Dr. Manfred Bethold is an assistant professor at the University of Technology in Vienna. In 1996 he was a guest lecturer at the University of Michigan in the United States and in 2000 at the Royal Melbourne Institute of Technology in Australia. He also lectured at the Roger Williams University and at the Massachusetts Institute of Technology in the United States.

INFLATABLE ARCHITECTURE

Manfred Berthold

Pneumatic objects and membranes can serve as a constructed example of morphology of the organic. Walls and roofs are formed architecturally, but only the inflated void gives a meaning to these constructions. Hence that which isn't there becomes the essence of what is there. Back in times when no one reasoned about physics and matter, when there were no architecture students, when no one distinguished between structure and shell of buildings, people and their architects built the shell which also was the structure. All types of clay, log and brick buildings, igloos and tents all were structure and shell at the same time. Structure equals shell equals tradition. It's just the same with pneumatic constructions, which also combine structure and shell. The shell of a building is the boundary between fickle outside climates and a more or less constant inner climate. It has numerous, even opposite physical functions to fulfil. It is expected to provide protection against heat loss as well as against excessive heat. It should be waterproof but let steam through. It has to be windproof yet grant air circulation. It should let light through but not be to a blinding degree. It should signal openness to the same extent as security. The shell becomes the skin, windows and doors the pores. The shell of the building consists of six different sides for orientation. The above part becomes the roof, the underneath part the floor and the sides the façade. A suspended floor becomes an open floor which allows a bottom view of the façade. The roof and the façade have similar functions, which just differ slightly according to the location. When a flexible membrane only stretched by pull is tightened through pressure differences, a pneumatic object is created. The essential components of pneumatic construction are both the shell and its filling with gasses or liquids. Every pneumatically tightened membrane can bear external forces. Thus the medium stretching the pneumatic object becomes the support medium and a pneumatic structure is created, an inflated structure consisting of air pressure and membrane tension. This construction already unites some of the functions mentioned before. Inflatable architecture = the shell becomes the structure and the structure the shell. The theory of pneumatic calculation was originally developed according to models for incompressible liquids, as these calculations are comparably simple to comprehend mathematically. The filling with incompressible liquids means that the volume of the pneumatic object remains constant even under pressure. The inner pressure however changes considerably under pressure, that means the "stiff" support material of incompressible liquids shifts the external loads by changing the inner pressure. By inflating the structure, volume and space is created. The use of a building is the space created to lay it out according to our needs. Space makes the architectural volume open for different purposes. The created space has to be filled with functions to generate acceptance. This pneumatic construction created by means of experiments challenges a change of thinking in interior design. Functions do not have to be stationary. Concave or convex walls as surfaces demand a new understanding of space. How and with what this space can be elevated and designed is the art of architecture. The artistic desire to shape a beautiful room becomes reality in architecture and the knowledge of the laws of nature is essential when space is "taken from the world" and combined with other conditions. The architect has to have extensive knowledge of all pneumatic materials used to capture spaces. "Soft" walls, flexible in structure allow short term spatial expansion. The notion of space becomes suddenly flexible. Structural engineering has to take these movements into account. Flexible structures are created. The cooperation with Michael Schultes facilitated model experiments which contributed to continuous insights. The work with Wieland Becker and Oliver Englhardt from the Institute of Structural Design and Engineered Timber Construction made it possible for students to analytically approach the subject with digital measuring and calculations. The cooperation with Michael Schultes also made it possible for the students to carry out their projects in a scale of 1:1.

DI P. Michael Schultes is a freelance artist with his own studio in Vienna. He is a lecturer for pneumatic structures at the University of technology in Vienna since 1997.

PNEUMATIC OBJECTS AND MEMBRANES

P. Michael Schultes

Nothing but air is needed to breathe life into all forms of pneumatic structures. In his studio in Vienna, the architect P. Michael Schultes plans and builds inflatable objects for artists from around the world under his label schultes.wien. Jeff Koons, Norbert Brunner, Dorothee Golz, Gerwald Rockenschaub, Carsten Höller, Martin Walde and more than 30 other internationally famous artists have been employing his services to put their ideas into action. Shortly after the war in 1949, his father started designing and constructing the first inflatable rubber dinghies and air beds in Europe using plastic foils. 50 years later his son P. Michael Schultes supports and instructs students of diverse universities and schools in handling polymers and plastics. The main subject is still pneumatic objects. They accompanied him ever since he studied architecture in the 60ies, when Walter Pichler and other artists, as well as architects like Hollein, HausRucker and Coop Himmelblau discovered their love for "castles in the air". Therefore his main interests focus around improved applications of pneumatic objects in architecture. For the past three years P.M.S. has been lecturing on "pneumatic structures" at the Institute of Building, Technology and Design for Architects in the department of Prof. William Alsop at the Vienna University of Technology. Pneumatic constructions are still a mostly uncharted and thus easily understandable special subject in architecture that offers perfect opportunities for finding starting points into many other areas of modern building, both from the perspective of the materials used (textiles, foils, coatings) as well as from the perspective of construction and application (detailed solutions, areas of use). In this subject, the students are supposed to get to know the latest developments in the area of textile building, to understand the laws of textile construction with a focus on pneumatic objects and to be inspired to find imaginative solutions by using system optimising technologies (control technology, alternative energy, biology) and implementing them in further classes in this fairly underdeveloped field of architecture. In order for the students to acquire first hand experience with the materials, laws and formal language of these pneumatic objects, they are given the opportunity to produce inflatable objects they have designed themselves at the studio of schultes.wien.

That way a great number of original objects have been manufactured over the past semesters, such as the brilliant inflatable light by Janina Jaensch and Wolfgang Kurtz, with no relation to common inflatable "kitsch". schultes.wien was also commissioned by Asymptote/Hani Rashid and Lise Anne Couture of New York to develop, produce and erect the pneumatic part of "FluxSpace 2.0" for the 2000 biennial architecture festival in Venice. The time between initial contact and successful project completion was 3 weeks. Without the spontaneous and enthusiastic commitment and the competent cooperation of Martin Eppensteiner, Martin Haas, Natascha Jung, Robert Roithmayr, Philipp Träxler, Ulla Unzeitig and Ali Wiesbauer it would not have been to possible to finish this job. The following projects which have been developed in the seminar "inflatable architecture" at the Vienna University of Technology during the winter semester 2000/2001 show some examples of this creative work and the great potential of design and application of pneumatic objects in architecture. As these were truly extraordinary projects we have considered presenting them to a larger audience at the international stage of the TECH-TEXTIL fair in Frankfurt.

Michael Scherz

ROOF IN MOTION

„Roof in motion" is a movable spatial shell that can react flexibly to the different usage needs of a building. Separate pneumatic cushions are joined together flexibly to form a dense wall/ceiling construction.

1 Office room: by lowering and closing the pneumatic body a shielding wall/roof structure is formed. The workplaces created by this offer views to the outside world through translucent pneumatic elements.

2 Info centre: one side of the pneumatic structure is raised and opened. Access for visitors is possible from three sides. Presentations can be held using mobile walls, computer terminals and video beamers. Optional use as stage.

3 Media wall: the pneumatic wall is completely raised vertically which creates a projection screen of 7,5 x 4,5 metres which can be used for projections with video beamers, for laser presentations etc.

Situation 1: straight
Situation 2: folded

Michael Prodinger

BUBBLE UP

- Tunnel: closed down U4 underground tunnel at Spittelauer Lände

- State of the tunnel: leaky STB ceiling, sandstone walls, STB floor, wet, dark, cool

- Goal: create a dry watertight room / warm atmosphere / material, light, form…
synonym for soul music

spatial experience
flexible, simple constructions

Section

Ground plan

Andreas Zimmermann

"PNEUMOTION"

This construction is a mobile tunnel or connecting corridor which can be moved in all directions my means of pressure controlled air chambers.

Starting from a compressed state the pipe can be stretched out to 12 times its compressed length. The floor construction adapts itself to the respective stretched state.

Through a central control computer the separate air chambers are supplied with excess or low pressure by means of electric valves.

Walter Benedikt

SITFIX

1 Seat
2 Bed
3 Shell

SITFIX is a mobile piece of garden furniture with seat space for five persons and bed space for two persons which is sheltered from wind and curious looks by means of a semicircle roof.

SITFIX consists of a five-piece aluminium skeleton which gets its stable, fan-like form through inflation with air. Simple connecting points ensure quick assembly.

Klemens Bichler

FOLDING WALL

System requirements:

?? Automatic assembly and disassembly of the system by means of inflating or deflating the air cushions
?? Saving the construction of costly technical support systems
?? Constant heat insulation without transmitters of cold along the joints
?? Entirely translucent
?? Watertight for use in swimming pool areas
?? Low overall weight

By inflating the cushions with air the separate wall parts are pressed apart. The wall glides out of its container along the rail.

Martin Blaas / Christopher Mayer-Berg

VACUUM SHELL

Phase 1
The limp two-fold membrane is spread out and fixed to the floor

Phase 2
The inner air tubes are inflated to get the shell into shape

Phase 3
The air is being sucked out of the intermediate chambers and the construction solidifies. At the same time the vacuum sucks the air through a valve out of the tubes so that a homogenous solid shell is created.

A vacuum construction is an airtight shell filled with Styrofoam granulate, the separate Styrofoam pellets of which are pressed against each other when the air is sucked off and thus create a solid form. Styrofoam is ideal for this purpose, as it is soft and can be pressed into every conceivable form. Its low weight make transport easier and it is perfect for heat insulation applications.

The sketch:
An example of a vacuum shell as a free form, a hall. By means of temporary air tubes inside the shell the hall is shaped and solidifies by sucking the air out of the vacuum chambers. Contrary to air halls this hall is open at the sides and does not need airlocks at the access points.

Nicole Oberrauner Rainer Baldauf Bernhard Eggl

IMPULSE

The IMPULSE event centre consists of three pneumatically mobile domes which respond to outside stimuli through opening and closing thus adapting to the respective environmental conditions.

Georg Stejskal

NIKE-AIR-PORT

The NIKE-AIR-PORT is a mobile pavilion for presentation, sales and diagnosing for Nike Air running shoes.

NIKE-AIR-PORT can be dismantled into elements measuring 280 x 280 cm. It is therefore easily transportable and is meant to be used at running events such as city marathons. NIKE is producing running shoes since 1979 using integrated air cushions in their soles for better suspension.

The NIKE-AIR-PORT also consists largely of air cushions and therefore promotes the products shown within through its mobility, lightweight construction and innovative design. Heart of the construction is the roof made of 16 air cushions which form a spatial structure in connection with wooden bars and tension cables which act as pressure bars.

Christian Wittmeir

SHADOW WINGS

Connection at ceiling

“Second skin” principle

Rolling up of an element

- Changeable pneumatically controllable façade element which can be used as outside shadowing constructions on existing office buildings.
- System consisting of a pneumatic cushion (material: either printed ETFE foil or PTFE-coated fibreglass membrane) and connected flexible bars of fibreglass-reinforced plastic.
- Upon increasing the pressure inside the pneumatic structure the bars are forced to bend and the system rolls up.
- When the pressure inside the pneumatic structure is low, the wings are unfolded and cover the entire window front.
- The segments provide protection against direct sunlight, while at the same time the translucency of the membrane provides sufficient daylight inside the building so artificial lighting is unnecessary.

Claudia Brandstetter Iris Iinortner

AIRWALK

Our search was aimed at “bridging” with considerable versatility in the area of possible locations for use and transport weight. The use for catastrophe relief operations is an additional usage aspect to its “ordinary” function as pedestrian bridge.

The development of temporary lightweight structures depends on the necessity of function and the existence of suitable materials.

The shapes can be more radical and reduced than with location-based long-term buildings. New solutions can be tried out, limited to the essential.

Ute Bauer Christoph Wassmann

„STACKING PNEU"

Is it possible to create structurally engineered buildings by means of air-based constructions? To set a clearly visible example in an empty building site in Vienna?

Working with inflatable concrete formwork walls we were able to do without classic technologies completely: instead of formwork grids concrete formwork elements were place on top of each other. The experimental nature of this design is represented by its function: a centre for contemporary video art with exhibition levels for projections and installations as well as a terrace over the rooftops of Vienna.

Andreas Hradil Michael Tesch

FULL THROTTLE (VOLLGAS)

FULL THROTTLE (VOLLGAS) is meant to be a compression of public space in the capital of Brazil. By means of a shell the city centre of Brasilia is confined without losing space.

Within 1,2 million cubic metres of space visitors have 8000 square metres of space at their disposal. This includes several bars and restaurants, a virtual library, rooms for resting and reading as well as several stages and platforms for events and presentations.

The visitor walks on a system of layers and sloping surfaces which constantly offer new perspectives.

Above the passable pneumatic structures a helium-filled cloud floats which allows the whole construction to be suspended over the ground. The cloud holding 5-6 million cubic metres of helium and the pneumatic structures provide shadowing of the otherwise unused area below and allow new forms of usage for sports grounds, kiosks, parks etc.

The primary construction made from GFK lies hidden in a high pressure pneumatic structure which ensures the formal transition between the inside and the outside pneumatic elements.

FULL THROTTLE (VOLLGAS) will be realized in the year 3346.

Section
Interior perspective

DI Wieland Becker is a university assistant at the Institute of Structural Design and Engineered Timber Construction since 1998. He studied at the Hannover University of Technology and finished his diploma at the FTH Stuttgart. Since 1997 he works self-employed in Hamburg in the area of textile lightweight construction.

DI Oliver Englhardt: University assistant at the Institute of Structural Design and Engineered Timber Construction. Studied civil engineering at the University of Technology in Munich (Focus: steel construction, constructive building with glass). He worked from 1989 to 2000 at the engineering office Grad in Ingolstadt. Scientific cooperation with the Laboratory for Steel and Light Metal construction (Prof. Bucak) of the FH Munich.

TEXTILE LIGHTWEIGHT CONSTRUCTION

Wieland Becker / Oliver Englhardt

Pneumatic objects and membranes have malleable surfaces and become sculptures in architecture. Inflated a membrane is additionally reinforced with wooden rods or sheets or combined with wood. New and creative ideas for strengthening and reinforcing soft structures should be designed and developed in a way that they become technically comprehensible - this was the task given. Who among us knew before taking the class that the normal atmospheric pressure amounts to 100 kN/m² which equals a mass of 10 tons per square metre? That our blood vessels as pneumatic-hydraulic constructions also have to be able to withstand such a pressure difference? Only few knew about the units Pa, bar or mbar and just to have heard of the Kessel formula was considered a plus. Constructions are referred to as “pneumatic” if pressure differences determine their shape and stability or contribute to them. These pressure differences are caused especially by gasses. As those gasses are volatile they are difficult to keep in their surrounding shell and with their dwindling their intended function of reinforcement also decreases. This is why pneumatic construction has become an unloved child within the world of building, a world programmed for solidarity, structural engineering and over-dimensioning, as it is unreliable and just about fit for “fun” and “leisure” architecture. With our design class in the winter semester 2000/2001 we intended to develop solutions which lets pneumatic construction present itself in its typical diversity but at the same time achieve stability through “freezing” processes. In this area astonishing solutions have been developed in the course of our work, which can be filed under the technical term “hybrid systems”. After the principle of vacuumed coffee or peanut packages ingenious solutions were combined with the morphology of biological structures in the form of high pressure cushions in the pressure zone and anchor cables in the pull zone and with wooden pockets and tubes. In the course of seminar cooperation between students of Manfred Berthold, Michael Schultes, Oliver Englhardt and myself it showed that the results have a high enough level of quality to present them to a larger professional public. We will take this opportunity by setting up a booth at the TECH TEXTIL 2001. The design class “Inflatable Architecture” held in the winter semester 2000/2001 focussed around the idea of developing structures by using air as a supporting material and to deal with the problems involved in this. Pneumatic constructions are fascinating on one hand because of the enormous capacity at low material cost, on the other hand due to their individual formal language which is unusual for “common” structures. Experiencing and learning the pneumatic structural mechanisms, the basic forms resulting from them and the development to additive systems were the centre of attention of the construction engineer in charge of the class. The students had to work on topics such as pre-stretching of the membrane and the resulting capability of the construction to be flexible, surface and spot effects on the membrane, the structure system properties regarding climate influences as well as on a mathematical proof of tensions within the membrane by using the Kessel formula. The strong commitment of the students and the intensive studying of materials, functions and the different construction types created a wealth of interesting projects. Especially the technically detailed models showed the diversity of possible forms and the potential of pneumatic objects in structural design.