Crafting the specialized Parkour equipment: Stabilize Structures

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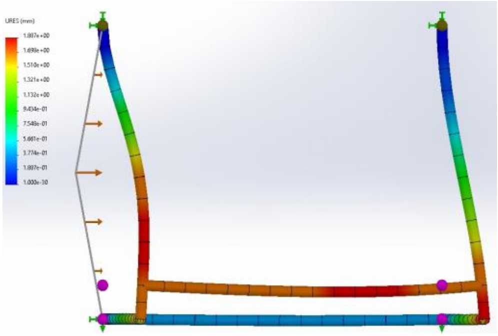
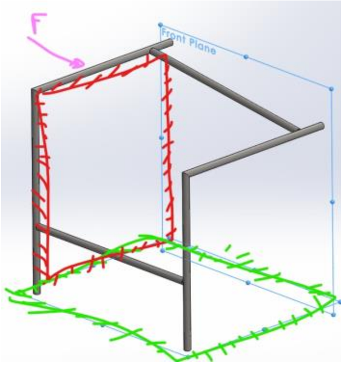
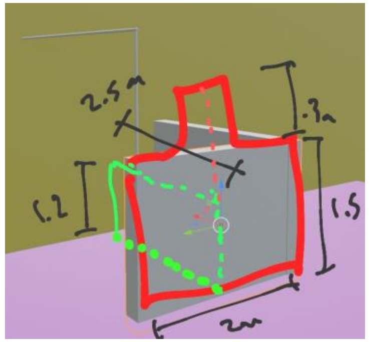
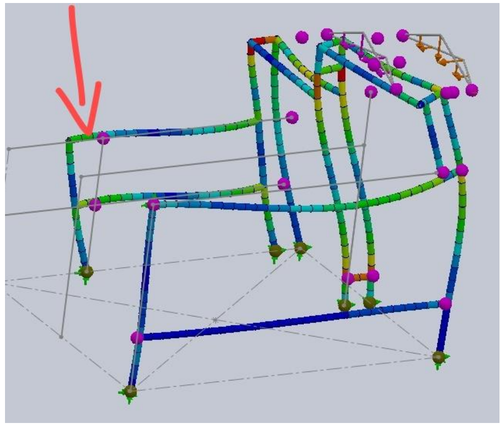
DESIGN VALIDATION AND CASE STUDY

- This (now) methodology was developed at *Parkour Studio* as a set of explanations between simulations
- At some point, we inverted the steps:
  - Start with a screenshot and drawing forces first, then simulate
  - Instead of simulating each time, we draw the expected behaviors first, then simulate only the most interesting ones
- We are now able to intuitively analyze complex situations, by phone, over WhatsApp
- **We still simulate before building**, design phase is way faster









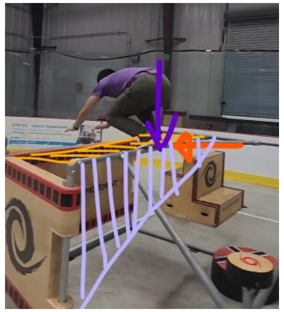
Originally intended as a quick explanation, is now our main design tool

APPLICATION AND FURTHER STEPS

WE WANT TO HEAR FROM YOU!

@ing_freestyle
@parkour_studio_mx

- We want to see your applications! Need help? Reach out!
  - Have you broken a Scaff before (we know you have!)
  - Do you have one Scaff that never builds quite right?
- We only cover the very basic info + adaptation of existing Scaff
  - Take any Scaff and draw into it! You need the repetitions
  - You see a fail? Analyze: You'll have tools to understand why
- Not covered here: Teaching you to design from the ground up



Sparsha and broken railing
Watch his video after this presentation; you will notice the early warnings from the railing

Let us know you use it! Next time we'll show you something cool

AXIOMS FOR QUICK DEVELOPMENT

DETAILS CAN BE PROVIDED UPON REQUEST @ING_FREESTYLE

ANSI Schedule 40 Steel Pipes - Dimensions

Pipe Size (in)	Diameter (in) (mm)		Nominal Thickness (in) (mm)
	External	Internal	
1 ½	1.900 48.3	1.61 40.9	0.15 3.81

Simplifications

- All development presented here is 1.5in steel SCH40 round pipe (black, galvanized or stainless steel is fine. Aluminum is not; wood/plastic/concrete is not)
- Load is assumed the same for any possible interaction: a 150kg[330lbs] person lands in any part of the structure. Although slightly unreal on the heavy side, this adds to the safety factor; if the analysis hold with this load, smaller loads are ok
- Using clamps or weldments as joints

10-8 - Single Socket Tee Kee Klamp, to suit 48.3mm O/D tube

15-8 - 90º Elbow, to suit 48.3mm O/D tube

Reasons

- Shape, size, hollowness and material alter behaviors, change any while keeping the others the same and you get a new behavior. Steel has very little variation* whether it's treated or not *treatments do matter at higher loads, but we are far from them
- Deformation, strain and failure are calculated from material and load; by using a standardized load, we abstract the effects of an adult or kid using the Scaff
- **Joints are the weak point in any structure;** by using clamps or weldments we standardize the usage (https://keesystems.com/technical/load-tables/)

1.5in sch40 steel pipe is what most of us are using already, we know it works

And now we can use this toolset to any known Scaff

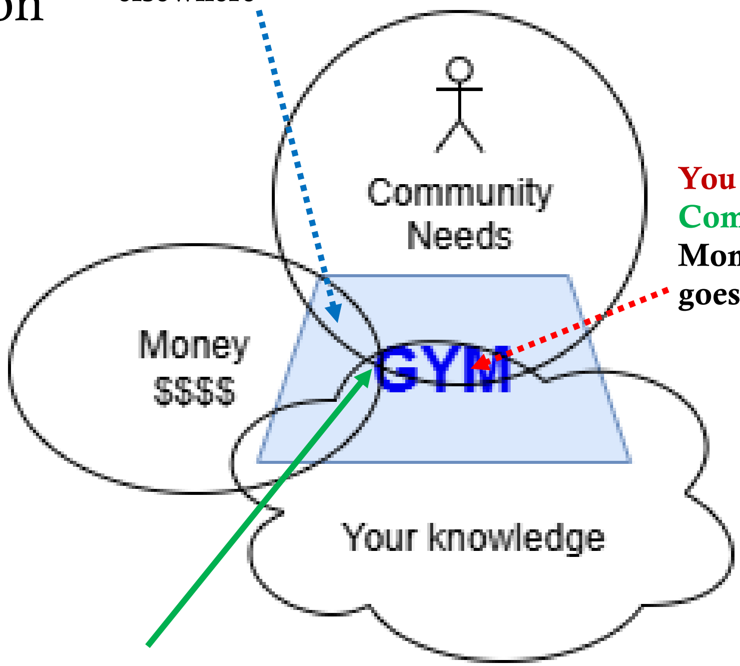
By creating a common framework, we can abstract load, material, connections, ***and math***

STATE OF THE ART: WE (COACHES) DESIGN*

*BUT DON'T HAVE THE MONEY TO BUILD

- Each gym is unique, for simplicity's sake, we'll focus on 3 topics: its community needs, the coach's knowledge and financial capability
- For every new and existing gym, we can only design and build within our reach of the 3
- Sometimes it works first try, sometimes your community won't use it.
- We fix it and try again. **This is costly**

You don't know how to build; but can afford. Community uses from you. **Your money goes elsewhere**



You don't have money for this
Community can afford
Money from the community goes elsewhere

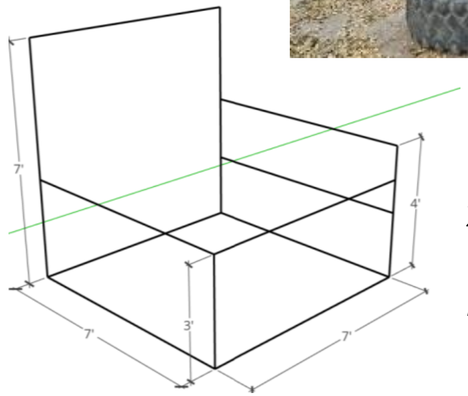
You can build and provide this.
Community pays you to use

We are addressing the problem with money; a thing we already struggle with

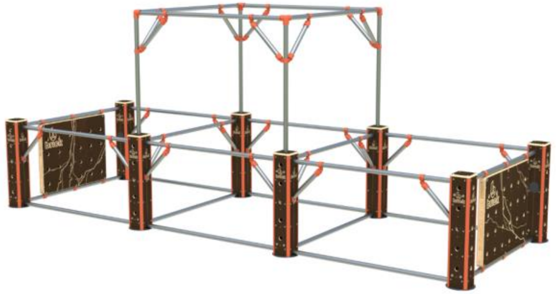
STATE OF THE ART: WE (COACHES) BUILD*

*AS WE CAN, AND EXPECT TO HAVE ROI TO REPEAT AND GROW

- We build ourselves with materials and knowledge at hand
  - Its cheap, it’s fast, might be safe. Insurance anyone?
  - Knowledge is hard to pass down to others, standards?
- We compromise our needs and look for other’s knowledge
  - Safe and proven Scaff. Might not meet our exact needs.
  - Standard-ish knowledge exists, growing knowledge is slow
- We buy from a brand
  - **Design, knowledge and cash stays out of the parkour industry**
  - Expensive, but safe
    - Want it to be scalable? modular? Sure, just pay more!



1-Street park photo
2- Scaff design
Courtesy of PKGen Boston
3- Gymnastics branded product
Price by quote only

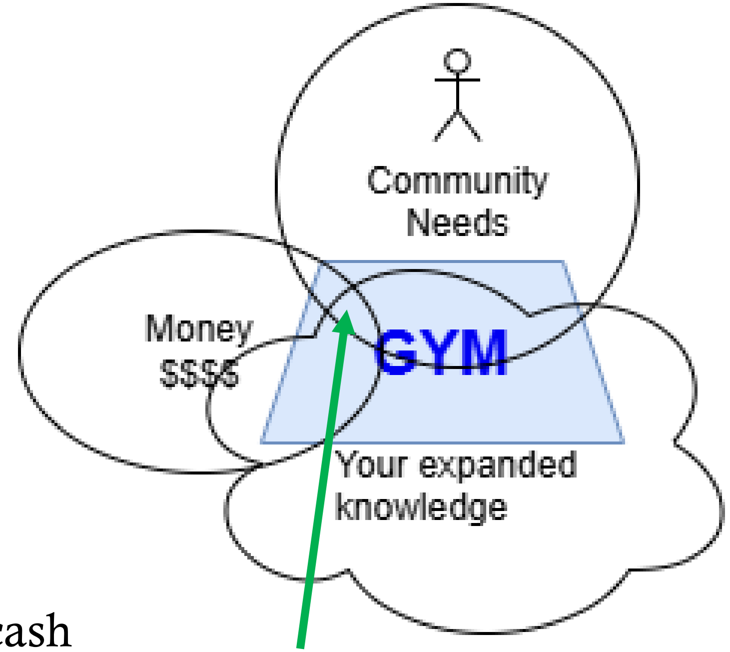


If we are to make a living out of parkour, we need cash to grow and stay within the community

THIS IS PART 1 ON THE SERIES

CRAFTING THE SPECIALIZED PARKOUR EQUIPMENT

- **Your knowledge afterwards: (You won't need math this time)**
  - **How to identify instability.**
  - **Fixing and adapting existing structures (yours and others)**
- Money related:
  - Why copy-pasting designs is expensive for you and your community
  - Enhancing designs cost-effectively and safely. Do more with the same cash
  - Design with scalability and variety from the start, not as byproduct
- Community
  - Expanding the design capabilities within the community saves money, time, and stress for everyone
    - We did this from the sport science field; we can do it for from the engineering and financial side



You can build and provide this. Community pays you to use

THE LÂCHE SCAFF

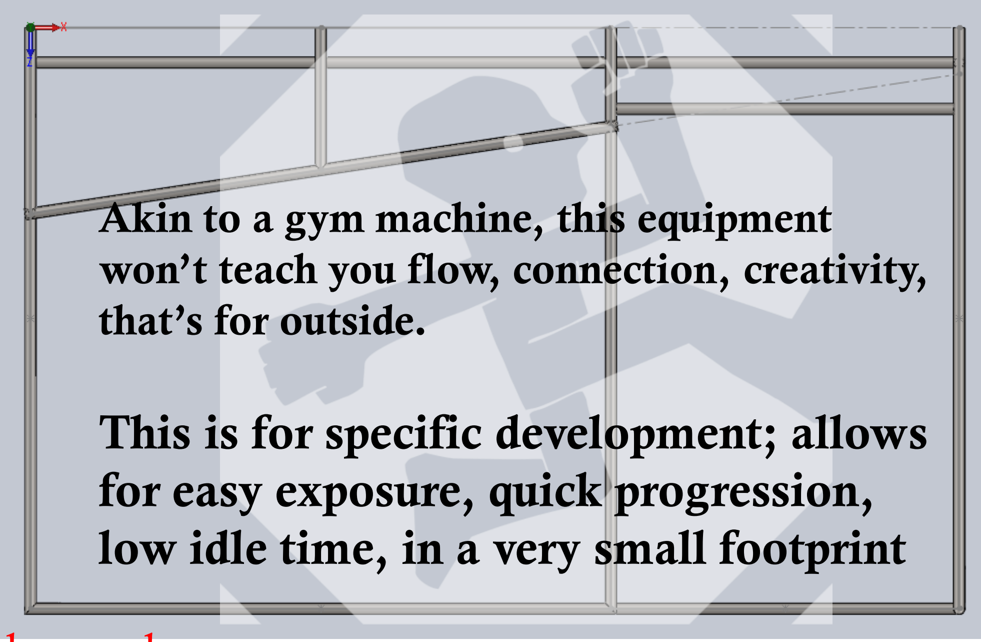
LIKE A *GYM MACHINE,* PACKS HIGH VARIATION OF A SINGLE MOVE SET

- A lache training scaff that serves everyone: kids, adults, beginners to highly advanced
  - 4x2.5m footprint, 3m high. [13 x 8 ft footprint, 10ft high]
  - Pipe usage: 40m [120ft] 1/5in sch40. Welded
  - Max displacement (wobbliness): 1cm [0.5in]
- Variations of height lache/precision and distances

Precisions can be done in ascent or descent

All distances available all the time

- Descending: 0.5m [1.6ft], Fixed: 1.5m[5ft]
- Equal height Fixed: 2m, 2.2m, 2.5m [6.5, 7, 8 ft]
- Ascending 0.5m[1.6ft]: Fixed 1.5, 2.2m [5, 7ft]
  - Variable 1.7-2m [5.5-7ft]
- Ascending 1m [3ft] Fixed distance: 2m [6.5ft], + same with lower clearance



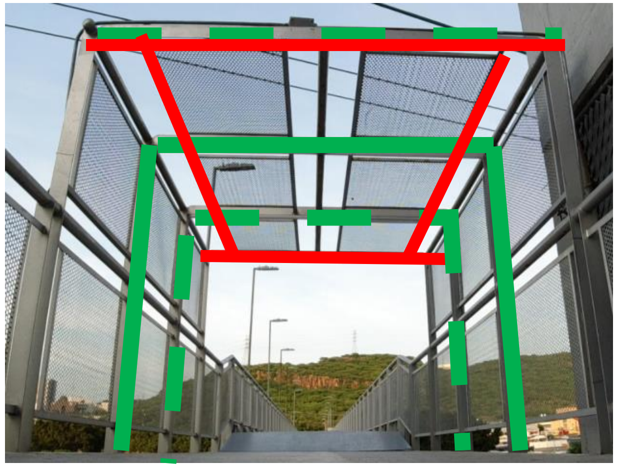
Akin to a gym machine, this equipment won't teach you flow, connection, creativity, that's for outside.

This is for specific development; allows for easy exposure, quick progression, low idle time, in a very small footprint

We are now designing *specific* equipment; is this something that interest you?

COPY-PASTING: WHY DO IT?

- We started copying solutions from the engineering world
    - Almost everywhere we look, it's a **pattern repetition**
    - Symmetrical or mirror in at least 1 axis, usually in 2
- The underlying reason, if you solve a problem once, you solved it forever: repeat the solution on the new problem
- This is great for stability and safety reasons, but provides very little variety (different movement possibilities) and variation (slight differences of the same movement)



And its not Scaff only; solid surfaces follow this approach too

We copy paste to avoid solving the problem twice, and it works for simple needs

COPY-PASTING: WHY WE SHOULDN'T

IT CREATES BAD GYMS

- *"The Parkour Design Handbook"* (Parkour Visions Org) summarizes why have a parkour park
- The handbook does a great job for solid surfaces, check that out first
- However, the handbook falls short when addressing scaffoldings
  - Square 90 Degree angles
  - Low height/distance variations
  - Density is NOT Variation

  (Amount is NOT Uniqueness)

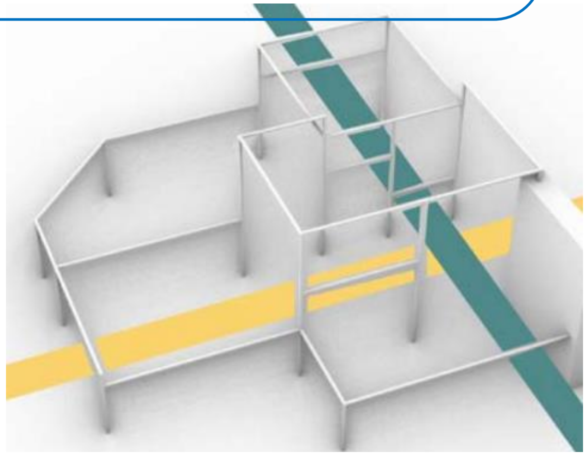
An accessible and inviting place to learn, especially for beginners

A community hub and meeting place

A higher density of challenges than typically exists at wild spots

Structures that are difficult or impossible to find in the wild

This is where we copy pasting becomes a bad idea
Without these at the gym, let's stay at the park

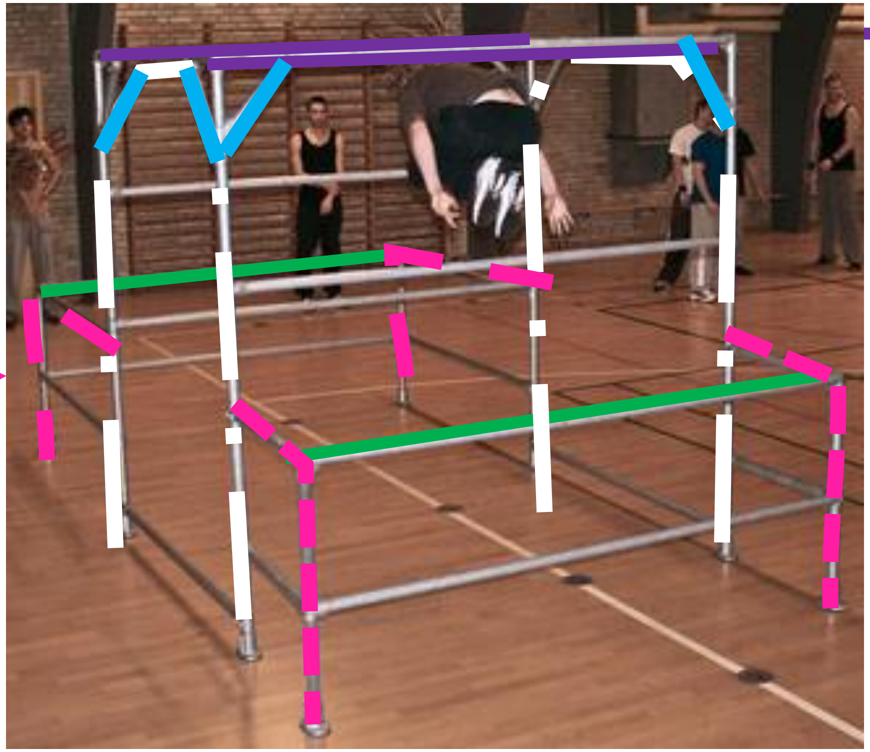


Your gym must be a better alternative to a park, or you end up coaching at the park

COPY-PASTING: WHY WE SHOULDN'T

YOU PAY EXTRA FOR REDUNDANT FEATURES WITH NO ADDED VALUE

- Each pair of colored lines is a mirror dimension
- These blue diagonals *stabilize* the structure, but are of little usage
- In one case (pink), we can argue exists to train ambidexterity
  - Ambidexterity can also be trained by using inside-outside and outside-inside



Not Visible:

- On top you get an empty square with all sides at the same height and same distance

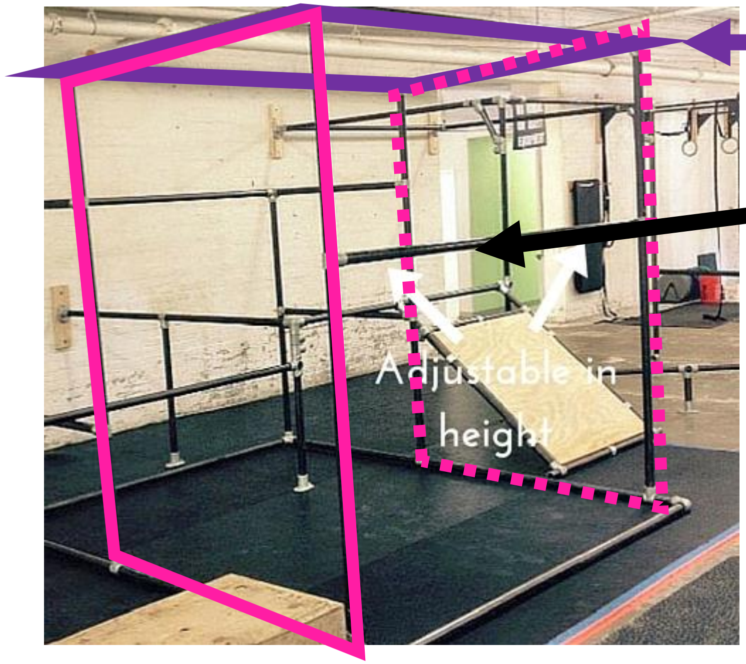
- All dimensions at the front are repeats with the back side
- **Build twice, spend twice**

Image from: https://www.simplifiedbuilding.com/projects/diy-parkour-gym-equipment

Redundant dimensions are wasted resources: No uniqueness gained from symmetry

HOW DID WE GET REDUNDANT?

WE SIMPLIFIED UP TO A CUBE, BECAUSE IT'S STABLE



At a fixed height, it's not easily accessible for both kids and adults

Image from: https://www.simplifiedbuilding.com/projects/diy-parkour-gym-equipment

- Being fully symmetrical, has poor variability
- We try to increase variety by adding extra elements inside a face, now we overuse resources twice:
  - The first time for a duplicate dimension (height)
  - The second time by trying to fix it
- This structure is readily available in the wild

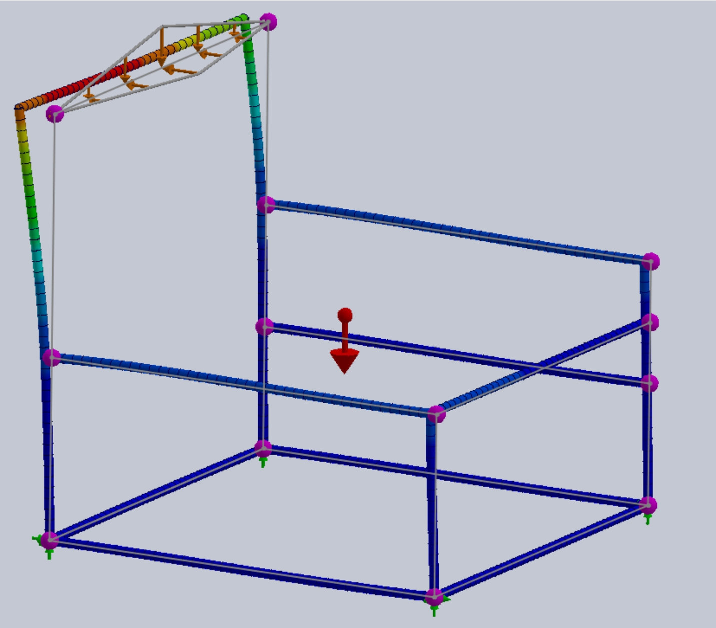
- An accessible and inviting place to learn, especially for beginners
- A community hub and meeting place
- X A higher density of challenges than typically exists at wild spots
- X Structures that are difficult or impossible to find in the wild

Why Build Parkour Parks
"The Parkour Design Handbook" (Parkour Visions Org)

The most stable structure is also the most boring and commonly available outside

HOW TO QUICKSTART YOUR GYM

REACH OUT TO THE COMMUNITY AND ADAPT TO YOUR NEEDS



This specific design is already tested and proven to work, this is the importance of knowledge sharing

Basic L Box Lache
Design Courtesy of PKGB for this summit

- By using a known Scaff we get:
  - A better usage for simultaneous kids and adults
  - Due to less symmetry, a higher movement variety than the cube (movement possibilities: Precisions, lache, vaults….)
  - Still has low variations (adjustments/scalability within a specific movement)
    - 2-3 unique precisions, 1 unique Lache
- Depending on the community needs, this might be enough or boring (beginners, advanced). We could modify, however:
  - For any modifications we face 2 main risks:

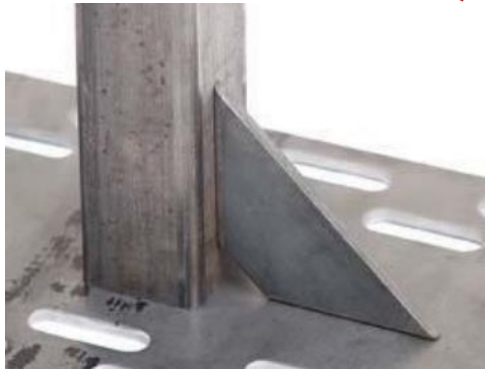
The structure can become too wobbly and/or can potentially tilt

The knowledge built up to "it just works" has been mostly empirical and costly

JOINTS ARE THE WEAKEST PART

DO NOT CHEAP OUT ON JOINTS

- This is why clamps break and pipes slip out
  - **Early warning: the design needs change**
- Don’t get a “stronger pipe” you’ll never break the pipe.*

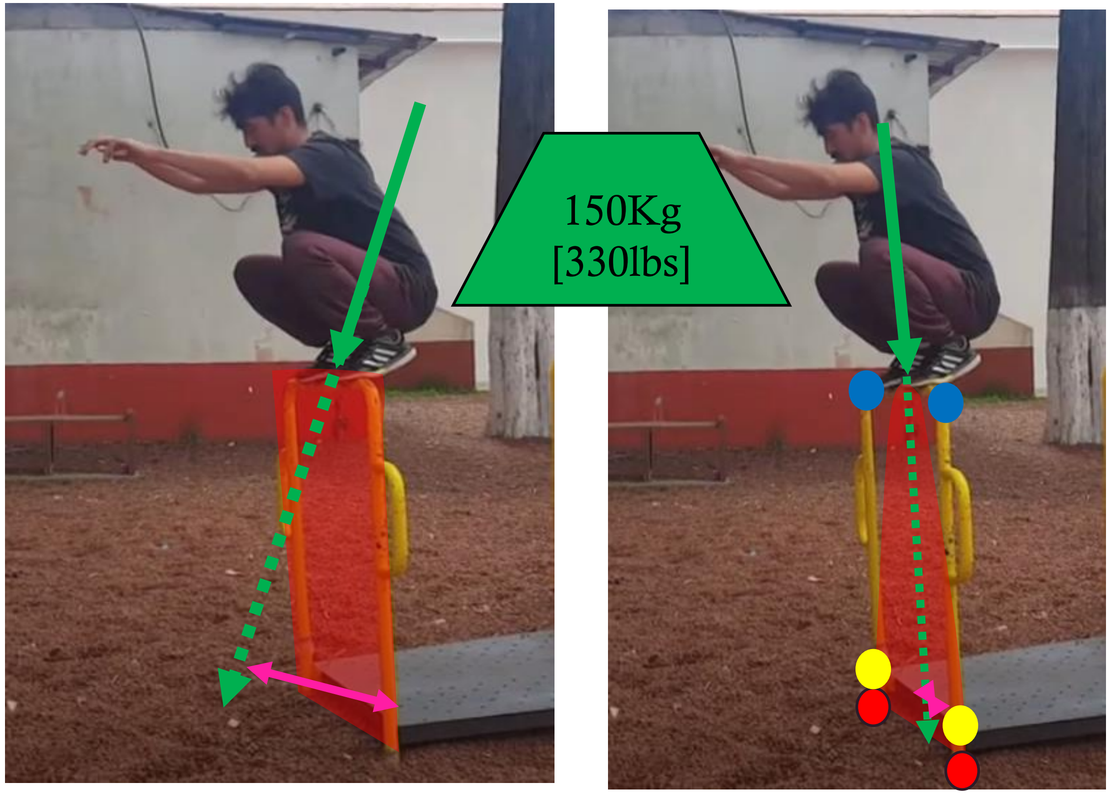


Inspect periodically your structure joints, that’s how you know something is amiss

STABILIZE STRUCTURES; SAVE YOUR JOINTS

WOBBLINESS IS AN INDICATION OF JOINT STRESS

- A structure is stable if the force applied to it is fully contained inside a load plane
- When a force is not contained inside the load plane, the structure shakes* *Or breaks, this is why we assume that the material can hold us (pipe 1.5in sch40)
- How much wobbliness? You can evaluate by how far (visually) the load is away from the joints
    - We are going farther than this

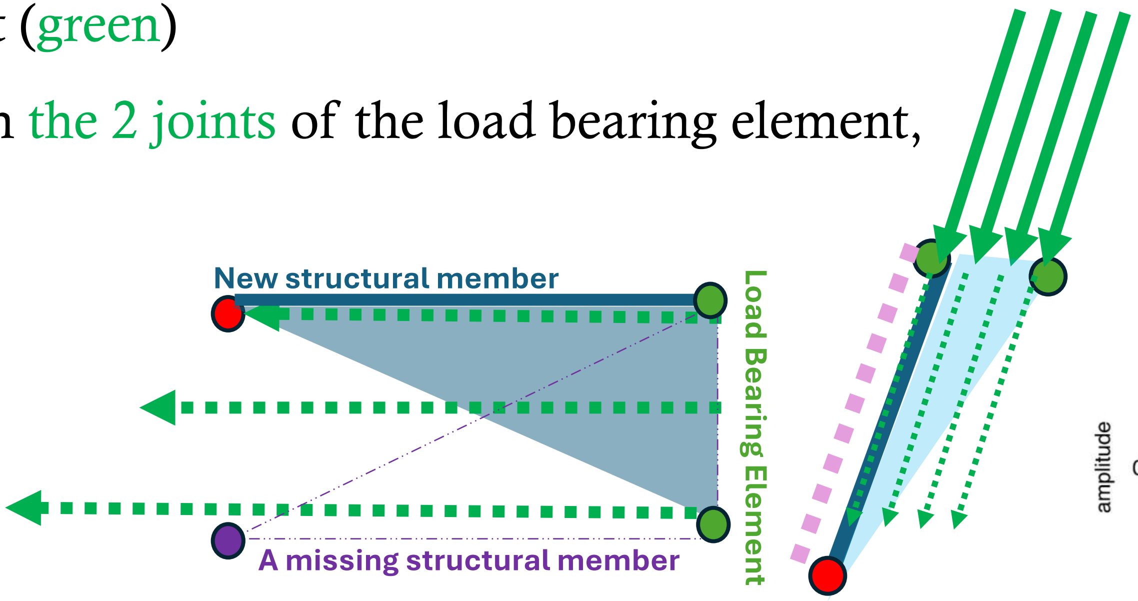


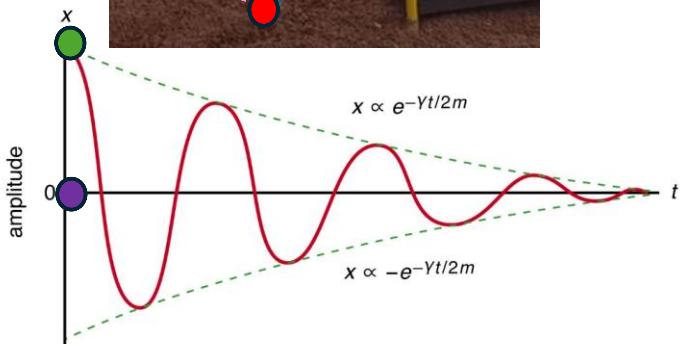
For a known material, shape and load, we can visually evaluate stability

LOAD PLANES

VISUAL EVALUATION OF INCREASED STABILITY

- When analyzing structures, assume the force can be in any part of the load bearing element (green)
- Define a load plane from the 2 joints of the load bearing element, to a chosen joint
- Evaluate the forces
  - Completely stable
  - Partially Stable
  - Not affected by plane





Multiple load planes can be defined as needed

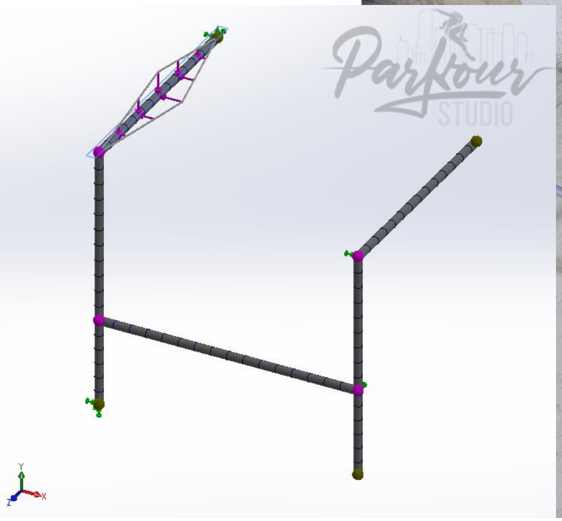
I have a truly marvelous mathematical demonstration on why/how this works; sadly, this margin is too narrow to contain, ask @ing_freestyle

The less contained a force is, the shakier the element. Oscillation decreases with time

DESIGN STEPS AND OBJECTIVES

DO THIS FOR EACH BEAM IN YOUR STRUCTURE

- Objective: Contain all possible loads inside at least 1 load plane
- Start with a diagram or a photo of the structure
- If a plane doesn't exist. Create it.
- Evaluate visually, if not contained
    - Change the plane
- Cannot change the plane?
    - Keep it, create a new one

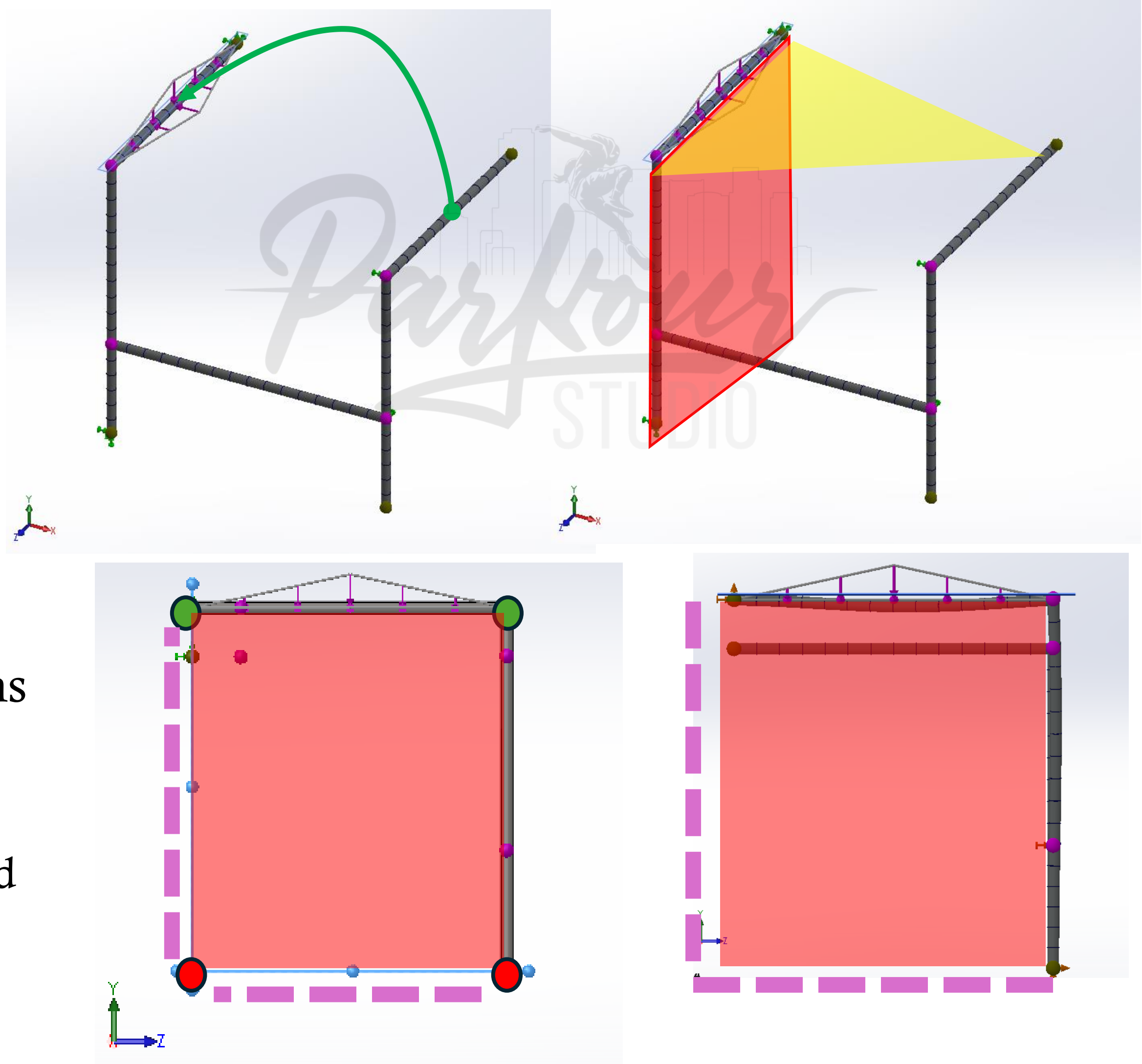


Draw your planes until the load is contained

GUIDED EXAMPLE 1

PRECISION TO THE HIGH BAR

- For a precision jump, shown in green, we can split the force in 2:
  - A vertical load (user weight) in Y axis
  - A horizontal load (reception) in X axis
- We'll manage the problem twice, once per axis
- For the vertical case, the load plane fully contains the vertical load; user can stand on top without shaking the structure
  - Notice that by being bolted to the wall, the dotted distances are invariable: cannot change length
  - Simulation on the right shows no deformation*

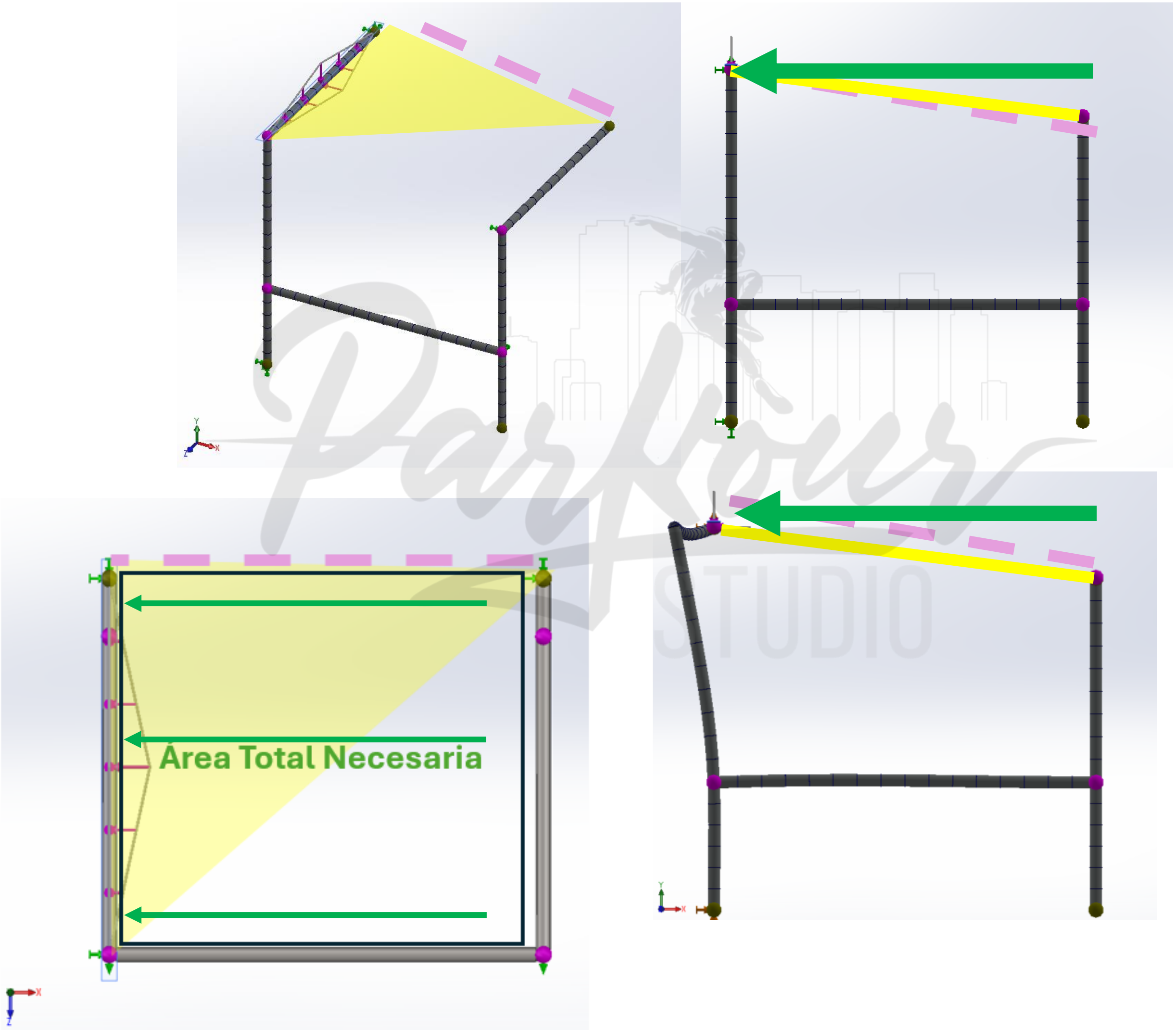


Decompose force into 2 components, vertical and horizontal

GUIDED EXAMPLE 1

EVALUATE VISUALLY

- For the horizontal case, we only have 1 joint (the wall fixture)
- Furthermore, heights are not equal
- **Load is not inside the plane. This shakes**
- Simulation below shows high deformation effects*
  - While you won't have simulations with you, you can identify shakiness from the fact that all possible green arrows are not inside the yellow plane

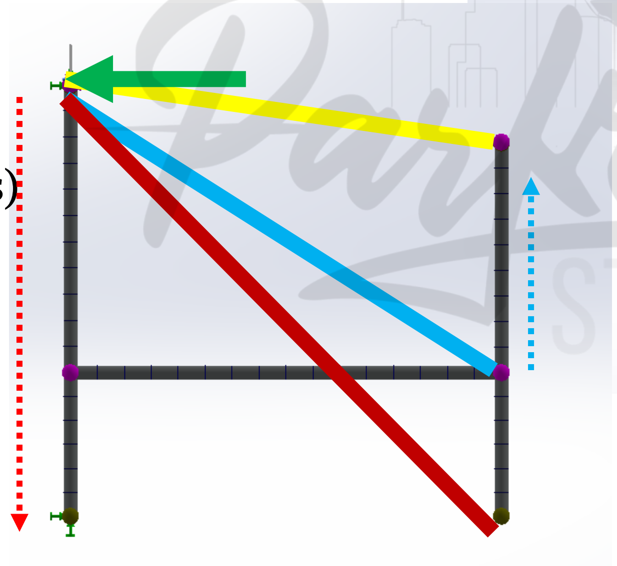


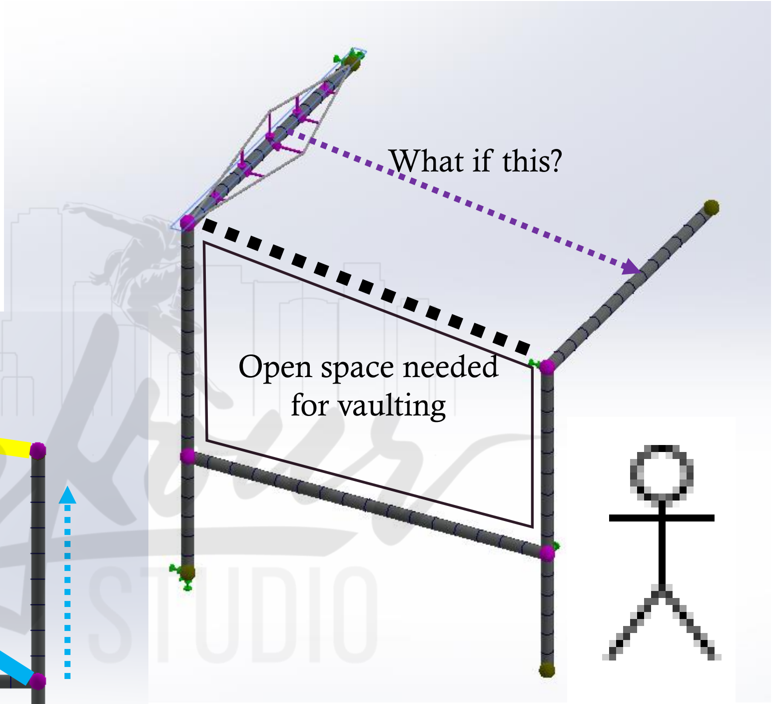
Evaluate visually if the load is contained, if no, this will move

GUIDED EXAMPLE 1

CANNOT CHANGE THE PLANE: KEEP IT AND CREATE A NEW ONE

- We could add a **new pipe** across; however, we want this open face so small children can use this for vaulting/jumping
- The more in line with the force a plane is, the best is contained
- We modify the structure by moving its planes
  - Yellow: Close the contour (Blocked by our needs)
  - Blue: rise the vaulting bar (if high enough, this becomes yellow)
  - Red: Lower the height



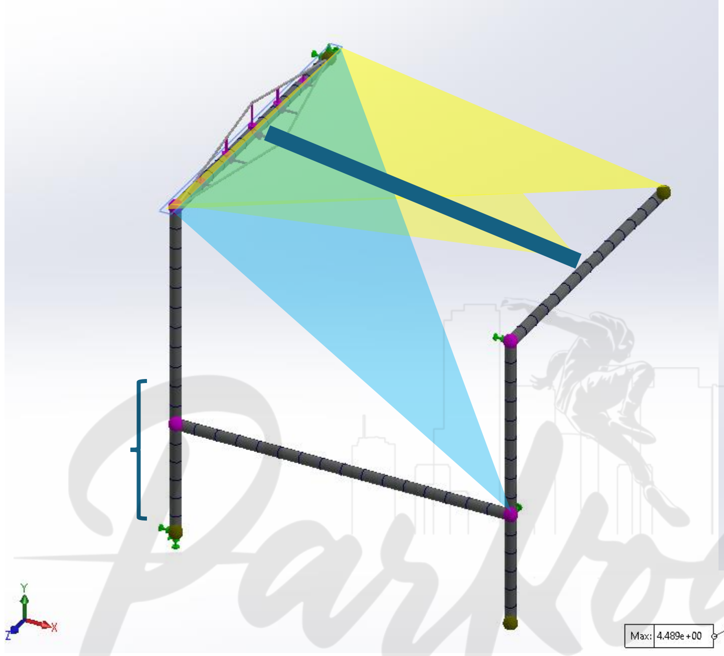


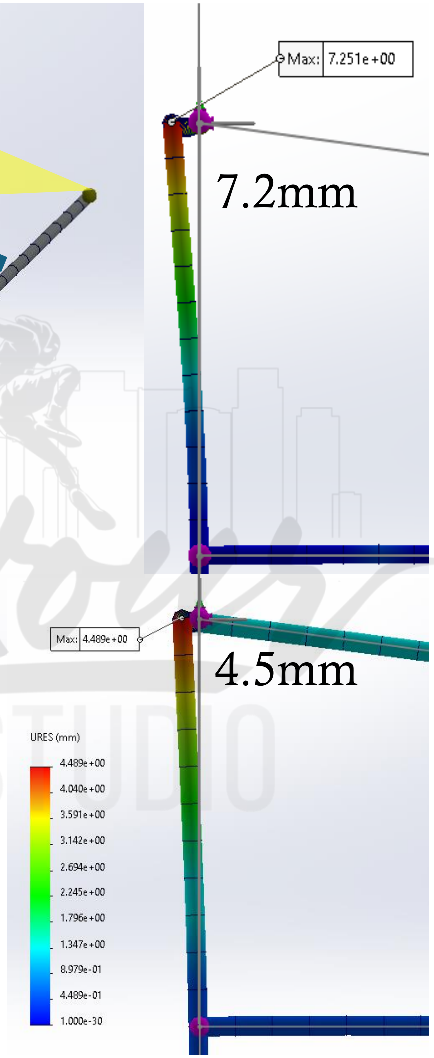
Scaff changing is joint manipulation, joint editing IS plane manipulation

GUIDED EXAMPLE 1

CREATE A NEW PLANE: ADD JOINTS

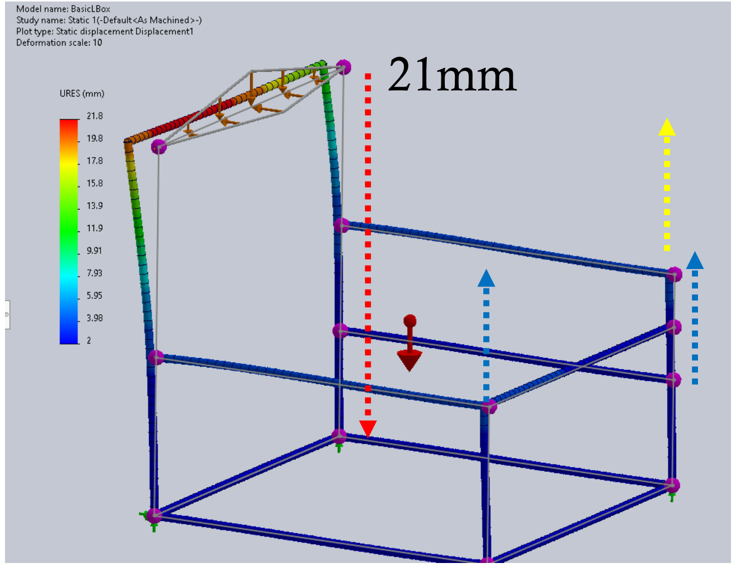
- We reduced oscillations:
  - Simulation check: from 7 to 4mm
  - This value is the max amplitude to one side, for a full *perceived* oscillation, take twice this value
- In 3D space drawing:
  - Each plane contributes at containing the load, however the less in-line, the less effect
- Visually:
  - We reduced vibrations by the area amount covered by the new plane



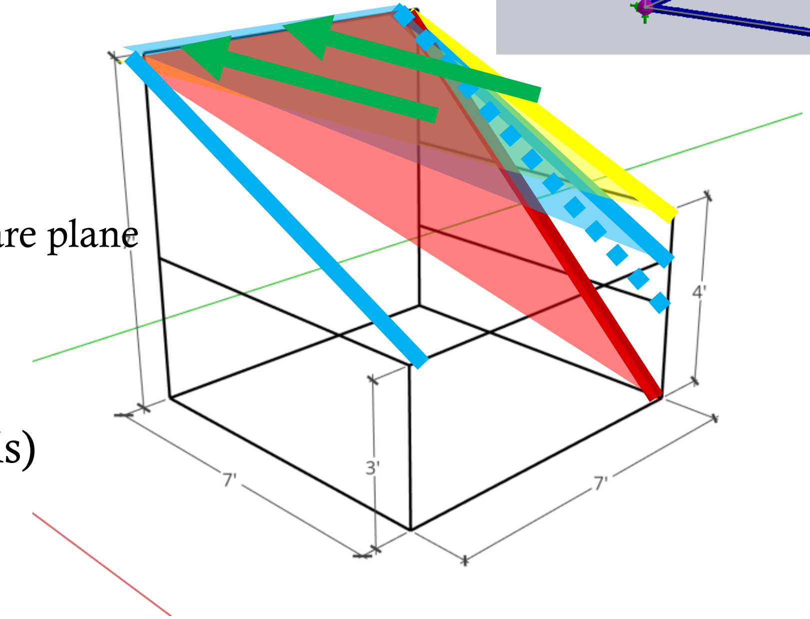


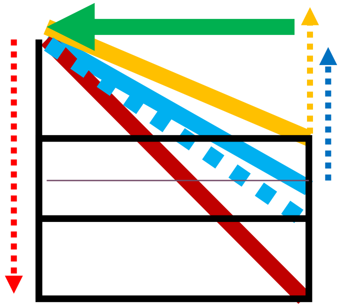
Instability can be drawn! This is huge news for non math people!!

GUIDED EXAMPLE 2:
MODIFIYING "BASIC L BOX"



- Decompose force into X, Y, investigate each for contention
- Vertical case is stable, go to next
- Look at all possible load planes
  - There are 2 blue ones almost overlapping
  - Overlap is redundancy:
    - Furthermore: solid blue has 2 joints to create a square plane
    - Let's see the simulation of their removal
- Manipulate the planes, move the joints
  - Red: Decrease height (we don't want to shorten this)
  - Blue/Yellow: Increase height



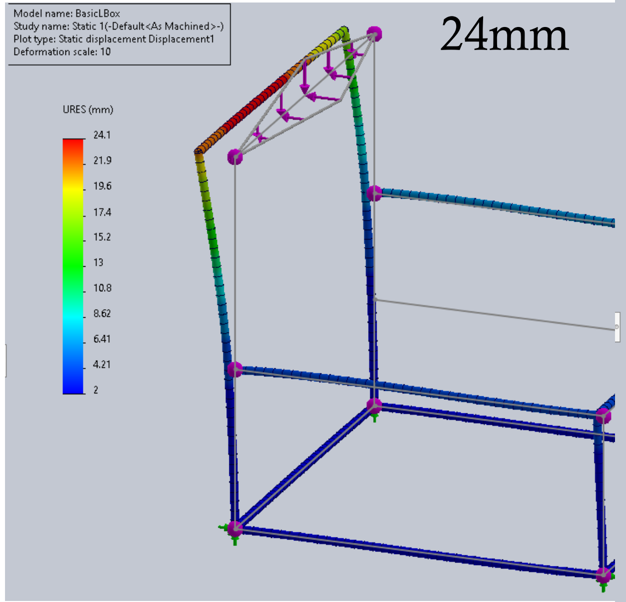


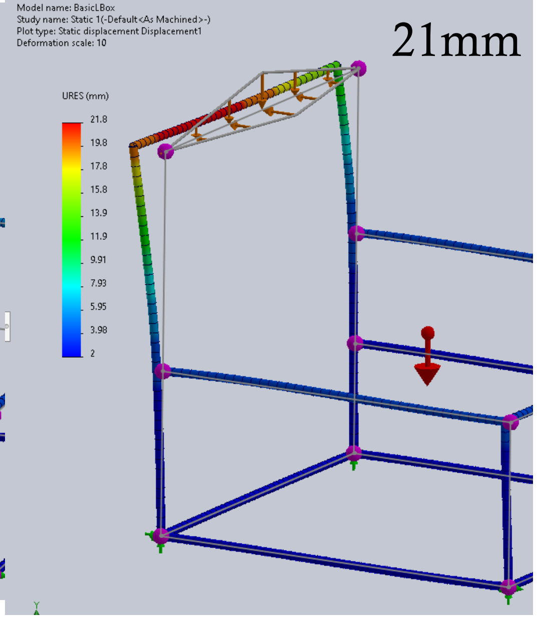
Choose your own here: your needs are going to be unique

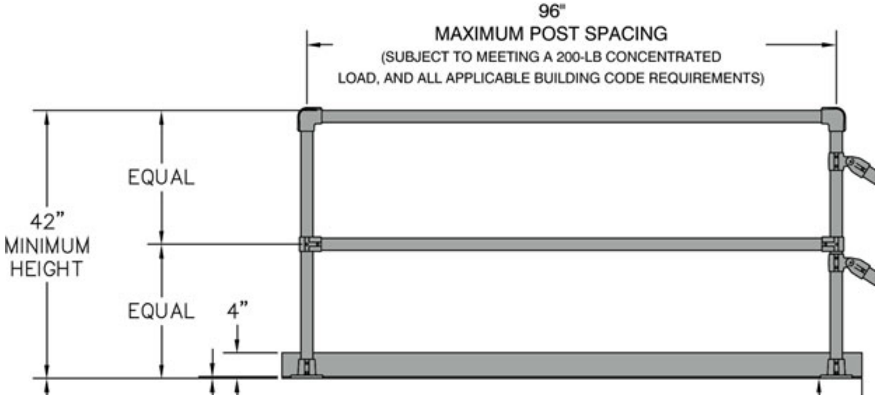
GUIDED EXAMPLE 2

SIMULATION CONFIRMATION

- The middle bar had no big effect on stability
  - If the bar serves a specific training function, we should keep it (OSHA railing maybe?)
  - If it serves no training propose, and was intended as a stabilizing element, we are overusing 1 pipe and 2 clamps
- For our example usage, we are aim at increasing variability (uniqueness)
  - From the original 2-3 unique precisions, 1 lache
  - How to: Using Unique dimensions
  - However, we want to use the same already cut pieces





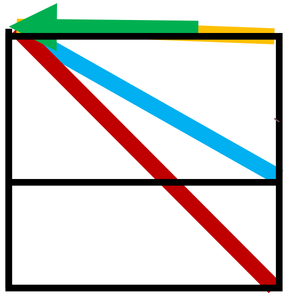


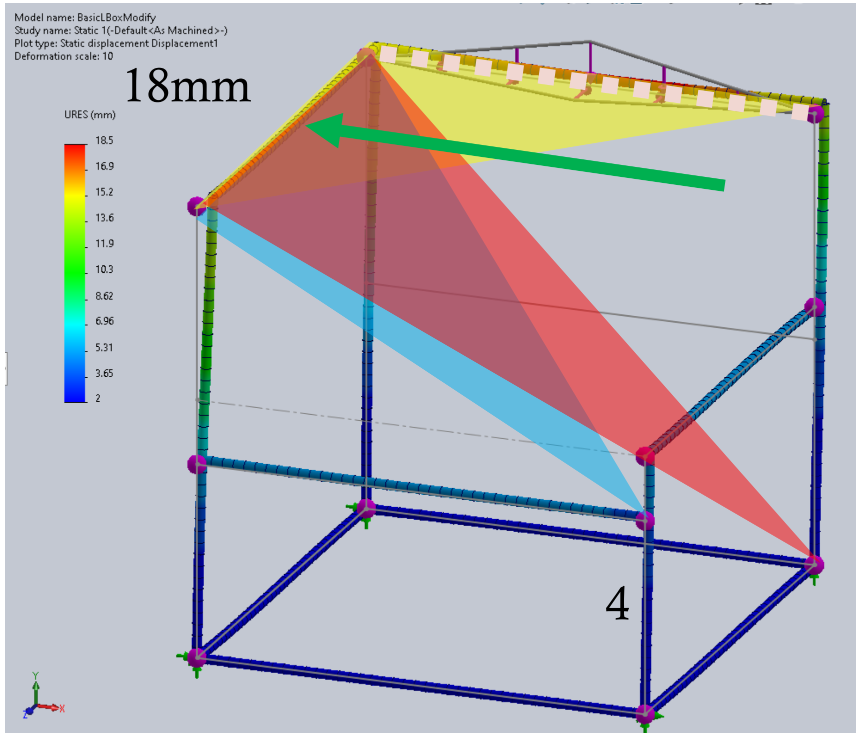
For this example, we will optimize for stability and uniqueness

GUIDED EXAMPLE 2

MOVING AROUND THE PIECES

- Moving around the pieces keeping the cut distances
- Use the 7ft to increase height
- Exchange the 3ft for the 4ft.
  - Leave out the 3ft
- Results:
  - Keep lache-pre 7-3, new lache-pre 7-4
  - Lose the 4-3ft precision (1ft ascent/descent)
    - We can regain them again with lateral vaults
    - Move the vaults around and now you get scalability
  - Slightly more stable, 1 less element





If we are to do this *before* cutting, a higher uniqueness can be achieved

THANK YOU

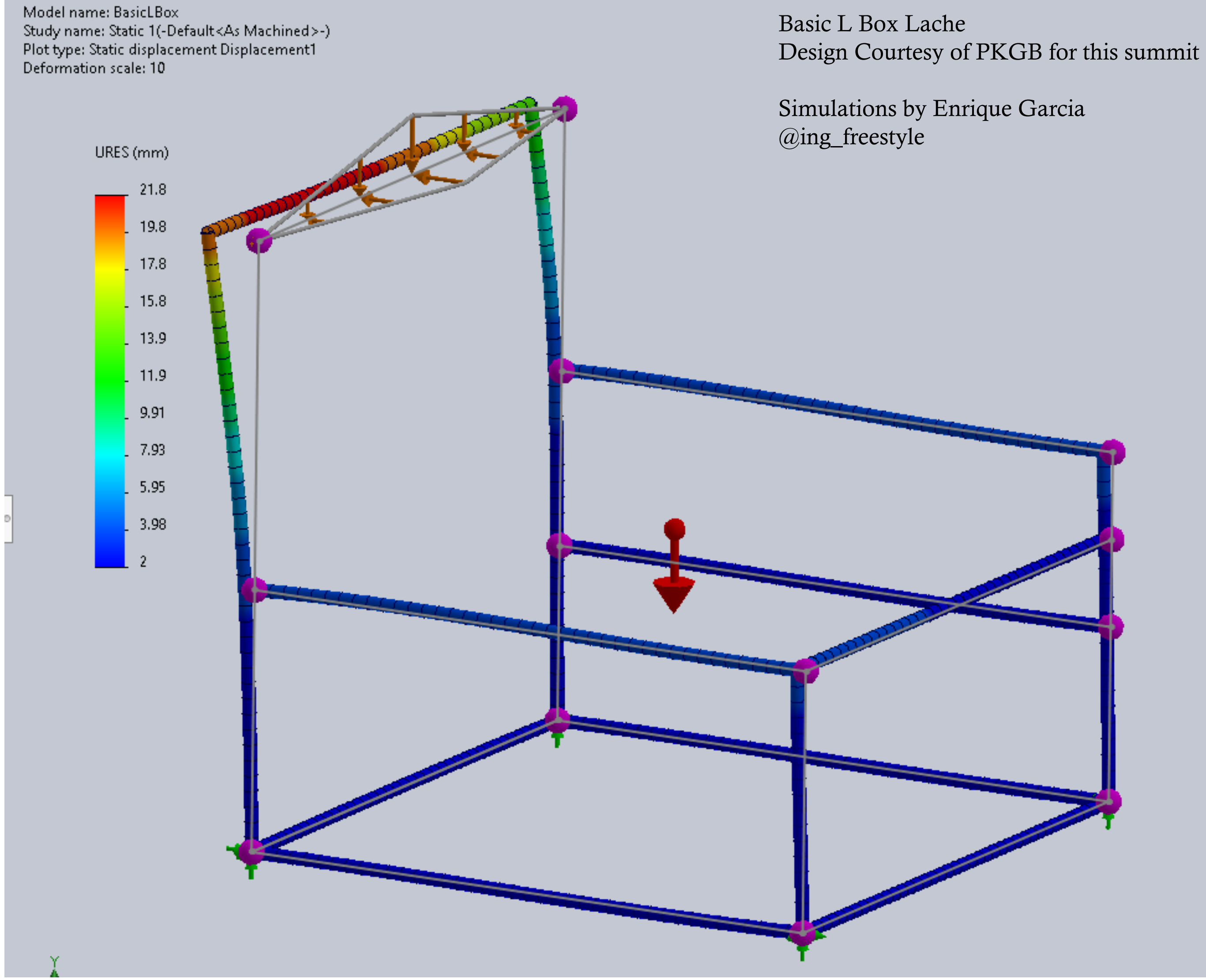
PHIMOVEM

FILOSOFÍA · EN · MOVIMIENTO

SUPPLEMENTS

SIMULATION MODELS 1

- Original L box Scaff from PKGB
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm: Max 21.8
- Deformation is not strain
- Redder: More oscillation, bluer, more stability

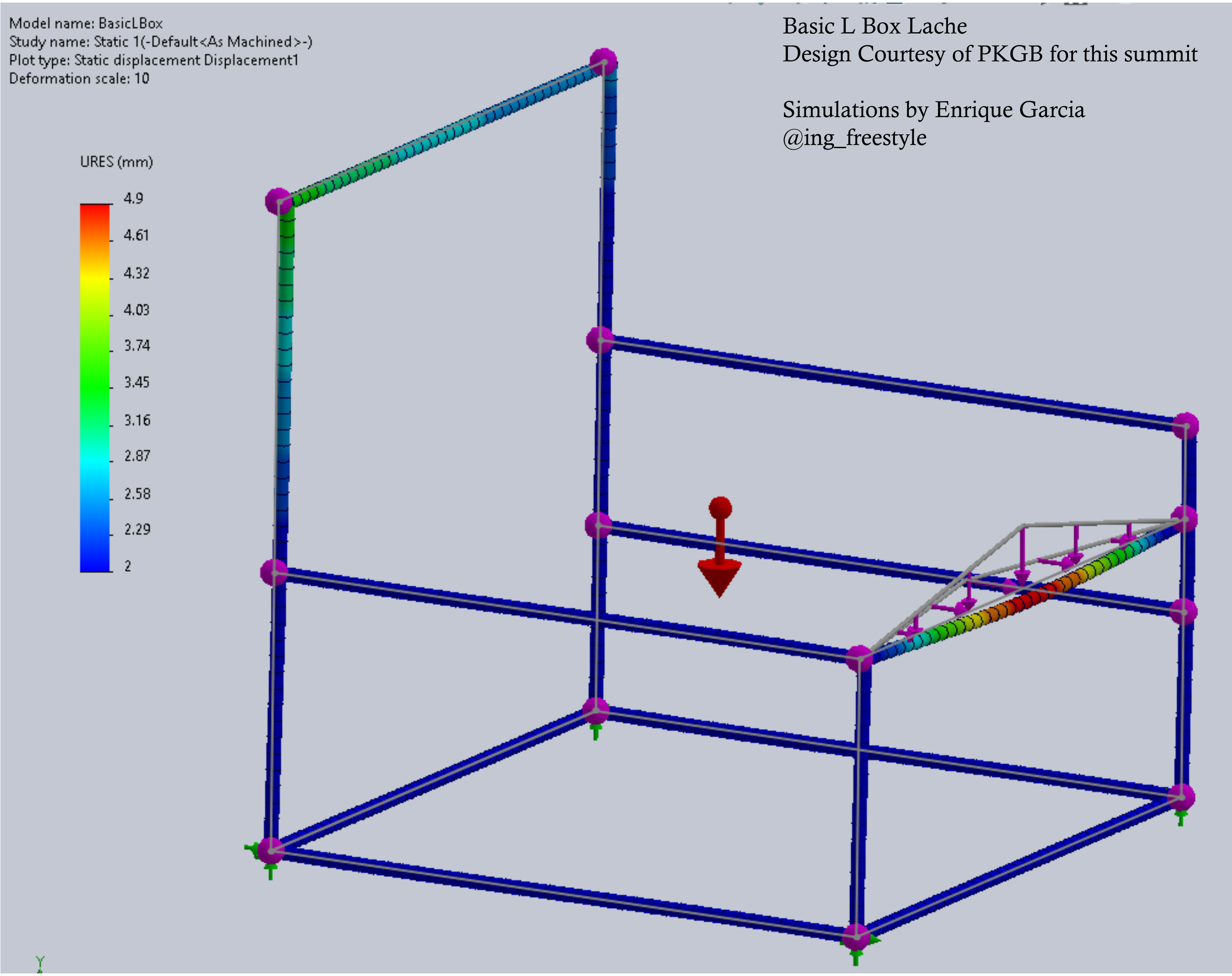


Simulated displacement effect (shakiness) when receiving a lache 3ft-7ft

SUPPLEMENTS

SIMULATION MODELS 2

- Original L box Scaff from PKGB
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 4.9
- Deformation is not strain
- Redder: More oscillation, bluer, more stability

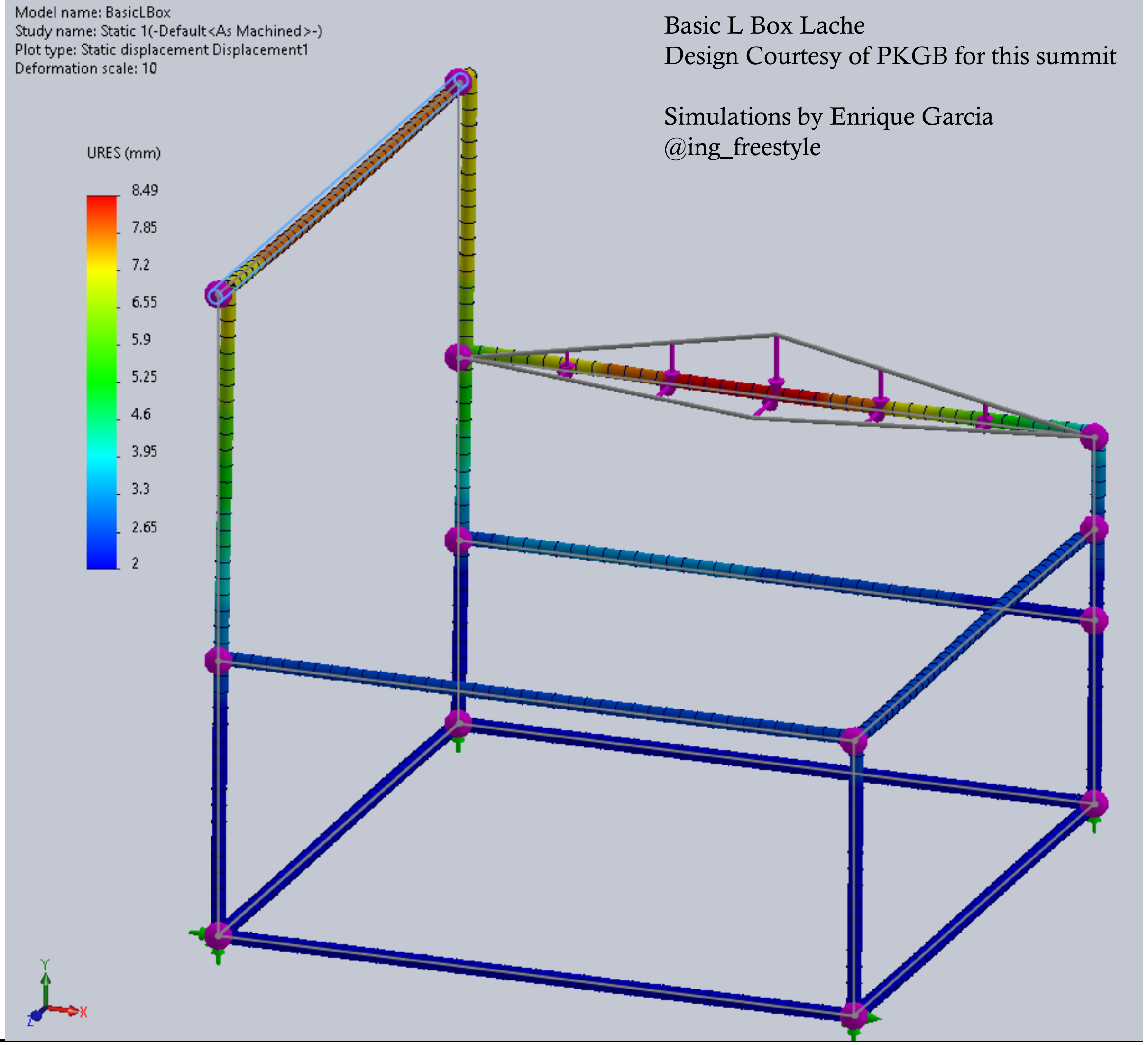


Simulated displacement effect (shakiness) when receiving a precision 7ft-3ft

SUPPLEMENTS

SIMULATION MODELS 3

- Original L box Scaff from PKGB
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm Max 8.5
- Deformation is not strain
- Redder: More oscillation, bluer, more stability

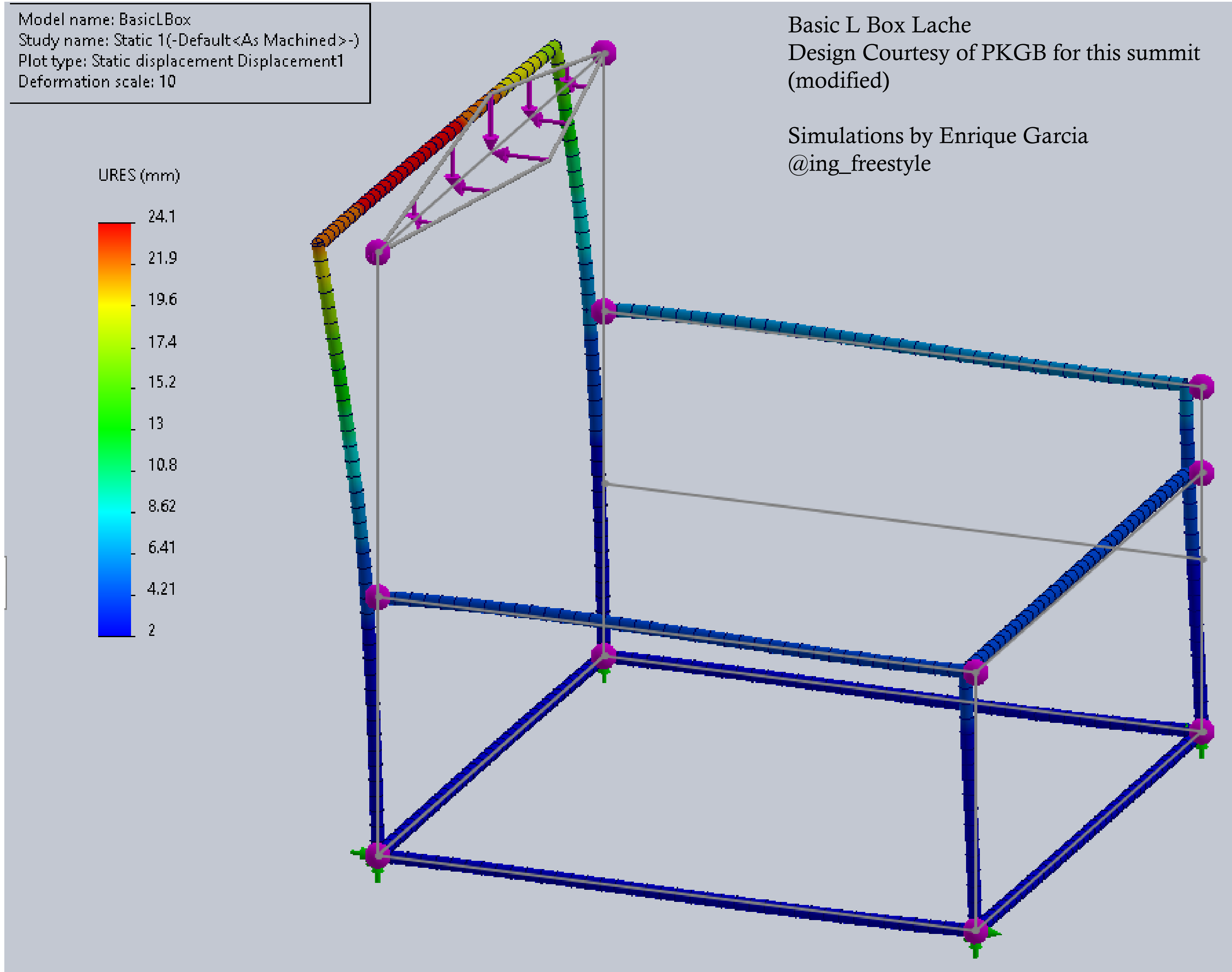


Simulated displacement effect (shakiness) when receiving a precision 3ft-4ft

SUPPLEMENTS

SIMULATION MODELS 4

- **Removal of 7ft horizontal**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm: Max 24.1
- Compare to simulation model 1



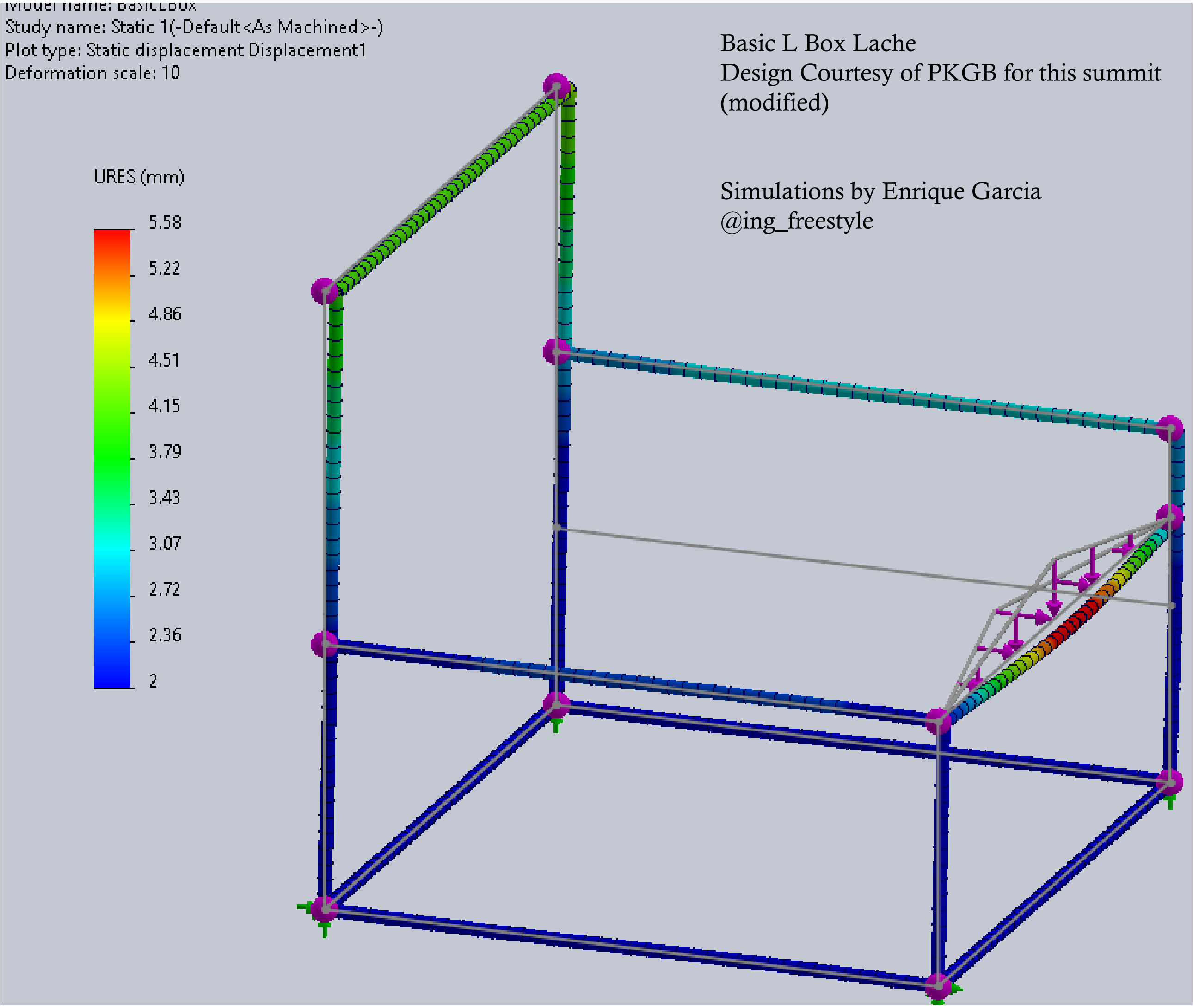
Simulated displacement when receiving a lache, 7ft member removed

SUPPLEMENTS

SIMULATION MODELS 5

- **Removal of 7ft member**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 5.6

- Compare to simulation model 2

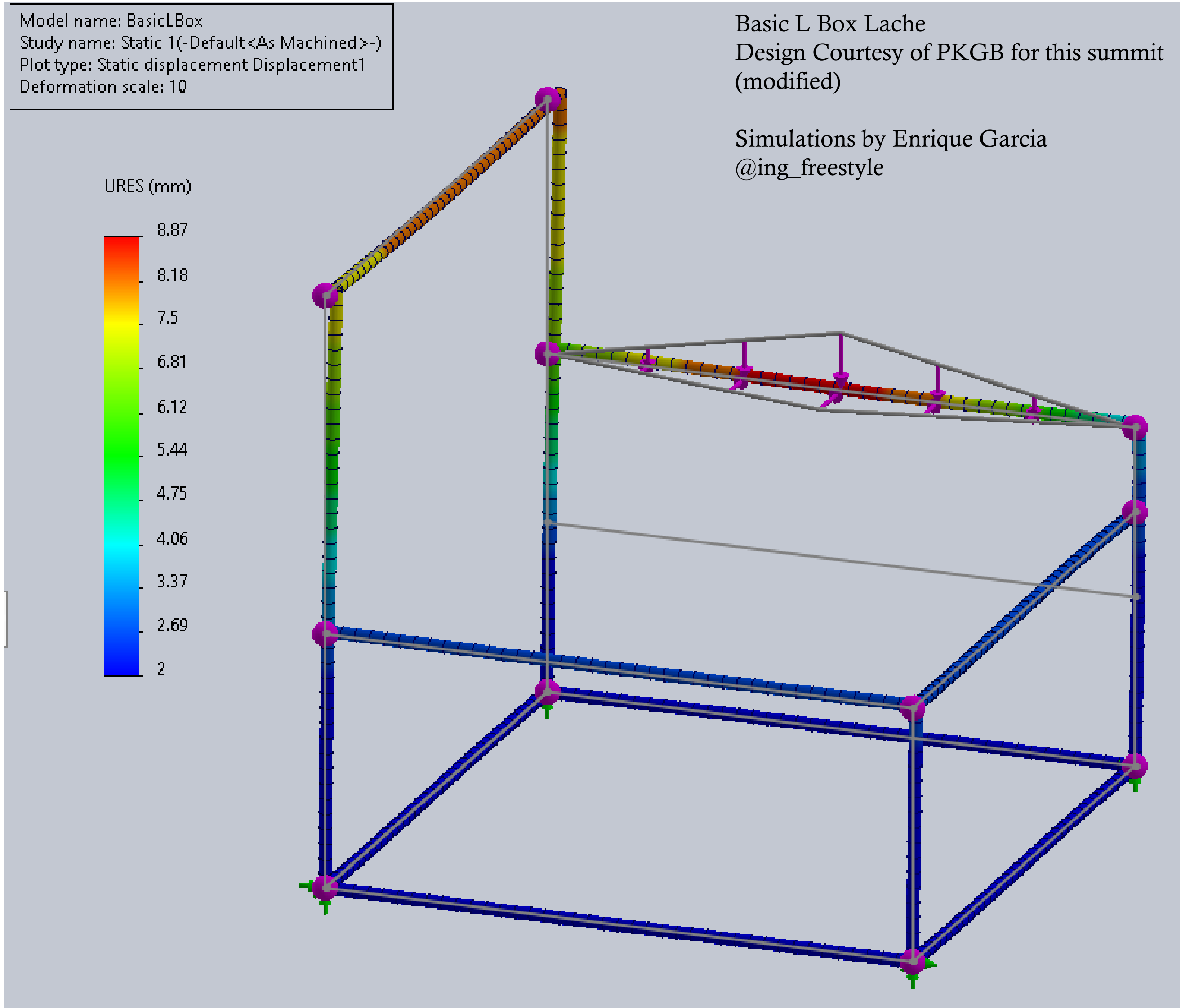


Simulated displacement when receiving a precision, 7ft member removed

SUPPLEMENTS

SIMULATION MODELS 6

- **Removal of 7ft member**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 8.9
- Compare to simulation model 3

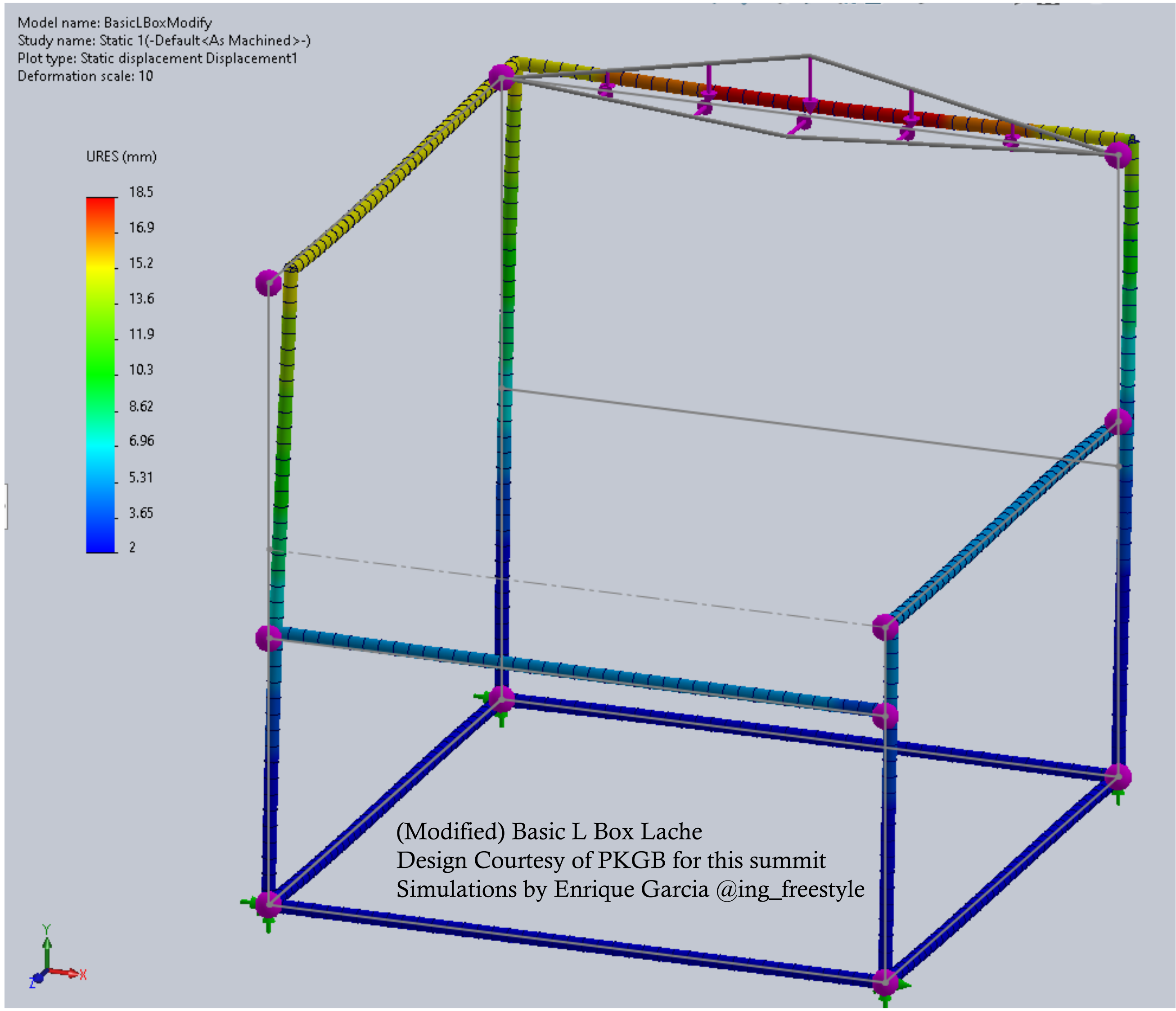


Simulated displacement when receiving a precision, 7ft member removed

SUPPLEMENTS

SIMULATION MODELS 7

- **Modified proposal**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm: Max 18.5
- Compare to simulation models 1, 4

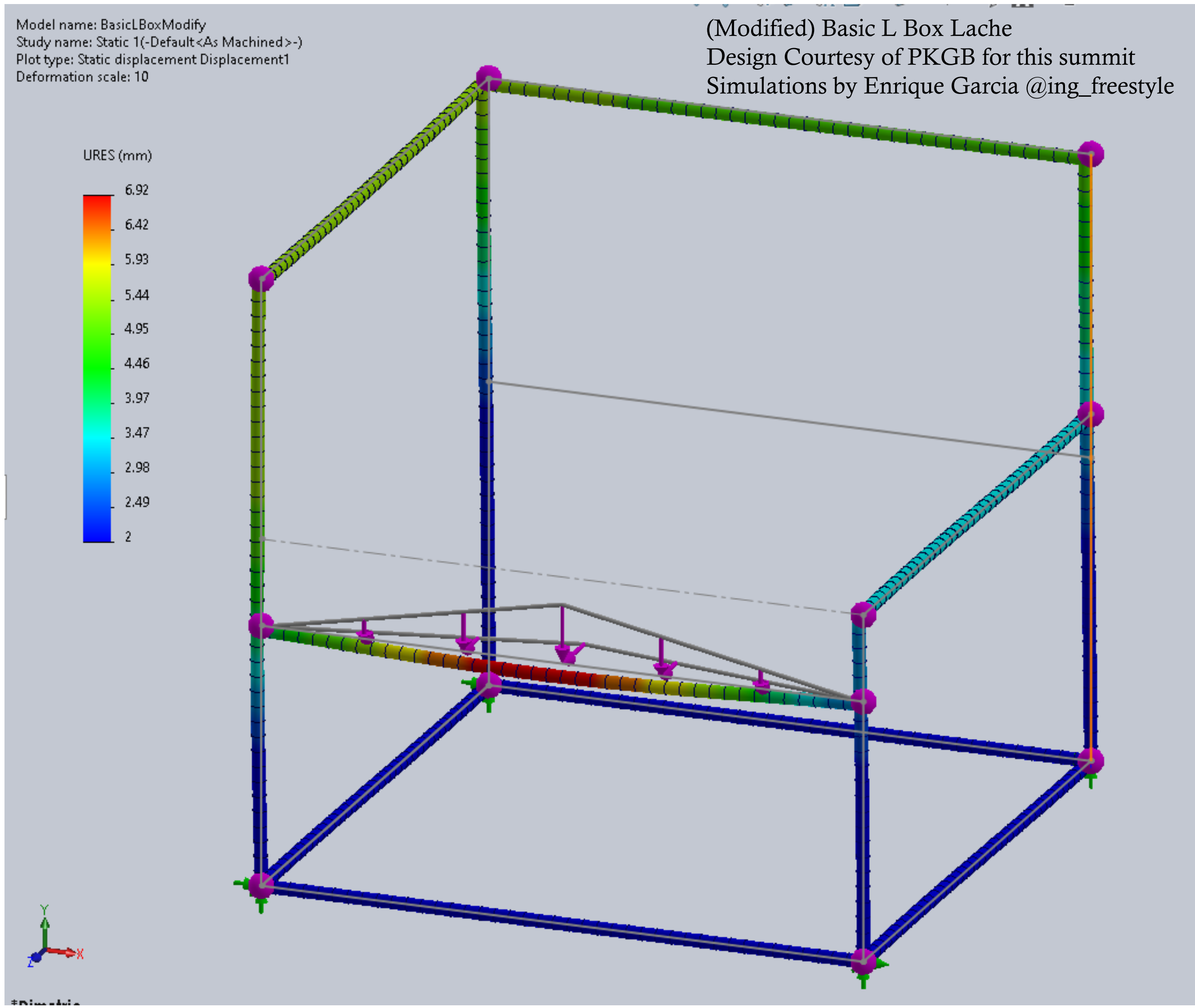


Simulated displacement when receiving a lache, 3ft-7ft

SUPPLEMENTS

SIMULATION MODELS 8

- **Modified Proposal**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 6.9
- Compare to simulation model 2, 5



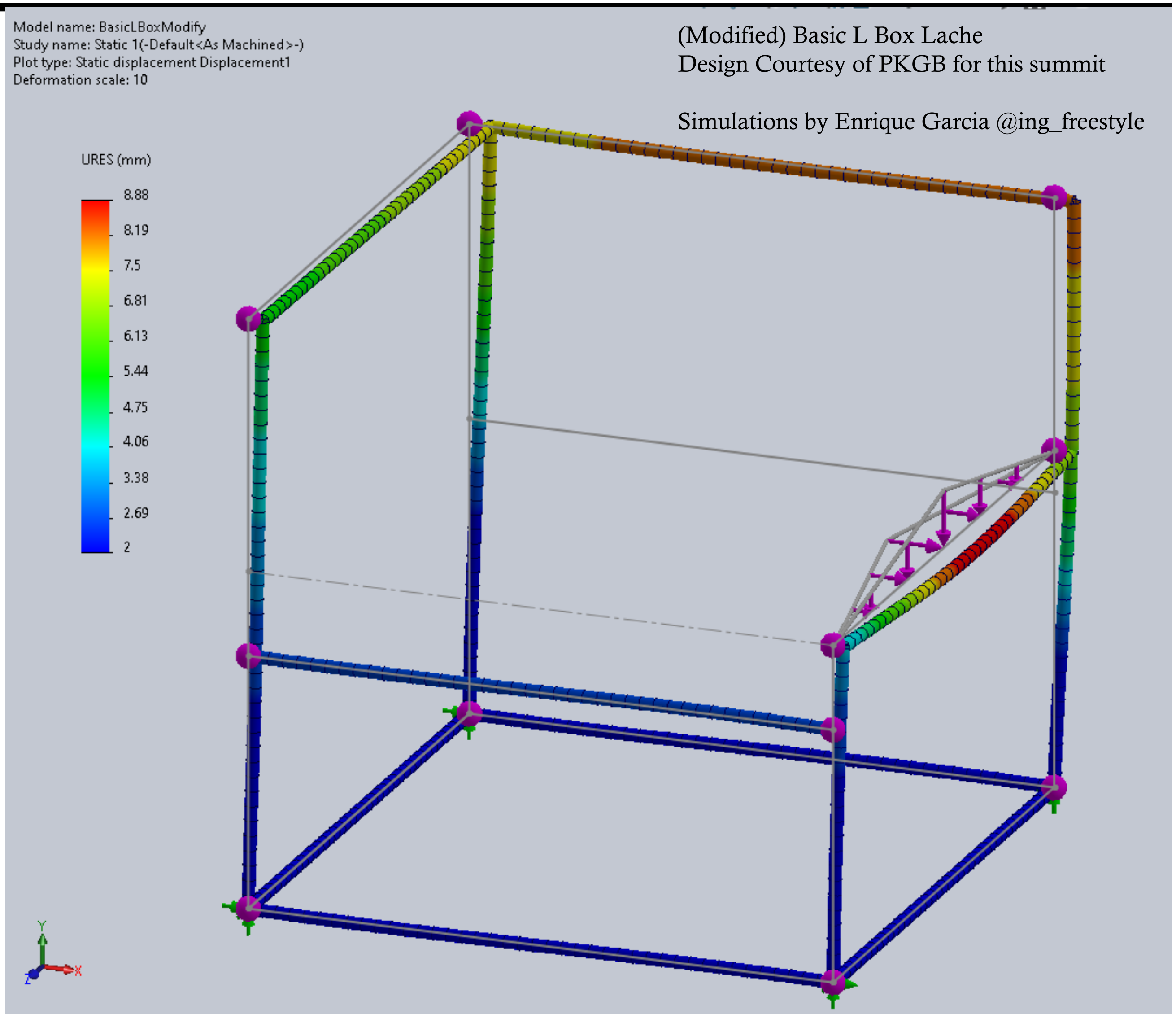
Simulated displacement when receiving a precision 7ft-3ft

SUPPLEMENTS

SIMULATION MODELS 9

- **Modified Proposal**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 8.9

- Compare to simulation models 3,6*
    - In models 3&6 this is precision 4ft-3ft

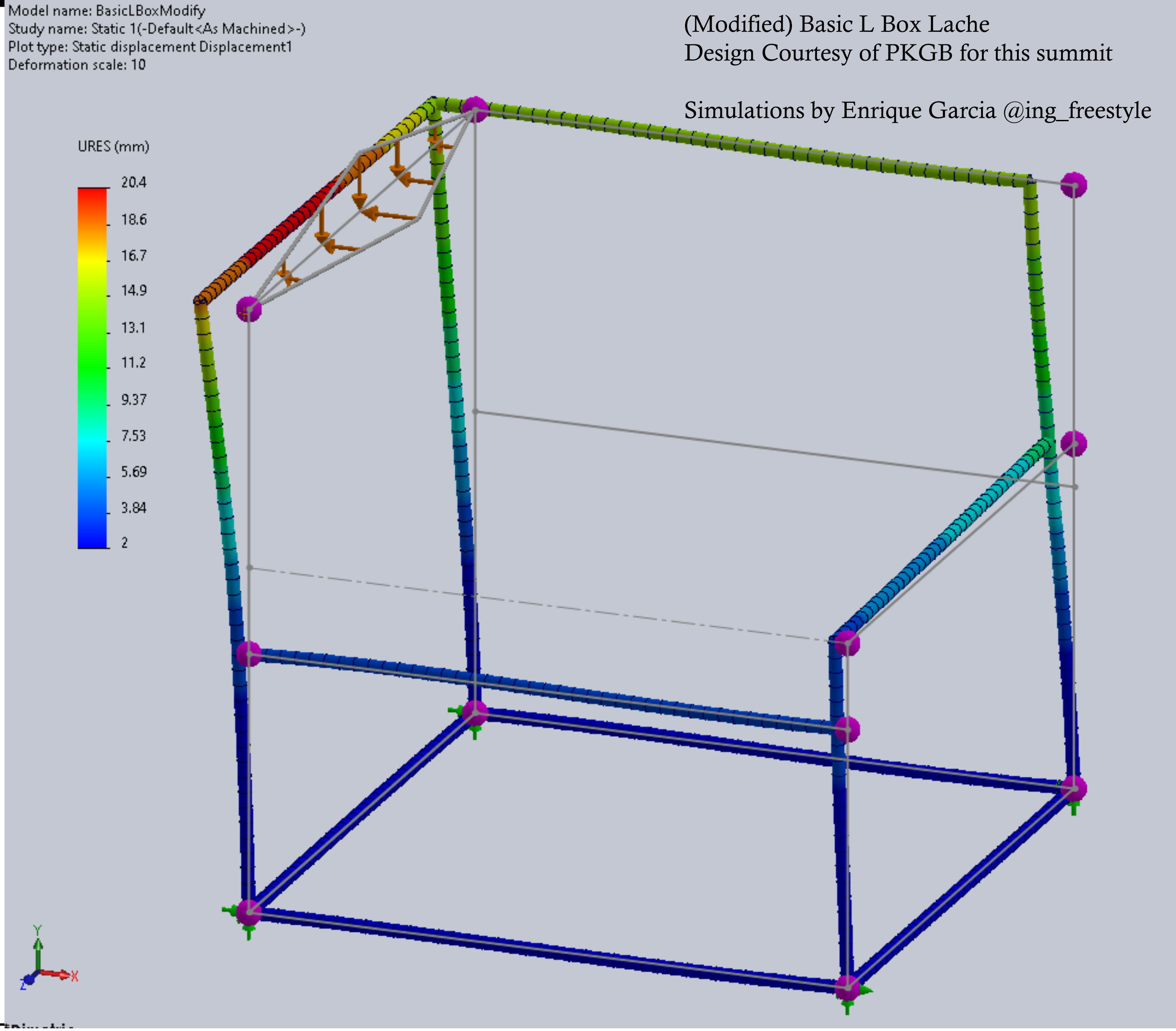


Simulated displacement when receiving a precision 7ft-4ft

SUPPLEMENTS

SIMULATION MODELS 10

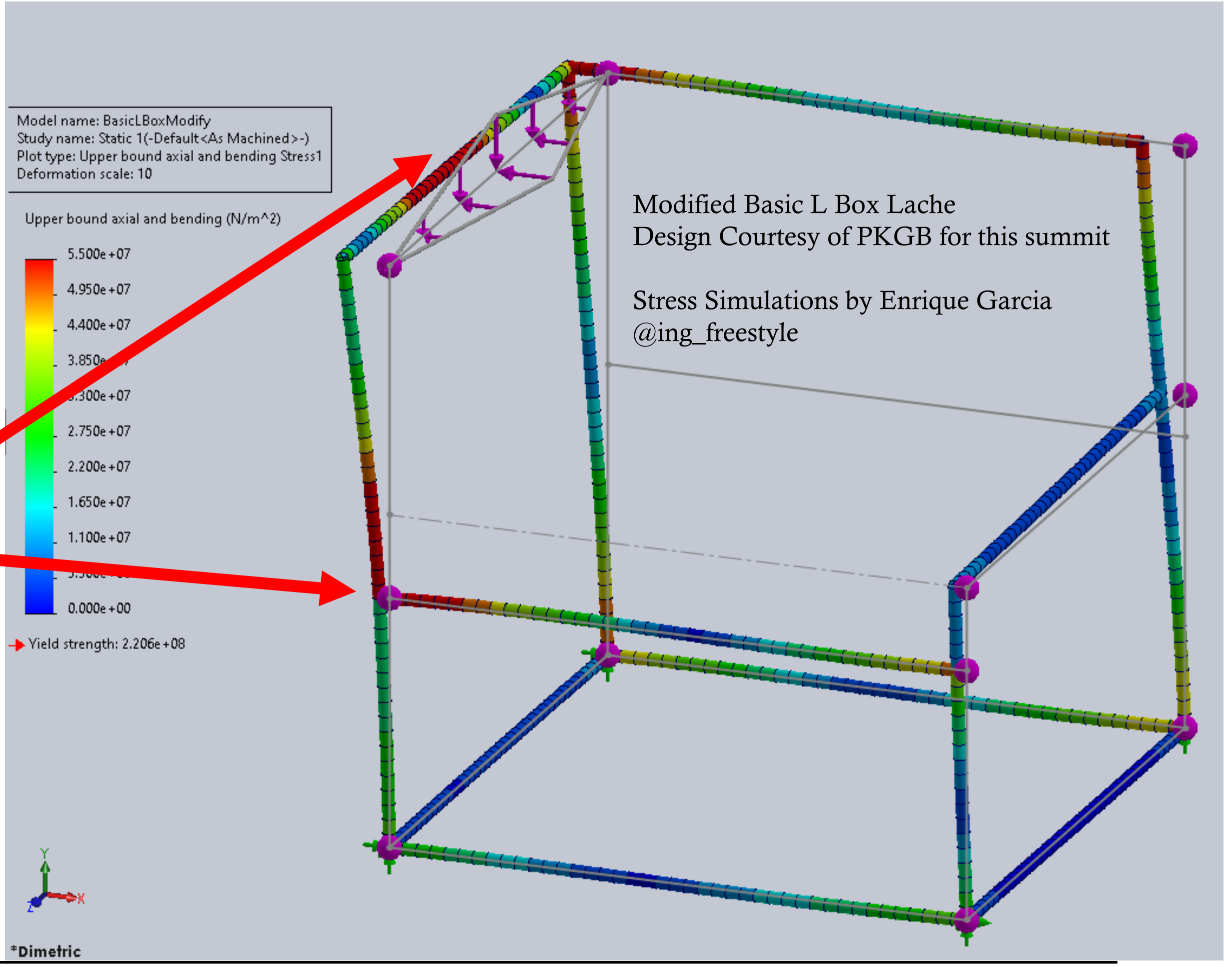
- **Modified Proposal**
- Assumed load 100kgf vertical AND horizontal (~150kgf at 45DEG angle)
- 1.5in sch40 steel pipe
- Deformation in mm, Max 8.9
- Compare to simulation model 1,4*
  - Models have no lache 4ft-7ft



Simulated displacement when receiving a lache 4ft-7ft (New possibility)

SUPPLEMENT: STRESS (WHY JOINTS BREAK)

- Stress is an indication of the internal material forces during deformation
- Higher stress is higher risk of failure
- 2 important stress points to look:
  - Landing point (that's why we check surfaces)
  - Joints that oppose movement
- Hos to read this graph: more red; Higher stress; bigger internal forces. More blue, less internal forces.
- Compare to deformation in model 6

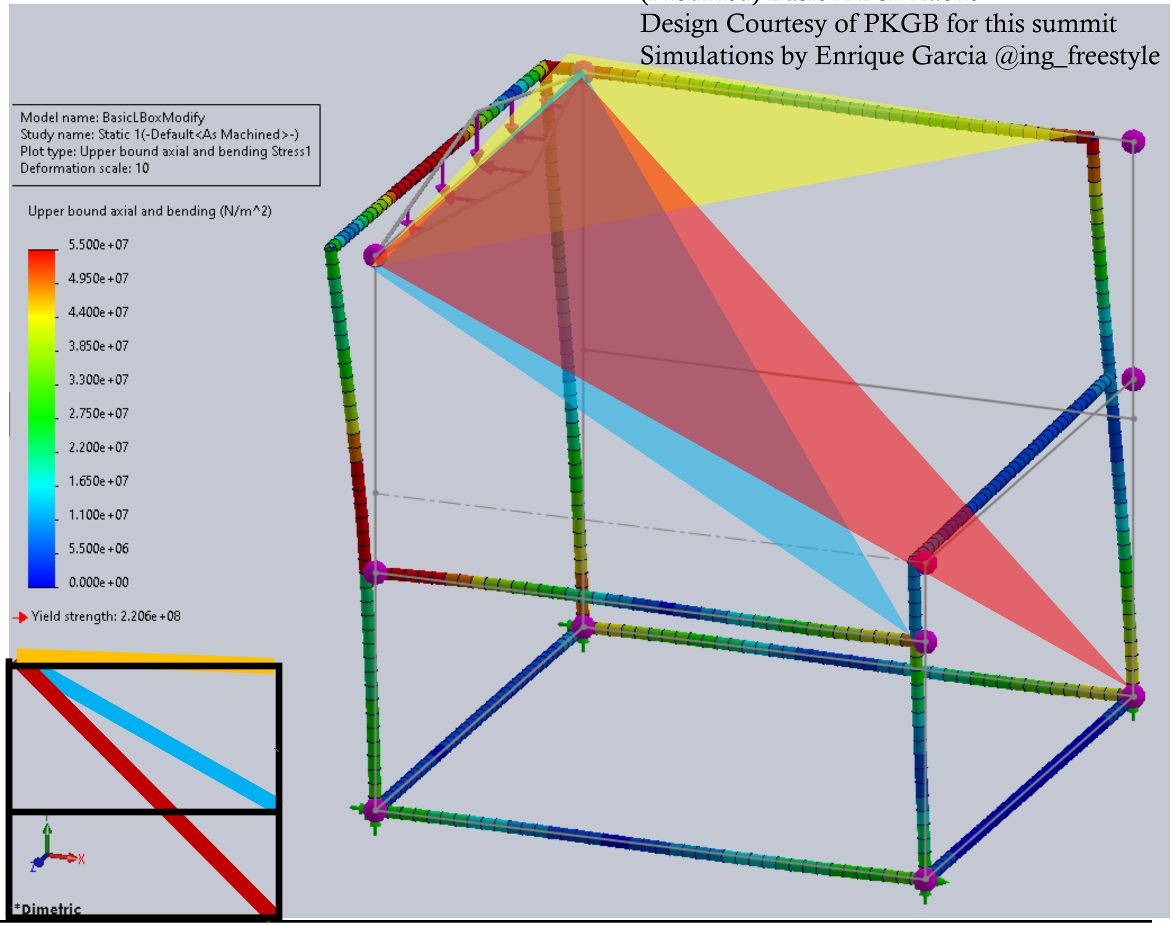


Deformation tells us which joints are stressed: the ones opposing the deformation

SUPPLEMENT: STRESS AND LOAD PLANES

- The closer the load plane to the load, the better stabilization, the higher the stress
- From what we studied:
  - Yellow: The best plane
  - Blue: Helps, but not as much as yellow
  - Red: The least helpful

(Modified) Basic L Box Lache
Design Courtesy of PKGB for this summit
Simulations by Enrique Garcia @ing_freestyle

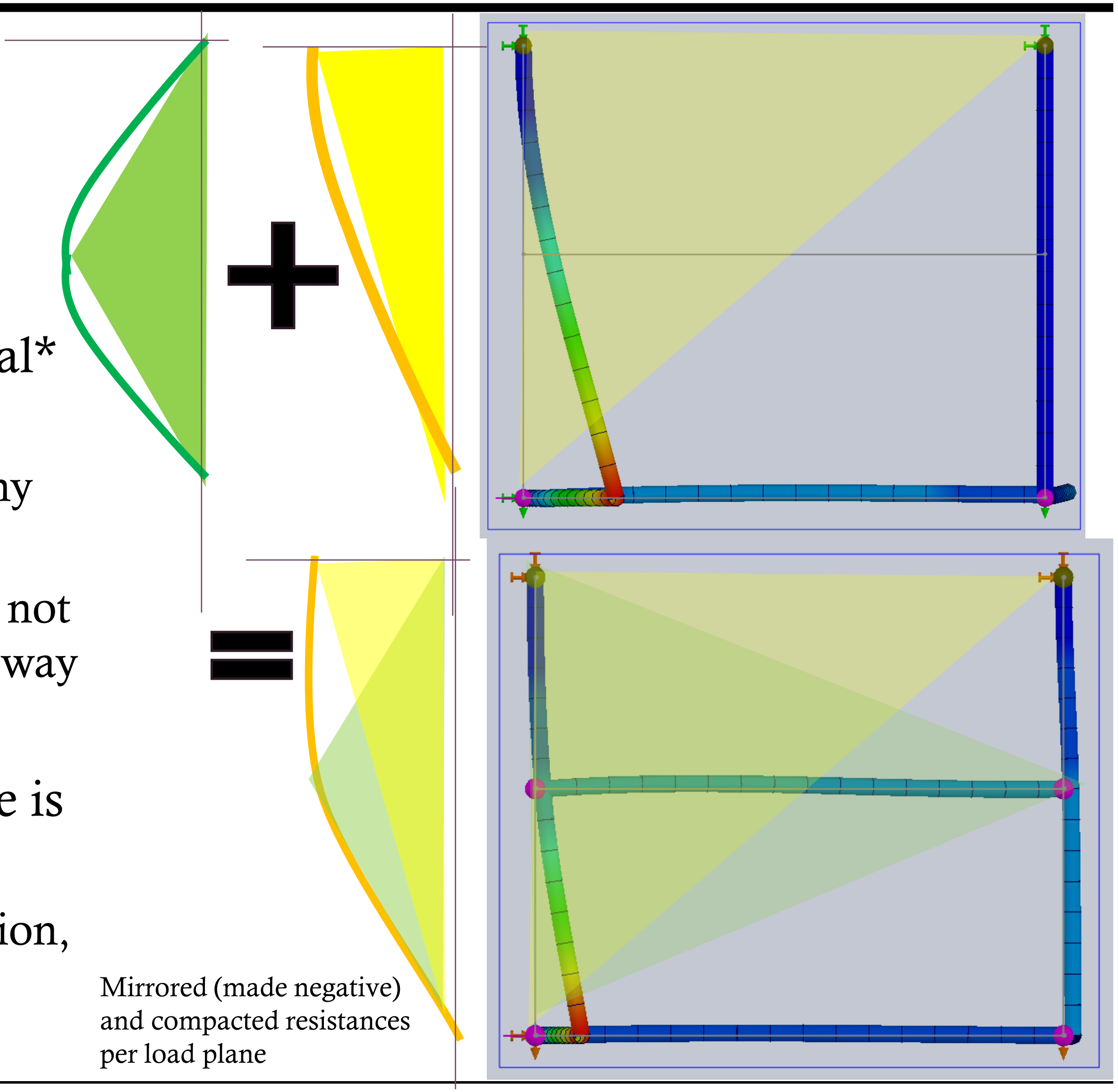


Load planes that better contain the force have the most stressed joints

ANNOYING MATH*

*TEACHERS AND PURISTS

- Load planes are also a visual indication of resistance (counter deformation) as the integral* of its shape
  - *Integral as in calculus, not bread, get a healthy amount of both, though :)
  - You can do integrals by graph; they're usually not taught at school, learn to do it and it's a great way of annoying your teachers
- Adding planes is adding curves, the new curve is always the addition of all curves
  - The new deformation is the original deformation, minus all resistances
    - Superposition principle



Mirrored (made negative) and compacted resistances per load plane

You can *see* the expected deformation by drawing, you don't need a computer

CONCERNS? ERRATA? INSULTS? COLLAB'S?

REACH OUT!

Enrique Garcia

@ing_freestyle

@svetikique