CASE STUDY
3D-HOUSE BECKUM

Innovative, effective, energy saving

Photo: Peri

Part of the Solution
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PROJECT:
Germany's first 3D-printed residential building

LOCATION:
Beckum, Germany

COMPLETION:
2021

APPLICATION:
Surface heating and cooling

PRODUCT:
aquatherm black

THE CHALLENGE:

Germany's first residential building produced with a 3D printer was to be complemented by innovative building technology in the area of heating and cooling.

THE SOLUTION:

The surface heating and cooling system aquatherm black was installed in the element ceilings made of concrete. In this way, a thermally activated building element is created that provides a pleasant, even climate without convection or draughts and allows complete freedom in the design of open and modern spaces.

On the construction site, the individual prefabricated ceiling elements only had to be joined together.

SURFACE HEATING AND COOLING SYSTEM FROM AQUATHERM PROVIDES THE RIGHT CLIMATE CONTROL IN GERMANY'S FIRST 3D-PRINTED RESIDENTIAL BUILDING

Probably the most innovative residential building in Germany at the moment has been built in Beckum, North Rhine-Westphalia: The two-storey single-family house with around 160 square metres of living space was not built using conventional construction methods, but printed by a 3D concrete printer, making it the first of its kind in Germany. The project, which received 200,000 euros in funding from the state of North Rhine-Westphalia as part of its „Innovative Building" support programme, was to be complemented by innovative building technology. Therefore, it was decided to use a special surface heating and cooling system that provides the appropriate air conditioning for the building.

The building was printed by Peri. A gantry printer was used: the print head moves on three axes on a permanently installed metal frame. The printer was operated by only two people, the print head and the print results were monitored by camera. The printer needed about 5 minutes to print one square metre of wall. The construction of the house consists of three-shell walls that were filled with insulating compound. During the printing process, the printer already took into account the pipes and connections to be laid later. Compared to conventional construction methods, this innovative technology not only saves a considerable amount of time, but also significantly reduces the consumption of resources. For example, the precise placement of the pressurised mortar can reduce the amount of material used for the walls by up to 50 % compared to other solid wall constructions. In addition, this technology opens greater freedom in building design. The building was planned by MENSE-KORTE architects from Beckum, the client is Hous3Druck.

PIPE REGISTERS INTEGRATED CLOSE TO THE SURFACE IN PREFABRICATED CEILINGS

The ceiling of the house was made of precast concrete elements and produced at the B. Lütkenhaus concrete and precast plant in Dülmen, Germany, which is part of Syspro Group Betonbauteile, an association of innovative companies in the precast industry that forms a quality community.

„Our member companies manufacture in a resource-saving way by means of fully automated and optimised production processes using state-of-the-art plant technology," knows Syspro managing director Dr Thomas Kranzler. „In conjunction with the constant optimisation of raw material use and concrete formulations, this results in building components that more than meet all requirements not only in terms of statics and building physics, but also in terms of appearance and sustaina-

After pouring the concrete, only the connection of the system is visible

bility."

This also applies to the Syspro climate control ceiling used in the 3D house, which is a precast concrete slab with a statically contributing in-situ concrete supplement. The special feature: The installation of the surface heating and cooling system aquatherm black from aquatherm was carried out close to the surface between the lattice girders directly on the lower reinforcement layer of the element slabs. With the result that the heating/cooling registers are protected from site damage after concreting the element slabs. In this way, a thermally activated building element is created, as the panel heating and cooling system allows for a pleasant, even climate without convection or draughts, and complete freedom in the design of open and modern spaces.

The registers, made of the corrosion-resistant plastic polypropylene, do not heat the air but the objects, the floor, the walls, the furniture - everything in the rooms. To do this, the system is installed in the ceiling and gently heats it to surface temperatures of up to 26 °C. The energy is now transferred as heat radiation. The energy is now emitted into the room as radiant heat. Where the heat radiation hits objects, these are heated. The measured air temperature can be approx. 3 °C lower with this type of heating than with convection heating because of the even heat radiation from the room's surrounding surfaces - the thermometer shows 20 °C and it feels like 23 °C. This promotes a feeling of well-being and saves around 18 % energy.

Installation in the ceiling also offers systemic advantages for passive co-

The print head of the 3D printer moved along three axes on a permanently installed metal frame.

Photo: Peri

At the Lütkenhaus concrete and precast plant in Dülmen, the aquatherm black panel heating and cooling system was installed directly into the precast concrete ceiling.

oling: Unlike conventional air-conditioning systems, which extract heat from the room by ventilation with air movement, air-conditioned ceilings dissipate the cooling load mainly by means of radiation from the room. With the exception of the partly hygienically necessary air exchange, draughts are excluded by this process or are reduced to a minimum.

HIGH HEATING AND COOLING CAPACITIES

Due to the small installation distance of the register pipes and the resulting high surface density of the aquatherm black per square metre, the system can be operated with lower flow temperatures than conventional heating or higher flow temperatures than other cooling systems and, in combination with its fast reactivity, enables a particularly efficient and energy-saving operation under changing conditions. The highly efficient split air-to-water heat pump (Coefficient of Performance up to 5.0 - according to EN 14511 at A7/W35 °C) with low flow temperatures used in the 3D house provides perfect conditions for the heating/cooling system.
aquatherm black was produced according to customer requirements in sizes from 24 cm x 60 cm to 48 cm x 500 cm in the main factory of the aquatherm group of companies in Attendorn, South Westphalia. A total of 97.4 m² of registers were used. This corresponds to an occupancy in the building of around 60 percent and thus a low occupancy area, which is nevertheless sufficient to heat and cool the building effectively. The coils were already equipped with an optical leakage control system at the factory. Thus, they only had to be inserted into the prefabricated ceilings to be cast at the Lütkenhaus company. The registers were specially arranged in the filigree ceilings so that a drilling depth of around 2.5 cm could be guaranteed for later installation options. This allows for easy installation of, for example, lamps or C-profiles of drywall.

„Due to the functional design of the aquatherm black with a small laying distance and a port-shaped design, the thermal energy can be transferred evenly and efficiently in heating as well as cooling mode, so that high heating and cooling capacities are achieved with low pressure loss. This means that the heat and cold can be distributed evenly. Thus, in combination with the low-pressure loss of the system, we achieve high heating and cooling capacities," explains Marius Bock, product manager of aquatherm black.

Later on, at the construction site, the individual prefabricated ceiling elements only had to be connected to each other.

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