THE FUTURO

History, Design and Construction in Finland and the USA

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ABSTRACT: The Futuro by Matti Suuronen reflects the confidence in the possibilities of plastics as a new building material of post-war times. A number of the 70 to 100 Futuros that were built worldwide still exist and, generally, they are now being preserved. A comparison of four restoration approaches of Futuro Houses, dating from 2007 to 2018, has given insights into the specific constructive features, modifications and the challenge of their complex materiality and innovative design. This explains the complexity of the conservation process.

KEYWORDS: Futuro House; Matti Suuronen; Polykem Oy; FUTURO Corporation; sandwich construction

INTRODUCTION: Suuronen's Futuro houses reflect the confidence in the possibilities of new building materials like plastics. Building envelopes made of fibre-reinforced plastics characterised the prosperous post-war decades of economic strength within architecture and design.

The aim of the paper is to explain the Futuro houses in terms of construction history based on design principles within Europe and the USA. The preservation of architecture presupposes an understanding of the materials, the structure and the technical details. In analysing their design, construction and engineering structure, Futuros and other plastic buildings can professionally be conserved for future generations.

THE FUTURO HOUSE

The Futuro, made in 1968 of fibre-reinforced plastics, reflects the optimism of the era of space exploration when people believed technology could solve all problems for

01 House of the Future, USA, 1957. © IBK Archive, 2004

02 Wilp-Futuro, Munich, GER. © BAKU, P. Voigt, 2017

the human race. In the post-war years building professionals and manufacturers were dreaming of low-cost prefabricated housing, of mobile housing, and housing built using the latest technologies and materials. Durable plastic furniture, dishware and hardware made life easier and colourful. Monsanto´s House of the Future, displayed at Disney´s Tomorrowland (1957-64), Matti Suuronen's Futuro house (1968) and Kurokawa´s Habitat-Capsule, presented at Expo70 in Osaka, Japan (1970) all embody the feelings of their age as the 'the look' due to their pure geometric design, colours and new materials. [FIGURE 01, FIGURE 02] (Lesley,1998).

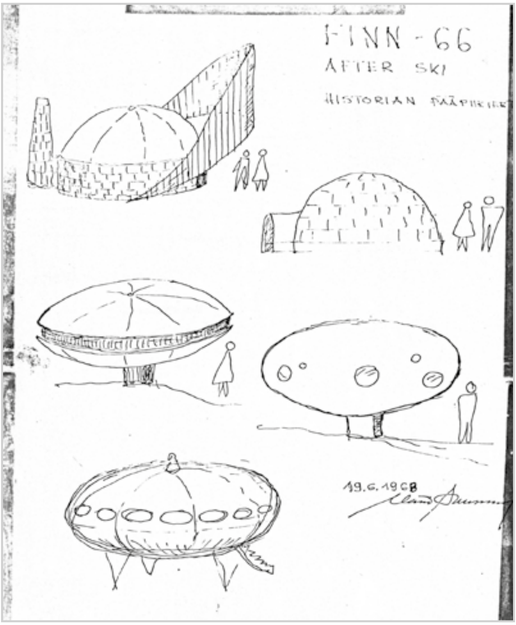
"The house (Futuro) represents very well its contemporary way of thinking and living with a strong confidence in the future – 'futuro'. In the same era in 1969 people saw on the blurry TV-screen as Neil Armstrong stepped onto the moon as a first human being. A Russian cosmonaut had already been flying in the orbit in 1961. The space seemed to offer an enormous potential for becoming a new playground for the human nation" (Kuitunen, 2010, p.3). The spaceship-like, capsule Futuro became a popular icon (Home, 2002, p. 48) and the photographer and advertising guru Charles Wilp (1932-2005), who was actively inspired by space throughout his life (and therefore called himself an "ARTronaut", Cleworth Archive), had one erected on the roof of his house in Düsseldorf in the 1970s. He received guests such as Andy Warhol and Christo, who apparently planned to wrap the Futuro during one of his art actions (Cobbers, 2010).

> *In their Manifesto of Futurist Architecture (1914), the founders of futurism—the architect Antonio Sant'Elia and the poet Filippo Marinetti—declared that the buildings of the future would be dynamic and mobile, and throughout the 1960s, the architectural group Archigram developed those ideas further. But whereas Archigram's designs existed only on paper, the Futuro is an intriguing physical example of space-age utopian architecture. (Stratford, 2012, p. 1)*

The peak phase of international building with fibre-reinforced plastics extended from the 1960s until 1973, when the first oil embargo by OPEC resulted in an international economic recession (Voigt, 2007). In addition, the growing awareness of nature, discredited plastics, and with them the striking, but only sporadically realized, plastic buildings. It was not possible to fulfil the hopes placed in them for inexpensive, technologically modern living spaces (Voigt, 2007). In the 1980s they fell into oblivion, but in due course the Futuro was the first plastic house to receive renewed attention. Futuro No. 000 was rediscovered in 1996 as part of the Skop exhibition of the Vienna Secession in Austria[1] (Home and Tamila, 2002, Suuronen, 1983). In 1997 the Utrecht Centraal Museum in the Netherlands bought this prototype as an art object and since 2007 it has been a collection object of the Boijmans van Beuningen Museum in Rotterdam. With the exhibitions of the renovated Futuro No. 001 in the Exhibition Centre WeeGee, Espoo, Finland since 2012 and the public presentation of the renovated Wilp-Futuro at the Pinakothek der Moderne (New Collection - The Design Museum) in Munich since 2017, the building has regained the awareness of experts and a wider public. Museums of Applied Art as well as design and architecture museums are increasingly interested in the now rare plastic buildings of the pioneering period (1942-1980) (Voigt, 2007).

THE ORIGIN OF THE PLASTIC CONSTRUCTION FUTURO

The history of Futuro is inextricably linked with Matti Suuronen (1933-2013), a Finnish architect. He studied at the University of Technology in Tampere from 1958-1961, but he had already worked in various architectural offices since 1955, so founded his own architectural office 'Casa Finlandia' in Espoo in 1961. His project portfolio, published in 1983, provides information about his professional career and the broad spectrum of his work (Suuronen, 1983). During an interview in 2004, however, he refers to a special project: the silo roofing of Seinäjoki from 1963 and he mentions a 4-day workshop on glass fibre reinforced plastics (GRP) shortly before finishing his studies (Voigt and Genzel, 2004). When, in 1965, a school friend asked for a ski lodge in rough terrain, he benefited from this experience and his contacts with the manufacturing company, Polykem Oy. His first idea of a dome with a diameter of 8 m was not sufficient for Suuronen as a complete design [FIGURE 03]. The hut as a ball on supports, which can be located on steep slopes or over water, satisfied him more in terms of design. The free-standing sphere was for him a man-made cave, a nest to have a warm and safe retreat in the wilderness of Finland. In several design steps, Suuronen moved away from the full sphere, as it creates too much volume, as well as from two spherical domes placed next to each other, i.e. flat spherical sections, as they again left too little space. In the end he found an ellipsoid a good compromise. Its volume was optimized, the statics defined and the formwork could be produced, because an ellipsoid is a mathematically defined shape [FIGURE 04]. Suuronen said about his design process: "The key factor is pi. It is pure mathematics. Since it is pure mathematics, it was easy to make the first wooden mould. We just followed mathematical guidelines. There were no alternatives. The measurements came from math" (Genzel and Voigt,



03 Drawing: Futuro-Sketches, 1966. © Archive Matti Suuronen, 2004

04 Drawing: sketches designing a ski-hut by Matti Suuronen, 2004. © Archive FOMEKK, BU Weimar, 2004

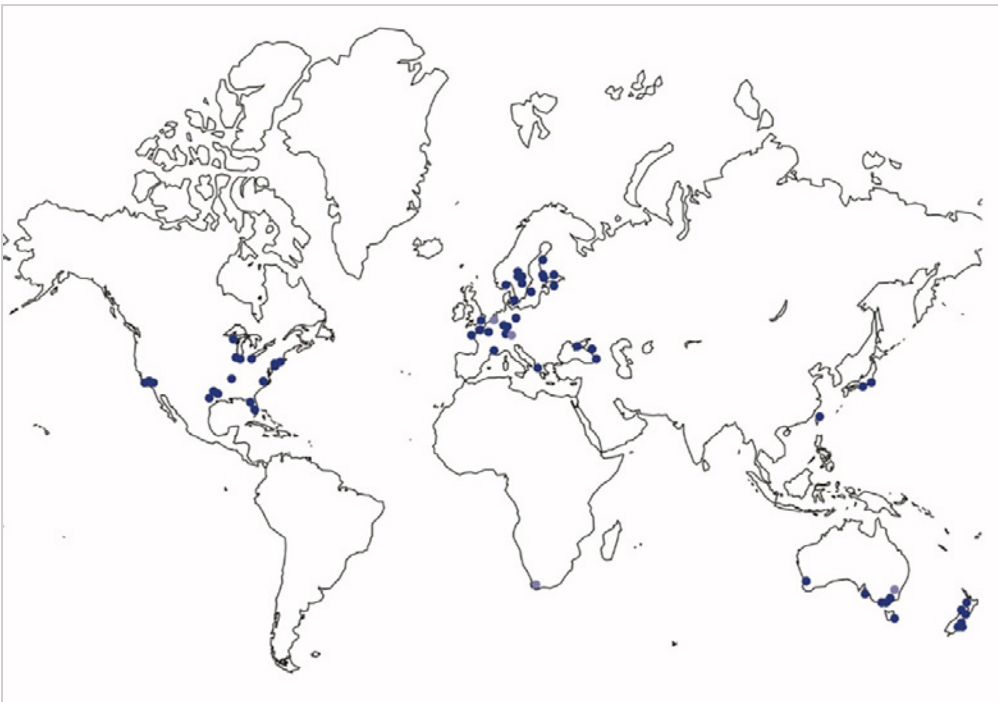
2005, 134). In designing and realizing the ski cabin Suuronen worked as the chief architect of a R&D team with Polykem Oy, that also included the structural engineer Yrjö Ronkka, technicians C.J. Olander and Heikki Tikkanen, Suuronens´s assistant Hannu Laitinen, project supervisor Peter Stude and production engineer Sven Lindfors (Mome and Tamila, 2002, p.17).

The designed ellipsoid with elliptical openings standing on a ring with filigree supports satisfied Suuronen's high design standards. Even the flap door becomes part of the outer shell, thus part of the ellipsoid. The feasibility of this unprecedented structure was assured for Suuronen and his team due to the same dimensions as the silo roofing and the mathematical derivation of the overall geometry and thus its static determinability.

This coherent, unmistakable final design, combined with the association of a UFO, hit the nerve of the time and was a prerequisite for financing the series production, international presentation and professional sales. This is also the basis for the name: Futuro. The House no. 002, advertised as a holiday home, was promoted at the Finnfocus export fair in London in October 1968, seven months after the presentation of no. 000 at Polykem Oy's premises.

As a result, 70 to 100 Futuro were produced worldwide in the 1970s. As the production was exported by means of licenced sales to the USA, Australia/New Zealand and Asia, no exact figures are available [FIGURE 05].

The oil embargo of the OPEC in 1973, the oil price increase in 1979 and the accompanying general increase in wage and production costs in the entire economic market put a temporary end to the dream of utopian plastic architecture. The industrial firms of the 1980s turned to other visions, materials and constructions. Plastic buildings



05 Visualisation of Futuro locations worldwide based on a research done by the authors showing a focus in Central Europe, the United States and in Australia and New Zealand. © Lola Kleindouwel, TU Delft, 2019

were frowned upon, considered outdated, ecologically questionable or too visionary. A phase of decay or destruction followed for most Futuros, although some – often unnoticed by the public – continued to be used.

According to Marko Home, there are 65 and a half Futuros left worldwide today. The half Futuro, split vertically, is part of Jugendhaus Frankfurt-Nied, Germany. [2]The main chronicler of the whereabouts and histories of individual Futuros can be accessed online (Futuro house). Some of the Futuros have been relocated, some dismantled, but only a few have been restored. In this article a comparison of four restorations dating from 2007 to 2018, gives insights into the specific construction, modifications and the challenges of the materials. Comparisons are made between the collection and exhibition objects, meeting the high conservation requirements of the museums on the one side, and buildings in use, whose usability must be ensured, yet still considering conservation principles and needs. This is all the more interesting because the durability of the structural restoration had to be developed with regard to the future usability of the specific interiors. Three of the four cases presented are kept outdoors, in line with the original intention of the architect, only one – the prototype no. 000 – is reserved for inside exhibition.

PRODUCTION AND CONSTRUCTION: LICENCES, VARIANTS, IMPLEMENTATIONS AND EXECUTION

From 1968 to 1978 the production of 20 Futuros in Finland is documented (Suuronen, 1983). These were delivered within Finland, to Sweden, Russia, Japan and one to Argentina for the UIA congress (Union Internationale des Architectes). The existence of a separate production site in the Federal Republic of Germany (FRG) could not be proven despite corresponding information in the publications of the 1960/70s (Bayer AG, 1969). Only the certificates of approval for the building permits were issued by licensees such as the office of Steffens & Nölle AG Stadthagen, FRG (Futuro-Haus, 1969). However, the Futuros themselves were manufactured by Polykem Oy, even if they are not mentioned on Matti Suuronen's archive list. There are also other licensed buildings, e.g. in Great Britain, Australia/New Zealand, USA and Japan. The Futuro was tested for earthquake and typhoon resistance by the University of Yokahama for the licensing to Japan (Genzel and Voigt, 2005).

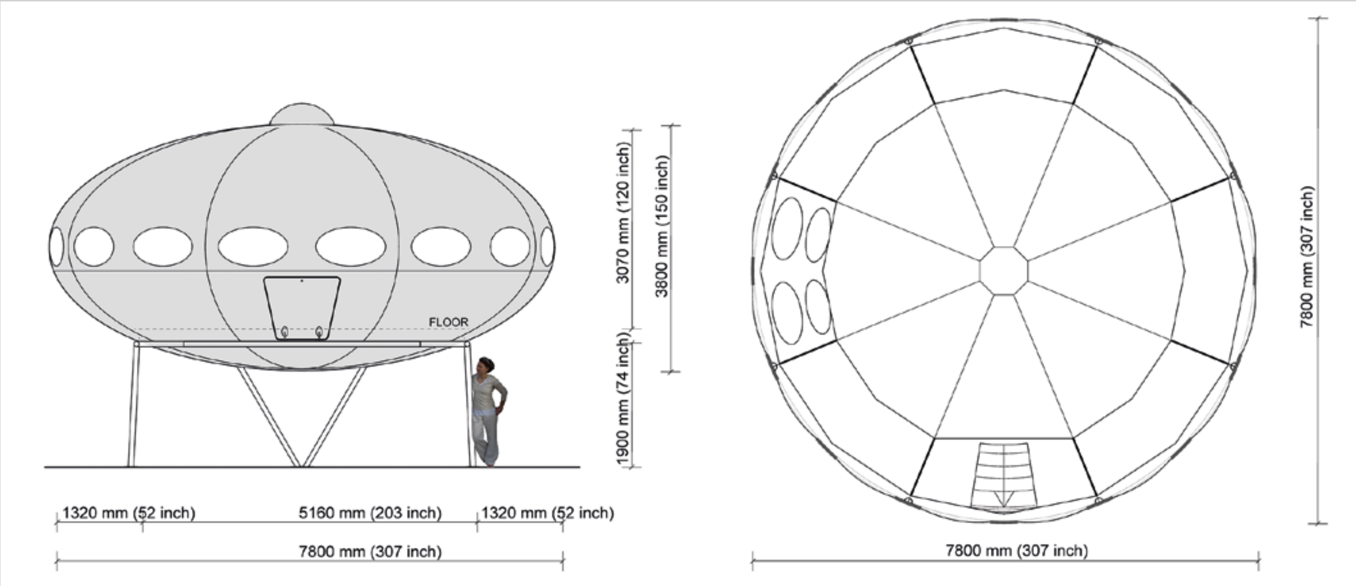
There are striking differences in structural design and construction between the Finnish and American Futuros. Accordingly, the granting of a licence to the USA included the authorisation of modifications, which will be discussed in more detail below. FUTURO Corporation is indicated as the licensee in the USA on original planning documents. Charles Cleworth's archive, which is accessible online (Cleworth Archive), testifies to his licensing, design modifications and manufacture as the FUTURO Corporation, Denver, Colorado. Since all Futuros in the USA have this construction design, it is reasonable to conclude that they were all produced and distributed by FUTURO Corporation. Confusingly for the historical research the original construction drawings of the US Futuros do not match the constructed buildings. A more comprehensive investigation of this Futuro history is therefore desirable.

The research basis for the following case studies was provided by the listed publications and the working plans made accessible to the author: Futuro Nr. 013, Berlin, 1969 (Archive BAKU, Voigt), Futuro Idylwill, California von M. Wayne Donaldson, 2004 (Archive Donaldson), Futuro Colorado, 1970 (Archive thefuturohouse), Futuro Austin, 1970 (Archive thefuturohouse). Furthermore, the author carried out building surveys and measurements during the Wilp-Futuro project (Archive BAKU, Voigt).

The production of a durable and efficient building made of plastics requires an appropriate design for the material, the individual parts and their connections, and the choice of hard-wearing plastics for a construction which will also provide a comfortable place to inhabit. Sandwich constructions made of glass fibre-reinforced polyester resins with a polyurethane foam core as thermal insulation were already commonly made in the mid-1960s. The glass fibres, which are protected by the thermoset resin matrix and permanently held in the desired form, provide–the structural capacity. Additives such as UV stabilizers, fire retardants and paint particles are added to the resin. The fibre mats, scrims or fabrics are impregnated with the resin mixture with an added hardener. The manufacturing process was known as hand lay-up or laminating. To achieve the desired form, exact negative formwork is produced to be reused several times. The sandwich construction elements, which are screwed together to form the building envelope, and whose joints are sealed with elastic seals, should be identical in order to keep production costs as low as possible. Transport sizes and the manageability of the individual parts during assembly are important factors in the design of plastic components and, ultimately, the complete plastic structure [FIGURE 06].

Matti Suuronen developed a holiday home for rough terrain. This meant that the components which were prefabricated in the factory had to be stackable on a transporter to save space and be quickly assembled without the need for lifting equipment. The famous transport of a Futuro by freight helicopter was only meant for advertising purposes.

Due to these material-specific manufacturing techniques and design parameters, the Finish Futuro consists of eight identical, double-curved, shell-shaped building sections in



06 Drawing: Wilp-Futuro: Elevation and top view. © P. Voigt, 2016

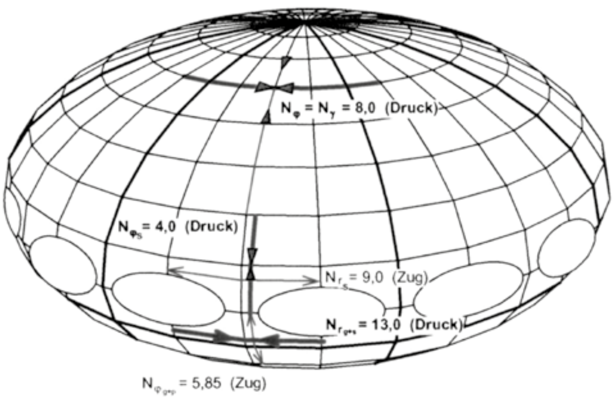
the top and bottom halves of the building – 16 sections in total. An upper section of shell weighs approx. 150 kg, a lower one approx. 300 kg. These composite shells are bolted together via their edge flanges, which also serve as stabilising ribs. The overall dimensions of the ellipsoid are 3.8 m x 7.8 m. The floor is 59 cm above the lower edge of the ellipsoid and therefore has a usable area of approx. 24 m². The room height is approximately 3 m at the zenith.

The Futuro sits approx. 50 cm deep in a steel ring (overall diameter 5.0 m made from 85 mm circular hollow section (CHS) steel). Under each structural joint there are metal lugs (10 x 10 cm) to support the ellipsoid on the ring, to which the sandwich panels are bolted and secured in position. The height of the ring is in the original design approx. 1.90 m above the ground. Four V-supports are welded to the steel ring, each with a 30 x 30 cm base plate at the foot to bolt down to individual foundations. The height results from the position of the V-supports, but could be changed as desired. For transport the ring is divided into 4 equal parts, each with a pair of V-supports.

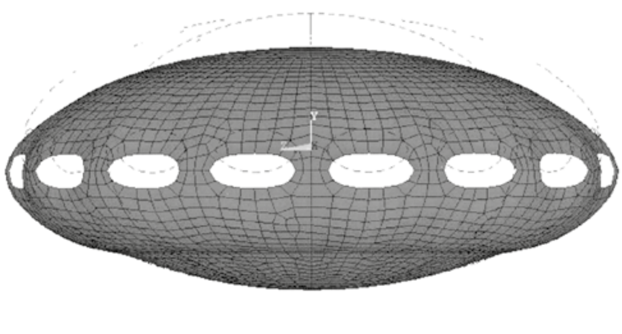
The real weight of the Futuro is about 4 tons, contrary to the original publications which indicated 3 tons. The total weight including the metal base and the complete interior is about 6 tons.

SUPPORT STRUCTURE, COMPONENTS AND FURNISHING

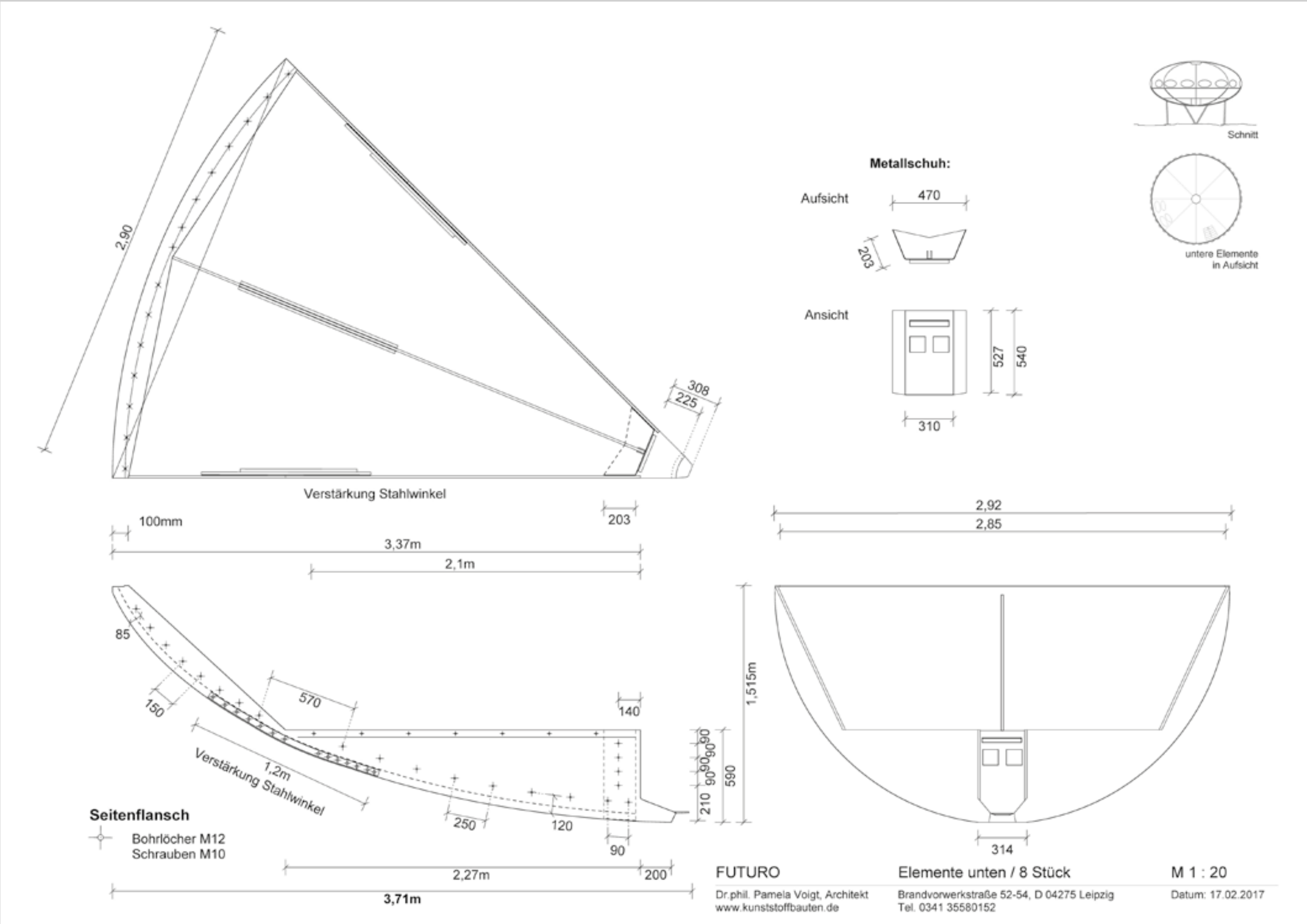
Support Structure: The Futuro has a beautiful and controlled bowl shape. The openings in the support structure are located in structurally logical positions, with the exception of the fold-out stairs. This is a major impairment of the shell's load-bearing capacity, which is why ribs have been inserted to stiffen it. Elke Genzel carried out a comparative structural analysis by both manual calculation and also by Finite Element Method (FEM) calculation with the software ANSYS (Genzel and Voigt, 2005). The manual calculation led to the same results as the digital FEM calculation. It checked the critical points: at the zenith, because at this point the curvature is the smallest and the compressive stress is the greatest, and at the equator because the material surface of the ellipsoid (position of the windows) is the smallest [FIGURE 07]. The displayed deformation pattern under dead load and snow clearly shows the calculated deformations [FIGURE 08].



07 Representation of the occurring stresses from dead load, support load, snow and traffic. © BAKU, Elke Genzel, 2005



08 Under snow the Futuro virtually sags together and hangs over the ring. © BAKU, Elke Genzel, 2005



09 Cutting and orientation of the PUR insulation in the sandwich visible in sidelight. © P. Voigt, 2016

Components: The Futuro is a sandwich construction. In a sandwich, the individual layers of material are bonded to each other, and therefore perform better as a whole than the sum of the individual layers. The structure is 3 mm GRP externally, 45 mm PUR foam and 2 mm GRP internally. In the construction file of Futuro No. 013, the use of the polyester resin Leguval (Bayer AG) is specified. The flanges of the upper Futuro shell have a height of 4.5-5 cm with a material thickness of only 5 mm, but in the case of the Wilp-Futuro, for example, they taper to 2 mm due to manufacturing inaccuracies. The lower flanges have a height of 5-56 cm with a material thickness of 15 mm [FIGURE 09].

Although the GRP sandwich is structurally adequate, only the outer building envelope is executed as such. In contrast, the side flanges and additional centre ribs of the lower shells were manufactured as GRP cross laminated plywood sandwiches (1.5 mm GRP, 12 mm cross laminated timber, 1.5 mm GRP) which were screwed to a 2 mm formed metal shoe. In addition, two metal angles (40 x 20 mm, t = 3 mm) were laminated into the sandwich adjacent to the steel ring. These are firmly connected to the plywood in the side flanges by means of screws. All side flanges and ribs of the Futuro are located inside the building. The individual components are joined at the flanges with M10 bolts and washers. In order to avoid possible cracks from structurally unfavourable stress peaks in the thin material, it was observed that screws were spaced at approx. 15 cm centres on the upper shells and 25 cm centres on the lower shells [FIGURE 11, 12, 13].

The insulation is commercial PUR foam (hardmoltoprene from Bayer AG), in the form of double-curved smaller panels or strips [FIGURE 13], which were placed on the wet laminate during production and should therefore be firmly attached to it. The insulation thickness results from Suuronen´s desire for high thermal insulation to ensure that the ski hut heats up quickly. The U-value of 0.6 W/m²K was indeed a very good value until the 1990s.

The elliptical windows are designed as double glazing made of double-curved PMMA (acrylic glass of the Macrolon brand). 16 windows with 1.25 x 0.62 m and 4 windows arranged in a lower element. Two of them are the same size as the surrounding ones, two with 1.05 x 0.43 m. These four serve as an escape route in case of fire. No windows can be opened, as Suuronen assumed that the ski cabin would be used mainly in winter and probably also in Scandinavian summers. Fresh air was supplied via the floor inlet and exhaust air removed via the ceiling opening. The floor is a wood-based panel resting on the flanges and centre ribs. For this purpose, additional squared timbers (20 x 45 mm) were screwed on. The joints of the upper elements visible in the living area are covered by a bead, also made of GRP.

10 Wilp-Futuro before disassembling. © P. Voigt, 2016

11 Wilp-Futuro element Cu wile restoration. © P. Voigt, 2016

12 Wilp-Futuro. © P. Voigt, 2017

The eye-catcher of the Futuro is the fold-out entrance staircase, which is copied from aircraft construction. It is part of the outer shell and therefore also manufactured as a GRP sandwich with five curved steps. The elevator mechanism worked via a steel cable connected to a manually operated winch in the entrance area.

The FUTURO Corporation, as the American licensee, adapted the Futuro to make additional space as a response to the needs of their customers. In the correspondence from 1970 there was even talk of a larger overall diameter, but this was not implemented [Cleworth Archive]. However, they achieved a larger usable area by raising the level of the floor by about 19 cm higher than in the original Futuro. This results in an area of approximately 29 m² instead of the 24 m². Because of this there are only two lower windows that are used for escape routes.

The FUTURO Corporation also expanded the dimensions of the prefabricated Futuro components, so that half shells were delivered. The support ring, which was also halved, was re-located within the building envelope and firmly connected to the sandwich panels. Only the steel legs penetrate the outer skin. This made assembly considerably easier, but required the use of a hoist crane.

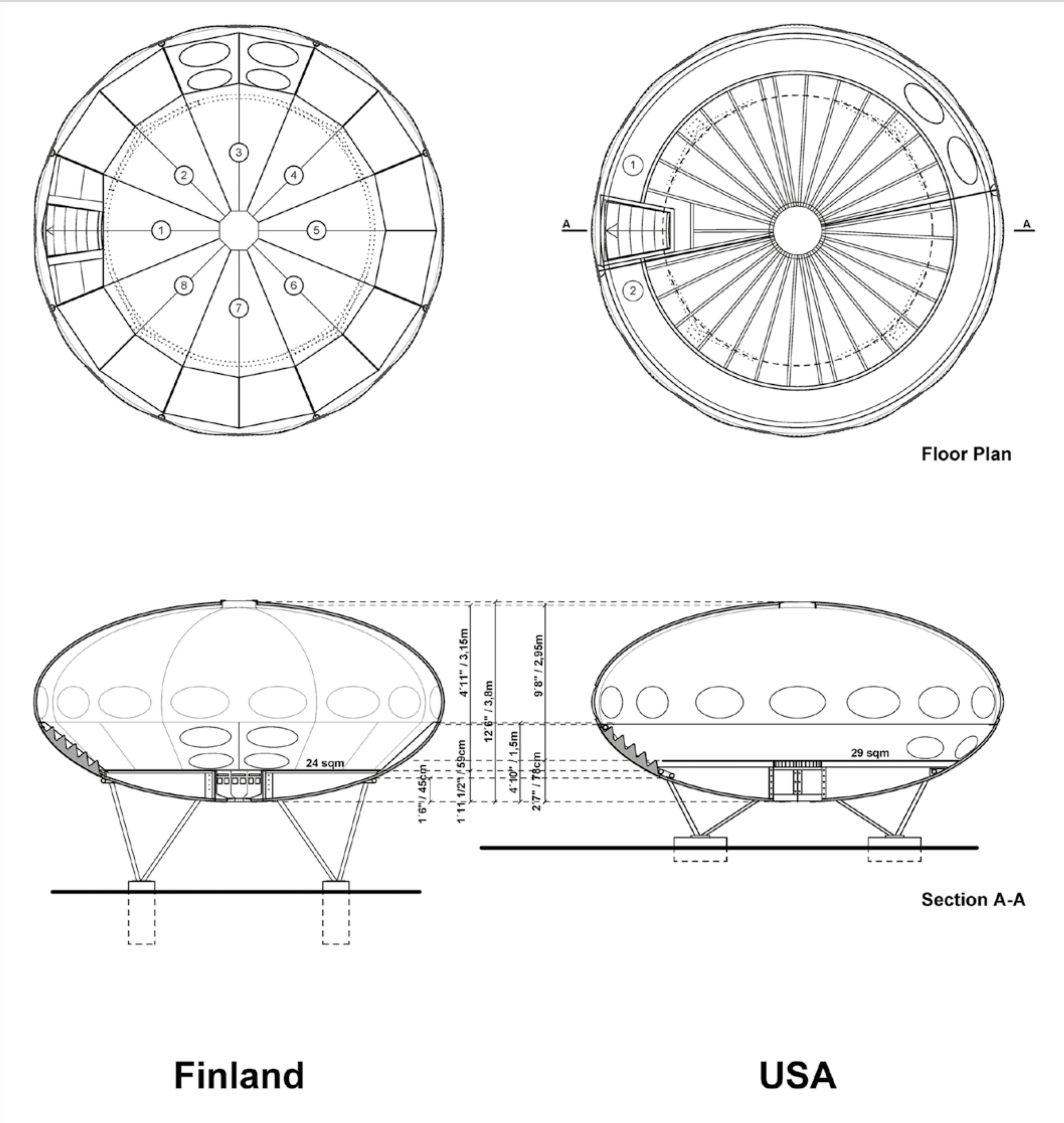
13 Cutting and orientation of the PUR insulation in the sandwich visible in sidelight. © P. Voigt, 2016

Four shell elements were assembled in the factory to form a half shell; and the individual joints then over-laminated. In some cases, the remaining vertical joints were over-laminated during assembly, so that only the horizontal joint divided the otherwise smooth surface. Also, for design reasons, the folding door was installed directly under a window. The door opening interrupts the support ring, which is why a steel reveal was inserted at that spot in order that the ring remained structurally effective.

Another difference to the original Futuro is the steel structure shown in the plan [FIGURE 14], and also visible in the photos [FIGURE 15, 16], consisting of the steel ring, a central metal frame, and steel beams arranged in a star shape, which function together as the main supporting structure with the entire building shell hanging from the internal steel ring. The detailed laminate structure, material specifications and connection details have not been published.

Interior Finishings: The approximately 24 m² floor space of the original Futuro is perfectly divided for a short holiday stay into entrance area, bathroom, lounge with attached kitchenette, and sleeping niche. As described above, Matti Suuronen designed the Futuro including the interior. Every detail refers to the ellipsoid overall shape and the round ground plan. This entirety forms the unmistakable design. In principle, the Futuro is a one-room building, as the inserted partitions can be changed quickly and easily by the user. Only the sanitary block and the kitchenette are fixed in their position due to the water and electrical connections [FIGURE 17].

The most fascinating part of the fitted interior is the extendable reclining seats. These recliners are positioned radially along the curved outer wall in the living room and are grouped around a fireplace grill placed in the



14 Drawing support structure in ground plan and section of the Finnish and American Futuro. © P. Voigt, 2020

15 Support structure of the Finnish Futuro. © P. Voigt, 2016

16 The American version and the thefuturohouse. © Rockwall-Texas, 2019

17 Berlin-Futuro No. 013. © Archiv FOMEKK, BU Weimar, 2004

18 Berlin-Futuro No. 013. © Archiv FOMEKK, BU Weimar, 2004

middle [FIGURE 18]. Suuronen called the backs of the seats between the loungers horses because of their two humps (Cleworth Archive). Integrated lamps make them attractive as reading seats. The fireplace grill stands in the centre of the Futuro and also serves as a table. This and the reclining seats best illustrate Suuronen's intention: the sociable, relaxed get-together of friends after skiing.

Thanks to the thermally favourable shape of the building with a minimal external surface area in relation to its volume, the insulation and the powerful electric-finned tubular heating elements in the intermediate space under the floor, it was possible to warm the Futuro up to a comfortable room temperature within 30 minutes, even in cold northern winters. In summer, air conditioning or a fan was required (Suuronen, 1983). Alternatively, an openable skylight enabled natural ventilation, as in the case of Wilp-Futuro in Munich. The kitchen is equipped with a sink, work surface, storage space and boiler for preparing coffee, tea and snacks. According to the owner of the Berlin Futuro, there was a lack of good planning of the individual parts. The sanitary unit was located between the entrance area and kitchenette, and contains a wash basin, shower and toilet. Since this cell is seamlessly formed from GRP, all that is needed is a drain on the floor to let the shower water run-off. Since the door threshold is 23 cm above floor level, the water is otherwise kept in the bathroom cell.

Futuro buyers could order individual elements, the entire interior or Futuros without interior finishing.

The American Futuro Licencee adapted the Futuro to the needs of the American market for more usable space (29 m^2), a more spacious bathroom and kitchen and a perimeter bench instead of the reclining seats [FIGURE 19, 20].

The first Futuros were coloured in white, yellow and light blue. The productions in other countries also offered gold and green. The interior was painted in a different colour, e.g. blue, red, orange or violet (Suuronen, 1983).

CONCLUSION

The Futuro captivates people all over the world with its space-age imagery. As a coherent architecture of the 1960s and 1970s, it is not only regarded as a museum piece now, but there are new lovers who continue to use the original Futuros. The preservation of architecture presupposes an understanding of the materials, the structure and the technical details. Why did this and that decision come about during the original production process? Why did that and this damage occur? The comparison of different models of the Futuro series and the American variant, adapted to different users, transport sizes and technical practices, sheds light on these questions. The preservation of museum objects serves not only to preserve the appearance, but, above all, to preserve the state of knowledge of the object at its time of creation. The maintenance of privately used buildings, on the other hand, may deviate from these principles and is therefore understood as repair that may include technical evolution. The case studies illustrate design and modifications of the Futuros to serve different needs and show the complexity of the conservation process.

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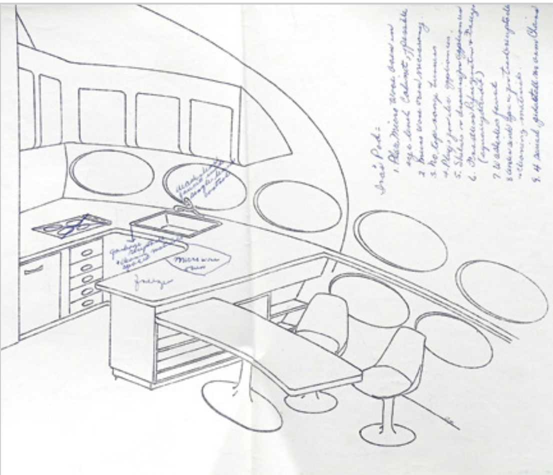

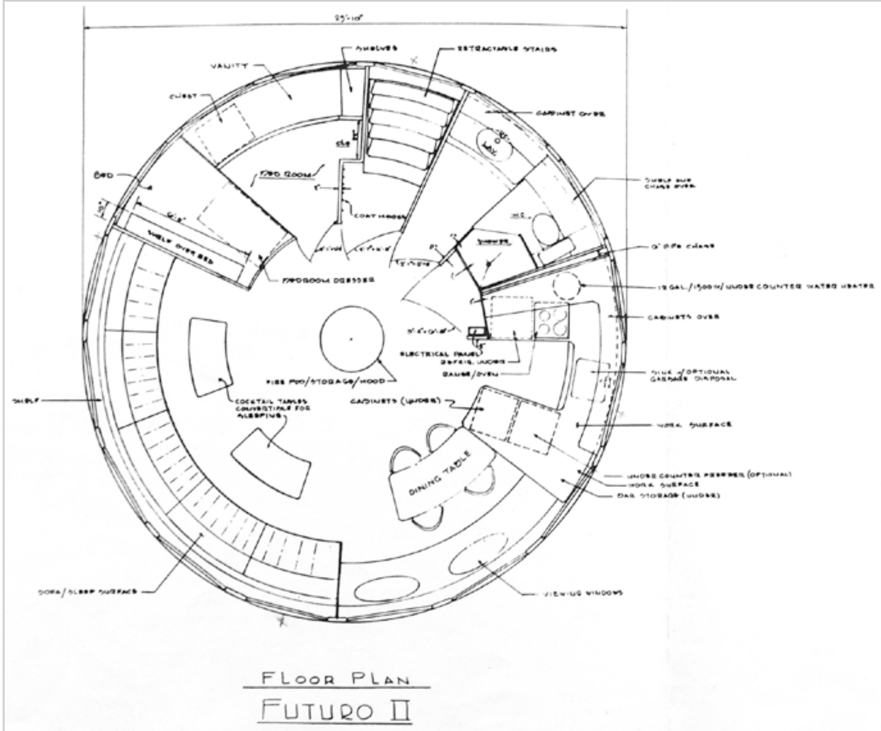

19 Sales documents from 1970. © Archive thefuturohouse, Futuro-Austin-Texas, USA

20 Detail of floor plan. © Archive thefuturohouse, Futuro-Austin-Texas, USA

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ENDNOTES

1 https://thefuturohouse.com/Futuro-Demolished-Locations.html#-frankammain [saved: April 15, 2020]

2 https://thefuturohouse.com/Futuro-Demolished-Locations.html#-frankammain (saved: April 15, 2020)

Pamela Voigt *(Dr. phil.), architect, studied architecture from 1994 to 2001 at the Bauhaus University Weimar. From 2001 to 2005 she taught and researched within the interdisciplinary research group for material-appropriate design and construction with fiber-reinforced plastics (FOMEKK) at the Bauhaus University Weimar. Early 2007, Pamela Voigt finished her dissertation on the art-historical topic: Die Pionierphase des Bauens mit glasfaserverstärkten Kunststoffen (GFK) 1942 bis 1980 (The pioneering phase of building with glass fiber reinforced plastics (GRP) 1942 to 1980). Since 2008, Pamela Voigt has been actively planning renovations and new developments of plastic structures, partly in cooperation with Elke Genzel as the BAKU working group.*
www.kunststoffbauten.de