Dr.-Ing. Stephan Schütz

Bauhaus-Universität Weimar, Germany

Folded Cardboard Sandwiches for Load-bearing Architectural Components

Experimental research on paper-like building components

WORLD SBE HONG KONG 2017
WORLD Sustainable Built Environment Conference
Organisers:
CONSTRUCTION INDUSTRY COUNCIL 建造業議會
HKGBC 香港綠色建築議會
International Co-owners:
SBE SERIES
iiSBE
Sustainable Buildings and Climate Initiative
FIDIC
Global Alliance for Buildings and Construction

MATERIAL

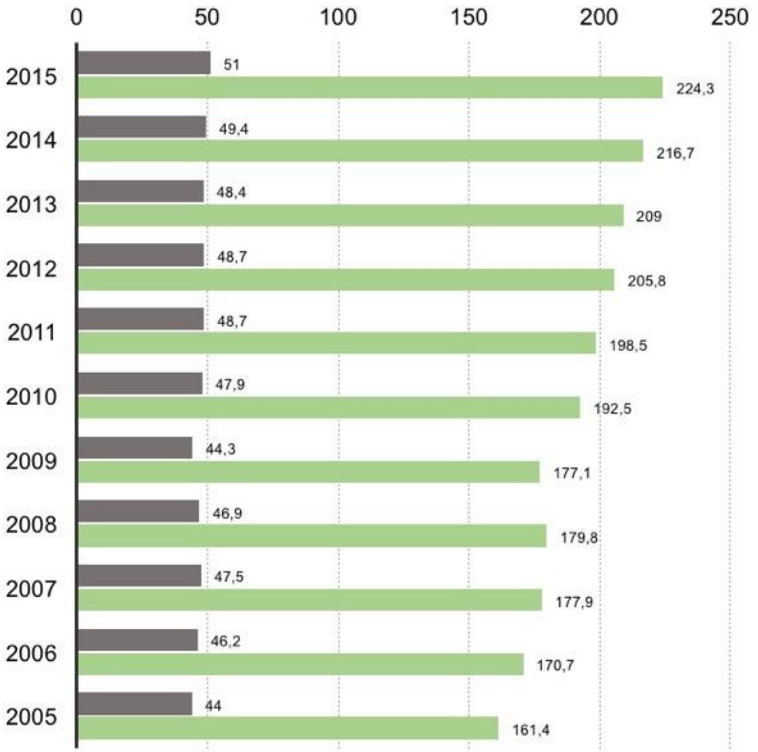
Characteristics of corrugated cardboard panels:

- highly developed
- produced worldwide
- cheap to manufacture
- light in weight
- easy to recycle
- very sustainable
- foldable after preparation

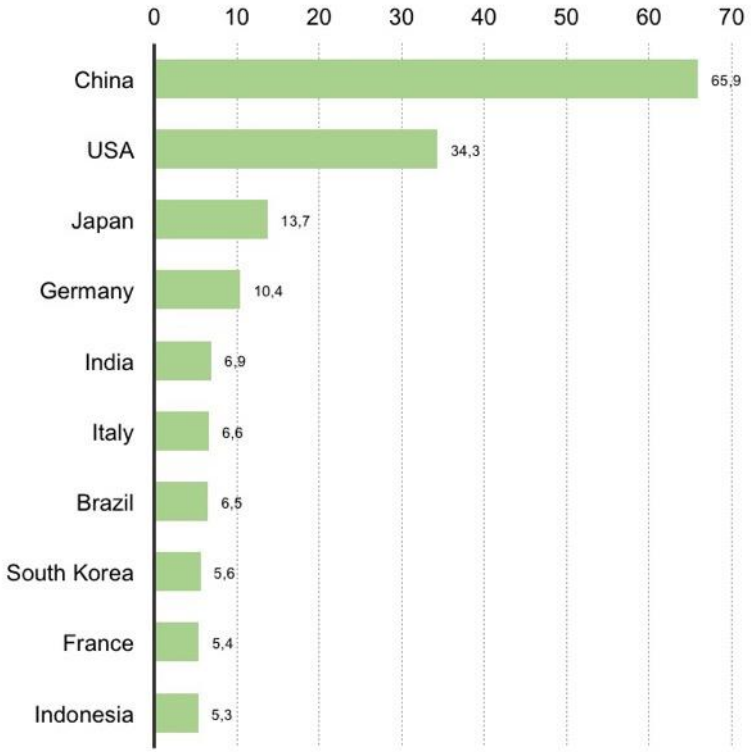
Credit: VDW Germany, 2017

Corrugated Cardboard Production in billions of m²

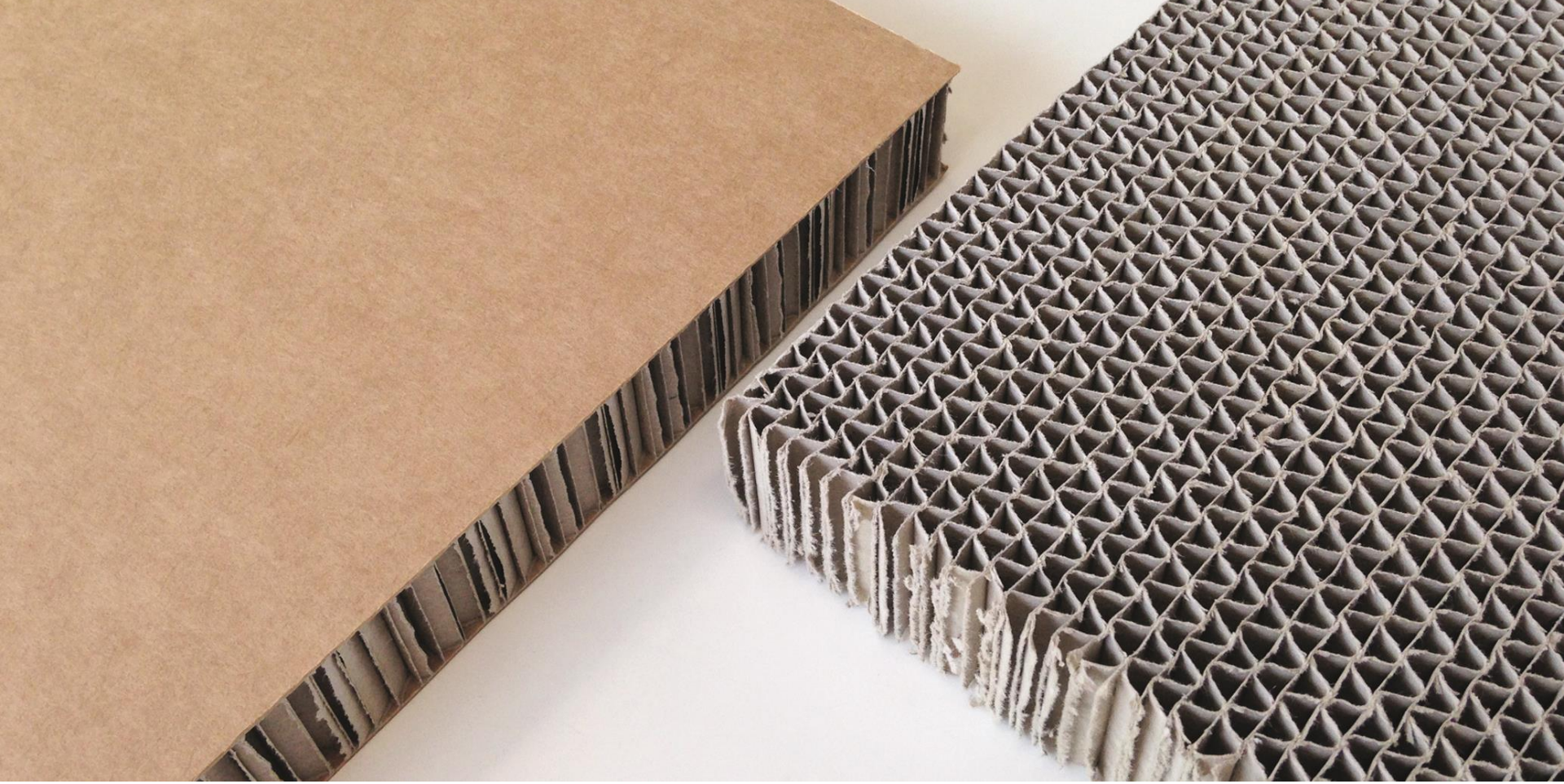
Europe / Worldwide 2005 - 2015



Output by Country



Source: Statista, 2017



SWAP Panel: Laminated and unlaminated corrugated cardboard panels

Thickness: from 5 to 100mm

FOLDING

Advantages of folded elements:

- Increased stability compared to flat elements
- Easy assembling of several parts by plugging or gluing
- Substitute for wooden parts
- Material saving due to additive construction
- Adaptability to the building geometry
- Free design possibilities

Normal folding with compressed surface

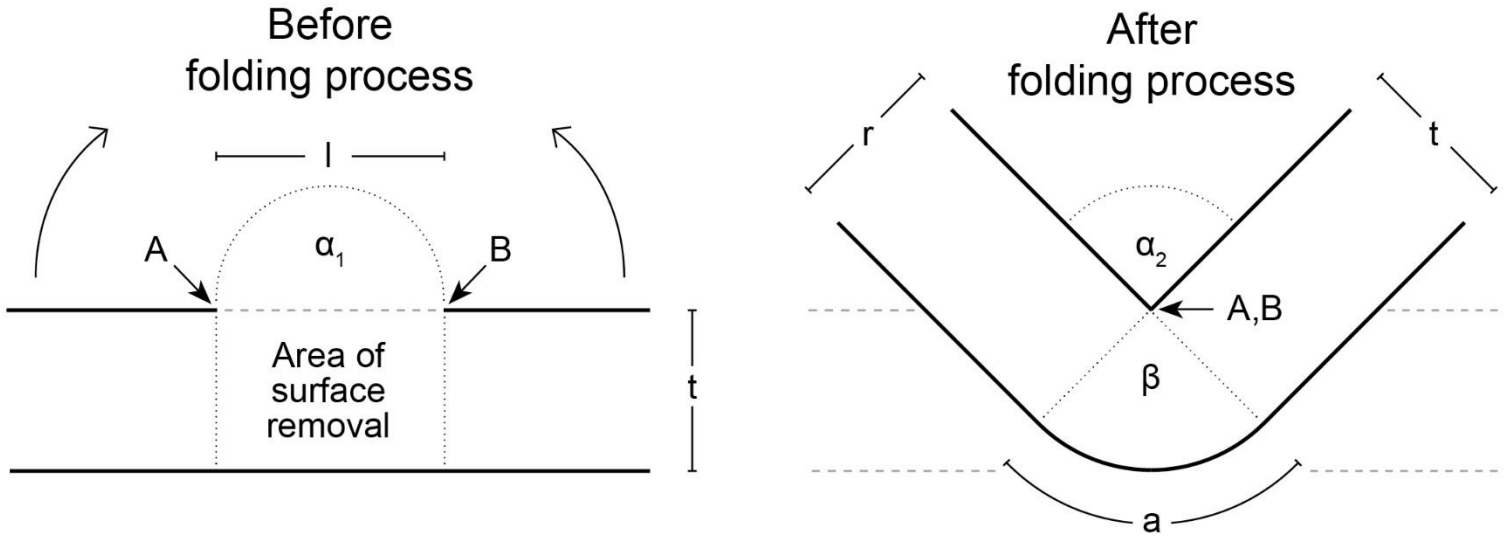
Folding after removing of a stripe-like part of the inner surface

Normal folding with compressed surface

Folding after removing of a stripe-like part of the inner surface

GEOMETRY

Geometrical connections

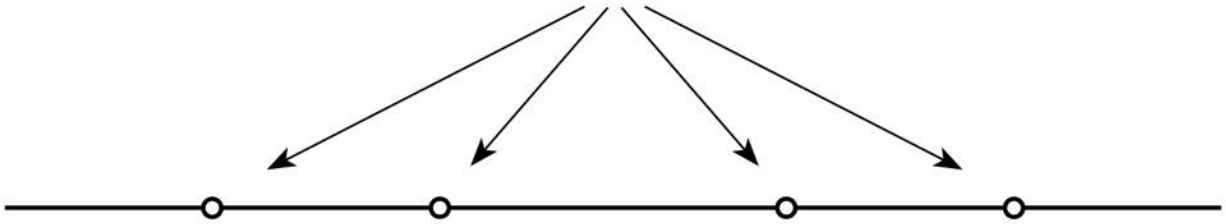


The paper removal (l) corresponds to the arc length (a)

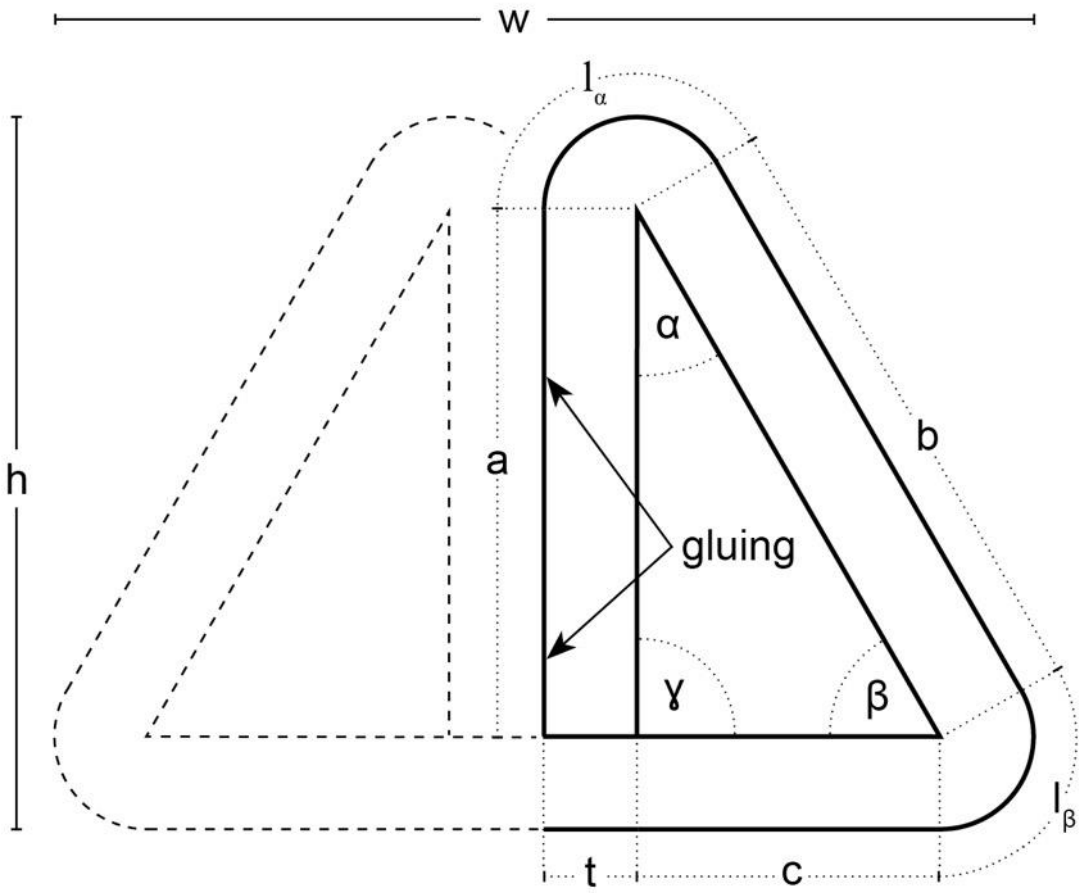
Lenght of surface removal = π * material thickness * quotient of β and 180°

Schematic folding process of a triangular element

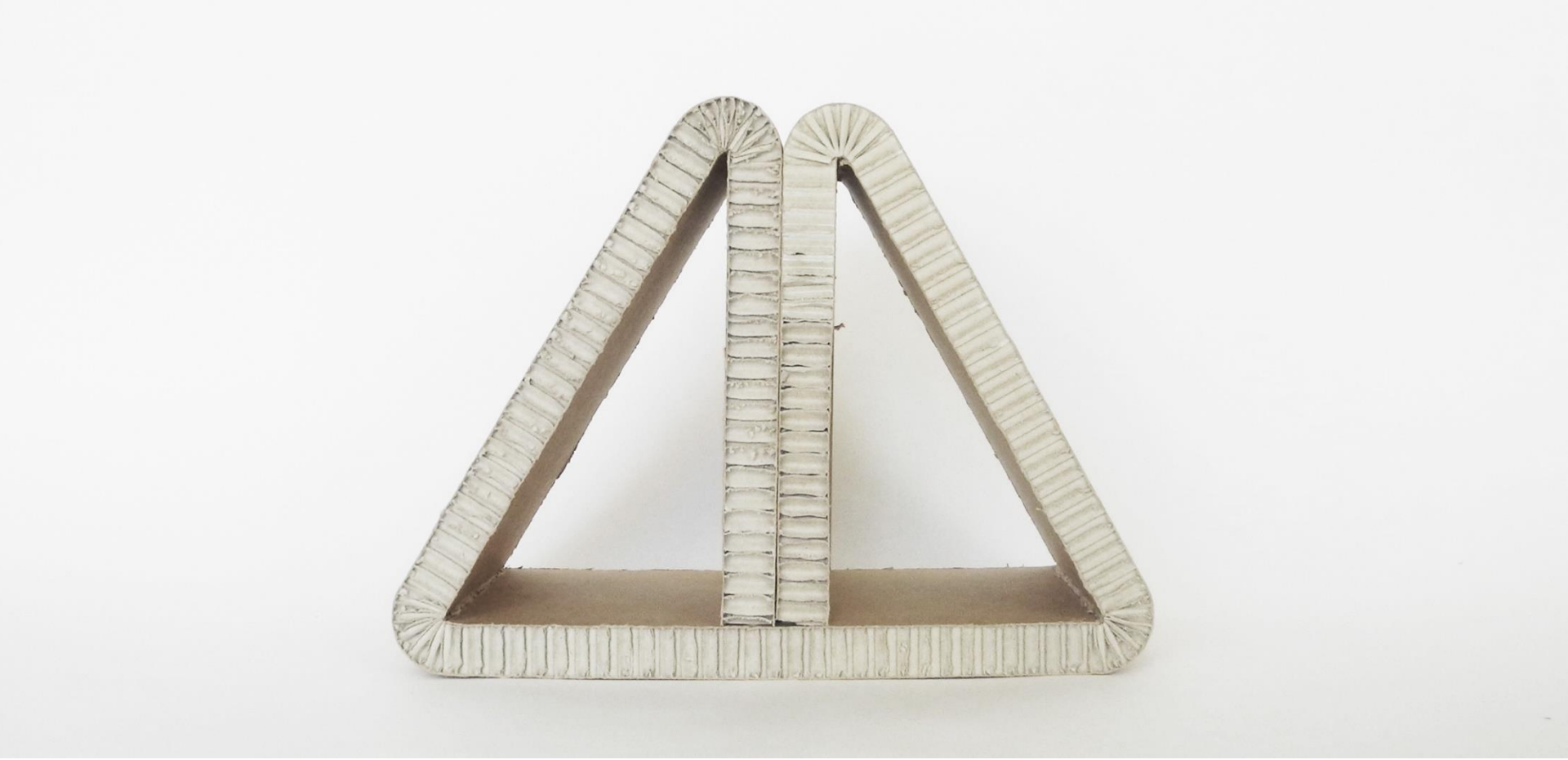
a) Flat sandwich plate with areas of surface removal



Example of a triangular component and ist segments



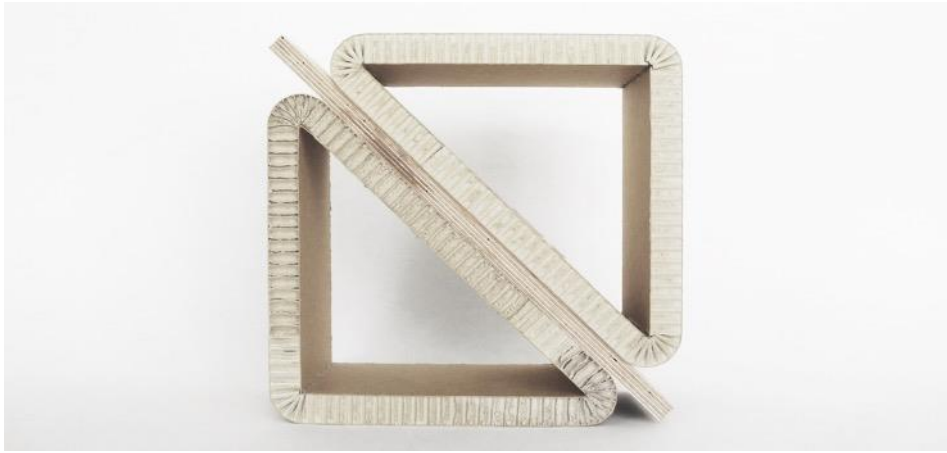
PROTOTYPES



Section model of a folded load-bearing element with triangular shape

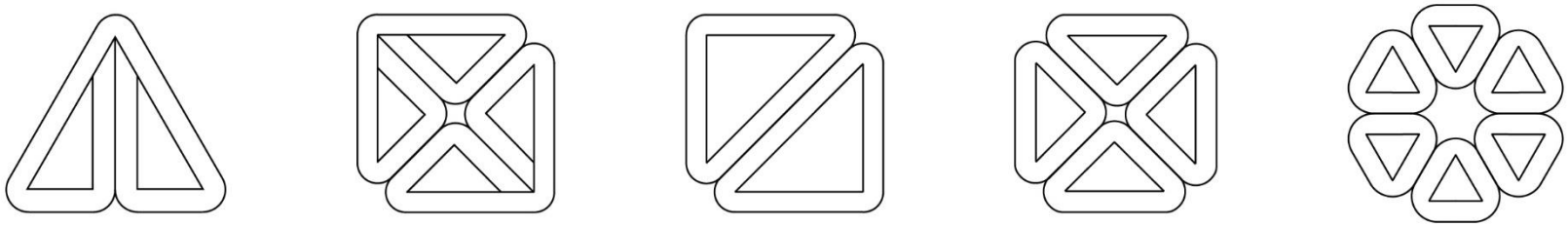
Variations based on a triangular shape (hybrid with inlaid wooden element)

Section model of a folded load-bearing element with rectangular shape

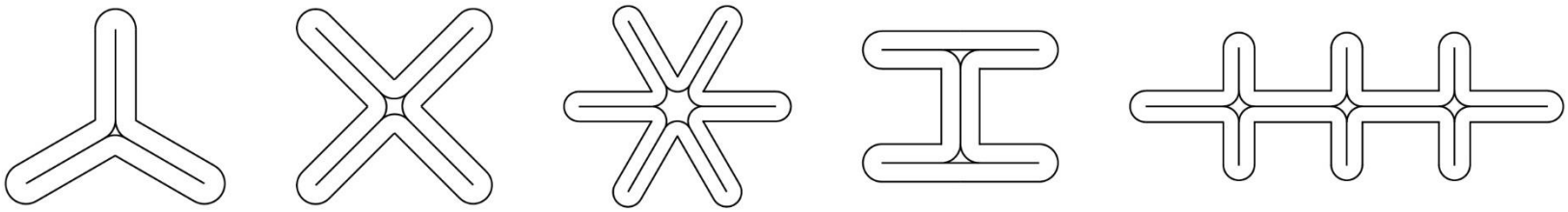


Variations based on a rectangular shape (hybrid with inlaid wooden element)

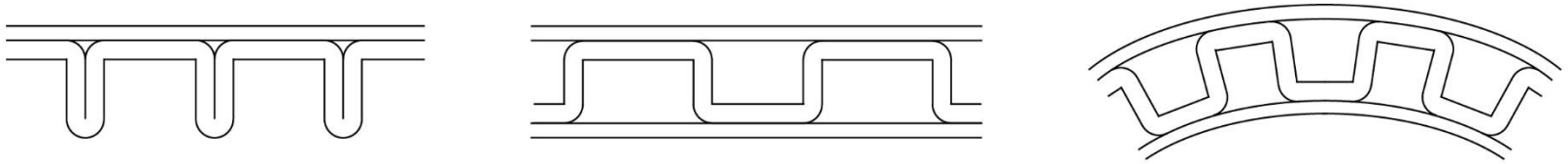
PILLARS AND BEAMS



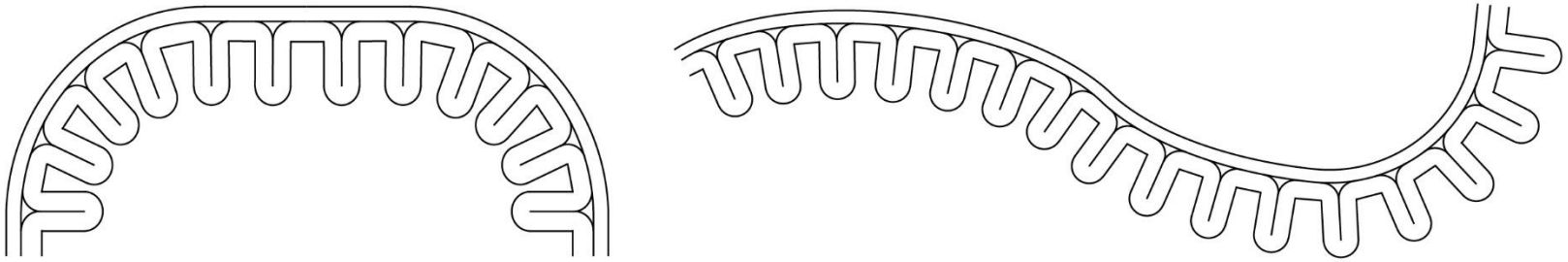
Pillars: Single and combined hollow profiles



Pillars: Double material profiles with different axes (material in force direction)

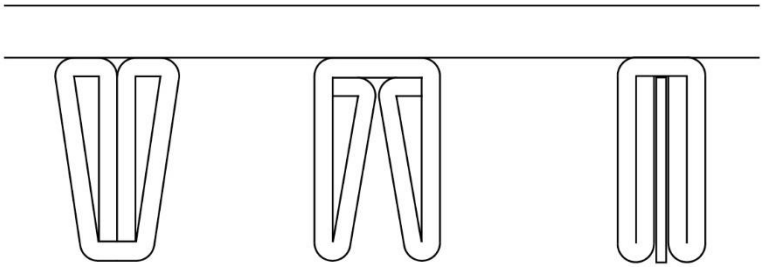


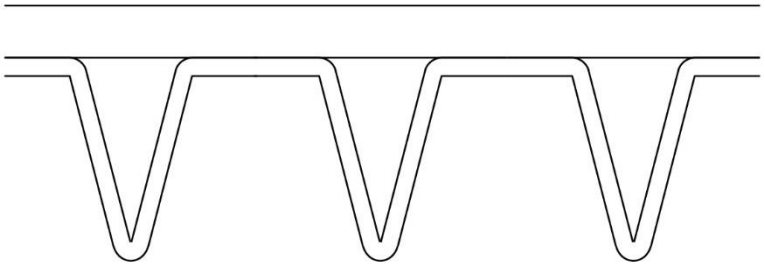
Walls: Single faced element, double faced sandwich, curved sandwich



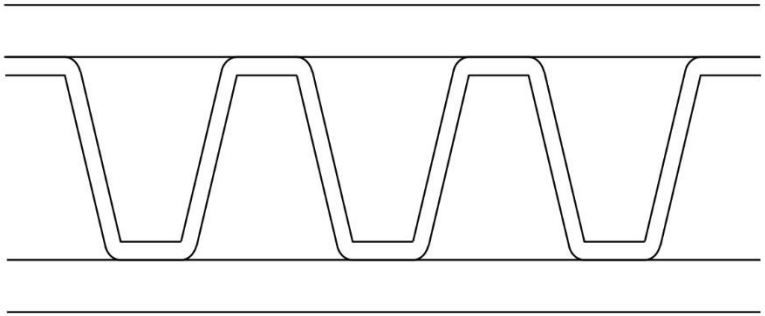
Walls: Single and double curved elements

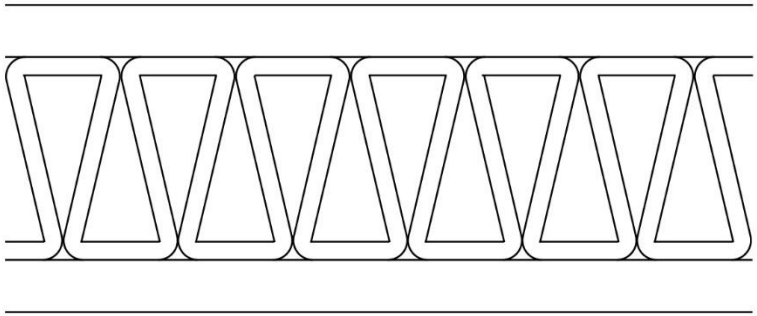
CEILINGS





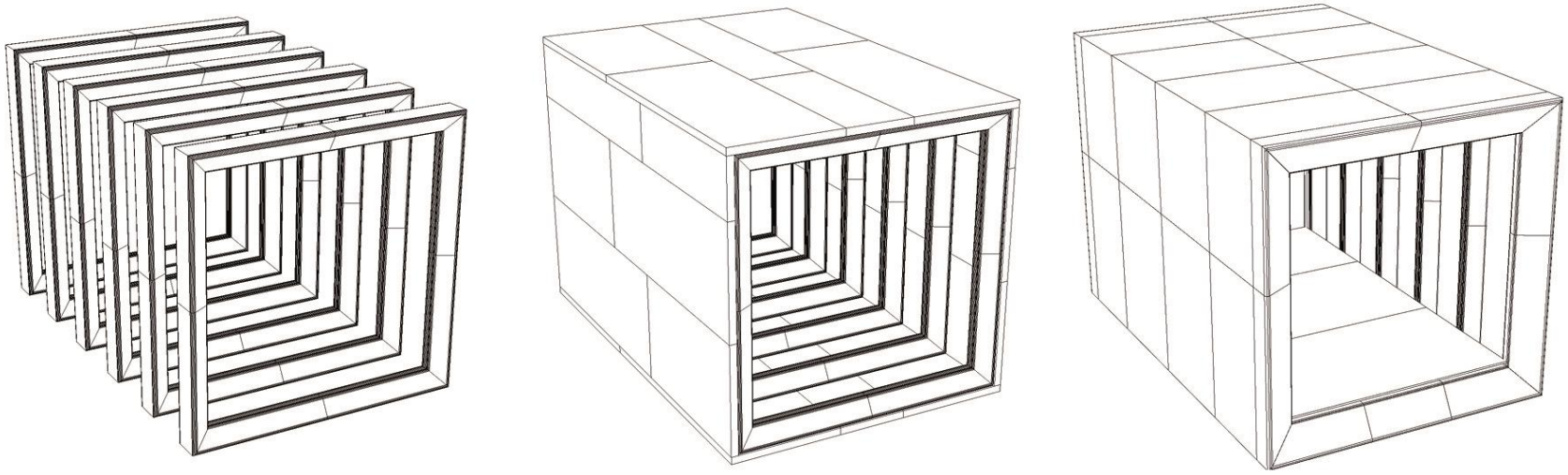
Ceilings: Single horizontal beams and continuous ribbed slab



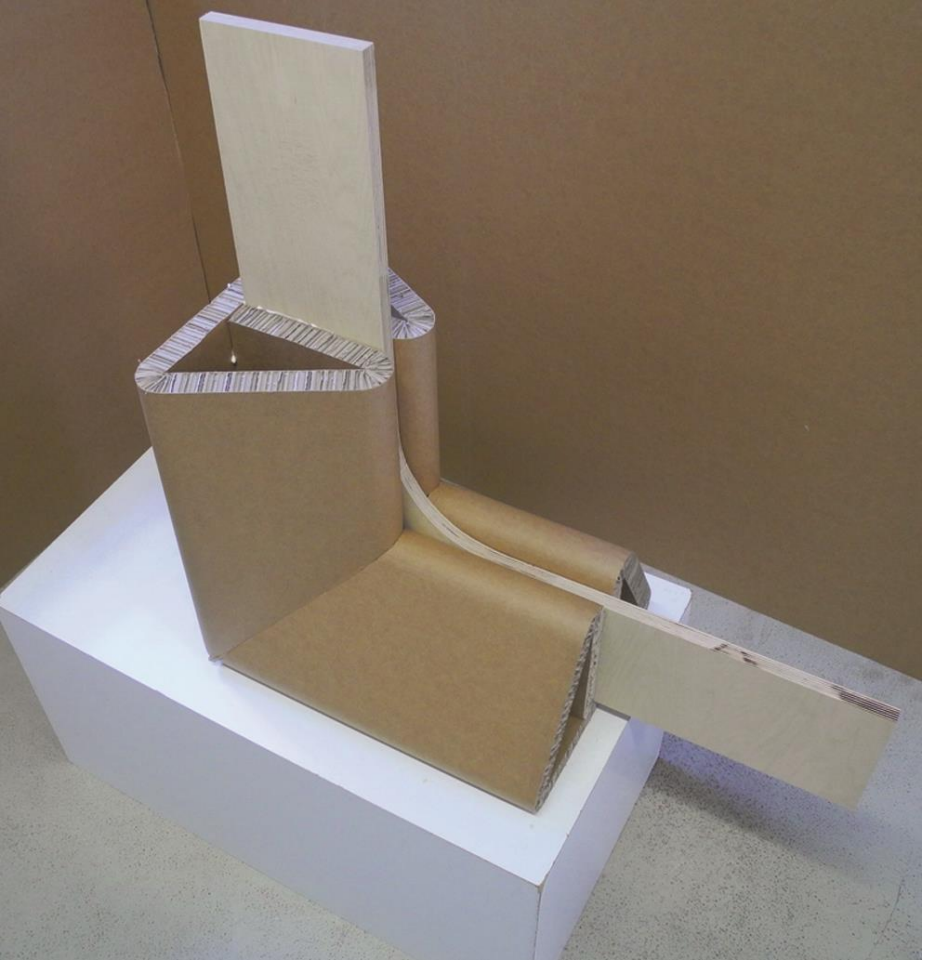


Ceilings: Sandwiches with sheet pile design and triangulated core

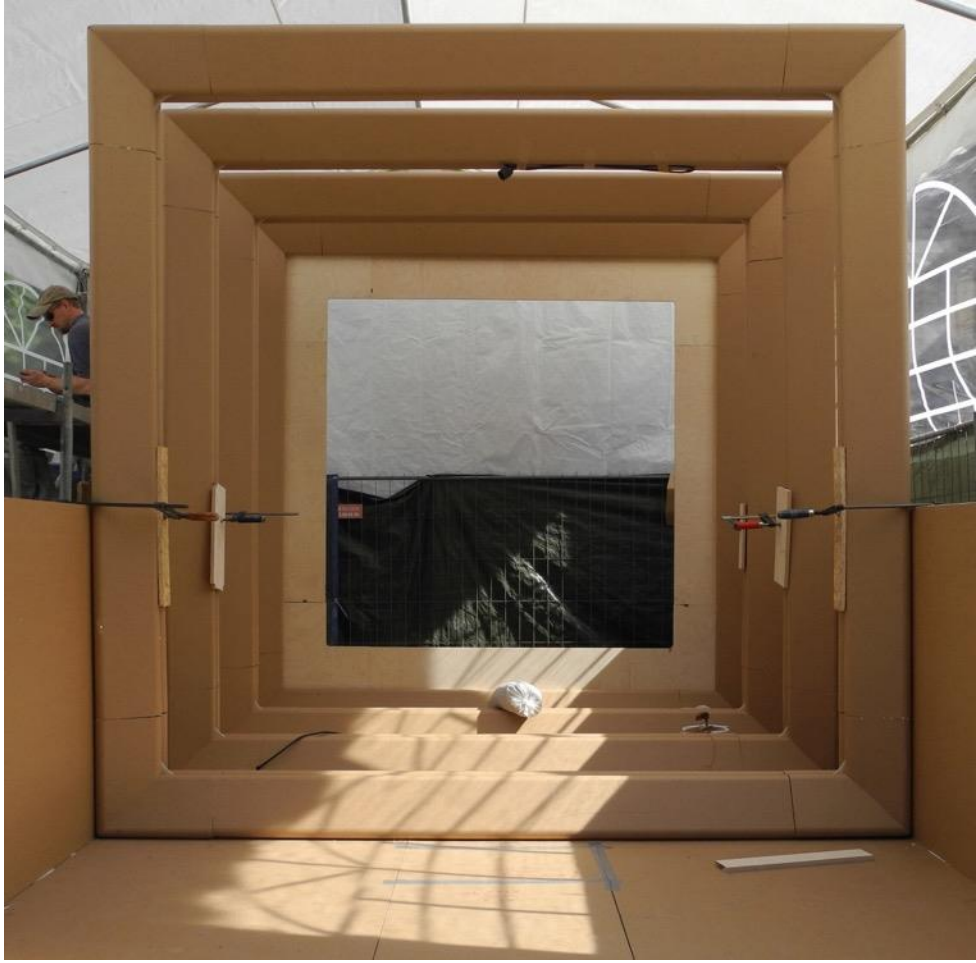
EXPERIMENTAL BUILDING



1. Load-bearing frames made of folded cardboard panels
2. Cardboard panels for isolation and cladding of a ventilated facade
3. Two-component sealing as protection against rain



Frame corner with wooden connector



Frames on construction site

Finished building with two-component sealing on the facade

West elevation with window made of prestressed ETFE foil

Interior

Structural system

THANK YOU!