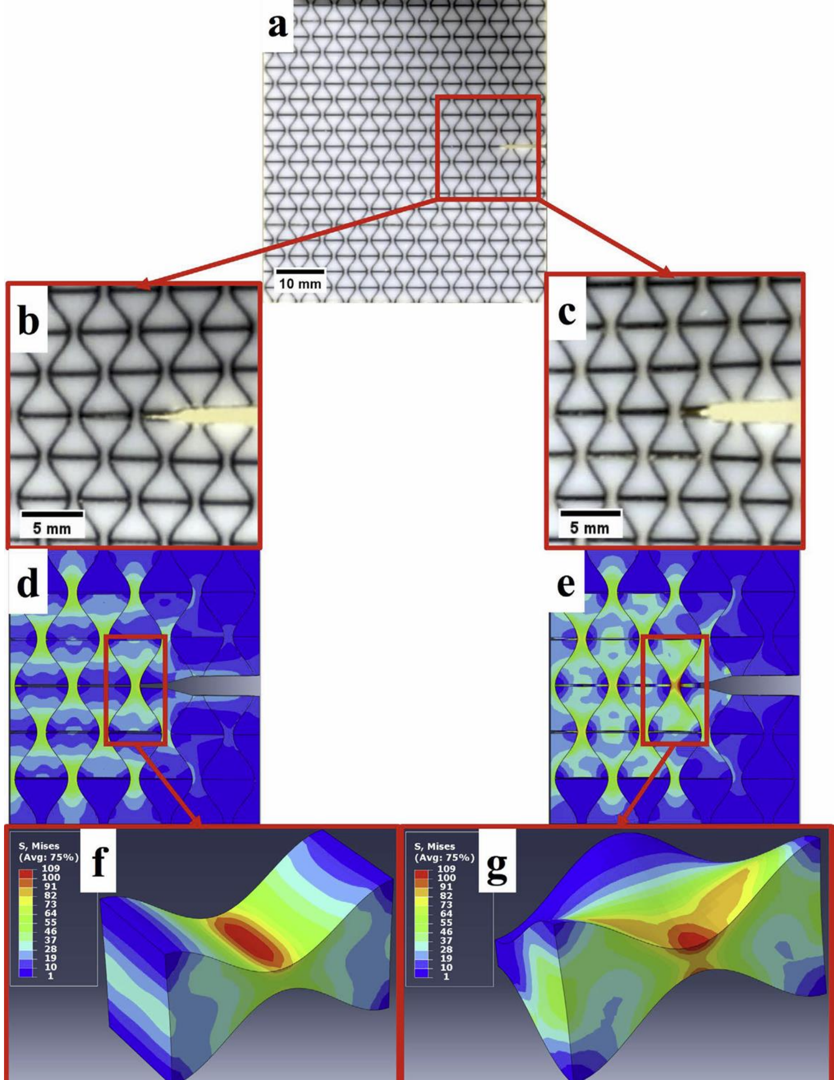
Building Construction

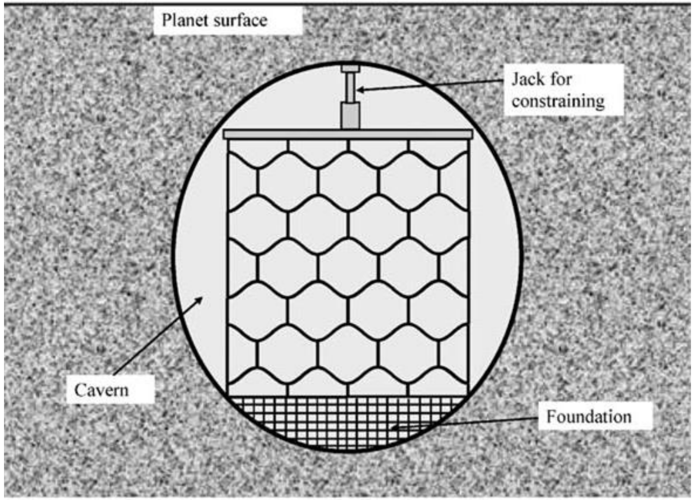
(Weizmann, 2016)

Now considered for

Bio-Inspired Hybrid Structures

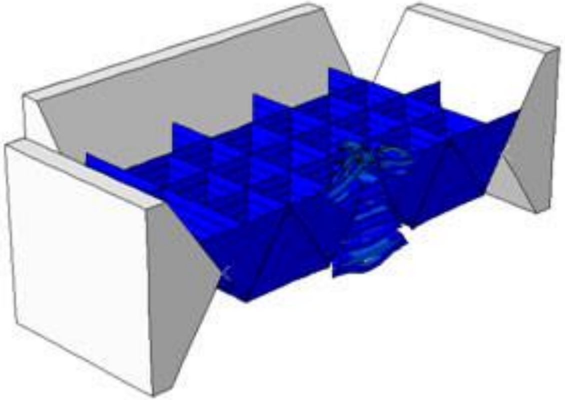
(Djumas, 2016)

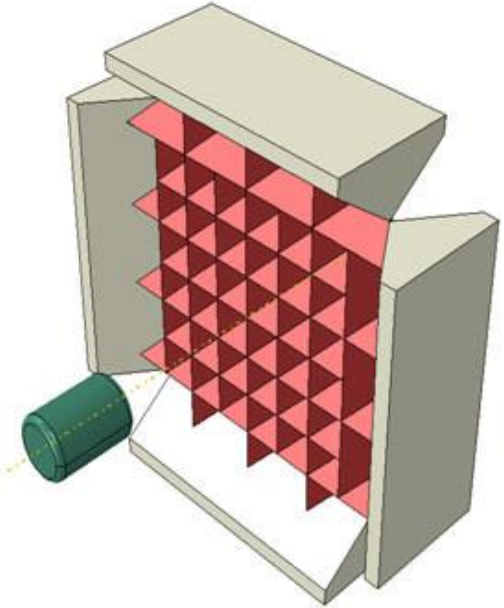




Also proposed as building block for
Extraterrestrial Constructions

(Dyskin, 2005)





The US army wants it to fix

Damaged On-The-Spot in combat zones

(https://www.arl.army.mil/www/?article=2273, 2013)

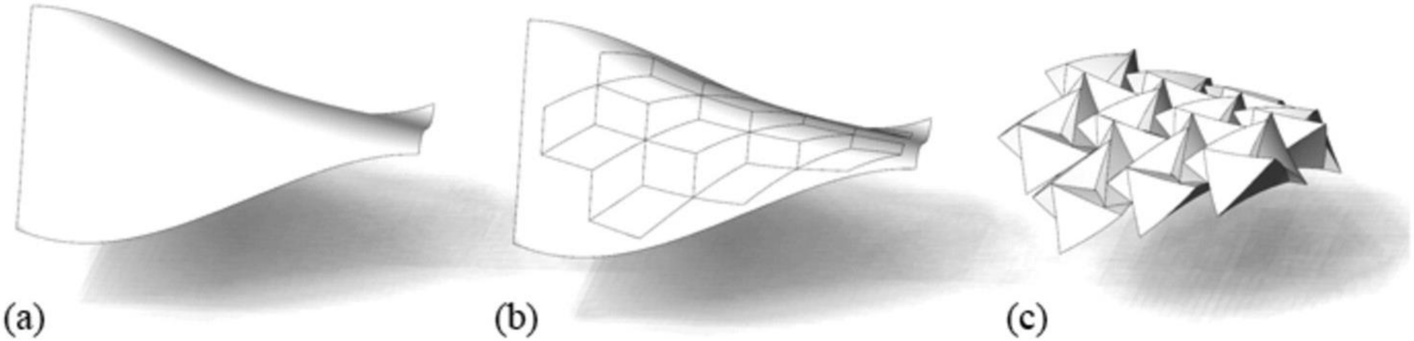
Even the Incas used it in **SACSAYHUAMAN**

Walls of the Sacsayhuaman ruin at Cusco.
By Bcasterline at English Wikipedia [Public domain], via Wikimedia Commons
https://upload.wikimedia.org/wikipedia/commons/a/a8/Walls_at_Sacsayhuaman.jpg

3.

How can it be extended to 3D?

Wrap a chessboard texture… What could possibly go wrong?

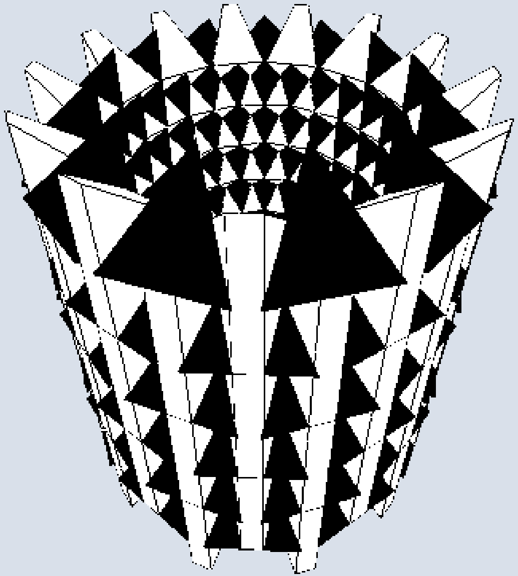


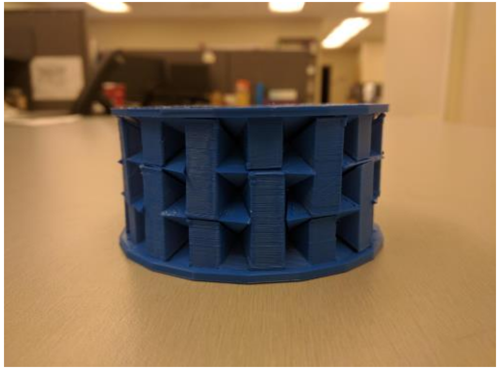
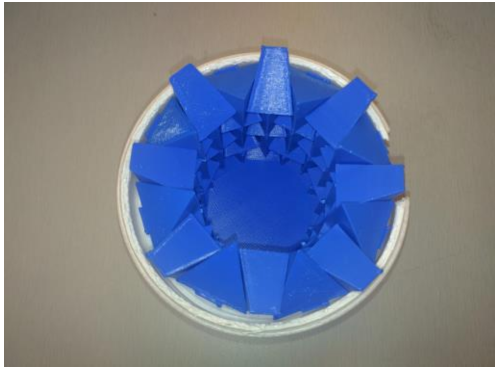
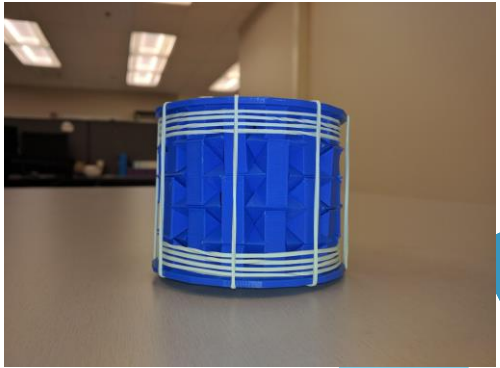
Already tried on **Curvilinear Surfaces**

(Weizmann, 2016)

First case:
Cylindrical Mesh

(Not published yet)



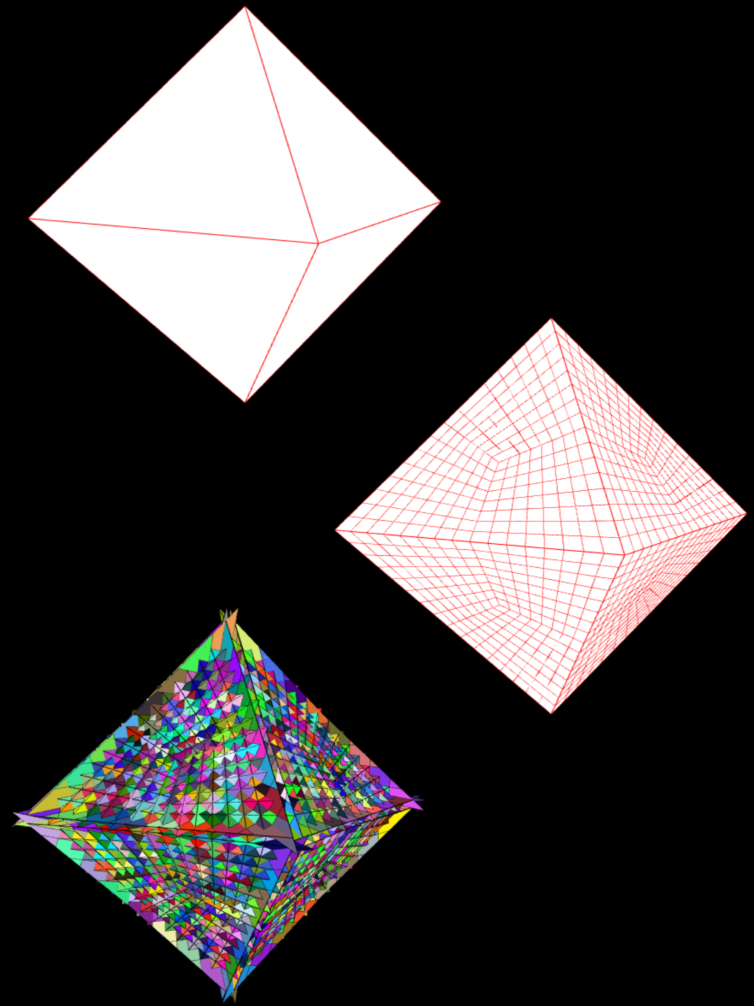




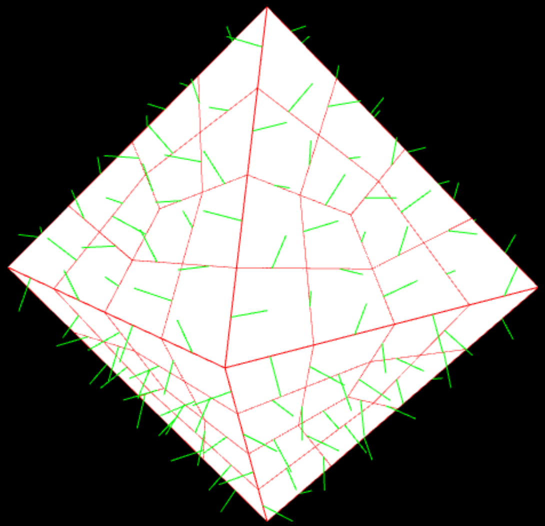
We have it
Physical

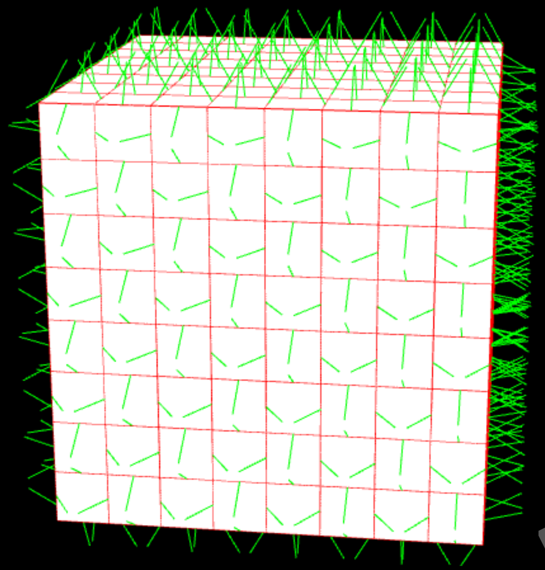
(Not published yet)

Second case:
Regular Meshes

(Not published yet)



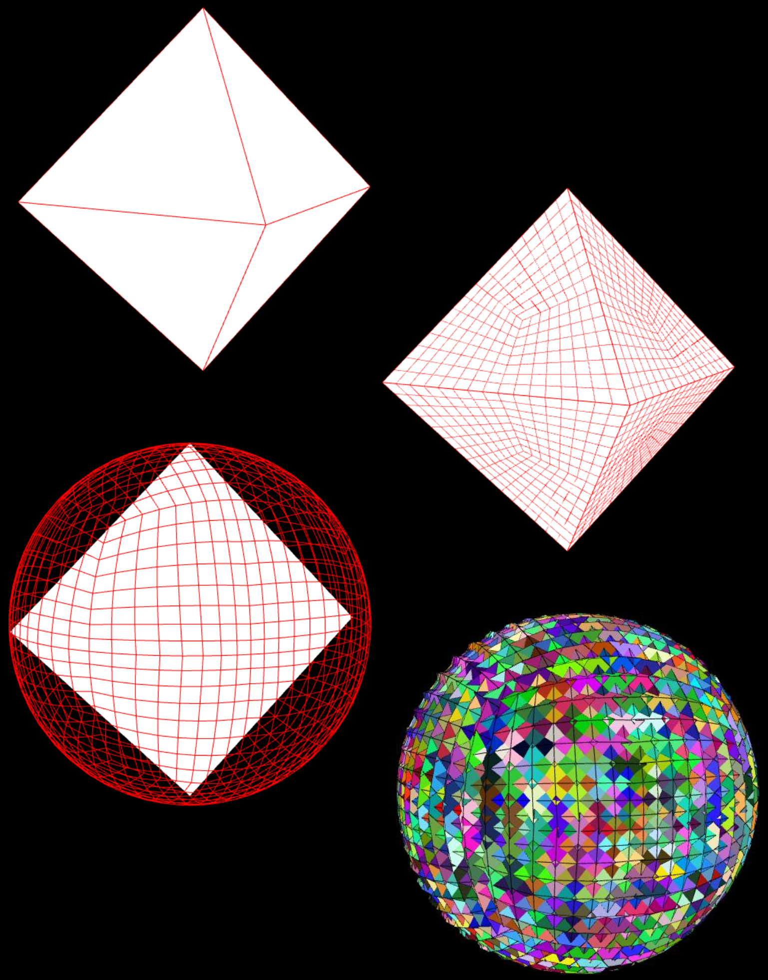


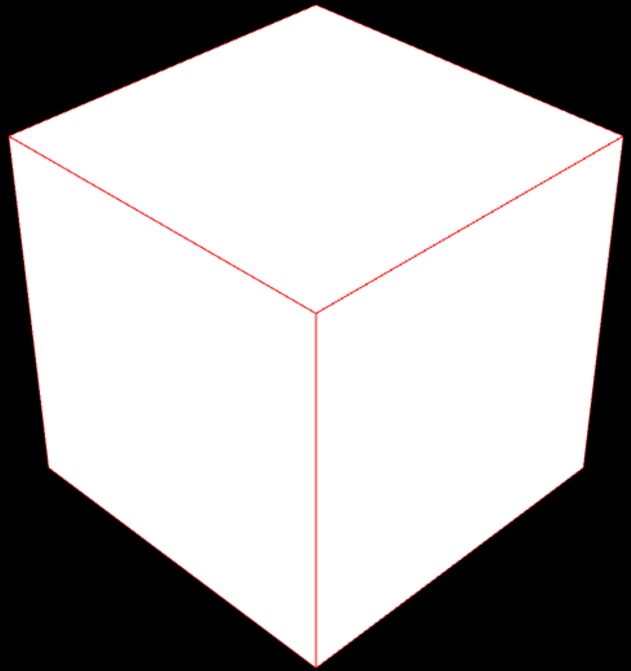


It’s all about
Directions

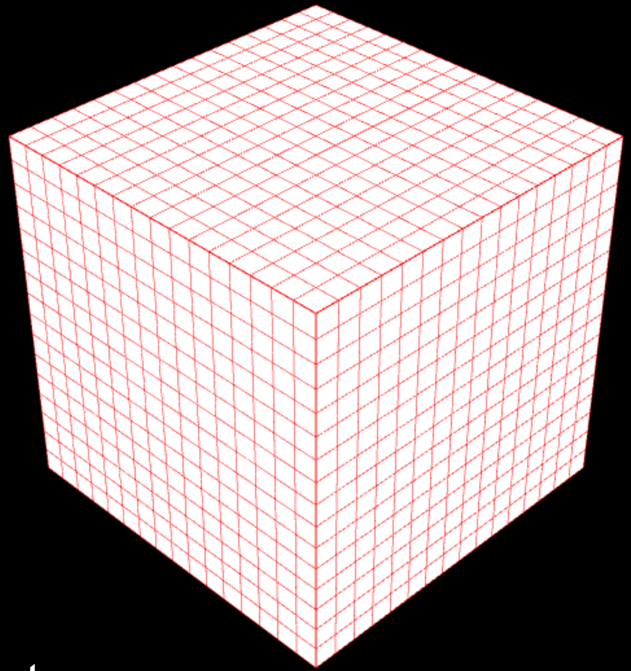
Third case:
Spherical Meshes

(Not published yet)

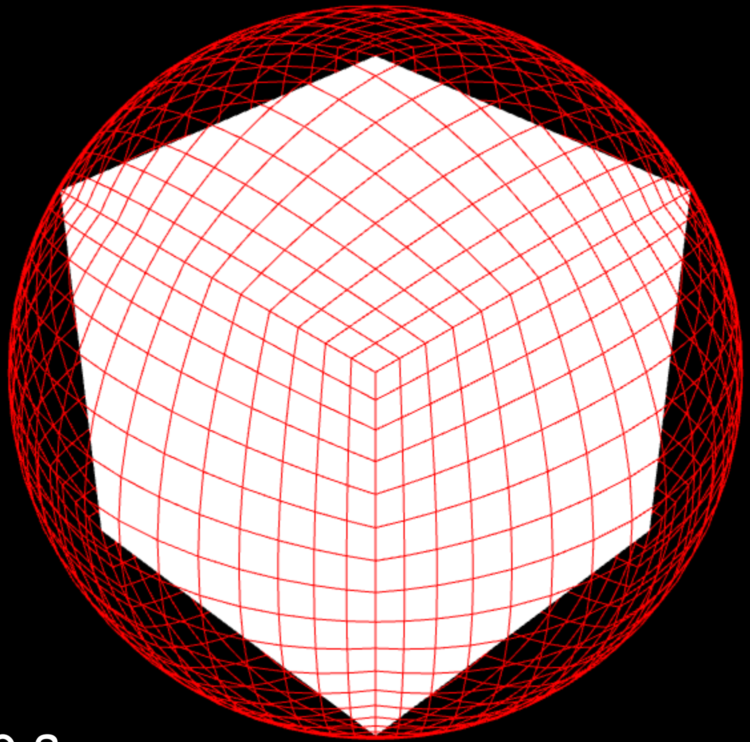




Start with a
Simple Solid



Subdivide each face into
Quadrilaterals



Map every vertex to a **Sphere**

Build the pieces using the **Directions on Edges***

*Plane rotation angle set to 30°

Results resemble to **Nexorades**

Nexorade Abeille Vault - Wood
by TaffGoch
http://www.deviantart.com/art/Nexorade-Abeille-Vault-Wood-207864955

Problems we're dealing with:

- Preventing piece **overlapping** but keeping topological interlocking
- **Building** such structures (not easy)
- Measuring **stability** of resulting structures
- Reducing the **support structure** to a minimum (during and after construction)
- Finding a **new interlocking** mechanism

THANKS!

Any questions?

You can find me at

- @andresbeja87
- www.cs.purdue.edu/homes/abejara*

*Some demos are not available to public yet

CREDITS

Special thanks to all the people who made and released these awesome resources for free:

» Presentation template by SlidesCarnival
» Photographs by Unsplash