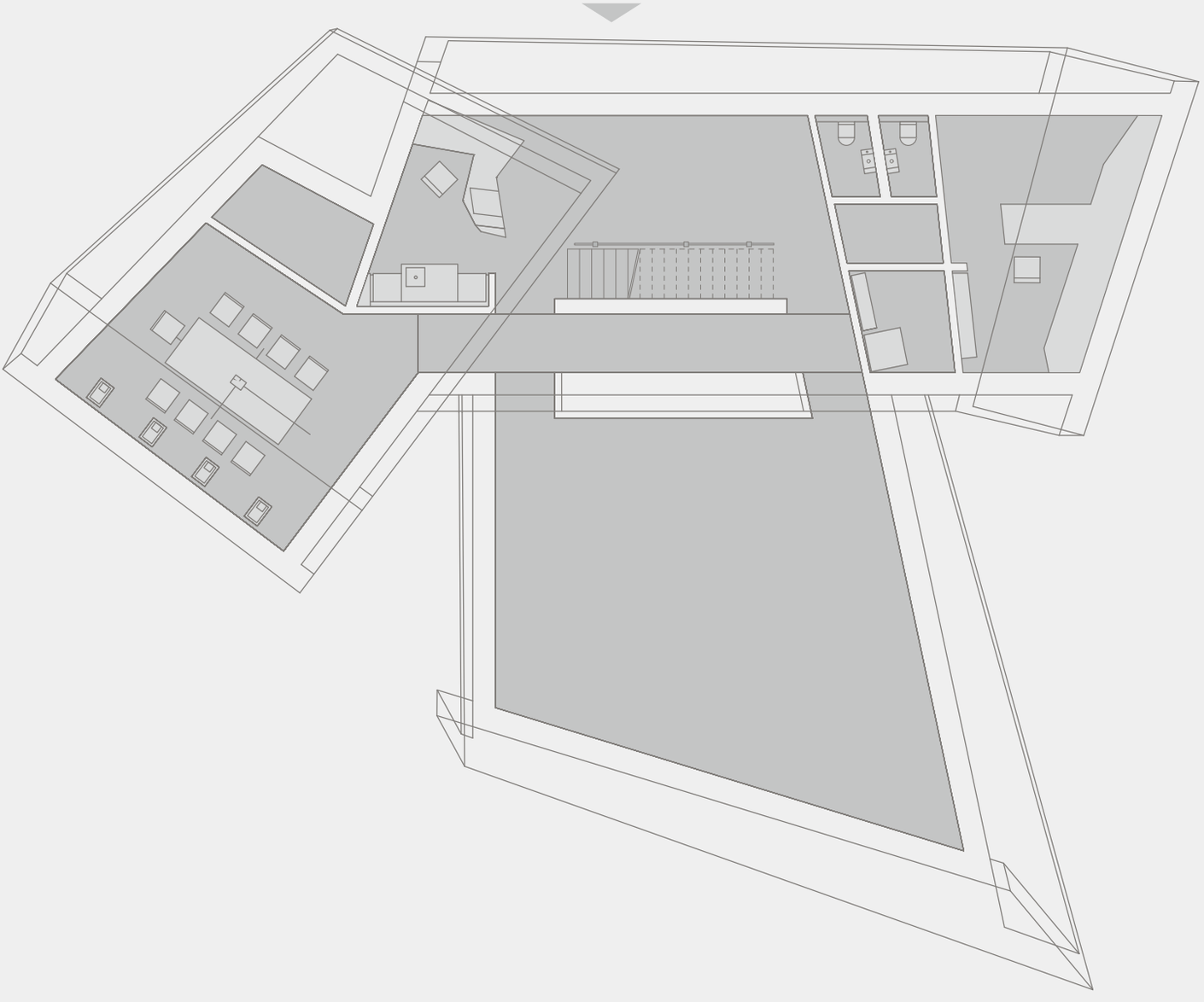
RHEINZINK®

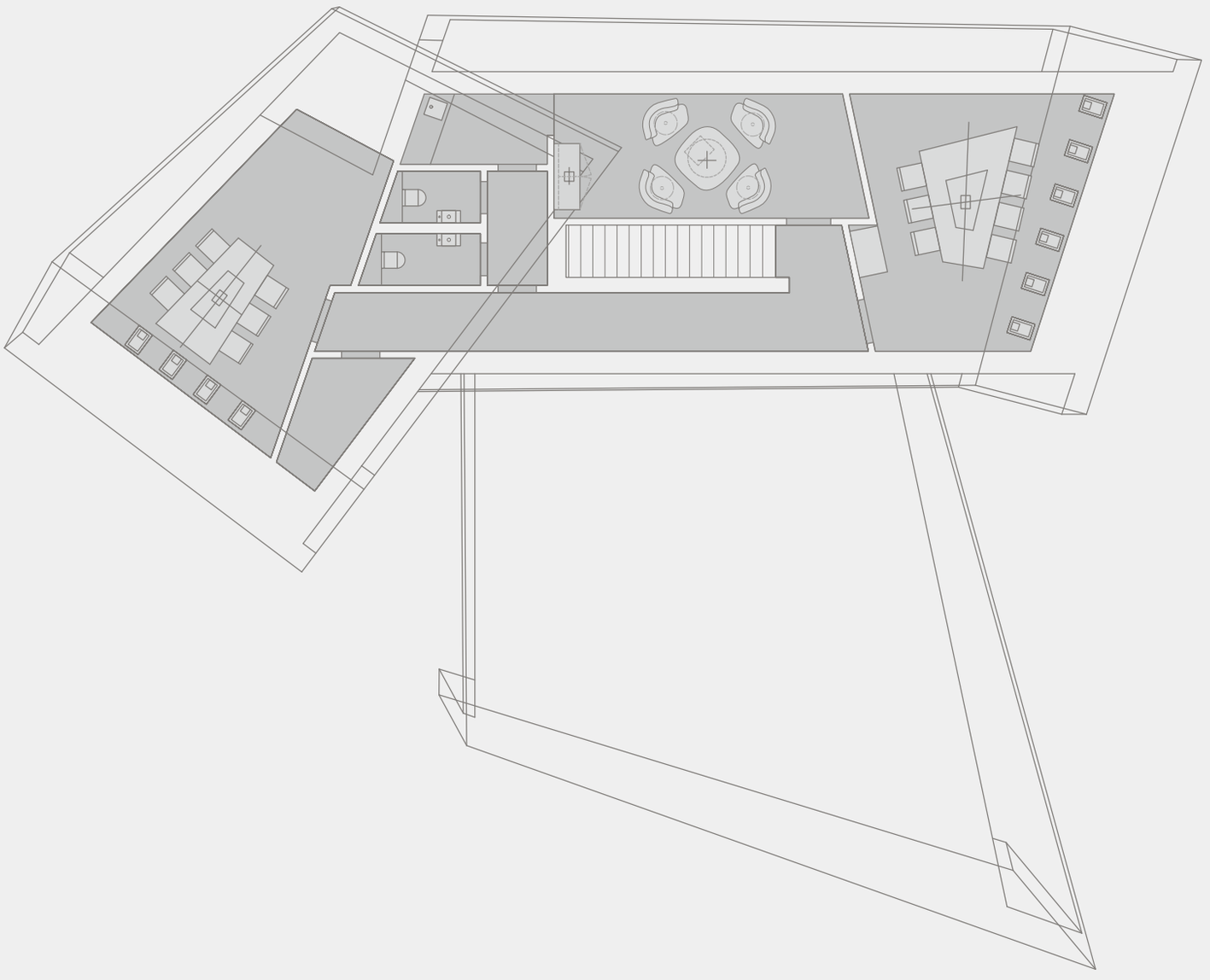
LIBESKIND**VILLA**

BOOK OF WORKS ABOUT THE RHEINZINK RECEPTION BUILDING
DESIGNED BY DANIEL LIBESKIND

FLOOR PLAN, GROUND FLOOR



FLOOR PLAN, FIRST FLOOR



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THE RHEINZINK RECEPTION BUILDING

Designed by Daniel Libeskind

Zinc and Libeskind – these two have written a story of a passion, which has brought the world of architecture a number of extraordinary buildings. Take, for example, the Felix-Nussbaum Museum in Osnabrück, the Museum Residences in Denver or the Jewish Museum Berlin. This Book of Works features an interview, in which the New York architect explains the fascination that zinc holds for him.

By now, however, the name Libeskind not only stands for an ambitious museum building and monumental architecture art, but also for the prototype of a residential building, which was built on our premises and, since its official inauguration on September 29, 2009, serves as our new reception building. The Libeskind Villa – an extraordinary piece of spectacular residential architecture and latest technology, as aesthetically pleasing as it is sustainable, designed by Libeskind, created as if for himself and available in a limited number throughout the world. He was able to give his vision and creativity free rein, and RHEINZINK feels privileged to have been able to assist Mr. Libeskind in realising his ideas.

This Book of Works documents this vision come true and describes the unique concept behind it.

Daniel Libeskind's unmistakable architectural vocabulary might have little in common with Karl-Friedrich Schinkel's signature style, but in a way Libeskind sees himself as the German architect's nephew in spirit. Both have succeeded in creating avant-garde architecture. Schinkel, too, loved working with zinc.

Like many architects throughout the world, Daniel Libeskind likes this natural material for its manifold application possibilities and its exemplary ecological properties. With regard to sustainability, RHEINZINK products for roof and facade cladding as well as building interiors are unrivalled. You might say that RHEINZINK is the wood among metals, extremely durable and easy on the Earth's natural resources. A premium quality material of timeless beauty.

Our new reception building is the result of a congenial collaboration with the famous architect: a crystal grown from the ground, as architecture critics have called it, maybe even an architectural jewel, a residential sculpture without equal.

With this Book of Works, we want to give inspiration to all those who are ready to take on the ever-changing challenges in the aesthetics, design, functionality and sustainability.

We hope to pique your interest and look forward to any feedback from you. Enjoy the Book of Works!

Visit **www.rheinzink.com** and **www.follow-your-inspiration.com** for a place of inspiration for a creative use of RHEINZINK. Our recent publication "ARCHIZINCTURE" documents other architects' visions come to life with our assistance. You can request this documentation free of charge.

THE EXCEPTIONAL ARCHITECTURE AND THE ARCHITECT

The architectural concept ..... 08 – 09
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THE ARCHITECTURAL CONCEPT

Design and sustainability in perfect symbiosis

The building looks like a crystal growing out of the ground. Vibrant lines intensify the building's energetic aura, alternating sunlight and cloud shadows give the outer surface a fascinating vivacity. The building's interior is pleasantly open and transparent and affords extraordinary spatial experiences. What the eye does not see at first glance, however, are the eco-friendly building services. The RHEINZINK reception building, designed by Daniel Libeskind, is an impressive blend of design and sustainability.

The Libeskind Villa stands for aesthetics, exclusivity, premium materials, innovative energy technology and sustainable construction. It also stands for a new type of private home because it is part of the "Signature Series", the designer home concept by the Berlin-based proportion GmbH. In collaboration with internationally renowned architects, this company designs residential sculptures, which set themselves apart by virtue of their extravagant contemporary architecture; these sculptures are being erected in a limited number all over the world. The first structure in this new building type was designed by Daniel Libeskind, who gave it an extraordinary look. Acute and obtuse angles, diagonal and vertical walls, some building parts encapsulating others, seamless transitions between rooms, and a balcony with a screen that offers both privacy and sun protection: all these elements combined create a unique atmosphere and a striking piece of architecture. Metal roof and facade liners wrap around the different structural elements merging them into a spectacular work of art.

Since RHEINZINK will use the Libeskind Villa's prototype as a reception building, and not as a residential building, a few functional alterations have been introduced. The impressive entrance hall is reception area and lobby in one. From there, a folded-plate self-supporting staircase leads to the upper storey, which houses several meeting rooms. The ground floor has another meeting room, utility rooms and – facing the plant entrance – the plant security room.

The Libeskind Villa's architectural highlight is the Grand Room, where tall, oversized windows and a slanted ceiling rising up to a lofty height of 7 metres exude a dazzling, dynamic energy. The Grand Room is reached via the lobby and is designed to house events and exhibitions. This impressive ambience is where RHEINZINK tells visitors about the company and its history and showcases its products and technologies.

Materials and technologies

The Libeskind Villa was built as a sustainable wood frame construction. Apart from the renewable material wood, every area of the construction saw the use of materials, which – like RHEINZINK – have a DIN EN ISO 14025 Type III-compliant environmental declaration by the German "Institut Bauen und Umwelt e.V." association or have earned some other kind of environmental innovation distinction. The RHEINZINK roof and facade cladding is part of the innovative low-energy concept because – although not apparent from the outside – it contains a solar energy installation. In combination with a geothermal absorber and modern heat pump technology, this installation makes for a heating system that is both visually appealing and sustainable. A new kind of mineral wool with a very low thermal conductivity was used for insulation. Heating, cooling and heat recovery are all based on an intelligent underfloor climate control system. Rainwater from the RHEINZINK roofing is collected in an underground tank and used to flush the toilets. Installations like windows, doors, washbasins, sanitary fittings and fixtures are made from premium materials; cutting-edge electrical installations and lighting combine intelligent building services with comfort, security and fine aesthetics.

A building with an extraordinary look

An interactive screen in the Grand Room allows occupants to monitor performance of the hidden heat generation, cooling and ventilation systems at all times. The data generated here is collected over a period of three years to gain detailed insight into the heating, cooling and ventilation systems' efficiency.

The Libeskind Villa is built on an area of approx. 290 m^2 (ground floor: approx. 200 m^2, first floor: approx. 90 m^2) and took only six months to finish. The unusual architecture, the craftsmanship, the use of high-quality materials and the ecological energy concept raise the bar in terms of design, craftsmanship and sustainability.

THE ARCHITECT DANIEL LIBESKIND

"Life itself, its vitality and diversity have inspired me in my design."

Mr. Libeskind, you work on a global scale, design major projects like museums and shopping centres. The Libeskind Villa is a prefabricated private home, which will be produced in a limited number. What makes this project special for you?

The Villa is an exclusive work of art designed in a limited quantity for unique locations around the world. I have designed it because there are so few private homes that can be designed in a truly architectural manner. The Villa has no cubic forms, which normally arise from the coordination of architecture and production constraints. I believe we need artistically designed, sculptural buildings. The Villa is just such a building, and it changes the landscape surrounding it.

The Libeskind Villa resembles a crystal growing from a rock. Why did you give it this unusual shape?

History teaches us that every great building is like a unique crystal. Frank Lloyd Wright once said that this was true architecture. If a building is not like a crystal, it is not architecture. I agree with him because crystalline forms are crisp and possess a great deal of radiant energy – in their silhouettes and surfaces, in the rooms and their organic relationship with their natural surroundings. For me, this kind of architecture is something very special, something that I really love.

The RHEINZINK reception building serves as a prototype for future production. What were the toughest challenges in realising your design?

The RHEINZINK building is a prototype with regard to construction, facade cladding, technology and sustainability. The challenge was that we have built something, which had never been built before. The Villa is an absolute pioneer work in spatial, construction and ecological innovation. The design focuses on using sustainable materials and technologies. This allowed us to combine excellent thermal insulation with power generation from renewable sources in a highly unusual manner. The building complies with the strictest existing energy standards in the world and has the advantage that it can be modernised or remodelled independent of its energy supply systems.

The transparency and seamless transitions in the building's interior are fascinating. What inspired you to design it like that, what did you wish to express?

The Villa was not supposed to be a box or a new prototype of contemporary homes. My concept was to create an entirely novel spatial experience for the 21. century that has artistic and cultural value. Life itself, its vitality and diversity have inspired me in my design. The Villa lives and breathes through the dynamic shapes of its rooms and the fluent movement of light. Inside it, you don't feel as though you are inside an abstract box; instead you truly feel in harmony with the sky, the earth and the elements.

RHEINZINK was used for the roof and facade cladding. What is it about this material that fascinates you?

I love zinc. It a superb, beautiful material, which is also sustainable. It is natural and needs no industrial processing, no additional finishing. This makes it comply with the requirements that Schinkel made of any material 150 years ago. The solar heat installation splendidly combines the material's advantages with the generation of energy and the recycling of rain water. I believe that, with the Villa, we have built one of the most beautiful homes in existence; and it will raise the bar in sustainable construction.

THE SUSTAINABLE BUILDING CONCEPT

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STRUCTURAL DESIGN

Realised with the natural material wood

Acute and obtuse angles, horizontally and vertically slanted surfaces: The planning engineers and construction teams involved in the project met the inherent challenges in these elements with great success. The Libeskind Villa was erected opposite the central administration building in immediate vicinity to the entrance to the RHEINZINK premises. A location that lends itself perfectly to combining the building's role as a reception, event and exhibition venue with the requirements of plant security. Also, there had not been built anything on the area except for a bicycle shelter. The soil was found to be sufficiently stable so that, apart from a layer of gravel for drainage purposes, no additional measures were necessary to guarantee the building's stability.

The Libeskind Villa's prominent features are the slanted walls, ceilings and lines. They give the Villa its expressive shape -- and they posed some unusual challenges for the construction teams. Even the building's footprint features acute and obtuse angles. This fact needed to be considered in creating the foundation and designing the formwork. And then there were the preparations and conduit layout for the geothermal system. More than 20 batter boards were needed to align the formwork modules so as to realise the building's unusual footprint. The 28-cm foundation slab is made of reinforced concrete (type C 25/30), it rests on an elastic foundation and helps distribute the vertical loads. Beneath this foundation plate, two layers of Styrodur 3035 CS form the 12 cm of perimeter insulation.

Work on the ground slab in progress

A wood frame construction makes for high dimensional accuracy and short construction times

The ceilings and support structures for both interior and exterior walls are made of wood. Using this renewable material is in keeping with the concept of sustainable construction and is also ideally suited for this new type of prefabricated construction. According to the www.CO_2-Bank.de portal, using wood as a building material produced 130 t less CO_2 when compared to conventional construction methods. The only exception is the reinforced concrete wall at the centre of the building, which was necessitated by the self-supporting steel staircase, which, due to its location at the centre of the building, forms part of the overall structural engineering concept by serving as an additional horizontal bracing element.

The wall elements of the Libeskind Villa are wood frame constructions, whose joists, posts and beams are made of solid structural timber. Because the walls run horizontally, vertically or at an angle and no two walls are the same shape or size, detailed planning was called for to guarantee the dimensional accuracy needed in the wooden components for a successful prefabrication of the wall elements. To achieve this, state-of-the-art CNC machines were employed. They guarantee a trimming precision that – considering all the different sections and construction details – would otherwise require a much greater effort. For wood joining, the planning engineers decided to use traditional carpentry techniques like tenon joints, dovetail joints and lap joints. Only for those joints that are exposed to larger amounts of stress, the nowadays more common gusset plates were used.

STRUCTURAL DESIGN

Built to the highest quality standards

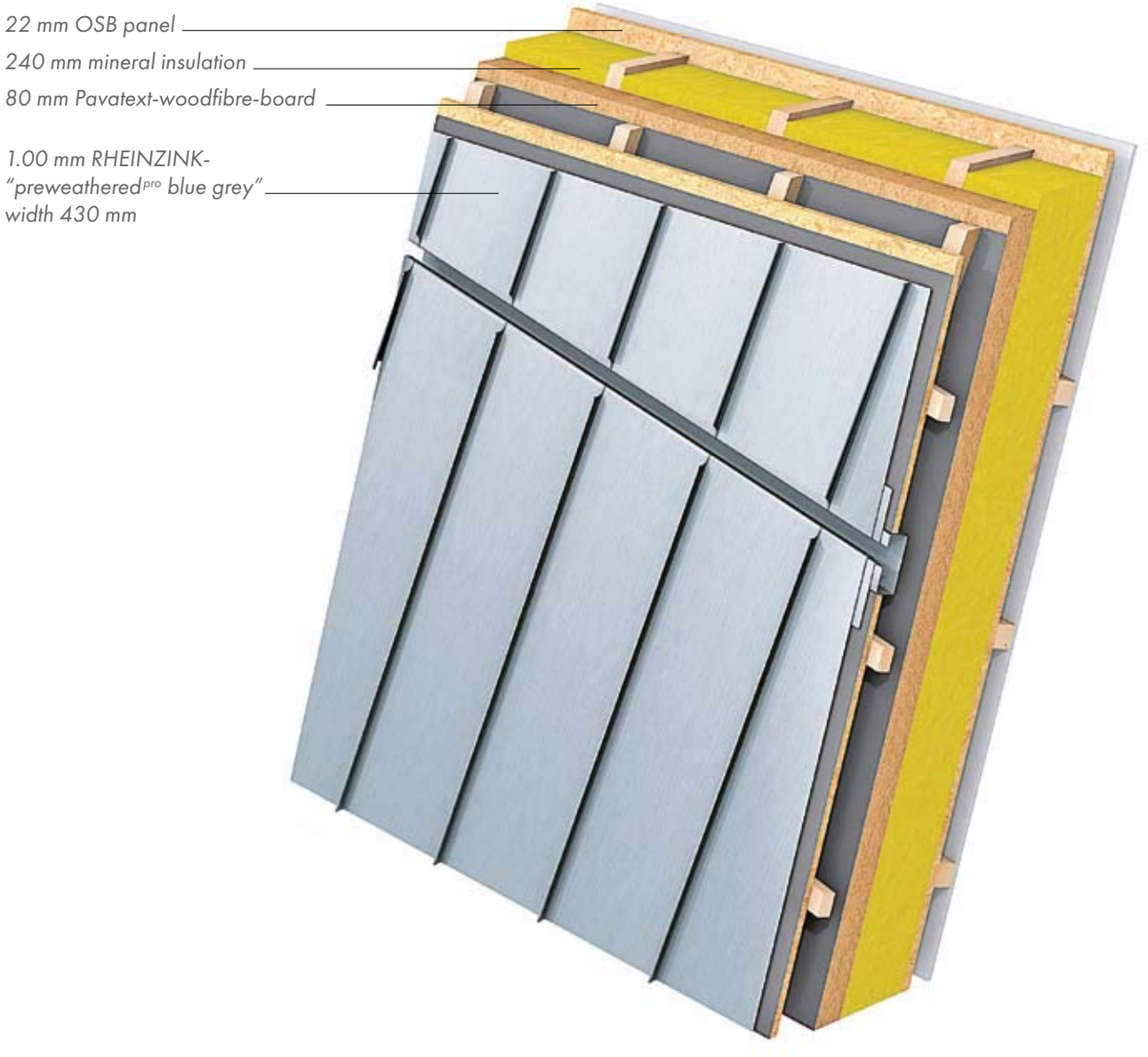
The structural integrity of the wood frame construction was enhanced by OSB panels (12 and 22 mm Eurostrand® OSB 4 Top) mounted on one side; these panels also serve as the airtightness layer and as the installation basis for wiring and plumbing. The low-emission OSB panels are glued together using absolutely formaldehyde-free glue, and they are approved by the responsible building control authority for use in load-bearing structural components in wet rooms. The Libeskind Villa is constructed from a total of 53 wall elements (21 interior wall elements, 32 exterior wall elements).The smallest measures approx. 1.30 x 3 metres, the largest roughly 12 x 5 metres. They were pre-assembled before being transported on flatbed lorries to the construction site, where they were installed using a crane. In total, more than 190 m³ of construction timber, OSB and wood fibre panels were installed.

Owing to the vertically slanted walls, extreme care needed to be taken in anchoring them so as to help transfer the horizontal and vertical loads. Standardised anchor rods and a custom-manufactured tension anchorage system were used to anchor the wall elements to the ground; the wall elements themselves were joined by nailing the OSB panels together. In order to protect them against ground moisture, a protective coating was applied to the joists, which rest on the ground slab. Bitumen sheeting on the ground slab itself offers additional protection.

The ground floor ceilings as well as the structurally necessary beams beneath it are made of glued laminated timber with cross-sections between 6 x 12 and 20 x 60 centimetres. The beams rest on the load-bearing wall elements and have clear spans of up to 10 meters. The glued laminated girders were also cut to size with CNC machines, transported to the construction site on flatbed lorries and mounted onto the ground floor walls using a crane. The wood frame construction was assembled in only 12 days.

The outer wall and roof surfaces were either plastered or clad with RHEINZINK. Looking at the overall shape of the Libeskind Villa, the lobby area together with the plant security room could be considered the main structure. Its front and rear facades are plastered, whereas the two lateral facades and the oblique flat roof, which could be said to form a sort of bridge across the building, are covered with RHEINZINK. At the rear of the building, two wings jut out from the main structure. Although different in orientation, the facade cladding follows the same pattern: two opposing facades of each wing are plastered, and the remaining facades and the two lean-to roofs are covered with RHEINZINK.

Wall structure in due consideration of heat insulation during the summer



THE RHEINZINK ENVELOPE

Following the latest concepts in energy conservation

Thanks to its superb thermal insulation, the Libeskind Villa complies with the German KfW-40 energy-saving standard. The wooden structural supports panelled with environmentally-friendly OSB, the wood fibre and mineral wool insulation as well as the windows represent the cutting edge of current insulation technology. Materials and construction techniques have been selected to work in perfect unison.

According to regulations by the German development bank KfW, in order for a house to comply with the KfW-40 standard, its primary energy consumption may not exceed 40 kWh/m² of usable floor space. Thermal insulation plays a major role in this respect, for elements both above and below ground. It was this constraint, which led to the use of an entirely new generation of insulating materials for the reception building. The insulation used for the Libeskind Villa features low thermal conductivity (0.032 W/mK) at an exceptionally low thickness. This makes for very slim constructions and less wasted space while still affording excellent insulation.

The wood frame constructions of the exterior walls and roof surfaces of the reception building were entirely infilled with generation-032 mineral wool, which was then covered with 80-mm wood fibre panels. Onto this, a counter-batten system with a total thickness of 8 cm was mounted to provide back-ventilation for the facade cladding and also to serve as the basis for mounting the expanded glass granulate baseboard. The last layer is formed by a reinforcing mesh and a pastel yellow silicone resin plaster with a hydrophobic surface. The wood fibre insulation used on the outer surfaces of the roof and wall sections, which are clad with RHEINZINK, was covered with OSB panels mounted onto counter-battens. The roof as well as the large, windowless exterior walls were clad with RHEINZINK titanium zinc angled standing seam modules. This material is made of electrolytically refined pure zinc with a 99.995 degree of purity that is optimised with precisely defined quantities of titanium and copper during the production process. Like any RHEINZINK product, these modules have a very good LCA result and so have a very low environmental impact. Using them in construction requires no additional health protection measures other than general statutory health and safety measures like wearing protective gloves. The same holds true for the environment as a whole thanks to the material's extremely low environmental impact.

RHEINZINK roof and facade cladding has a life cycle of more than 75 years. It requires no maintenance, upkeep or cleaning because of the material's natural property to develop a patina that offers effective surface protection. To sum up, this is a highly durable material that has a low environmental impact throughout its life cycle.

The angled standing seam modules used on the reception building can be arranged at any inclination and are easy to install because all it takes is the closing of a single seam. Angled standing seams are predominantly used where they can form part of the visual design because the seams give even large flat surfaces a lively and elegant character; in the case of the Libeskind Villa the seams help to accentuate the vibrant lines that characterise the building. RHEINZINK-"preweathered^{pro} blue-grey" was chosen here. This preweathered look of the titanium zinc surface is available in blue-grey and graphite-grey. The surface quality is achieved through a specially developed, unique corrosion technique, which meets the highest environmental standards and complies with the current German environmental protection legislation.

Large-scale windows, some of them up to 7.12 m high, create seamless transitions between outdoor and indoor spaces, between man and nature. The window frames are highly thermally insulated aluminium constructions. The triple-glazed windows have two special features. First, innovative spacers with improved thermal properties were inserted between the individual panes to further improve the insulating effect. Second, the space between the panes was filled with the noble gas krypton instead of argon. Krypton has a lower thermal conductivity than argon, thus reducing thermal transmittance.

An unusual design element that offers both privacy and sun protection is presented by a large and elaborate metalwork ornament. Extending the roof surface, it grows out of one of the rear wings of the building, curves around the wing in front of it and slants back toward the first-floor balcony at an acute angle. The tetragon has a surface area of 86 m^2 in the roof area and 111 m^2 at the part along the facade. In both the roof and the vertical areas, it has the shape of an oblique rhombus with no two sides having the same length. The structure resembles a roughly woven fabric and is built from hollow aluminium profiles of different widths. Depending on the geographical location and the amount of thermal stress to be expected, the profiles were welded to the building's structural supports in different ways to ensure the necessary flexural rigidity.

The balcony structure above the main entrance serves both as banister and design element.

INTERIOR FINISH

Design with innovative building services

The intelligent floor structure incorporates heating and cooling capabilities

As with the building's exterior, the materials and constructions used for the Libeskind Villa's interior finish merge elegant aesthetics with excellent functionality. The floors are used for heating and ventilation, the flooring is both elegant and robust, the wall and ceiling finishes play a part in the noise reduction and room climate control concepts. Flush finish doors and door jambs create a streamlined and sophisticated look.

One of the Libeskind Villa's characteristics is that all building materials and technologies follow the criteria of the overall sustainability concept and – if possible – serve several purposes at once. This is why, for example, the proKlima technology was used for the floors on both storeys. proKlima is an underfloor climate control system, which combines heating and ventilation capabilities and which can be upgraded to act as an efficient displacement ventilation cooling system, even after construction is complete. Its technological heart is the special deep-drawn spacer plate made from a type of plastic that is also used in food packaging. The plate's upper side is equipped with fasteners for the underfloor heating pipes. On the underside, 30-mm truncated cones create the cavity needed for the airflow. The bases of the truncated cones rest on the impact noise insulation material, which is lined with robust, tear-proof foil. When the screed is laid, it fills the open cones and covers the heating (cooling) pipes resting on the cones; in combination with the spacer plates, this creates a stable hypocaust system. Through channels installed into the floor, air is conducted into the cavities created. These channels have a height of 55mm and a varying width that depends on the amount of air desired. The air enters the rooms at a low velocity through the walk-on outlet grilles.

A perfect marriage between conference technology and design

Decorative screed and parquet flooring

On the ground floor, the topmost layer of the floor structure is prefabricated, ready-to-use concrete screed, which is specially designed to produce decorative surfaces and is available in several colours. Grey homogenous Secundur HF decorative screed was laid in the Libeskind Villa. Through a series of mechanical smoothing cycles, the screed was given a slightly glossy surface, into which rhombic designs were carved repeating the building's expressive line design. The rhombic design is repeated again on the first floor, this time in the parquet flooring mounted onto the climate control system, where 8-mm-wide cork strips create the characteristic pattern. The parquet wood used is dark brown wenge from the Listone Giordano collection. One special feature of this premium hardwood floor is a multi-layer birch support, which renders the flooring stable over time and virtually non-deformable for life, even when installed on top of an underfloor heating system.

The wall finish – quiet elegance

The OSB panels reinforce the wood frame constructions of the exterior walls (see "Structural design" on p. 14-17) and serve as the basis for installing the wiring and plumbing. First, vertical battens were mounted onto the OSB panels and – after installing wiring and plumbing – covered with 40 mm WLG 032 mineral wool noise insulation. For the final layer, high-performance Rigidur H gypsum board was chosen. This material is extremely durable and resilient and has a hard, smooth surface protecting it from mechanical wear, scratches and similar damages. The non-load-bearing walls are wood frame constructions, which are insulated with 032 mineral wool, reinforced on both sides with OSB panels and also covered with Rigidur H boards.

Since the ceilings, too, serve as installation surfaces, the visible ceiling is suspended approximately 30 cm below the structural frame. A dust-proof Rondo/SD acoustic plaster ceiling was installed, which is made up of perforated plasterboards with excellent sound-absorbing qualities, a system that has proved very reliable over the decades. On the visible side, the panels are lined with glass fibre fleece. They are easy to install and facilitate the fitting of lamps, speakers and ventilation and inspection openings. For the final layer on the ceilings and on one wall in the Grand Room, a 3-mm layer of seamless mineral acoustic plaster was used, whose hygroscopic properties facilitate room climate control.

The visual impact of the floor, wall and ceiling finishes is rounded off by the white-varnished interior doors. Jambs and door leaves are made of high-quality wood and have an impressive, yet puristic look. Three different door models were installed: Cube, RE-Cube and Undercover. All three models feature concealed hinges directly fastened to the wall. This takes the load off the jambs, whose remaining purpose is merely decorative. The special feature of the RE-Cube model is that the door leaf opens through the jamb into the room allowing it to sit flush with the hallway wall, thus making for a more streamlined look. The jamb of the Undercover model is entirely invisible, as it is installed in such a way that is completely recedes into the wall. Some of the doors feature an innovative reversible handle and lock allowing entirely new movement possibilities when passing through a door.

OVERALL STRUCTURAL CONCEPT

Excellent results in the energy-saving department

The RHEINZINK reception building is one of a kind – not only in shape and architecture. Its energy footprint is far below the requirements of the German Energy Savings Ordinance. In terms of heating energy, the building is self-sufficient. For the Libeskind Villa, sustainability was not only a key criterion for the selection of materials and technologies used, but also for managing the heat and energy consumption to keep utility costs low. This meant that in planning and constructing the building envelope, the goal was to reduce energy losses through the exterior walls, the roof and the ground to a minimum. Thanks to the measures taken to this end, the heat transfer coefficients (U values) are far lower than the limits defined in the Energy Savings Ordinance (EnEV) 2007 and 2009 (table 2).

BUILDING DATA	Table 1
Net floor space	291 m^2
Heat-transferring building envelope surface (A)	1.029,1 m^2
Heated building volume (Ve)	1.095,0 m^3
A/Ve-ratio	0.94 m^{-1}
Interior volume	1.189,4 m^3

The lower the heat transfer coefficient, the better the thermal insulation capacity of that particular component. The arrangement of the rooms, the roof overhangs and the underfloor climate control system made further measures to counteract elevated room temperatures during summer unnecessary. A few windows facing due south were equipped on the inside with a highly reflective sun protection foil system that prevents the sunlight from heating up the rooms or blinding the occupants. The wood fibre panels installed into the outside walls offer additional insulation. They have a high heat storage capacity and, during the night, give off the heat stored during the day via the facade's back-ventilation.

The RHEINZINK company uses the Libeskind Villa as a reception building, which means that, according to the criteria set down in the EnEV 2007 and 2009, it classifies as a non-residential building. The calculations according to the EnEV are based on a reference building and factor in the overall energy consumption, the energy losses as well as the energy gains through direct sunlight, lighting and the people working inside the building. The reference building has a similar geometry, net floor space, orientation and purpose as the building in question and, based on the criteria set down in the EnEV, defines the maximum annual primary energy consumption and the heat transfer coefficient. The primary energy consumption comprises the building's energy consumption as well as the energy losses sustained through collection, processing, transport and distribution of the energy resources. The heat transfer coefficient determines the allowable amount of energy lost through the building envelope.

With its annual primary energy consumption of 268.9 kWh/m^2, the reception building complies with the German Energy-saving Ordinance. The heat transfer coefficient deserves special mention because, at 0.35 W/m^2K, it reaches only about 70% of the maximum allowed by the EnEV. This means that the Libeskind Villa gives off less energy through the building envelope – that is to say: considerably more heat remains within the building than is required by the EnEV (table 3).

The useful energy consumption also bears mentioning. Ordinarily, its amount is lower than the final energy consumption. However, in the Libeskind Villa the reverse is true. Final energy is that part of the primary energy that is available to the building after energy losses due to collection, processing, transport and distribution of the energy resources have been accounted for. The useful energy, on the other hand, is the energy, which – after a conversion process (for example by burning oil or gas) – can be used as thermal energy to heat the rooms. But because the Libeskind Villa gains solar and geothermal energy, the building actually has a higher total of useful energy.

The energy needed to heat the Libeskind Villa totals 87.0 kWh/m² per year, a third of which is used to operate the building services. Two thirds, i.e. the actual thermal energy, are collected exclusively through the solar and geothermal energy systems. This means that in terms of heating energy the Libeskind Villa is self-sufficient.

HEAT TRANSFER COEFFICIENT (U) Table 2

	EnEV 2007* ($U_{max.}$ in W/m²K)	EnEV 2009** ($U_{max.}$ in W/m²K)	RHEINZINK reception building ($U_{max.}$ in W/m²K)
Ground slab	0.5	0.35	0.22
Exterior walls	0.35	0.28	0.14 (zinc cladding) 0.11 (plaster covering)
Flat roofs	0.25	0.20	0.12
Windows	1.7	1.30	0.82–0.99 0.89 (average)

CALCULATION ACCORDING TO EnEV 2007 Table 3

	EnEV 2007 reference building	RHEINZINK reception building
Heat transfer coefficient (H_T')	0.51 W/m²K	0.35 W/m²K
Absolute primary energy consumption (Q_p)	71.413.0 kWh/a	71.181.8 kWh/a
Specific annual primary energy consumption (Q_p'')	270.0 kWh/m²a	268.9 kWh/m²a
Specific heat transfer coefficient (H_T')	0.51 W/m²K	0.35 W/m²K

AIR CHANGES PER HOUR Table 4

	EnEV 2007	Passive house	RHEINZINK reception building
Air changes per hour	n50 = 1.5 1/h	n50 = 0.6 1/h	n50 = 0.63 ± 8.3 % 1/h

* Residential buildings and non-residential building zones with inside temperatures > 19° C

** Traget room temperature when heating >19° C

In order to prevent energy losses through leakage and at the same time ensure a consistently high room air quality, all the joints between the OSB panels, openings for utility lines, between windows, ceilings, floors and walls were sealed on the inside of the building. Before the screed was laid, a blower door test using a 50-Pascal pressure difference yielded a result of 0.63 air changes per hour. This value is much lower than the maximum set down in the Energy-saving Ordinance of 2007 and 2009 and only slightly higher than that prescribed for passive houses (table 4).

Regarding preventive fire safety engineering, the North Rhine-Westphalian state building regulations (BauO NRW) apply to the Libeskind Villa. The building structure has the German F 30 fire resistance rating, and the marking of the escape routes and the location of fire extinguishers comply with the BauO NRW.

The unique shapes of the rooms and their interiors with many smooth, high-impedance surfaces required some special measures to be taken to improve acoustics. In order to reduce reverberation times to a minimum, suspended acoustical ceilings with high sound absorption qualities were installed. In addition, sound-absorbing pictures, exhibition pieces and shading devices were used.

ENERGY CONCEPT

A unique blend of cutting-edge technology

The building's energy concept, and thus the building services chosen are a decisive factor in future utility costs and the building's overall sustainability. Heating, cooling and ventilation in the Libeskind Villa are controlled through a unique combination of groundbreaking, innovative technologies. The Libeskind Villa's energy concept comprises several components, which make the building virtually self-sustaining in terms of heating and cooling technology. These components are: **a solar thermal system, a geothermal system, a reversible-cycle heat pump, heat recovery, and an underfloor climate control system.**

Unglazed solar collectors

The building's overall energy concept centres around the RHEINZINK material. On the Grand Room's roof, the prototype SolarThermie Standing Seam was installed to collect solar energy. This innovative system combines the proven advantages of QUICK STEP® SolarThermie with the tried and tested angled standing seam profile. At the same time, it combines sophisticated roofing architecture with reliable weather protection and a renewable source of heating energy in a perfect symbiosis. In this unglazed solar collector system, the reverse side of the roof profiles is equipped with absorbers, which make use of direct and diffuse solar radiation, the temperature of the surrounding air as well as the heat collected from condensation water. Even in low temperatures, the system produces high yields, which makes it a good heat source for a system employing a heat pump. The Grand Room's roof faces east and has a 30° pitch. It is covered with 38 collectors with a photovoltaically active absorber area of 0.9 m² each, for a total of 34.2 m².

Behind the reception building, approximately 700 m of polyethylene pipes were laid into the ground at a depth of 1.20 metres. The pipes have a diameter of 32 mm and were laid in seven 100-m loops spaced at 60 cm. This gives the building's geothermal heat collector a total area of approx. 600 m². Heat generation from solar energy and geothermal collectors is controlled by the hydraulic RHEINZINK SolarGeoThermie 2Q module, which represents an addition to the conventional brine-water heat pumps and does not interfere with their control mechanisms. It features perfect integration of controlling and hydraulics. This type of controlling – with its easy-to-use, intuitive menu navigation via the monitoring screen – makes displaying and reading system status and temperatures easy. The increased efficacy of SolarGeoThermie 2Q has been proved by a research project using several pilot installations. RHEINZINK has integrated the results of the data collected from these pilot installations into the controlling mechanism, collector layout and the module development.

Two heat sources – three modes of operation

The unique advantage in combining solar thermal energy and geothermal energy lies in the fact that RHEINZINK SolarGeoThermie 2Q allows the system to be operated in three different modes depending on the season and outside temperatures:

- During winter, the heat pump collects heat from the earth through the geothermal collectors and uses it to heat the building (mode of operation: geothermal collector feeds heat pump, heat pump is on).
- During summer, energy is transferred from the solar installation to the ground. This increases the source temperature; the ground contains more energy during winter. (Mode of operation: solar collectors feed the geothermal collector, heat pump is off.)
- In case of a large heat demand inside the Libeskind Villa, the output of both systems is combined (parallel operation: solar and geothermal collectors feed the heat pump, heat pump is on).

Assembling the standing seam solar energy absorbers integrated into the roof

The suitable mode of operation is controlled depending on the temperatures measured at the solar and geothermal collectors. The integration of solar and geothermal energy generation in RHEINZINK SolarGeoThermie 2Q allows a balanced, long-term utilisation of geothermal energy. The module increases the system reliability and – thanks to the increased ground temperature level throughout the year – the efficiency (seasonal performance factor) of the heat pump. At the same time, input energy costs can be reduced, as can investment costs if geothermal probes are used because boreholes are shorter. Thus, even at low ambient temperatures with no direct sunlight, the QUICK STEP® SolarThermie absorber technology is highly effective and yields a higher energy output.

Installation of the geothermal system – approx. 700 m² of geothermal absorbers in two layers

ENERGY CONCEPT

SolarThermie and geothermal energy ensure a self-sufficient energy supply

The heat pump utilising the solar and geothermal energy to heat the Libeskind Villa is a carno brine heat pump model HCS-PN 60. At a brine temperature of 0°C and a supply water temperature of 35°C, it achieves a performance factor of 4.5, and in combination with the RHEINZINK SolarGeoThermie 2Q it achieves a calculated seasonal performance factor of 4.8. The heat pump is a reversible-cycle heat pump. This means that the cooling process is reversible, effectively transforming the heat pump into a cooling machine. The way this works is that during summer the heat of the building is channelled off into the ground and – at extreme temperatures – also conducted to the RHEINZINK SolarThermie collectors. The system's performance (incorporation both the unglazed solar and the geothermal collector output) is calculated through a specialised computational procedure developed by RHEINZINK in research projects and pilot installations.

A floor that heats, cools and ventilates the room

Another key feature within the overall energy concept is the underfloor climate control system installed on the ground and upper floors (see Interior finish, p. 20-21). To heat the rooms, the piping in the upper part of the installation is supplied with heated water by the heat pump. Owing to the large heat exchange surfaces (underfloor heating), relatively low temperatures suffice, making the installation ideally suited for solar and geothermal energy systems. If necessary, the underfloor climate control system can provide cooling as well. In this case, the piping is supplied with cold water, which also cools the incoming air. The result: the rooms are supplied with pleasantly cool air despite high outside temperatures.

The Libeskind Villa features a controlled ventilation system. In a central ventilation appliance equipped with an aluminium cross-flow heat exchanger, the fresh exterior air is heated up utilising the outgoing air's temperature (from -10°C to 11°C).This process accounts for approximately 70% of the energy needed to heat up the fresh air.

The fresh air is conducted through ventilation ducts, the ventilation appliance and channels, which are incorporated into the underfloor climate control system, into the hypocausts beneath the underfloor heating. The air flows through this cavity at a low velocity and, in the process, is heated up almost to heating temperature by the large heat exchange surfaces. In this way, the Libeskind Villa recovers downward energy losses, which would be lost in conventional surface heating systems, and utilises them to heat up the incoming air.

ENERGETICAL BUILDING DATA	Table 5
Heating energy consumption of the building	28 MWh/year
Storage and distribution losses	2 MWh/year
Total thermal energy consumption of the building	30 MWh/year
Solar collector orientation	- 90° (East)
Solar collector pitch	30°
Solar collector surface area (38 collectors with 0.9 m² each)	34.2 m²
Seasonal performance factor/efficiency of the heat pump according to the manufacturer	4.4
Stationary seasonal performance factor/efficiency of the heat pump	4.5
Seasonal performance factor/efficiency of the heat pump with SolarGeoThermie 2Q	4.8
Primary energy demand of the heat pump without SolarGeoThermie 2Q	18.400 kWh/year
Primary energy demand of the heat pump with SolarGeoThermie 2Q	16.900 kWh/year
CO_2 emissions by the heat pump with SolarGeoThermie	4.0 t/year
Avoided CO_2 emissions by the heat pump when compared to conventional gas condensing boilers	3.6 t/year

This permanently keeps the incoming air above room temperature; draughts so frequently experienced in other homes are eliminated. The system leads to a consistent room temperature profile with almost equal surface temperatures on the floor, the walls and the ceiling, which is such an ideal environment that comfort levels are increased even at temperatures 2 or 3 °C below that of conventional rooms. It is this feature, along with a maximum heating temperature of 30°C, which considerably reduces energy consumption, utility costs and heat pump operating costs. The heat pump operates at a much higher coefficient of performance (COP) because bringing the heating water up to a maximum of only 30 °C makes a big difference when compared to the 35 °C that are commonplace with conventional underfloor heating systems.

During the warmer periods, the air is cooled down by the cold water in the underfloor piping when passing through the underfloor cavity. Owing to the large floor surfaces, the cold water temperature is consistently kept above 16 °C – the critical dew point temperature – by an appreciable margin. The floor thus becomes a cooling floor and, in conjunction with displacement ventilation, provides the rooms with a sizeable cooling effect. And the same overall effects are achieved as in the heating scenario above: low utility costs, low energy consumption and a maximum of comfort. The walk-on outlet grilles are installed into the floors close to the windows and in some cases close to the exterior walls. The suctioning off of used air, which is full of pollution, smells and dust, is done via shadow gaps in the ceilings.

RAINWATER MANAGEMENT

Rainwater utilisation also follows the precept of sustainability

Roof structure with integrated roof drainage

Water is a precious resource; it is the basis for all life and for a healthy ecological balance. With this in mind, eco-friendly rainwater management is of the utmost importance and a key element in sustainable construction. That is why the Libeskind Villa collects and utilises rainwater.

An eco-efficiency analysis of titanium zinc carried out by the German Federal Environment Agency yielded excellent results. In all environmental impact categories (i.e. global warming, ozone depletion, acidification, eutrophication and summer smog), titanium zinc has the lowest impact potential of any construction metal. A life cycle assessment conducted in accordance with DIN ISO 14040 also yielded good results for RHEINZINK titanium zinc. And finally, long-term studies conducted by independent research institutes in various parts of Germany and in Stockholm have shown the RHEINZINK material to be environmentally harmless and to save resources. Based on these results, the precautionary principle for groundwater protection that had been in effect in some German states was lifted on October 1, 2008. This means that roofs, facades and roof drainage elements made of RHEINZINK are safe to use for rainwater collection. Following the M 153 guideline on rainwater management by the German Association for Water Management, Waste Water and Waste, the collected water is allowed to seep into the ground or to be conducted into bodies of surface water. An additional form of using precipitation in a natural and ecological way is presented by rainwater harvesting systems, which use the water collected for irrigation, cleaning purposes or as service water for toilets or washing machines.

The Libeskind Villa utilises rainwater to flush the toilets and irrigate the grounds around the building. The three roof surfaces make up the collection area totalling around 225 m². From the roof, the rainwater is conducted via RHEINZINK eaves troughs into a closed system of welded high-grade steel pipes to be collected in a Smart-Line 4000L rainwater tank. This polyethylene tank has a storage capacity of 4,000 litres, is acid-proof, food-safe and absolutely resistant to all types of roots. Thanks to the material's low adhesion, very few particles cling to the tank's inside wall. The tank is part of a ready-to-install system comprising, apart from the tank itself and the corresponding tubing, an overflow siphon with animal protection, a volume filter, a calmed inlet and a float switch. To remove leaves and debris, the rainwater passes through a volume filter with multiple cascades and narrowly spaced grilles before reaching the tank. The filter is self-cleaning because the debris is continuously washed away by the incoming water and into the public stormwater sewer system. The rainwater enters the tank via the calmed inlet; by slowing the water flow, this inlet prevents the disturbance and re-suspension of fine sediments that gather on the bottom of the tank.

Water is withdrawn via the Hya-Rain water utilisation system, which is installed in the reception building and, depending on the water level inside the tank, controls the water supply to the toilets and the outdoor irrigation system. Water is withdrawn from just below the water surface, i.e. where the cleanest water resides, by means of a floating inlet filter. If the storage tank does not contain enough water, mains water supply is automatically activated. The size and position of the installed system was based on the annual average precipitation in the Datteln area as well as the water consumption through toilets and the irrigation system.

Installation of the nautilus rainwater tank (4 m³)

RAINWATER MANAGEMENT	Table 6
Roof surface area	225 m²
Run-off coefficient ***	0.9
Precipitation	880 mm/year
Rainfall intensity	15.3 l (s*ha)
Rainfall duration	15 min.
Storage capacity to last	3 weeks
Influx	0.19 m³/h
Total consumption	15 m³/year
Total yield	178 m³/year
Rainwater consumption	14,600 l/year
Rainwater tank storage capacity	4,000 l

*** Quotient of total precipitation and the amount of water actually running off, which varies with the roof-cladding material used

ELECTRICAL AND SANITARY CONCEPT

Consistency in design and technology

Supreme comfort levels, sustainable energy consumption and ease of use. These were the guidelines for planning and constructing the building services for the Libeskind Villa. In addition, a silent wastewater system was installed. With the goal of preparing the Libeskind Villa for cutting-edge technologies and also for technologies to come, all presently conceivable options were considered in planning and installing the electrical and IT-related wiring. The hub controlling all the building services is the HomeServer/Facility Server, which represents the interface between all electrical devices controlled by the installation bus as well as those devices, which are accessed via the TCP/IP Internet protocol suite.

In the Libeskind Villa, everything from the electrical power supply, security systems, motion detectors and access control systems to lighting, heating, air conditioning and ventilation is intelligently managed by the Instabus KNX, the more flexible and more comfortable successor to the European Installation Bus (EIB). This system requires its own wiring in addition to the electrical lines and allows local or remote control of all the building's electrical and electronic systems. This requires the installation of temperature, motion and other detectors and actuators connected to lamps, blinds and other electrical and electronic appliances. Detectors register information from the rooms, like the presence of people, light conditions and temperature and transfer them to the HomeServer. There, the collected data is processed according to the programmed parameters and the resulting commands relayed to the corresponding actuators. For local system management, the Libeskind Villa has an InfoTerminal installed (Pro-face Server Client with a 5.7 inch touch screen). This allows all parameters to be set from within the building itself. In addition, the system can be accessed remotely anytime via the Internet. A SmartSensor control and operating unit allows individual room adjustments. This unit has an information display panel and offers temperature and lighting control as well as eight individually configurable programs at the touch of a button. The solar and geothermal energy systems are also integrated into this automation system. Current performance information can be monitored via a 60 inch flat screen in the Grand Room.

High comfort levels also mean good noise insulation, especially for the water and wastewater piping. The drinking water pipes are metal composite pipes, which feature heat-loss insulation and reduce structure-borne noise. The wastewater pipes in the Libeskind Villa are Silent-db20 pipes. This is a wastewater system that reduces noise levels to below 25 dB(A) in lightweight constructions or close-coupled sanitary systems like Duofix. The pipes are made from mineral-reinforced plastic, and parts like forks, bends and reducers feature a uniquely ribbed surface. These features, in addition to an installation that eliminates structure-born noise, make for reliably low-noise wastewater drainage.

Technology and design

Duofix modules were used to install the sanitary fixtures. These elements have proven reliable over many years and are ideally suited for both close-coupled and concealed cistern systems. Unique features are the dual-flush cistern plates installed in the toilets and urinals: The Sigma50 plates are customisable and, in the Libeskind Villa, are covered with RHEINZINK.

INTERIOR AND OUTDOOR DESIGN

A logical continuation of the high aesthetic standards

Aesthetics, exclusivity and premium materials. These principles are immediately apparent on the Libeskind Villa's inside, too. The furniture combines functionality and design with cutting-edge technology, and the lighting concept enhances the building's crystalline appearance. The grounds repeat the dynamic lines of the building, thus reinforcing the unique architectural concept.

In the lobby, visitors are welcomed at a stately reception counter. The multitude of angles and slanted surfaces repeat the overall architectural design. An immediate eyecatcher is the integrated desk protruding from the reception counter. On the front, it is covered with RHEINZINK titanium zinc as a visual reminder and example of the products manufactured by the building's owner.

Reception area for RHEINZINK's guests

The meeting room furniture, just like the reception counter, is finished with white soft touch paint. The shape of the conference tables, sideboards and shelves interact with the overall architecture by either continuing the rooms' lines or presenting deliberate contrast to them. The tabletops deserve special mention. At first glance, they look like stained glass; they reveal their uniqueness only when touched. The surface has a warm, soft touch to it, yet is still hard, robust and scratch-resistant. The tabletops are a shimmering white and take on the shade and colour of the room's furniture.

For efficient meetings in unique surroundings

All the conference technology elements like power outlets, network, video and audio connectors as well as control panels for the screens and speakers are invisibly integrated into the tables. They are hidden behind hydraulic hatches, which open at a light touch to reveal the technology behind them. To accommodate multimedia presentations, the conference rooms are equipped with DVD players and LCD screens. They, too, are recessed and invisibly installed into the sideboards, from where they slide out when needed. In one of the four meeting rooms, the sideboard also serves as a sliding panel that darkens the room.

Innovative conference presentation technology is also installed in the Exhibition Room on the ground floor. Special features in this room include the invisible speakers installed there. These digitally controlled speakers are hidden behind plasterboards so that they don't disrupt the room's pristine look.

The sanitary facilities, too, feature a successful blend of functionality and aesthetics – washbasins, fittings and even details such as angle valves and lotion dispensers follow the same fascinating, puristic design. The white washbasins are made of enamelled steel. This material is extremely robust, produces very vibrant colour tones and stands out through its clear-cut designs. Another advantage is the shock-resistant and highly durable surface, which is achieved by means of a special burning process and provides the objects with excellent hygienic properties. The washbasins are part of a modular product line that allows a variety of combinations that can be configured to suit any room.

INTERIOR AND OUTDOOR DESIGN

The interiors, lighting concept and the grounds are noticeably part of the architecture

Natural and artificial light create ever-changing spatial perception

The sanitary fittings possess an almost sculptural quality. Hallmark of the selected Supernova range is the multitude of facets and polygonal surfaces, which reflect and take on the colours of their surroundings. The single-lever mixers in the visitor lavatories feature a novel type of cartridge. If the lever is turned in a clockwise direction, first only cold water flows out, which is gradually mixed with hot water as the lever is turned further and further. In this way, water flow can be comfortably controlled while at the same time saving energy; and the lever's smooth motion makes for superb ease of use.

The economical lighting concept makes use of energy-saving luminaires and follows the precept "Light without lamps". This means that, for the most part, vertical lighting was installed. This provides the rooms with ample light and highlights the Libeskind Villa's forms and dimensions. Different kinds of recessed luminaires with aluminium housings and protective glass lenses were installed. For each room, different lighting profiles for different times of day and types of room usage can be set. The symbiosis between architecture and lighting becomes startlingly apparent after dark, when the lighting gives the Libeskind Villa a unique transparent quality. The outdoor space around the building is largely illuminated indirectly by directing the light onto the RHEINZINK-clad wall surfaces, which act as reflectors.

The building is surrounded by an expressive composition of concrete slabs and greenery. High-grade steel profiles repeat the architectural lines of the Libeskind Villa separating these sections from one another. Drainage is handled by slotted channels also made of high-grade steel. The corresponding Faserfix components are made of fibre-reinforced concrete and are part of a modular system. They are joined by tongue-and-groove joints and installed beneath the covering surface so as not to interfere with the streamlined visual impression. The visible slots create an elegant line pattern and guarantee fast and efficient rainwater drainage. Lawns, low box and cherry laurel hedges as well as the incorporation of existing trees round off the outdoor design concept.

Evening snapshot

IMPRESSIONS

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IMPRESSIONS BUILDING PHASE I

An idea becomes reality

Planning phase and the first sod – project launch

Preparing the building site;
moving a bicycle shelter;
concrete construction

IMPRESSIONS BUILDING PHASE I

An idea becomes reality

Work on the foundation begins and skeleton assembly is prepared

Wood frame construction –
prefabrication and assembly

IMPRESSIONS TOPPING-OUT CEREMONY

May 13, 2009

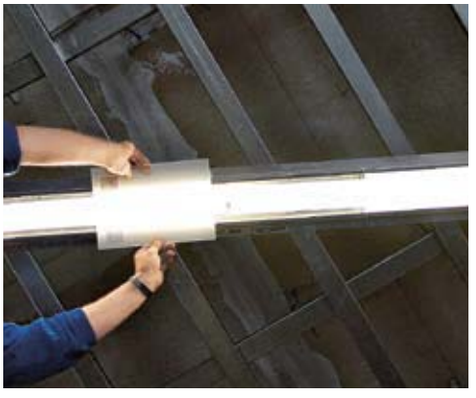
Topping-out ceremony after only 8 weeks of construction

A workman's tradition –
the last nail is hammered in

IMPRESSIONS BUILDING PHASE II

Where the subsections meet

Organising the subsections – from skeleton construction to the finishing touches



Constructions turn
into sculpted bodies

IMPRESSIONS INAUGURATION

September 29, 2009

Implementing an idea –
a model becomes reality

Sustainable construction
in the public interest

A VISION BECAME REALITY

The most beautiful side of architecture

Light and shadows give the outer surface of fascinating vivacity

A VISION BECAME REALITY

The most beautiful side of architecture

Daniel Libeskind's signature lines and angles are repeated in the building's interior

The interior room concept: aesthetics, exclusivity and premium materials.

We are all about sustainability in thoughts and actions. This publication is printed on FSC-certified paper, produced from wood from sustainable forestry!

Concept/preferences/realisation: JACQUES D., Gesellschaft für visuelle Kommunikation mbH, Since 1983
Text: Jola Horschig (Dipl. Ing.) in collaboration with RHEINZINK GmbH & Co. KG

THANKS TO OUR PARTNERS

In implementing the entire building concept, we have selected and collaborated with other innovative German quality manufacturers. We would like to take this opportunity to thank all our partners once again for their dedicated support.

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