

# Innovation and Sustainable Development in Civil Engineering Degrees: Constructing Structures with re-used skins

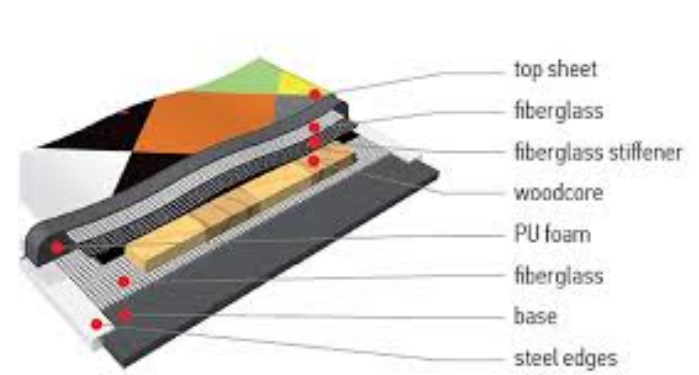
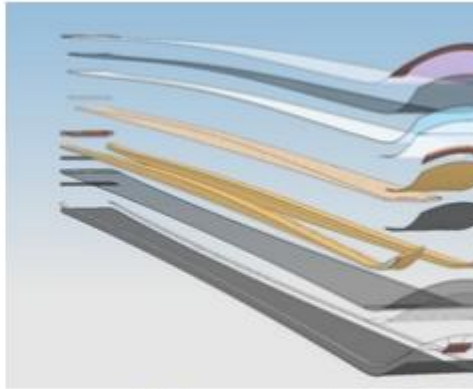
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**L3SR- PHITEM-Grenoble Alpes University**

# Innovation and Sustainable Development in Civil Engineering Degrees: Constructing Structures with re-used skis

- **Sustainable development teaching Challenges**
- **Re-Use of skis**
- **Geodesic Dome Project**
- **Other skis's projects**

# Re-Use of skis : Why ?

Annual production = 3.5 M pieces in the world, and 0.47 M in



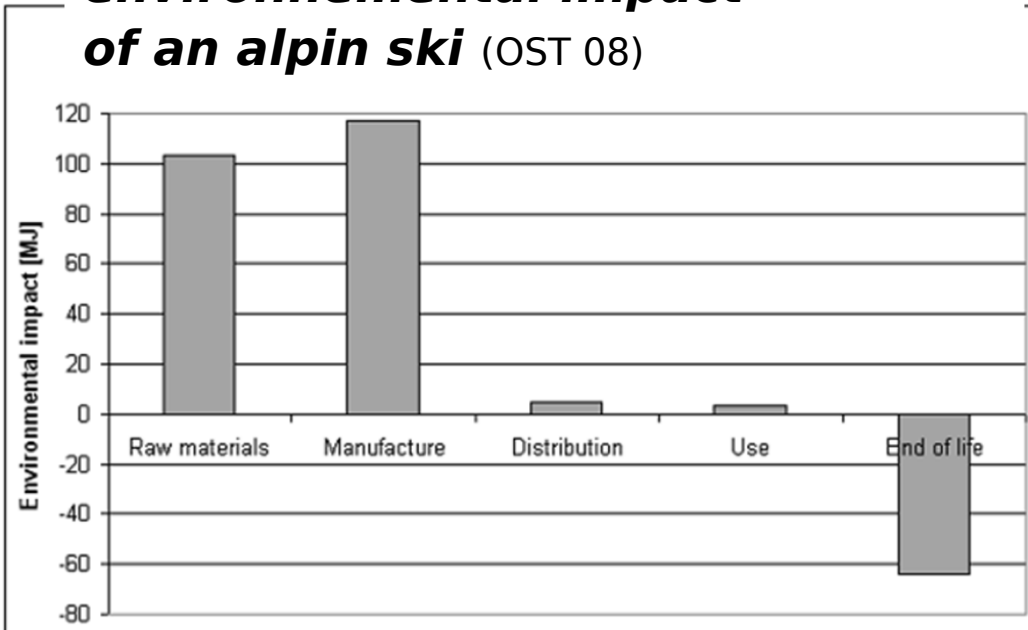
Wood only



ten different materials

complex and sophisticated structure

## *environmental impact of an alpin ski* (OST 08)



**Foot-print in Kg Equivalent of Co2**

**22 kg-17kg /skis;** (Luthe 2013)

**Multiplied by 1500 t or 0.4 M of paires.....**

**3kg /kg of crud spagettis**

Tesco 2012

**And because I like skiing....<sup>3</sup>**

# 2015 : What happen to old fashioned skis....

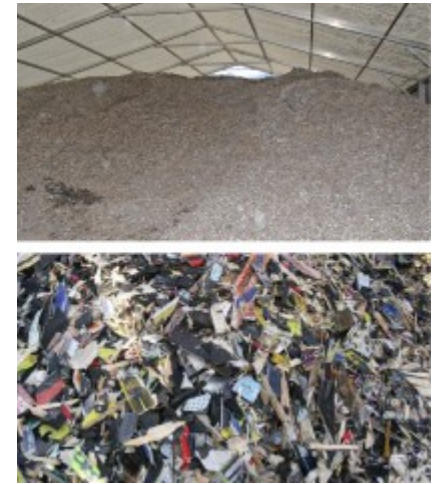


## Waste disposal

183.7 kJ /skis (Herva 2013)



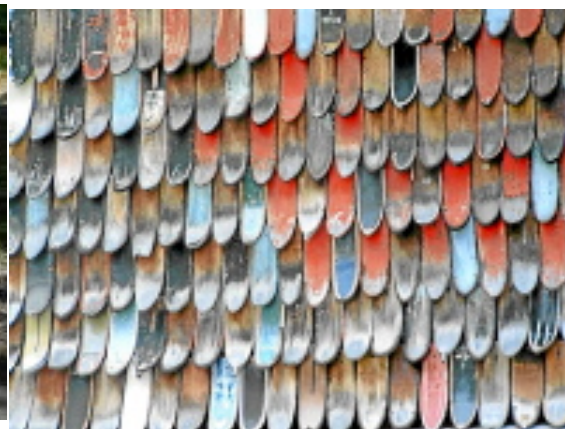
**Re-sell** : Emmaüs, Boite à ski



## Re-cycling :

cementeries  
SCOP TRIVALLEES (73)  
3000 t /since 2005

## Re-using : various original products



<http://www.latribune.fr/>



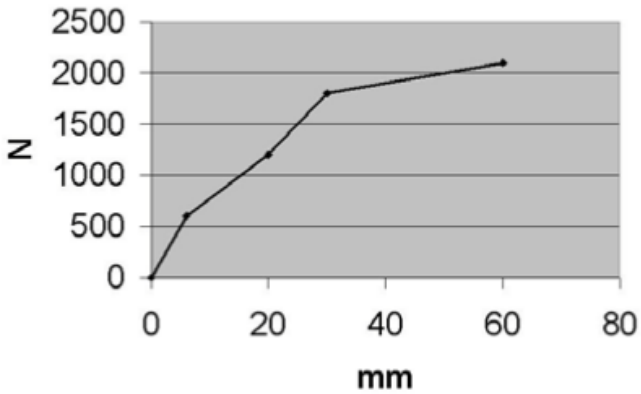
<http://www.instructables.com>



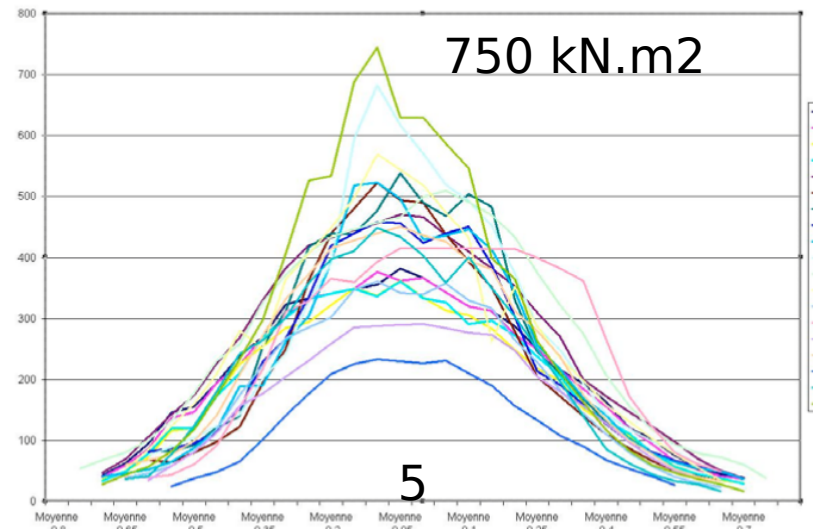
# A so Sophisticated product needs a more sophisticated 2<sup>nd</sup> life ! Baverel 2005, 2013



Load Vs Displacement



Variability Ski stiffness



## **to Design AND to Construct a temporary structure for festive events with Re-used Skis**

### Game Rules

- Assembly and Disassembly quickly
- LEGO/IKEA notice type
- 100 m<sup>2</sup> of usable surface
- Protected against sun, rain ...
- NO Cutting, lightweight, mechanical performance
- Eurocodes verification
- Inauguration for the defense

### Playing to

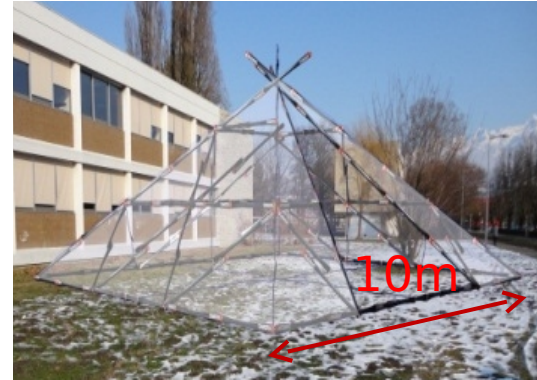
- Architecture agency
- Design agency
- Construction agency

# Architecture agency



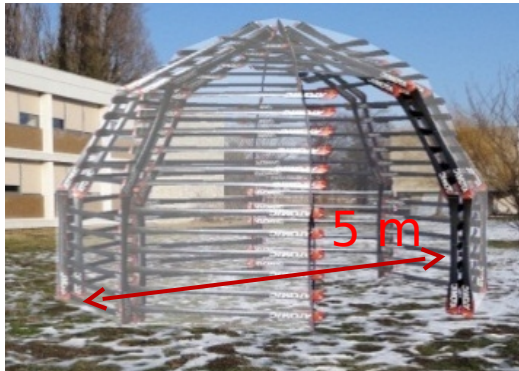
dome (high volume)

183 skis



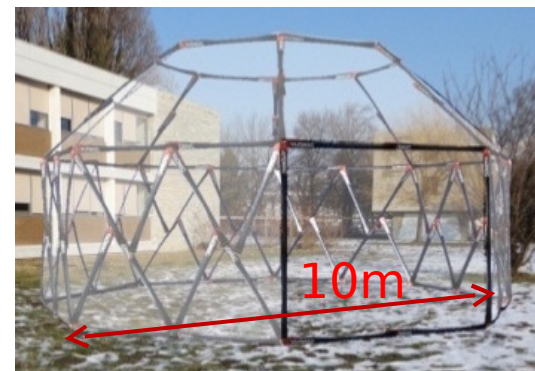
pyramide (small volume)

149 skis



« tonnelle » (too much skis)

148 skis



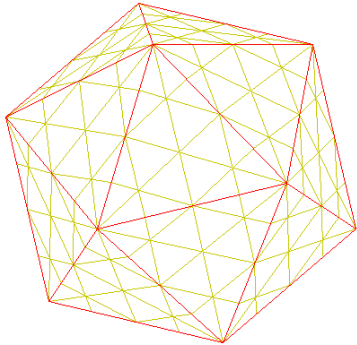
yurth (OK to improve)

116 skis

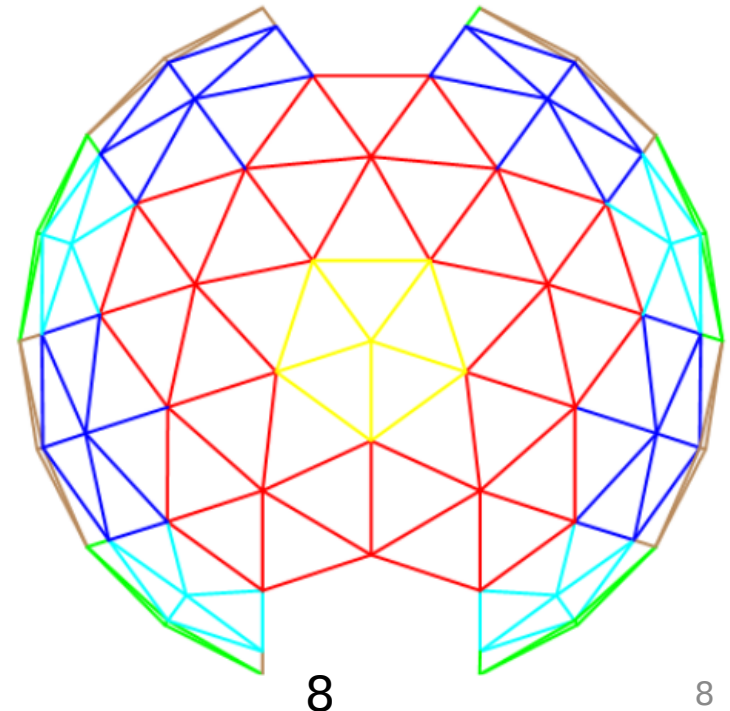
# Geodesic Dôme (fascinated by the mathematical rules of design)



- From icosaèdre and projection on a sphere
- Varying dimension depends on the rank !
- percing lenght

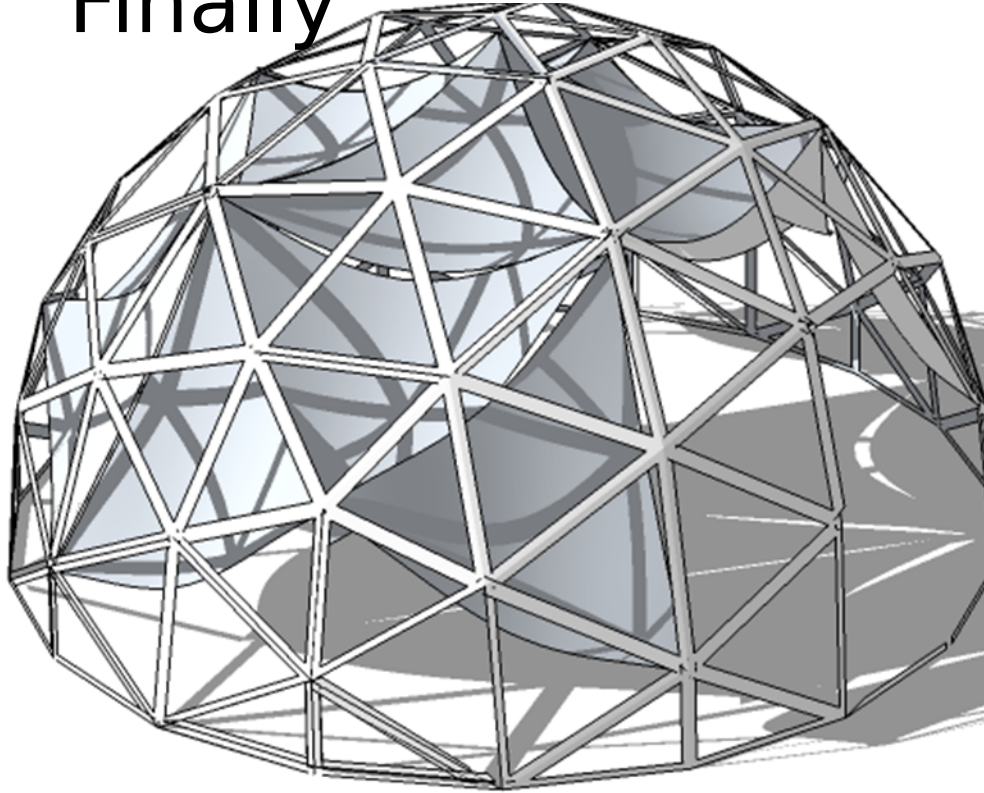


LONGUEUR	No DE SKIS
0,69 m	4
0,74 m	4
1,13 m	4
1,15 m	21
1,25 m	16
1,33 m	15
1,34 m	13
1,41 m	10
1,42 m	8
1,43 m	18
1,44 m	30
1,45 m	8
1,46 m	25
1,47 m	4
<b>AU TOTAL:</b>	<b>180</b>

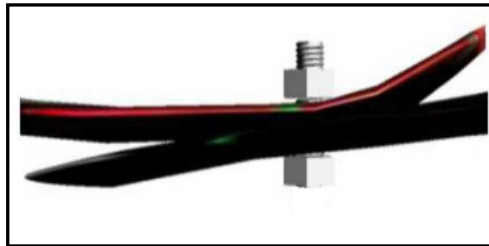




# Finally



- hexagones and pentagones
- No bump
- 8 m of diameter
- 4 m high
- Triangles of canvas as suspended ceiling
- 2 opposed entrances
- 180 skis classified by height
- Laid flat (minimal rigidity)
- 79 Nodes of 3 to 6 skis

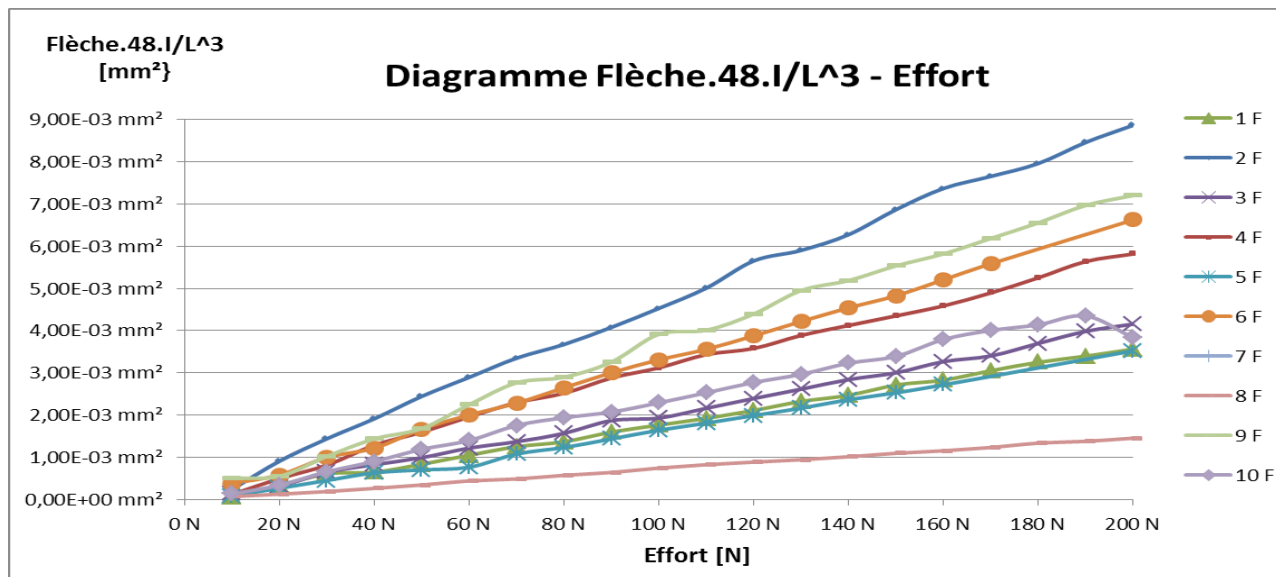




# Bending Results

## Basic Bending interpretation (constant inertia)

- $f = P.L^3 / (48.E.I) \rightarrow E = P.L^3 / (48.f.I)$
- Mean Young Modulus **Emoy = 51,8 GPa** (steel= 210 Gpa)
- Mean inertia **Imoy = 9.1E-9 m<sup>4</sup>**
- Mean rigidity **EI = 0.471 KNm<sup>2</sup>**



# Tension tests on assembly

## 3 tests



Spatule-Talon  
Spatule



Talon-Talon



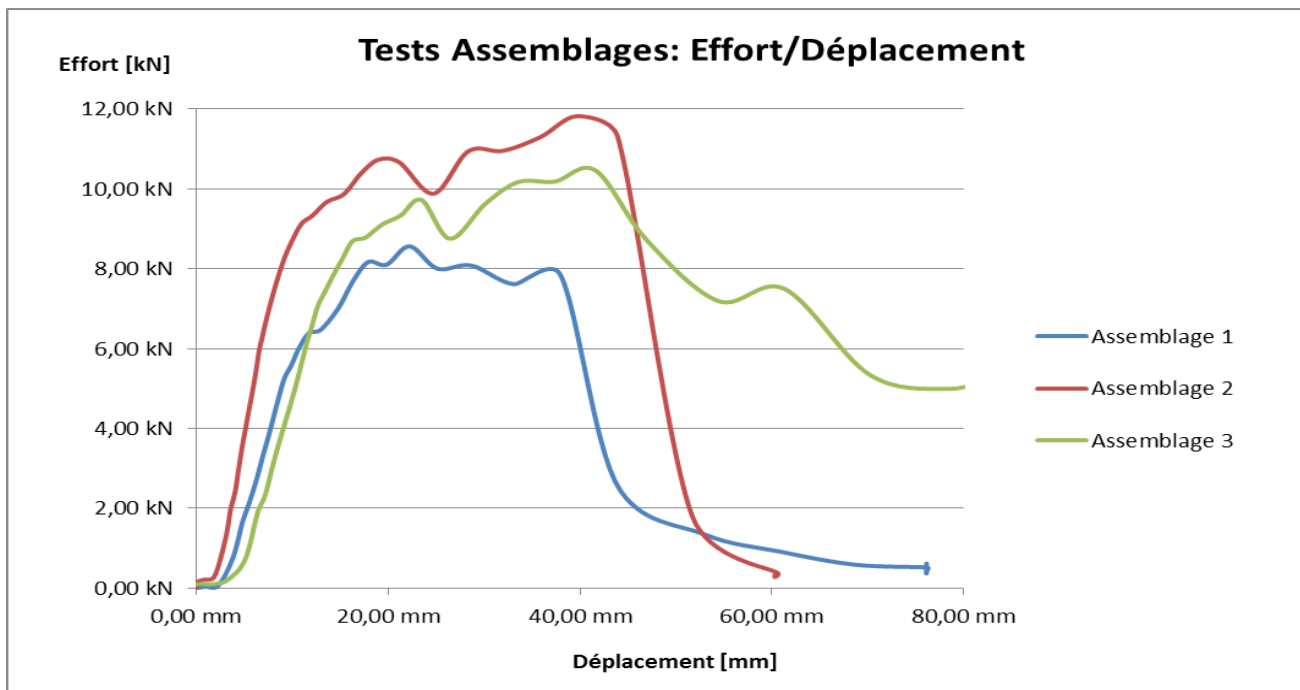
Spatule-  
Spatule



# Tension Tests Results

## Résistance des assemblages en traction

- Valeur limite de traction **Ft = 8,56kN**
- Choix **Ft, lim = 7,5kN**



### **Assemblage 1 :**

Les deux spatules  
assemblées

### **Assemblage 2 :**

Une spatule associée  
à un plat

### **Assemblage 3 :**

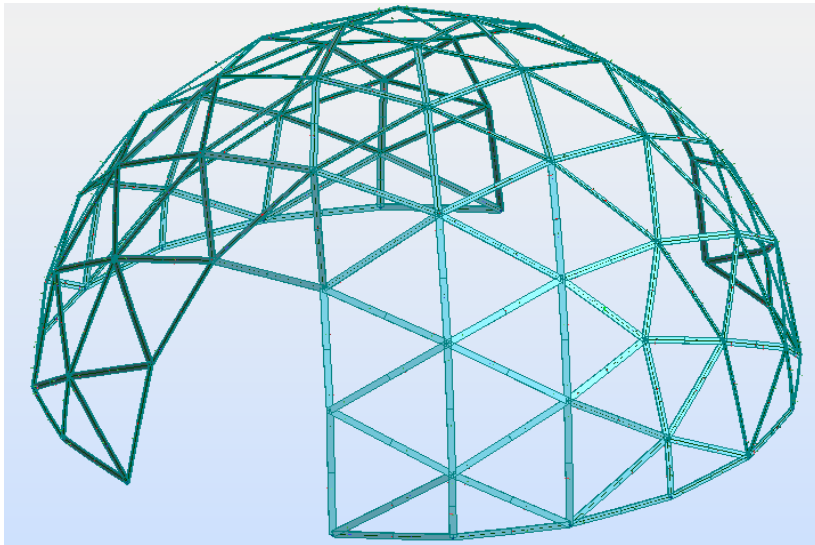
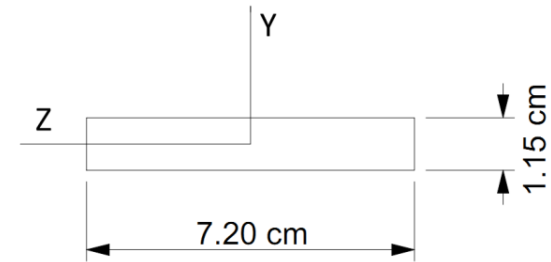
Les deux plats  
assemblés

# « Eurocodes » Verification

- Robot structural engineering

Hypothesis :

- constant section,
- no curvature, but bi-slope



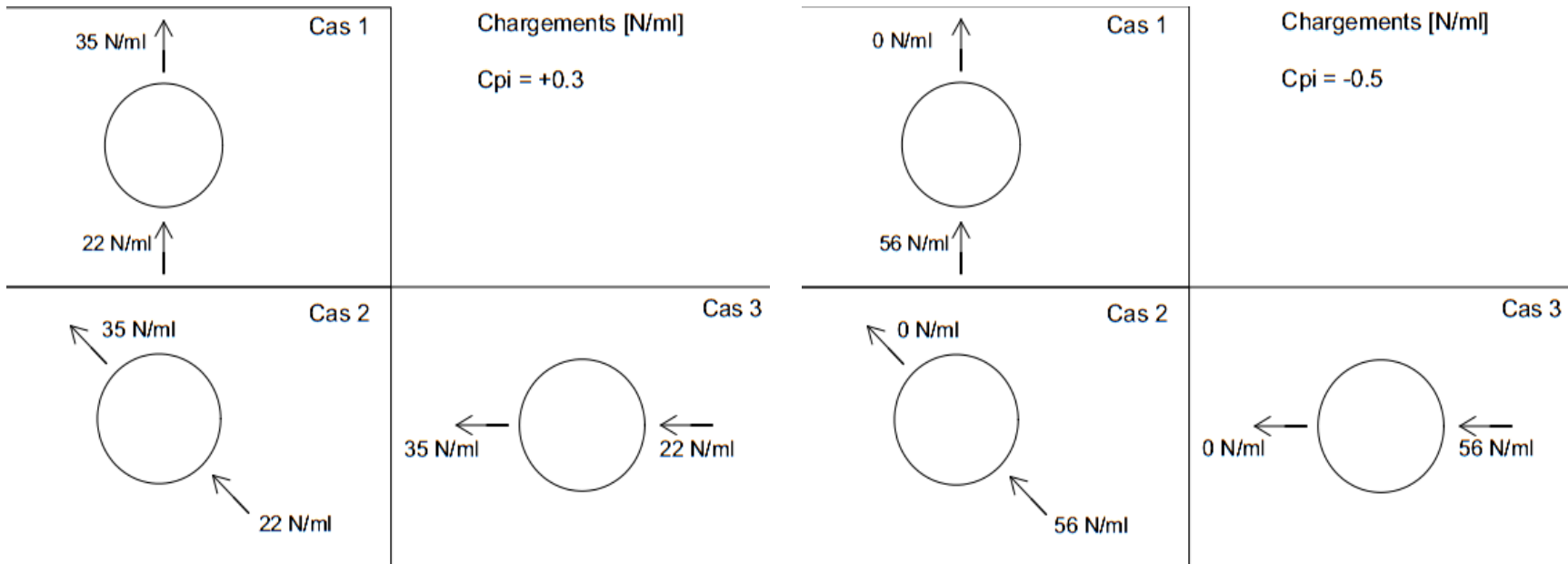
<b>Inertie faible moyenne Totale</b>	9,1E-09 m <sup>4</sup>
<b>Module E moyen Totale</b>	51801 MPa
<b>Contrainte admissible</b>	190 MPa

# Load cases

## Own weight load

- Based on **2Kg/ski**
- weight: **22.84 Kg/m<sup>3</sup>**

## Climatic loads (Cpi 0.3, -0.5)



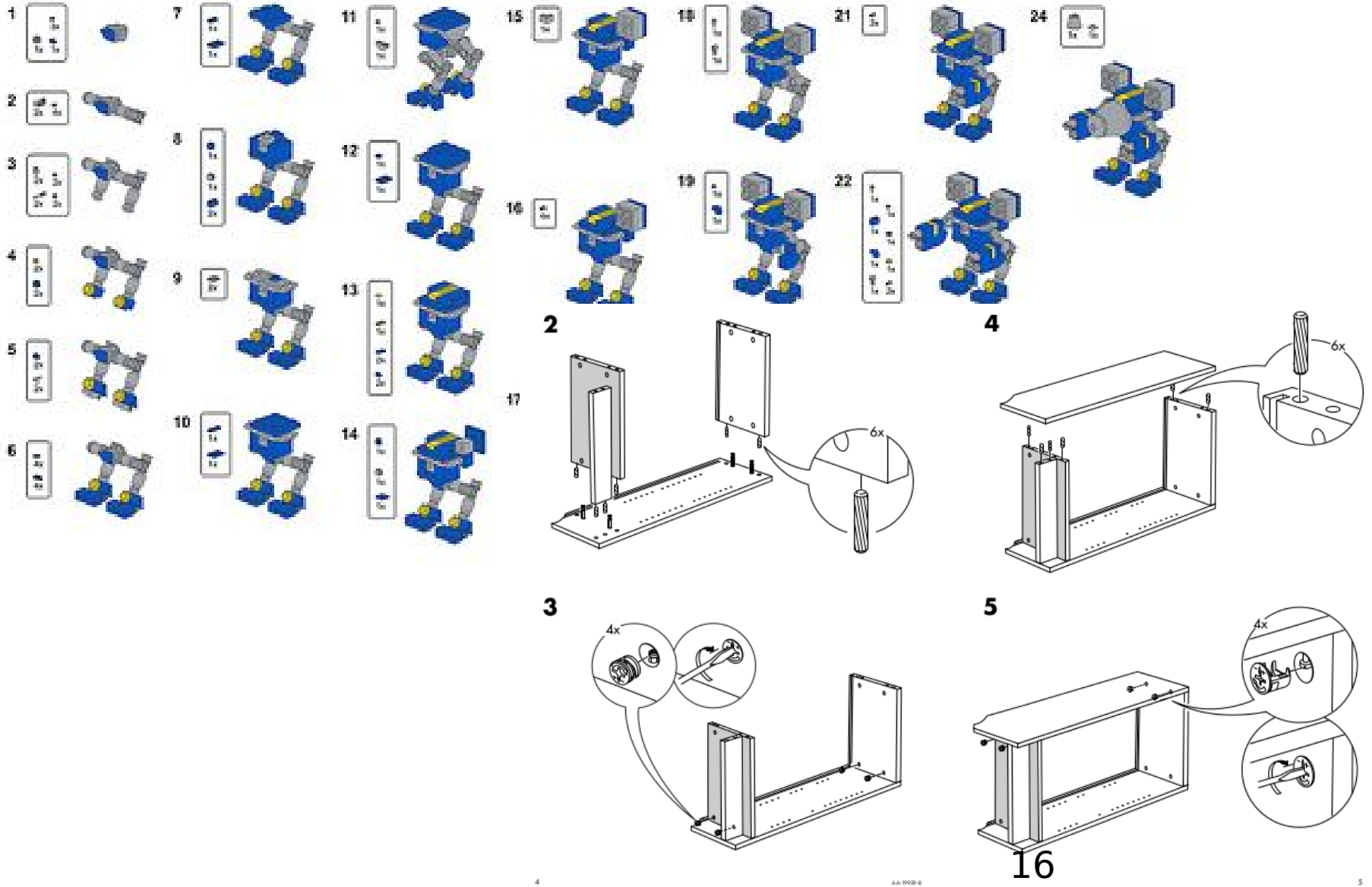


# Load Cases

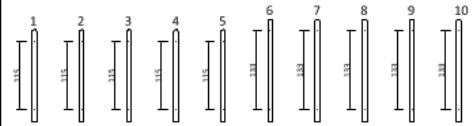
- Combinaison fondamentale 1.35G+1.5.W à **l'ELU**
  - **Buckling analysis** compression in skis, Traction
  - no more than **300 daN**
  - Stress max = de **56.73 MPa** << Limit Stress **190 Mpa**
  - **(no canvas.....)**
- 
- Résultats of displacements with ROBOT (4 cm, 10° )

	UX [cm]	UY [cm]	UZ [cm]	RX [Rad]	RY [Rad]	RZ [Rad]
<b>MAX</b>	2,585139654	4,697169750	2,235705753	0,102	0,164	0,046
<b>Noeud</b>	169	168	168	168	168	22
<b>Cas</b>	2	2	18	2	2	2
<b>MIN</b>	-3,582268851	-3,458963826	-1,543581319	-0,092	-0,142	-0,041
<b>Noeud</b>	169	169	169	168	168	168
<b>Cas</b>	19	19	2	18	18	2

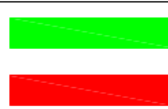
# The Lego/IKEA Notice type : Only drawing and simple scheme



Liste des skis:



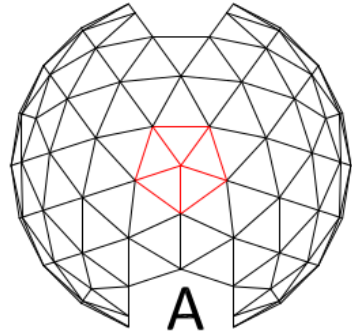
Repere:



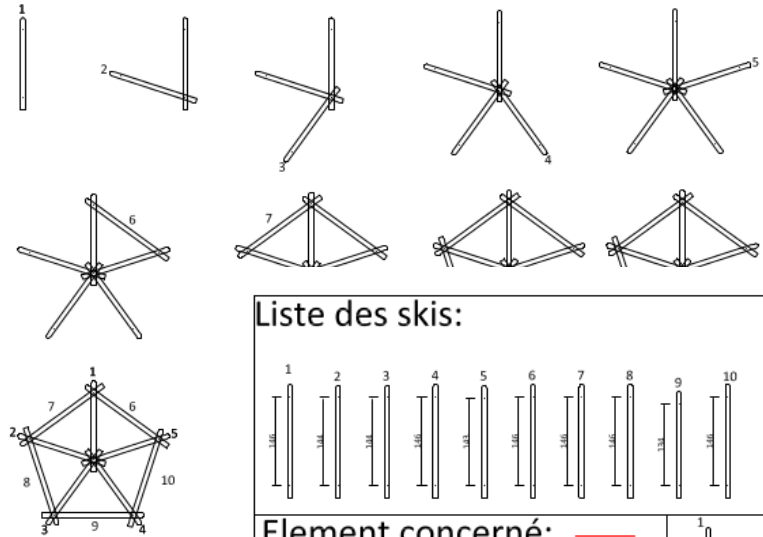
# Starting from the top pentagone

Element concerné: — (red line)

Element réalisé: — (blue line)

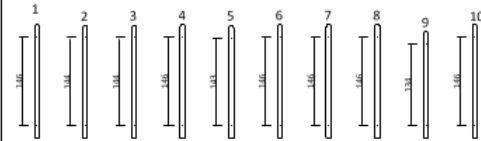


A



Réalisation de l'élément : A

Liste des skis:

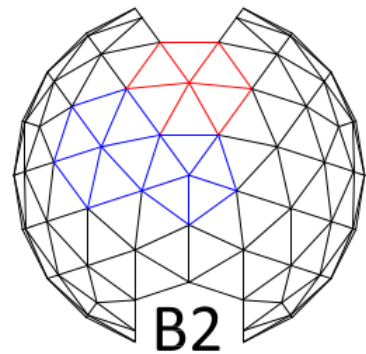


Repère:

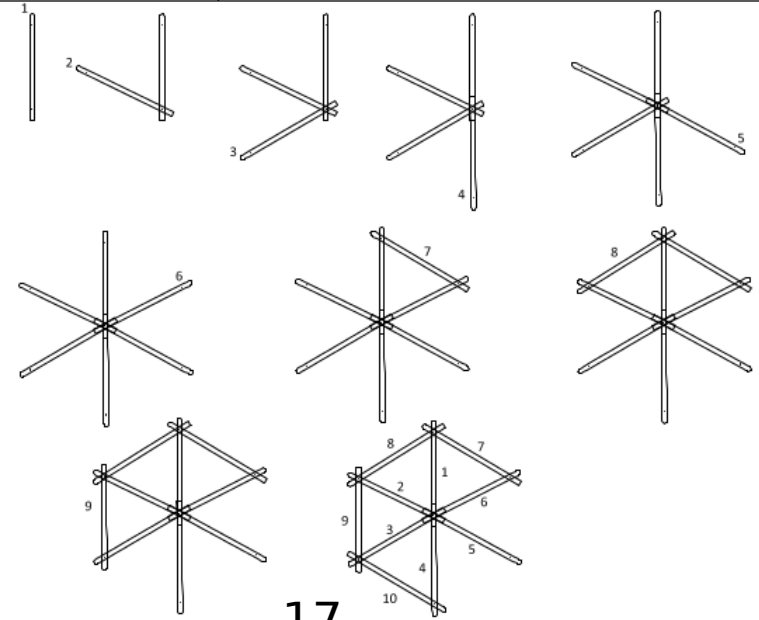


Element concerné: — (red line)

Élément réalisé: — (blue line)



B2



Réalisation de l'élément : B2

# Elementary element test and mounting

- deployed pentagone



- Folded Pentagone



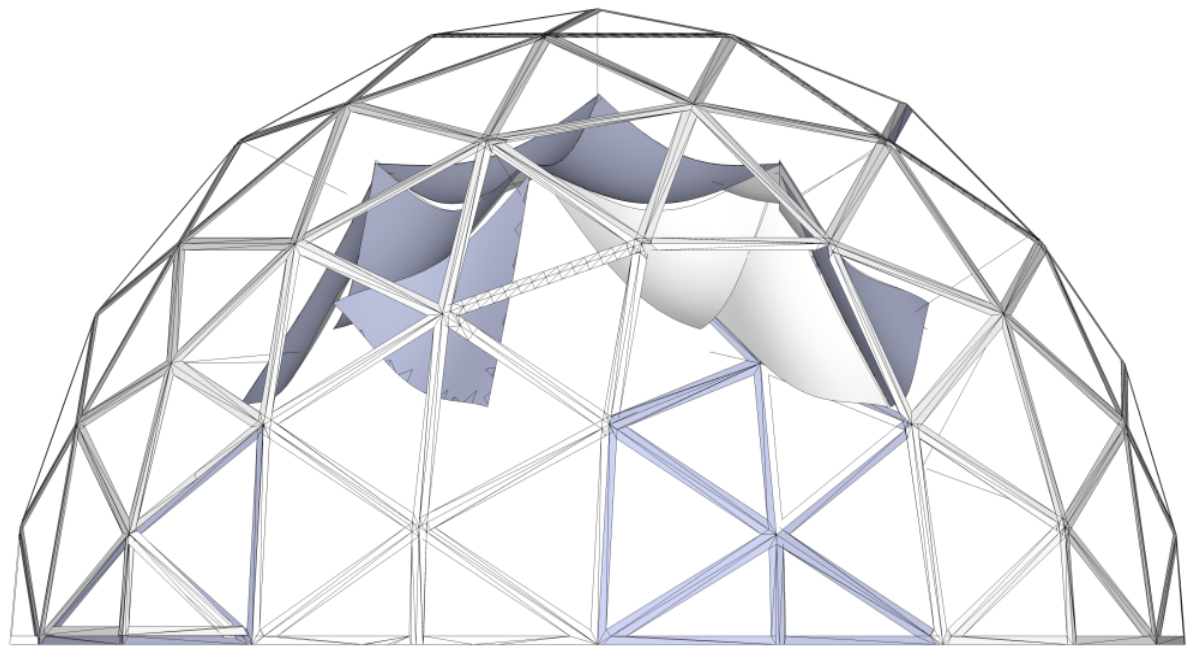
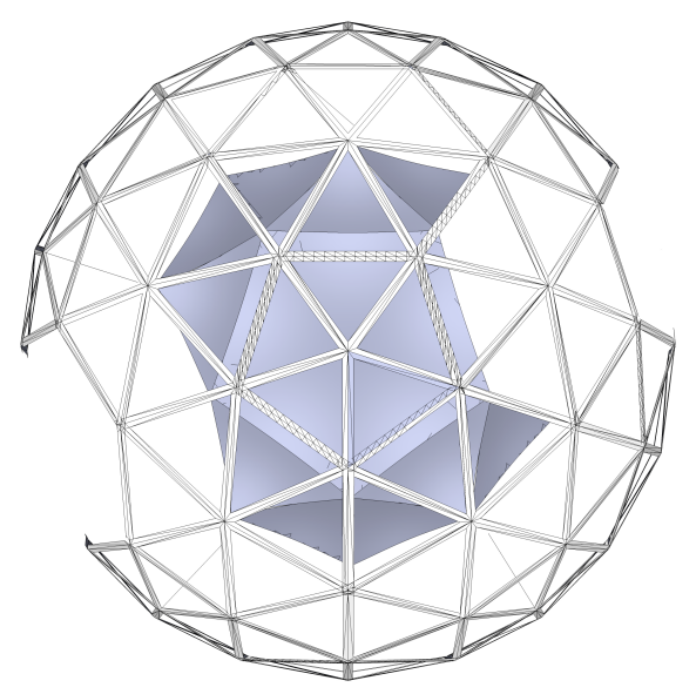
- a chinese girl student....



- a french boy student





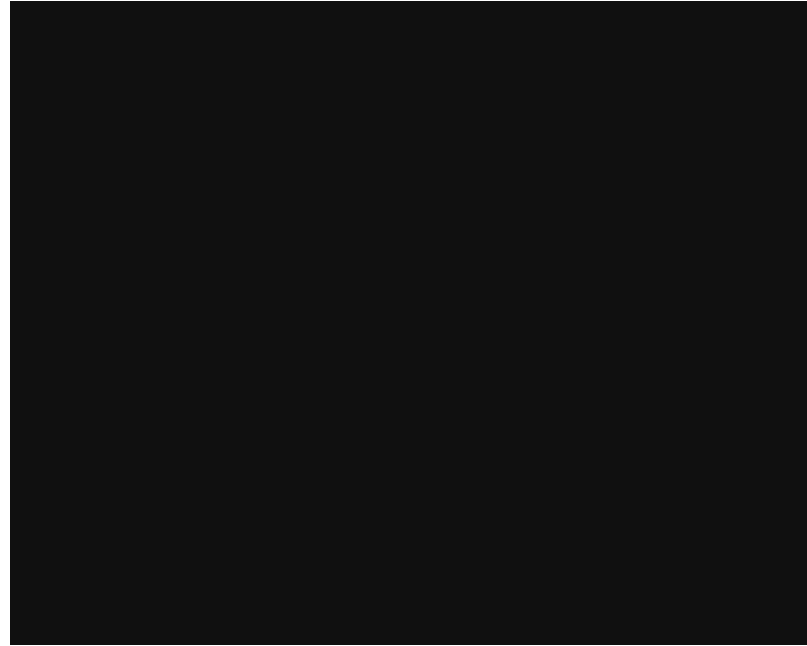


The architecte girls dream  
Planificated Mounting duration : 2 h





# Reality .....



mounting duration : 6 hours

**M2 GCI : Marseille Workshop...**

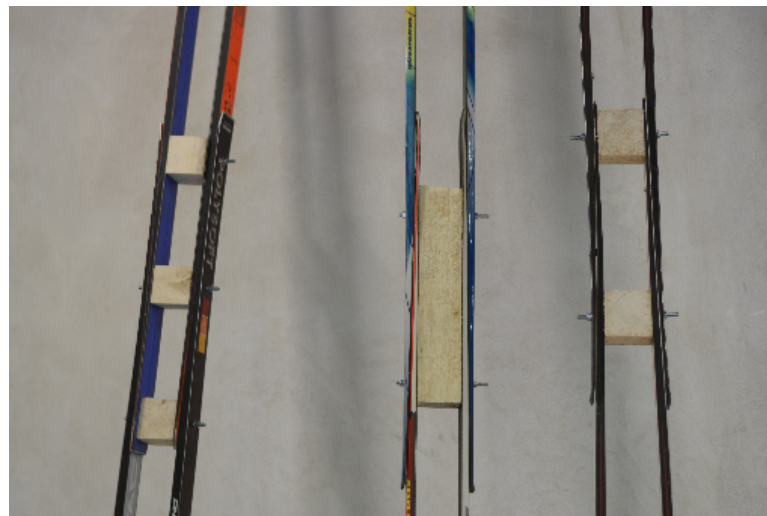
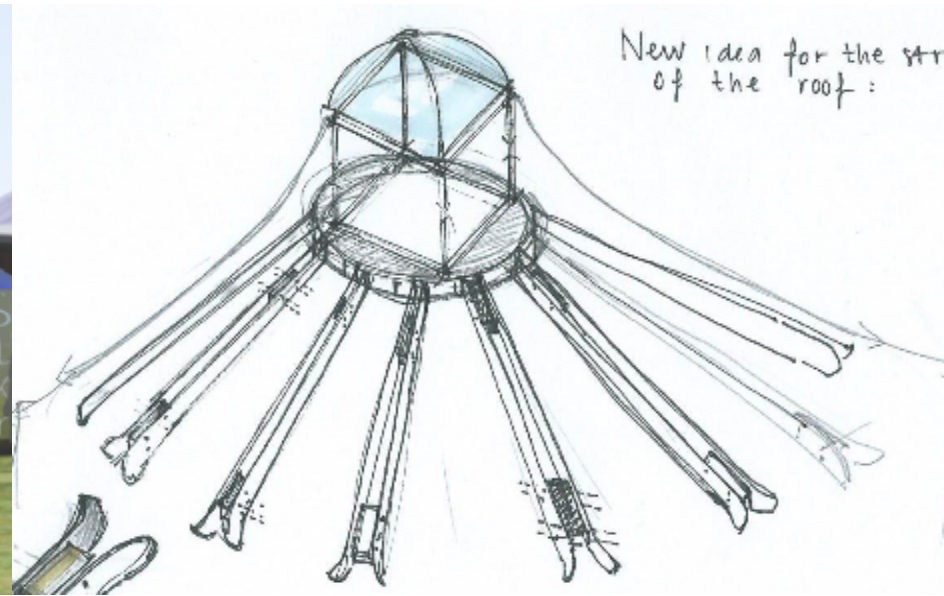
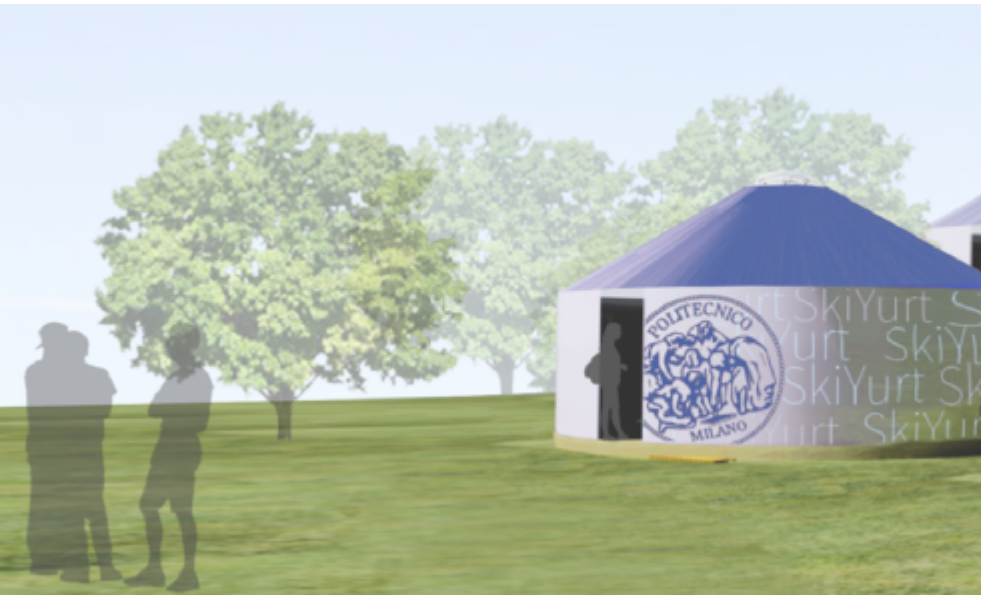
**not so easy to re-invent something else, but not so easy only to re-adapt**







# Project 2015 : the yurth project with politecnico





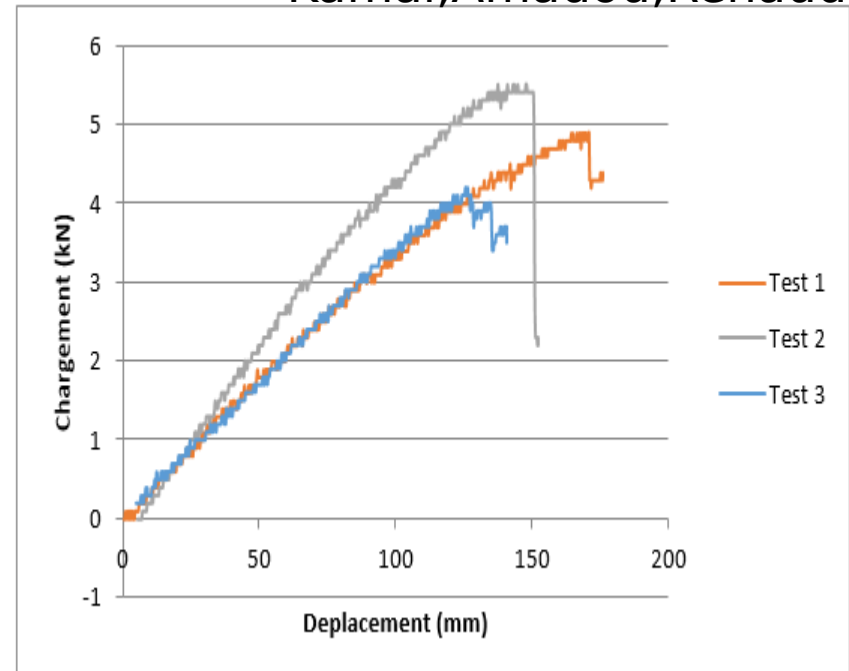
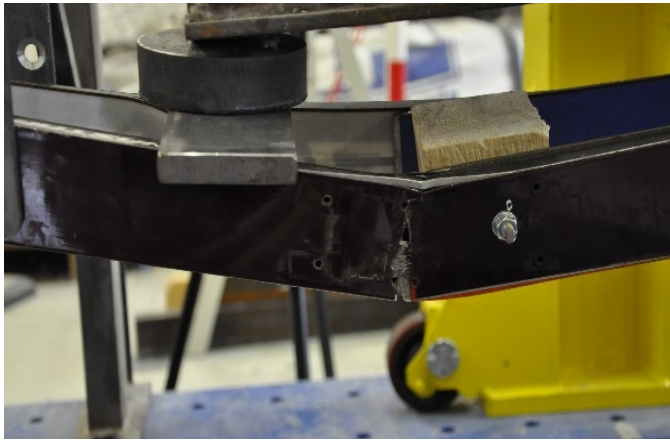
# Project 2015 : the yurth project with politecnico





## Type de rupture :

- cracking
- delamination



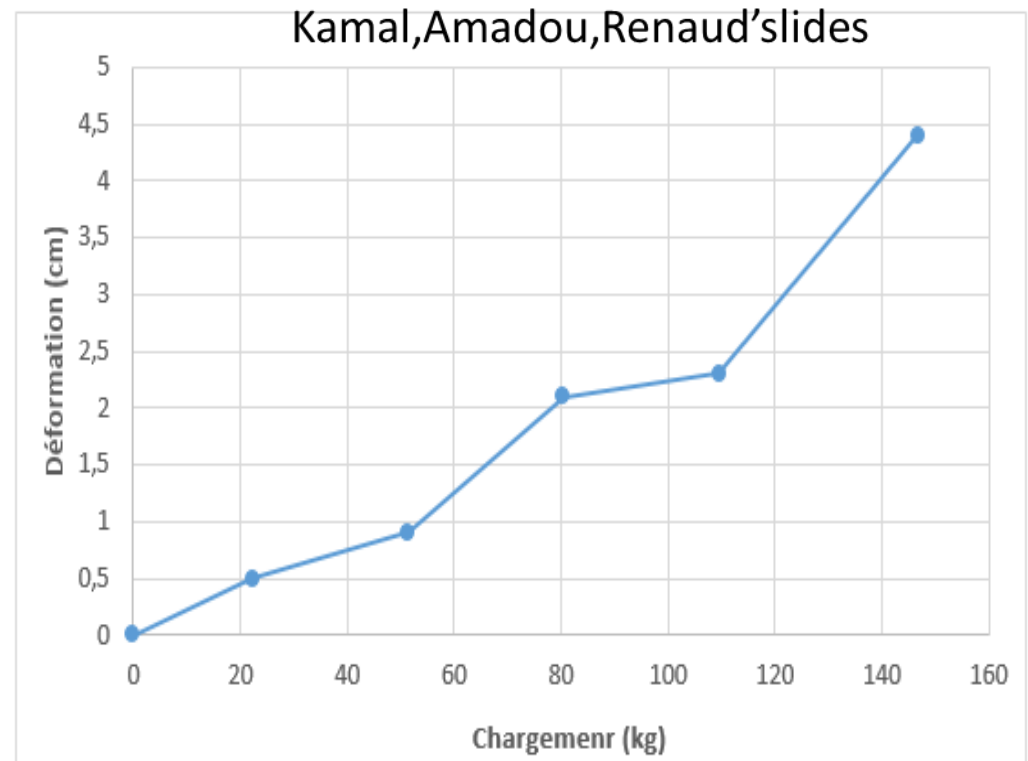
## Observation :

- Linear elastic behavior
- Rupture : 4 kN
- Displacement max : 130 mm

## Conclusion :

Good enough !

## Loss of equilibrium by Rotation



### Observation :

- Linear Elastic behavior
- Loss of equilibrium at 150 kg
- Displacement max = 4,5 cm

### Conclusion :

Good solution as the complete geometry will constrain the yurt and increase resistance.



Prefabricacion y verificacion

A Milano

Envio en Guinea Bissau

“la casa del pescadore”



# Project 2013

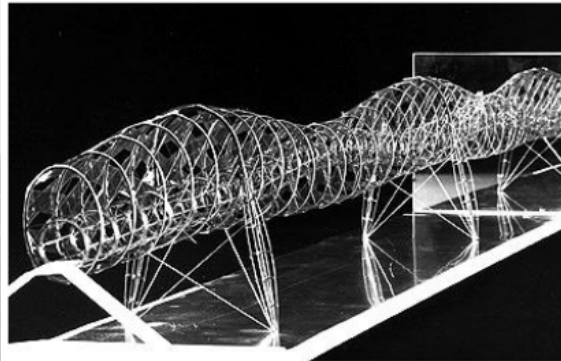
Mobile, retractable ski-yurt using tensegrity

Or

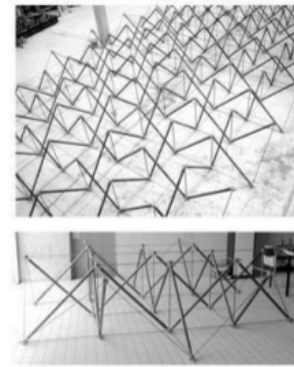
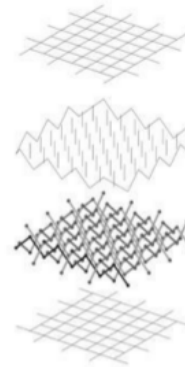
*When Engineers Students try to be Architects .....*



*Tour*



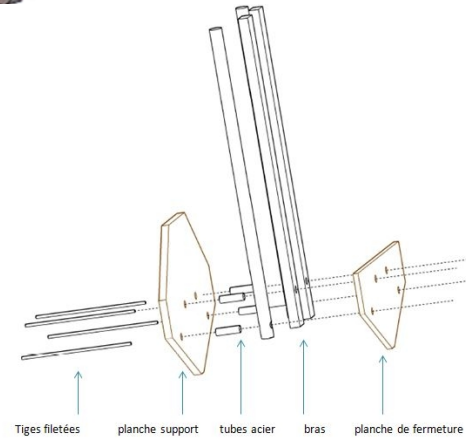
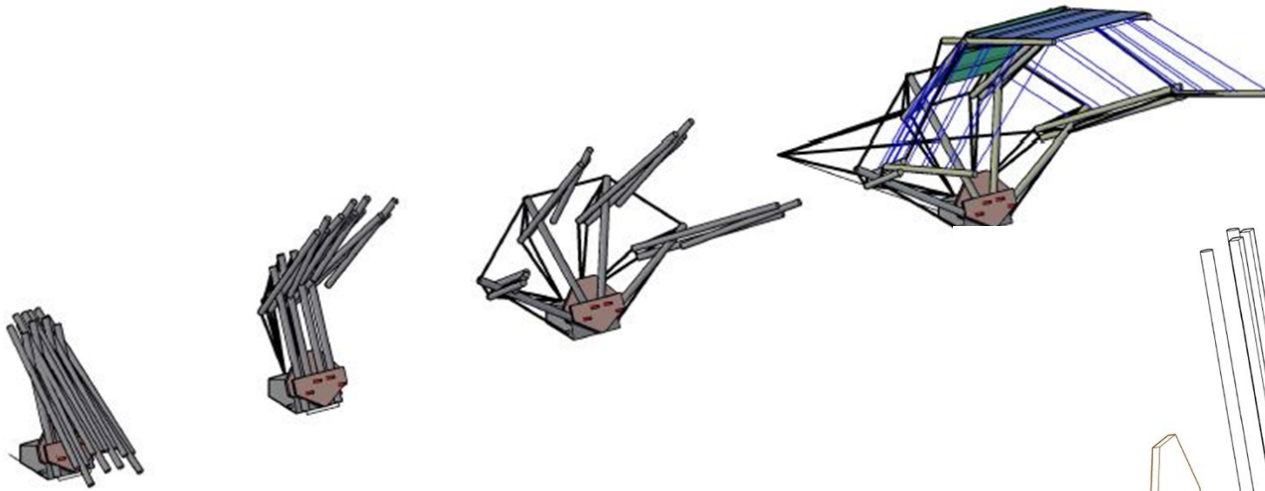
*Passerelle*



*Dalle*

**tensegrity**





100kg .....



# Conception Colaborativa y Planificación

Taller introductorio del curso “concepción colaborativa en diseños urbanismo” (30 h para los ingenieros, 25h los arquitectos)

=>Concepción de **garaje colectivo para bicicletas**

construido con residuos en un sitio elijado cada año,  
con grupos de un ingeniero por 3 arquitectos

Evaluación : una nota de grupo, órale, y escrita, mas un trabajo personal por los ingenieros.

Una visita de un galpón del municipio a donde se guarda varios elementos ;

**Mini-Taller introductorio de un día completo : Construir con pequeños elementos de madera**

=> imaginar un braguero de 5 metros , cargado con el grupo

Un conjunto de vigas y varios elementos chiquitos de madera (4 metros hasta 30 cm , cable, carril, tornillos, sierra de mano.







# Garaje para bicicletas realización con el curso “proyecto interdisciplinario”



PLAN 1/50 :

