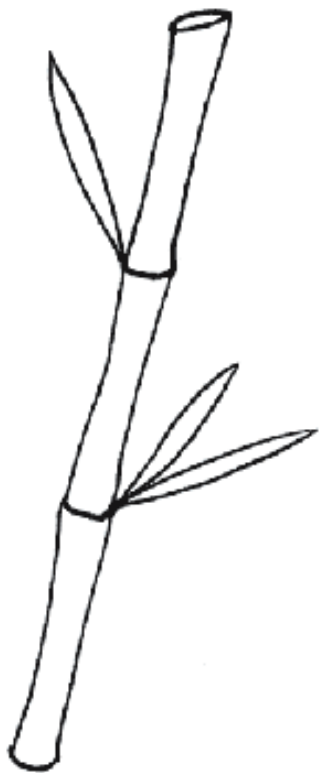




bambú

como material de construcción

Universidad de Chile – Facultad de Arquitectura y Urbanismo – Curso Diseño Constructivo en Madera
Prof. Luis Goldsack Jarpa – Ayud. Mauricio Loyola Vergara

bambú como material

Existen sobre 2500 especies

Es el vegetal de mayor crecimiento en el mundo: hasta 40 centímetros por día

Pueden sobrepasar los 30 metros

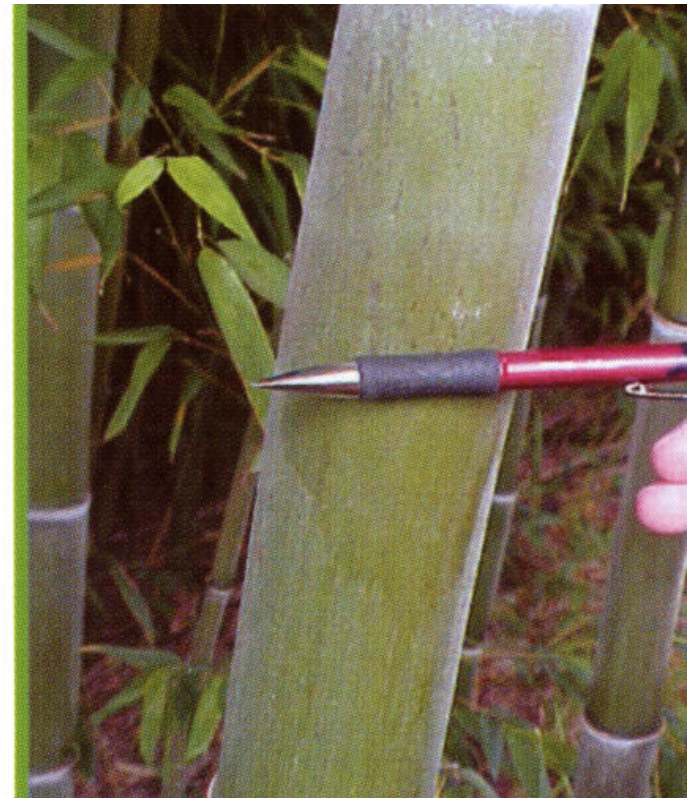
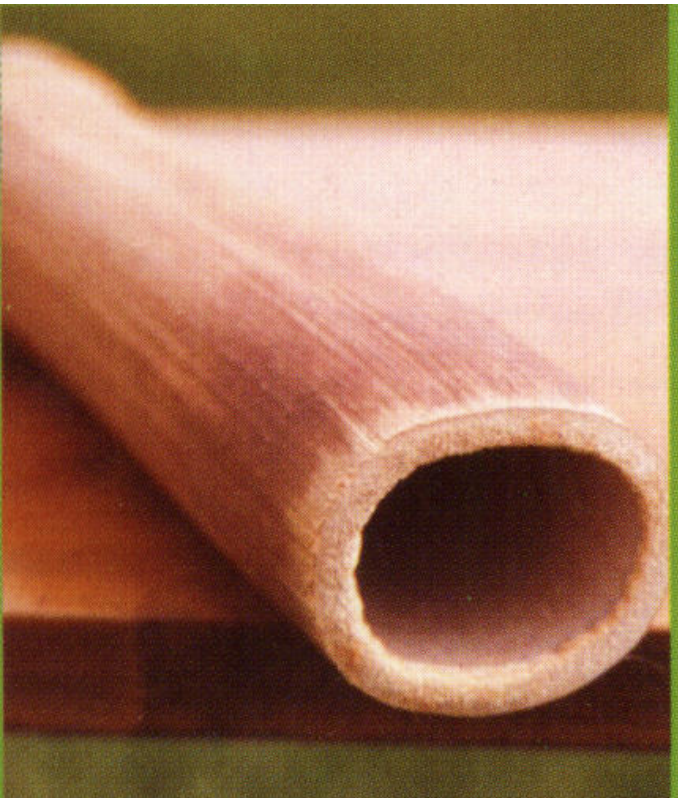


bambú como material

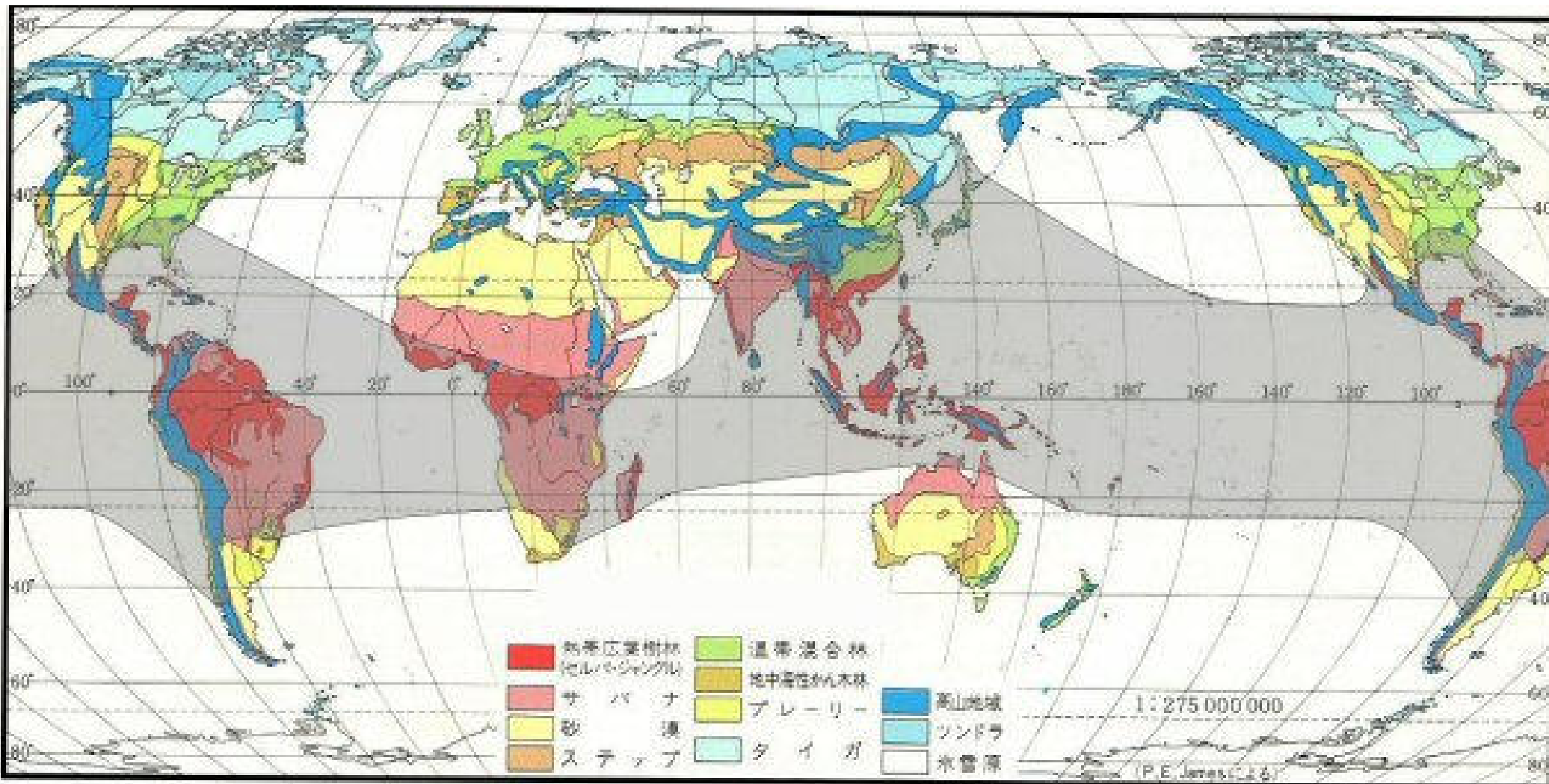
Son “usualmente” huecos

Pueden llegar a tener una pared de 2 cms y un diametro de 15 cms

Hay de varias propiedades mecánicas y físicas



distribución



bambú como material

Las especies mas importantes en el mundo son la **GUADUA ANGUSTIFOLIA** (Colombia) y el **PHILLOSTACHYS** (China y Asia en general)



bambú chileno

Chusquea culeou, o simplemente “colihue” o “koligüe”

Es sólido!!!!

Tiene hasta 3 cm de diámetro y 5 m de alto

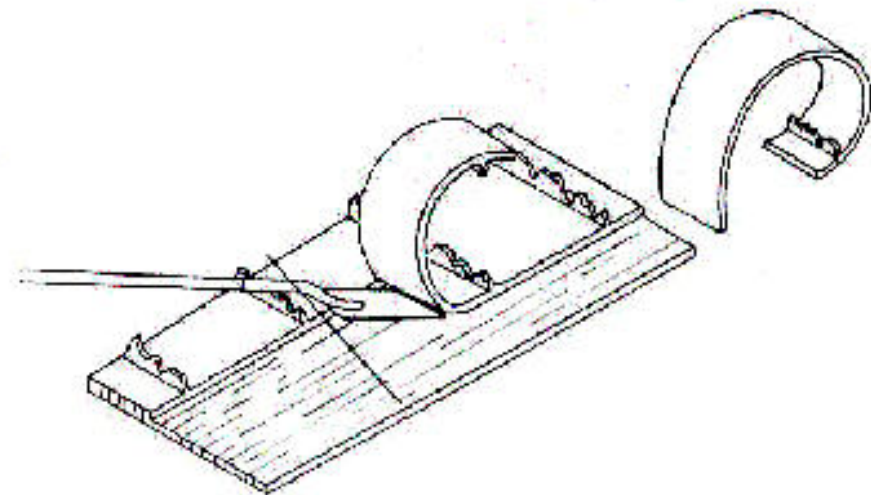
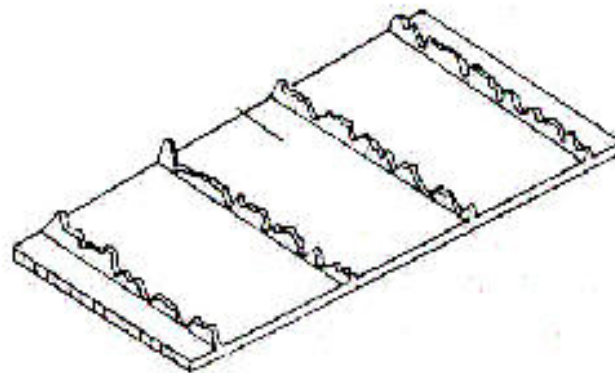
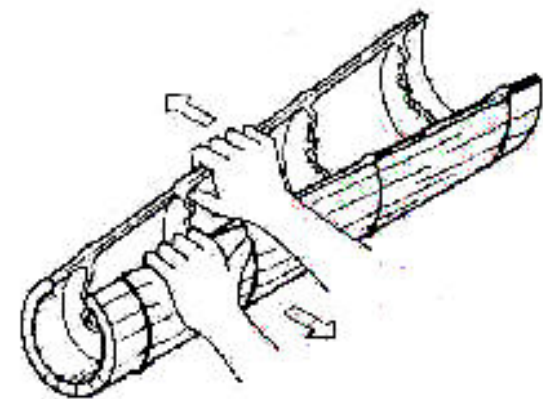
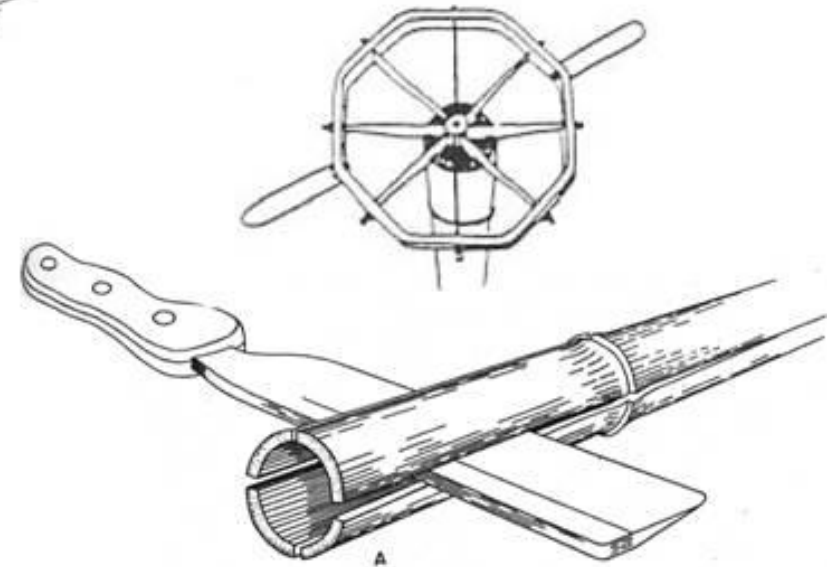
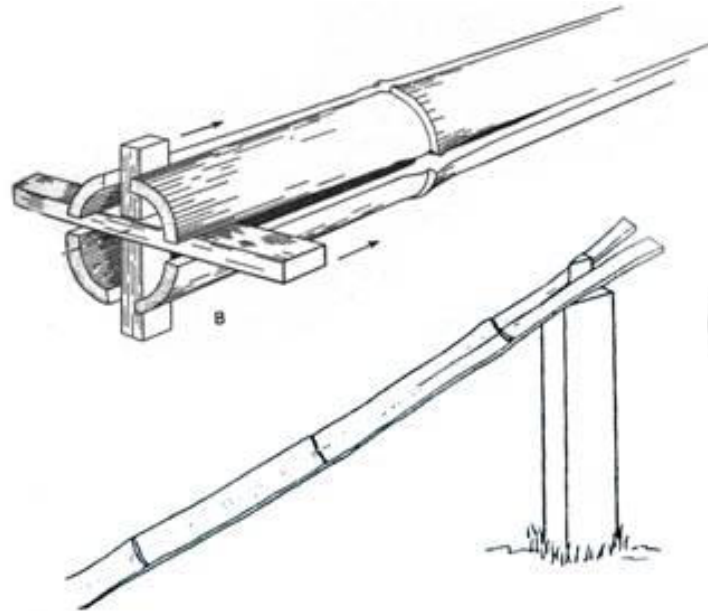
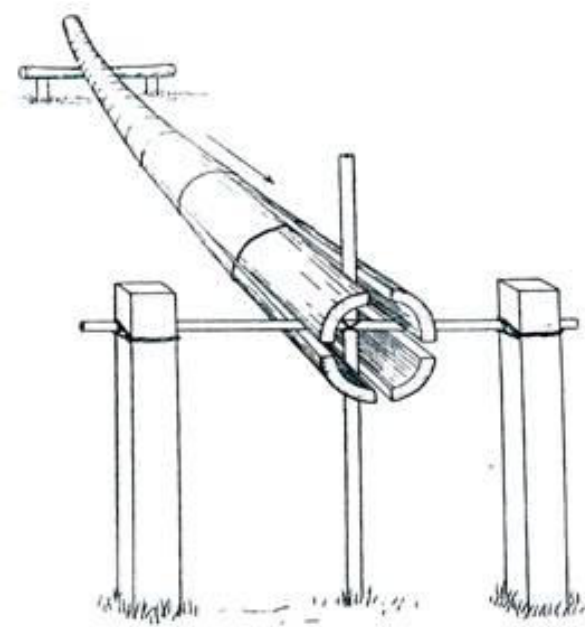


trabajabilidad

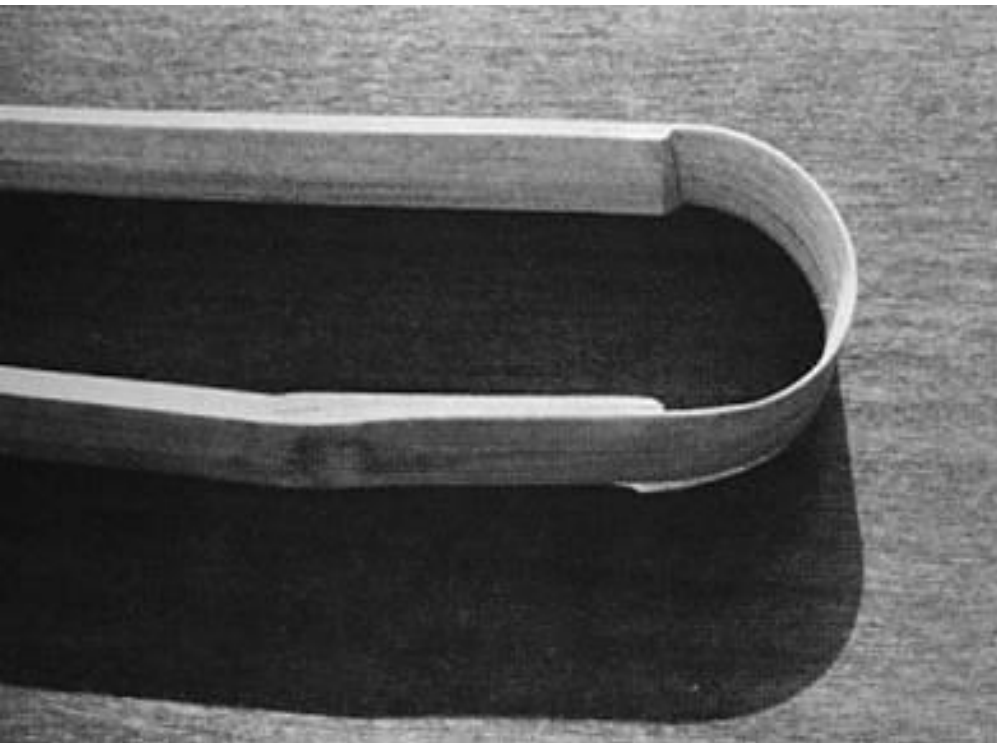
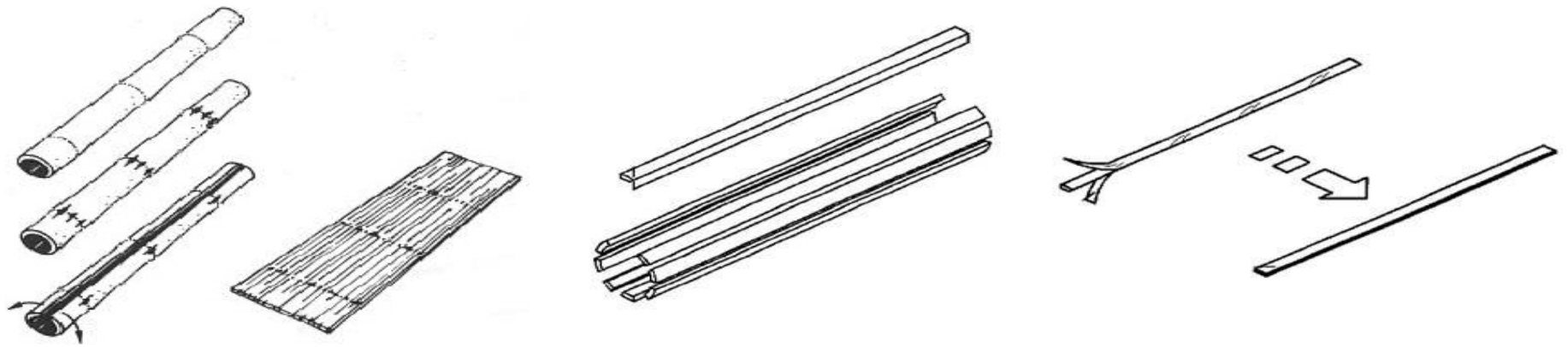
Se puede partir, cortar, curvar, torneear, lijar, clavar, encolar, impregnar, tinturar, barnizar
Solo tiene fibras longitudinales, cortes transversales manuales no son faciles o limpios



partido, cortado, lijado



partido, cortado, lijado



partido, cortado, lijado

El bambú chileno se puede fresar y laminar



curvado

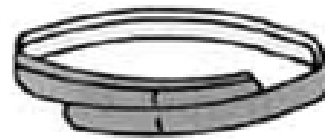
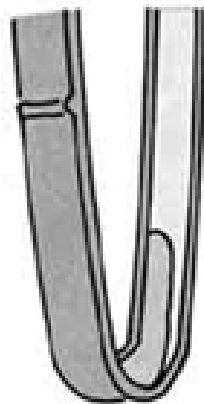
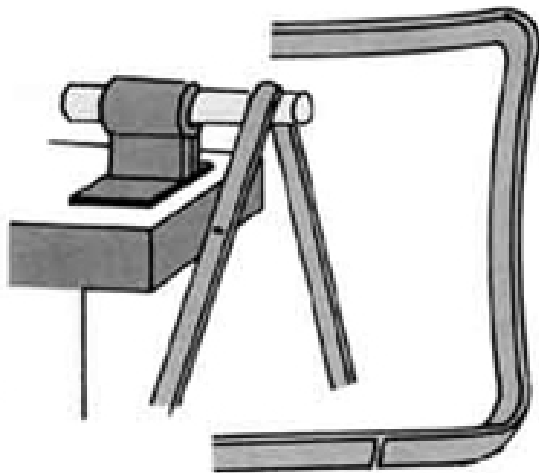
Por preformado inmediatamente despues de la cosecha (mecánico, con pesos)

En frío, por humectación

En caliente, con fuego directo o indirecto



curvado



curvado

Colihue: Por laminación





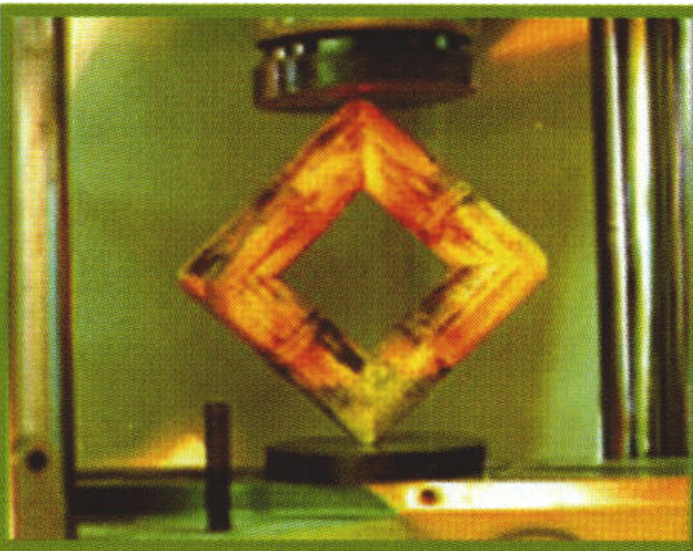
torneado

Solo bambú chileno



clavado y encolado

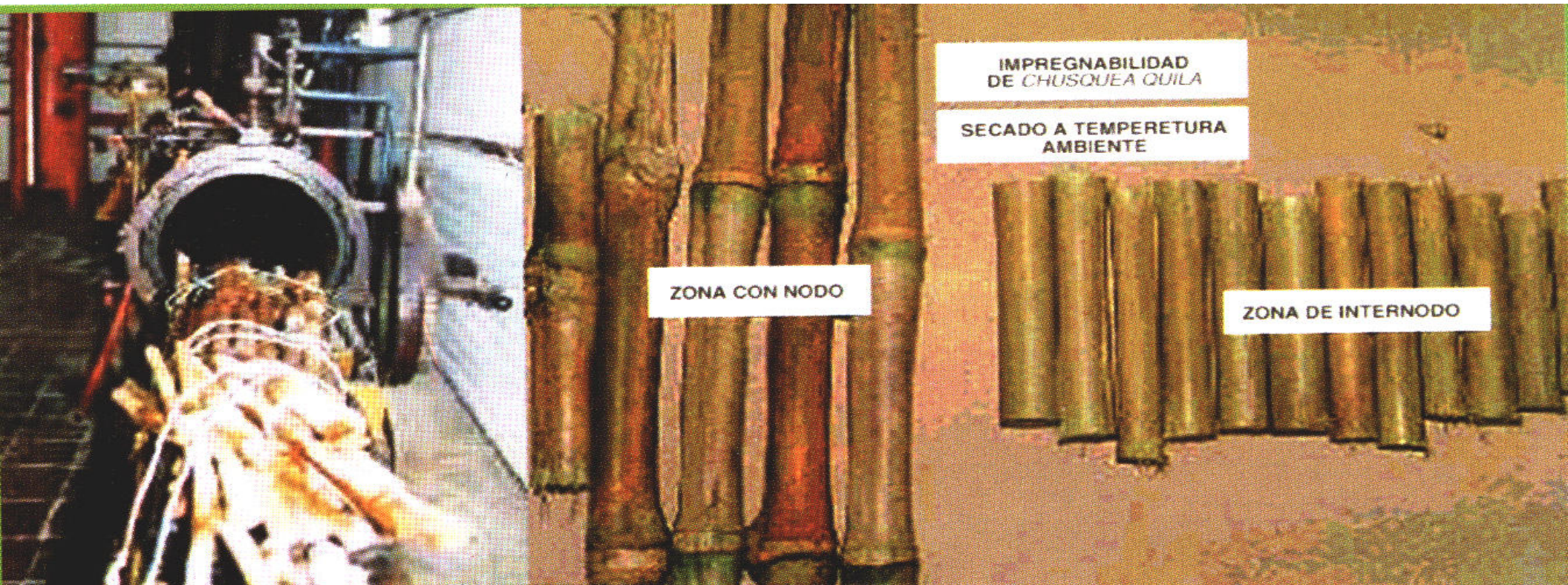
Lo más resistente es el encolado en caliente



Cargas de rotura de uniones en ángulo				
Variable	Elemento de unión			
	Clavo 4x8	Perno Parafuso		Lengüeta
	(Kg)	(Kg)	(Kg)	
PROMEDIO	285	318	369	
Desv. Estandar	39.51	7.58	85.91	
Coef. Variación	13.84	2.38	23.28	
Valor Mínimo	220	310	270	
Valor Máximo	320	325	500	

impregnación

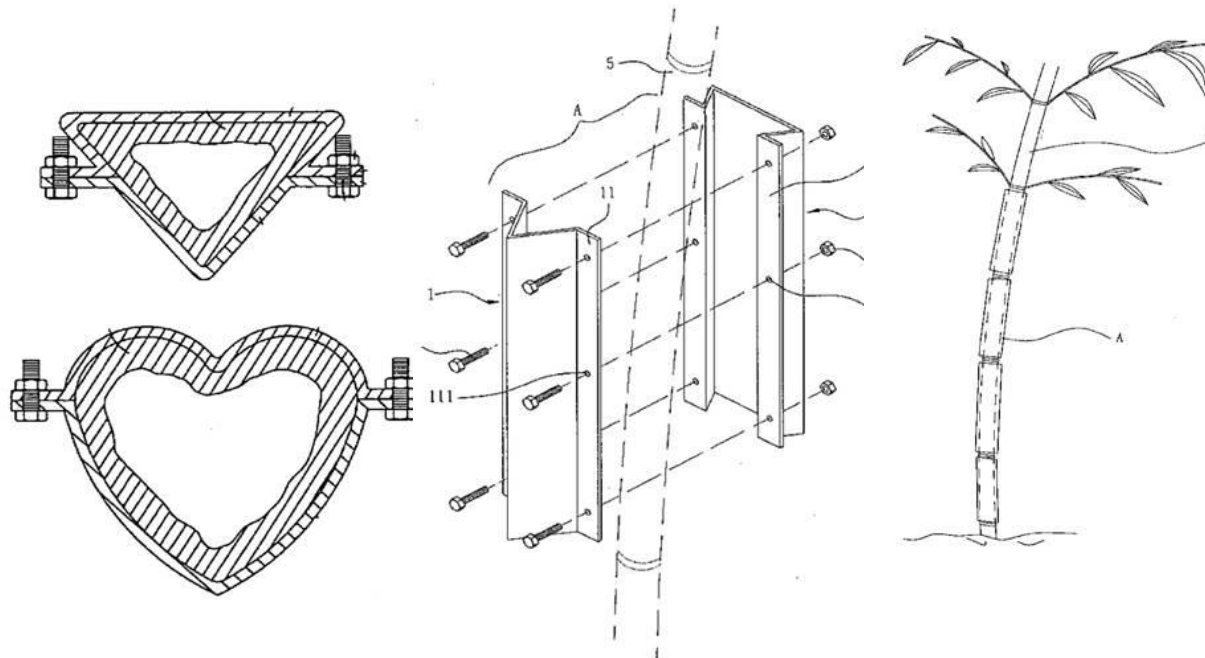
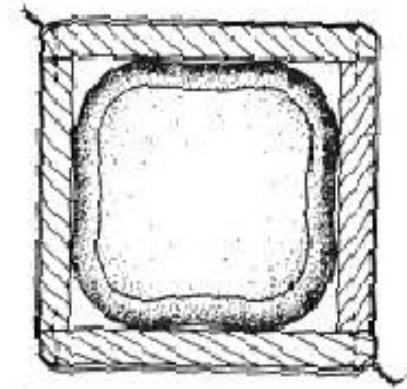
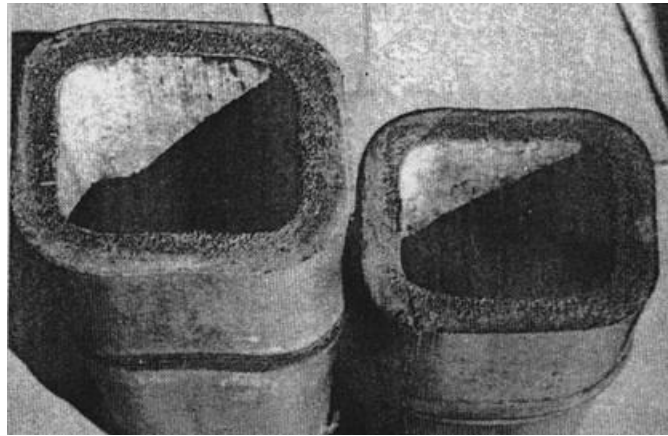
La tasa de retención es homogénea y ligeramente inferior al P. Insigne



Tinturación, barnizado



Deformación de la caña



Diseño de uniones

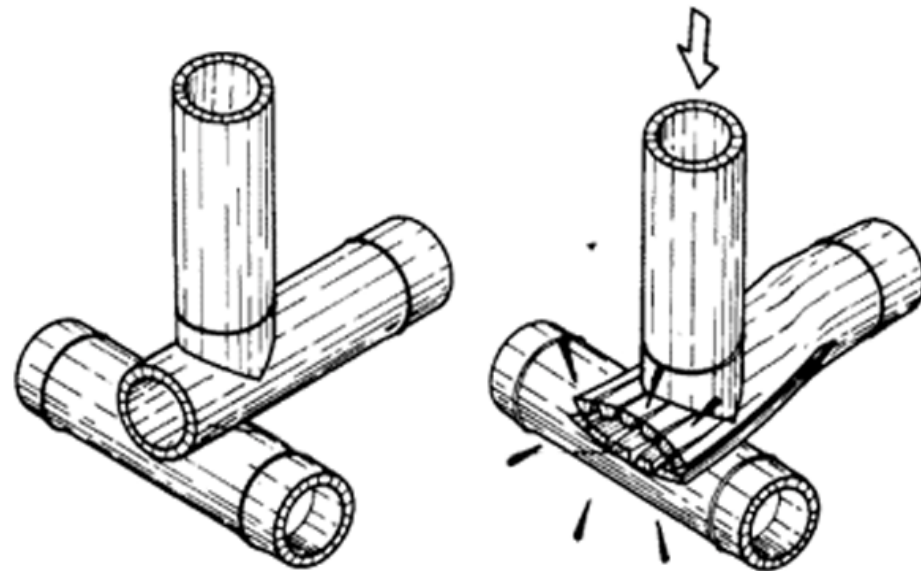
Seccion circular, complicación geométrica

Hueco, no se puede comprimir

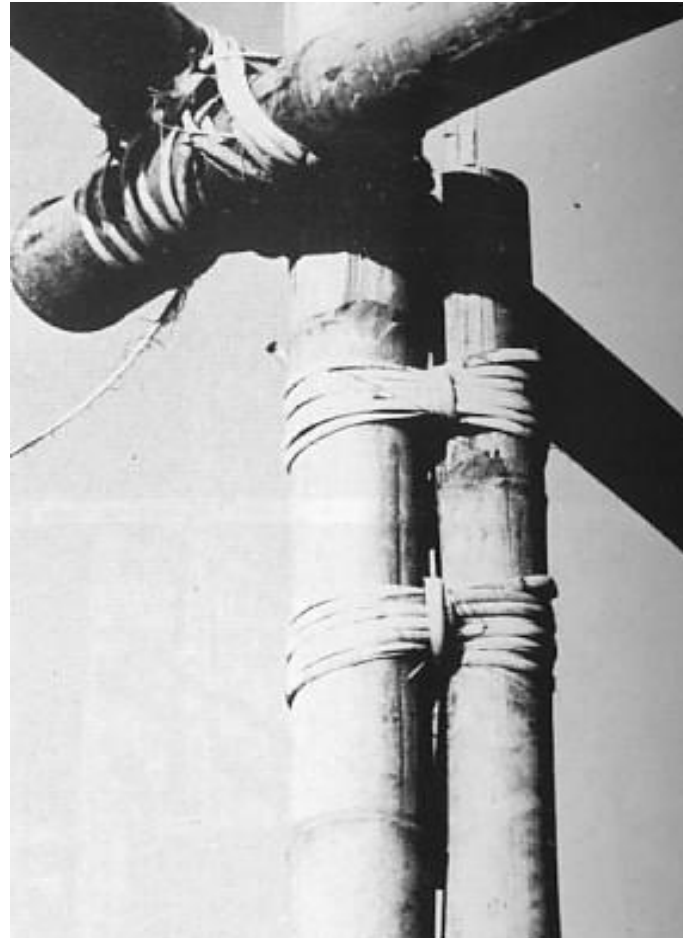
La pared tiene sílice, resbalosa y dura

Es una caña vegetal, tiene diámetro irregular

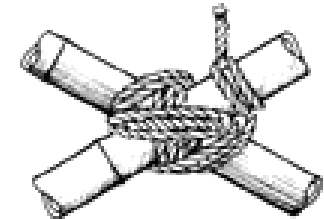
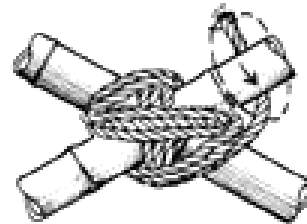
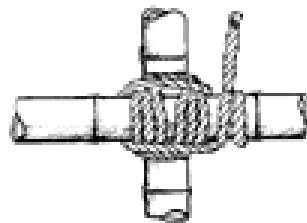
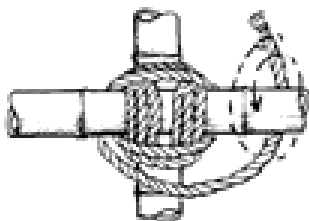
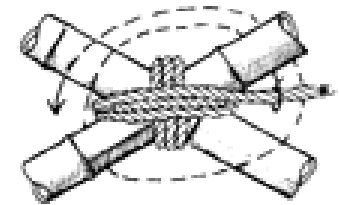
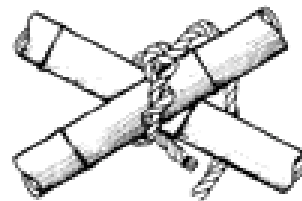
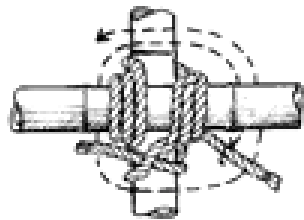
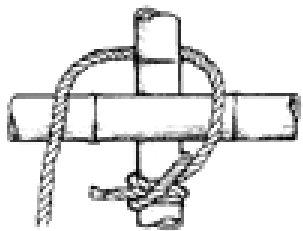
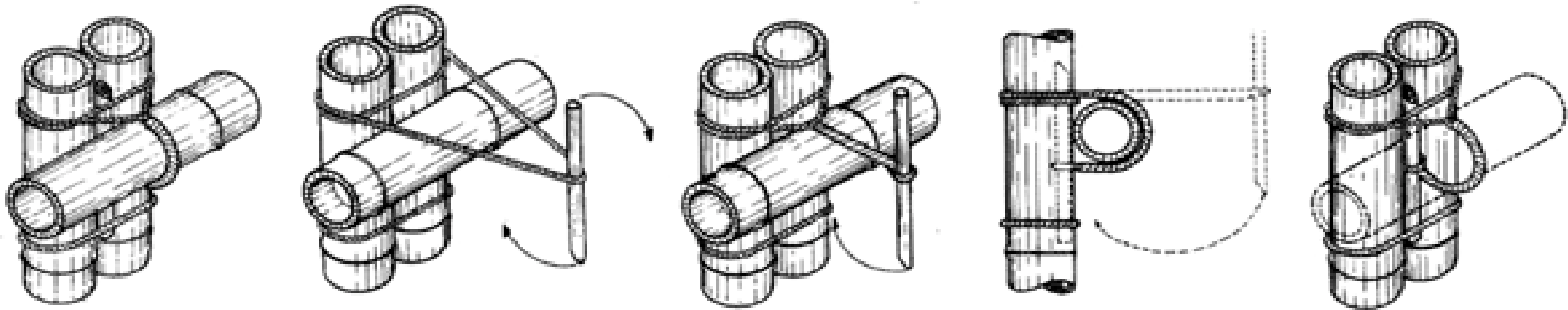
No se puede clavar sin que se raje



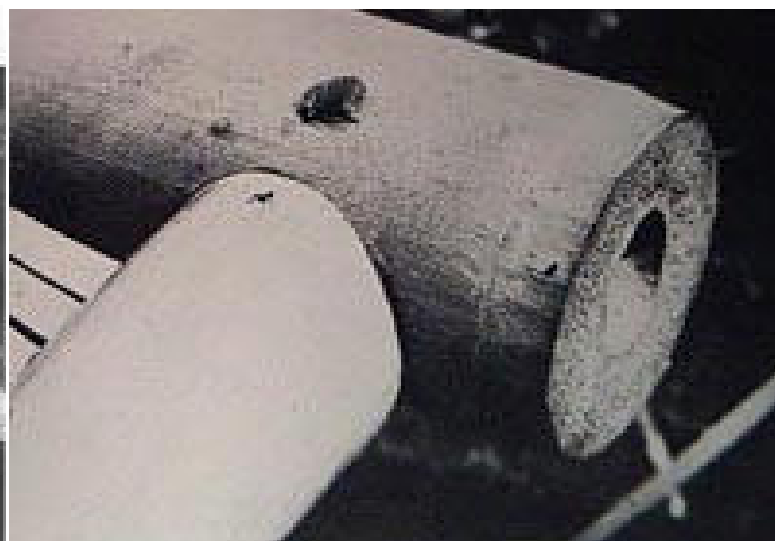
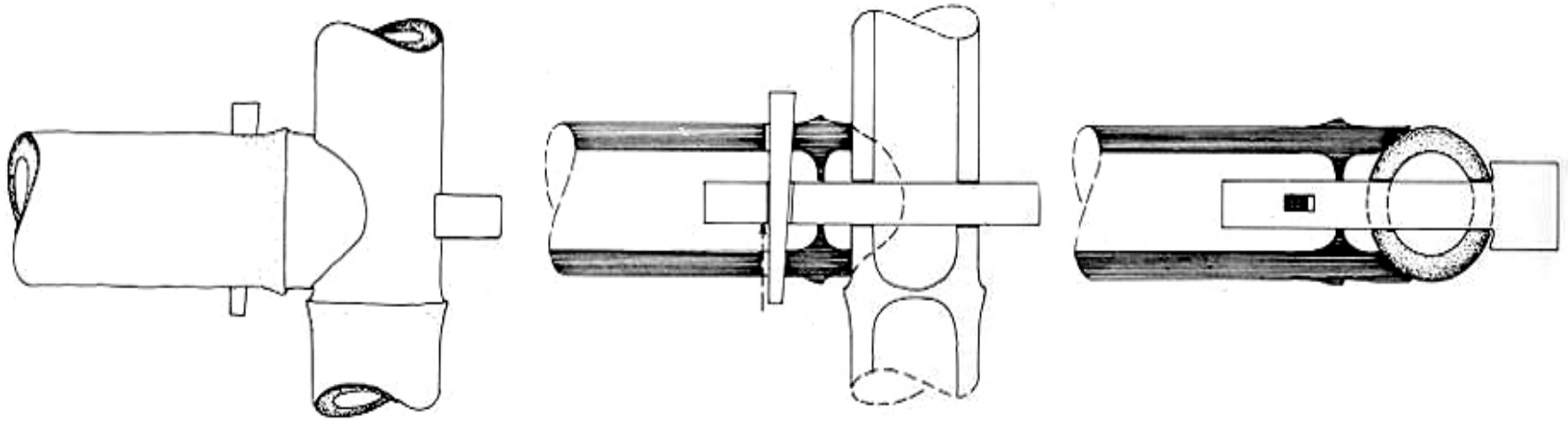
Uniones amarradas



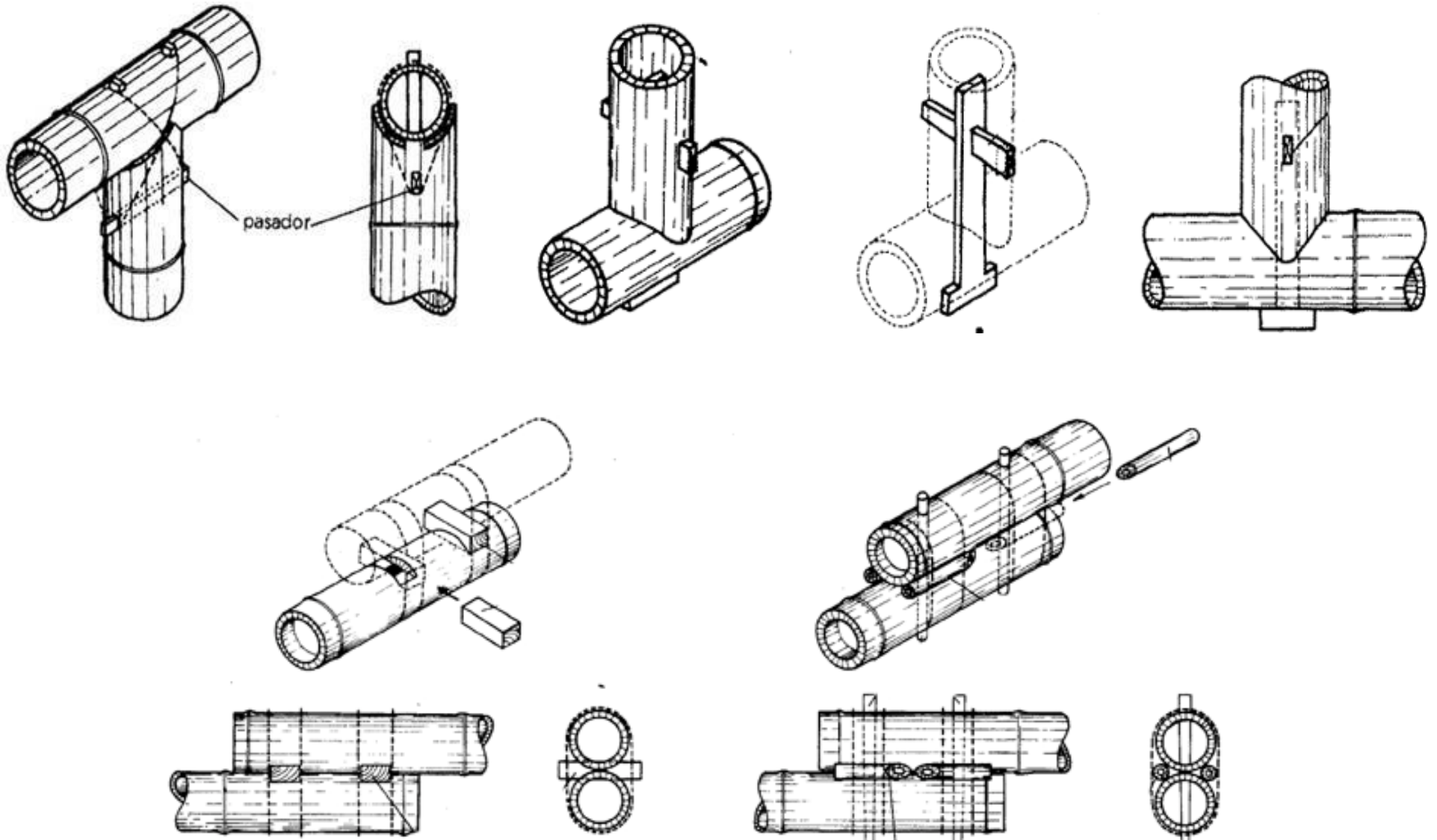
Uniones amarradas



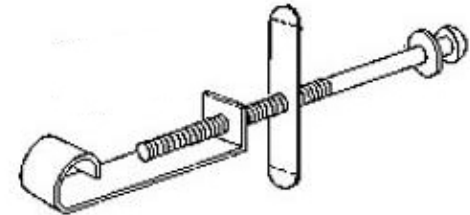
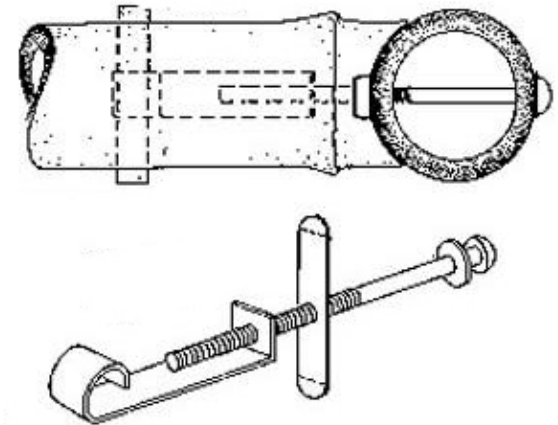
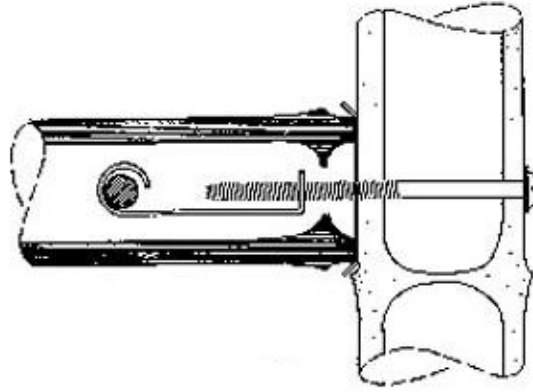
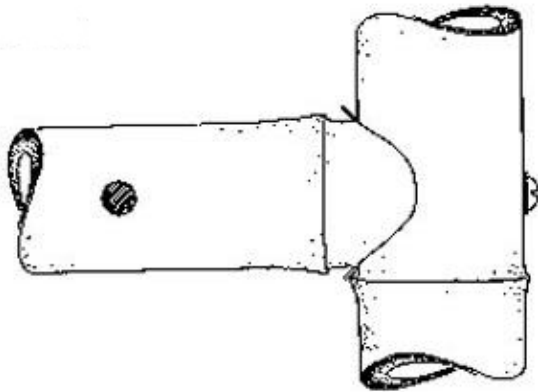
Uniones con pasantes



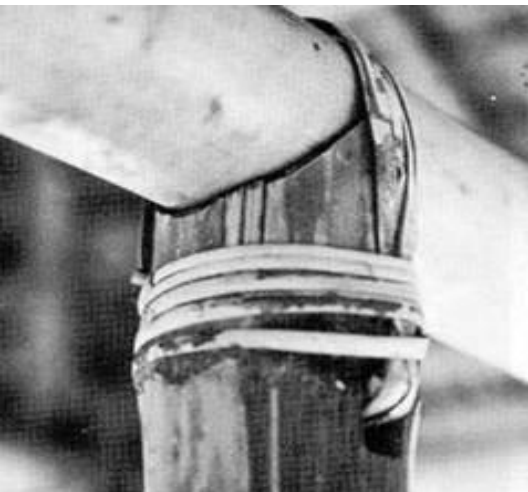
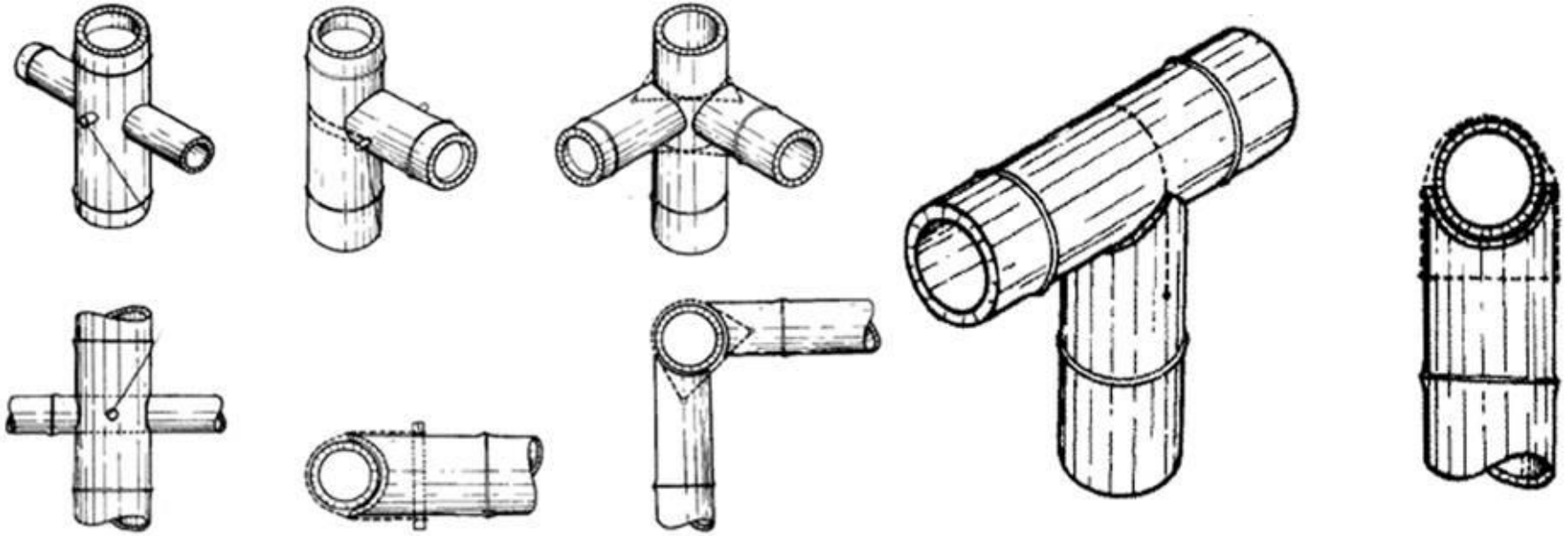
Uniones con pasantes



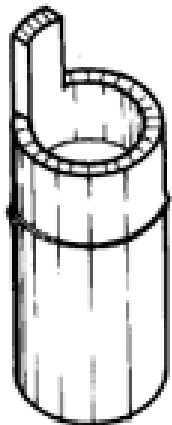
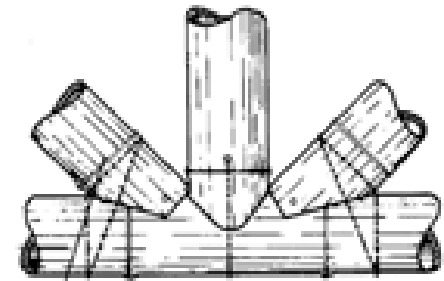
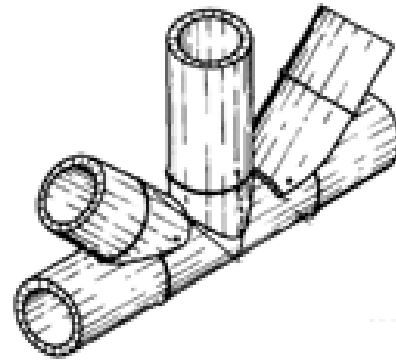
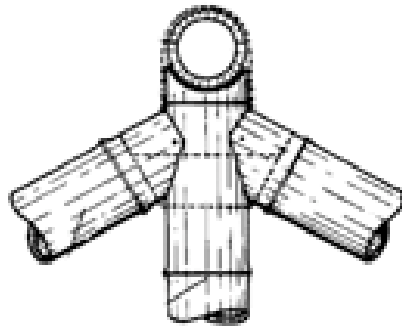
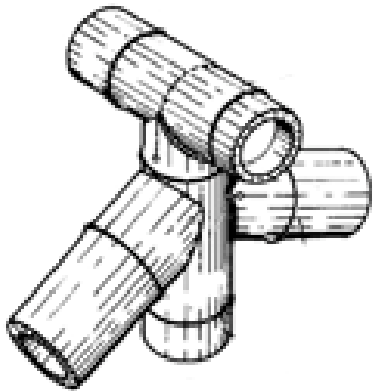
Uniones con pasantes



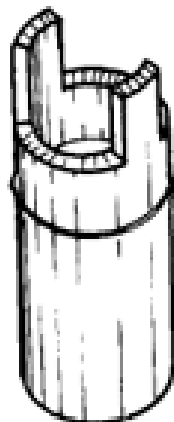
Uniones de encaje



Uniones de encaje



1



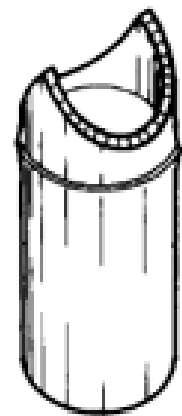
2



3

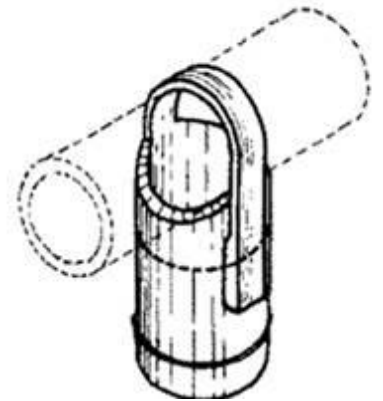
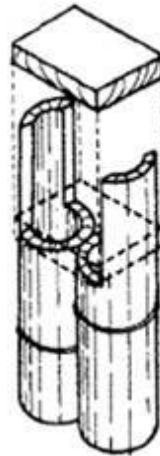
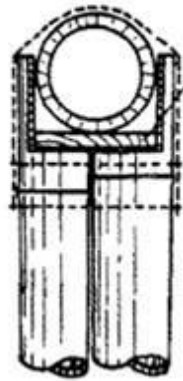
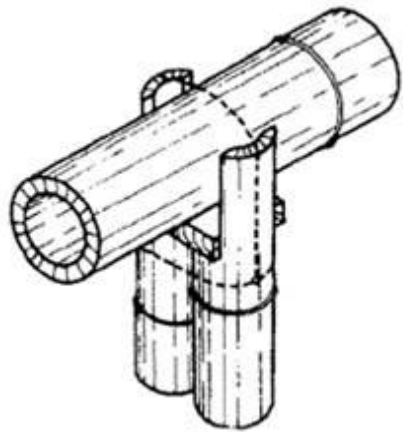


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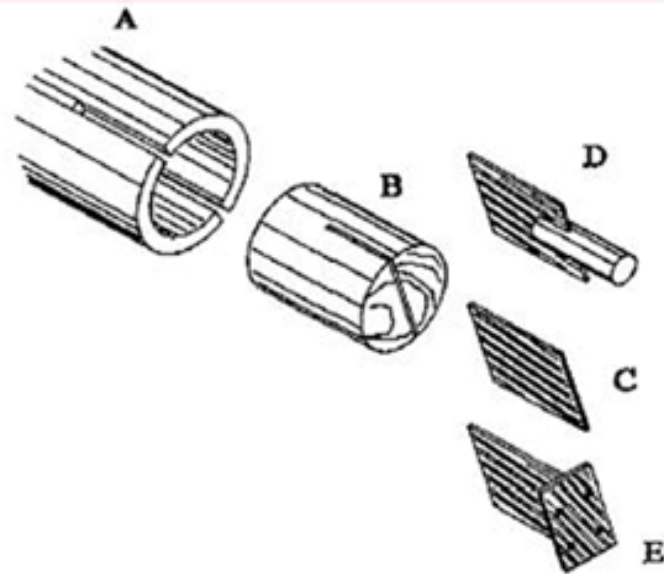
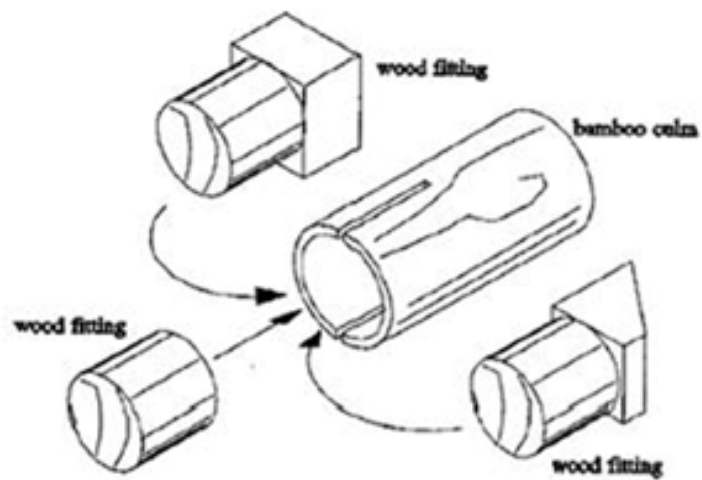
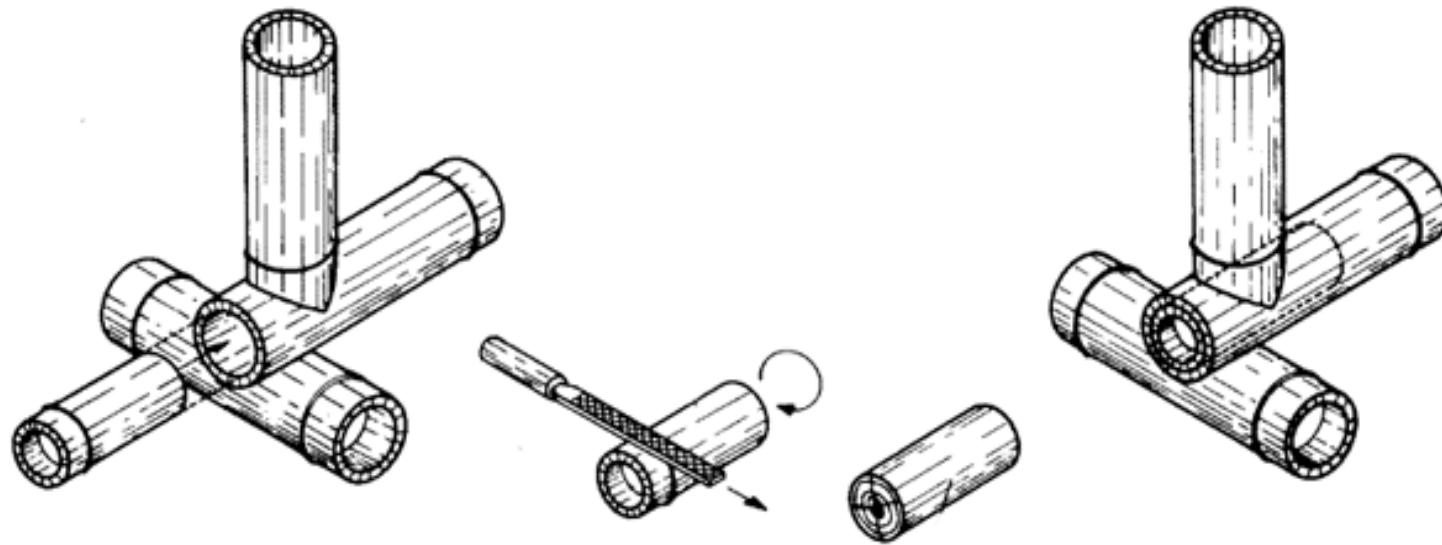


5

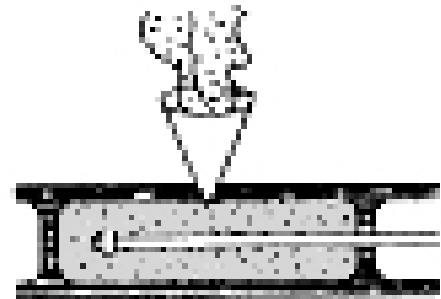
Uniones de encaje



Uniones de culmo sólido



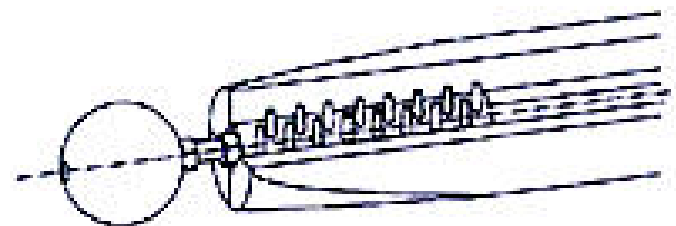
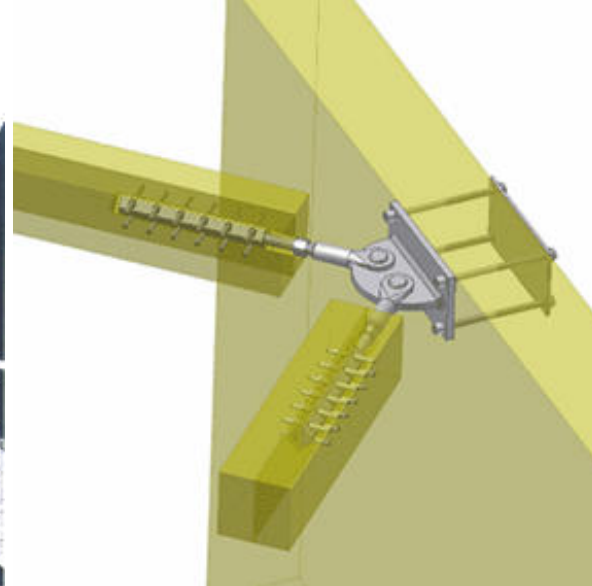
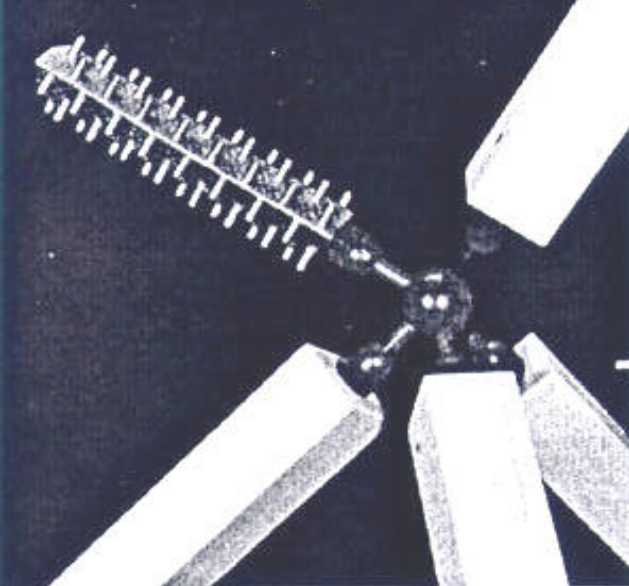
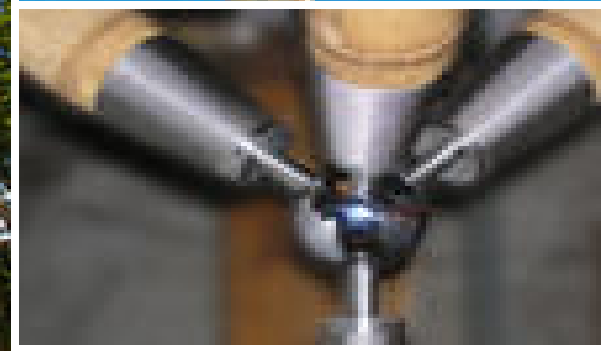
Uniones de culmo sólido



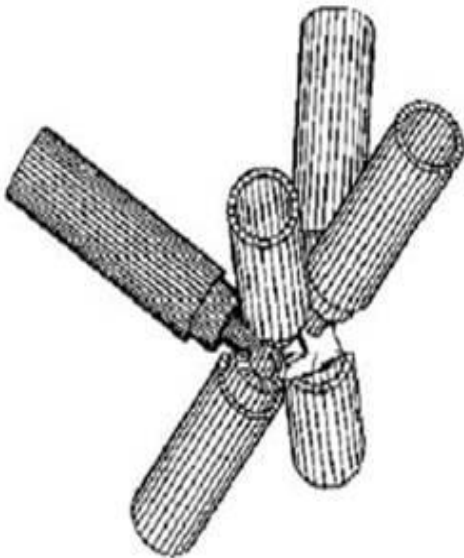
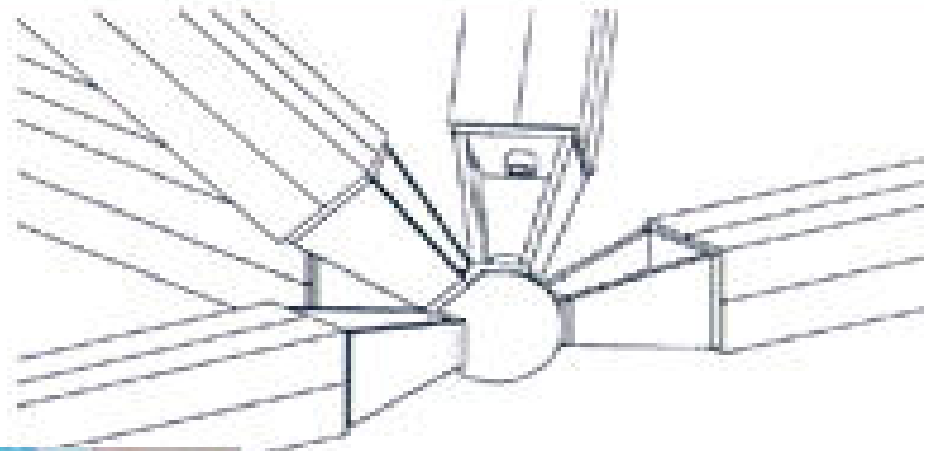
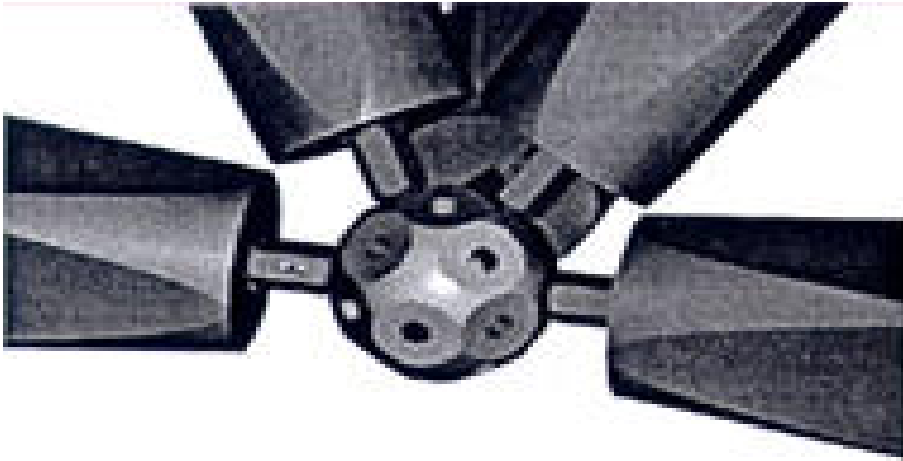
Uniones con conectores



Uniones con conectores



Uniones con conectores



Preservación de la caña

Ahumado, se alteran las propiedades organolépticas

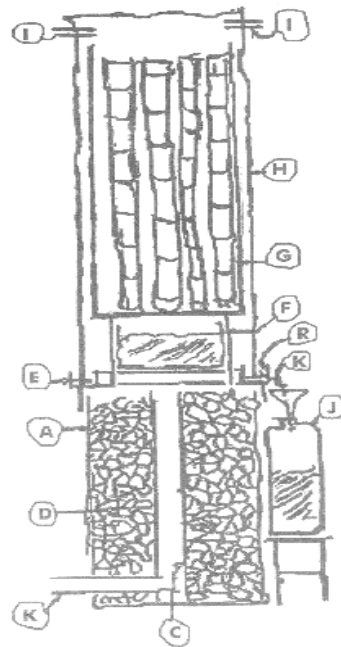
Calentamiento, sobre 150°, se alteran propiedades físicas y químicas

Inmersión en agua, entre 4 y 12 semanas, disuelve el almidón

Impregnación, CCA

Bañado, CCA

Pinturas y pátinas, CaO (cal viva)



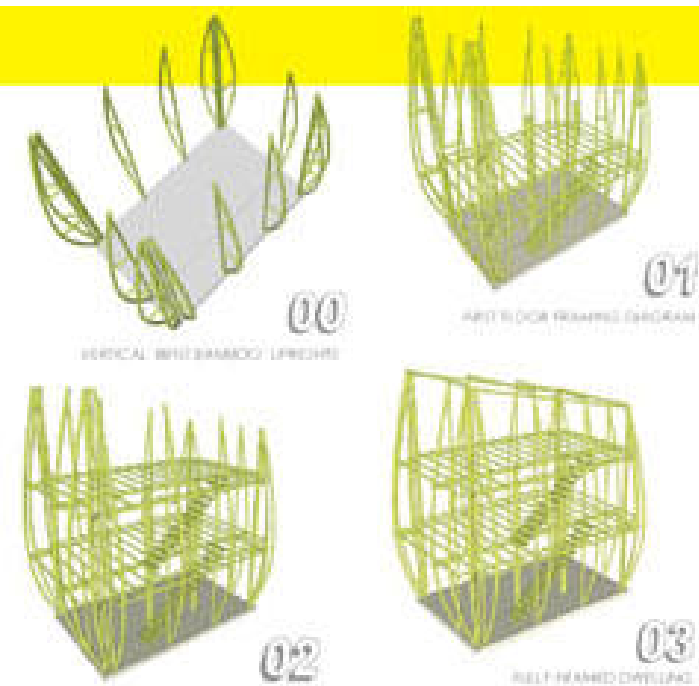
Sistemas constructivos

Entramados menores

Láminas, cáscaras y entramados espaciales

En combinación con tierra cruda: quinchá y baraheque

En combiación con mezclas cementicias: bambú-cemento y bambucreto



Entramados menores

Tabiquerías arriostradas con diagonales de bambú y con diafragma flexible

Panelería autoportante con caña entrelazada

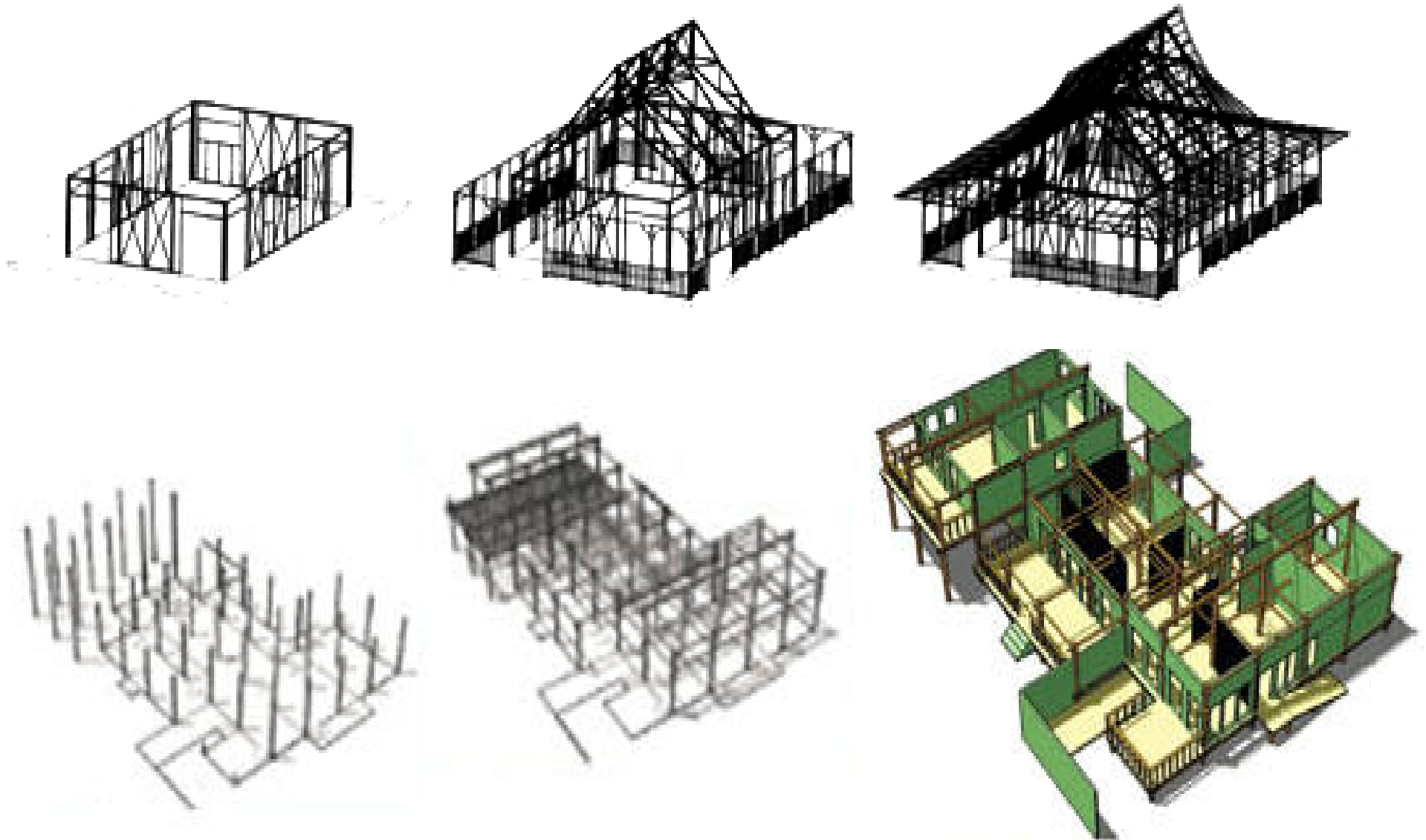
Usados en sistemas comerciales



Entramados menores



Entramados menores



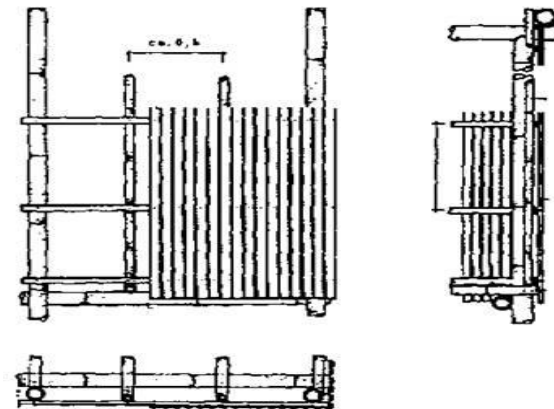
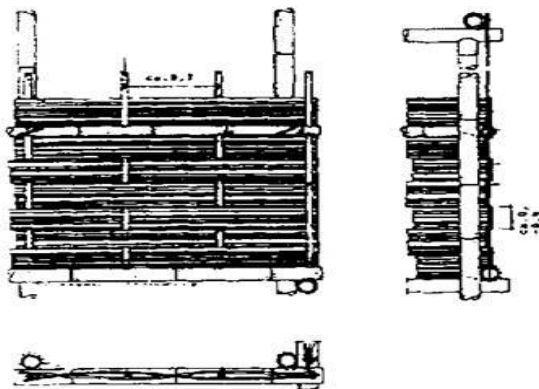
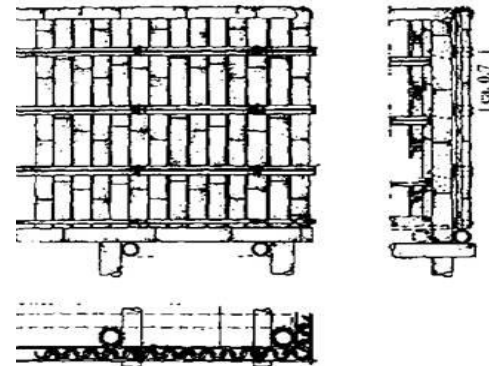
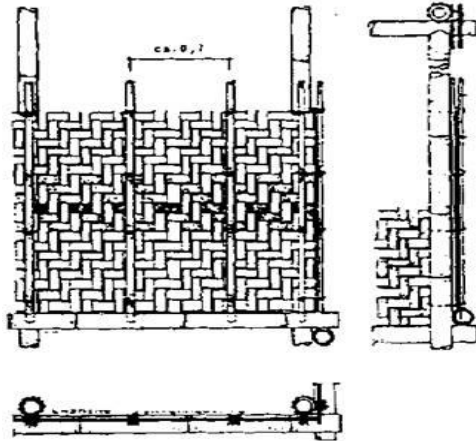
Entramados menores



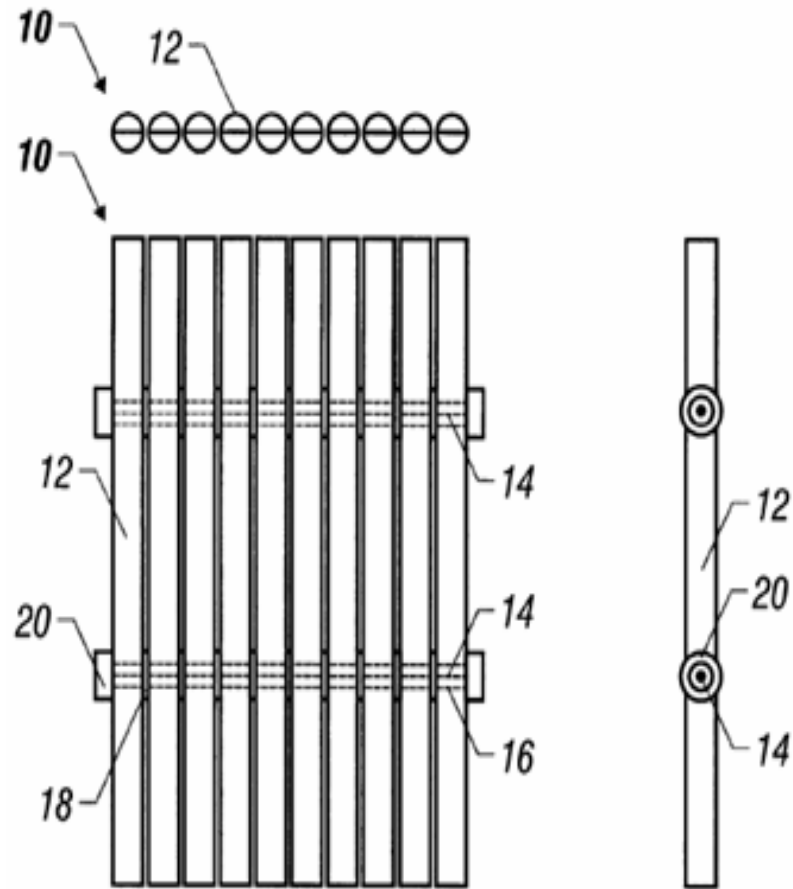
Entramados menores



Entramados menores (paneles)



Entramados menores (paneles)



Láminas, cáscaras y entramados espaciales

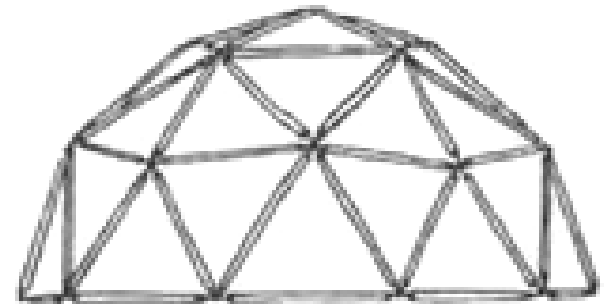
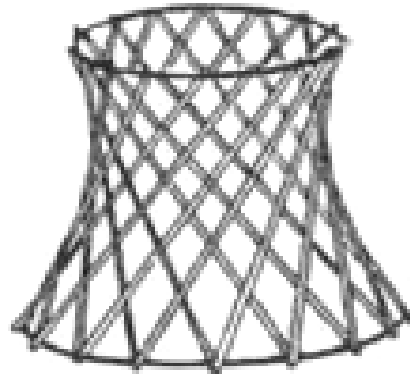
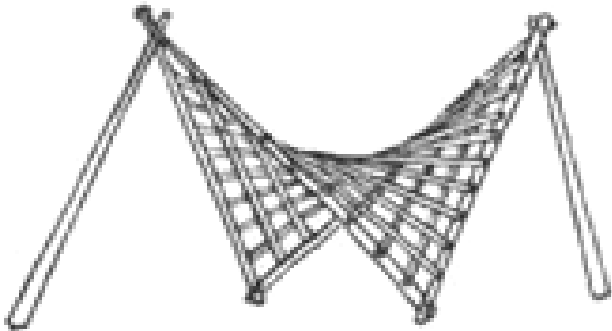
Por barras rectas:

Mallas (mesh)

Laminares curvos en traslación o rotación (bóvedas y cúpulas)

Cáscaras (shells)

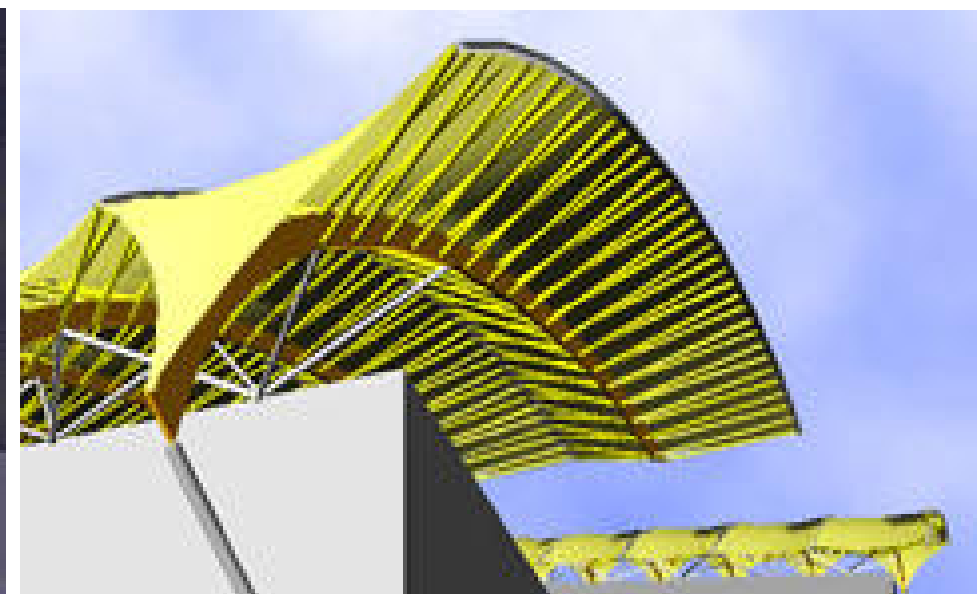
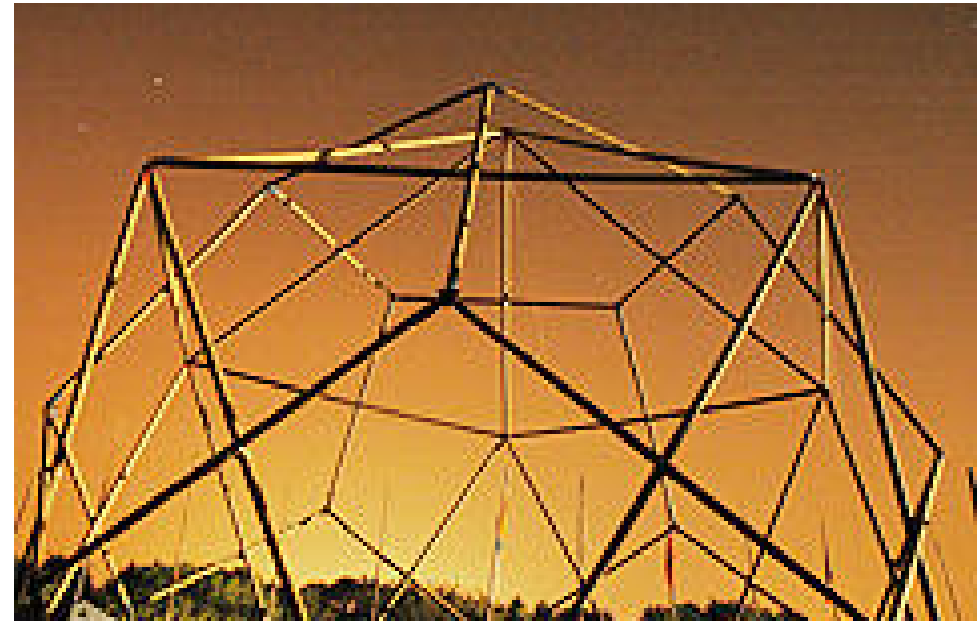
Geodésicas (domos)



Láminas, cáscaras y entramados espaciales



Láminas, cáscaras y entramados espaciales



Láminas, cáscaras y entramados espaciales

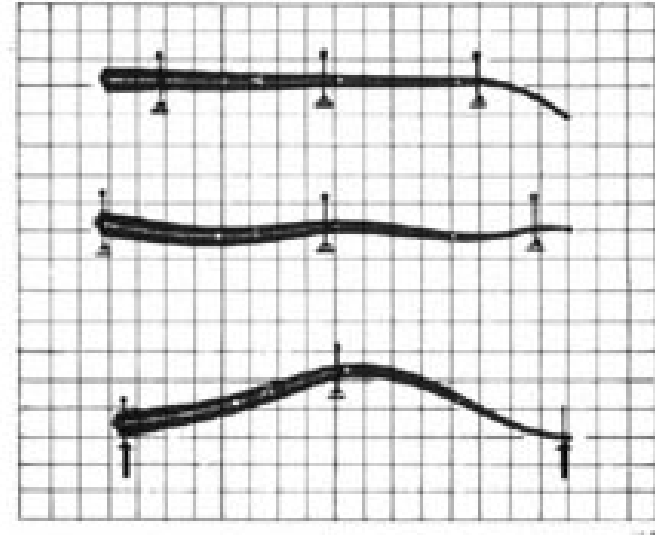
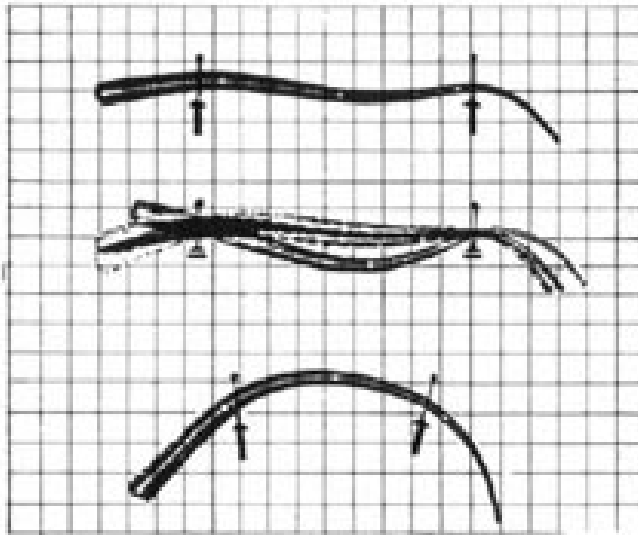
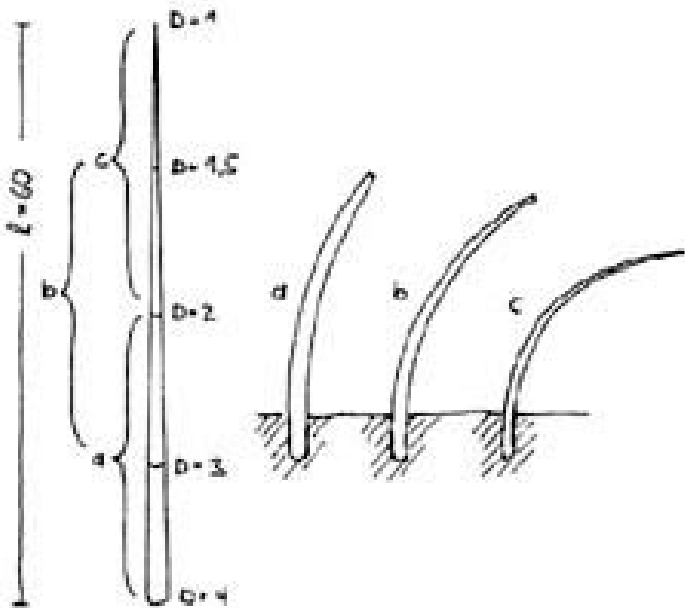


Láminas, cáscaras y entramados espaciales

Por deformación:

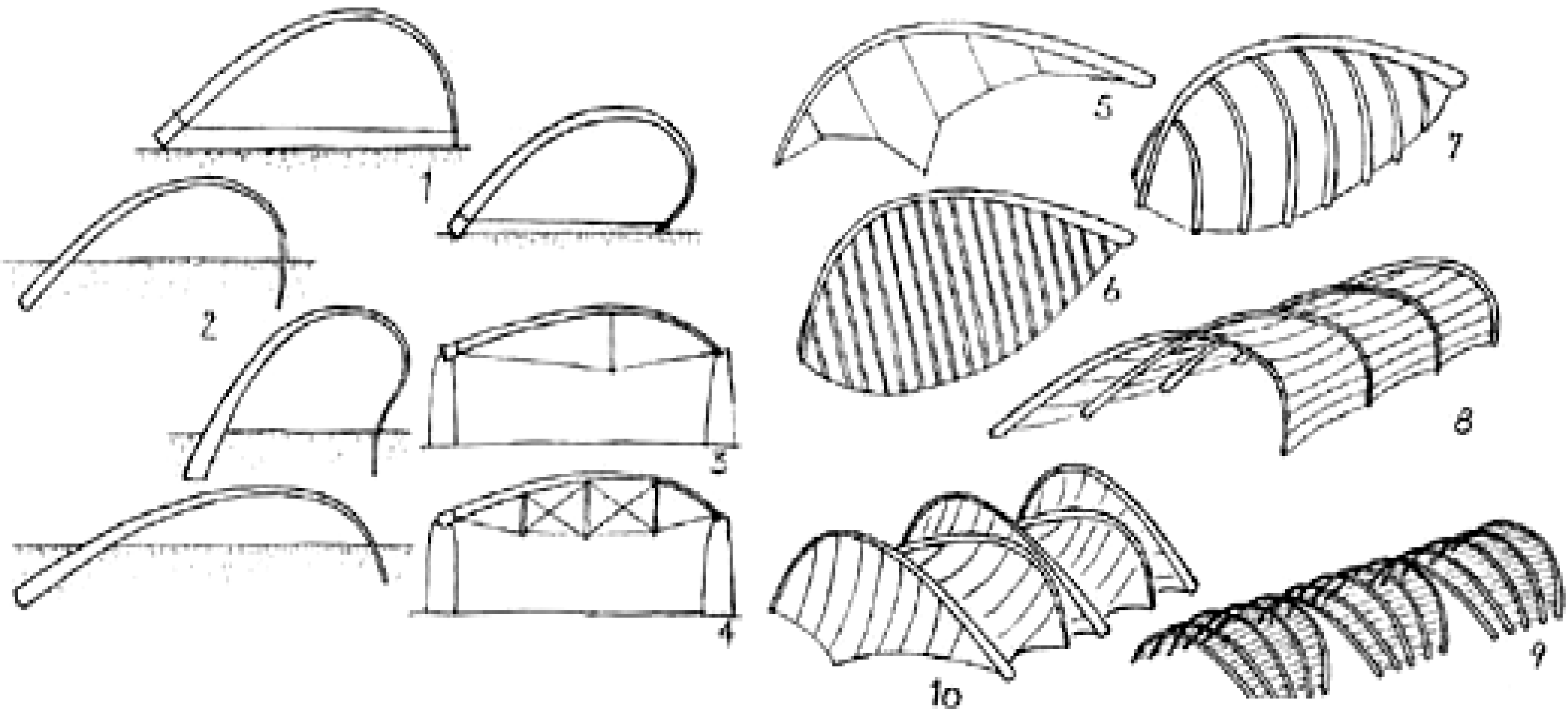
No es homogénea ni simétrica

Sigue la curva típica de la “caña de pescar” (fishing rod curve)

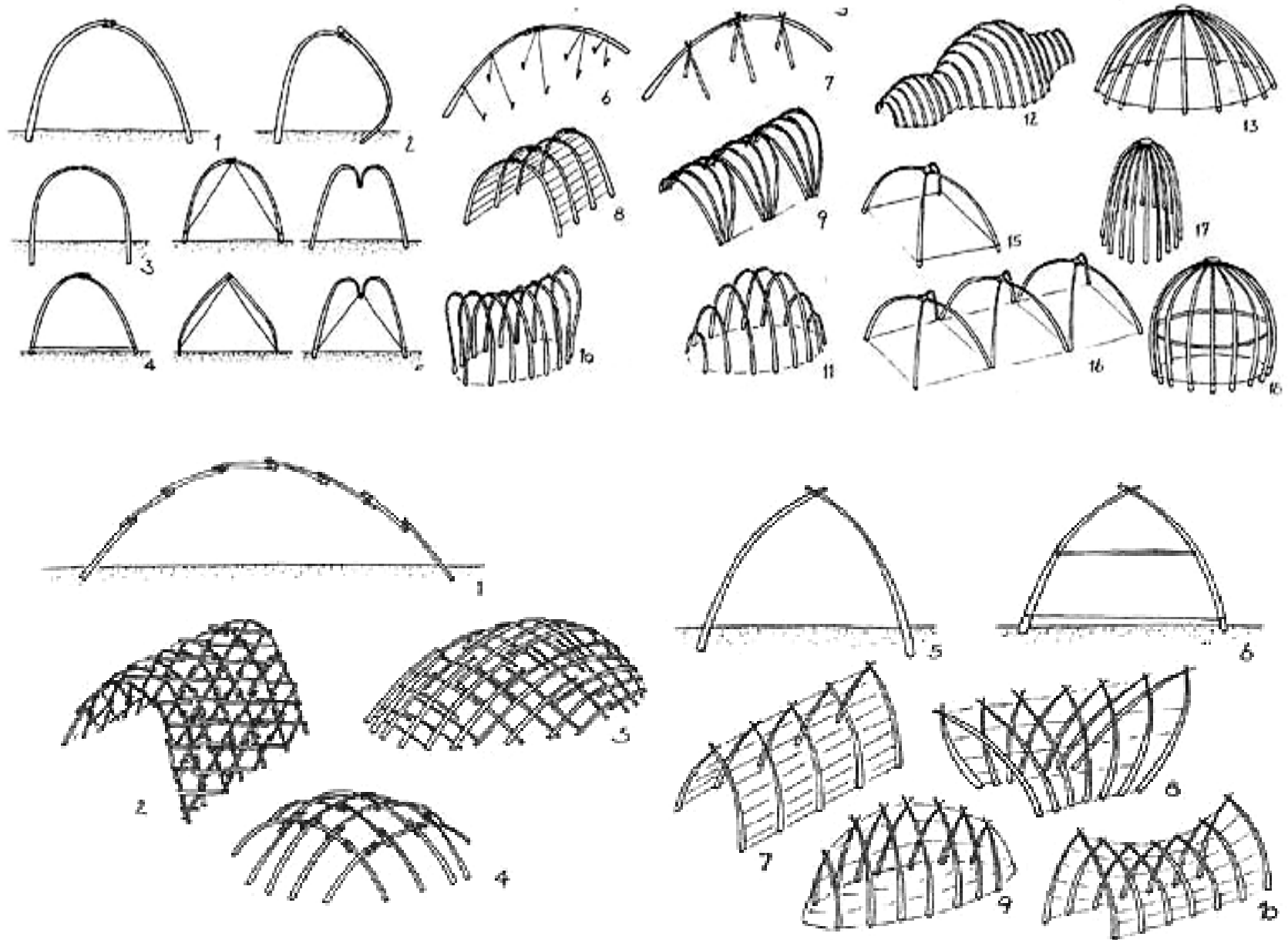


Láminas, cáscaras y entramados espaciales

Asimétricos y ojivales

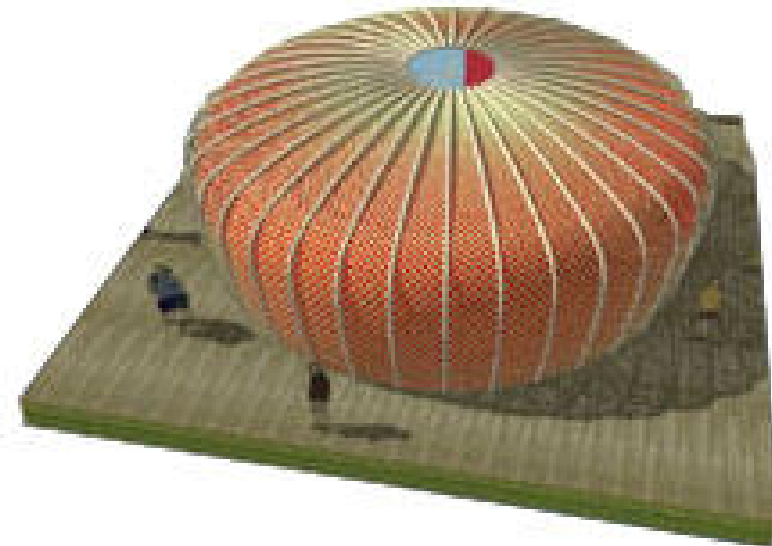
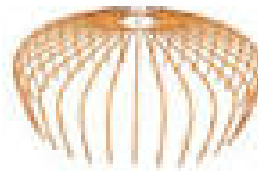
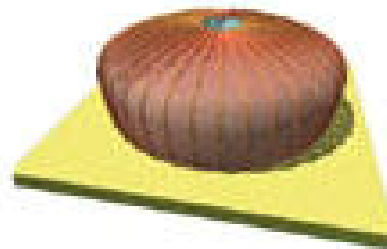
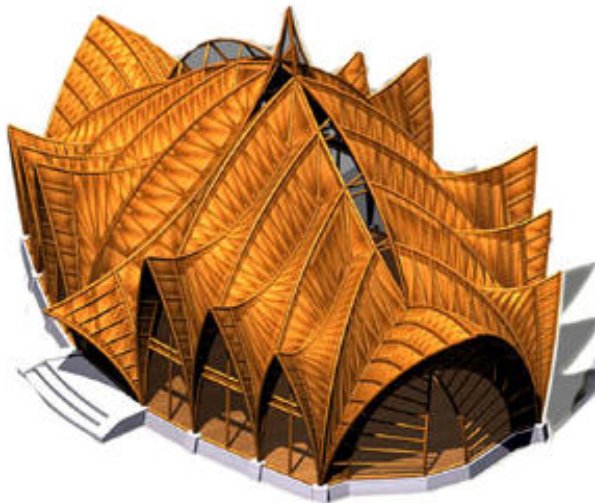
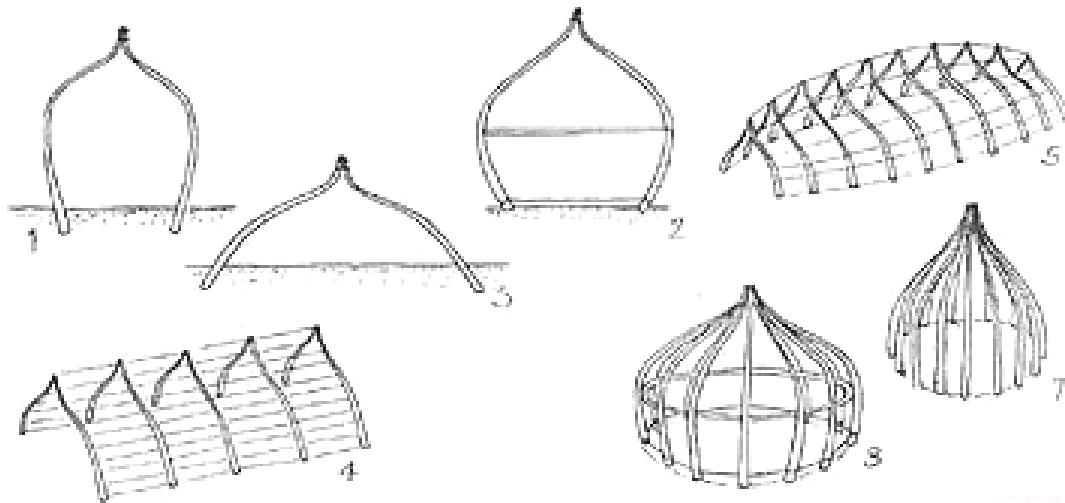


Láminas, cáscaras y entramados espaciales



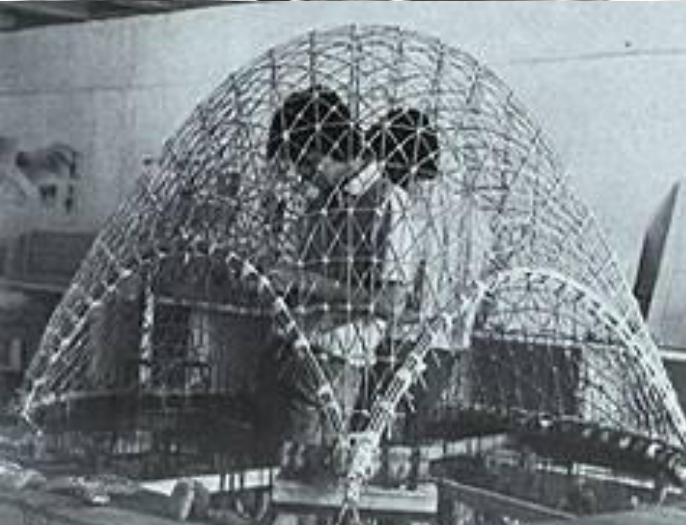
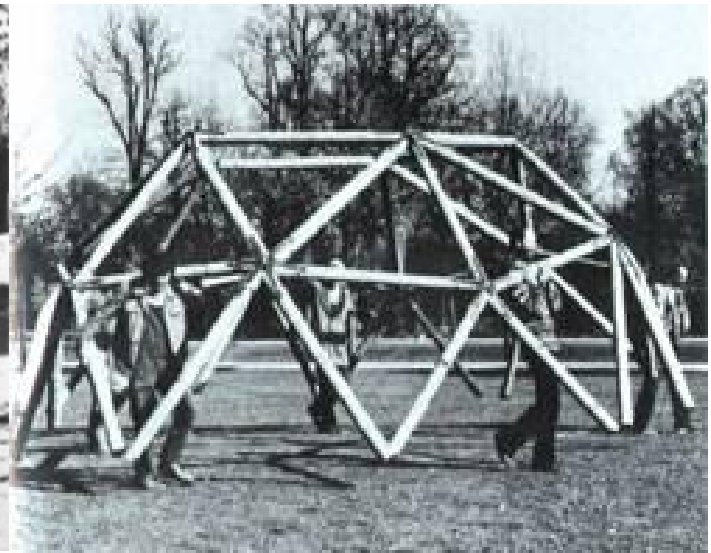
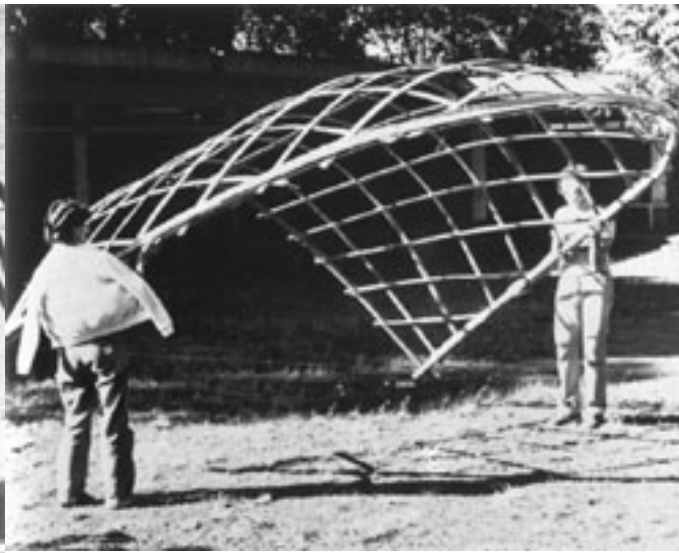
Láminas, cáscaras y entramados espaciales

Arco de cebolla, para bóvedas y cúpulas



Láminas, cáscaras y entramados espaciales

Geodésicas, cáscaras

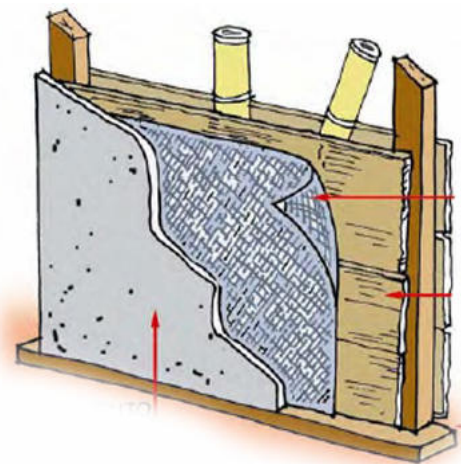
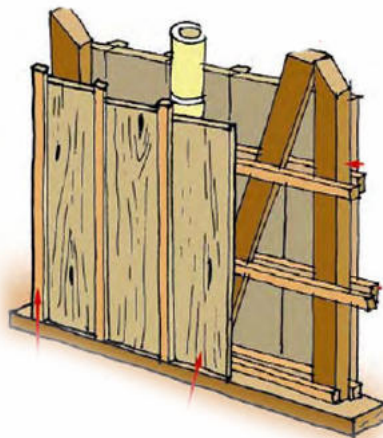
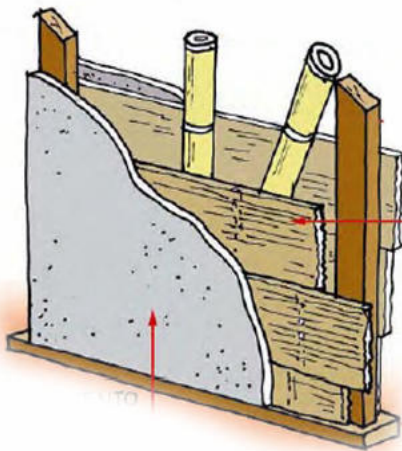
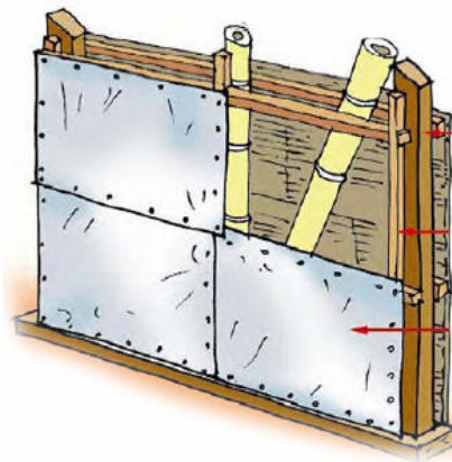
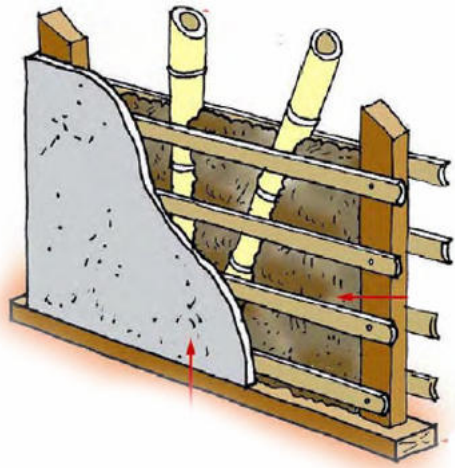


En combinación con tierra cruda: bahareque

Bahareque: muros de estructura de madera o bambú rellenos con barro, cagajón, mortero y recubiertos con cañas partidas, madera o metal



En combinación con tierra cruda: bahareque



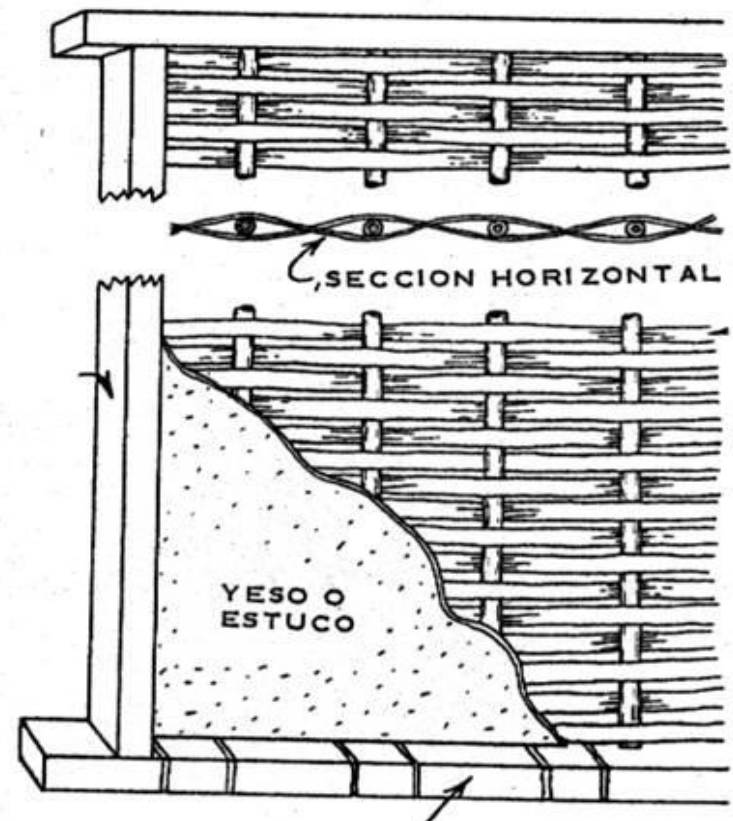
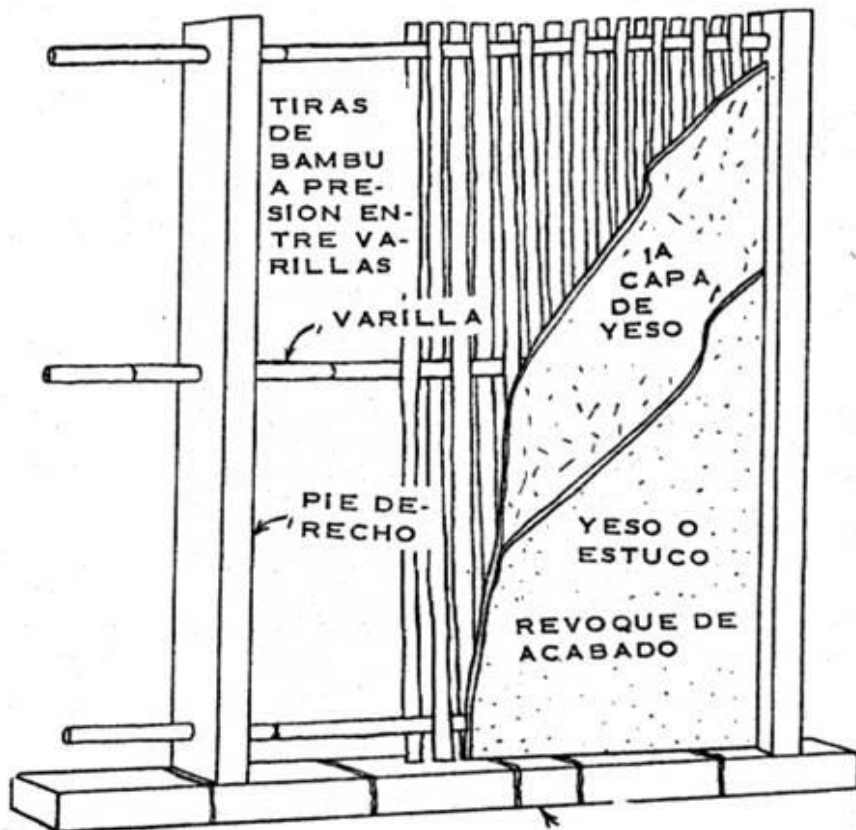
En combinación con tierra cruda: bahareque

Es habitual en viviendas aborígenes o muy humildes

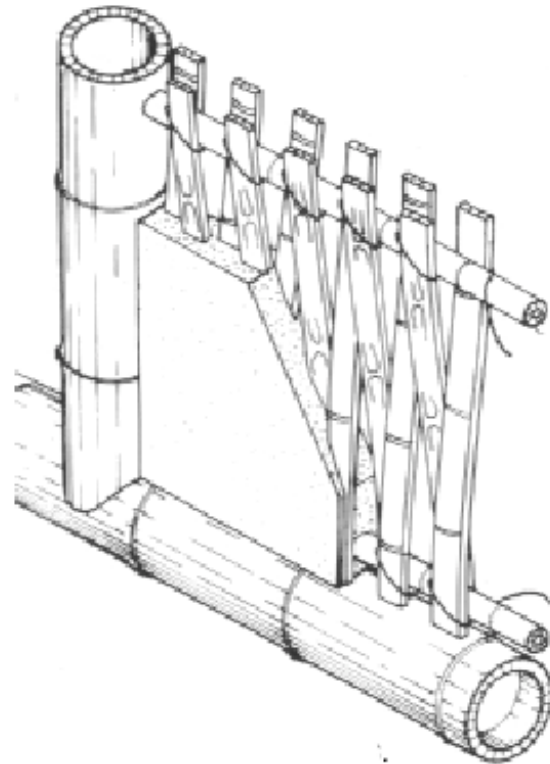
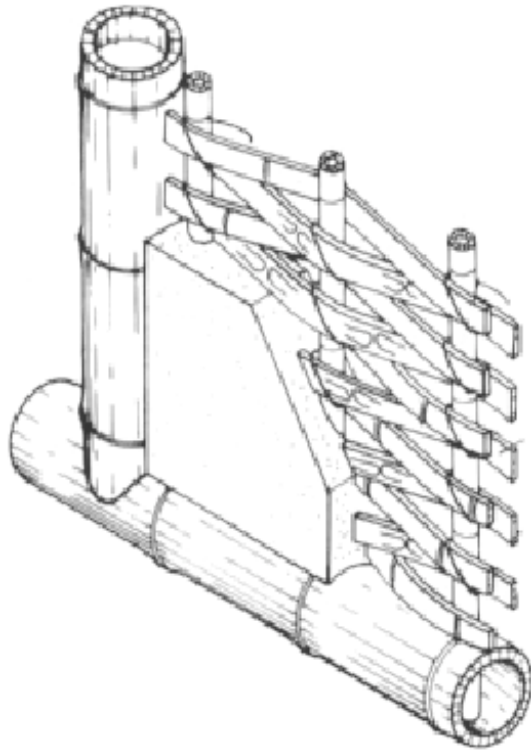


En combinación con tierra cruda: quincha

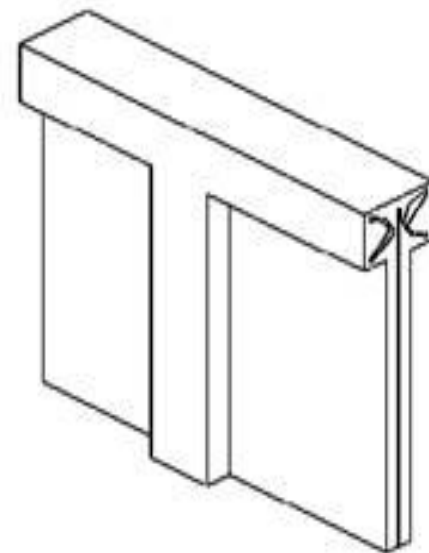
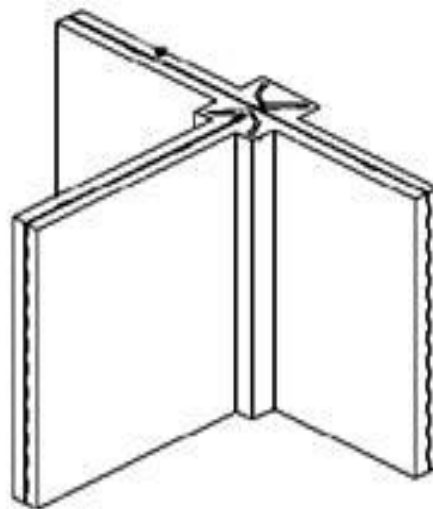
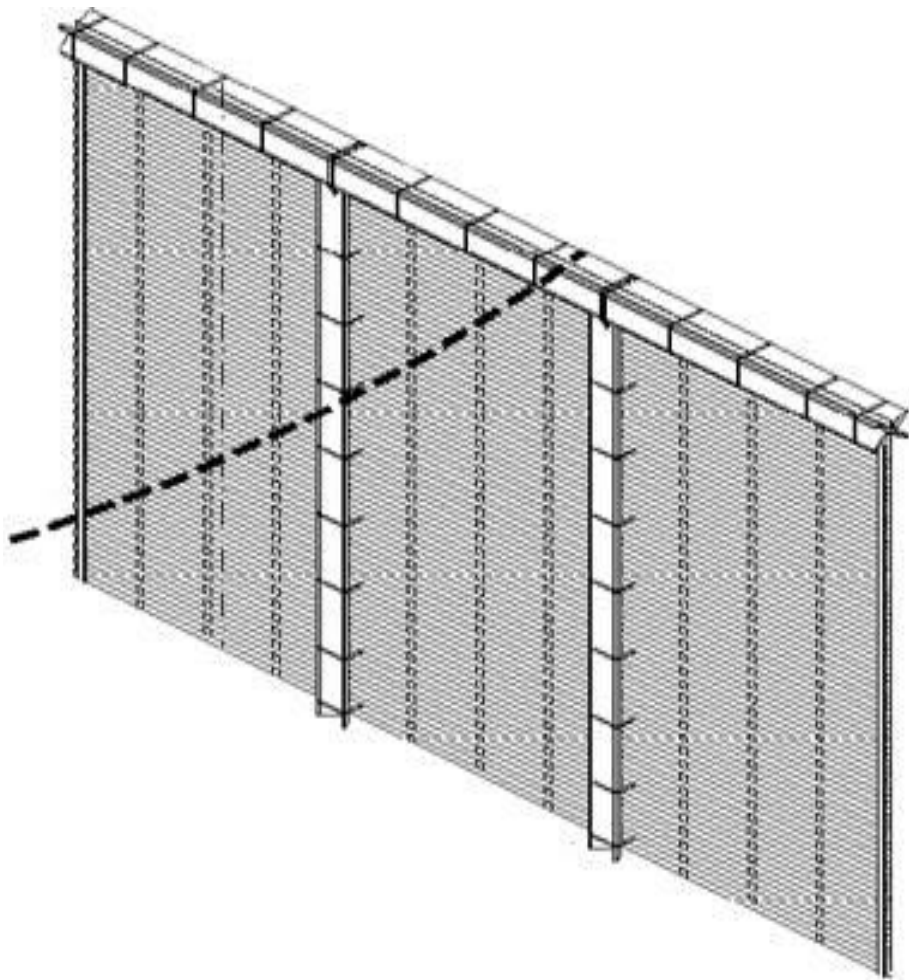
La quincha “quechua: cerramiento de palos” son entramados de maderas o cañas entrelazadas y recubiertas con barro o mortero



En combinación con tierra cruda: quinchas



“Quincha confinada”



“Quincha confinada”



“Quincha confinada”



“Quincha confinada”

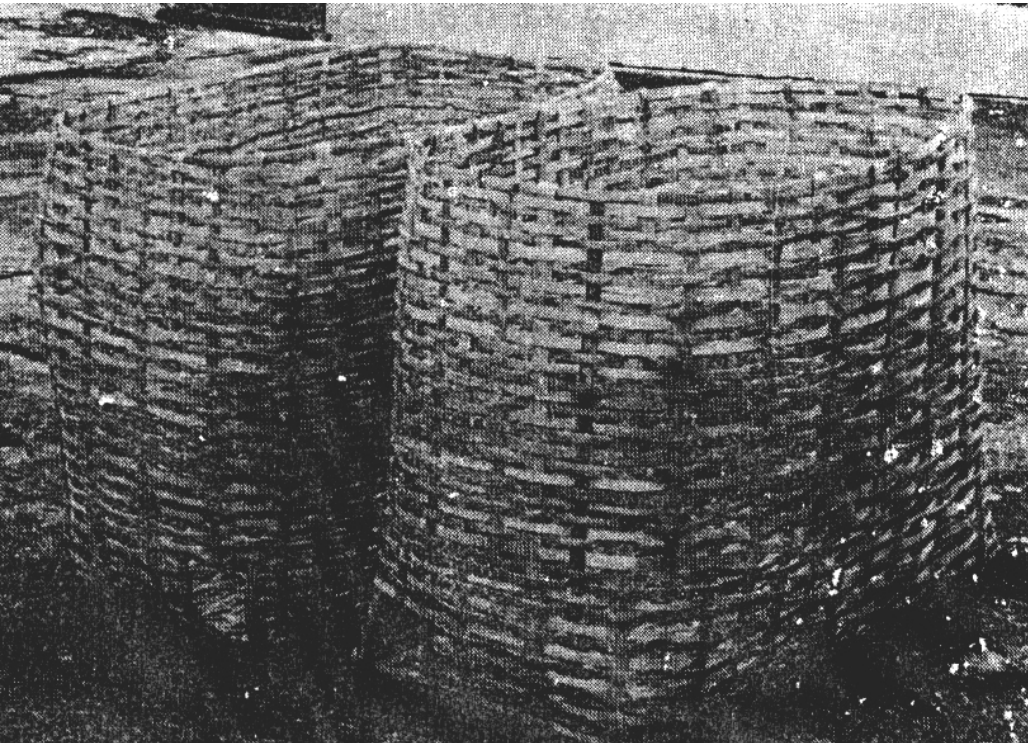


Bambú-cemento

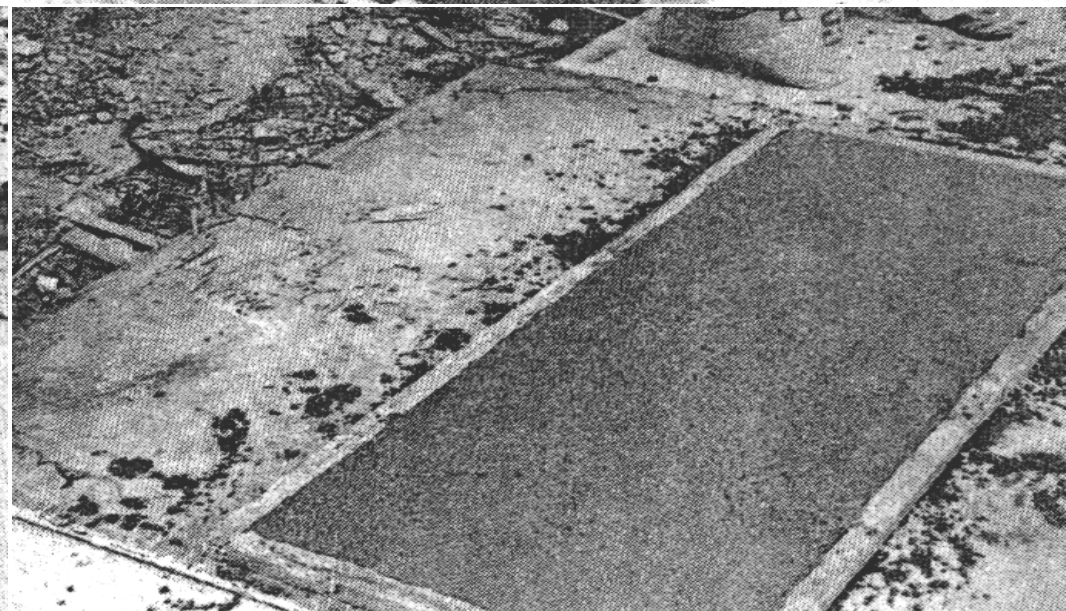
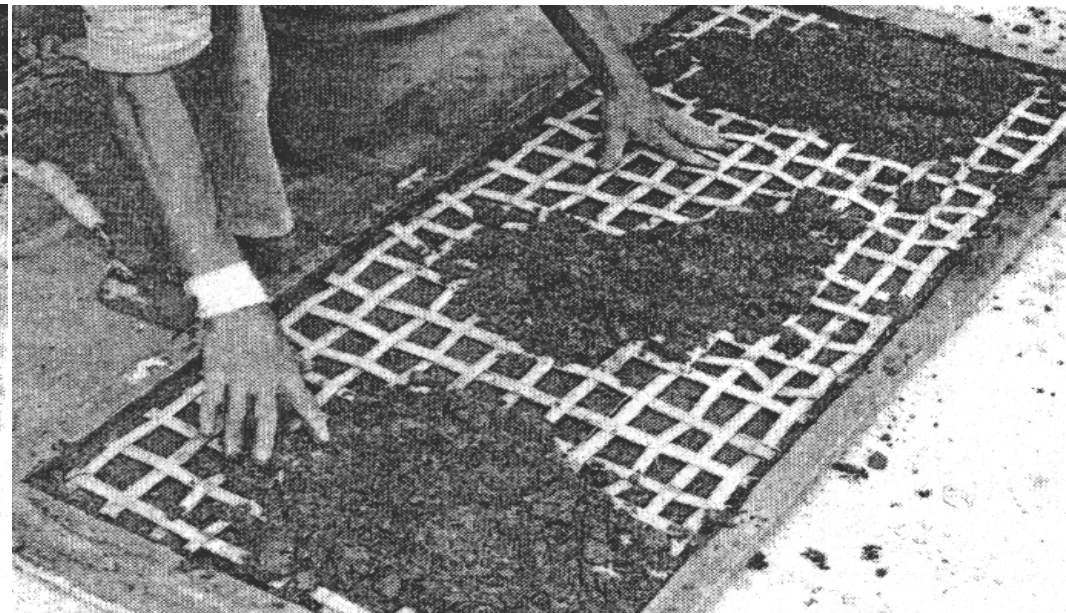
Similar al ferrocemento pero con fibras de bambú tejidas

Usada en zonas rurales de Colombia para la fabricación de estanques de agua

Se recomienda usar cintas de cañas jóvenes, mas blandas y flexibles



Bambú-cemento



Bambúcreto

Es concreto reforzado con fibras de bambú

Se utiliza principalmente para postes y elementos menores

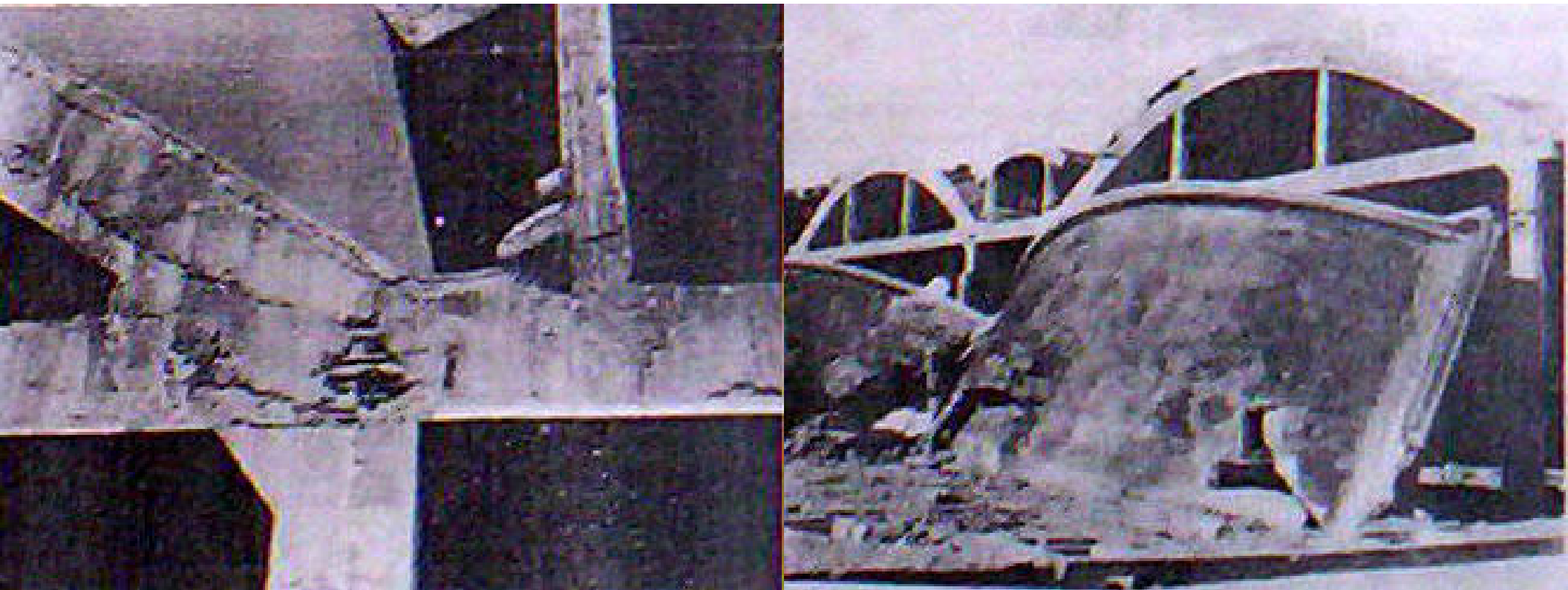
Tambien se utilizan fibras de sisal, fibras de coco, de palma, yute, lino, juncos, algas marinas y bagasse (fibra de la caña de azucar)



Bambúcreto

Durante la década del 40 se realizaron numerosos edificios, especialmente durante la Segunda Guerra Mundial por las fuerzas armadas de Japón

Los resultados fueron catastróficos!



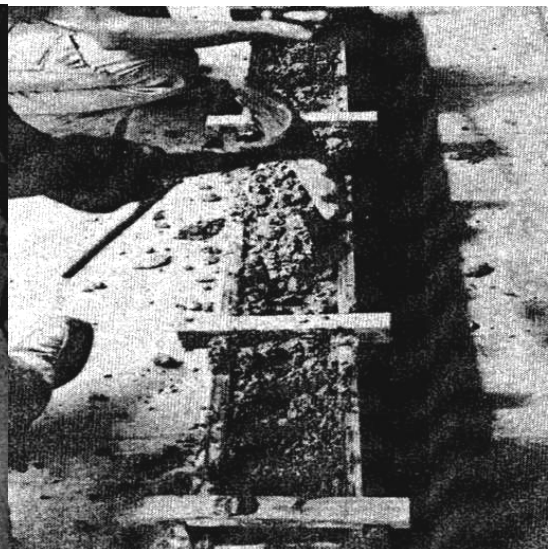
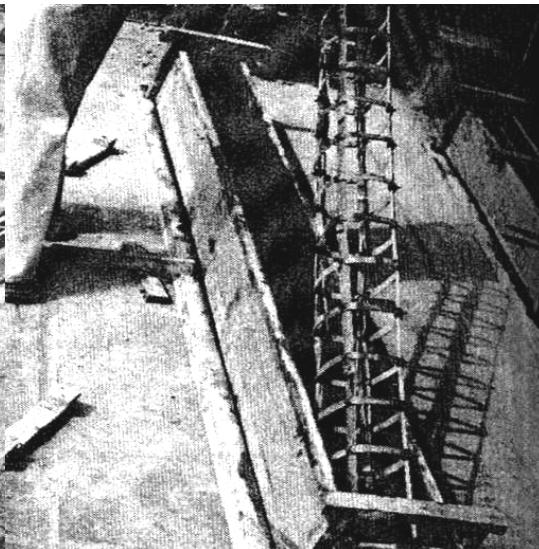
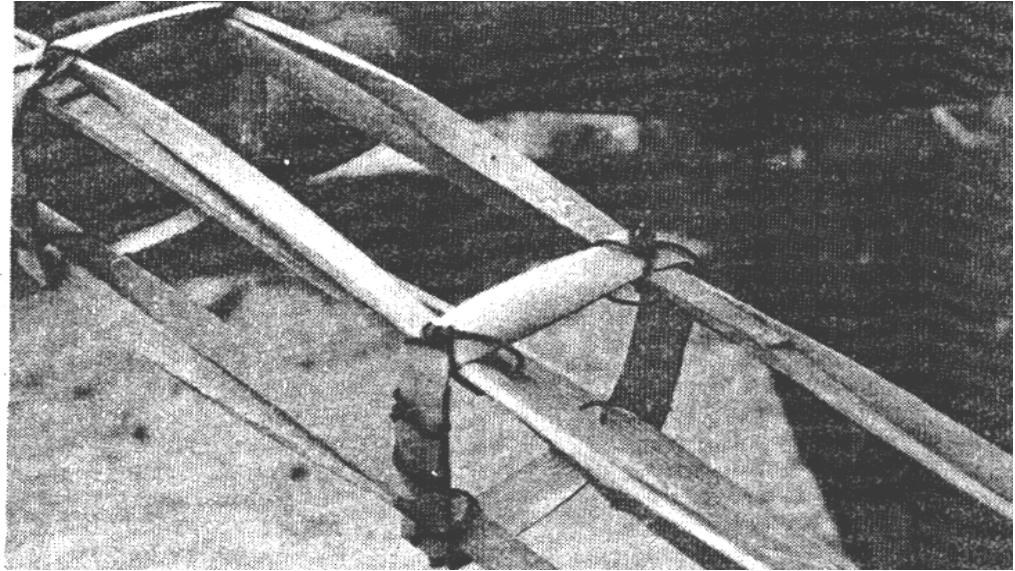
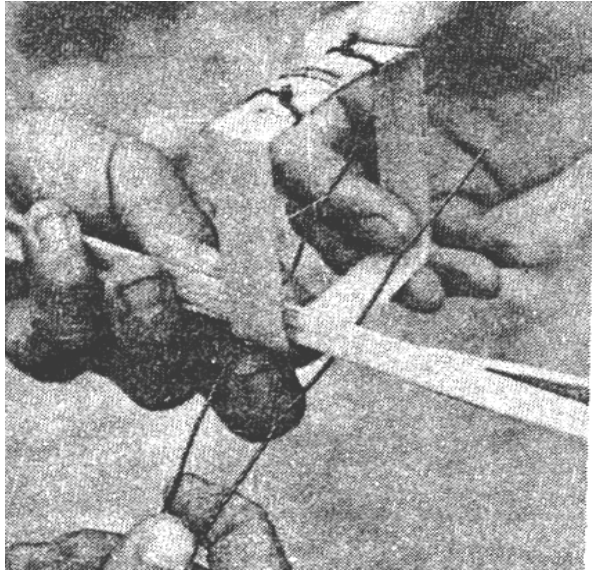
Bambúcreto

Hoy se sabe que fue debido a poca adherencia, bajo módulo de elasticidad e inestabilidad de las fibras frente a los cambios de humedad

Material	Variación transversal (%)	Variación axial (%)
Bambú	2 - 5	0,012 – 0,05
Concreto	0,06	0,06

<i>Material</i>	<i>Coeficiente expansión térmica ($\times 10^6 / ^\circ\text{C}$)</i>	
	<i>Transversal</i>	<i>Axial</i>
Bambú	25 - 58	1,5 – 5,0
Concreto	12,0	12,0

Bambúcreto



Productos para la construcción



Tableros y madera laminada

Se obtienen “latas” de la cepa, la basa y la sobrebasa de la caña (la parte gruesa del tallo)

Luego de cuadran, pegan y prensan



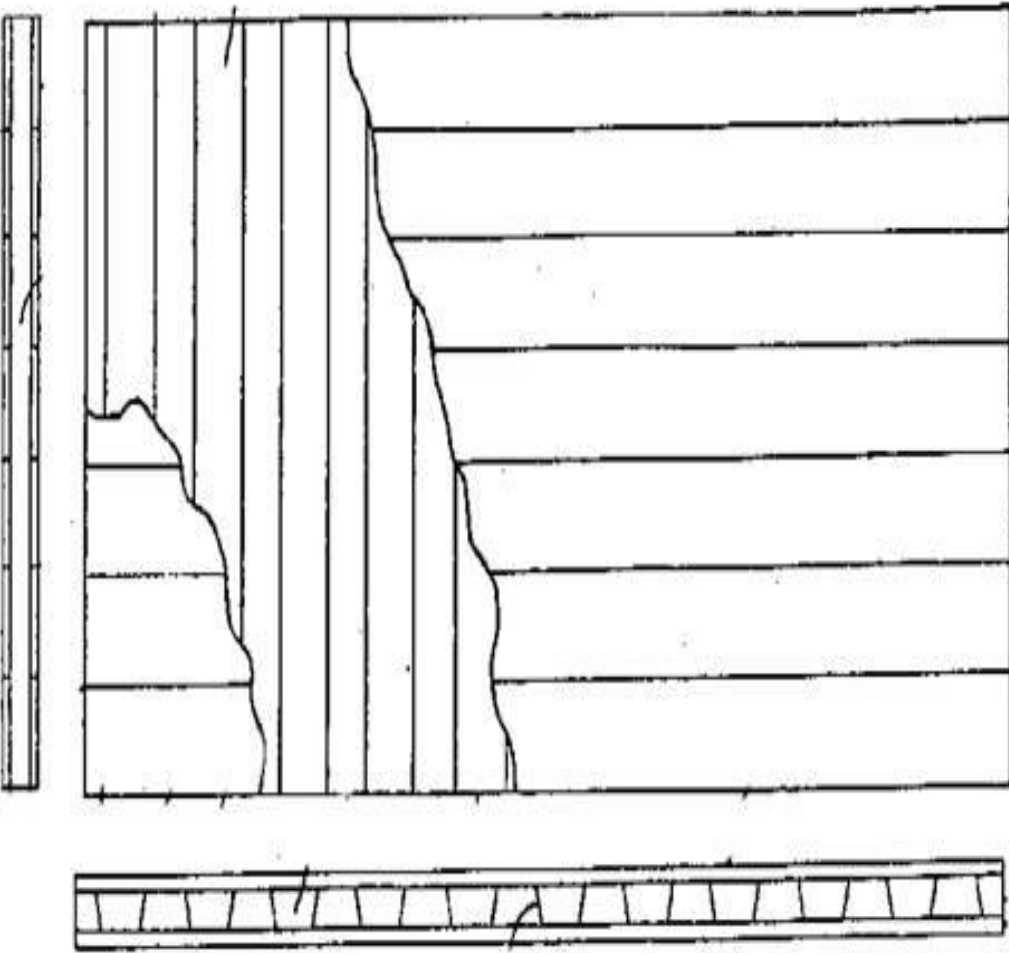
Tableros y madera laminada



Tableros y madera laminada



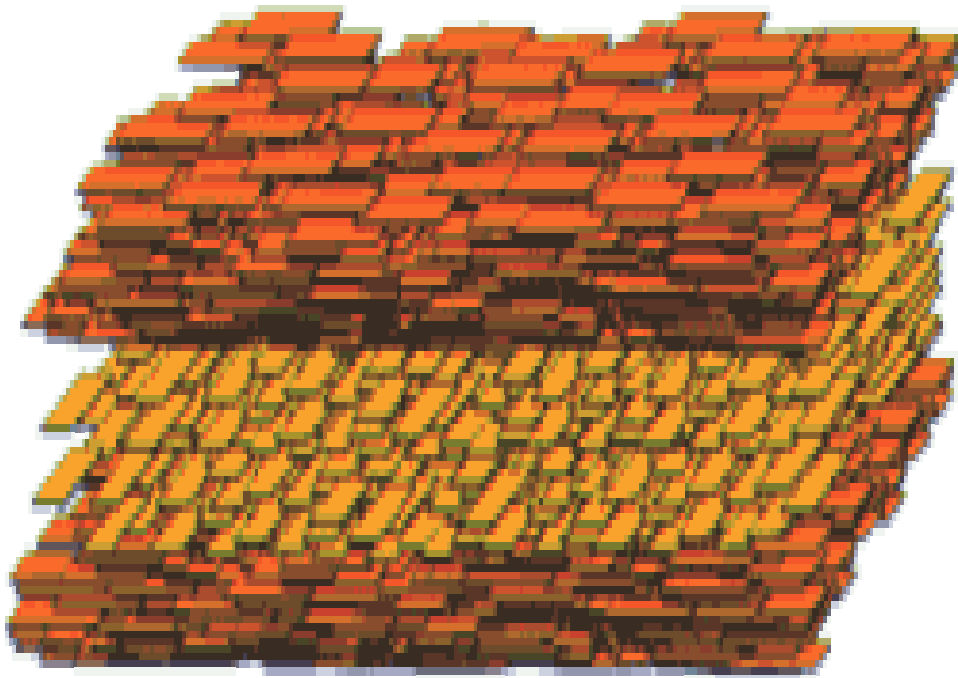
Tableros y madera laminada



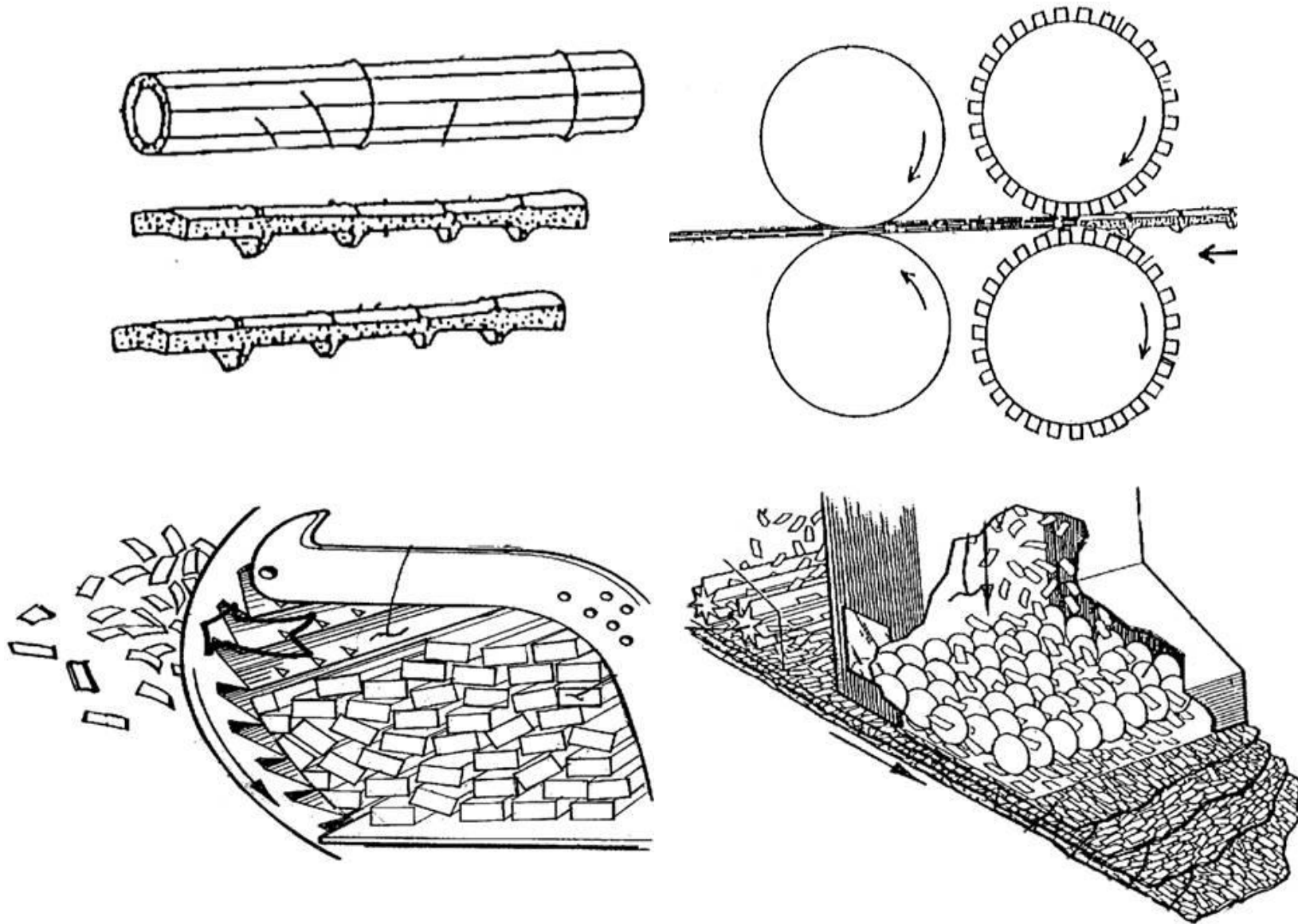
Tableros y madera laminada



Tableros de OSB



Tableros de OSB



Madera maciza laminada

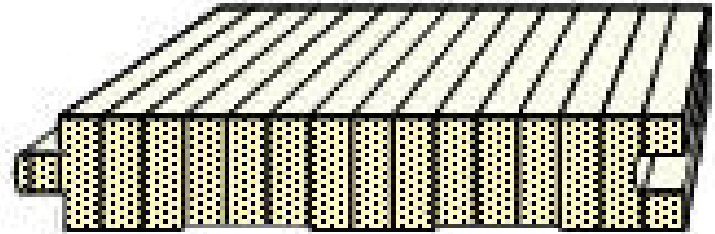
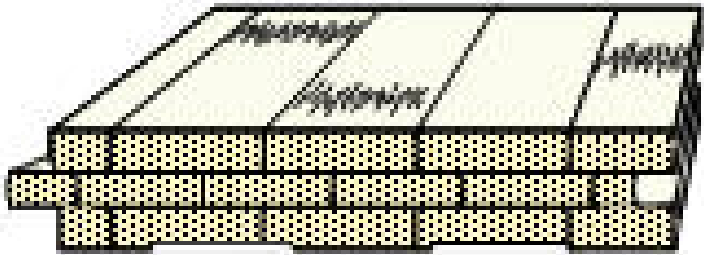


Madera maciza laminada

Puede tener aplicaciones estructurales



Revestimientos de piso

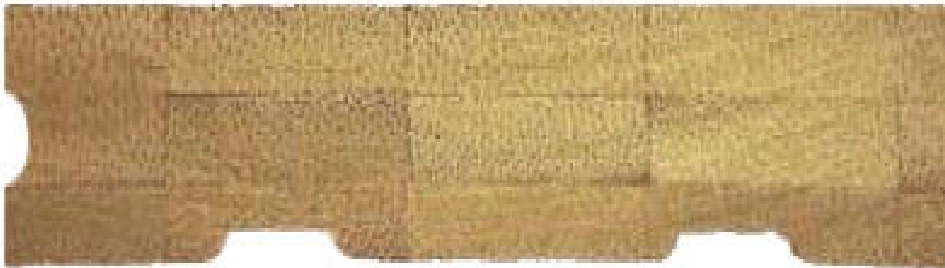


Revestimientos de piso

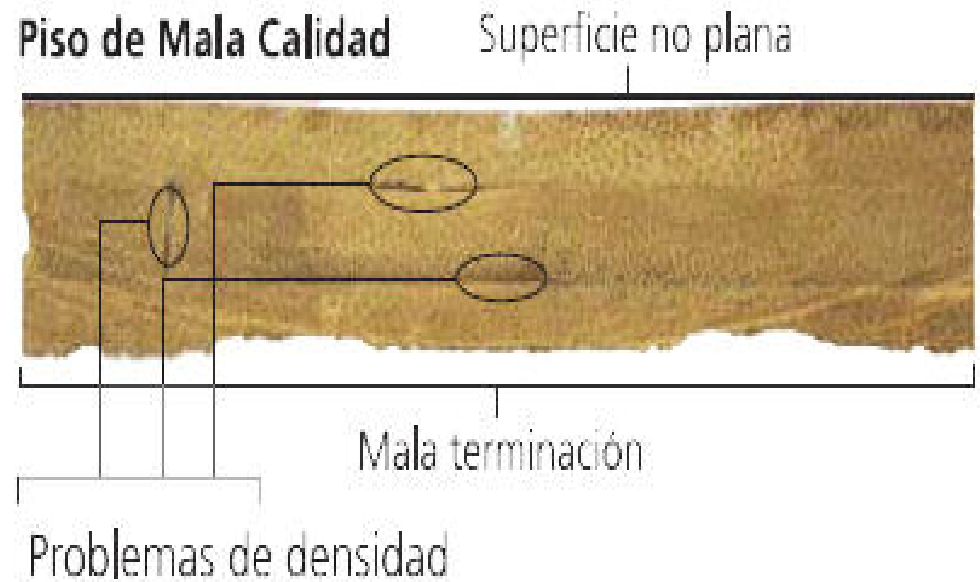


Revestimientos de piso

Piso de Buena Calidad



Piso de Mala Calidad



Revestimientos de pared y cielo

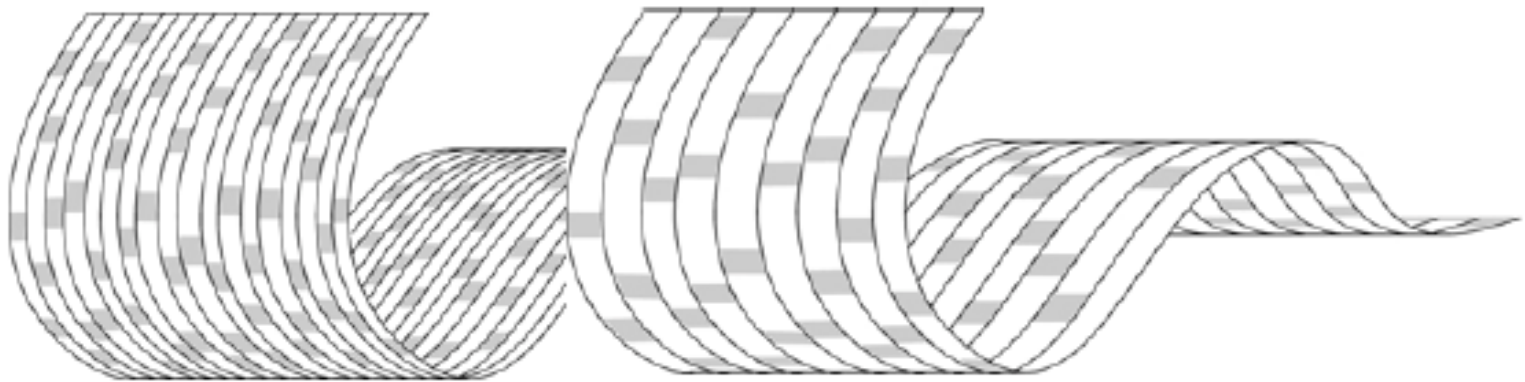
Enchapes de media caña



Revestimientos de pared y cielo

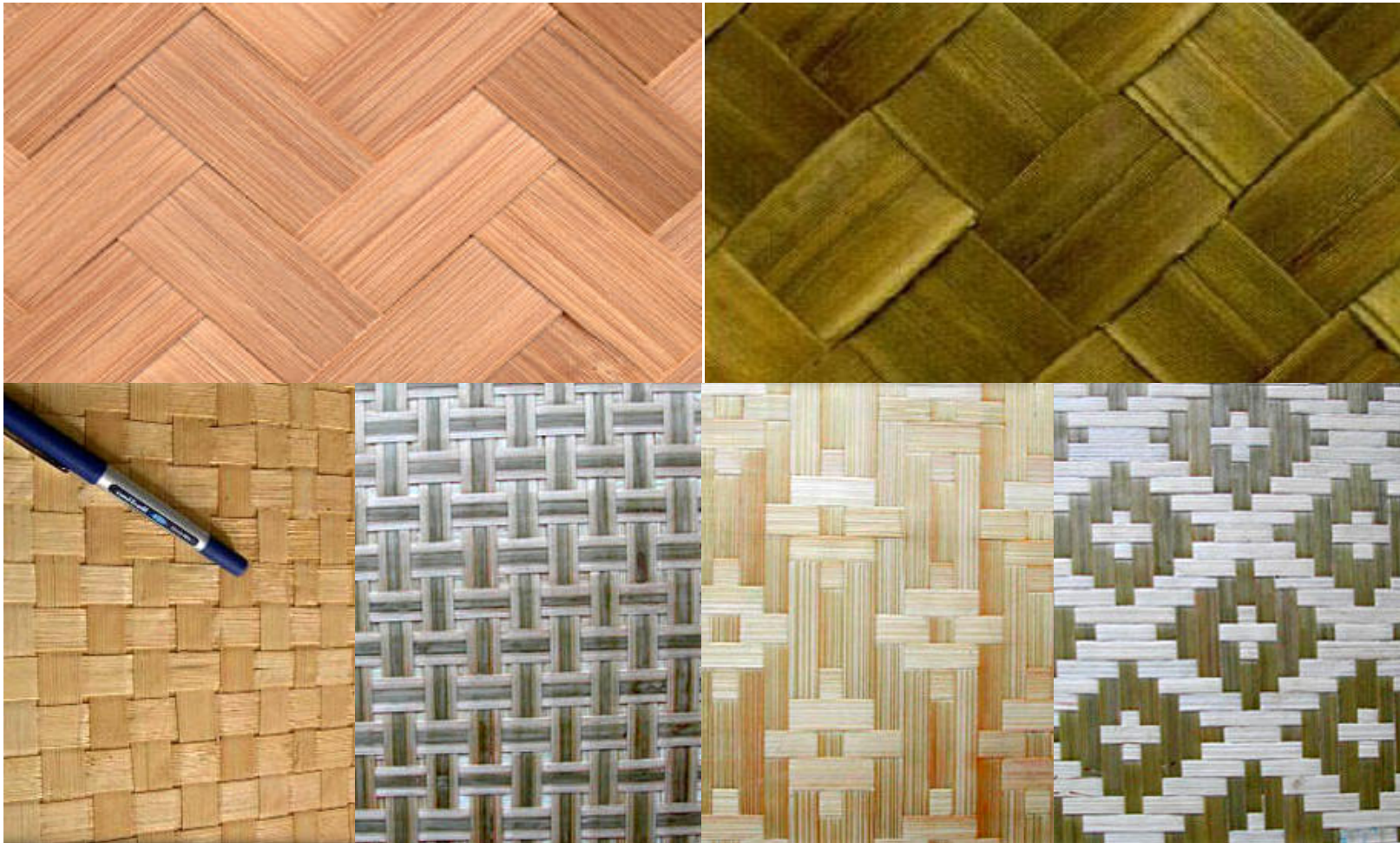
Enchapes laminares (0.6 mm)

Se pegan sobre laminas plasticas hidorepelentes (PVAC)



Revestimientos de pared y cielo

Esterillas tejidas (1.5 mm)



Revestimientos de pared y cielo

Esterillas tejidas (1.5 mm)



Revestimientos de pared y cielo

Cielos de caña completa (encolihuado)



Entramados autosoportantes

Rejas, cercos, cierros, celosías, portones, emparrados, pérgolas, treillages, etc.

Con o sin bastidos

Utilizan cañas completas, medias cañas, cuartos de caña, tablillas o hilillos



Entramados autosoportantes



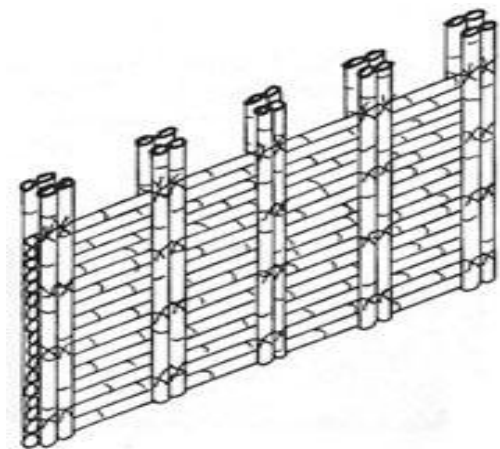
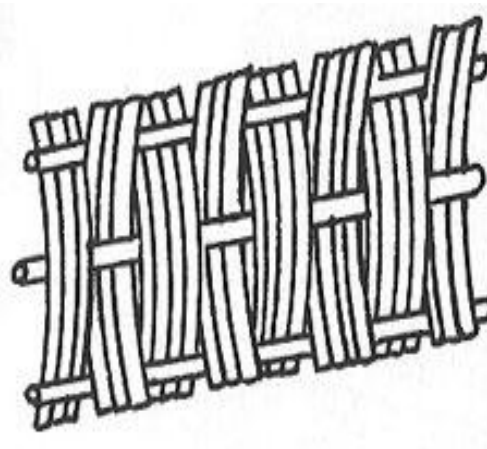
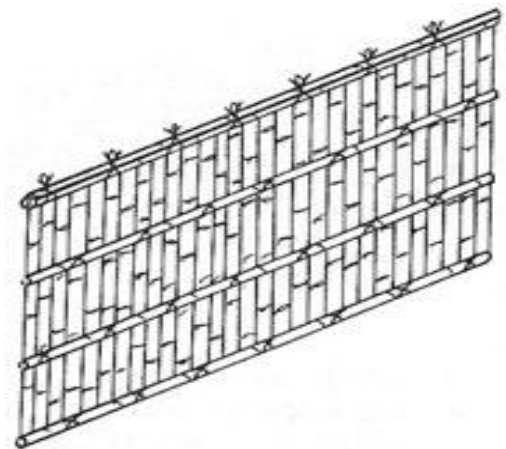
Entramados autosoportantes



Entramados autosoportantes



Entramados autosoportantes



Otros productos menores

Persianas, tatamis, luminarias



Andamiajes

Son predominantes en Hong-Kong



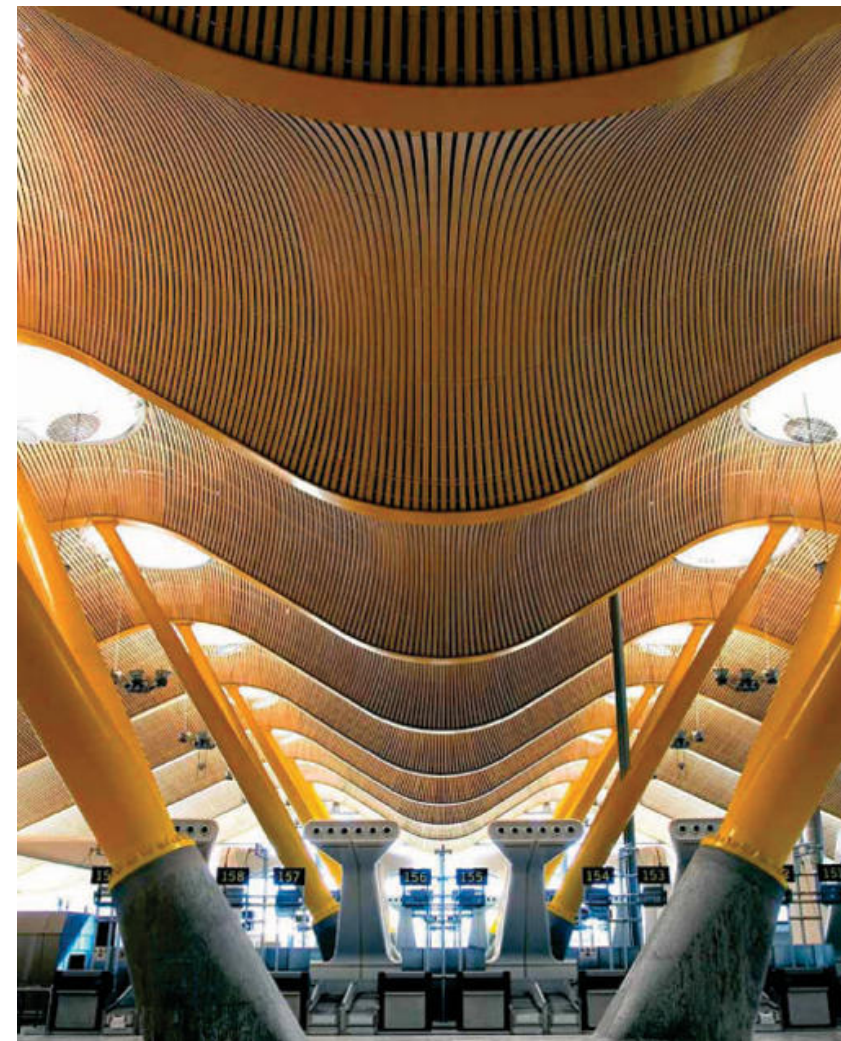
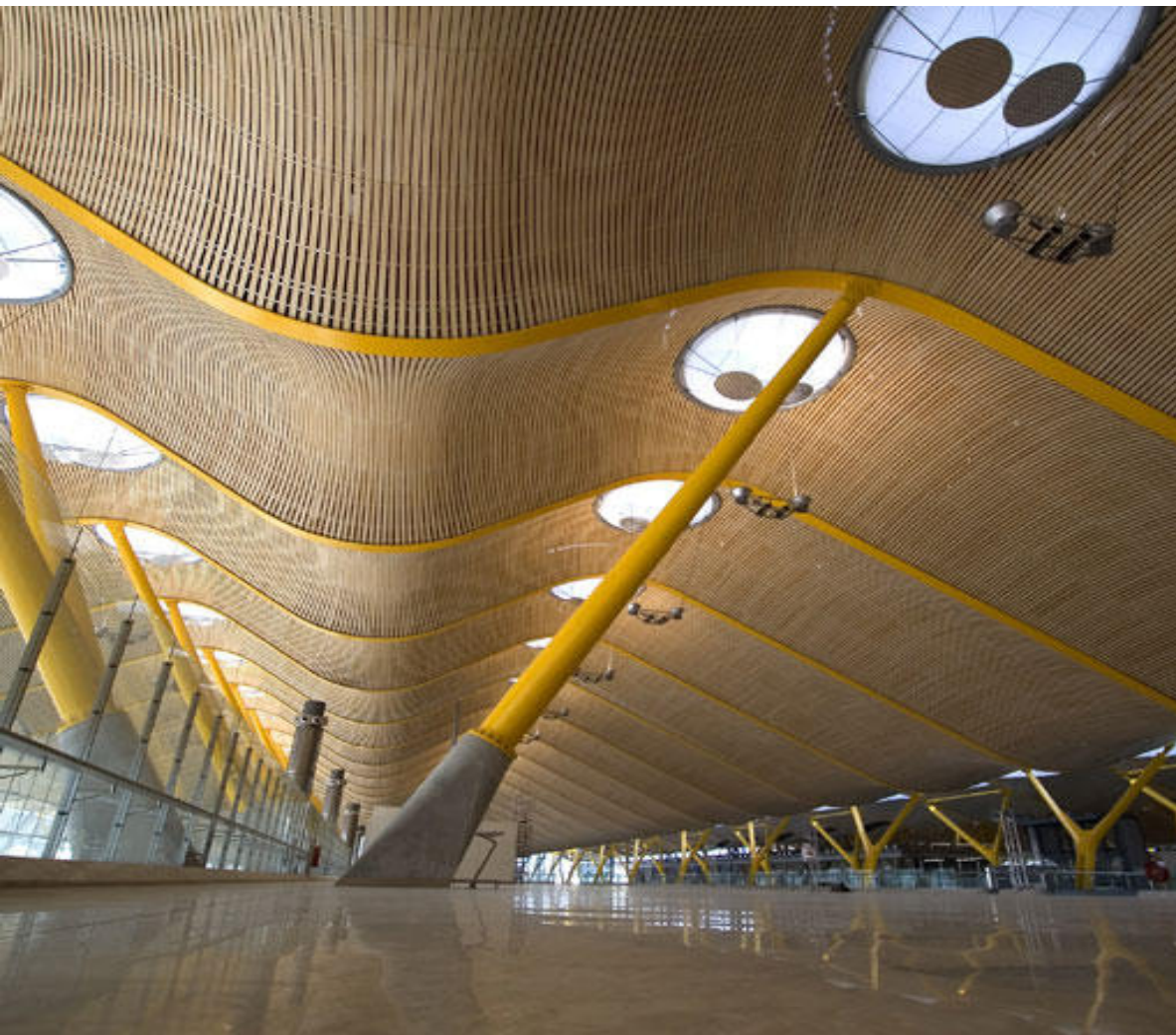
Arquitectura contemporanea

Renzo Piano y Shigeru Ban



Arquitectura contemporanea

Richard Rogers Aeropuerto Barajas



Arquitectura contemporanea

Kengo Kuma Great Bamboo House



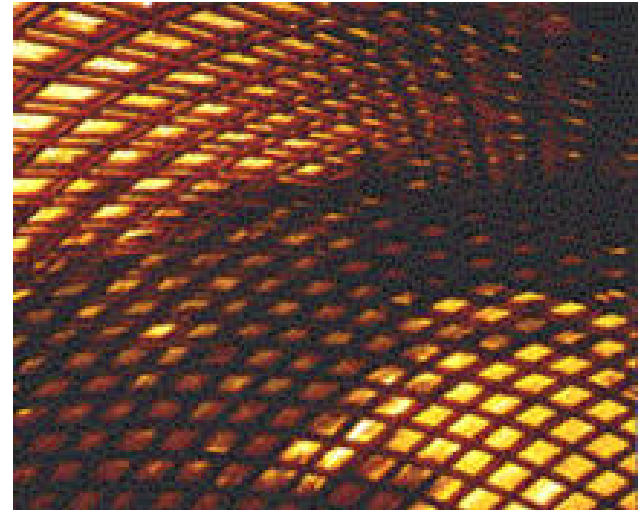
Arquitectura contemporanea

Kengo Kuma Great Bamboo House



Arquitectura contemporanea

Shoei Yoh y Jorg Stamm



Simón Velez

Arquitecto colombiano, ha construido sobre 100 proyectos con Guadua, incluyendo el pabellón para la Expo Hannover 2000





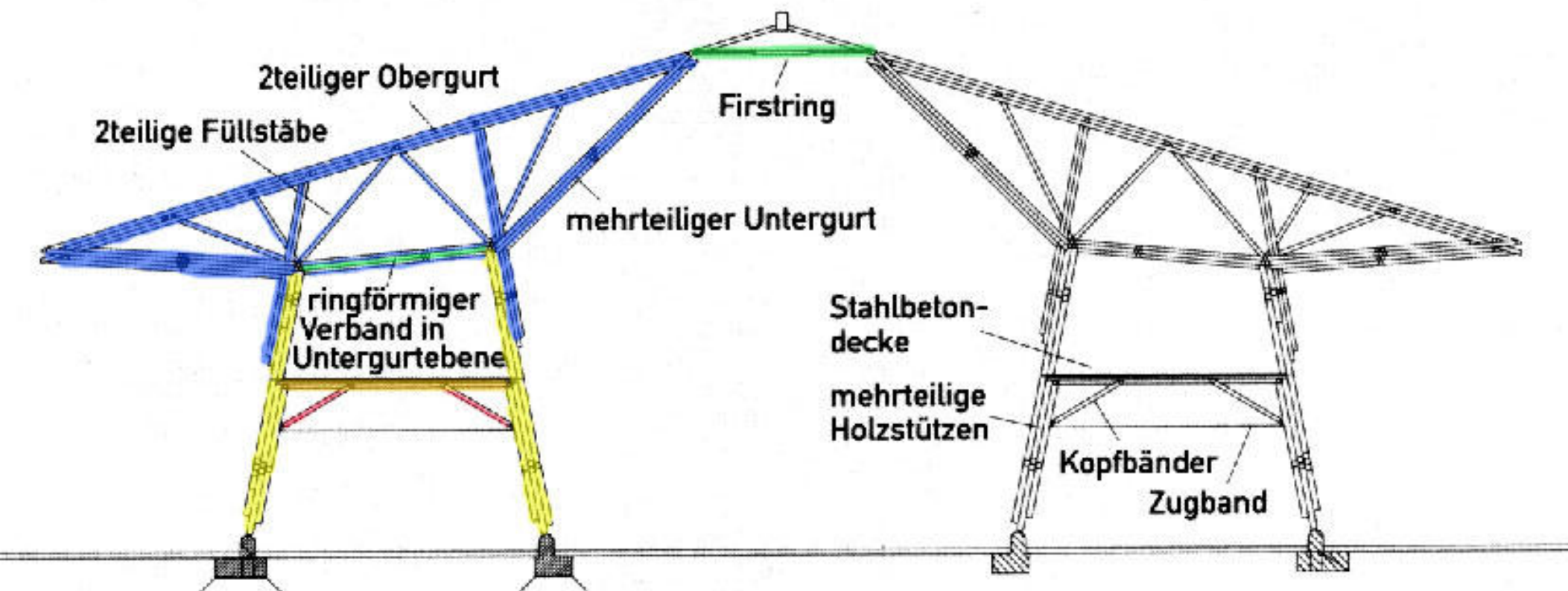


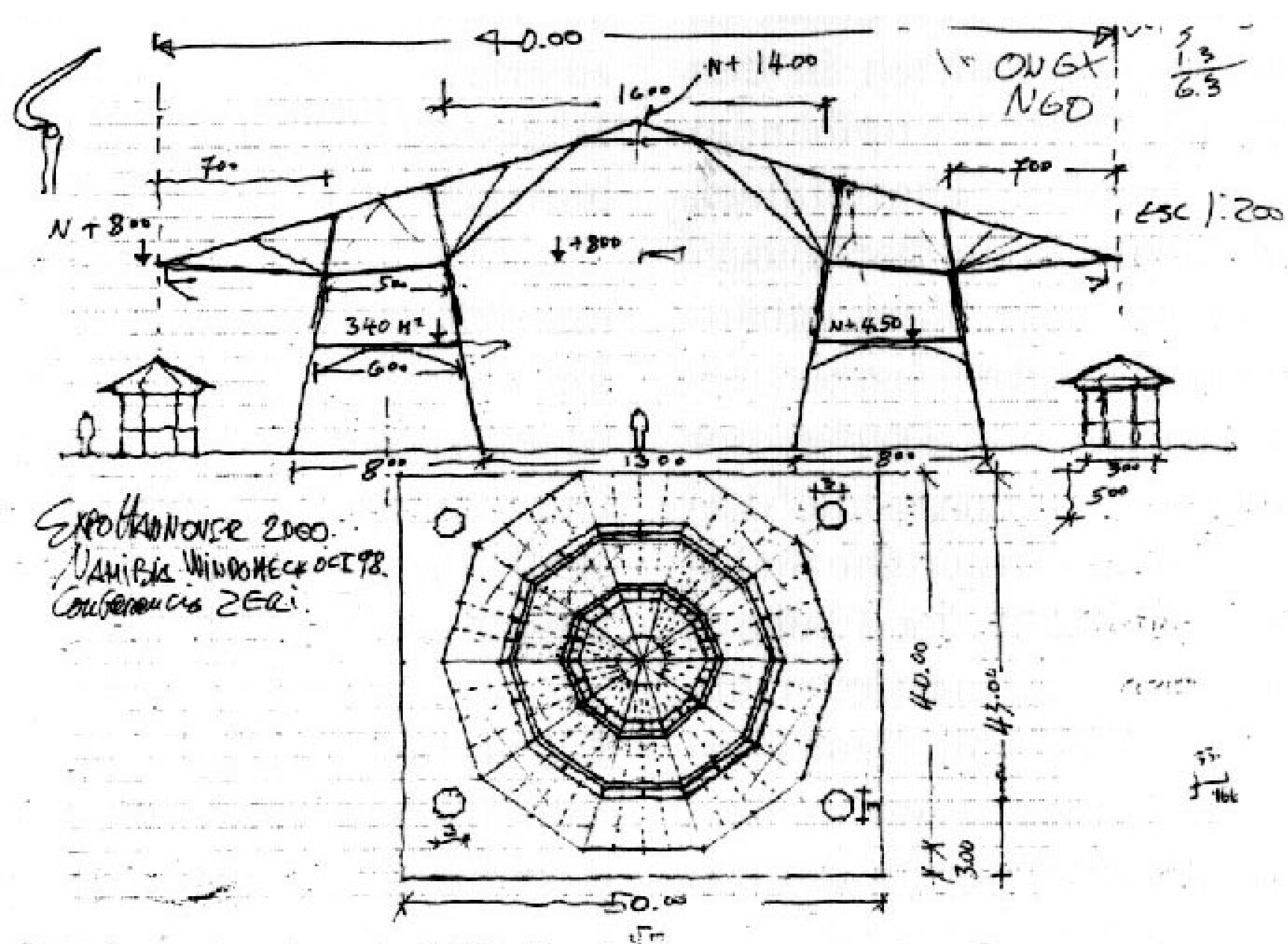


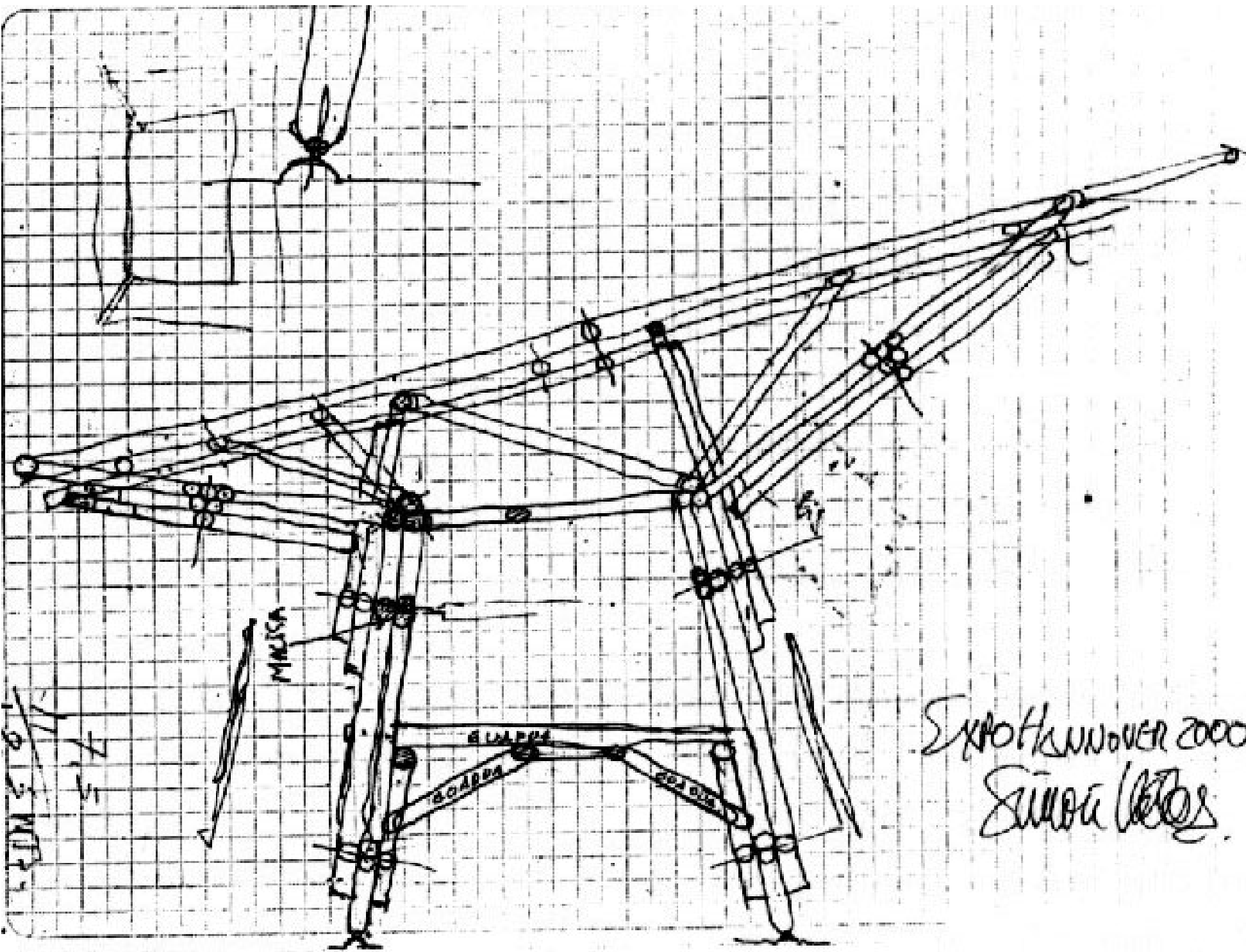


Expo Hannover



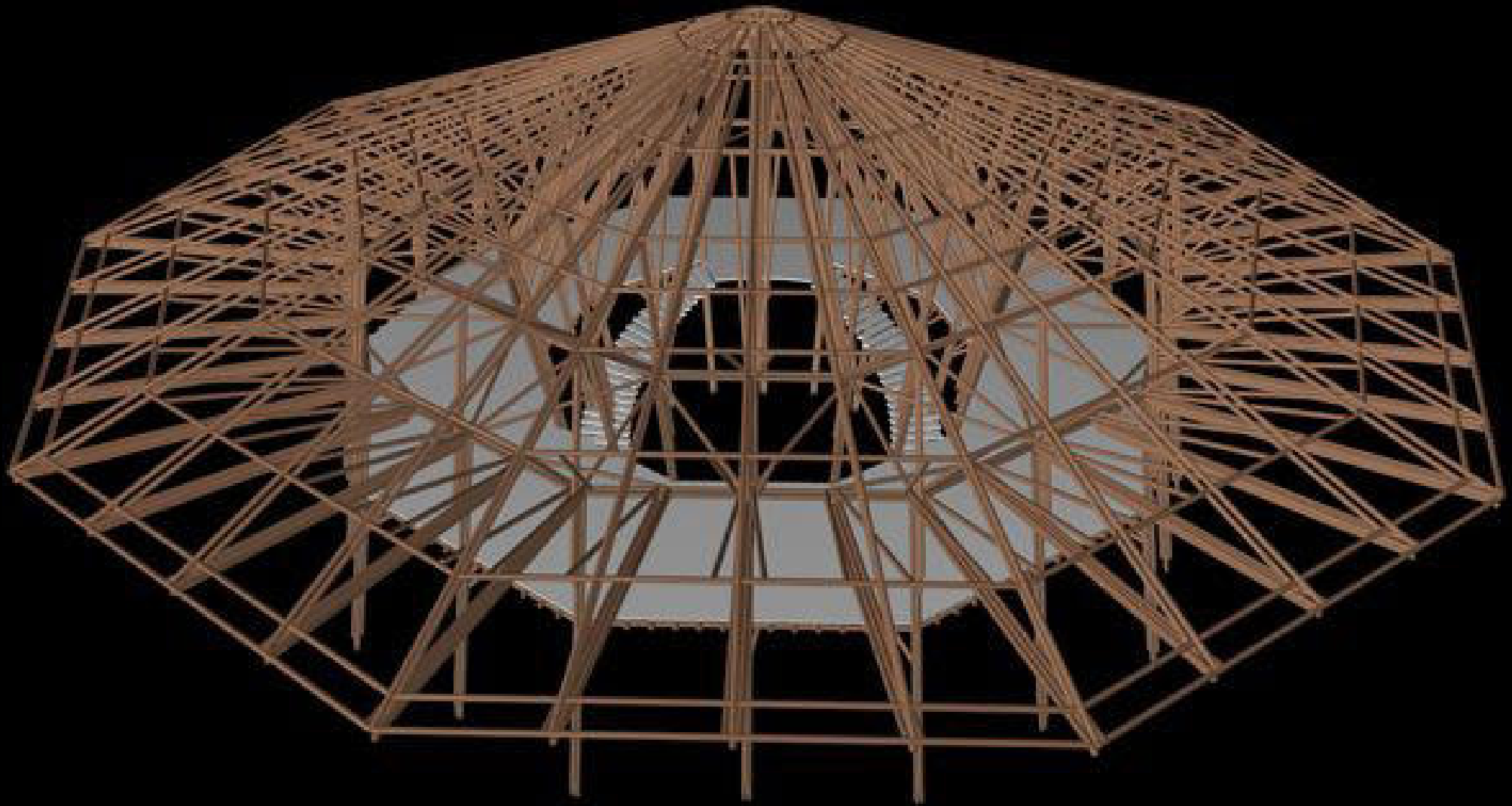


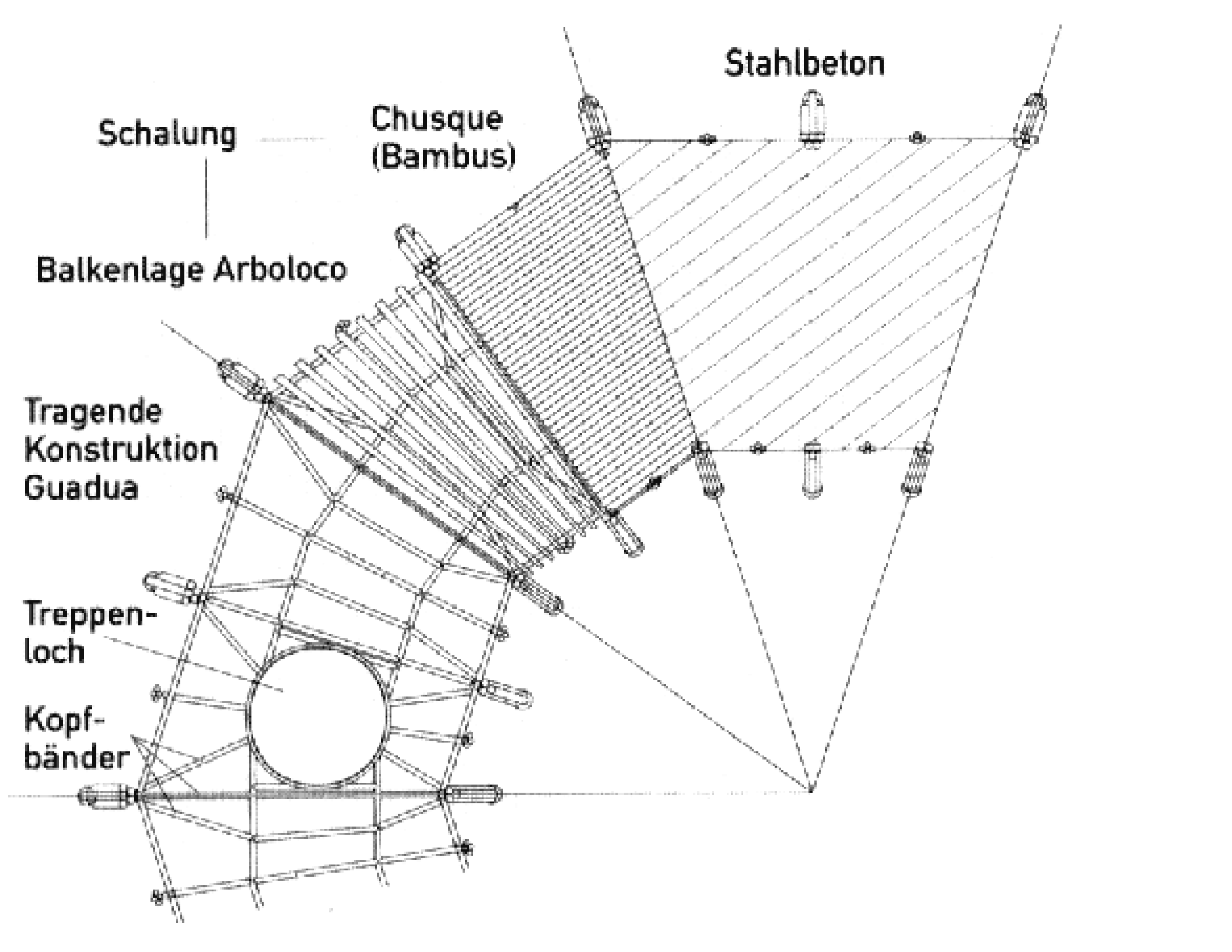




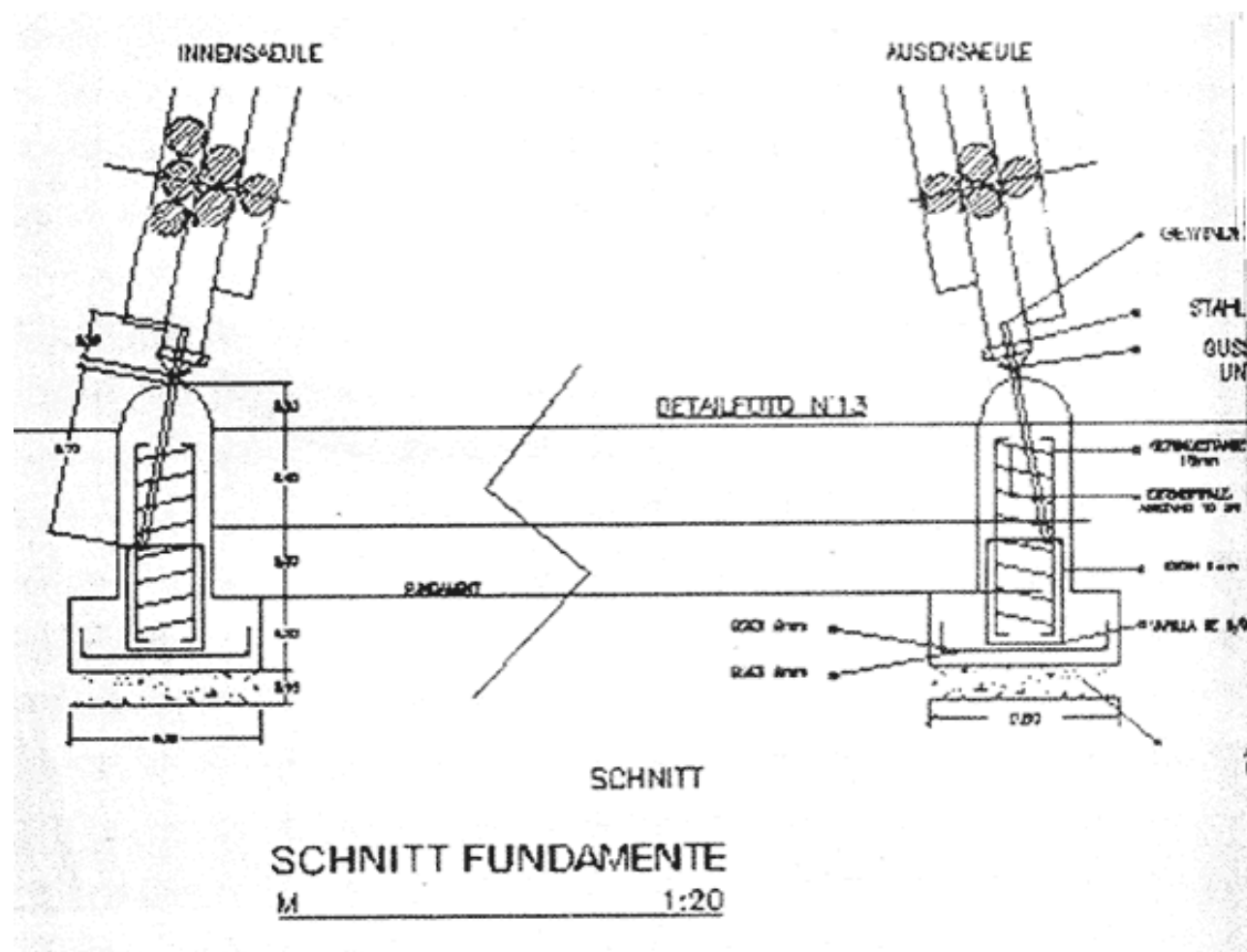
1/2
 7.5
 1/2

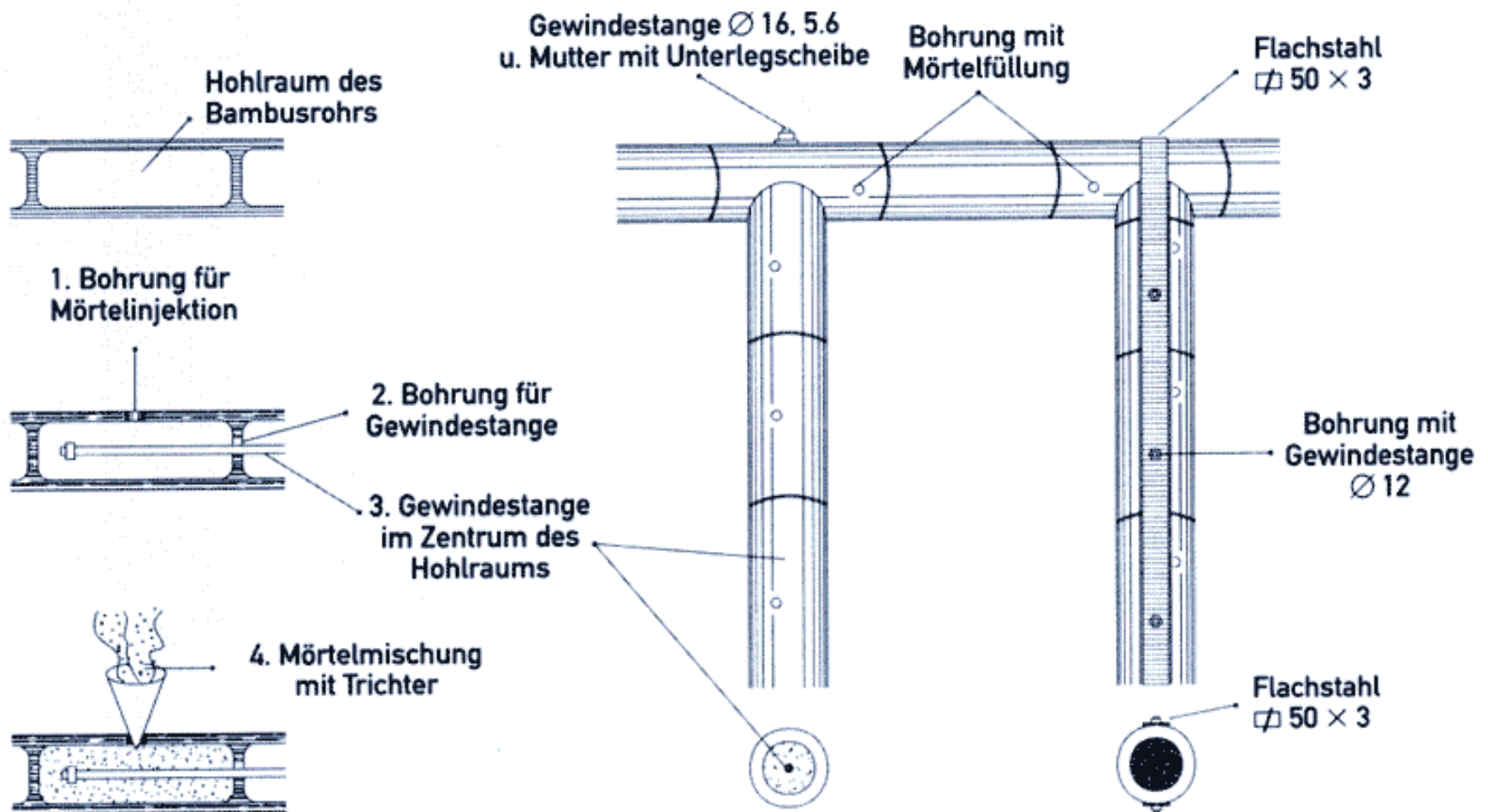
EXPO HANNOVER 2000
 SIMBA (BOS)



















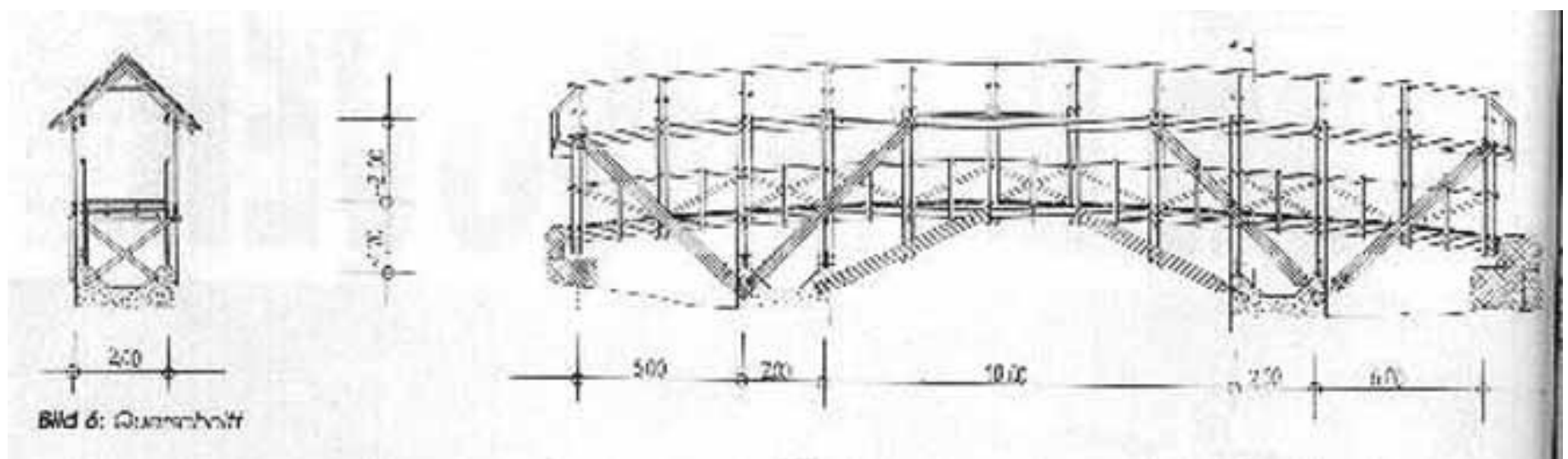
Jorg Stamm

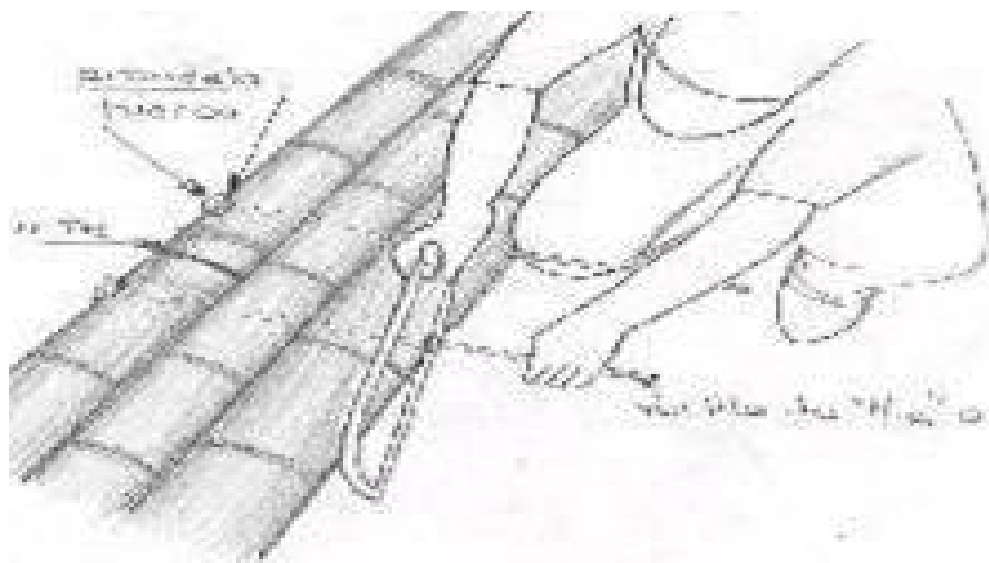
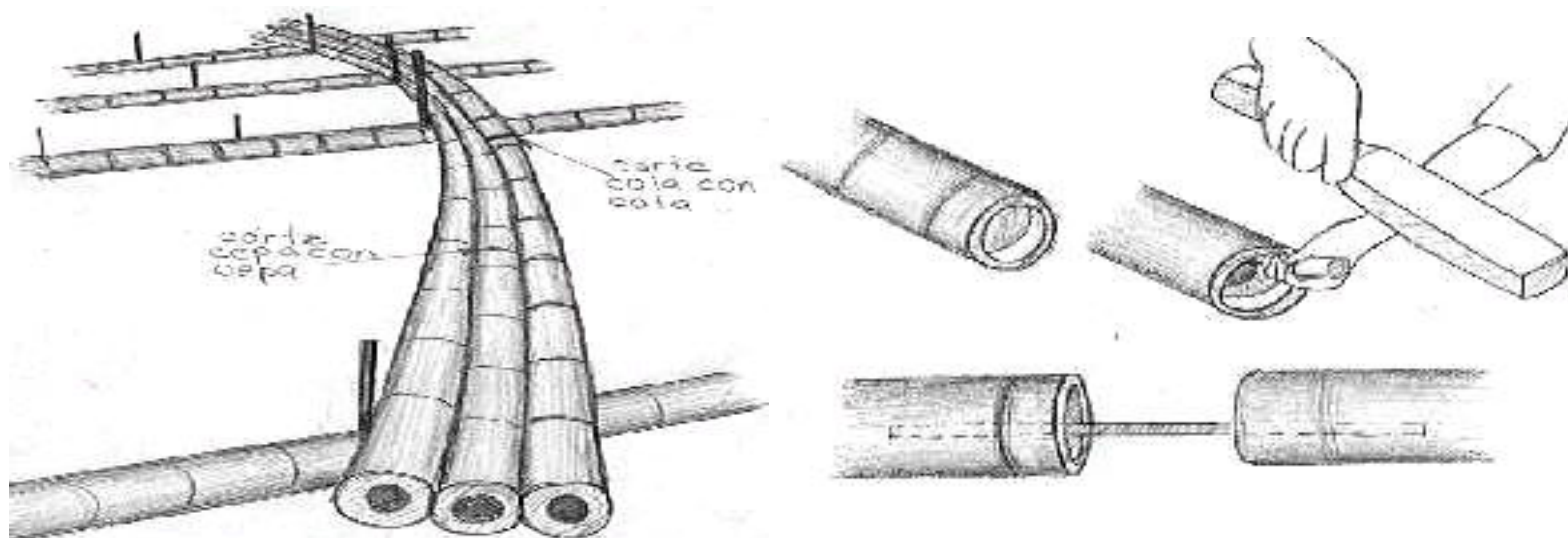
Carpintero alemán reconocido por el diseño y construcción de puentes.

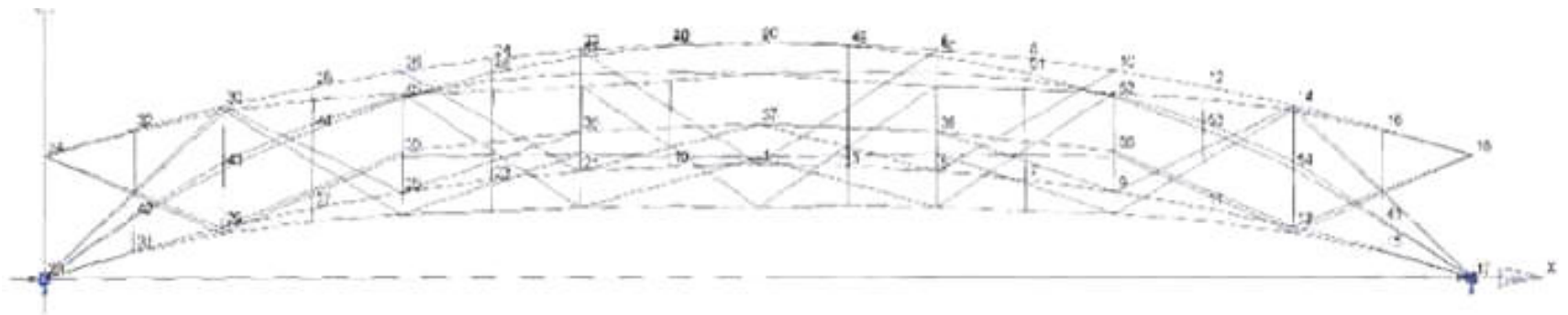
Puente Tierradentro 30 mt de luz

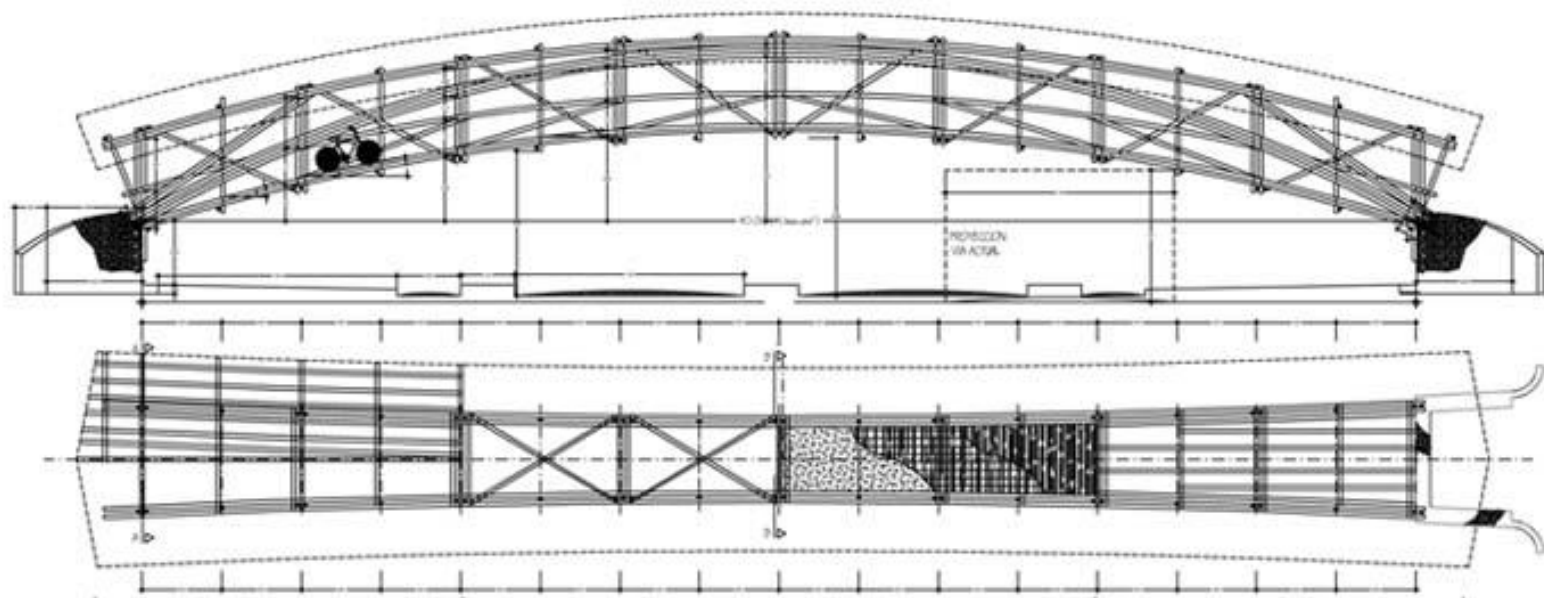
Puente Pereira 52 mt de luz













Bamboo Technologies

Localizadas en Paia, Maui, Hawaii

Fabrica viviendas prefabricadas con bambú traído de Vietnam

Exporta a todo el mundo



Bamboo Technologies



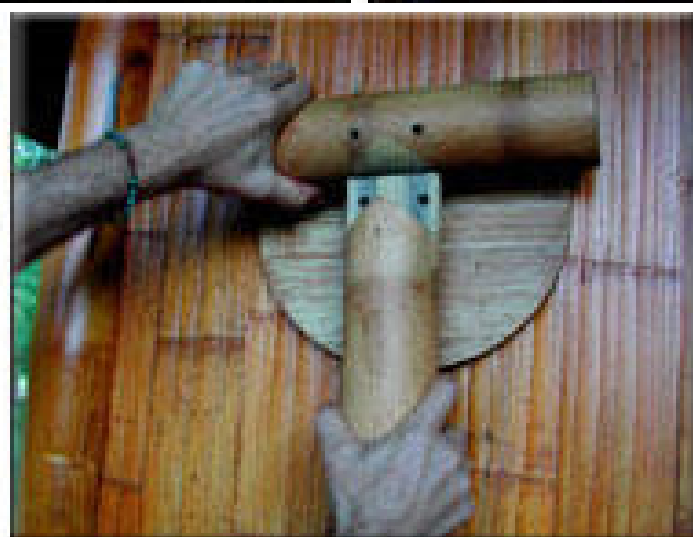
Bamboo Technologies



Bamboo Technologies



Bamboo Technologies



Bamboo Technologies



Viviendas Hogar de Cristo Ecuador



Viviendas Hogar de Cristo Ecuador

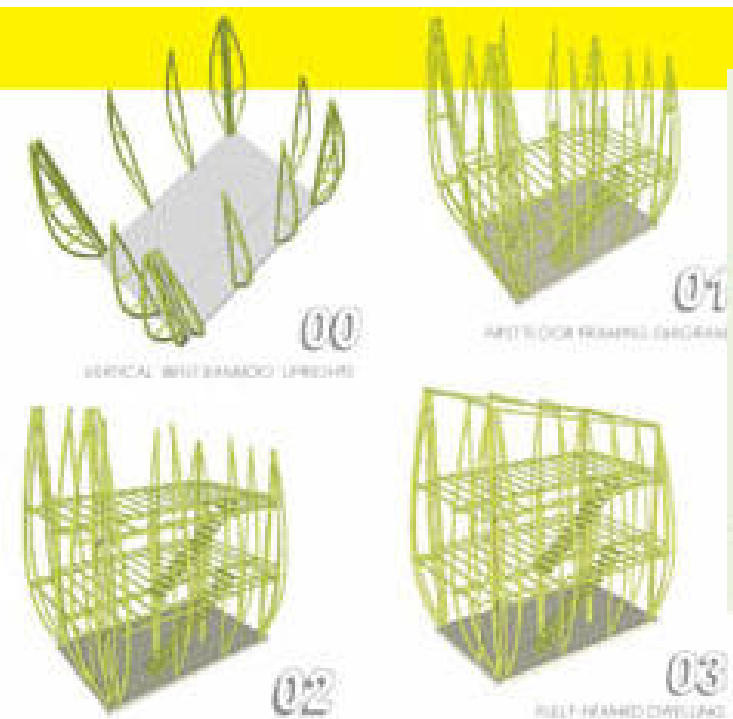


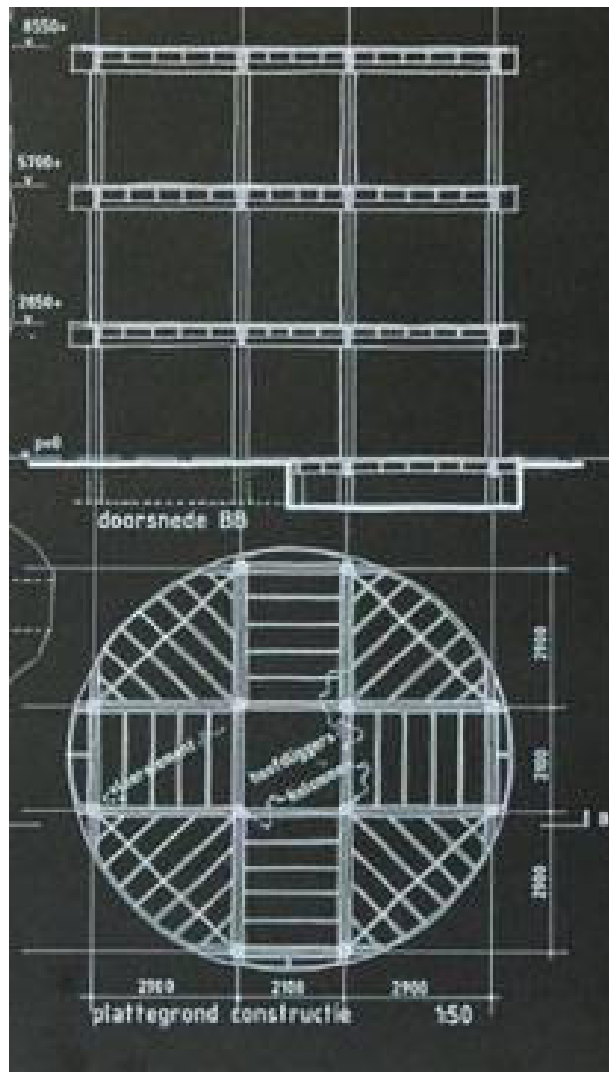
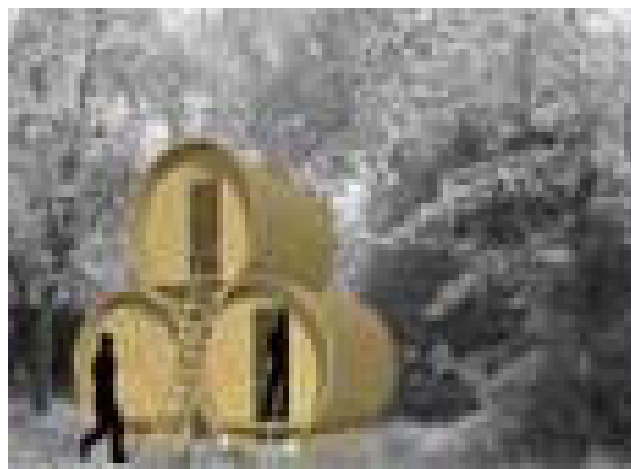
Viviendas Hogar de Cristo Ecuador

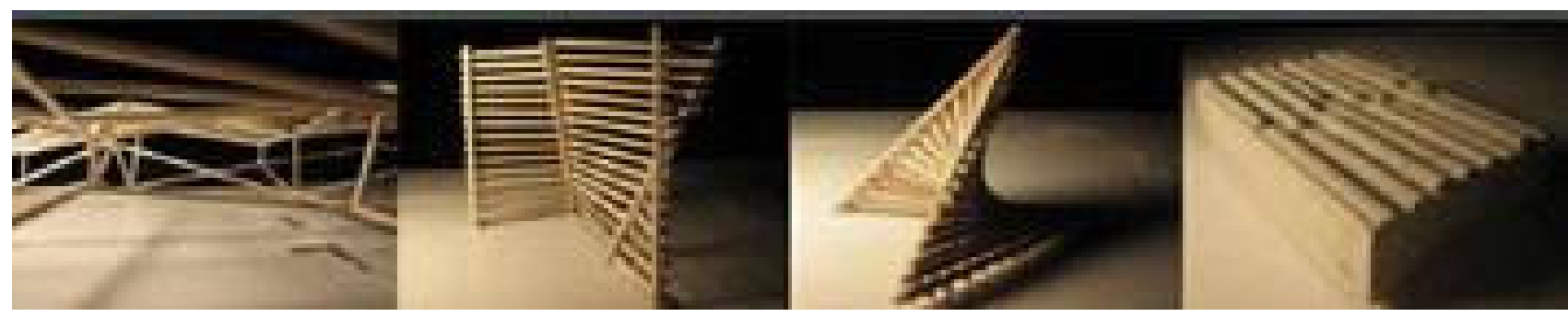
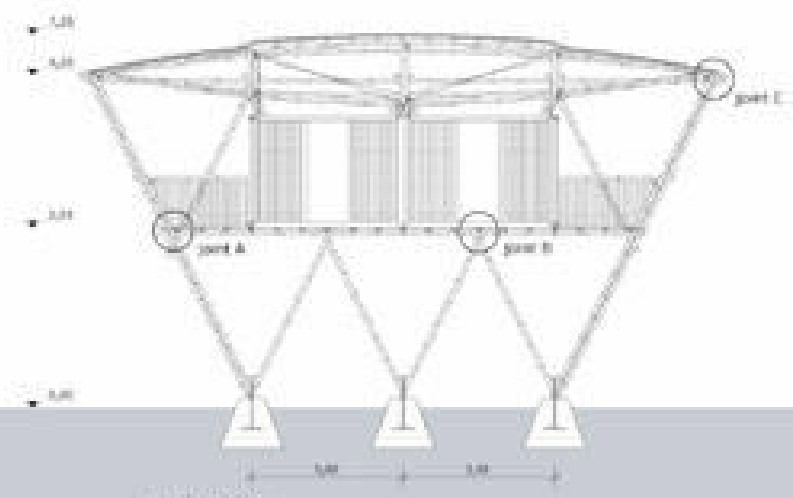
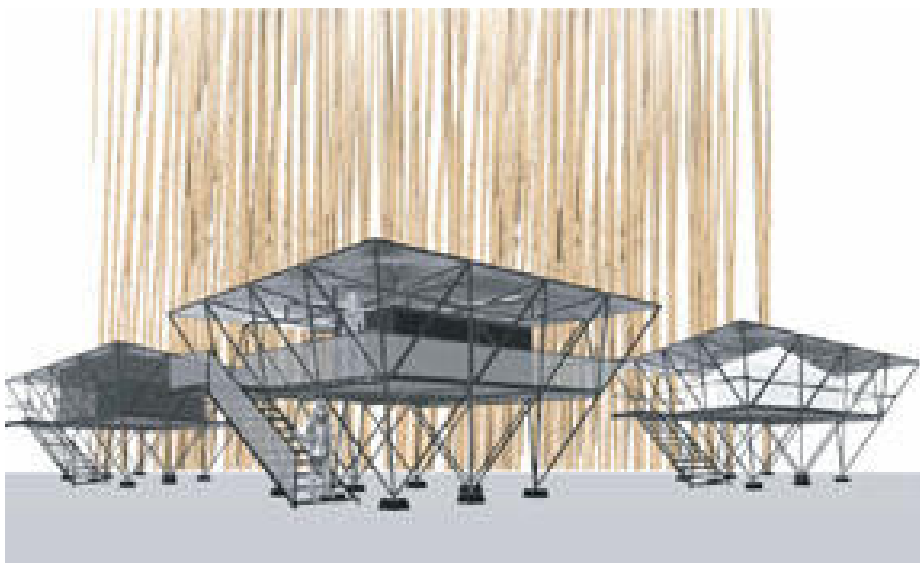


Proyectos de estudiantes

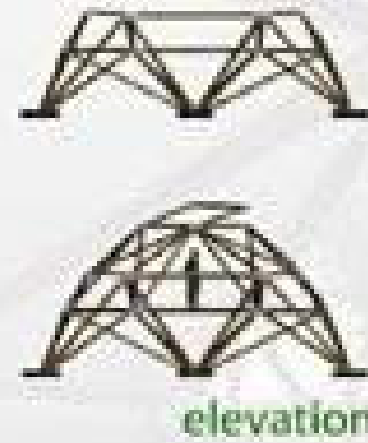
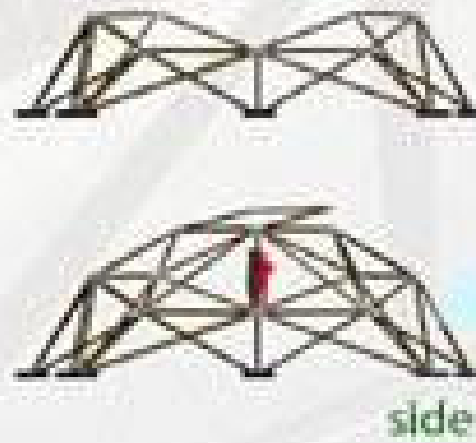
Primer Concurso Internacional de Construcción con Bambú, 2007
Red Internacional del Bambú y el Ratán (INBAR)



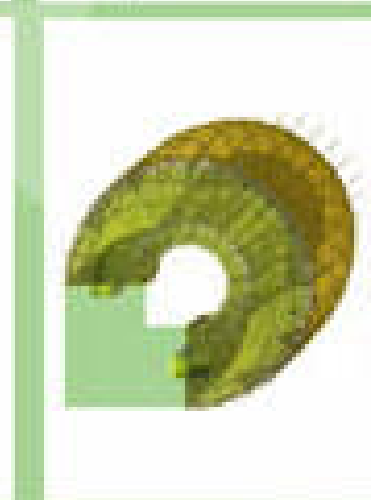
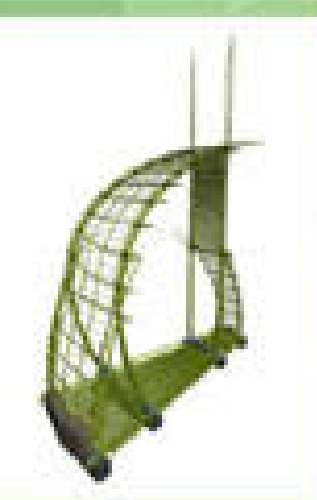
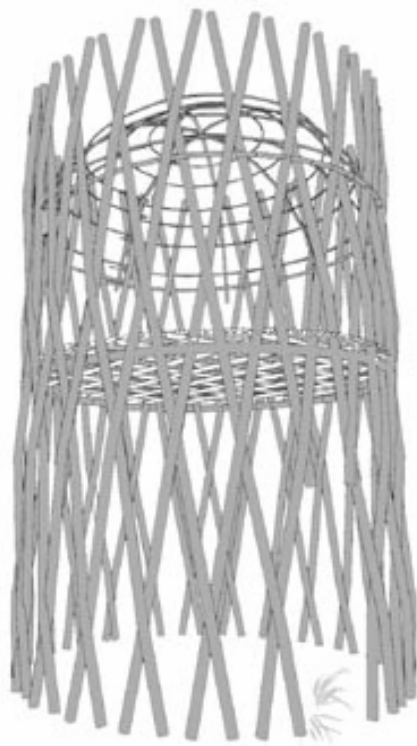
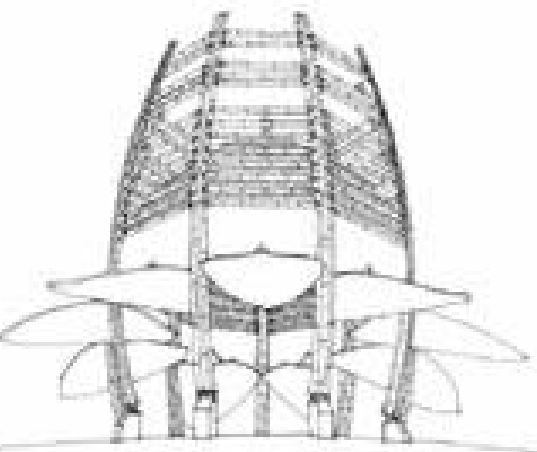
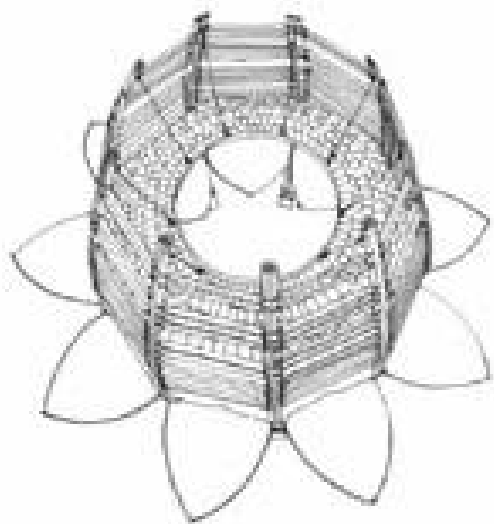
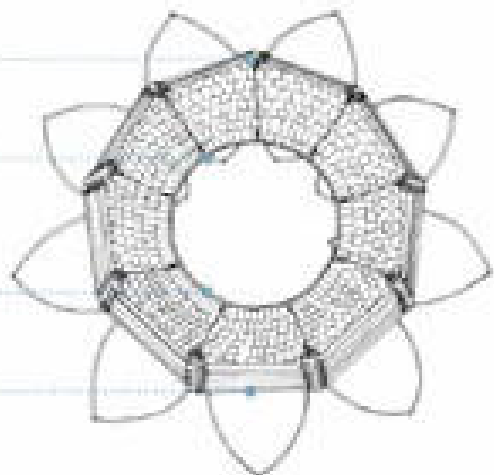


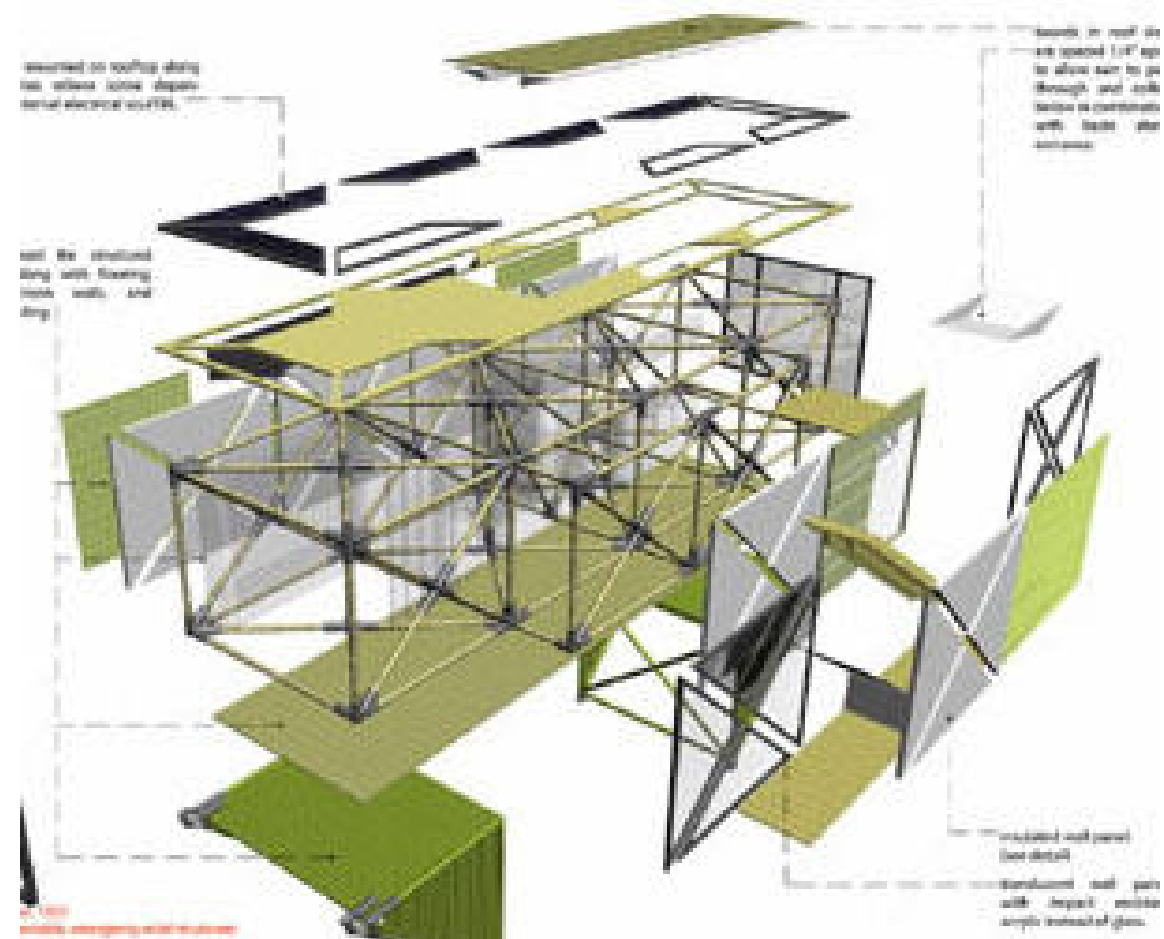














Construction Diagram



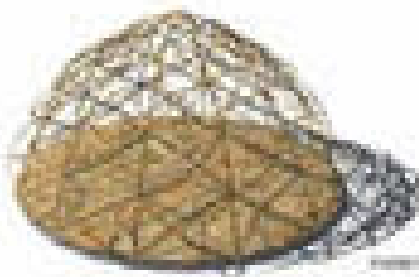
1 The foundation is poured



2 Floor is constructed



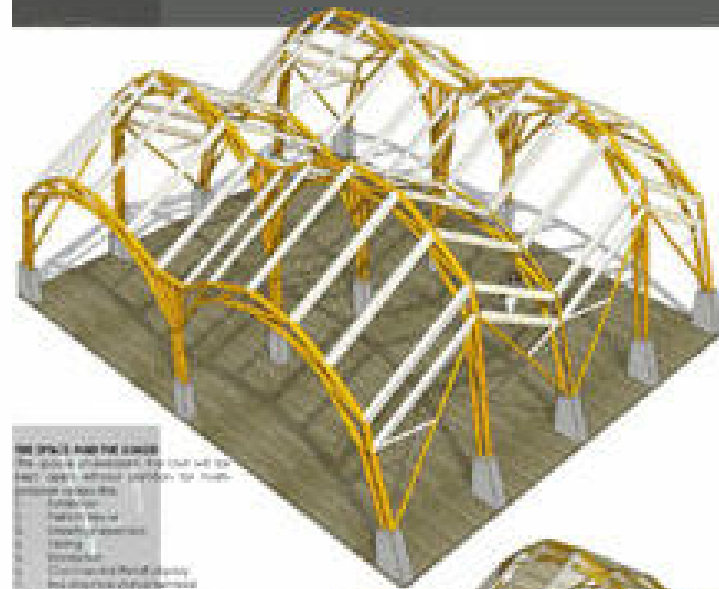
3 Structure raised & constructed



4 Working material is fixed



5 Covering skin imposed



THE (PVC) SKIN AND GLASS

The glass is placed on the floor and the PVC is placed on top of it.

- 1. PVC is placed on the floor
- 2. Glass is placed on top of the PVC
- 3. The structure is raised
- 4. The structure is constructed
- 5. The structure is raised
- 6. The structure is constructed
- 7. The structure is raised
- 8. The structure is constructed
- 9. The structure is raised
- 10. The structure is constructed

MODULAR SYSTEM & DIMENSION

The structure is made of modular units. The units are made of wood and are connected by a network of poles.

The structure is made of modular units. The units are made of wood and are connected by a network of poles.

CONSTRUCTION OF POLES

- 1. The poles are made of wood
- 2. The poles are connected by a network of poles
- 3. The poles are connected by a network of poles
- 4. The poles are connected by a network of poles

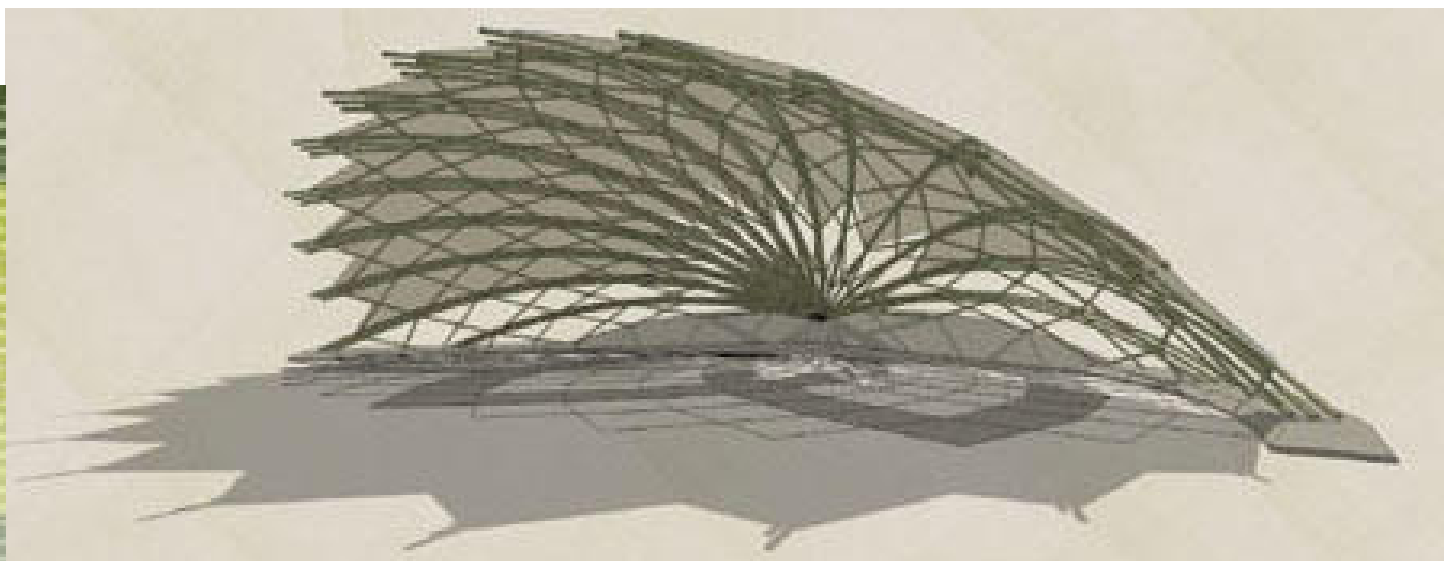
DETAILS

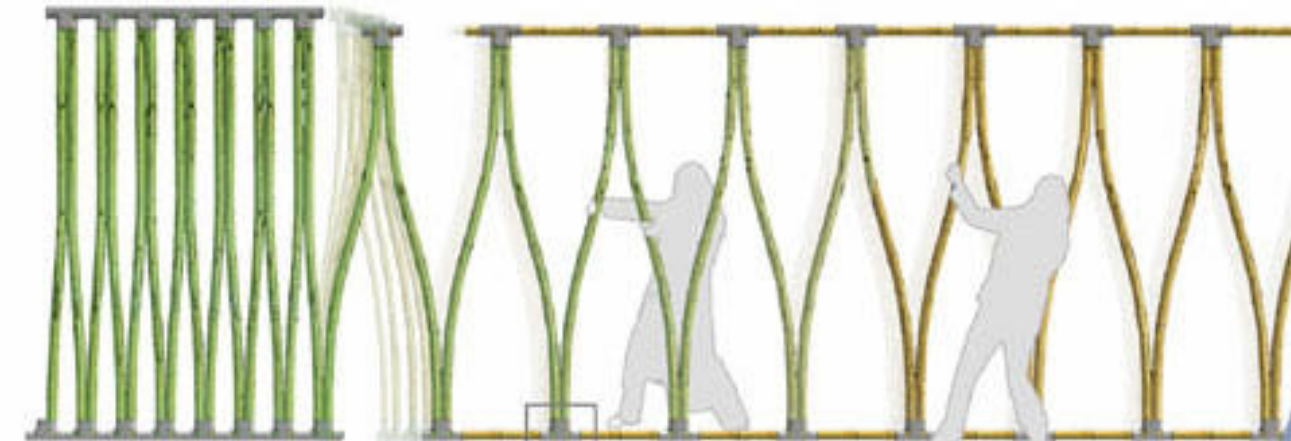
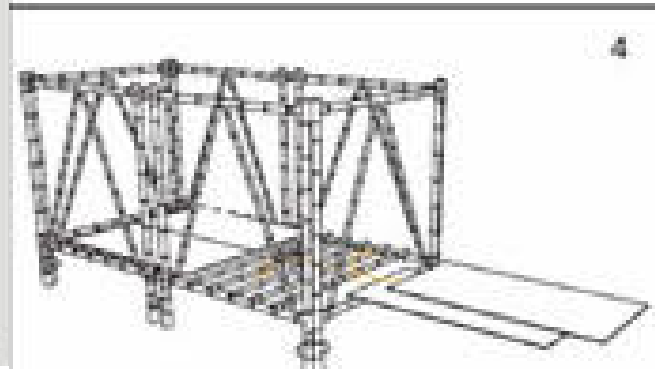
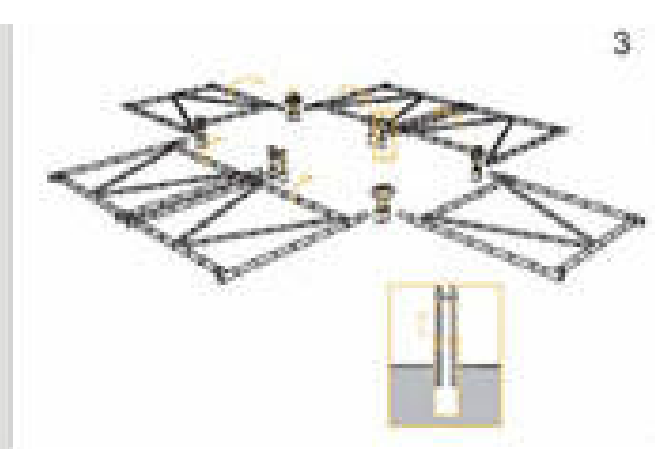
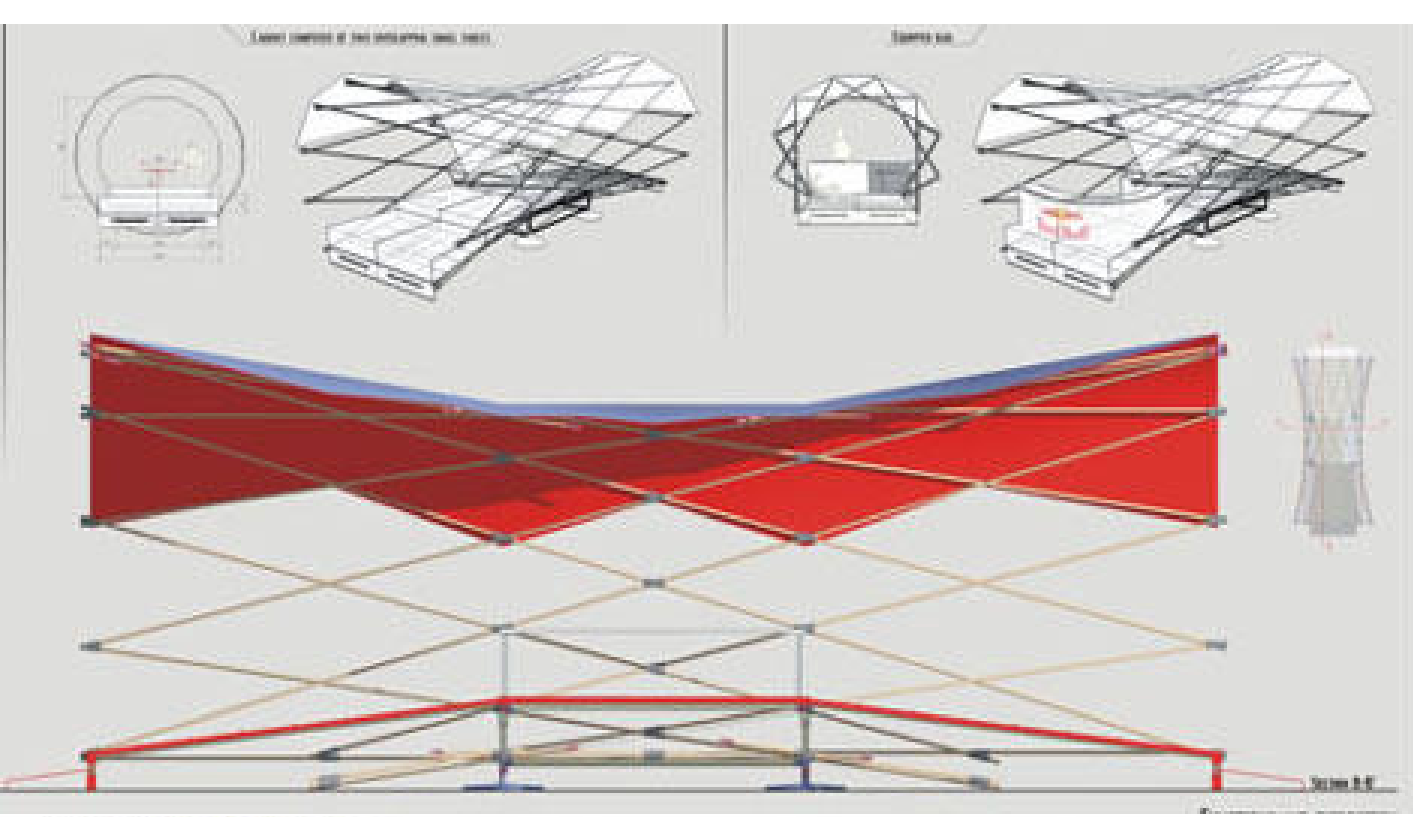
- 1. The details are made of wood
- 2. The details are connected by a network of poles
- 3. The details are connected by a network of poles
- 4. The details are connected by a network of poles

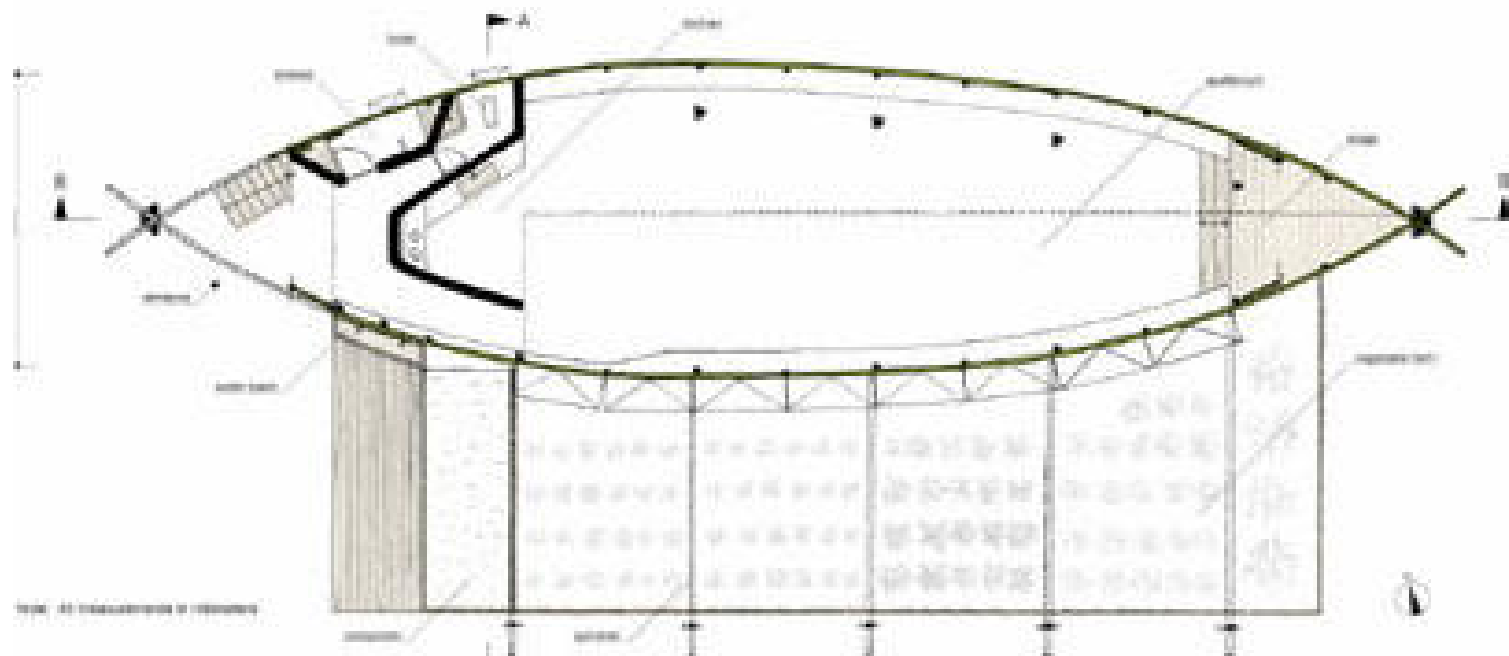


CONSTRUCTION
DETAIL

A V I L I O N
ARCHITECTURE







Construction Procedure

