Studio Anne Holtrop

ETH Zürich

semester book FS19

MATERIAL GESTURE:

GYPSUM

GYPSUM CASTING IN TEXTILE, STUDIO ANNE HOLTROP, BAHRAIN

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VERB LIST, RICHARD SERRA, 1967

MATERIAL GESTURE:

GYPSUM

> About the concrete; no metaphor (no transformation), no transcendence (no abstraction), and no representation (only presentation).
> — Ellsworth Kelly

For this first semester, FS19, we will work with GYPSUM, as part of our six-year MATERIAL GESTURE research and design. Our starting point is a geological understanding of the mining of our source material and the consequent irreversible changing of the environment.

Geology has its own entropy. Everything is gradually wearing down, as we can see in the beautiful Karst landscapes where gypsum is naturally dissolving. However, by mining our building materials, we change our environment in a very different way with open mining, quarries, and their related infrastructure. In order to build, we mine. Therefore we

work in parallel on two sides: the sourcing of our material and its use in construction.

Gypsum is widely used in architecture, either as part of the process of making architecture, or in constructing architecture itself, such as the mass production of plaster, gypsum board and building blocks. Gypsum has been used since the time of the ancient Egyptians as a painted plaster finish inside the pyramids and as a structural material for the mortar in between the large stone blocks. Some researchers believe that it was even used as a complete structural material by casting the building blocks themselves in gypsum.

As a prototyping material, gypsum is used for model making: think of Vincent de Rijk's famous positive and negative cast models of the Très Grandes Bibliotheque for OMA, or the recent Incidental Space by Christian Kerez for the Venice Architecture Biennial, for which he started by casting amorphous substances in gypsum as a way of spatial form-finding.

Gypsum is used as a casting material for ceramics, glass, bronze or aluminium. In addition to its applications in architecture, gypsum is widely used as an additive in the food industry, and as fertilizer in agriculture. At ETH Zürich, several research projects have been conducted by a number of different departments that involve gypsum as their main subject, or where gypsum is as an important material used to support laboratory experiments.

When we take all aspects of the material into consideration – the geology, the mining, 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.

We will define our gestures of making and working with material(s) in which gypsum is a key element in order to produce an architecture where the reality of the work lays within the materiality, the space, and the act of making. The architecture that results from this approach does not reference or represent something, but simply attempts to exist as a physical reality.

Richard Serra's VERB LIST is a beautifully rich summary of all manipulations and all gestures that we can apply to matter. He created this list while he was making one of his most fascinating works in which he cast the corners of an exhibition space by throwing liquid lead in it – to splash. The final form resulted from a process of making.

Before anything else, there occur … paper, canvas, pencil, crayon, oil paint. The instrument of painting is not an instrument. It is a fact. Twombly imposes his materials not as something which will serve some purpose but as an absolute substance, manifested in its glory (in the theological vocabulary, God's glory in the manifestation of his Being). The materials are what the Alchemists called MATERIA PRIMA–what exists prior to the division of meaning: a tremendous paradox, since in the human order nothing comes to man that is not immediately accompanied by a meaning, the meaning which other men have given it, and so on, back to infinity. The painter's demiurgic power is that he makes the materials exist as substance; even if meaning emerges from the canvas, pencil and color remain 'things', stubborn substances whose persistence in 'being-there' nothing (no subsequent meaning) can annul.

Twombly's art consists in making things seen–not the things he represents (that is another problem), but those he manipulates: these few pencil strokes, this graph paper, this patch of pink, that brown smudge. This art has its secret, which is in general not to flaunt substance (charcoal, ink, oil paint) but to permit it to linger. We might think that in order to express the pencil's character it would have to be pressed hard, emphasized, made thick, black, intense. Twombly thinks the opposite: by withholding the pressure of substance, by letting it come to rest quite casually, so that its texture is somewhat scattered, matter will revel its essence, grant us the certainty of its name: this is pencil.

(…)

The task, then, is always, in very circumstance (in any work whatever), to make substance appear as a fact (pragma). To perform it Twombly has, if not methods (and even if he had, in art method is noble), at least habits.

(…)

It is through these gestures, then, that Twombly utters (could we say: spells out?) the substance of what is drawn: (1) scrathing: Twombly scratches the canvas with a scribble of lines; the gesture is that of an occasionally intense oscillation of the hand, as if the artist were doodling, like someone bored during an union meeting and blackening a scrap of paper in front of him with apparently meaningless lines; (2) clotting: Twombly controls his clots, shifts them around as if he intervened with his fingers; the body, then, is here, close to the canvas, not by projection but, so to speak, by contact, though always light: nothing is ever ground in; hence, it might be better to speak of maculae rather than 'clots'; for the macula is not just any stain or clot, it is (etymologically) the stain on the skin, but is also the mesh of a net, suggesting the reticulation of certain animals; Twombly's maculae, as a matter of fact, do suggest a network; (3) smearing: my name for the streaks, of color or of pencil, often of indefinable substance, with which Twombly seems to cover up other marks, as if he wanted to erase them, without really wanting to, since these marks remain faintly visible under the layer covering them; this is a subtle dialectic: the artist pretends to have 'spoiled' some piece of his canvas and to have wanted to erase it; but then he spoils this erasure in its turn; and these two superimposed 'failures' produce a kind palimpset: they give the canvas the depth of a sky in which thin clouds poass in front of each other without canceling each other out.

We might observe that these gestures, which aim to establish substance as a fact, are all related to dirtying. A paradox: the fact, in its purity, is best defined by not being clean. Take an ordinary object: it is not its new, virgin state which best accounts for its essence, but its worn, lopsided, soiled, somewhat forsaken condition: the truth of things is best read in the castoff. The truth of red is in the smear; the pencil's truth is in the wobbly line. Ideas (in the Platonic sense) are not shiny, metallic Figures in conceptual corsets, but somewhat shaky maculations, tenous blemishes on a vague background.

THE WISDOM OF ART, ROLAND BARTHES
published in The Responsibility of Form

ASSIGNMENT

The project you will develop in this studio is based on research and free explorations in the material aspects and ways of making (gestures). You are required to design and make a model of a building in the actual proposed and tested material(s) in which gypsum is a key element.

In our studio, we will work in a workshop and laboratory-like setting where you will research, design and test the proposed material of your project. 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 programme for the building, nor is there a specified location. Both can be chosen at any time in the development of your project. However, they should not complicate the building, but rather 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 building, or a fragment of it, in a scale of 1:15. The model should show the material and the gestures (the ways of making). This is the key element of your presentation, along with samples of the material research. 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. For a maximum of three projects, the models and material research will be crated and archived for future exhibitions.

SCHEDULE

WEEK 1	TUE, FEB 19, 9–12 Introduction with Anne Holtrop
WEEK 2	TUE, FEB 26, 9–18 Studio work with Anne Holtrop and guest Rainer Kündig
	WED, FEB 27, 9–12 Studio work with Anne Holtrop and guest Joni Kaçani
WEEK 3	TUE, MAR 5, 9–18 Studio work with assistants
WEEK 4	TUE, MAR 12, 9–18 Studio work with Anne Holtrop
	WED, MAR 13, 9–12 Studio work with Anne Holtrop
SEMINAR WEEK	MON, MAR 18 – FRI, MAR 22 Trip with Anne Holtrop
WEEK 5	TUE, MAR 26, 9–18 Studio work with assistants

WEEK 6	TUE, APR 2, 9–18 Midterm presentation with Anne Holtrop and guest Cecilia Puga	
	WED, APR 3, 9–12 Feedback with assistants	
WEEK 7	TUE, APR 9, 9–18 Studio work with assistants	
WEEK 8	TUE, APR 16, 9–18 Studio work with Anne Holtrop 18–20 Lecture Anne Holtrop	
	WED, APR 17, 9–12 Studio work with Anne Holtrop and guest Mario Monotti	
WEEK 9	Easter break	
WEEK 10	TUE, APR 30, 9–18 Studio work with assistants	
WEEK 11	TUE, MAY 7, 9–18 Studio work with Anne Holtrop	
WEEK 12	TUE, MAY 14, 9–18 Studio work with Anne Holtrop	
WEEK 13	TUE, MAY 21, 9–18 Finalizing with assistants	
WEEK 14	WED, MAY 29, 9–18 Final presentation with Anne Holtrop and guests Bijoy Jain and Raphael Hefti 18– Apero!	

GUESTS

As an introduction to the semester, two guests lecturers will share with us their knowledge of gypsum: on the 26th of February, the geologist Rainer Kündig will speak about gypsum as a mineral resource, and on the 27th of February, the architect Joni Kaçani, former collaborator at Christian Kerez's office, will present his experience of working with gypsum for the Incidental Space at the Venice Architecture Biennal. On the 2nd of April, for the midterm presentation, our guest is architect Cecilia Puga. On the 17th of April, Mario Monotti will visit our atelier to share with us his expertise as a structural engineer. For the final presentation, on the 29th of May, our guests will be the architect Bijoy Jain and the artist Raphael Hefti.

RAPHAEL HEFTI is an artist born in Biel, Switzerland, in 1978. He lives and works in both Zürich and London. He started an apprenticeship in Electronics and Mechanics and then moved to École Cantonale d'Art de Lausanne before studying at Slade School of Fine Art. Raphael Hefti is dedicated to the practice of creating artifacts of unexpected beauty by applying innovative, industrial processes to ordinary materials.

BIJOY JAIN was born in Mumbai, India, in 1965. He received his M. Arch from Washington University in St. Louis, Missouri, in 1990. Between 1989 and 1995, he worked in Los Angeles and London, returning to India in 1995 to found his practice, Studio Mumbai. Mr. Jain currently teaches at the Accademia di Architettura di Mendrisio in Mendrosio, Switzerland.
In an interview, Mr. Jain emphasized the making and its relation to the maker and the environment: "My interest lies primarily in doing what I do, with care. As an architect, the way you imagine opening a door, developing a chair, designing the texture of a wall or a floor, is very important. It's about quality, about the consideration you apply to the making of something. And it's about being attentive to the environment, the materials, and the inhabitants. It has to be inclusive."

JONI KAÇANI is an Austrian architect born in 1990. He currently works and lives in Zurich. After finishing his studies in architecture at ETH Zürich, he worked at Christian Kerez' office, where he was project leader for the Swiss Contribution to the Venice Biennale of Architecture 2016. At present, he holds a teaching position at ETH Zürich dedicated to the depiction of contemporality in today's architectural production. In 'Parenthesis,' a zine he co-published with Christian Portmann, he argues for the creative potential of specific circumstances surrounding architectural projects, a notion he also pursues in his own independent work, which currently includes the realization of smaller buildings in Austria, Albania and Switzerland through different collaborations.

RAINER KÜNDIG is a geologist and graduated from ETH Zürich with a degree in fieldwork in the Upper Engadine followed by a doctoral thesis on 'Crystallisation and Deformation in the Higher Himalaya' with a multi-year research project in the Himalayas. Today he is Managing Director of NEROS, the Swiss Mineral Resources Network in Bern. Prior to that, he headed the Swiss Geotechnical Commission at ETH Zürich for 28 years, where he is still a lecturer in the fields of Applied Mineralogy and Earth Resources.

MARIO MONOTTI was born in 1975 in Locarno, Switzerland. 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.

CECILIA PUGA was born in Chile in 1961. In 1990, she received her degree in architecture from the Pontificia Universidad Católica de Chile after studying history and the restoration of architectural monuments at the Universitá della Sapienza in Rome from 1987 to 1989. From 1990 to 1993, Ms. Puga served as the Director of the School of Architecture at Universidad Nacional Andrés Bello in Chile, and the editor of the magazine CA published by the Colegio de Arquitectos de Chile. Ms. Puga currently teaches at ETH Zürich. Last semester, she focused on the 'cultural dimension of everyday life' – 'in the ability of architecture (and the ways in which it articulates space and matter) to shape and promote human interaction'.

KARST CAVE, LECHUGUILLA CAVE, NEW MEXICO, USA

GEOLOGY

The first known mention of the word Gypsum was by the Greek philosopher Theophrastus around 300–325 BCE. Gypsum stems from the Greek word γύψος (gypsos) meaning plaster. Gypsum, $CaSO_4·2H_2O$, is the most common selenite mineral. Its main component is calcium sulfate, $CaSO_4$.

Gypsum crystals range from transparent to opaque with a hardness of 2 on the Mohs hardness scale (can be scratched by a fingernail). The four main crystal varieties of gypsum are selenite, alabaster, satin spar (TV stone) and desert rose. Selenite is characterised by its high transparency. Alabaster, which is often found in limestone, can be recognised by its fine-grained white or lightly tinted appearance. Satin spar has a silky, fibrous form. Desert rose is the colloquial name given to rosette formations of the minerals gypsum and barite with sand inclusions.

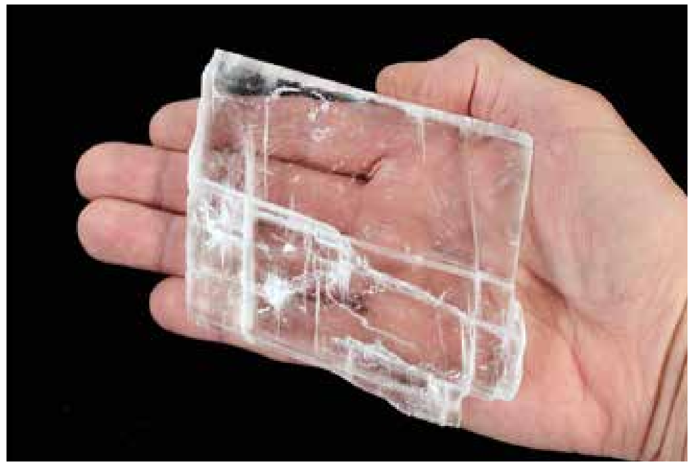
Gypsum occurs in nature as both crystal and masses called gypsum rocks. Gypsum rock is an evaporite and it is typically deposited in thick beds or layers as strata. Evaporite is a type of sedimentary rock created by the evaporation of seawater after sub oceanic sediments appear on the earth's surface due to tectonic activities.

The largest selenite crystal exists in the spectacular Giant Crystal Cave, Nica Mine in Mexico. It reaches 11 metres in length, 4 metres in diametre, about 55 tonnes in weight, and is around 5,000,000 years old.

Because gypsum dissolves in water over time, it is rarely found in the form of sand. However, the unique conditions of the White Sand National Monument in the US state of New Mexico have created a 710 km^2 expanse of white gypsum sand, enough to supply the construction industry with drywall for 1,000 years.

Gypsum is found not only Earth but also on the surface of Mars. This explains the presence of water on Mars.

Karst cave and Tower karst are topographic formations formed over time as the gypsum components in the earth, typically limestone or dolostone, are dissolved by ground- and rainwater. When water drains into the soil, it reacts chemically with the carbon dioxide that occurs naturally in the atmosphere and the soil, and becomes weakly acidic. This acidic



SELENITE

ALABASTER

SATIN SPAR (TV STONE)

DESERT ROSE

GYPSUM ROCK IN STRATA

GIANT CRYSTAL CAVE, NAICA MINE, MEXICO

TOWER KARST, NEAR GUILIN, SOUTH CHINA

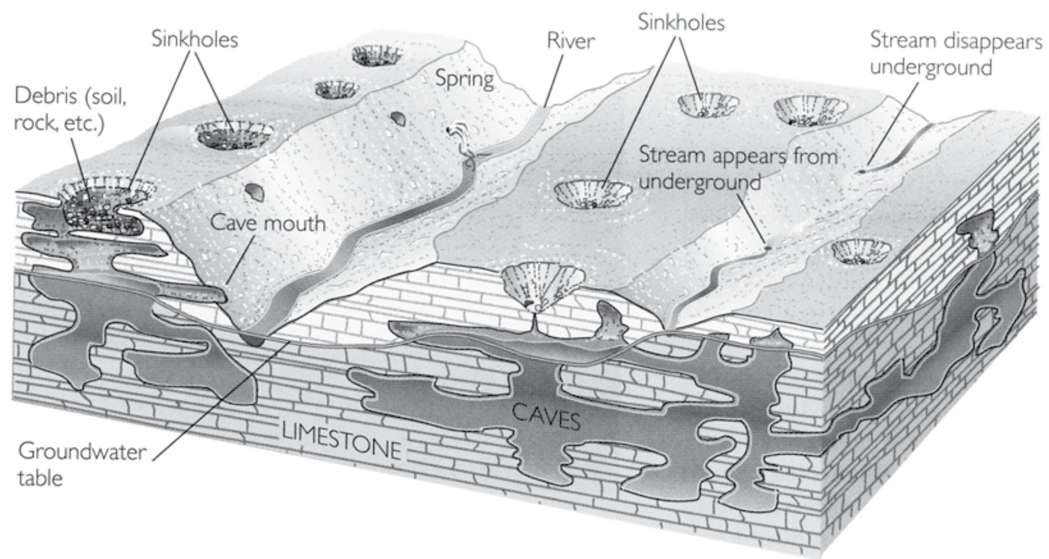


DIAGRAM OF KARST GROUND

water starts breaking down gypsum parts in the ground and, when it enters the underground drainage system, it accelerates the development of karst formations. Lechuguilla Cave in New Mexico is the deepest cave in the USA. It contains six-metre gypsum chandeliers and other varieties of rare speleothems. Tower karst, the spectacular towers that range in height from 30 to 300 metres, occur throughout Southeast Asia. The formation of the tower is a combination of tectonic uplift and tropical karst erosion.

MINING AND PROCESSING

Since gypsum dissolves in water over time, it is rarely found in the form of sand. Most of the world's gypsum is extracted by surface-mining operations. Large quantities of gypsum are found in Brazil, Pakistan, Jamaica, Iran, Thailand, Spain, Germany, Italy, England, Ireland, Canada, and the US. Gypsum rock is mined or quarried, crushed and ground into a fine powder.

No gypsum deposit is 100 percent pure as the raw material is often found in combination with limestone, sand, shale, anhydrite, and sometimes, rock salt. However, a gypsum content of at least 75 percent is necessary for it to be considered commercial-grade gypsum. The quality of the final product depends on the nature and purity of the raw material. Other major parameters are determined by the heating time and temperature as well as the type of grinding. These characteristics define a wide range of materials with very different properties which can be used for very different purposes.

In a process called calcination, the powder is heated to 80–150°C, evaporating 75 percent of the chemically combined water, which is released as steam ($CaSO_4 \bullet 2H_2O$ + heat → $CaSO_4 \bullet 1/2H_2O + 3/2H_2O$). The calcined gypsum, or hemihydrate, becomes the base for gypsum plaster (Plaster of Paris), which does not have strong mechanical properties.

The action is reversible and when dry gypsum powder is mixed with water, it re-forms into gypsum dihydrate ($CaSO_4 \bullet 2H_2O$). This state of gypsum is fast-setting and is employed in mould construction and modelling. The triggering of the phase transition when gypsum reacts with water molecules is a unique property of the material.

If the material is heated over 163°C, it loses all water molecules and forms $CaSO_4$. The material in this state has a longer setting time and is used in the manufacture of gypsum plaster, boards and some other products.

When gypsum is heated to 500–600°C, the chemical composition remains unaltered. However, the material does not react when it comes into contact with water (dead burnt gypsum).

Finally, if gypsum is heated up to 1,000°C, it acquires a very slow setting time. This makes it ideal for use in flooring products which need high mechanical strength and take a longer period to execute.

MONTE TONDO, OPEN MINING, SAINT-GOBAIN GYPROC, ITALY


EXTRACTION OF SOURCE MATERIAL


CRUSHING AND HEATING OF GYPSUM POWDER


PRODUCTION OF GYPSUM BOARD

BUILDING MATERIAL

Gypsum is widely employed in the production of building materials such as gypsum plaster, plasterboards and gypsum blocs. Plaster is a building material used for the protective or decorative finishing of walls and ceilings. The plaster is manufactured as a dry powder, which is mixed with water to form a stiff but workable paste before it is applied to the surface. The reaction with water releases heat through crystallisation and the hydrated plaster hardens. Gypsum plaster is considered to be an ideal surface for a wall because it has the same pH value and thermal conductivity properties as human skin. In addition, gypsum can absorb a lot of humidity through its open and crystalline pores and then automatically release this moisture when the space becomes too dry. Additives can radically change the properties of the plaster thus generating a wide range of diverse products suitable for a variety of different purposes.

Gypsum blocks are generally used for lightweight, fire-resistant, non-load bearing interior elements. In the event of fire, the water crystals vaporise, actively slowing the spread of the fire. In the production process, calcinated gypsum powder is mixed with water – and in some cases additives like vegetable or wood fibre for greater strength – stirred, and poured into moulds to form gypsum blocks of standard shape, either solid, or with round or square open cores to reduce weight and conserve materials. Each block is moulded with tongue-and-groove on all sides to enable quick and easy assembly. Still wet, the gypsum blocks are taken out of the moulds and put into drying chambers.

Plasterboards, or gypsum boards, are panels made of gypsum used in the construction of interior walls and ceilings. They are typically extruded between thick sheets of paper. The plaster is mixed with fibre (such as paper or fibreglass), foaming agent, plasticizer, additives that may inhibit the growth of mildew or increase fire resistance, and wax emulsion or silanes to lower water absorption. When the core sets, it is dried in a large drying chamber and the sandwich becomes rigid and strong enough for use as a building material.

Calcined gypsum also plays a crucial role in cement. Although it is used in small quantities – in the range of 2.5 to 3 percent in terms of

SO_3 – gypsum acts as a retardant, controlling the setting time of cement. It renders workability to mortar or concrete by keeping it in the plastic state at the early stages of hydration. This is achieved by changing the course of hydration of calcium aluminate, which manifests as retardation in cement hydration. Furthermore, gypsum also contributes to strength acceleration in the early stages of hydration.

ASSEMBLING OF GYPSUM PREFABRICATED PLASTER BOARDS AND GYPSUM BLOCKS
The mortar used in the seams is also gypsum-based and the final layer of finishing will be gypsum plaster. The resulting wall is made entirely of gypsum components.

OTHER INDUSTRIAL APPLICATIONS

The list of the applications of gypsum expands far beyond the building industry. Throughout history, it has been employed in very diverse fields, from agriculture to the decorative arts. With slight modification by physical or chemical means, gypsum products can be used for a range of different purposes.

Moulding for the ceramics industry is one of the major uses of gypsum. Ceramics are produced by the slip casting technique. The peculiar porosity of gypsum allows it to quickly absorb part of the water from the clay, thus supporting the hardening process. The enhanced hardness of the gypsum moulds allows them to be re-used for several casting cycles.

In agriculture, gypsum is used for alkaline soil amendment, that is, it is used to reduce the soil's pH and remove excess sodium. It is also used as a fertilizer, a source of calcium and sulphate sulphur for plant growth, and a removal agent of pollutants such as lead or arsenic from contaminated waters. For centuries, gypsum has been used in enology as part of wine plastering to clarify the colour of the wine, as well as for the production of nutrient salts and ammonia-controlling litter in animal breeding activities.

The food industry uses gypsum as a safe additive and binder. Small amounts of gypsum help in preserving several kinds of foods such as ice cream, bread, spaghetti, beer, and tofu. Over a lifetime, a person is estimated to eat about 12 kilograms of gypsum. It is also an additive to some bread and dough mixes as a calcium source and baking aid.

In the healthcare sector, gypsum is used as an excipient for pills, for orthodontic impressions and equipment, as well as for orthopaedic casts to set broken bones.

LAUFEN, TOILET MANUFACTURER, SWITZERLAND

CERAMIC TOILETS ARE SLIP-CASTED IN GYPSUM MOULDS

FOOD-GRADE CALCIUM SULPHATE GYPSUM BLOCKS
USED AS FOOD ADDITIVE, CHINA

CURRENT RESEARCH AND APPLICATIONS

Gypsum is a topic of research in several scientific fields. At ETH Zürich, a number of departments are involved in gypsum-related research.

At the Institute for Building Materials, chemical engineers study gypsum crystal growth at a molecular level to inform the development of building technologies. They have conducted experiments to study the behaviour of gypsum and improve its performance in areas such as resistance to compression or flexion, capacity to bound to other building materials, water resistance, and heat and noise insulation.

The Rock Deformation Laboratory conducts research on the mechanical behaviour of rocks exposed to high pressure deformation forces, which mimic the Earth's natural deformation processes. Because of its softness, gypsum is a malleable rock to use for deformation experiments and is therefore often employed as an 'analogue mineral'. In the laboratory, the behaviour of gypsum exposed to artificial deformation forces is studied and compared to naturally deformed rocks. This research, led by the Structural Geology and Tectonic Group, informs different fields such as seism assessments, prevision of tectonic cycles, and the understanding of forces governing the Earth's topography.

Magnetically Assisted Slip Casting is another example of research involving gypsum at ETH Zürich. This manufacturing technique uses the 100-year-old technique of slip casting in combination with modern material research to create complex materials that are almost perfect imitations of their natural models, such as nacre or tooth enamel. During the cast, a magnetic field changing in direction is applied around the gypsum mould. This continuous process can be used to produce multiple layers with differing materials properties in a single object.

QUEEN’S CHAMBER IN THE GREAT PYRAMID, GIZA, EGYPT

ARTISANAL PRACTICES

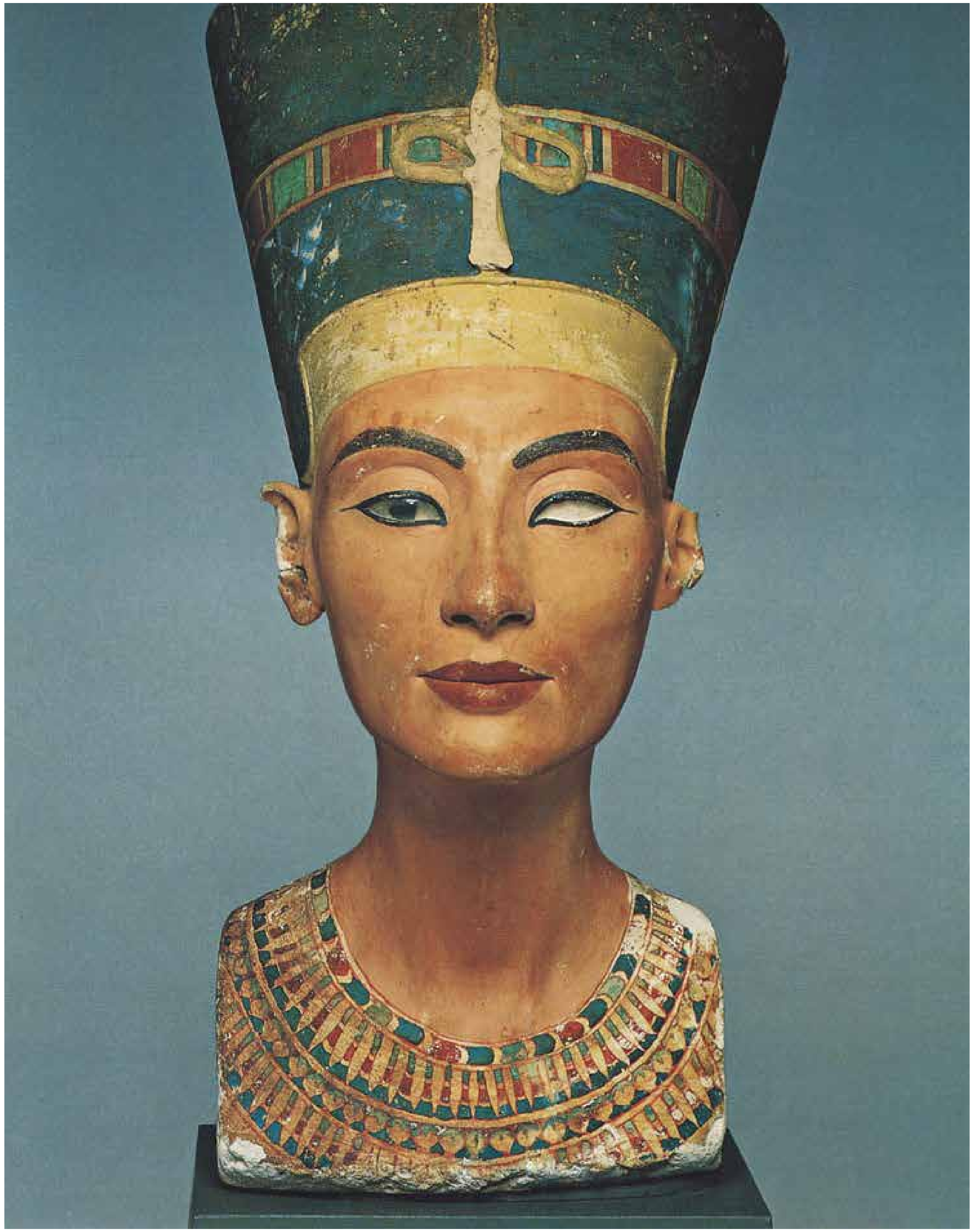
The capacity of gypsum to be worked under different states and its ability to reconstitute itself after being mixed with water has made its use prevalent in artisanal practices since ancient Egypt. It is still widely used today by contemporary craftsmen and artists.

Crushed gypsum was the white pigment ancient Egyptians painted with. As a surface, it was the plastering they applied on their wooden and soft-stone sculptures before colour-painting them. Gypsum has been a basic ingredient for the development of classical Italian craft techniques, such as Stucco and Scagliogla.

Used as a binder, gypsum is found in the mortars holding together the blocks of the Pyramids of Giza. In the ancient Egyptians’ funerary workshops, plaster was used to stiffen the layers of fibre or papyrus applied to mummified bodies for moulding cases and masks. It was among the components of the Opus Caementicium, the concrete Romans used to build structurally complex forms such as the Pantheon Dome.

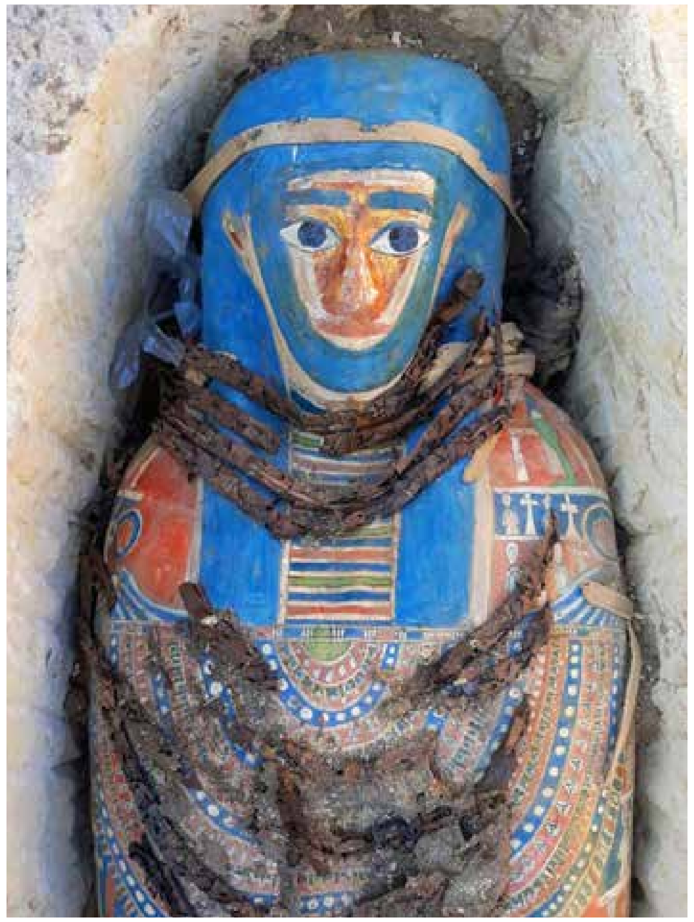
In Egypt, Italy and Spain, gypsum alabaster has been used as a mass – carved or sliced – to produce objects, reliefs, sculptures or window panes since ancient timesy n. Imprinting and casting with plaster was a convenient way to reproduce, collect and exhibit notable examples of facades and sculptures in the 19th century. Rachel Whiteread applies a similar technique to rooms and spaces, casting positive masses out of negative voids.

In many design and form-finding processes, the properties of gypsum are crucial. As an intermediate step in the making of his marble sculptures, Canova used cast plaster models. More recently, pouring plaster allowed Christian Kerez to look for the features of his Incidental Space. In Anne Holtrop's work for Maison Margiela Artisanal Show, gypsum was both the working and the finished project material. From 1:10 models, the behaviour of plaster poured into textile formworks was surveyed and scanned in order to be hand-cast in scale 1:1. In his models for OMA's Très Grande Bibliothèque project, Vincent de Rijk deliberately used gypsum to materialise the constitutive idea of the building.



STUCCO COAT SCULPTURE, ANCIENT EGYPT, PAINT ON GYPSUM PLASTER

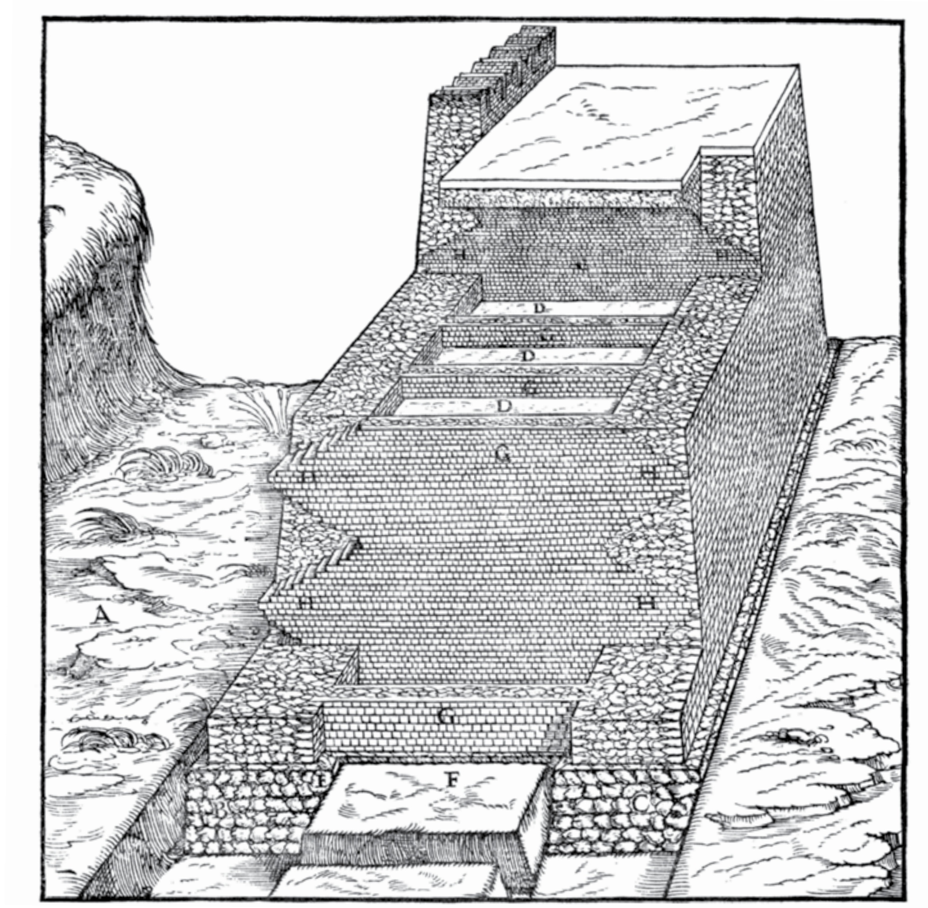
PYRAMIDS OF GIZA, EGYPT, 2550 BC
The mystery of the construction of the pyramids is still under debate. One hypothesis theorizes that the Egyptians used gypsum as a mortar to stabilise stone structure. Another posits that the blocks of the pyramids were not carved stone, but they were cast into reusable wooden moulds in a manner similar to modern limestone concrete.



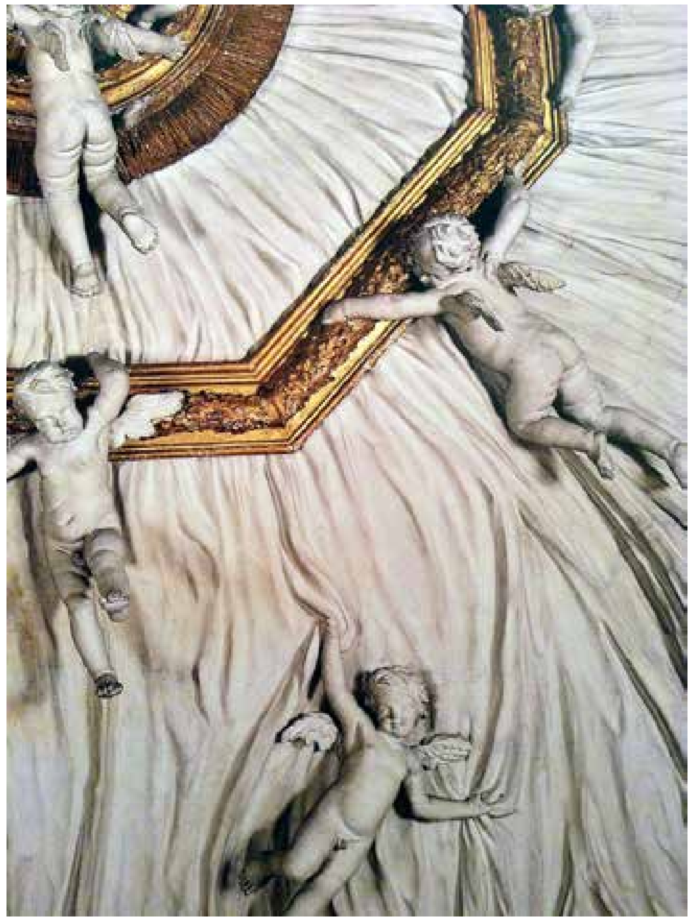
GYPSUM MUMMIFICATION
Eight mummies were recently discovered during excavations near a pyramid in Dahshur, Egypt. Dating from the Late Period (664–332 BCE), the mummified remains were each covered in painted cartonnage – a form of paper-maché made from ground gypsum plaster and papyrus or linen – and buried in a limestone sarcophagus.

ROMAN 'CONCRETE'

Roman concrete, like modern concrete, was an artificial building material composed of an aggregate, a binding agent, and water. Aggregate is a filler, such as gravel, chunks of stone and rubble, broken bricks, etc. The binding agent, also known as mortar, is a substance which is mixed with the aggregate wet (water added) and solidifies as it dries, or sets. Many materials, even mud, can be used as a binding agent. Historically, lime mixed with rubble has been used as a binding agent in making a strong mortar. In some regions of the former oriental Roman Empire, local gypsum was used as a substitute for lime in the opus caementicium. Another Roman contribution to the basic structural mixture was the addition of pozzolona, a special volcanic dust found in central Italy, as a primary binding agenty. Pozzolona created an exceptionally strong bond with the aggregate. The binding agent used in modern concrete is cement. It is manufactured artificially using natural, earth substances. Modern concrete is stronger than Roman concrete mainly because it incorporates steel bars to build up tensile strength; technically, it is reinforced concrete.



RUSCONI, I DIECI LIBRI DELL'ARCHITETTURA, 1660
Illustration of traditional Roman construction techniques



ROCOCO GYPSUM STUCCOS, PALAZZO ALBRIZZI, VENICE

Palazzo Albrizzi (1690–1710) is probably the most scenographical example of Venetian Rococo gypsum stuccos. The stuccos are not merely a decoration but have a strongly narrative quality of the space as well as being a portrait of the aesthetics and the taste of 18th and 19th century culture. Gypsum is the manifesto material of the Rococò period as much as reinforced concrete is of the Modernist movement. Through its intrinsic plasticity and lightness are born lively, suspended compositions simulating waving and folding textiles, expressing the desire of lightness and joyousness of the contemporary aristocracy.

SCAGLIOLA

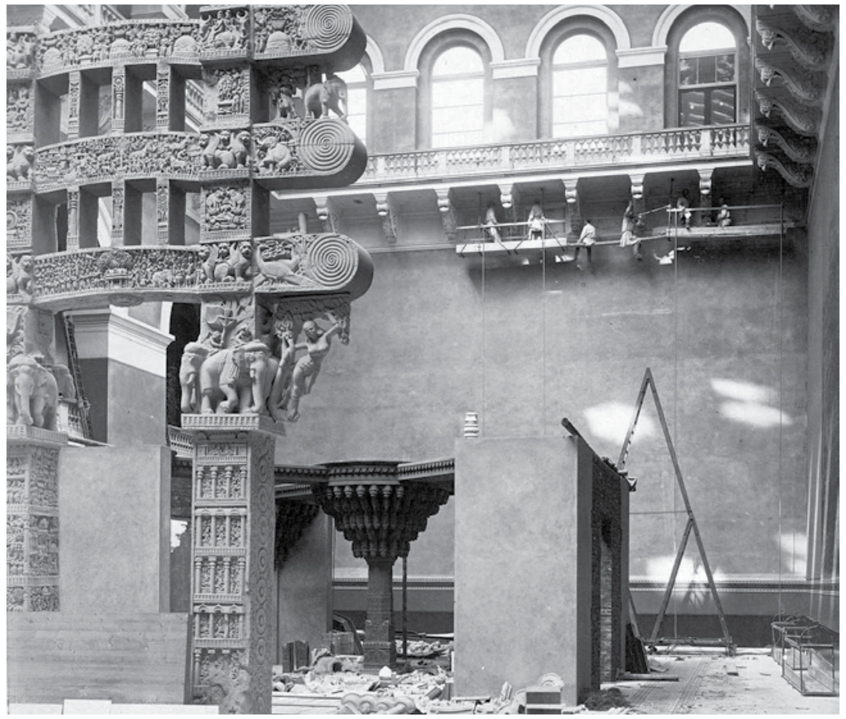
Scagliol literally means 'made with chips'. It is a technique that became very popular during the 17th century to substitute hard and precious stones such as marble with an agglomerate of selenite, glue and natural pigments. Mixing and elaborating these elements makes it possible to perfectly imitate the nuances and textures of marble. Nowadays, this technique is still widespread throughout Italy.

SANTA MARIA IN MONTICELLI IN ROME

All the columns that look like various hard stones are scagliola

MUSEO CANOVA, CARLO SCARPA, POSSAGNO, ITALY

ANTONIO CANOVA, 1757–1822
Canova used an interesting method to copy 1:1 gypsum models to a mass of marble. 'Repère' bronze nails on the gypsum model were key to the method. He measured the distance between 'Repère' using a machine, 'Tellaio,' which had plumbing strings on the wooden frame. He used clay to make the first prototype and cast it to a gypsum model before eventually translating it into marble.



CAST COURTS, THE WESTON CAST COURT, C. 1872, VICTORIA AND ALBERT MUSEUM

For centuries, antiquarian interest in world architecture and sculpture led to reproductions being made of outstanding national monuments and notable sculptures. Casts were made by placing several plaster moulds upon the surface of the original structure. Once hardened and removed, the moulds were then enclosed in an outer casing, the interior coated with a separating agent and the wet plaster poured in. When set, the pieces were assembled and the joints and surfaces finished off to make a complete reproduction of the original work. In addition to being a formidable technical achievement in its own right, the finished product enabled admirers to study faithful reproductions of important monuments and works of art.

INSTALLATION OF TRAJAN'S COLUMN, C. 1873, VICTORIA AND ALBERT MUSEUM, LONDON

Segue TABELLA 6.

PRODOTTI IMPIEGATI	Valutaz. dell'effetto prodotto	OSSERVAZIONI
Bisolfato di sodio . .	+ +	Si usa nella proporzione di 0,25 p. per ogni 100 p. di gesso. Aumenta sensibilmente la rapidità della presa ed accresce la durezza.
Bitartrato di potassio o di sodio.	—	Si discioglie nell'acqua di impasto in ragione di 70 g/l. Produce un ritardo non molto sensibile, mentre promuove una migliore compattezza e resistenza dei manufatti.
Borace	— —	Si scioglie in acqua bollente e si usa nella proporzione dallo 0,3% al 3% fino al 5%. Ritarda la presa, secondo la quantità usata, da 15 minuti a 12 ore. Aumenta la durezza dei manufatti.
Calce spenta	—	Per azione dell'anidride carbonica dell'atmosfera la calce spenta o idrato di calcio si trasforma in carbonato di calcio. Va quindi usata come questo e produce gli stessi effetti.
Carbonato di calcio, di sodio e di magnesio	—	Ritardano la presa, ma in misura meno sensibile dei cloruri. Non si deve superare la dose 10-20 g/l dell'acqua di impasto, poichè i manufatti tendono a screpolarsi. Producono un buon indurimento che può essere migliorato con successivi trattamenti di solfatazione, ecc.
Carbossimetilcellulosa e metilcellulosa . .	— —	Gli effetti prodotti sono identici a quelli ottenuti con gli alginati, ma i manufatti presentano minore resistenza all'umidità.
Caseina calcica . . .	—	Il gesso acquista in resistenza e durezza. Il ritardo della presa non è molto sensibile, comunque l'impasto può essere facilmente lavorato e modellato.
Cloruro d'ammonio .	+	Va usato in piccole quantità perchè origina sempre un sensibile degradamento della resistenza dei manufatti.
Cloruro di calcio . . Cloruro di potassio . Cloruro di magnesio . Cloruro d'alluminio. .	— — — — — — — —	I cloruri di calcio, magnesio ed alluminio, usati in soluzione dell'1 ÷ 2% possono ritardare la presa del gesso da 20 minuti a più di 10 ore. Sono consigliati per lavori che devono essere plasmati a mano. Producono un certo indurimento del gesso che può essere migliorato con successivi trattamenti con ossido di magnesio, di alluminio, di zinco, ecc.

IL GESSO, ANTONIO TURCO, 1990

Il Gesso is a scientific manual which provides a broad and detailed overview of the processing and application of gypsum. The publication covers all facets of this natural material: the geographical locations, the geology, the chemical compositions and physical properties.

Svariatissimi pure per numero e forma risultano gli spazi interni i quali possono essere passanti oppure a fondo cieco.

I blocchi più applicati sono quelli da 2 a 4 vani interni passanti, od a fondo cieco, disposti verticalmente, ossia parallelamente alle pareti del muro; i vani a fondo cieco isolano meglio, quelli passanti permettono l'introduzione di armature metalliche e la formazione di pilastrini, in malta di gesso armato, d'irrobustimento (vedi fig. 17).

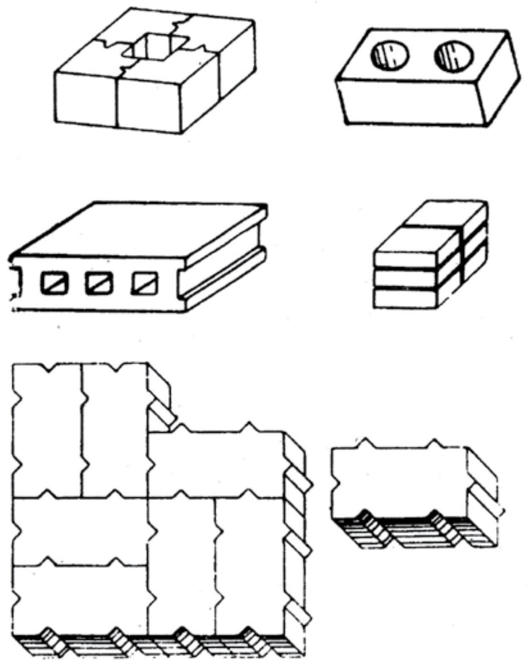


Fig. 16. – Paramenti in blocchetti ad incastro.

◆ Quando il manufatto è di forma, dimensioni e spessore da abbisognare un aiuto di collegamento, si formano nei lati di contatto, vuoti od apposite appendici le quali, incastrandosi fra loro durante la messa in opera, conferiscono all'insieme una elevata resistenza e stabilità.

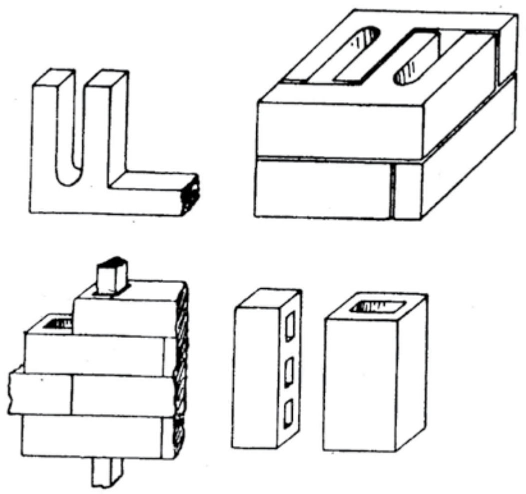


Fig. 17. – Pezzi speciali per pilastri.

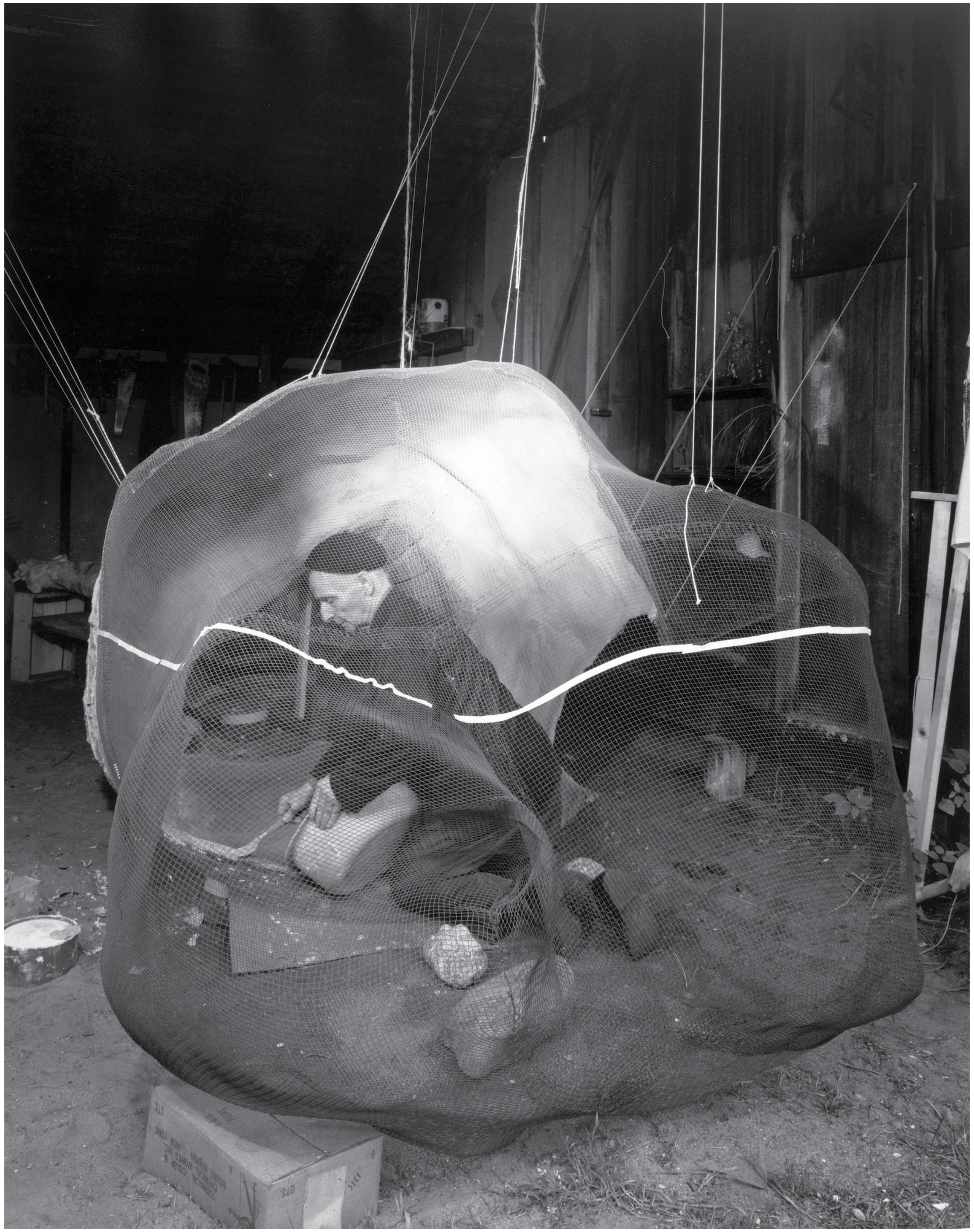
◆ Un elemento speciale molto ingegnoso dal punto di vista geometrico è il cosiddetto *pezzo angolare* (fig. 18) con il quale si può eseguire la rapidissima messa in opera di pareti, pilastri e

Furthermore, the manual investigates the uses, classifications, and the numerous possible superficial modifications of gypsum, and the fabrication of stuccos, plasters, moulds.

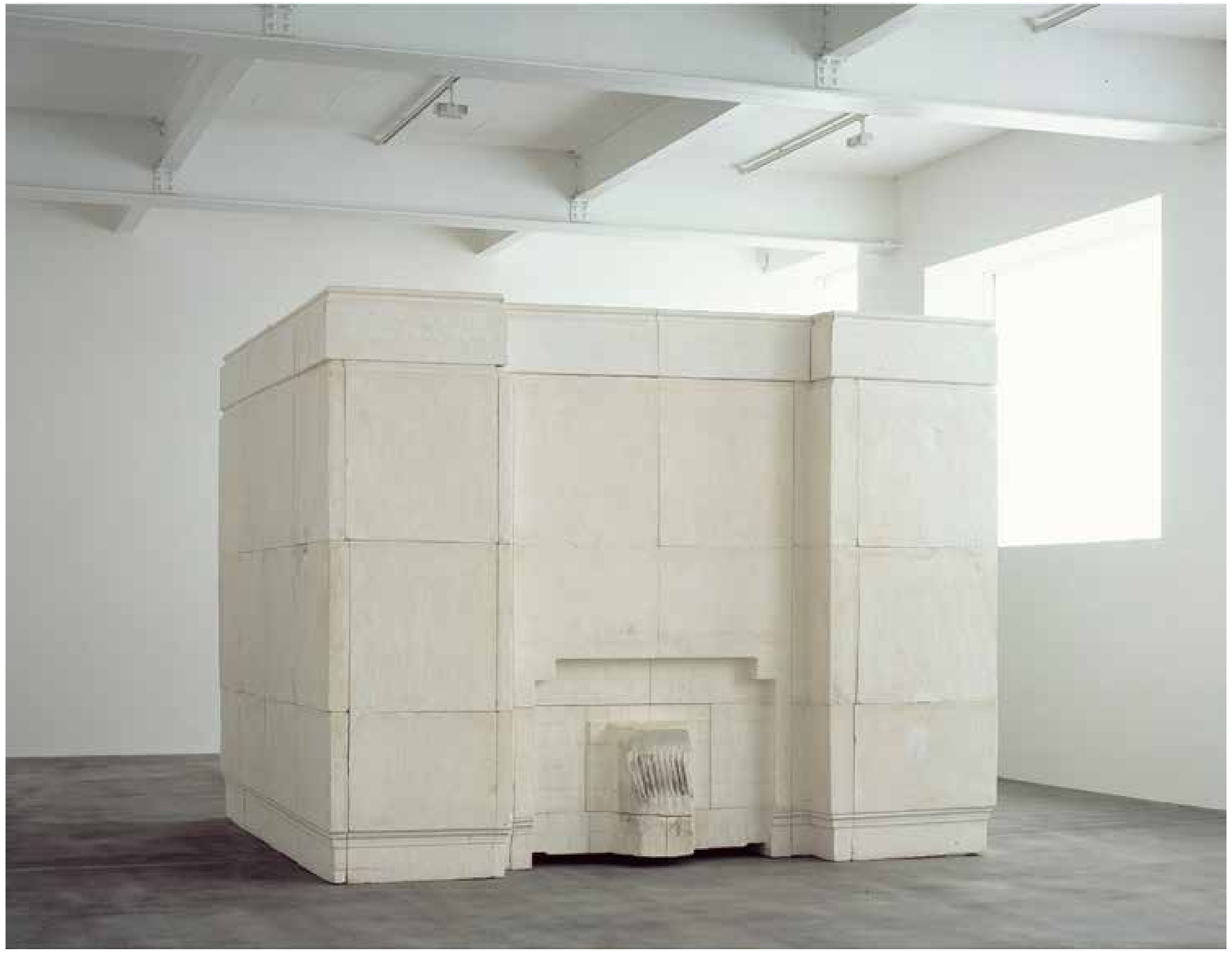
ENDLESS HOUSE, FREDERICH KIESLER, 1950–1960

Throughout his career, Frederick Kiesler worked across mediums. He believed that "sculpture, painting, architecture should not be used as wedges to split our experience of art and life; they are here to link, to correlate, to bind dream and reality."

Kiesler, an architect, set designer, artist, and philosopher, began to explore 'endless' architectural space in 1922, and he continued to develop this theme throughout his career. The biomorphic Endless House is Kiesler's vision of a free-form, continuous, human-centred living space synthesizing painting, sculpture, architecture, and the environment. Designed in direct opposition to the static, rectilinear rooms of the sterile boxes that were beginning to dominate modern architecture in the 1950s, this house, he said, was to be "endless like the human body – there is no beginning and no end." He saw this womblike form as related to female anatomy; others see an egg, or even the human heart, with the different rooms as aortic chambers.

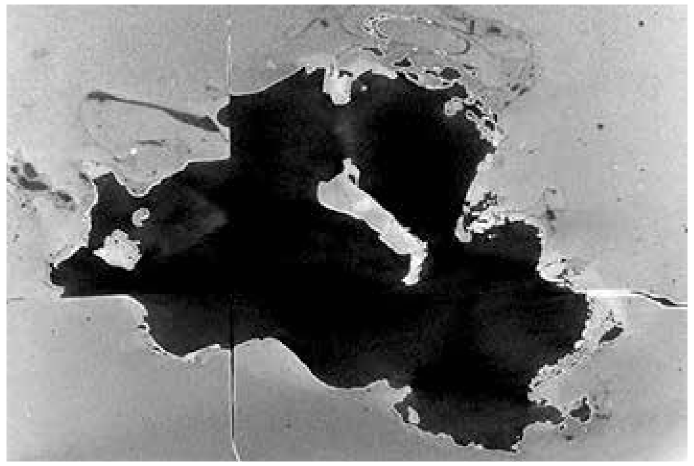


MAKING OF ENDLESS HOUSE, PLASTER OVER WIRE MESH



GHOST, RACHEL WHITEREAD, 1990
RW: “Ghost was hand cast, and I made a lot of it entirely on my own. It was the first piece in which I realized that I could absolutely disorient the viewer. While I was making it, I was just seeing one side at a time. I then took all the panels to my studio and fixed them to a framework. When we finally put the piece up, I realized what I had created. There was the door in front of me, and a light switch, back to front, and I just thought to myself: ‘I’m the wall. That’s what I’ve done. I’ve become the wall.’”
— from an Interview with Rachel Whiteread by Craig Houser

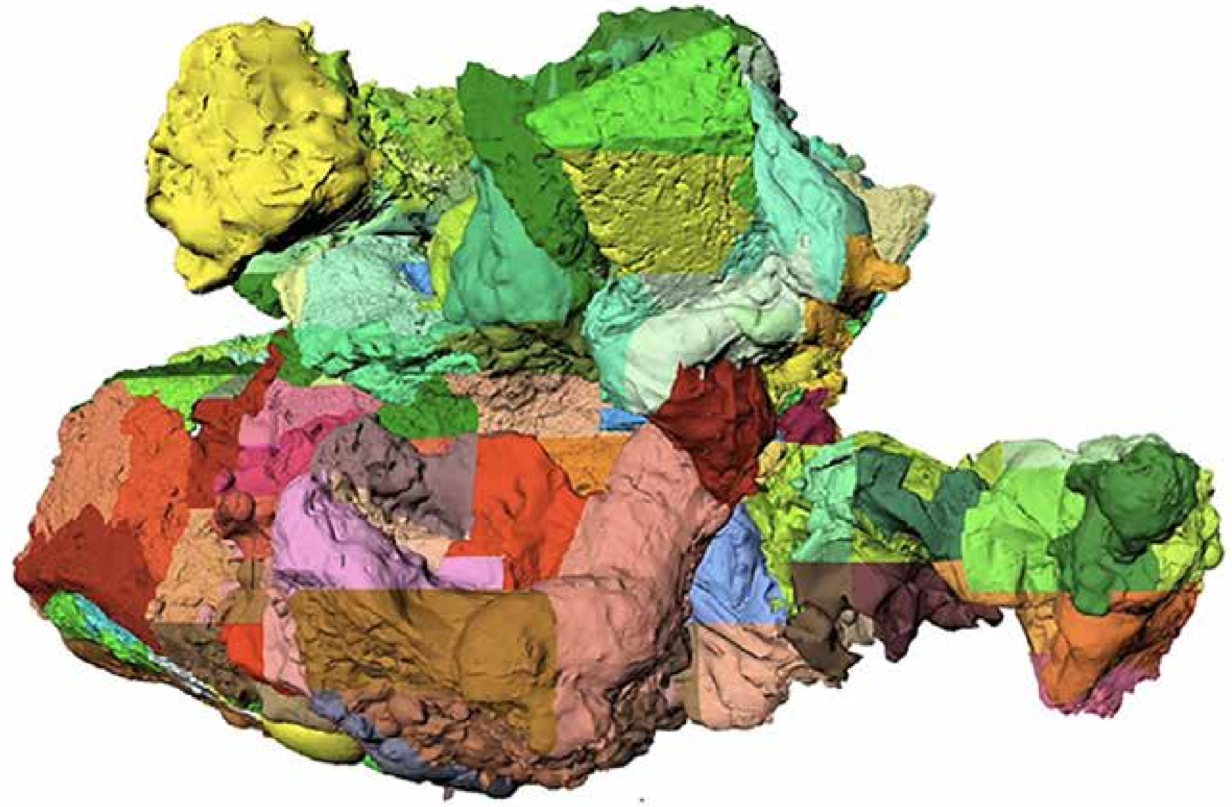
UNTITLED (APARTMENT), RACHEL WHITEREAD, 2001
Process photos, published in Transient Spaces



INCIDENTAL SPACE, CHRISTIAN KEREZ, 2016,
THE SWISS PAVILION AT THE 2016 ARCHITECTURE BIENNALE IN VENICE
Producing Incidental Space

The first phase was literally one of form-finding. Over three hundred small models – none measuring larger than 40 × 25 × 15 centimetres – were created by experimenting with different techniques and materials, combining a variety of amorphous substances like wax or sand into solid chunks, and then casting them in plaster. The ETH student studio where most of these experiments took place seemed more like a chemist's or alchemist's laboratory than a model-building workshop. The resulting gypsum casts are effigies of something imageless and unrepresentable – they are, in fact, a visualization of the contingent process of casting itself.

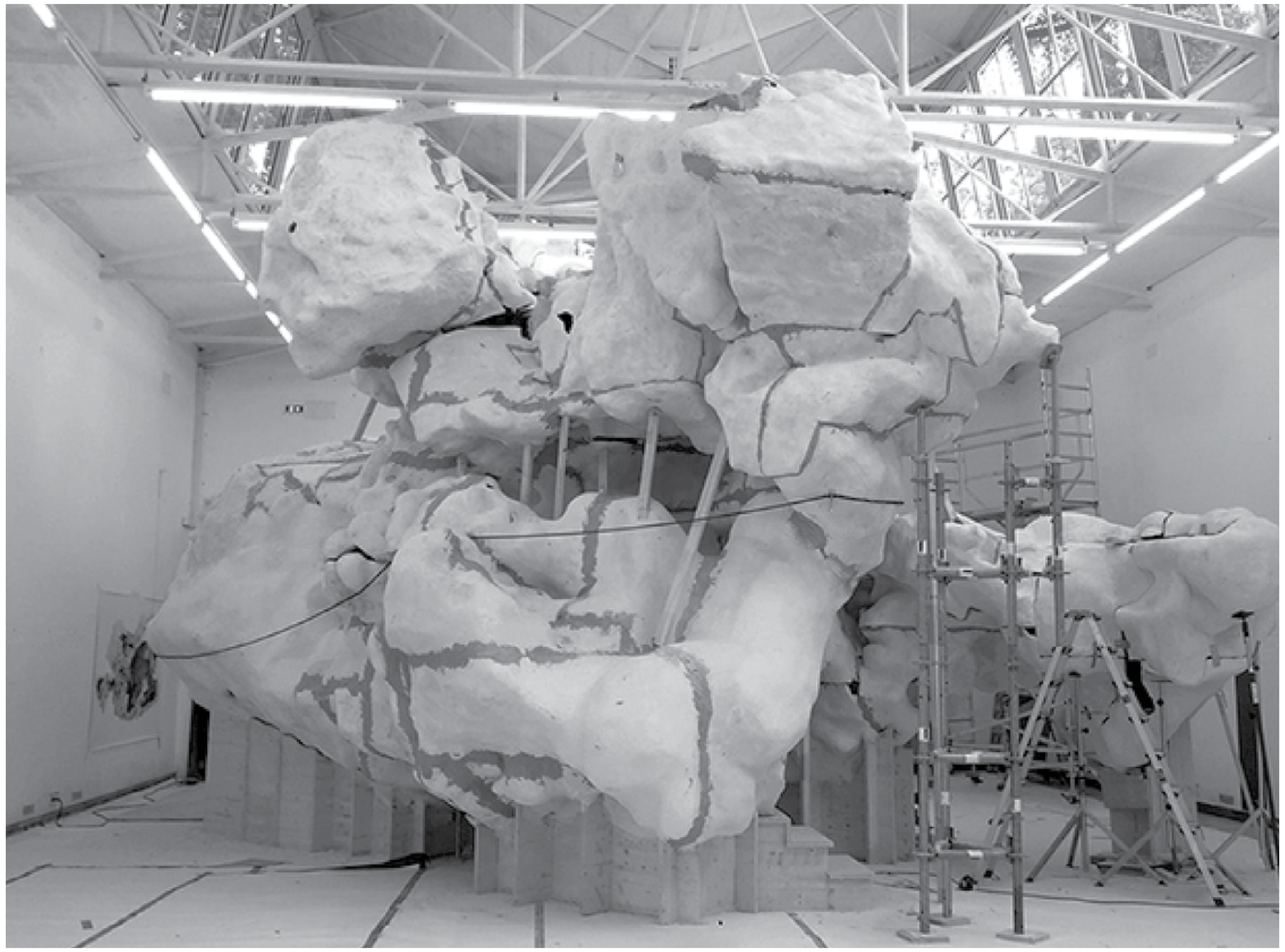
After the blocks had solidified, they were split open and – using a variety of techniques – their complex internal cavities were exposed. These cavities then became candidates for the space that would be 3D-scanned and digitally rescaled to form the Incidental Space. Thus, the 'incidental' gypsum cast is tone interpreted as an architectural model, rescaled to fill the Sala di Pittura of the Swiss Pavilion in Venice. There, it is transformed into a quite different object, one large enough for a human being to physically enter, allowing it to be physically experienced on another bodily scale. After being submitted to a tomographic scan, the model chosen for the exhibition had to be gradually broken into pieces during the process of optical scanning.



That is to say, the process of extracting the skin of the space, a skin with a surface and structure of the desired complexity, literally destroyed it. Then the resulting digital surface was segmented into different areas, so that a positive physical form of the space could be manufactured industrially. Depending on the specific surface and textures of the area in question, this was either done additively, using a 3D printer that deposited layers of furan sand to create a three-dimensional rendering, or the process was subtractive, the CNC milling of foam blocks. The highly advanced technologies used in this process here serve merely as a means to an end, part of a holistic design approach.

Finally, the manually prefabricated elements were shipped to Venice and assembled in the Sala di Pittura of the Swiss Pavilion, creating a space inside a space. Being statically over-determined by its geometric complexity, the space consists of a remarkably thin shell, a mere two centimeters thick, produced with a specially developed mixture of shotcrete reinforced with fiberglass. The space has a precisely molded interior, while its exterior remains quite rough. This thin concrete skin is a space to be entered and experienced in the greatest possible richness of detail, a space where shell, structure and ornament are inseparably one and the same.

MODEL, 1:20



The built space manifests itself as a thin line where interiority and exteriority coalesce. Since the interior space is an image that can actually be entered, it serves as a kind of zograscope for those who are afraid to enter it or otherwise incapable of going in. Even a brief glimpse inside facilitates the experience of a new kind of depth perception. Since the space is highly complex in visual terms, decoding it presents a challenge to the viewer: thanks to the sheer multiplicity of possible readings, in its material presence a moment of resistance is produced, stimulating reflection.

TEXTILE GYPSUM CASTING, MAISON MARGIELA, STUDIO ANNE HOLTROP, 2018

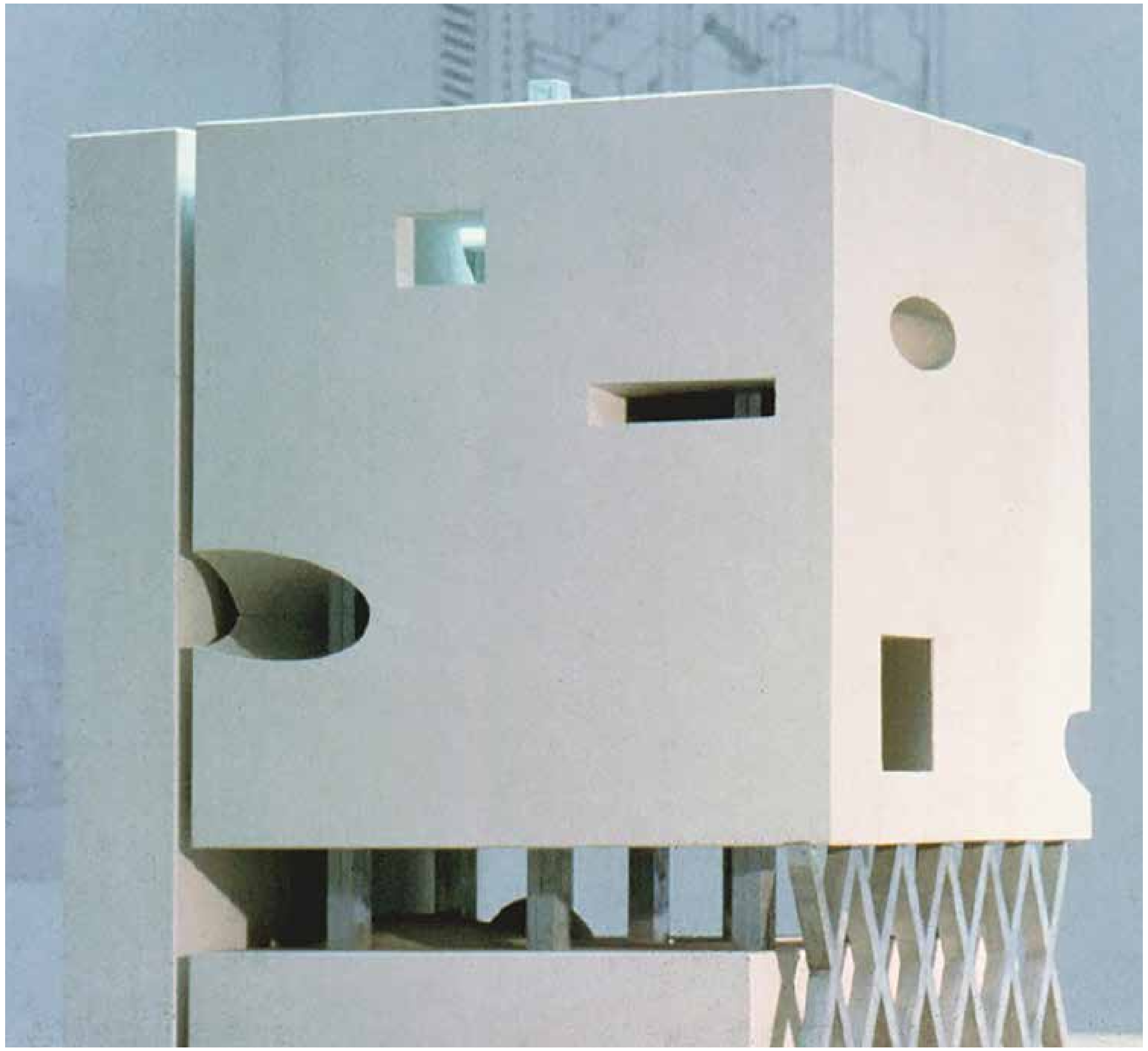
In our work for Maison Margiela and creative director John Galliano, we started by defining gestures of making in relation to materials. Based on the unique codes of Maison Margiela, like 'dressing in haste', 'the memory of' and the 'décortiqué', the material gestures were used to create a new architectural identity for 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 typical architectural elements. They are the primary space definers.

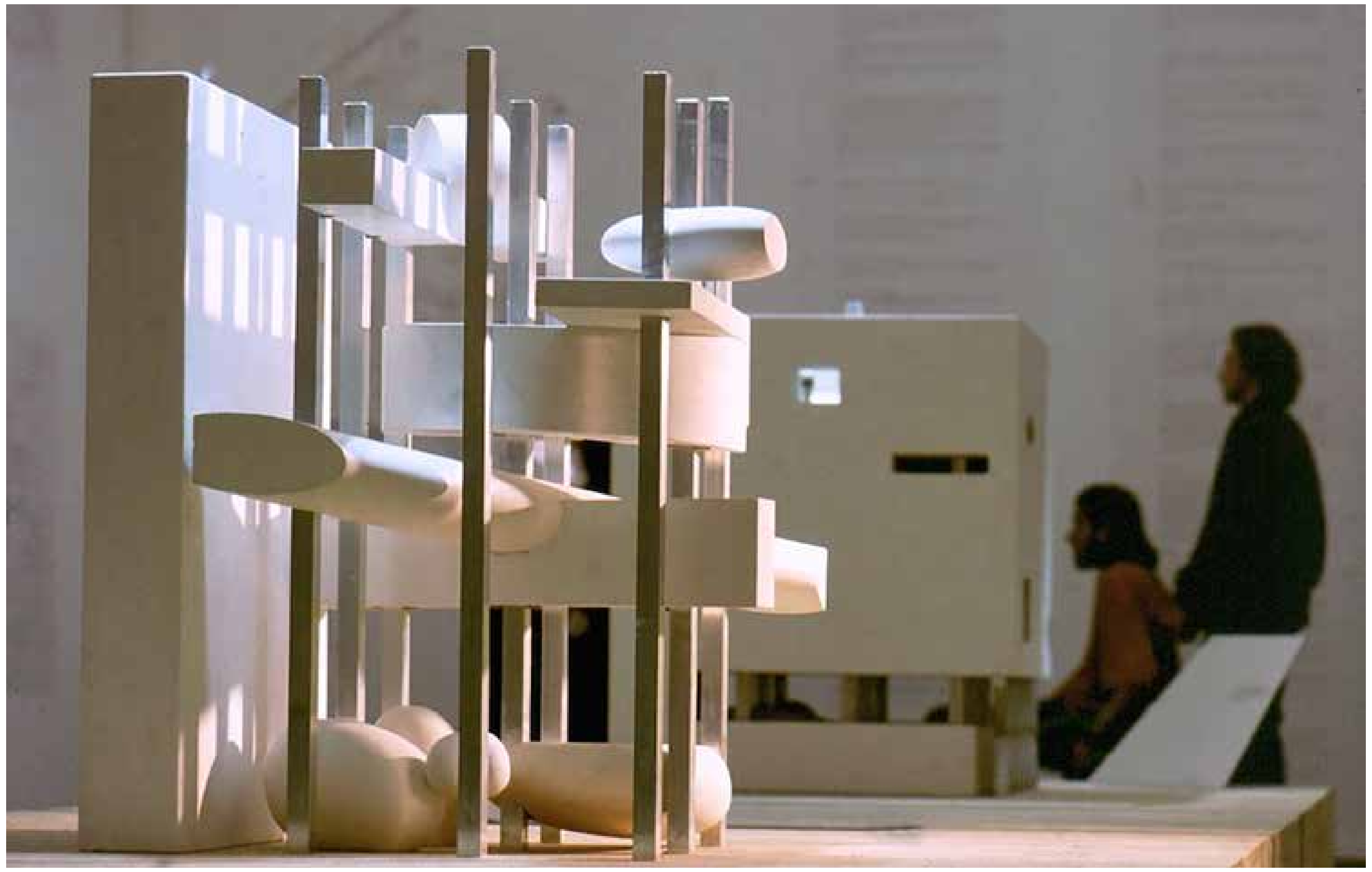
GYPSUM STUDY MODELS

COLUMN, GYPSUM, SCALE 1:10

WALL, GYPSUM, SCALE 1:10

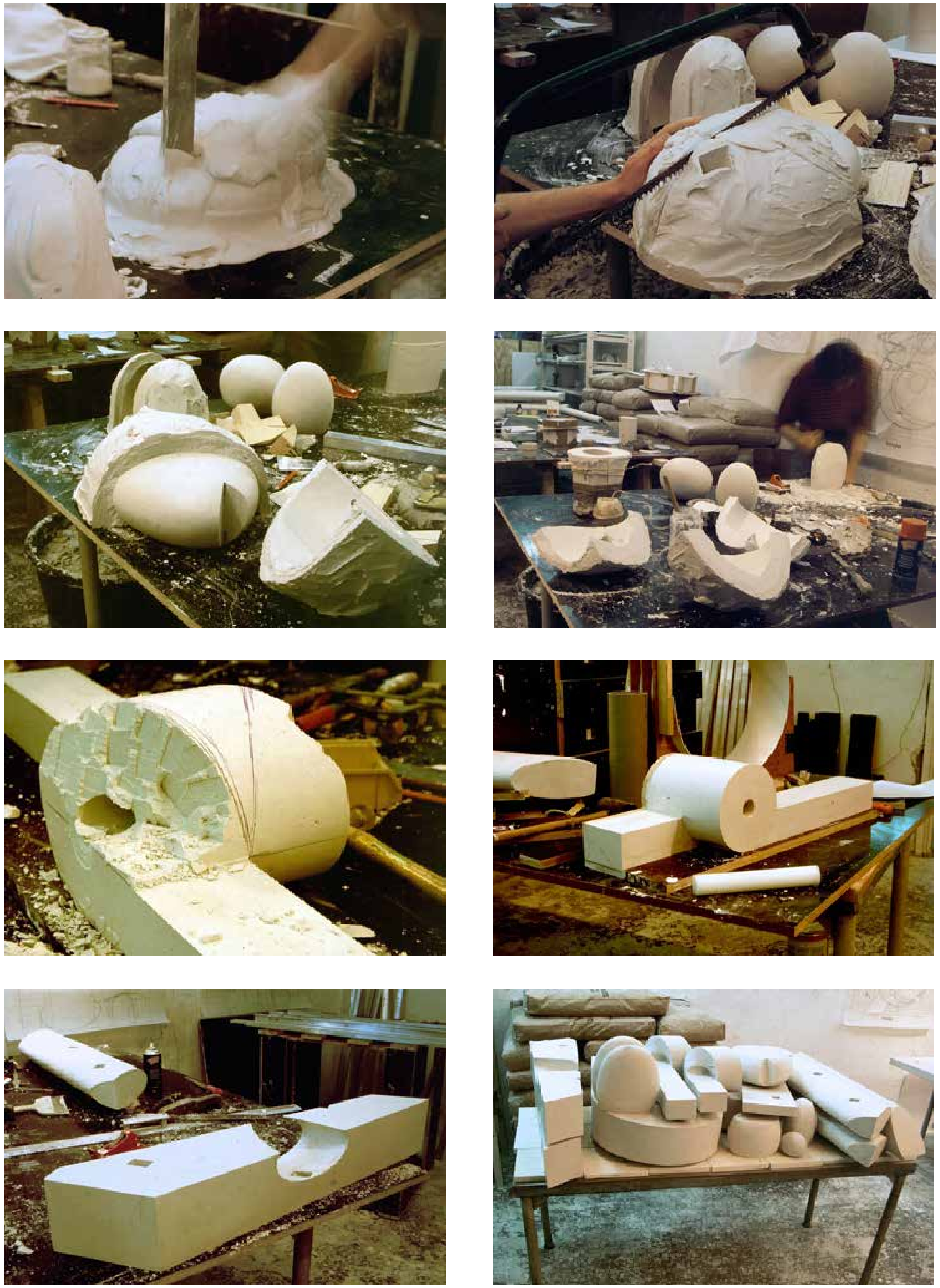
PRODUCTION OF GYPSUM CAST WALLS, ITALIAN ART DECORATION SRL, MAISON MARGIELA ARTISANAL SHOW, STUDIO ANNE HOLTROP, 2018, ITALY
1:10 gypsum models made in the studio in Bahrain were 3D scanned in Amsterdam. This scanning data was used for CNC milling of 1:1 scale PS moulds. Craftsmen cast positive forms into the moulds by inserting gypsum plaster and natural plant fibre by hand.





TWO PLASTER MODELS FOR OMA'S TRÈS GRANDE BIBLIOTÈQUE, VINCENT DE RIJK, COMPETITION ENTRY, 1989

One model was poured around the other. As a result, the negative of one model is the positive of the other. At one point in their making, the two models become fused together, forming one block. The finished objects carry the genesis of their making and could not have been made in another way, and so was also conceived the building they represent. One cannot tell which comes first: void or mass.



MAKING OF OMA'S TRÈS GRANDE BIBLIOTÈQUE MODEL, 1989

GYPSUM COPY OF OMA'S TRÈS GRANDE BIBLIOTÈQUE MODEL, 2012–14

KUNST GIESSEREI, ST. GALLEN, SWITZERLAND

The Kunstgiesserei is a large foundry in St. Gallen, Switzerland known as the foundry for Hans Josephson. This foundry mainly uses the lost-wax technique (cire-perdue), one of the oldest casting techniques in use since the Indus civilization, The lost-wax method allows the duplication of metal forms in metals such as bronze, brass, aluminum, silver and gold.
It is an antique method but no means a simple cast.

FEUR UND FLAMME, DOCUMENTARY FILM OF IWAN SCHUMACHER ABOUT THE KUNST GISSEREI, 2014

Plaster is a classic, inexpensive material for sculptors, which is used in moulding as a supporting shell mould for elastic molds: calcium sulfate activated by being heated to a high temperature, which hardens again when mixed with water. It is possible to influence how it behaves when setting by means of temperature, mechanical action, and additives. By adding lemon juice, it is possible to extend the setting time, while already set plaster or table salt speed up the process.

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