Studio Anne Holtrop

ETH Zürich

design studio FS20

MATERIAL GESTURE:

WEAVING AND BONDING

CONTENTS

MATERIAL GESTURE:

WEAVING AND BONDING

We currently live in a geological age called the Anthropocene Epoch, in which humans are the primary cause of permanent planetary change. Our interest in the Anthropocene Epoch centres around the invention of materials that did not exist before as they cannot be found in nature. For this semester, we focus on man-made materials that are synthesized from naturally found oil.

The development of synthetic materials, commonly misunderstood as plastics, began alongside the production of oil as a fuel. In 1907, Bakelite, the first truly synthetic plastic, was invented. Marketed as “the material of a thousand uses,” Bakelite could be shaped or molded into almost anything. After the Second World War, many architectural experiments were conducted, fully embracing the new materials and their possibilities. In 1956, Alison and Peter Smithson made a complete plastic interior for their House of the Future. In the movie The Touchables (1968), a large transparent pneumatic dome featured as the house of a rock star. In the late 1960s, the Finnish architect, Matti Suuronen, made the Futuro, which could be ordered anywhere in the world as a weekend house. The first plastic age in architecture ended with the oil crisis in 1973.

Nowadays, plastics are still used in almost every aspect of our consumption and have become a huge problem in recycling. A large portion cannot be recycled and sinks back into our earth. Geologists have identified new kinds of stone, known as plastiglomerates. The veins in these rocks are not formed by metal or quartz, but with plastic.

In building construction today, we see plastics and bonding materials in many applications. They are in MEP installations, in all kinds of foils, in glues as bonding materials, or composite boards, in window and door frames, and in sheet materials, to name a few. However, unlike in the '50s–'70s period, synthetic materials are less embraced and researched as being a significant defining element of architecture.

The aim of this studio semester is to rethink the applications of plastics with the knowledge of contemporary research done in advanced synthetic textiles, composites and bonding materials. We will engage with research conducted at the ETH, such as Mariana Popescu's on pre-stressed fabric formwork principles. We will visit companies such as EMPA, Oerlikon and 3M in Switzerland, that are focused on advanced fibers, polymer processing, and adhesive materials and foils, respectively.

Through the theory of Gottfried Semper, we will look back at textiles in the pre-oil era, which were used as a bonding material to string and bind, and as woven material to cover, to protect and to enclose.

DESIGN STUDIO

When we take all aspects of the material into consideration – the geology, the sourcing, the industry, the different properties, the craftsmanship, the specialised techniques, and the cultural significance – we can deploy the full potential of the inherent qualities of the material itself and our way of working it in what we call MATERIAL GESTURE.

In this design studio, you will define your gestures of making and working with material(s) through research and experiment, and in response to the topic of the studio. You are required to produce an architecture that results from your specific engagement with the material and the spatial condition you construct with it. The architecture that results from this approach does not reference or represent something, but simply attempts to exist as a physical spatial reality in its own right.

Your research should be supported by the knowledge made available by our studio, and engaged through you with the use of available resources and facilities at departments of the ETH and specialists / fabricators from outside.

Throughout the whole semester, and for your final presentation, we require that you work with physical (fragment) models of your building in the actual material(s). It is important in this design studio, not to make a complete building, but to show and support the found values of the material engagement in a spatial way, based on the full potential of the inherent qualities of the material itself and your way of working it.

ASSIGNMENT

In this studio, we will work in a workshop and laboratory-like setting where you will research, design and test the proposed material. The material and the ways of making are not a presentation outcome of the design studio but rather, an integral part of a process of working, researching and designing. You are required to work individually in the design studio.

There is no given program for the space. This can be chosen at any time in the development of your project, and should support the spatial and material conditions that you have set out.

For the final presentation, you are required to make a physical model of your work, or a fragment of it, in a scale of 1:15. The model should show the material and the gestures (the ways of making) and the specific spatial condition it constructs. This is the key element of your presentation, along with samples of the material research and test models. You are required to display the material gesture research, drawings of the project, and photos of the model alongside your model on portrait A2 sheets.

The A2 material will be collected in print and digitally in PDF format for the material gesture archive. A semester result book will be made after the presentation. Of a selection of a maximum of three projects, the models and material research will be crated and archived for future exhibitions.

SCHEDULE

INTRODUCTION

FEB 18, 10–18 h & FEB 19, 9–13 h

On the first day, we will give an introduction on MATERIAL GESTURE and the specific topic of this design studio. We will take an excursion to visit Swiss laboratories that are carrying out research for the development of innovative synthetic fibres as well as companies that are specialised in the production of industrial adhesives and high performance glues for a wide spectrum of applications. On the second day an invited guest, Mariana Popescu, will give an introductory lecture on the fabric formwork research she conducted with the Block Research Group.

STUDIO WEEK 2

FEB 25 & 26, 9–18 h

with Stephan

FIRST REVIEW

MAR 3, 9–18 h & MAR 4, 9–13 h

Research and First Experiments.
You will present the material research and the first experiments with the material and ways of making. A first architectural spatial element, think of a column, a room, a window, a floor, a roof, a wall, etc, should be made in a scale of 1:15 and should relate to the material engagement. In this review, your material research will be discussed, and you will have to present the sources and the specialists/ETH departments involved that are essential for your research. The material research and experiments are documented through photography, material samples, writing, and drawing.

STUDIO WEEK 4

MAR 10 & 11, 9–18 h

with Stephan

SEMINAR WEEK

MAR 16–22

During our trip to the Kingdom of Bahrain, we will visit the Pearling Path, which comprises the coral reefs and oyster-beds, the pearl diving and trading culture, and traditional buildings. We will see new architectural projects that have been added to rehabilitate the old city,

such as the Visitors Centre by Valerio Olgiati, the Dars and Public Squares by Office Kersten Geers David Van Severen, the Search Library by Atelier Bow-Wow, the Parkings by Christian Kerez, and ongoing and recently completed projects by Studio Anne Holtrop, such as the Qaysariya Suq and the Siyadi Pearl Museum.

STUDIO WEEK 6

MAR 24 & 25, 9–18 h

with Stephan

SECOND REVIEW

MAR 31, 9–18 h & APR 1, 9–17 h

Space. You will be required to present an architectural space that fully exploits the material gesture in a spatial way. We will discuss the architectural articulation and cultural significance in relationship to the material research and ways of making. For this review we invite guests whose expertise is related to the topic. One of them will be Mariana Popescu.

STUDIO WEEK 8

APR 7 & 8, 9–18 h

with Stephan

EASTER HOLIDAYS	**APR 10–19**
THIRD REVIEW	**APR 22, 9–18 h** Structure. We will continue our discussion of the previous reviews and aspects of your work together with the structural aspects, construction techniques and organisation. Our guest will be structural engineer Mario Monotti, Professor of Structural Design at the Accademia di architettura in Mendrisio, Switzerland.
STUDIO WEEK 11	**APR 28 & 29, 9–18 h** with Stephan
FOURTH REVIEW	**MAY 5, 9–18 h & MAY 6, 9–13 h** Full Preview. The aim of the fourth review is to have a semi-final presentation of your project. The minimum requirements are: introductory text that explains the concept of the project, drawings of a site plan, floor plan, and technical horizontal or vertical section, (fragment) model of your work with the chosen material(s), material experiments, and photography. It is important to show and support the found values of the material

engagement in a spatial way based on the full potential of the inherent qualities of the material itself and your way of working it.

STUDIO WEEK 13	**MAY 12–13, 9–18 h** **with Stephan**

STUDIO WEEK 14	**MAY 19–20, 9–18 h** **with Stephan**

FINAL PRESENTATION	**27 May, 9–20 h** **Together with the all the assistants, you will work on the final presentation with an exhibition of the final models, material samples and A2 drawings and photos. One of our guests will be Smiljan Radić.**

GUESTS

MARIANA POPESCU

She is post-doctoral researcher at the Block Research Group (BRG) at the Institute of Technology in Architecture at ETH, involved in the NCCR Digital Fabrication. Popescu is an architect with a strong interest in innovative ways of approaching the fabrication process and use of materials. She studied architecture at the Delft University of Technology, before obtaining her PhD at the BRG in 2019. Her research focuses on the development of KnitCrete, a novel, material-saving, labour-reducing, cost-effective formwork system for casting of doubly-curved geometries in concrete using 3D knitting. She is the main author of the award-winning KnitCandela shell and has been included in the MIT Technology Review Innovator Under 35 list in 2019.

MARIO MONOTTI
(Locarno, 1975)

He graduated from Zurich Polytechnic with a degree in Civil Engineering and subsequently, earned a PhD in Technical Sciences where he focused his research on the plastic analysis of reinforced concrete slabs. Since 2009, he has held the position of Professor of Structural Design at the Accademia di architettura in Mendrisio, Switzerland. He is also the founder and owner of the Monotti Ingegneri Consulenti SA in Locarno. His company specializes in structural design in architectural contests in the public and private sectors on national and international levels. Mario Monotti works collaboratively with young architects. His name is associated with the school of Leutschenbach of C. Kerez (European steel design award 2011), the House on Two Pillars of C. Scheidegger and J. Keller (Betonpreis 2017), the National Pavilion of the Kingdom of Bahrain for Expo Milano 2015 of Anne Holtrop and many other project and exhibition pavilions.

SMILJAN RADIĆ
(Santiago de Chile, 1965)

He graduated from the Catholic University of Chile's School of Architecture in 1989 and undertook further studies at the Istituto Universitario di Architettura di Venezia, Italy. He opened his own architecture firm in Santiago de Chile in 1995. He was selected as the best architect under 35 by the College of Architects of Chile in 2001; he was

given the Architectural Record's Design Vanguard award in 2008; named honorary member of the American Institute of Architects, USA, in 2009; in 2013, 2015 and 2018 he obtained the award for best Chilean Building, by Universidad Mayor, Chile; in 2015, the Oris Award, Croatia; in 2018 the Theater Bio Bio was nominated as one of the best building by Architectural Record's Design Vanguard and in 2018 he obtained he Arnold W. Brunner Memorial Prize of the American Academy of Arts and Letters, USA. Radić was selected to design the 2014 Serpentine Gallery Pavilion in London. He is the president of Fundación de Arquitectura Frágil. The aim of the foundation is to promote the study and dissemination of experimental architecture or that of an improbable reality, where the boundaries of architecture are blurred. With a distinctive approach to form, materials, and natural settings, Radić mostly builds small- to medium-sized projects that deal with the notion of fragility often using artisanal production techniques, materials of different weight and density to contrast what is alterable from what is permanent. He currently lives and works in Chile, always in close collaboration with the sculptor Marcela Correa.

More guest critics of the midterm and final reviews will be announced during the semester.

HISTORY OF WEAVING (PRE-OIL PERIOD)

The German architect and writer on art, Gottfried Semper (1803–1879) wrote a theoretical book, Style in the Technical and Tectonic Arts, or, Practical Aesthetics (1860–62). Semper's interest in common primeval forms was a crucial part of his theory. In his book, Semper classified four artistic activities: 1. textile, 2. ceramics, 3. tectonic (carpentry), and 4. stereotomy (masonry) based on raw materials. The use of any technical product remains essentially the same at all times. It is dictated by universal human needs and is based on natural principles seeking formal expression that are valid everywhere and at all times. For example, Egyptian temples have their earliest beginnings in caves. The cave is also the basic architectural model for India, and Mongol tents are believed to have served as prototypes for curved Chinese roofs.

Here are some of his descriptions of materials and artistic activities, which relate to the topic WEAVING AND BONDING in pre-oil period:

THE STRING

The string is an articulation of a simple and therefore aesthetically neutral band and is probably the oldest artistic product. It is the first actual manifestation of the sense of beauty striving to bring about the expression of unity through multiplicity, to combine it in a eurythmic form.

THE COVER

The need for protection, cover, and spatial enclosure supplied some of the earliest inspiration for industrial invention. Human being first learned to recognize the essence and purpose of natural covers(shaggy animal skins, protective tree bark) and began to use them for their own ends according to their correctly perceived natural use. Later, they imitated them with synthetic weaving. The use of these covers is thus older than language. as a construction material as it is a renewable material made from natural fibres. It is also easy to repair.

TREE BARK

The skin of trees (their bark and bast) and skin of animals display a remarkable rapport that is doubly relevant to the question under discussion. Like a pelt, bark naturally suggests the idea of peeling the tree's natural cover and using it for purposes related to its original function. The natives of North America are perhaps the most advances in this field: they have developed a unique artistic style for their bark-and-leather canoes, highly original in both form and colour. In India, too, tree bark and bast were made into clothing fabrics from earliest times.

RUBBER USED FOR COVERING HOUSES

There is an important natural material that has only recently brought about a radical change in many areas of industry thanks to the remarkable flexibility with which it adapts and lends itself to every purpose. I mean gum elastic, or caoutchouc, as the Indians call it. It has the broadest stylistic range imaginable, as its natural sphere – imitation – has almost unlimited application.
It is, so to speak, the ape of useful materials. It is made from the milky sap of tropical plants: in the East Indies from Ficus elastics, in Java from varieties of theft tree, in Brazil and Central America from Siphonia elastica, in the Indian archipelago from Urceolaria elastica, a giant creeper. Only inthelast fifteen years has this material started to attract the attention of industrials, having previously been used more for gewgaws and for erasers as a construction material as it is a renewable material made from natural fibres. It is also easy to repair.

THE KNOT
→ 30–32

Rope makers and boatmen are familiar with a number of knots. They could provide many details that would be of interest to us, but this too will be left to more qualified hands. A very ingenious and ancient use of the knot led to the invention of netting, which even the most savage tribes knew how to make and use for fishing and hunting. Plaiting (PLAIT, BRAID, SEAM, CANEWORK, MATTING). Plaiting should perhaps have been discussed before knitting, as one of the products of the textile arts. Plaiting consists of at least three strands placed alternately over one another (see figures). The number of strands can be increased at will. Guipure is the most ancient lace. The motif is executed freehand with needle. Figure 1 and 2. Pillow lace is made by a combination of weaving, twisting, and plaiting. The design of most varieties is produced by an interlocking of threads like that used for weaving linen (fig. 3): the ground, by contrast, is made by plaiting the threads or, in some varieties, by simple twisting (see figs. 4, 5). French points are identical in principle with old Portuguese and modern Brussels laces. Figure 6 shows the ground stitch, figure 7 the stitch for the pattern or filling. Brussels points exhibit a variety of basic stitches (fig. 8). Later the ground or net was bobbing and still later made on a machine. The art of preparing coverings from plaited cane is very ancient and has made no significant technical progress since the Old Kingdom of the Pharaohs. Nevertheless, the Egyptians of that time and now the North American Iroquois (and many others savage or half-savage peoples) handle the motif with less aesthetic inhibition – more happily and ingeniously–than do we Euroeans with all our admired technical omnipotence.

RELATION OF COSTUME TO ARCHITECTURE

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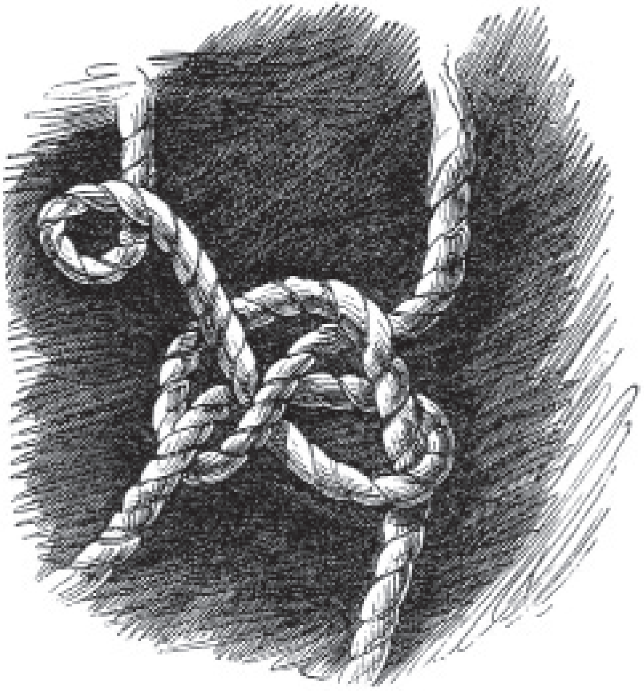
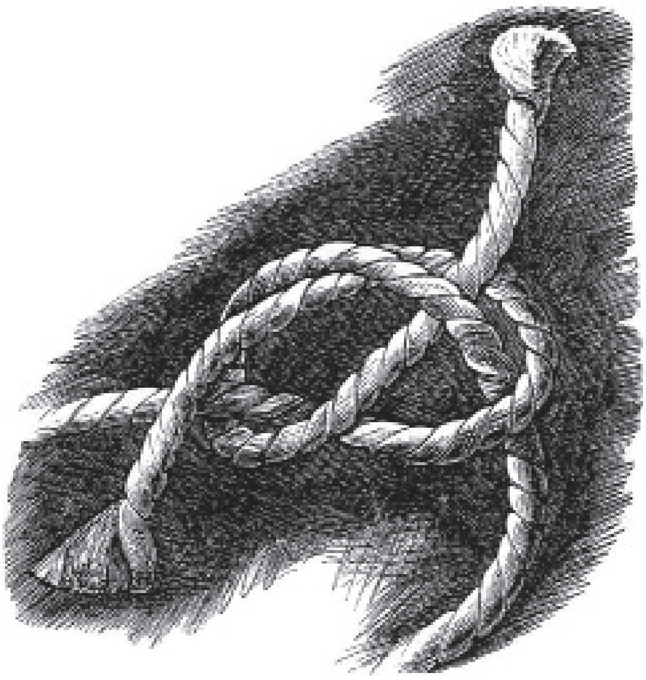
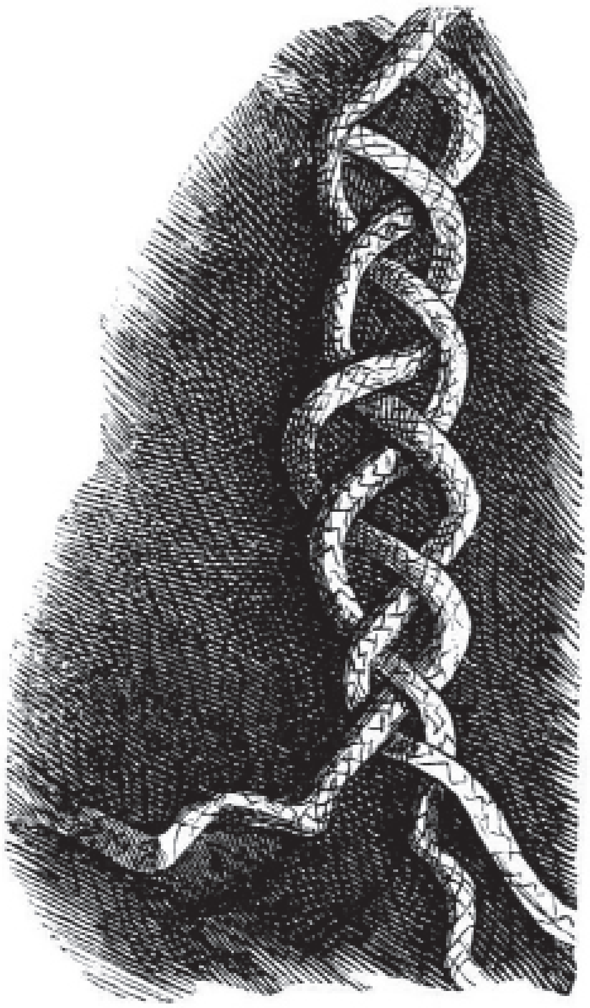
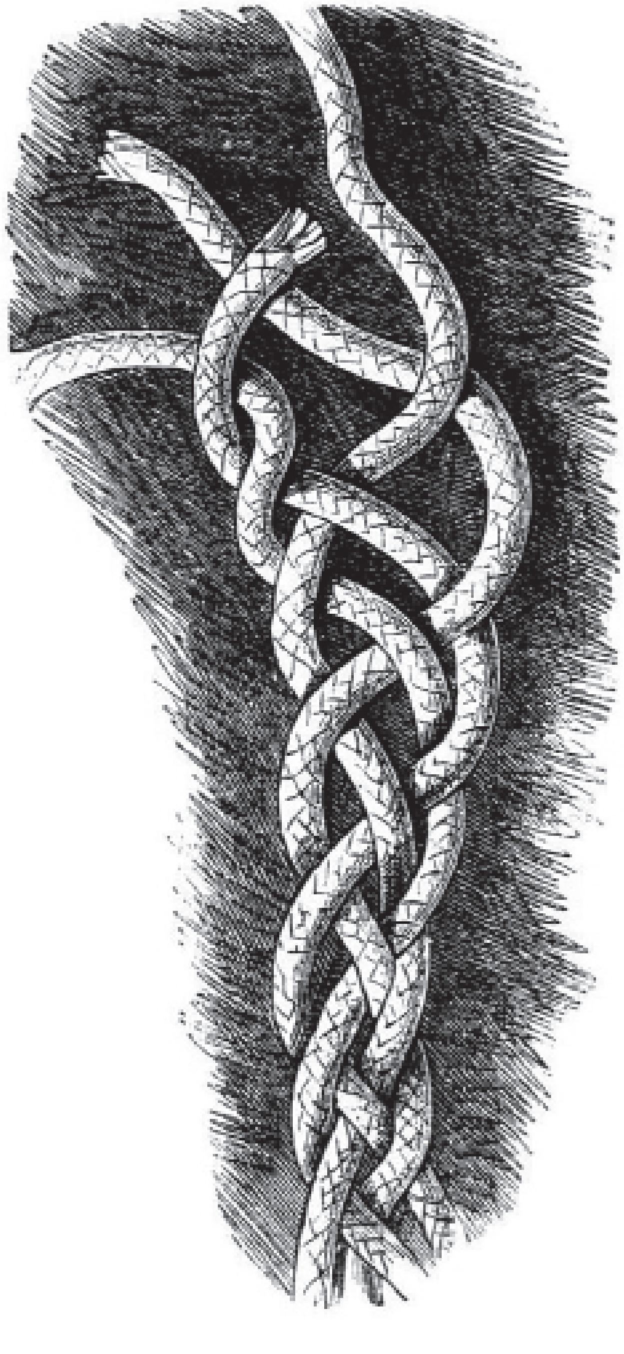
A direct and material connection between costume and sculpture is evident, for expale, in the fact that the ancient tradition of dressing wooden statues with actual garments led to the invention of clothed sculpture figures. Another connection is clearly evident in the shape of the Egyptian capitals illustrated here: they are decorated with lotus blossoms inserted in the same way that the ladies of that country ornamented their heads by fastening stalks of these flowers in their hair or behind of their ears.









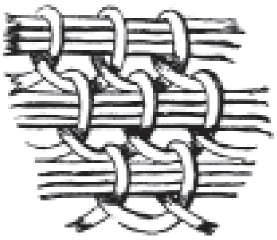


Fig. 1

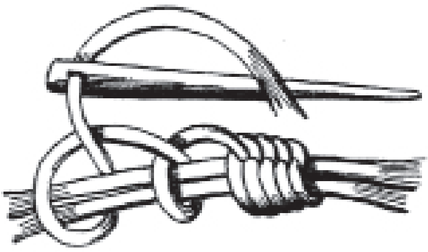


Fig. 2

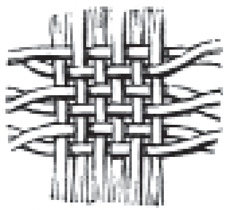


Fig. 3

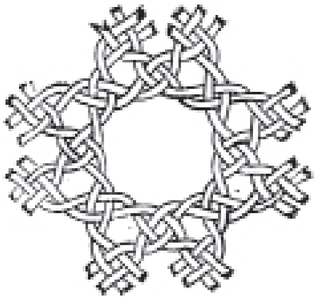


Fig. 4

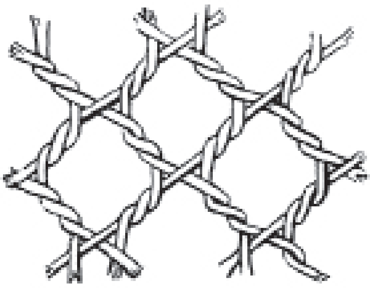


Fig. 5

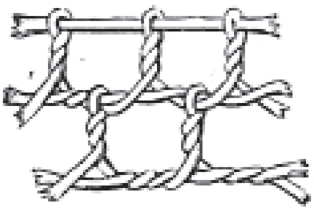


Fig. 6

Fig. 7

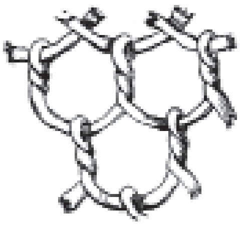


Fig. 8

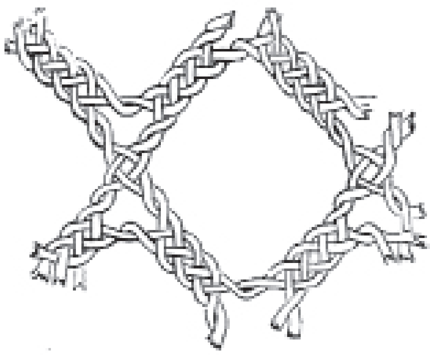
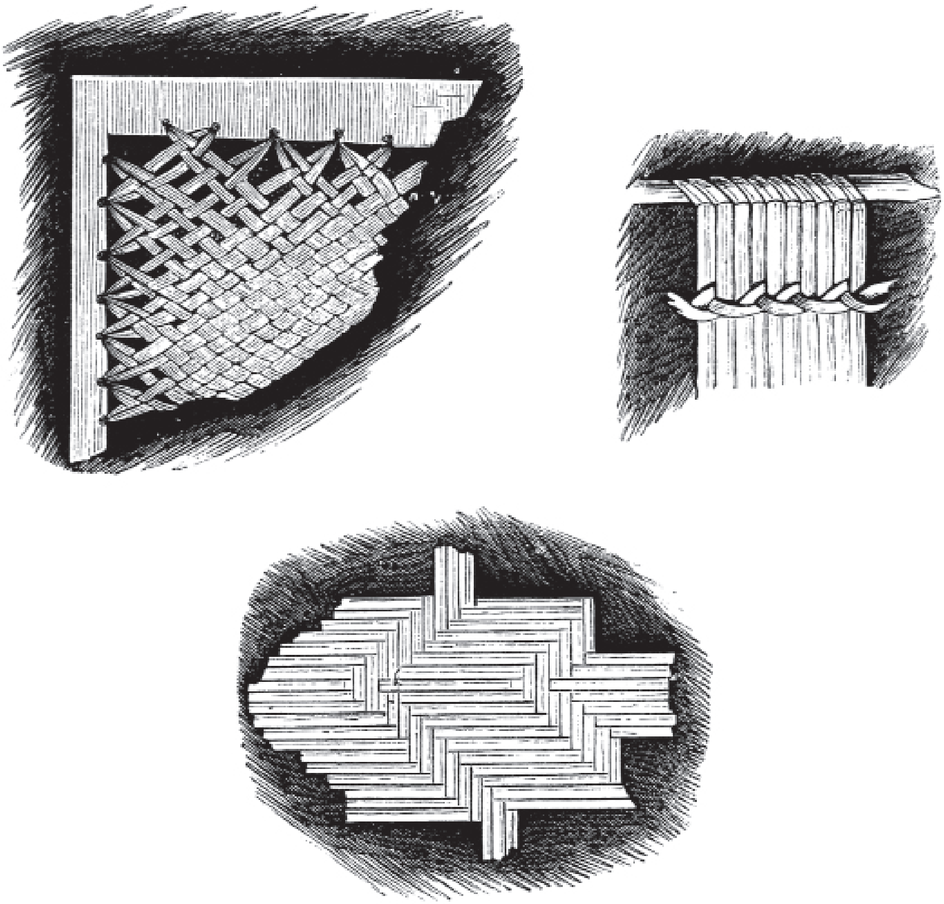
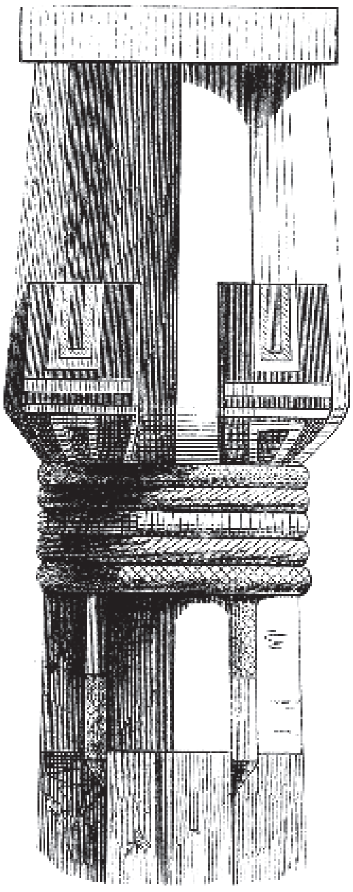


Fig. 9



Egyptian latticework



Egyptian capital

Egyptian ladies' hair decoration

WOOL

Wool is a natural fibre made out of animal hair, usually that of sheep although, hair from other animals such as goats and camels is also used. It is a material with tensile properties that allow it to be stretched and pulled into different shapes. The wool fibre has a crimped shape, which gives it a high specific heat coefficient, that is, it can retain heat and has good insulation properties. From a sustainability point of view, wool is interesting as a construction material as it is a renewable material made from natural fibres. It is also easy to repair.

SPINNING

→ 40

Fibres such as flax and wool have been traditionally spun by hand to produce a strong thread. The person doing the spinning would pinch a few strands from a mass of fibres and hook them to a hand-length stick called a spindle. A small, round weight, called a whorl, helped the spindle turn. By dangling the turning spindle, the spinner would twist the fibres into long threads.

TEXTILE YARN

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A textile yarn is a continuous strand of staple or filament fibres arranged in a form suitable for weaving, knitting, or other forms of fabric assembly. Yarn is a textile product of substantial length and

GROUND LOOM
→ 42–43

a relatively small cross-section consisting of fibres (twisted) and/or filaments (untwisted). The yarn can be twisted with one or more yarns to create added value or aesthetics. Traditionally, yarns have been made of fibres of finite length called staple fibres. Filament yarns tend to be smoother, more lustrous, more uniform, harsher, and less absorbent. Spun yarns have a hairy surface, are more uneven in appearance, have lower lustre, are softer, and more absorbent. Spun yarn is the yarn of choice in many woven and knitted fabric products. The Bedouin loom, like the Egyptian horizontal loom, consists of two beams staked into the ground with the warp stretched between them, and a heddle rod and shed stick for making the openings in the warp. The Bedouin loom is generally narrow, although it may be operated by from one to three weavers, and unlike its Egyptian prototype, the heddle rod's position is fixed by being set up on rocks. The loom is ideally suited to nomadic life as it can be easily rolled up with the unfinished weaving still on it, and loaded onto a camel to be transported to a new site. It requires a minimum of framing wood, which is a scarcity in the desert.

THE BLACK TENT
→ 44–46

Probably originating in Mesopotamia, the black tent is the tent of nomadic Jews and Arabs. The black tent lives with the family living in it and its life ends with that of the family. The size of the tent depends on the wealth of the owner. The structure of the tent has evolved over thousands of years along with the lifestyle of the nomads. The dwellers transport their tent with them as they go in search of water and food for themselves and their herds, or in response to seasonal changes. It takes two people to carry it. The fast and far traveling nomadic Bedouins inhabit the traditional regions of the black tent: Arabia, parts of Syria, Israel, and Iraq. The structure is tensile. It uses a minimum of material. The roof of the tent plays the main role. It is stretched over poles erected in three rows and fastened to the ground with anchor ropes and guy ropes. Two to four columns of poles are usually used. The rectangular cloth can exceed 20 metres in length in the largest of constructions. In addition to the roof fabric, a wall fabric is suspended along the perimeter of the tent. The wall fabric can be buried into the ground, or if needed, rolled up for air to flow in. In black tents, the roof, the walls and the floors are all woven. The fabric of the black tent derives its strength from the goat's hair, which is spun and woven to form a piece of cloth. The cloth is the modular unit
of the black tent. Several clothes sewn together form a rectangle, the cover

of the black tent. Sometimes combined with other material, wool, cotton, hemp or camel hair, the fabric is resistant to tearing, and is smooth and water repellent due to the fibres' natural oils. The life span of a strip of cloth is approximately five years. The roof is constantly renewed from the top so that the strip touching the ground is the oldest, and most worn out, part of the tent. The shape of the black tent and the material properties of the woolen tent membrane create a natural ventilation inside the structure. When the sun hits the black roof of the tent, hot air starts to rise above the cloth and forces air to be drawn out from inside the tent. This creates a cooling wind effect on hot days. On rainy or snowy days, the woolen fibres absorb water and swell, creating a thicker and tighter tent membrane.

GADDAFI TENT
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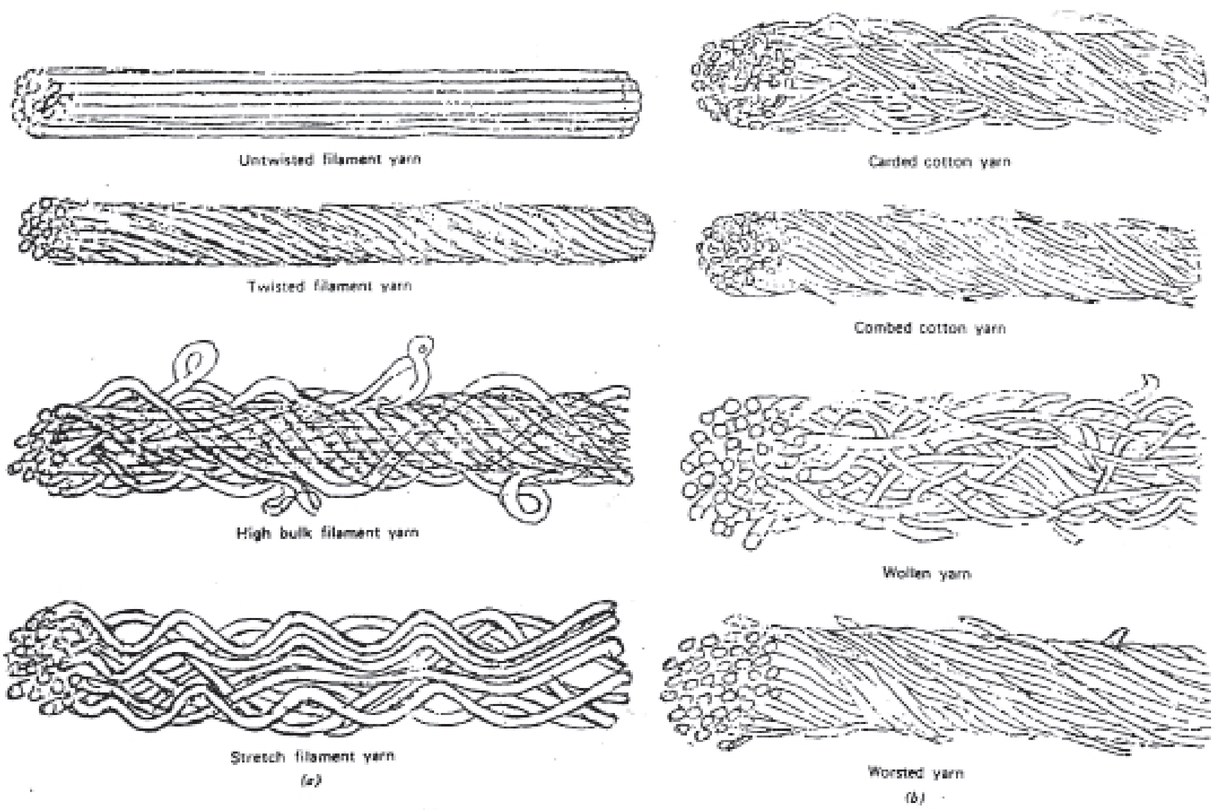
The valued qualities of tents are lightness, flexibility, contemporaneity, and portability. Muammar Gaddafi used to travel with his beduin tent on official visits and used the tent to receive official guests. He would bring with him different furniture depending to the nature of the meeting. Gaddafi's tent was a large tent with rugs and patterned wall hangings.

ARISH: PALM-LEAF ARCHITECTURE

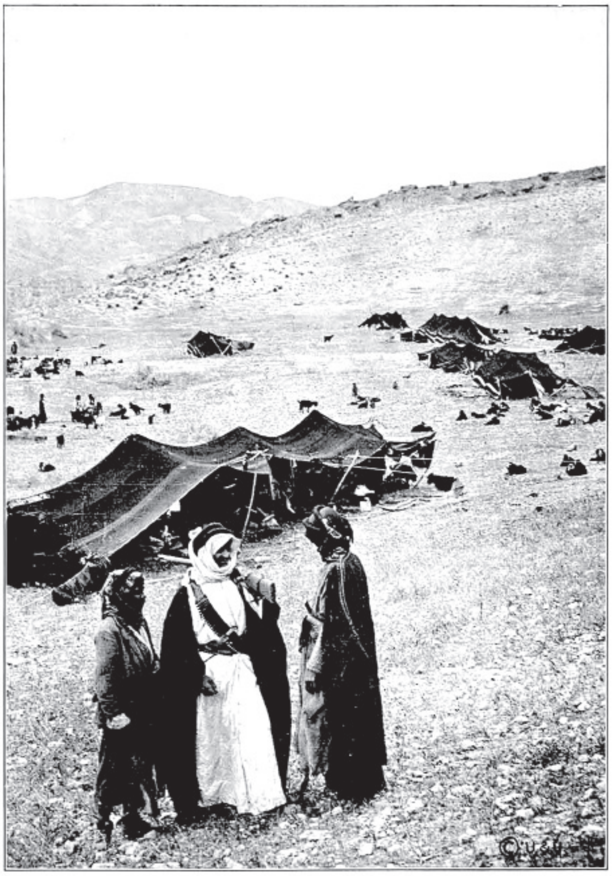
→ 48–51

**Arish is the traditional summer dwelling in the Emirates built using the palm-leaf technique. The first settlements using the palm-leaf technique date back as far as 7,000 years. These buildings provided shelter from the extreme heat and the arid climate. The walls were made of a double layer of tightly woven palm leaves. The orientation was always north-south. Clusters of houses, less than one metre apart, acted as another layer of cooling. The structure is made up of interwoven elements and knots are used for joints.
It contains no nails. Each region has its own style of weaving.**

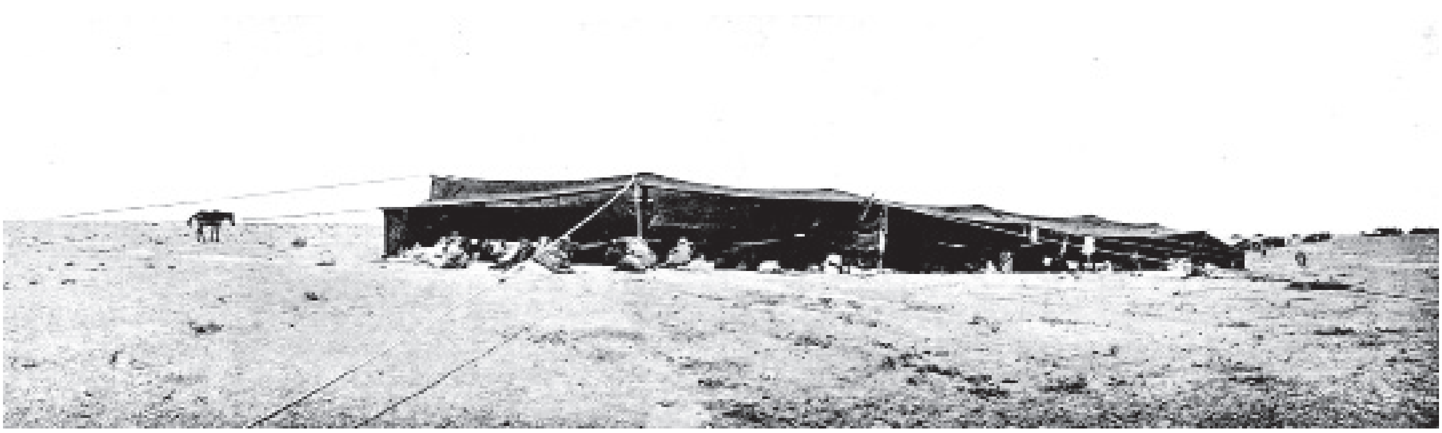


(a) basic filament

(b) spun yarn structures.



The nomadic Bedouins live in brown tents so low that the people have to stoop to get into them. They camp wherever they find good grazing for their stock



PLASTIC ERA '60s–'70s

Plastics are manmade materials, which do not exist in nature. As their name implies, they are plastic at some stage of their production, and, at that stage, can be moulded into shape by a variety of techniques.

Many materials which today are household names were invented long before the Great Exhibition of 1862, such as styrene (1831), melamine (1834) polyvinyl chloride (PVC) (1835), and polyester (1847). However, in none of these cases did the inventor appreciate the potential of his materials, and none of them was really exploited until well into the twentieth century. The next major advancement in the development of plastics was in 1907 when Leo Baekeland, a Belgian chemist, invented Bakelite. This was the first entirely synthetic plastic. It was lightweight, durable, and heat resistant. Baekeland found a way of controlling the fast reaction between phenol and formaldehyde, which enabled the material to be moulded. Because of its properties, Bakelite was quickly adopted by designers and made into household objects ranging from telephones to clocks, doorknobs to radios. At that time, Bakelite products were considered glamourous, high-end and were associated with luxury.

By the end of the 1940s, most of the plastics that are in use in construction today had already been invented. Some of these include polymethacrylate (PMMA), polystyrene (PS), polyethylene (PE), polyurethane (PUR) and polytetrafluoroethylene (PTFE). Fibre-reinforced plastic (GRP), the most common architectural plastic material in use today, was invented in the late 1940s. This new composite material quickly became an essential part of many manufacturing industries, used in airplanes, boats, and automobiles. Because of properties such as weather resistance, and high strength, as well as its light weight and the ease with which it is moulded, it is also used in architecture.

Pioneering architects and engineers such as Ionel Schein, and Alison and Peter Smithson led the experimentation with this new material after the Second World War and pioneered new concepts of living spaces. The moulding technique allowed architects to think of the possibilities of buildings with a modular shell. Curved building elements and rounded forms featured heavily in the buildings of the 1960s because of the excellent forming qualities of plastics.

However, the aspirations that industrial designers, engineers and architects had for plastics failed to be realized due to a considerable increase in price caused by the oil crisis in 1973.

PLASTIC

Plastic materials are manmade substances which do not exist in nature. Most are organic materials, that is, they are carbon based, although there is a growing number of exceptions to this rule. They are high polymers - giant molecules made up of small simple repetitive units assembled into large groups. As their name implies, they are plastic at some stage of their production and, at that stage, can be moulded in shape by a variety of techniques. There are many chemical types of plastics and many varieties within each chemical type. It is these differences which make one plastic superior to another for specific applications but there is one structural feature common to all plastics: they all contain resins which are composed of long, thread-like molecules.

MANUFACTURE OF PLASTICS
→ 67

Most synthetic plastics are derived from crude oil, representing 8 percent of all crude oil production. The crude oil is distilled by fractionating to the different boiling points, into gas, raw gasoline, diesel, heating oils and gas oil. The most important fraction for plastic manufacture is raw gasoline (naphtha).

POLYMERS
→ 67

Polymers are materials made up of long, repeating chains of molecules giving them unique properties depending on the type of molecules bonded, and how they are bonded. There are three plastic synthesis processes for deriving macromolecules from small-molecule substances: polymerization, polycondensation and polyaddition. Plastics are categorized as polymers, polycondensates and addition polymers depending on the production process.

POLYMERS REACTOR AND PILOT PLANT
→ 68

Polymer reactors offer control over polymerization reaction parameters, such as temperature, pressure, mixing, concentrations, and reaction times. This advanced control enables chemists to reduce the polydispersity of their reactions and achieve batch-to-batch reproducible results. Novel polymers and copolymers synthesis are conducted in both laboratory scale, and pilot plant scale.

THERMOPLASTICS AND THERMOSETS
→ 69

Thermoplastics and thermosets are two different classes of plastics which are differentiated by their reaction when reacting to the application of heat. The primary difference between the two is that thermoplastics can be re-melted and thermosets can not.

Properties of THERMOPLASTICS:
— Highly recyclable
— High-impact resistance
— Reshaping capabilities
Common THERMOPLASTIC:
Polyethylene(PET), PVC, nylon, vinyl

Properties of THERMOSETS:
— More resistant to high temperatures than thermoplastic
— Highly flexible design
— Thick to thin wall capabilities
— High levels of dimensional stability
— Cannot be recycled
— Cannot be re moulded or reshaped
Common THERMOSETS:
Silicon, epoxy, polyurethane.

VARIETIES OF FABRICATION

Generally speaking, the thermoplastics materials are easier to handle than the thermosets. Thermoplastics can be re-softened by the application of heat, and the curing cycle is therefore not so critical as is the case in the one-way thermoset reaction.

EXTRUSION

→ 70

Extrusion is used for producing plastic parts that are generally simple and continuous in nature such as pipes and sheets. It is more commonly used for thermoplastics than thermosets. Granular material is fed from a hopper into the screw and is heated, not only externally by the heated walls of the cylinder, but also by the friction caused by the screw cutting through the granules. As the material is forced along the screw, it becomes more fluid and is finally forced out through a die, which determines the shape of the extrusion.

INJECTION MOULDING
→ 70

Injection moulding is by far the most important method of forming plastic materials, both thermoplastics and thermosets. The process is similar to extrusion. The polymer liquid is injected into a fashioned mould and cooled until solid at the end of the moulding machine.

VACUUM FORMING
→ 70

This is a low-cost technique used for molding thermoplastic sheet materials for relatively small production runs.

ROTARIONAL CASTING

This is an well-established and relatively low-cost technique now being extensively used in the production of large hollow objects in two-piece moulds, normally from PVC paste or polyethylene powder.

CALENDERING

A calendering plant consists of a series of mangles for the continuous production of thermoplastic sheet or film at a very high rate. The rollers control the thickness very accurately and can also apply a texture. The technique can also be used for coating fabric.

LOW PRESSURE LAMINATION

This is a simple and cheap technique used in the production of glass reinforced polyester laminate, the composite material most commonly used in the construction of plastic structures. This is normally referred to as GPR or RP (reinforced plastics).

FILAMENT WINDING

→ 70

This is a technique developed for small or large components which have to carry high stress. A collapsible mould is rotated on an axle, and continuous rovings of glass fibre are passed through a bath of resin and wound around the mould under tension. The winding may move back and forth along the length of the mould in order to align the fibres in the direction required for maximum strength.

TRANSPARENCY

→ 71

Plastics materials are unique in that they permit the designer to create structures which are transparent, translucent or self-coloured.

COATING ON FABRIC

Plastic coatings, usually applied to both faces, protect the membrane against moisture, UV radiation, fire, and microbe and fungus attacks. They also influence the resistance to soiling and the life of a fabric, and sometimes provide fire resistance. In regions with a humid climate, the most common coatings are polyvinyl chloride. (PVC), olytetrafluoroethylene (PTFE) and silicone.

MANMADE FIBRES

Manmade fibre is fibre whose chemical composition, structure, and properties are significantly modified during the manufacturing process. Hilaire Bernigaud de Chardonnet presented the first samples of rayon at the International Exhibition in Paris in 1889. As shiny and silky as natural silk, this was the first artificial fibre ever made by man. Processes to obtain filaments from poly (vinyl chloride) and threads from poly (vinyl alcohol) and polystyrene were patented in Germany as early as 1913, 1931 and 1932. However, the era of synthetic fibres truly began in 1935 at the laboratories of the DuPont Experimental Station, Pure Science

Section in Wilmington, Delaware, USA. There, Gerard Berchet obtained just over 10g of polyhexamethylene adipamide, which was subsequently commercialized in 1938 under the name nylon, the first totally synthetic industrial fibre. The chemical compounds from which manmade fibres are produced are polymers. Natural fibres also consist of polymers (in this case, biologically produced compounds such as cellulose and protein), but they emerge from the textile manufacturing process in a relatively unaltered state. Some manmade fibres are derived from naturally occurring polymers. For instance, rayon and acetate, two of the first manmade fibres ever produced, are made of the same cellulose polymers that make up cotton, hemp, flax, and the structural fibres of wood. Another group of manmade fibres, by far the larger group, is synthetic fibres. These are made of polymers that do not occur naturally but instead are produced entirely in the chemical plant or laboratory, almost always from by-products of petroleum or natural gas. High-performance fibres are manmade fibres that are engineered for specific uses that require exceptional strength, stiffness, heat resistance, or chemical resistance. These fibres have generally higher tenacity and higher modulus than typical fibres. Glass is the oldest high-performance fibre, one that has been manufactured since the 1930s. Carbon fibre is one of the most important high-performance fibres used in military and aerospace applications which is engineered for strength and stiffness. High-performance organic fibres have also become very important in recent years. Aramids are among the best known of the high-performance, synthetic, organic fibres.

FIBERS PRODUCTION

→ 72

Polymer that is to be converted into fibre must first be converted to a liquid or semiliquid state, either by being dissolved in a solvent or by being heated until molten.
The resulting liquid is extruded through small holes in a device known as a spinnerette, emerging as fine jets of liquid that harden to form solid rods with all the superficial characteristics of a very long fibre, or filament. This extrusion of liquid fibre-forming polymer, followed by hardening to form filaments, is called spinning. One of the oldest methods for the preparation of man-made fibres is solution spinning, which was introduced industrially at the end of the 19th century. Solution spinning includes wet spinning and dry spinning. In both methods, a viscous solution of polymer is pumped through a filter and then passed through the fine holes of a spinnerette. The solvent is subsequently removed, leaving a fibre.

COMPOSITE MATERIALS

Reinforced plastics, called composites, are plastics strengthened with fibres, strands, cloth, or other materials. Thermosetting epoxy and polyester resins are commonly used as the polymer matrix (binding material) in reinforced plastics. Due to a combination of strength and affordability, glass and carbon fibres, which are woven into the product, are the most common reinforcing material. Organic synthetic fibres such as aramid offer greater strength and stiffness than glass fibres, but these synthetic fibres are considerably more expensive. The Boeing 777 aircraft makes extensive use of lightweight reinforced plastics.

HOUSE OF THE FUTURE

Alis and Peter Smithson, 1956

→ 73

In 1956, a plastic house designed by Alison and Peter Smithson was exhibited at the Ideal Home Exhibition in London. This house, although largely a mock-up and containing a rather large number of space-age gadgets and fashions, demonstrated some of the first examples of GRP(glass-fibre reinforced plastic) shell chairs, in both saddle and petal form, and also ‘Pogo’ fold-flat chairs in transparent acrylic. The construction was never intended to be fully industrialized, as the design was an examination of the way in which we might live rather than of the means whereby that end might be attained. This was also a most under-rated design which might well have generated further exercises into ways of living.

RELAY ROOM SYSTEM
British Railways, 1959
→ 74–75

In 1959, the first British shell structure was designed by a group working in the architect's research and development section of British Railways (Eastern Region). Three shells were designed which could be put together in a variety of ways. The body of the shell was made of GRP and polysulphide, a rubber sealant strip, was applied on the eade to join the pieces.

GERMAN PAVILION
Frei Otto
Expo 67 Montreal, 1967
→ 76–77

Frei Otto was a pioneer in the research of lightweight tensile and membrane structures, cable nets, grid shells and ecological buildings. His first tensile structure was built together with a tent maker in 1955. One of Otto's best-known designs is the roof of the Federal Republic of Germany's pavilion at the Expo '67 World's Fair in Montreal. Otto believed that his tensile canopies promised an architectural solution that was cheap, durable, and highly versatile.

RENZO PIANO
'60s–'70s works
→ 78–79

Renzo Piano's early works were projects that experimented with different materials and construction methods. At that time, he focused on the concept of the "open-plan" space. He worked mainly with a primary skeleton steel structure and a secondary structure which was a frame with plastic shell infill. He developed

several buildings using the same principle but with different geometries. He was investigating how best to use, at that time new and non-traditional construction materials, such as polyester and its derivative products, including fibreglass. He studied the physical properties of materials were studied and experimented with transparency or translucency, lightness, strength, flexibility, facility of fabrication and assembly.

FUTURO
Matti Suuronen
Finland, 1968
→ 80

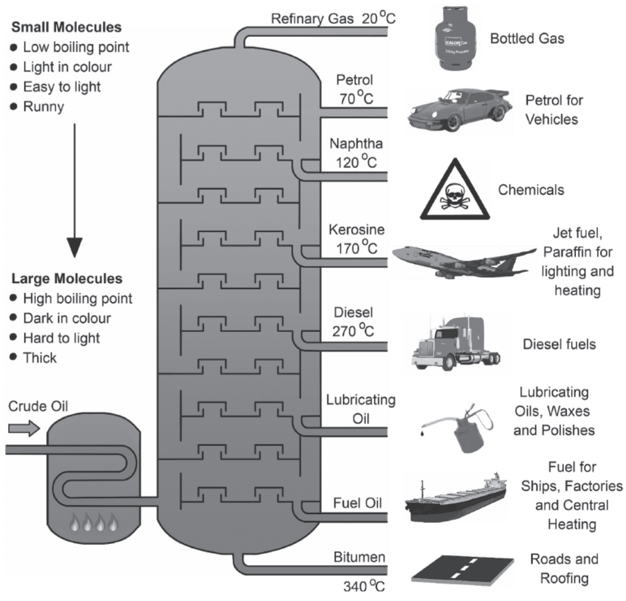
Futuro is a prefabricated GRP house, measuring 4 metres in hight and 8 metres in diameter, designed by Finnish architect Matti Suutonen. It was initially designed as a ski cabin that would be "quick to heat and easy to construct in rough terrain.” However, the end result was a universally transportable home that could be mass replicated and situated in almost any environment.

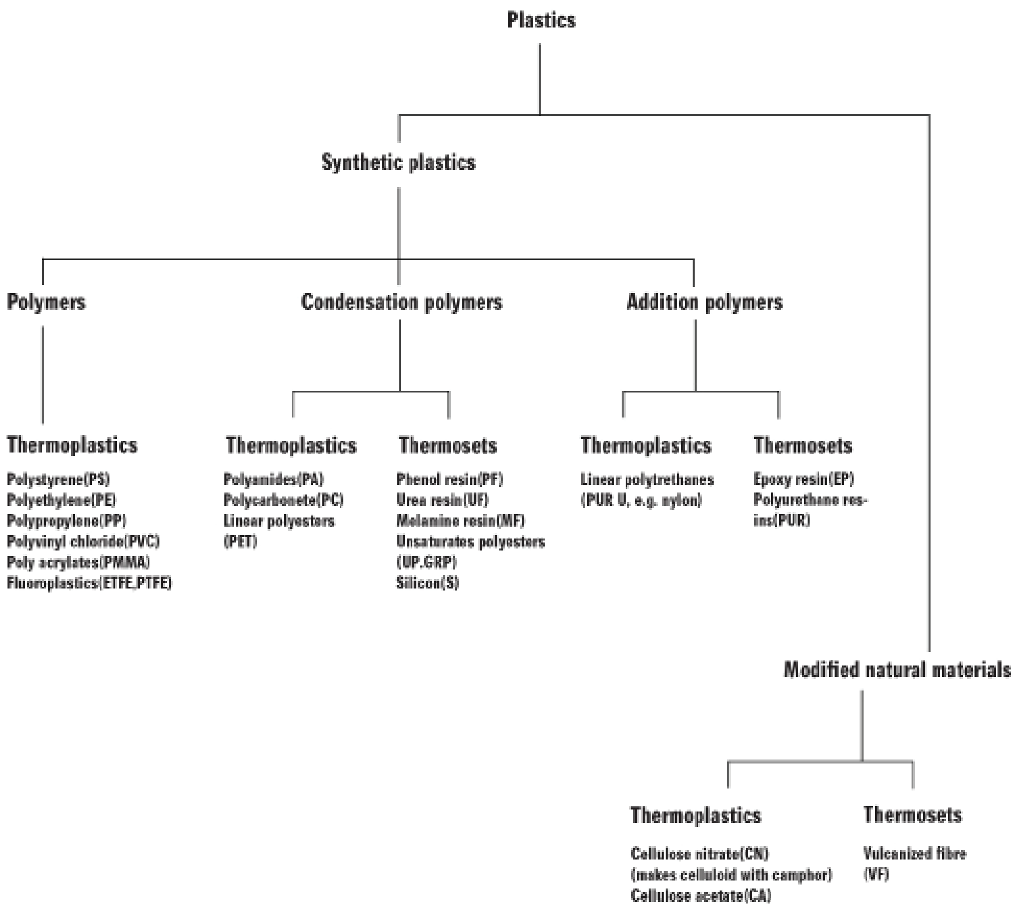
INFLATABLE PLEASURE DOME IN THE MOVIE THE TOUCHABLES
1968
→ 81

With its polished aluminium floor and transparent walls, the Dome appears simultaneously boundless and finite, yet the slightly opaque quality of the plastic created a hazy barrier that kept what was inside in sharp, brightly lit focus, and rendered what was outside less precise and more impressionistic.

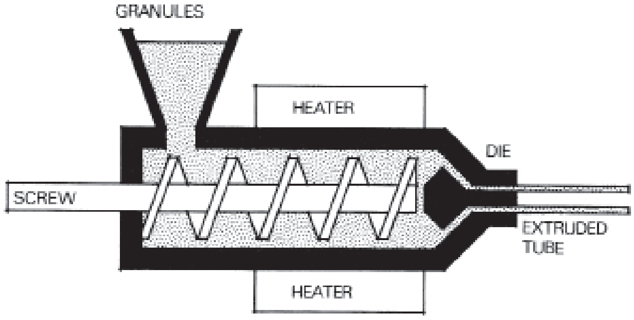
HOUSE IN ALMARGO 1978
HOTEL TRES ISLAS 1973
Miguel Fisac
→ 82–83

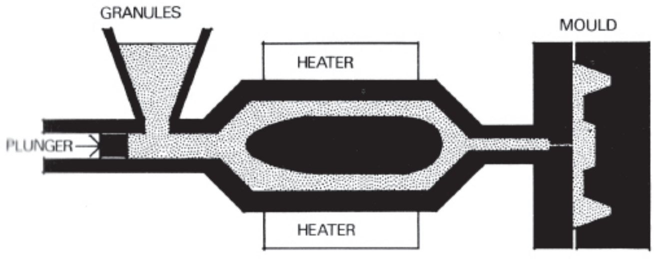
In the '70s and '80s Spanish architect Miguel Fisac (1913–2006) developed and applied a construction system that included prefabricated, flexibly formed walls. His interest in the texture and aesthetics of concrete led him to his inventions and works.

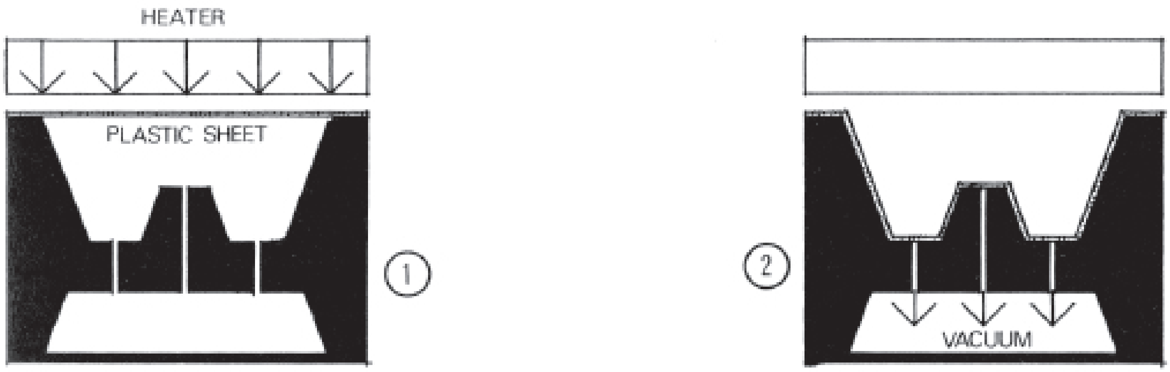

Small Molecules
Low boiling point
Light in colour
Easy to light
Runny
Large Molecules
High boiling point
Dark in colour
Hard to light
Thick
Crude Oil
Refinary Gas 20 °C
Petrol 70 °C
Naphtha 120 °C
Kerosine 170 °C
Diesel 270 °C
Lubricating Oil
Fuel Oil
Bitumen
340 °C
Bottled Gas
Petrol for Vehicles
Chemicals
Jet fuel, Paraffin for lighting and heating
Diesel fuels
Lubricating Oils, Waxes and Polishes
Fuel for Ships, Factories and Central Heating
Roads and Roofing

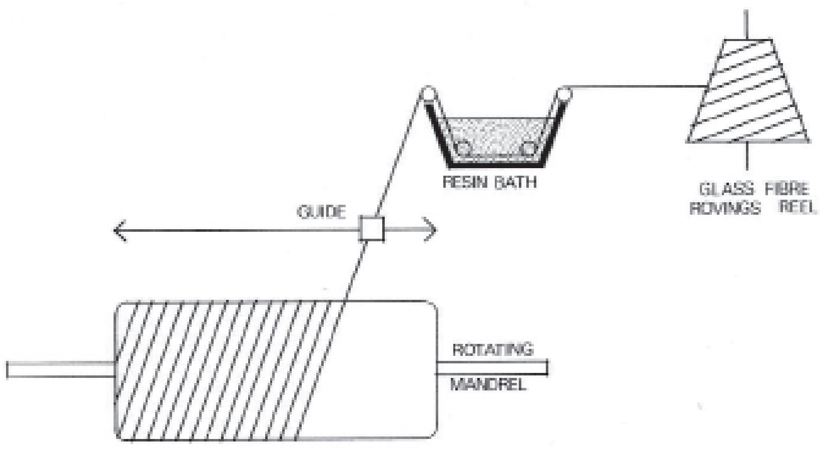

Plastics
Synthetic plastics
Polymers
Condensation polymers
Addition polymers
Thermoplastics
Polystyrene(PS)
Polyethylene(PE)
Polypropylene(PP)
Polyvinyl chloride(PVC)
Poly acrylates(PMMA)
Fluoroplastics(ETFE,PTFE)
Thermoplastics
Polyamides(PA)
Polycarbonete(PC)
Linear polyesters
(PET)
Thermosets
Phenol resin(PF)
Urea resin(UF)
Melamine resin(MF)
Unsaturates polyesters
(UP,GRP)
Silicon(S)
Thermoplastics
Linear polytrethanes
(PUR U, e.g. nylon)
Thermosets
Epoxy resin(EP)
Polyurethane res-
ins(PUR)
Modified natural materials
Thermoplastics
Cellulose nitrate(CN)
(makes celluloid with camphor)
Cellulose acetate(CA)
Thermosets
Vulcanized fibre
(VF)

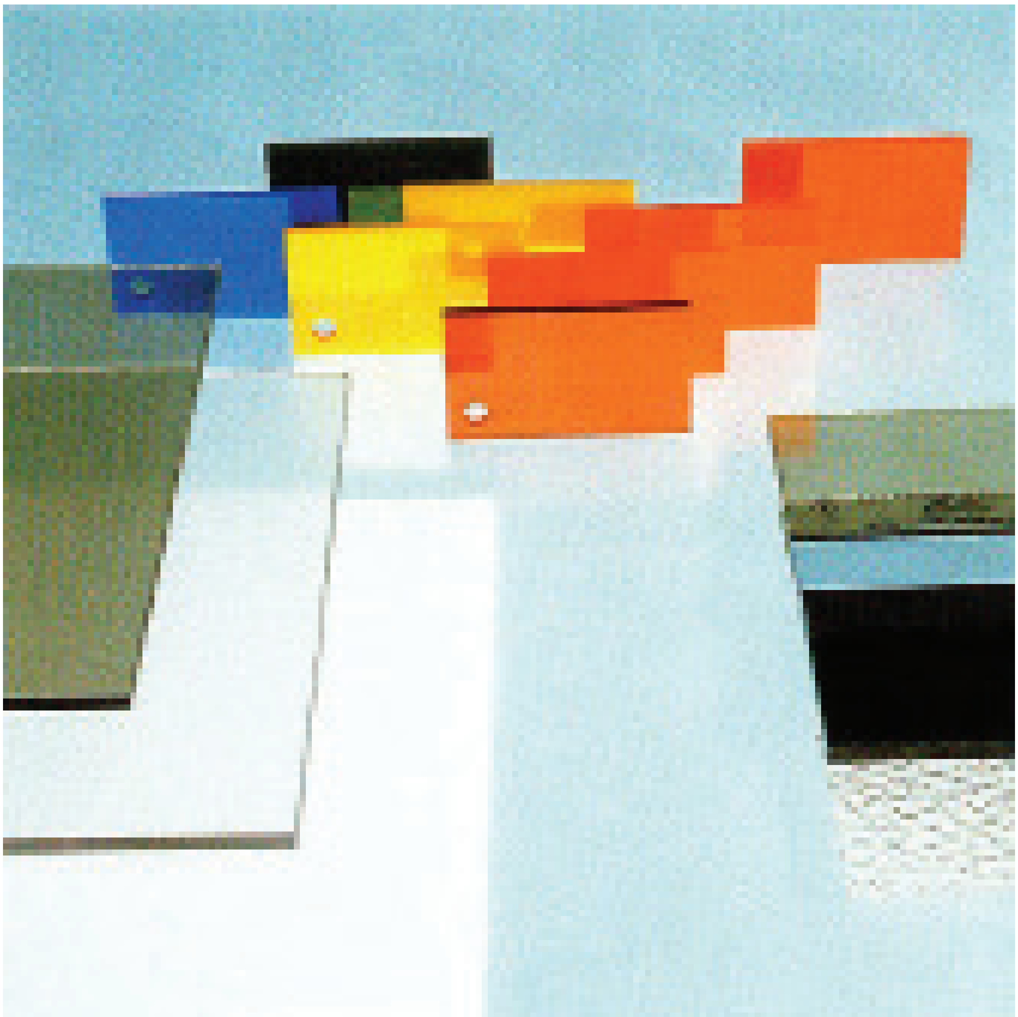
	Clarity/ transparency potentiality	*Compressive strength (where relevant) p.s.i. × 1,000*	*Tensile strength (where relevant) p.s.i. × 1,000*	*Modulus of elasticity (in tension) (where relevant) p.s.i. × 100,000*	*Thermal movement in./in. per °C. × 10^{-5}*	*Softening point °C.*	*Water absorption $\frac{1}{8}$ in. thickness % in 24 hours*	*Burning rate (inflammability)*
Thermoplastics								
Polythene (low density)	cloudy translucent	cold flows	1-2·3	0·17-0·35	16-18	85-87	0·015	very slow
Polythene (high density)	cloudy translucent (film-transparent)	2·4	3·1-5·5	0·8-1·5	11-13	120-130	0·01	very slow
Polypropylene	transparent to translucent	8·5-10	4·2-5·5	1·3-2	6-8·5	150	0·01	slow
Nylon	cloudy transparent	7-14	7-12	1·6-4	8-15	melt 220-264	0·4-3·3	self extinguishing
Acrylic	glass clear	12-20	7-11	4·5	5-9	80-98	0·3-0·4	slow (drips flame)
Rigid p.v.c.	glass clear	8	8·5	3·5	5	82	0·05	self extinguishing
Flexible p.v.c.	glass clear	—	—	—	—	—	0·5-1	self extinguishing
Polystyrene (normal)	glass clear	11·5-16	5-12	4-6	6-8	82-103	0·03-0·4	slow
Polystyrene (high impact)	glass clear	4-9	2·5-7	2·5-4·5	3·4-18	78-100	0·1-0·3	slow
ABS	translucent	2·5-11	2·5-9	1·0-4·1	6-13	85	0·1-0·3	slow
Polycarbonate	glass clear	11	8·5-9·5	3·2	6·6	165	0·3	self extinguishing
Acetal	translucent	18	10	4·1	8·1	175	0·12	slow
Cellulosics	glass clear	according to type	according to type	according to type	10-15	70	according to type	slow
Thermosets								
Phenolic (without filler)	transparent	10-30	7-8	7·5-10	2·5-6	—	0·1-0·2	very low
Phenolic (with filler)	opaque	22-40	6·5-8·5	8-12	3-4·5	—	0·3-1·0	very low
Urea	transparent	25-35	6-13	15	2·2-3·6	—	0·4-0·8	self extinguishing
Melamine	transparent	40-45	—	—	4	—	0·1-0·6	self extinguishing
Polyester (glass fibre reinforced)	translucent	18-25	9-20	5-8	2-3	—	0·01-1	slow
Epoxy	amber transparent	15-30	5-12	2-6	4·5-6·5	—	0·05-0·1	moderate to self extinguishing
Polyurethane	glass clear	according to grade	—	—	—	—	—	slow
Comparison Materials								
Mild steel	opaque	110-130	70·6	300	0·126	—	—	—
Aluminium	opaque	50-60	12	103	0·240	—	—	—

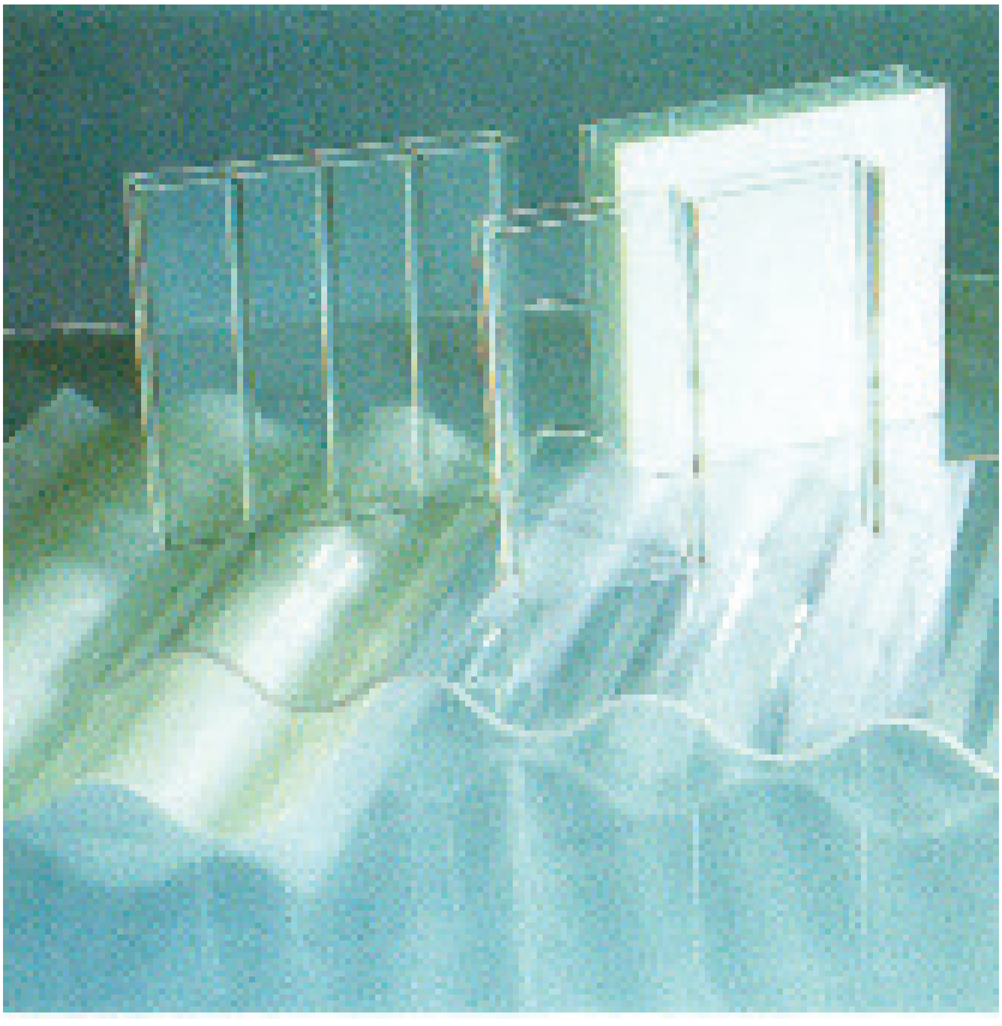

GRANULES
HEATER
DIE
SCREW
EXTRUDED
TUBE
HEATER


GRANULES
HEATER
MOULD
PLUNGER
HEATER


HEATER
PLASTIC SHEET
1
2
VACUUM


RESIN BATH
GLASS FIBRE
ROVINGS REEL
GUIDE
ROTATING
MANDREL



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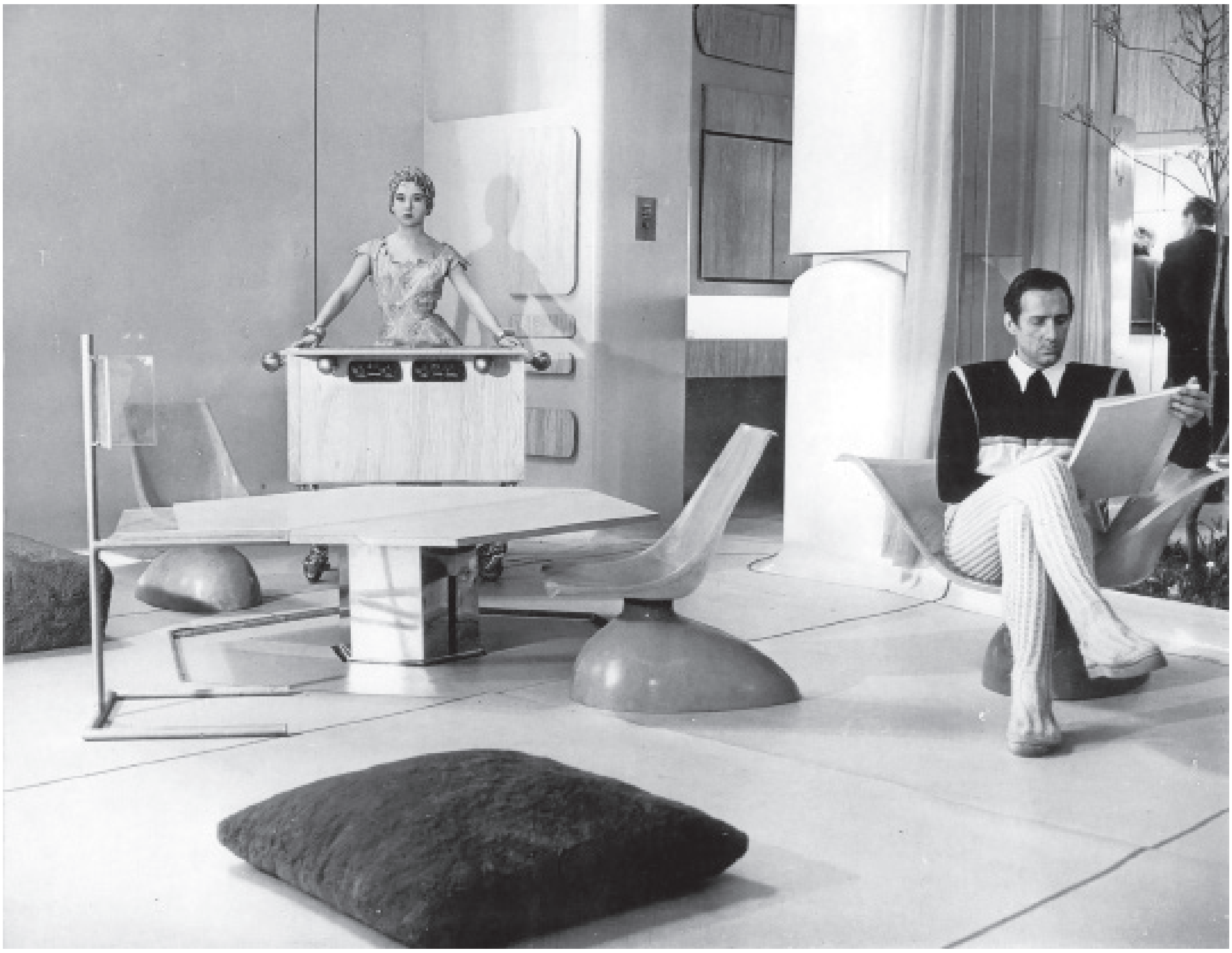

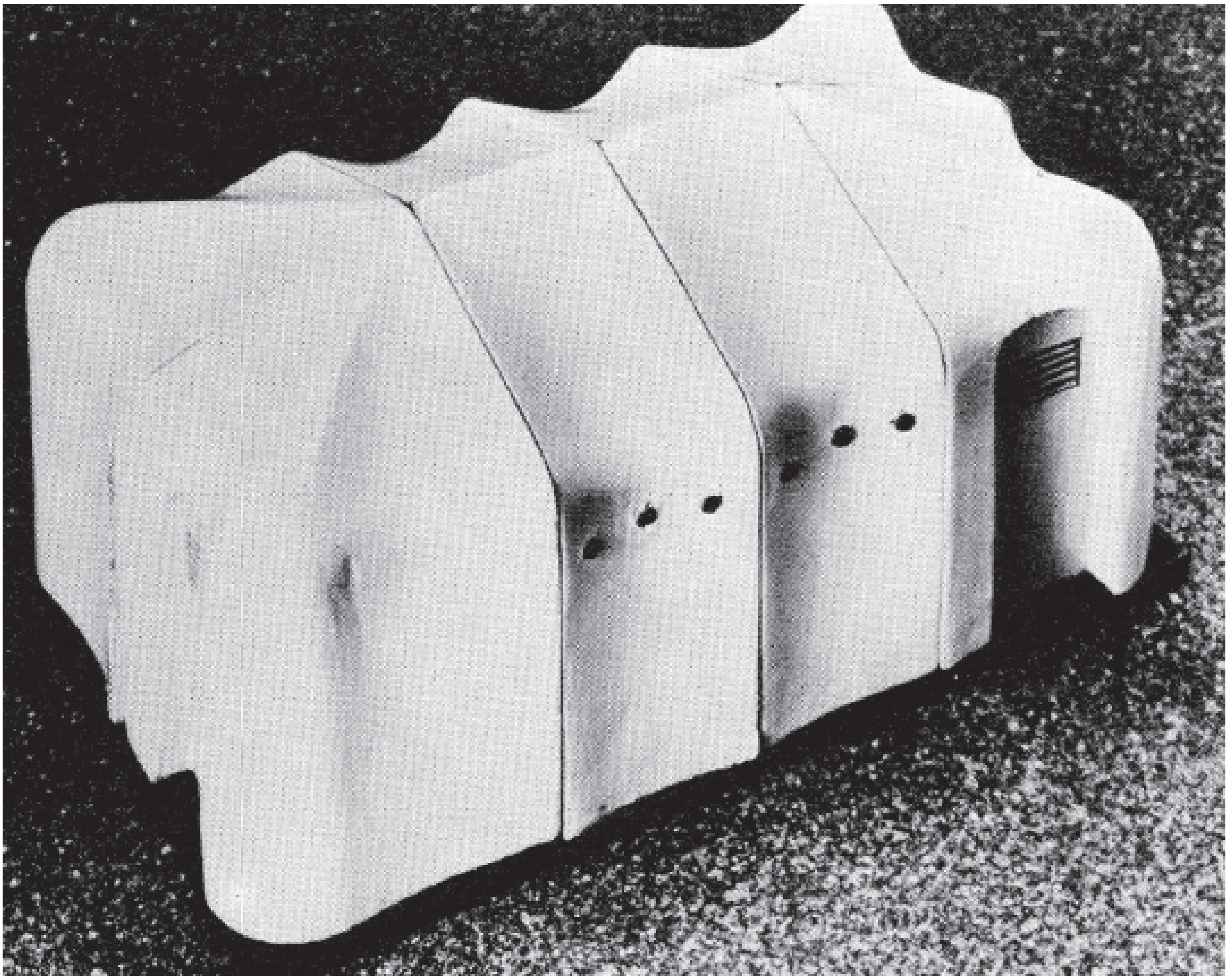

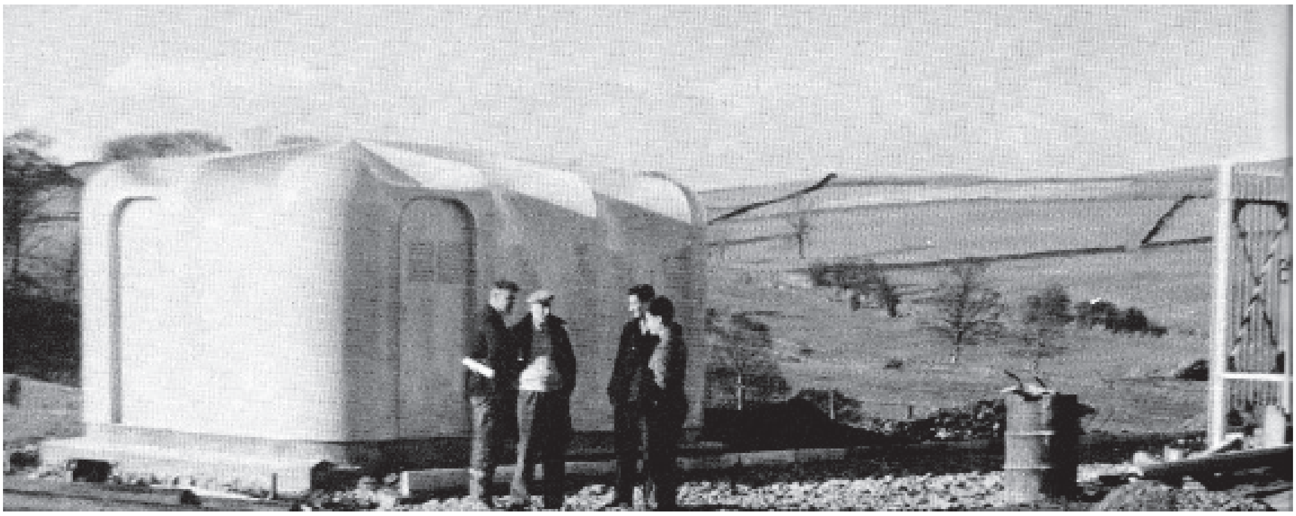

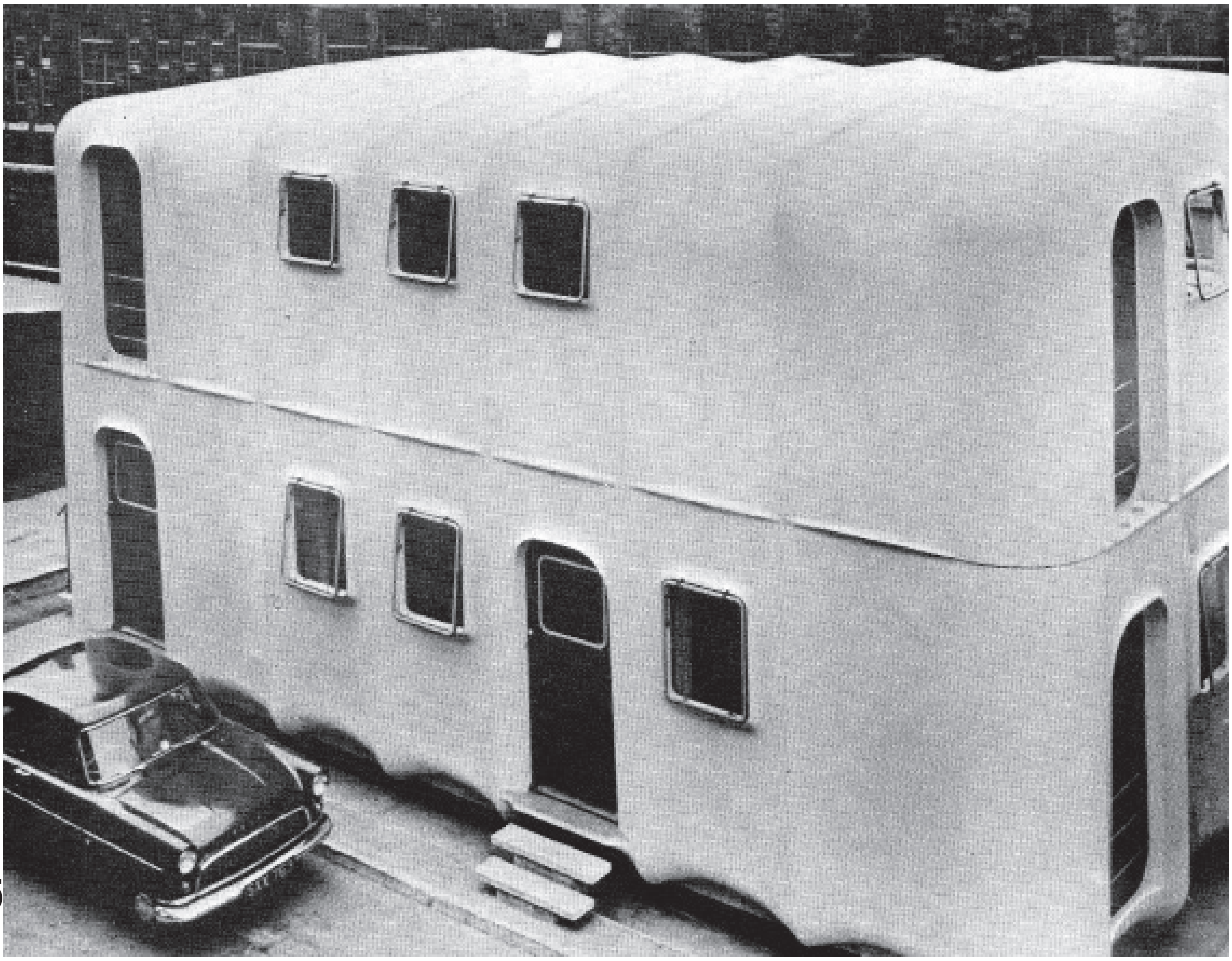

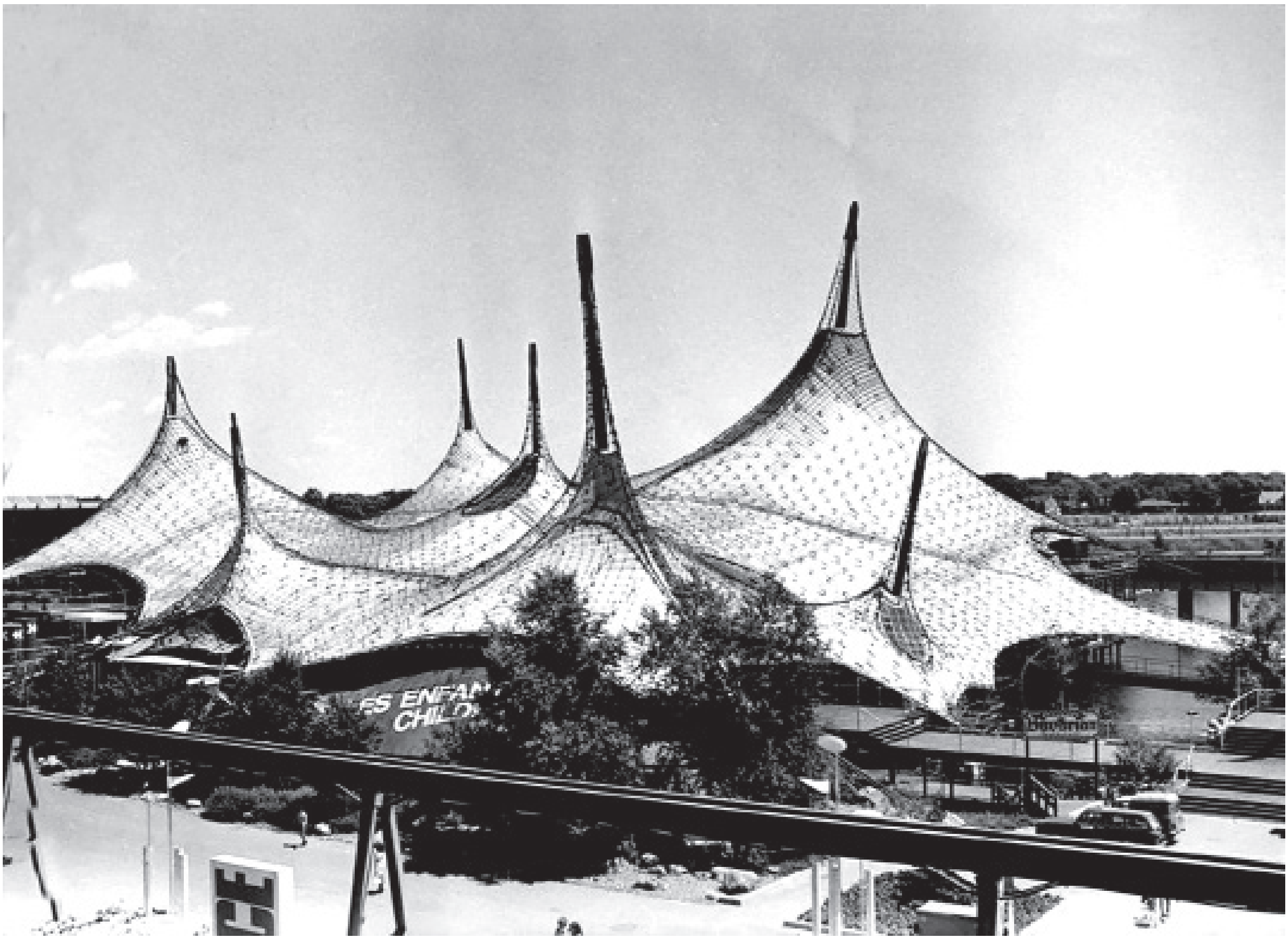

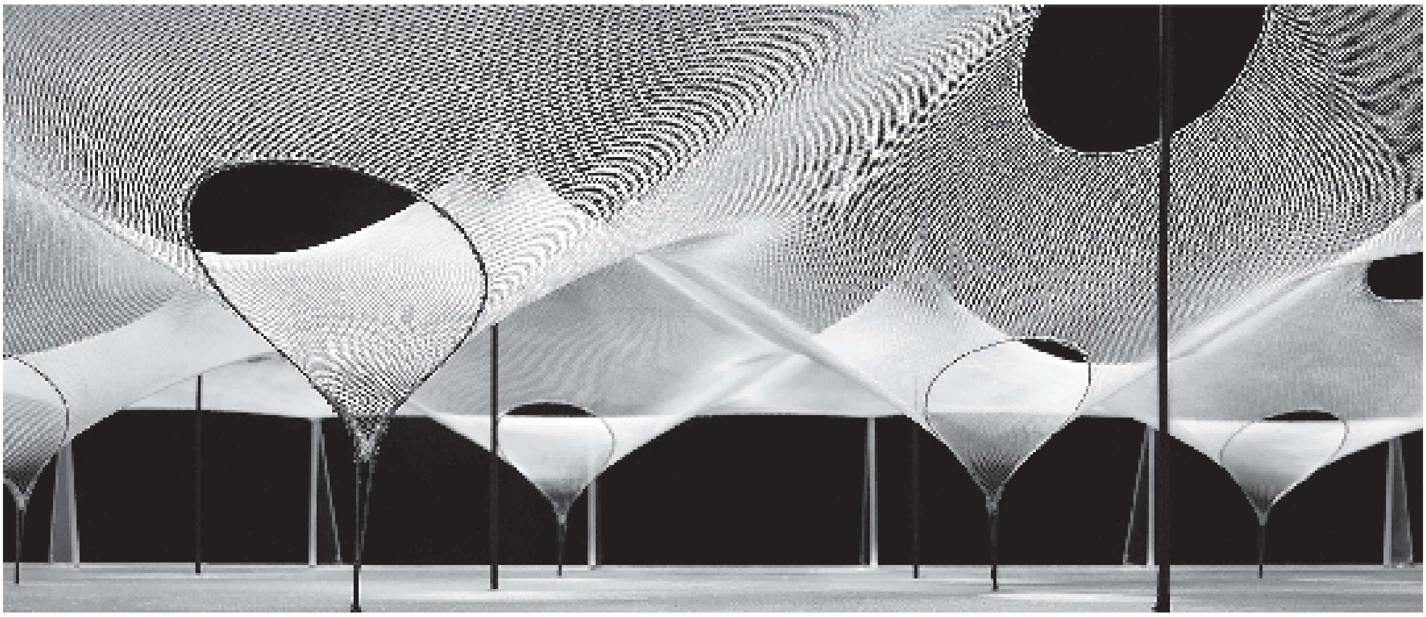

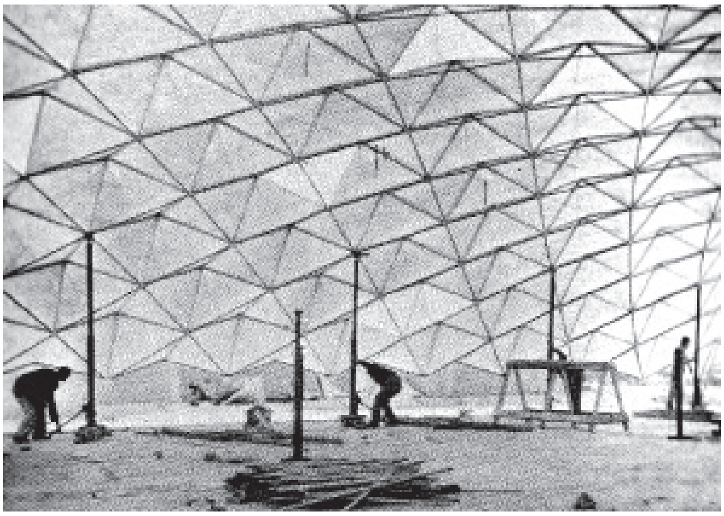

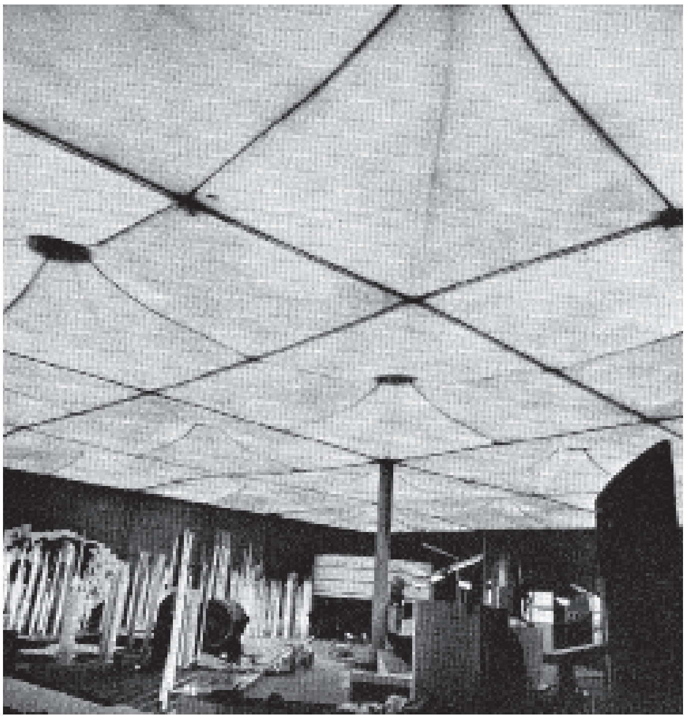

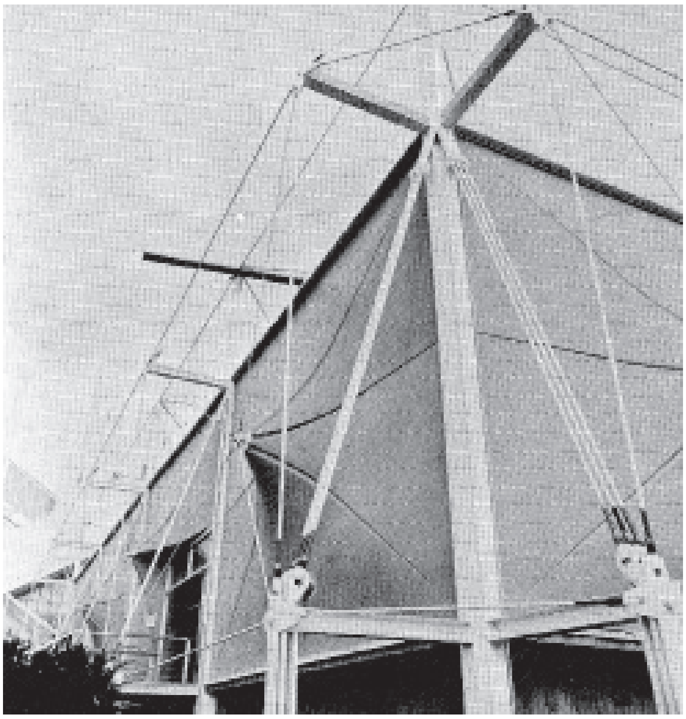

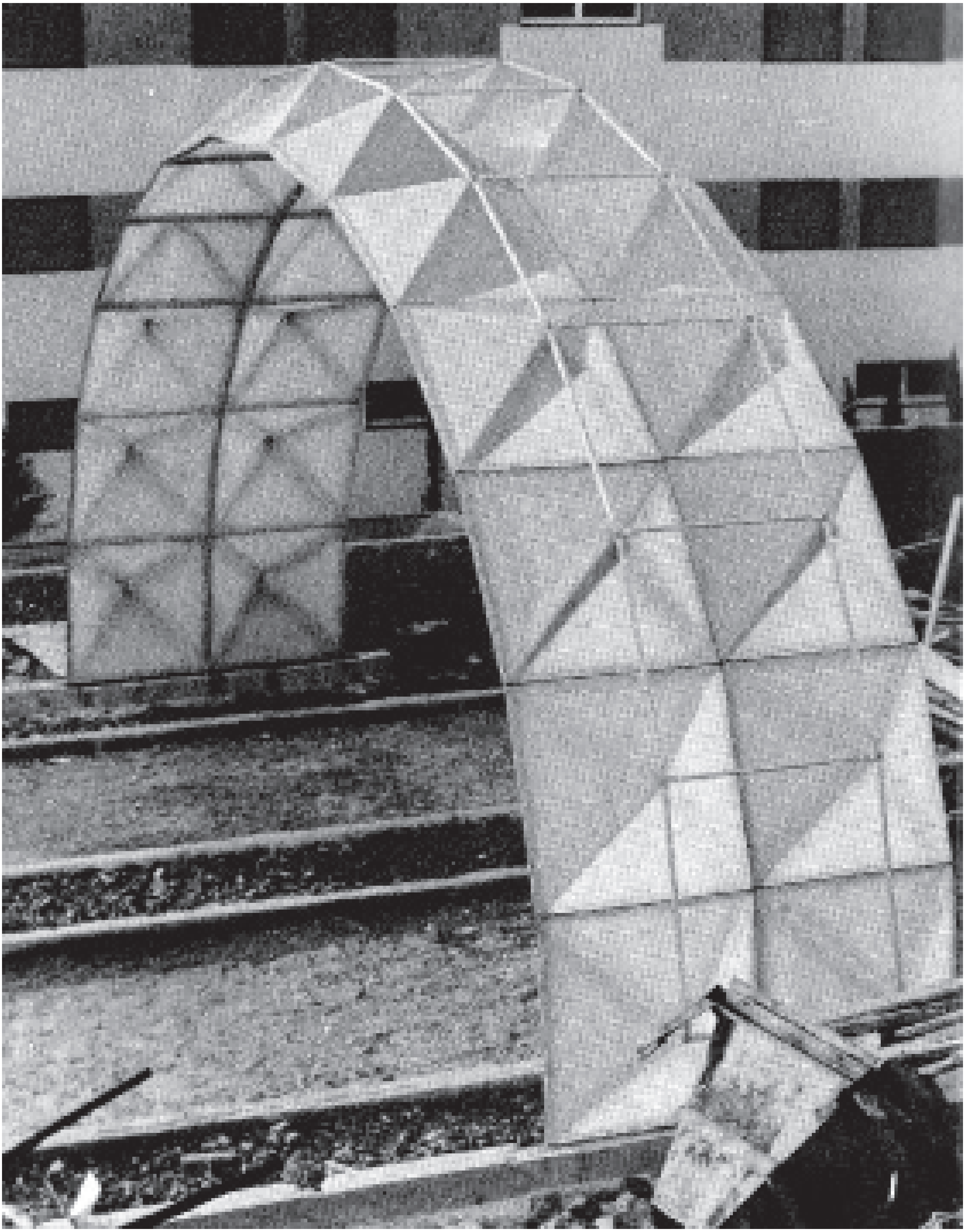


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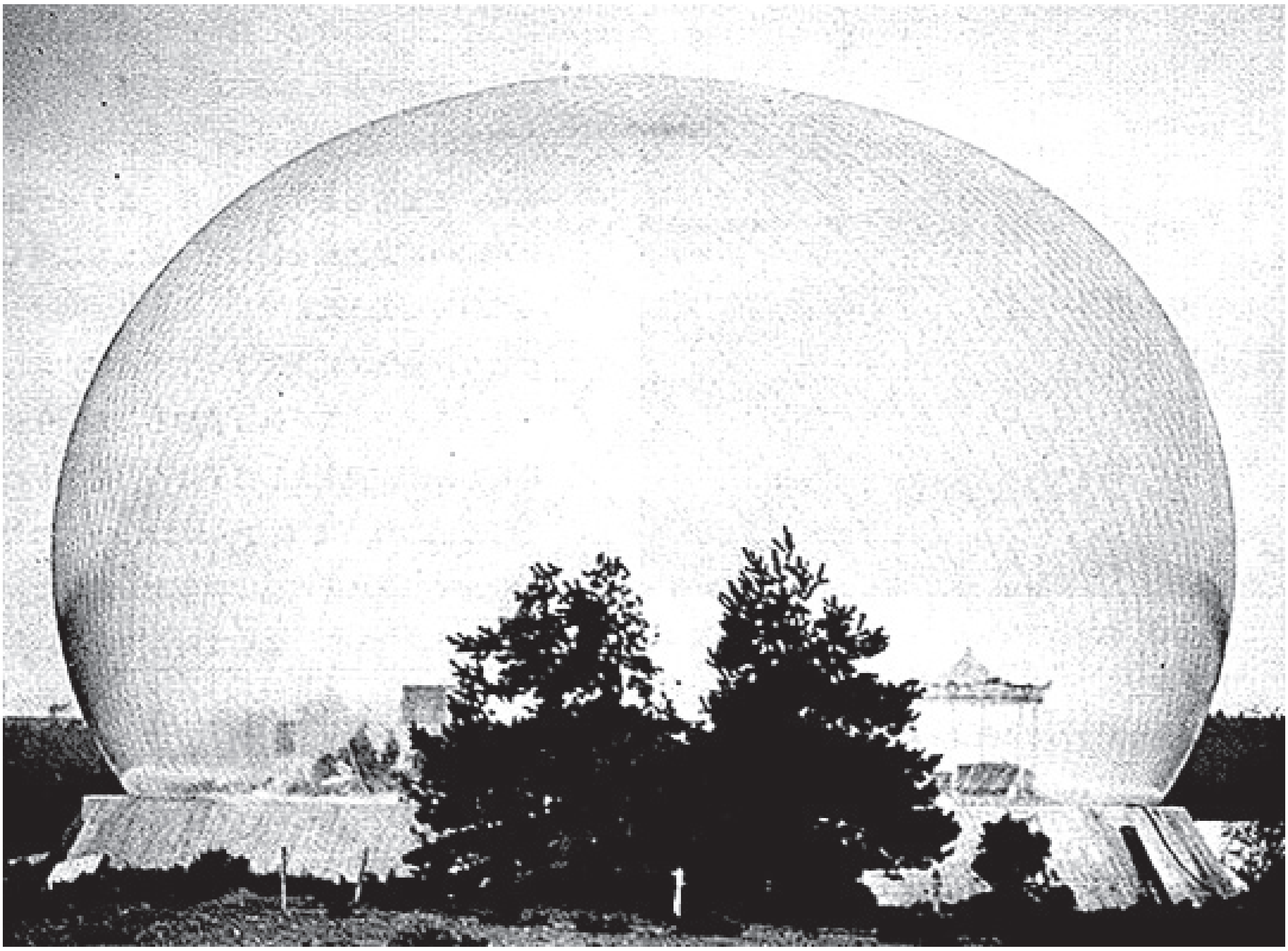
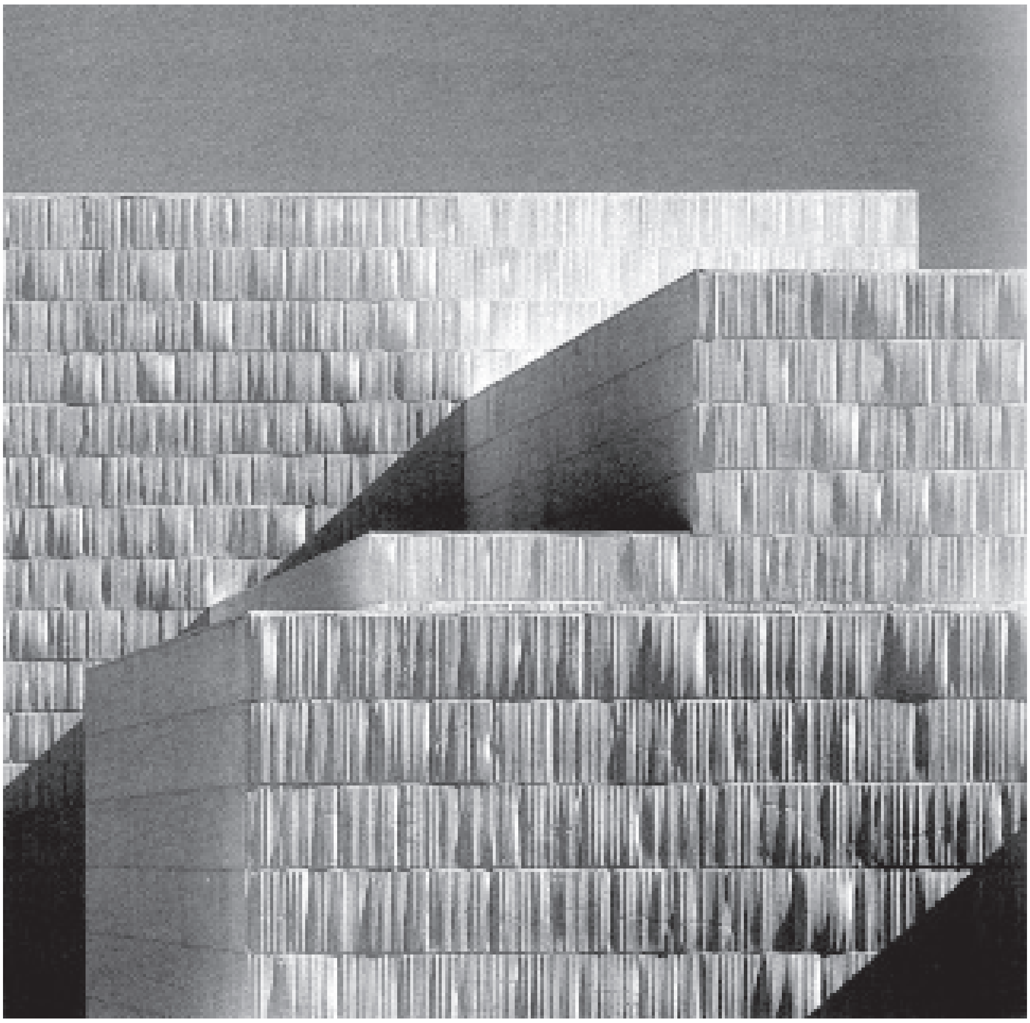
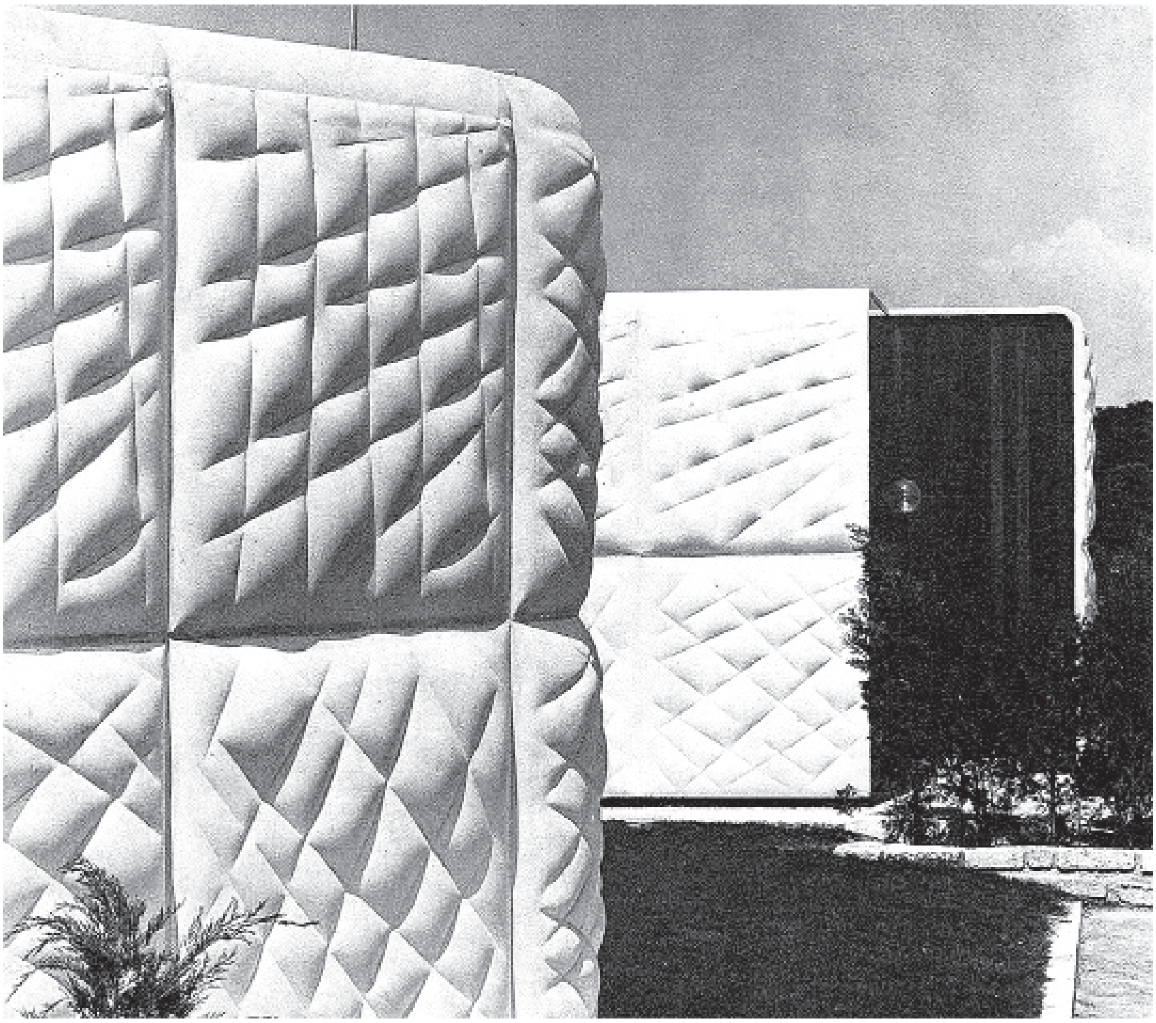







2

CURRENT RESEARCH ON SYNTHETIC MATERIALS AND RECENT PROJECTS

Today, architects use fabric surfaces, often synthetic fibres or composite plastic materials, to design spaces. They make use of techniques inherited from both tradition and experiments conducted by the pioneers of plastic construction of the 1960–70s.

The scientific development of both material and production technologies plays a fundamental role in the creation of new, increasingly efficient materials. Advanced materials companies, such as the Zurich-based Oerlikon, employ state-of-the-art technologies, and research laboratories like EMPA – Swiss Federal Laboratories for Materials Science and Technology carry out research for the development of new materials and surfaces.

Advanced materials adhesives represent a new engineering and technology industry, producing excellent results in the bonding of different materials and surfacess thanks to research carried out by companies such as 3M, a leader in the field of adhesive materials.

At the Institute of Technology in Architecture at the ETH, research is currently being carried out on the use of textile fibres in construction, in particular by Mariana Popescu, on pre-stressed fabric formwork. This technique allows the formwork used to be left exposed as the outer surface of the structure after casting.

ETH RESEARCH FOR A KNITTING STAY-IN PLACE FORMORK
→ 96–97

Mariana Popescu from Block Research Group at the ETH conducted research on developing a novel type of formwork for concrete based on pre-stressed fabric formwork principles. It aims at creating geometries that are fabricated in one piece by knitting technical fibres, which could ultimately be used as reinforcement for concrete. This approach would result in a spatial textile that minimizes the need for patterning, sewing, welding or gluing compared to the conventional approach to fabric formwork and textile reinforcement based on woven fabrics. It makes it possible to create directional material properties aligned to the internal force flow. They have used the new technology to create a five-tonne concrete structure for an exhibition in Mexico City. The heart of the four-metre-tall curved concrete shell is knitted. The structure's formwork is a textile supported by a steel cable-net. The prototype KnitCandela marks the first application where this technology is being used on an architectural scale. The structure is an homage to Spanish-Mexican architect Felix Candela (1910–1997) and a collaboration with Zaha Hadid Architects Computation and Design Group (ZHCODE), and Architecture Extrapolated (R-Ex). Following a digitally generated pattern, an industrial knitting machine produced the shuttering of the formwork for the shell structure: in 36 hours,

it knitted a fully shaped, double-layered 3D textile consisting of four long strips. The lower layer forms the visible ceiling – a designed surface with a colourful pattern. The upper layer contains sleeves for the cables of the formwork system and pockets for simple balloons, which, after the entire structure is coated in concrete, become hollow spaces that help save on materials and on weight. Manufacturing a formwork for such a geometrically complex structure using conventional methods would cost substantially more in both time and material.

CELINE PAVILLION
Smiljan Radić,
Paris Fashion Show, 2017
→ 98–101

Radić designed an inflatable bubble installation using parachute cloth for an eight minute fashion show. He inflated a huge simple bag with a banal geometry, which, as it began to inflate to its full size, would settle into the surrounding space, turning the structure of the existing building into an unwitting mould for its shape. The chosen material, slightly resembling thick silk, gave the structure a sensual, textile-like aspect that would be hard to obtain with PVC-covered polyester cloth, the material commonly used in this type of inflated structure.

BIO BIO REGIONAL THEATRE
Smilijan Radić
Chile, 2017
→ 102

The primary material of the building is PTFE, a Teflon coated woven fibreglass. PTFE is a linear polymer. It is an engineered material which has excellent physical and chemical properties, such as outstanding thermal stability and toughness at low temperature, low thermal conductivity, perfect insulating and dielectric properties, an extremely low coefficient of friction and chemical resistance. By day, the building looks like a solid object and sunlight gently pours inside through the PTFE shell. At night it glows invitingly.

SERPENTINE PAVILION
Smilijan Radić
London, 2014
→ 103

The pavilion, a glass-fibre reinforced plastic (GRP) shell resting on large quarry stones, was inspired by a papier mâché model which Radić created four years earlier. GRP is more commonly used in boatbuilding. A seemingly impossibly thin translucent shell of 12mm gives the sensation that the entire volume is floating. During the evening hours, the amber tinted light glows from inside.

SOCIAL HOUSING MULHOUSE
Lacation & Vassal
France, 1993
→ 104

Until a few years ago, there was a partly justified view that many plastics discolour and so were seen as low-value products with short lives. Now, however, the new US stabilizes materials are seen as the essence of contemporary architecture. Industrial clear polycarbonate corrugated sheets are the light weight walls. Lacation & Vassal, through the use of polycarbonate corrugated sheets, want to solve the cost-efficiency issue for social housing. Plastic textile surfaces are used as a solar shading.

STEILNESET
Peter Zumthor,
Norway, 2011
→ 105

The building is a floating passageway of fabric. It is made of fibreglass canvas coated with Teflon, which looks rather like sailcloth. The flexible textile form is stretched on a wooden frame. It moves with the constant coastal wind. The light bulbs suspended in front of the windows sway gently. Interior wall is inside surface of the canvas coated in black. Therefore you can directly see formed canvas by tension when you are in the building.

THE FABRIC FORMWORK BOOK
Mark West, 2017
→ 106–107

The use of flexible moulds for concrete construction represents a very simple technical change - one common material such as plywood, is replaced with another such as a plastic trap, for example. Yet the results of changing rigid panels for flexible membranes have profound repercussions for sculptural, architectural and structural form, as well as for construction logistics and economy. In “The Fabric Formwork

Book” authored by Mark West, you find comprehensive explanations of the history of fabric formwork and various construction techniques of concrete cast in flexible formwork for actual built projects. West states that polyethylene (PE) and polypropylene (PP) fabrics are the preferred formwork fabrics because of their cost efficiency and great durability. Coated fabric with PE and PP can be welded by heat as in the photo below.

TESHIMA ART MUSEUM
Ryue Nishizawa,
Japan, 2010
→ 108–109

This is a built example of a freeform shell cast on earthen formwork. The reinforcement was laid out, following the curved surface of the shell, and white concrete was poured in one step within twenty-two hours. Seven weeks after concreting, the soil bellow the shell was scraped out with equipment and conveyor belts. The seamless shell of the open gallery space stretches over 40 x 60m with a shell thickness of 25cm. There are no further structural elements like columns and beams. With a museum, opened to light, air and rain, the architect materializes a goal to generate a fusion of the environment, art and architecture.

TEXTILE GYPSUM CASTING
Studio Anne Holtrop, 2018–
Maison Margiela Bruton Street Flagship Store, London and AW2018 Artisanal Show Runway Paris
→ 110–113

Studio Anne Holtrop designs flagships stores and a runway for an artisanal show for fashion farm Maison Margiela. One of the core elements are the gypsum casts in textile formwork. Due to the flexibility of the textile, the cast results in a different form every time. After removing the textile formwork, the imprint of the textile remains visible on the surface of the walls and columns, together with the pleats of the textile and volume of the gypsum that pushed the formwork out. The walls and columns are turned inside out. We look at the lining and the interior of the wall. We see the memory of the textile that was once there. Gypsum traces the texture of the textile and stitched details as well.

CARBON TUBE CHAIR
Jonathan Muecke, 2011–
→ 114–115

The Carbon tube chairs are a specific outcome of an ongoing research of a very specific kind of the composites – a ‘biaxial woven sleeve’. This format was chosen for its linear nature and its simplicity – and the chance to develop a basic forming technique that does not require an external mould but rather a soft internal mould (mandrel) made from air or foam. These expectations and choices keep this project far from industries established composite production practices thus allowing me to seek patients and to begin to develop a company dedicated to the production of carbon tube structures. Muecke has been developing unique techniques for a series of Carbon tube chairs since 2011. Epoxy resin is injected in 'biaxial woven sleeve' and the resin and the soft sleeve are solidified together. This technique results in unconventional possibilities of joint in his furnitures.

CONDITIONS–CONTRADICTIONS–CONSTELLATIONS,
Julius Henkel,
Graduation Project, 2018
→ 116–118

In collaboration with the company 3M, Henkel explored techniques of the structural joining of stone material that both pays tribute to the different properties of stone and glue. Properties of the two materials are in a way opposed in their actual nature, especially the rocks on site, which are metamorphic and in that way especially fragile in the direction of their foliation. Since glue is a highly efficient material, it allows the project to remove itself from a building site that has to be connected to an infrastructure, usually needed to provide the building material. The rocks, the second building material for this project, can be found on site.

PLASTIGLOMERATES
→ 119

Geologist have conducted a study on a new type of stone 'Plastiglomerate.' The study points to how the Anthropocene Era is leading to the formation of new manmade minerals. It consists of a mix of molten plastic debris and beach sediment, including sand, wood, and rock.

BASALT FIBRE
→ 120

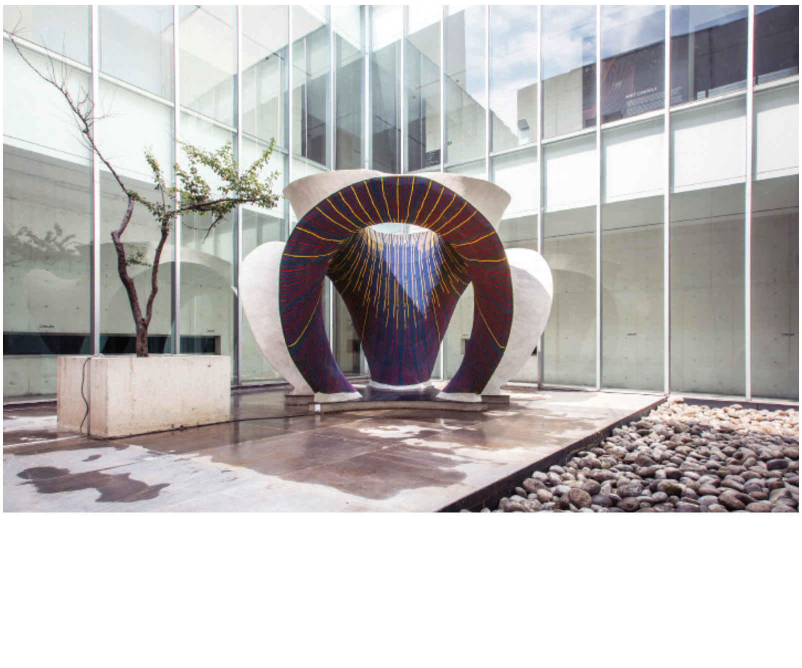
The rfibre-reinforced composite materials sector is also constantly evolving in terms of eco-sustainability. A recent discovery is the use of fabrics made with basalt sfibres, which can be impregnated with both epoxy matrices and cementitious matrices, and which are currently used in the civil industry and architecture sector. Basalt rfibres are produced from volcanic rocks composed mainly of aluminium-silicates, titanium oxide and calcium oxide.y The composition of the rock can vary depending on the location of the quarry. Thanks to their composition and the spinning process, these fibres have excellent mechanical and chemical-physical properties. They are ideal for all applications that require high static and impact resistance, resistance to high temperatures (over 900°C), insulation properties, electromagnetic transparency, and durability in aggressive environments. Basalt fibres are an excellent alternative to glass and aramid fibres since they have a comparable stiffness and better fire and corrosion resistance properties.

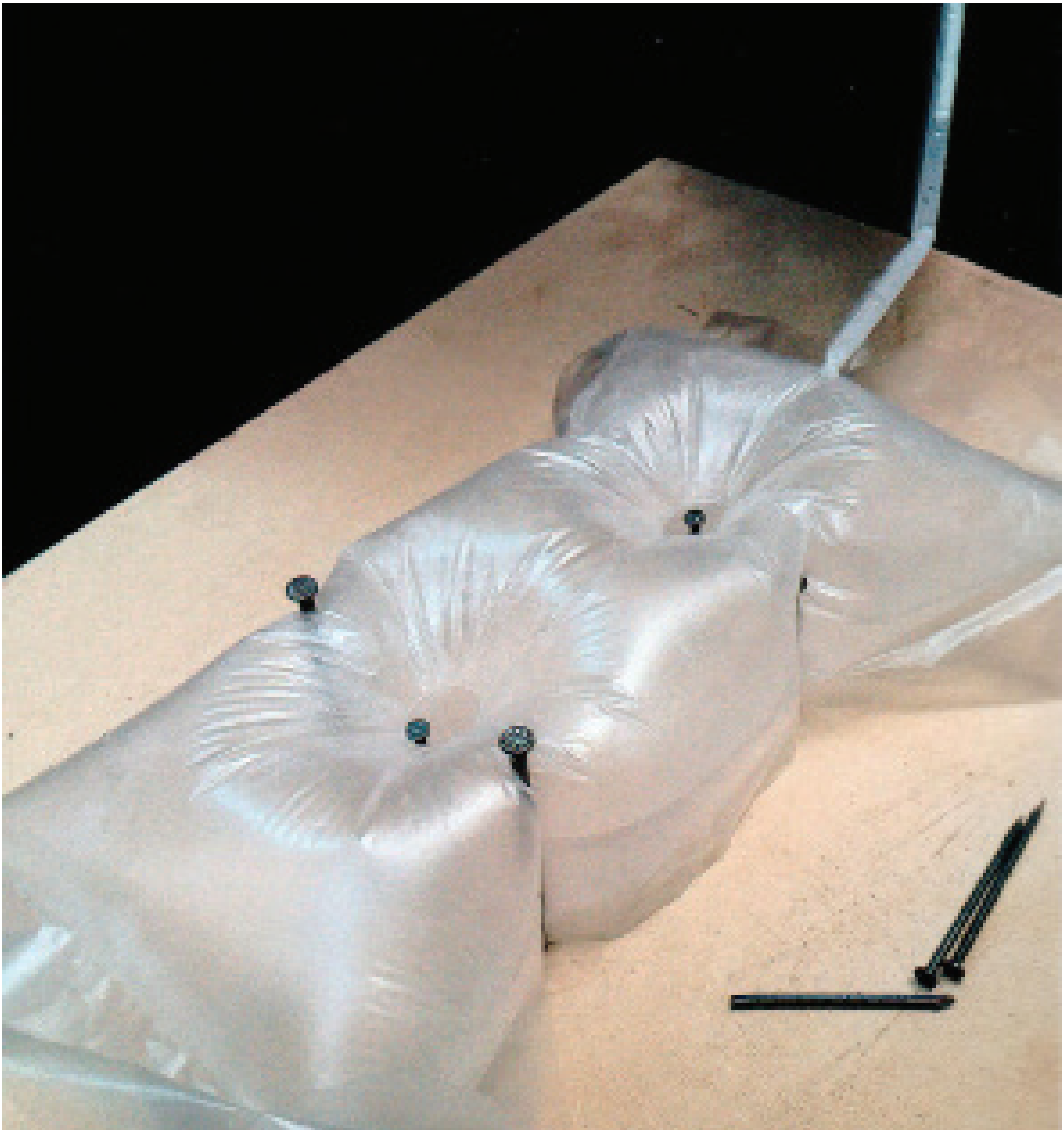
OERLIKON METCO AG
Advanced Material Company, Zürich
→ 121

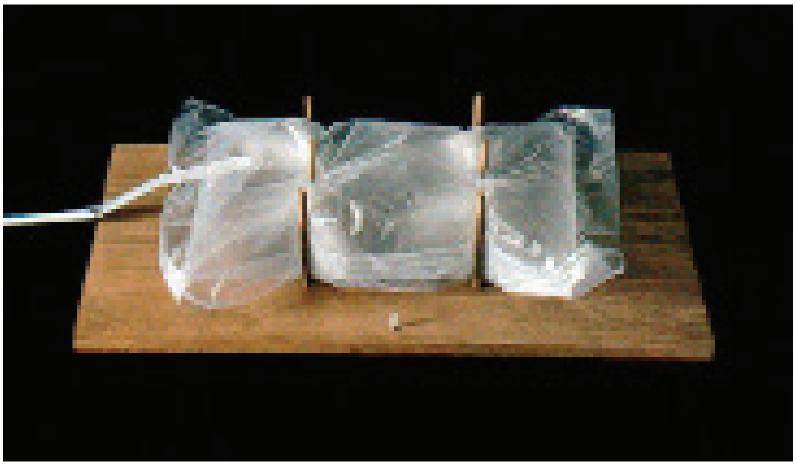
Oerlikon is a leader in filament spinning systems used for manufacturing manmade fibres. They provide the entire production process, from the monomer (polymer processing) to the textured yarn. Oerlikon coordinates technologies and processes based on excellent raw materials and works with high levels of technological expertise in the production and handling of synthetic materials such as manmade fibres. In addition to manmade fibres, Oerlikon is engaged in advanced materials and surface engineering.

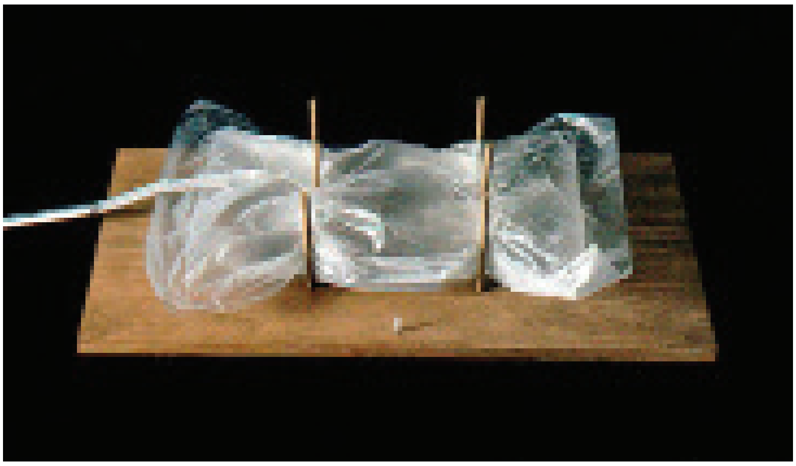
EMPA MATERIALS SCIENCE & TECHNOLOGY
Advanced Fibres, St. Gallen

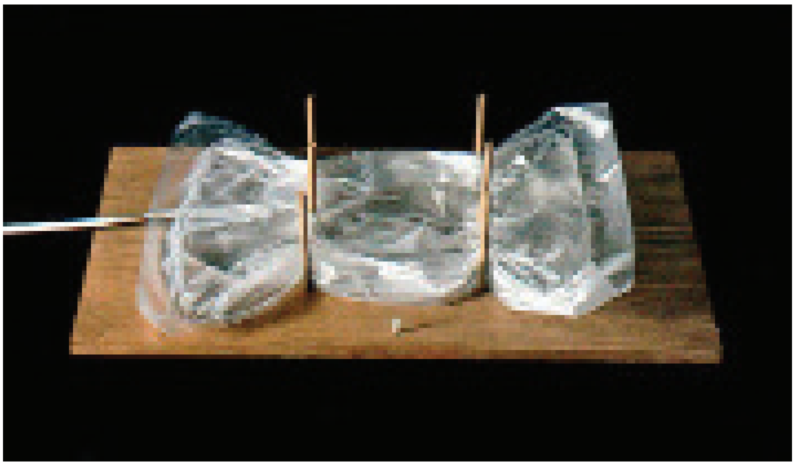
EMPA Laboratories focuses mainly on the development of novel synthetic fibres. EMPA analyzes and modifies the fibre structure on nanometer to micrometer scales using cutting edge analytical tools and by controlling the melt-spinning process in new ways. EMPA develops fibres with new properties and collaborates with industries that use these fibres in textiles for different application areas, like architecture. Besides collaborating with industries, EMPA closely collaborates with the ETH. EMPA develops materials and surfaces, environmental, energy and sustainable building technologies, as well as biotechnology and medical technology.

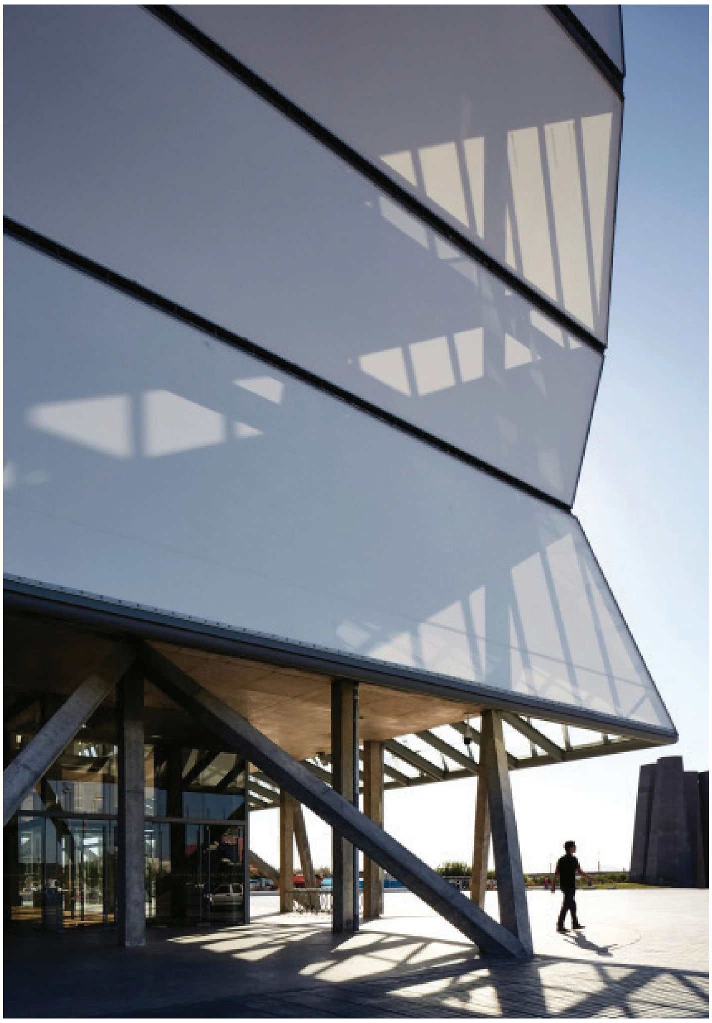


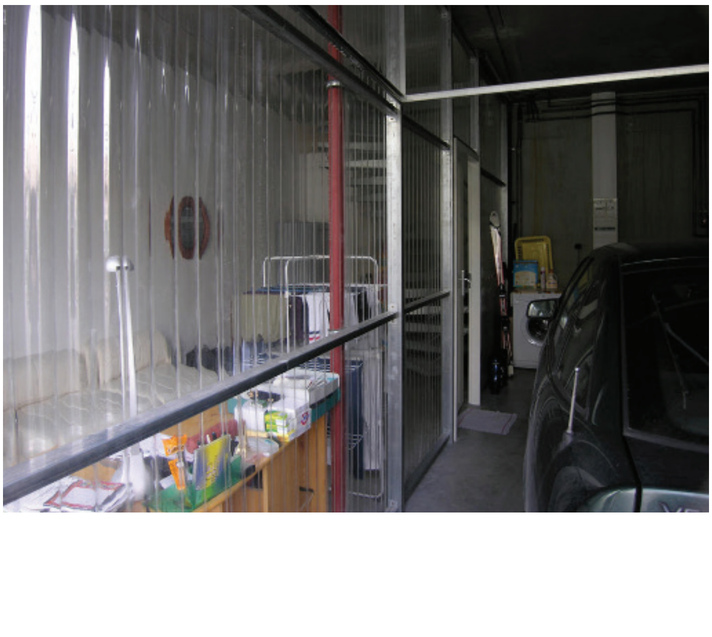


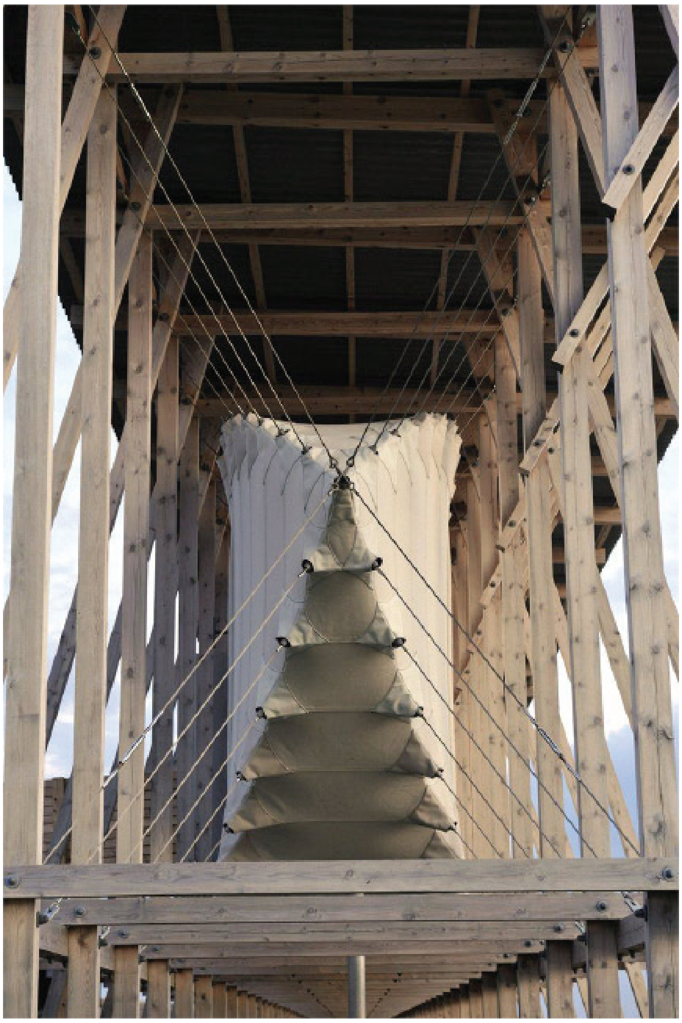


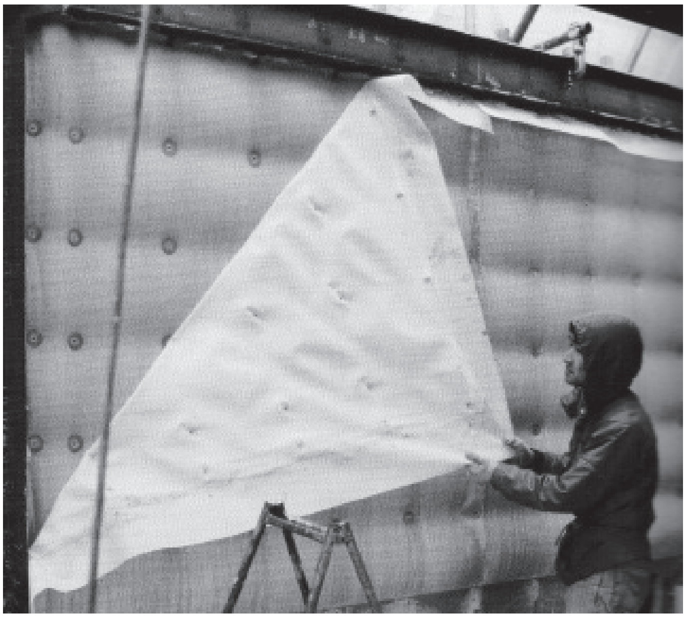


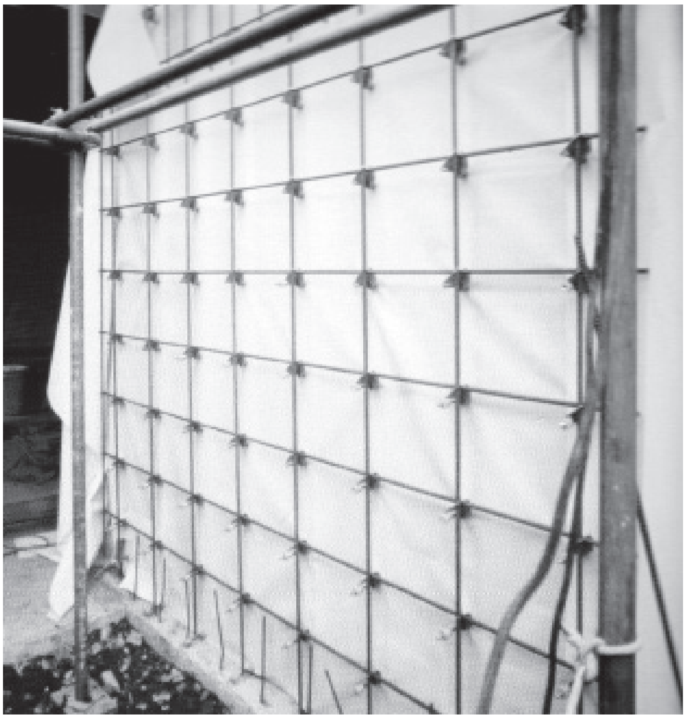


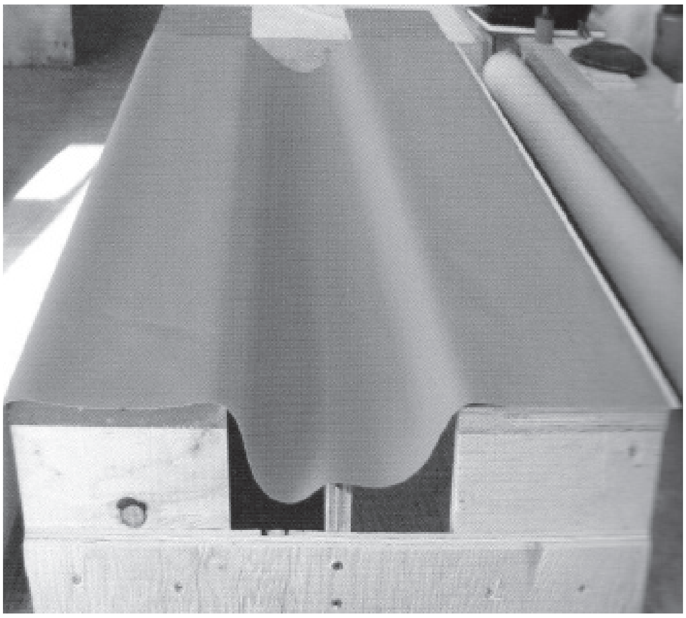


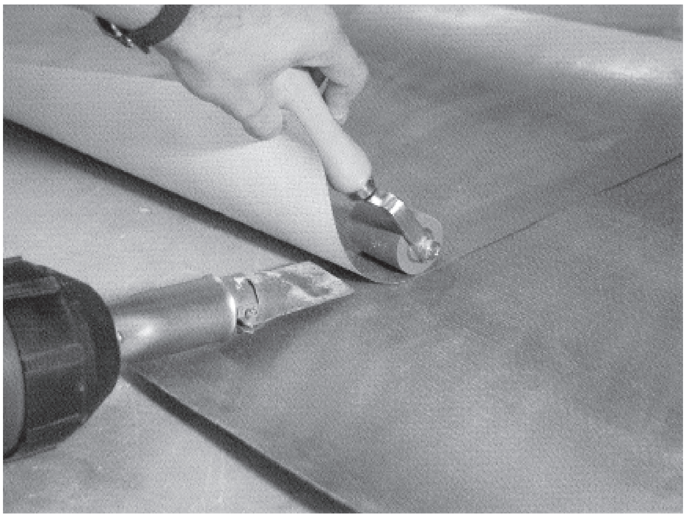


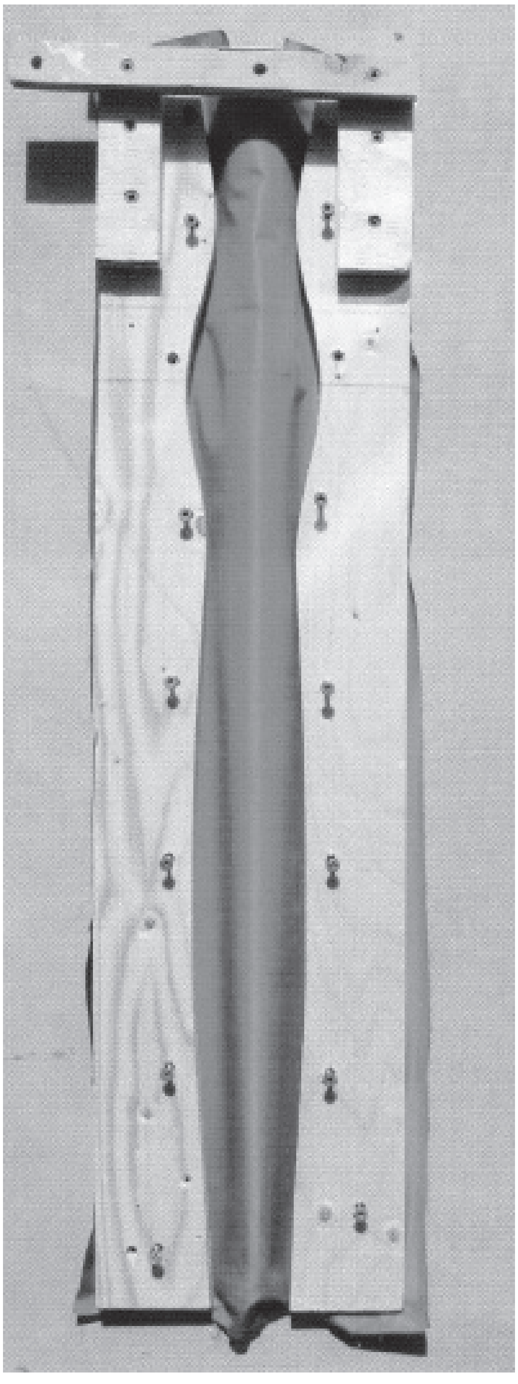


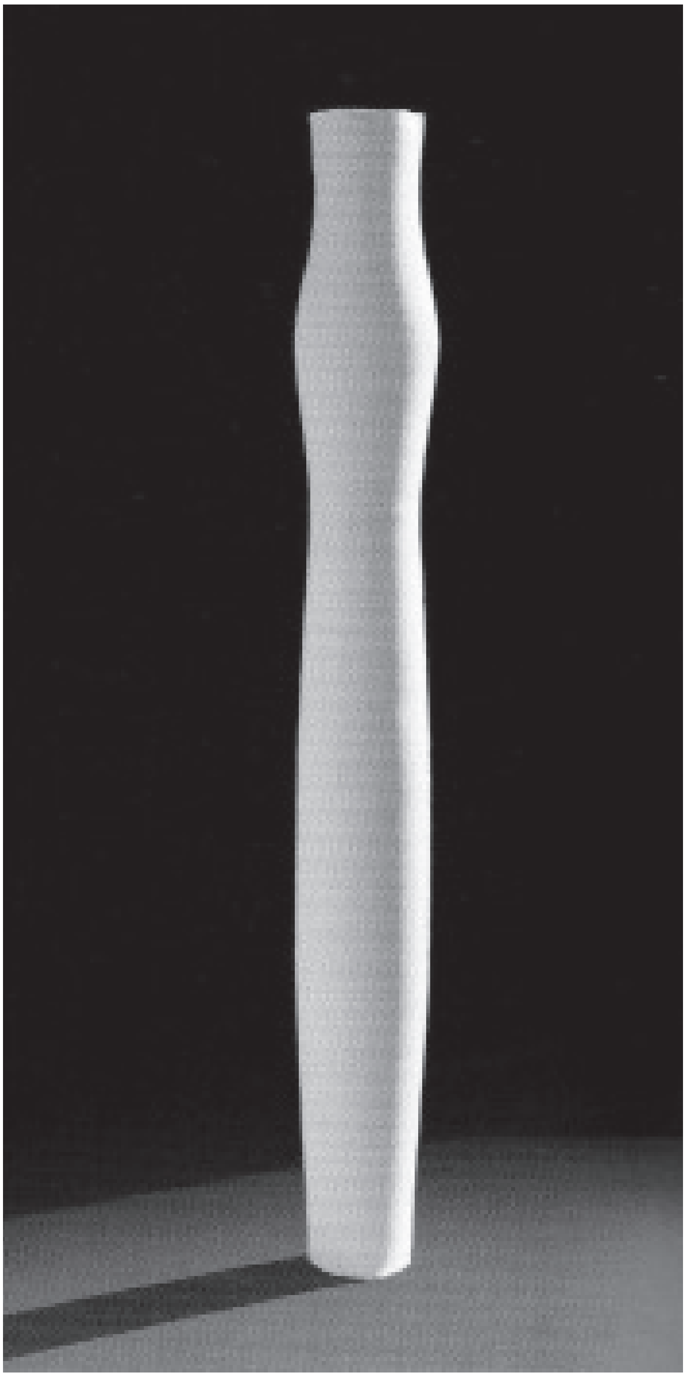



















1

Scotch-Weld 7240 B/A – FR, modified

B/A epoxy adhesive is a high performance, two-part toughened adhesive. Offers high shear and peel adhesion and outstanding levels of durability. Contains 200 µm glass beads for accurate glue line control.

properties:

high weather resistance
temperature resistance −60°C -> +80°C
visco elastic, rubber particles
fire resistant
high pressure resistance
translucent
possible fibre reinforcement (glass fibres) for tension loads
up to 3cm layer thickness
application through injection

2

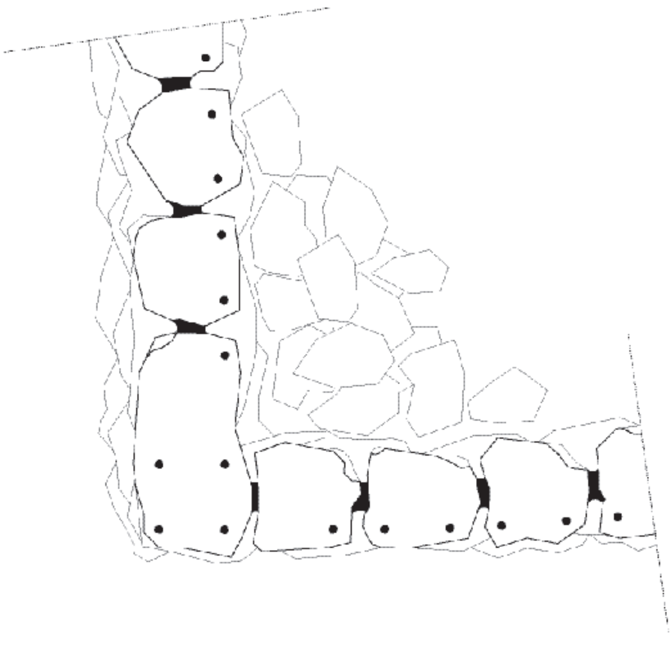
drilled holes in two different diametres ensure the interlocking of the glue strings

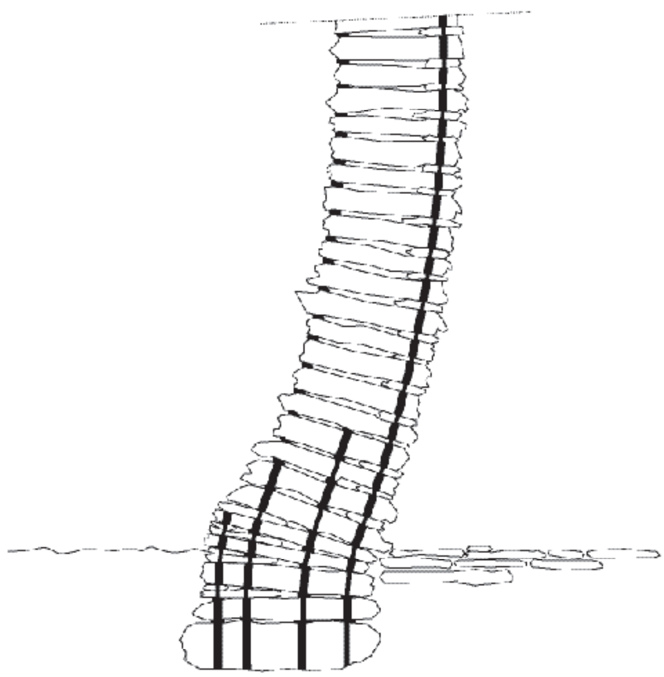
3

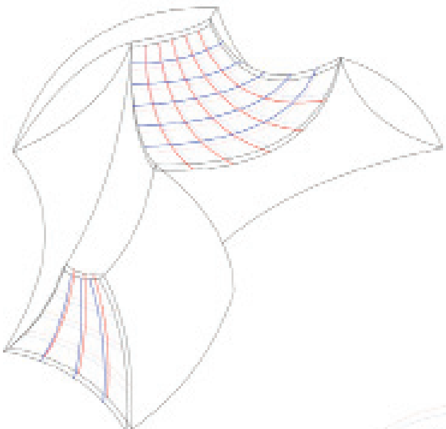
regional metamorphic rock
phyllite + mica schist

properties:

high weather resistance
good tensile strenght along foliation, low tensile strenght against foliation
hight pressure resistance against foliation
good cleavability along foliation







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COMPANIES

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Winterthur

EMPA Materials Science & Technology – Advanced Fibres
St. Gallen

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