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Presentations

The First Certified Passive House in Poland

In November 2007 a certified passive house was opened to public for the first time in Poland. The house designed and built (in Smolec near Wrocław) by "Lipińscy Domy" Design Office has been visited by thousands of those who are interested in the issue of energy saving. The idea of living without heating is effective also in our country.

The Concept of Passive House

Over 20 years ago the creators of the Passive House Concept – Dr Wolfgang Feist and Prof. Bo Adamson, set themselves a target to decrease the losses of house heat so that it would need almost no heating. The passive sources of heat such as humans, household devices, and heat recovered from the air, passive gains from natural sources, and solar energy would satisfy the demand for heat to a great extent. For this reason the standards of building passive houses were specified. In 1991 the first passive house was constructed in Darmstadt in Germany. For the next fifteen years the concept of the passive house was consistently implemented. A few thousand houses have been constructed so far. The concept of passive houses is successfully used also in the construction of the multi-family houses and commercial buildings.

In 1996 the Passivhaus-Institut (the Passive House Institute) was established in Darmstadt. The Institute is managed by Dr Wolfgang Feist and operates as an independent research entity. The researches of different scientific fields work out highly efficient solutions for energy saving in construction; they also help to implement the concept of the passive house. They focus on the optimisation of components for their construction. The Institute organises conferences, trainings, and trade fairs in reference to passive building. The concept of the passive house is winning more and more supporters. Several hundred enthusiasts and sceptics of the new idea participated in the first conference organised in 1996 in Darmstadt. This year scientists from all over the world took part in the conference on the Passive Houses in Nuremberg. Passive houses are being built already in the United States, China, and Russia. Obviously, the greatest amount of such houses was constructed in a neighbouring country, namely Germany – the cradle of the concept. During annual passive building fairs participants are introduced to material and technological offers. Large producers of construction materials as well as enthusiastic inventors creating the systems of building passive houses present their products, which are developed for the sake of the passive houses.

A passive house can be constructed with the use of various technologies and components. Facing the increase of the energy prices, more and more private investors are becoming interested in the concept of the passive house. The awareness of cost saving as well as the comfort of living in a passive house is higher. Every year in November the Passive House Institute in Darmstadt organises the so-called open days in new passive buildings. Such an event provides an opportunity to realise what is the quality of the climate obtained in a passive house and to meet investors directly. A characteristic feature is that the occupants of such houses are satisfied with the climate and especially with the minimal bills for heating. When used normally, the passive house consumes not more than ca. 1.5 litre of fuel oil or 1.5 m^3 of gas (15 kWh) per one m^2 of the living space during a year. This allows for about 90% of savings in relation to the average demand for heating in the existing houses and at the same time constitutes the consumption value four times lower than in the case of a low-energy house (50–70 kWh/m^2 per year). Such a house is characterised primarily by remarkable thermal insulation, the optimisation of passive solar gains, and controlled heat recovery ventilation. The mutual correlation between gaining and giving up the heat is important for the final balance. Giving up the heat takes place through ventilation and transmissions (losses of heat through walls, windows, and roofs). Gaining the heat occurs through the so-called internal gains (human and animal body heat, the heat of the household equipment, etc.), passive solar gains via glazing in the southern façade of buildings, and thermal gains from ventilation as a result of the use of exchangers in the house installations. In the houses in which insulation is insufficient transmission losses are so significant that the solar and internal gains are disregarded. Whereas in the passive house the passive solar gains are optimized due to the southern windows and transmission losses are dramatically reduced thanks to the superinsulation employed in the house and to its compact shape. The losses of the ventilated air are compensated by means of heat exchangers.

Project

The architecture of the passive house refers to an archetype of a single-family home. A simple compact shape projected on a rectangular plan and covered with a pitched roof integrates perfectly with the Polish urban landscape. The proportions of the roof and the walls were designed to be similar as in a traditional house. The only element enriching the mass of the house is a triangular lucarne on the façade with a window lightening the bathroom. The window shapes were designed according to the energy standards. The maximisation of the solar gains was reached thanks to an appropriate location of windows in the house façade. Big windows on the southern façade of the house not only guarantee heat efficiency provided by rays of sunlight but also give a modern touch to the house architecture emphasised by a solar energy collector on the roof surface. The size of the windows on the remaining walls was selected in order to guarantee conformity with the Polish outdoor lighting standards and minimise heat losses. Purposefully, the northern façade was designed not as a full wall; a full façade could spoil the appearance of the architecture and make it less attractive. This issue was solved by means of the traditional approach, yet with certain innovation. It is the effect of large glazed surfaces constituting the walls of the dinning room and the lounge. The house is designed for a four-person family or alternatively for an extended family. You will find a place for house works - a hobby room. The lounge with a mezzanine constitutes the space for daily activities. The big glazed southern façade makes the interior optically larger. The house is very spacious, despite its relatively small area (usable floor area – 131.4 m^2). The kitchen, which is connected with the dining room, also includes a room for a device substituting a traditional heating medium. The openwork steps will take you to the attic divided into two rooms for children with a terrace over the garage, a spacious bedroom with a dressing room for parents, and a bathroom well equipped and full of light. And the mezzanine perfectly unites the interior. The design and the structure guarantee a maximum limitation of heat losses and the greatest efficiency of the sun's heat at the same time. The compact character of the building has been confirmed by the shape coefficient of 0.75, and the independent garage placed on the western wall plays the role of a heat buffer. The project gained an energy label issued by the Institute of Passive Buildings (Instytut Budynków Pasywnych) by the National Energy Conservation Agency (Narodowa Agencja Poszanowania Energii), according to which the calculated requirement for heat amounts to 13.7 kWh/m^2 a year with the ideal building location in relation to four directions.

Fig. 1. Visualisation of the northern façade

Fig. 2. Visualisation of the southern façade

Technology

We worked for half a year over the design and concept in reference to the choice of materials and technologies necessary to complete the passive house. We performed a market analysis on the availability and quality of materials. Basing on the products available on our market, the expert team of the design agency Lipińscy Domy has worked out technologically innovative solution in cooperation with "Instytut

Budynków Pasywnych przy NAPE" (Passive Buildings Institute at NAPE). This solution made it possible to construct a passive house being in line with the standards of the Darmstadt PHI in Poland. We decided to apply simple solutions generally accepted in Poland, which would be of good quality and for a reasonable price. The construction of external dividing structures was subordinated to the maximum limitation of heat losses resulting from the penetration. Standard construction guidelines for passive houses suggest that the value of the *U* heat penetration coefficient of the external walls, floors, ceilings, and roof should not exceed 0.15 W/m^{2}K. During the design process we realised that the house will meet the passivity standard in the climate conditions characteristic for the vicinity of Wrocław if the average *U* coefficient of the external dividing structures reaches 0.1 W/m^{2}K. In order to reach such a low coefficient, we had to apply insulation layers 30–44 cm thick and very good insulation materials. The house is built on the strip foundation being traditional in Poland and which supports the foundation walls reaching the ground level. We carefully planned the thermal insulation of the foundations and the floor slab resting upon foundation walls. Nevertheless, even perfectly insulated external dividing structures cannot guarantee the passivity standard if thermal bridges are not excluded from the house structure. Thermal bridges appearing in arcades or in the places where an insulation layer breaks or as a result of unevenness of the dividing structure should be totally excluded from passive buildings. It is extremely important to provide an unbroken insulation layer in the external dividing structures and in their junctions. We managed to meet this requirement almost everywhere in the completed project. The foundation walls were the only place where we did not manage to have the insulation layer unbroken. In order to reduce the vertical thermal bridge cooling down the walls of the house, we used base course thermal insulation hollow bricks. The Poles are extremely attached to the brick technology. The offer was prepared as the "complete passive house", so we used prefabricated elements. For individual investors, however, we developed a project in the technology of Silka calcium-silicate brick. The technology of prefabricated walls from gravelite-concrete seemed to be a good compromise. The producer's additional colouring in a brick colour highlights the fact that it is the ceramic material. And this is important in a country where its inhabitants are antagonised by the large panel building. The asset of the prefabricated technology in the passive construction is a great accumulation capacity of the gravelite-concrete prefabricated elements. The level of the solar gains in a passive house does not always equal its current requirement for heat and this can result in overheating of the building. In order to avoid this phenomenon, the exceeding levels of heat should be stored to be released later when the temperature in the house decreases. The direct accumulation in the solid house structure constitutes the simplest way of heat storage. Its appropriate usage beneficially impacts the utility comfort of a passive building and its energy balance. We used the unique silver-grey polystyrene foam for the house insulation. At present, this is the warmest material available on the Polish market. The boards are enriched with a graphite composition improving their insulation properties. This polystyrene foam is produced on the basis of the innovative Neopor raw material. Its thermal conduction coefficient is record-breaking and equals λ = 0.031 W/mK. The window frames used in the house guarantee perfect thermal parameters and also the tightness required in a passive house. The house is equipped with mechanical ventilation including the heat recovery function with the use of a compact device suitable for passive houses. This compact device is equipped with an integrated exhaust and blow-in air handling unit with a counter-current heat exchanger. In order to improve the efficiency of the ventilation devices, we installed a ground exchanger.

Fig. 3. Projection of the ground floor

Fig. 4. Projection of the attic

Performance

The house was built in a beautiful area of newly constructed detached houses in Smolec near Wrocław (Lower Silesian province). The building orientation differs slightly from the project assumptions. The garden façade of a big glazed surface is directed towards the South-West and not towards the South. This difference was taken into consideration in the energy calculations which confirmed that the passivity standard will be met also in this orientation. The construction works were started by placing the ground heat exchanger. The pipes were arranged below the freezing line 1.5–2.0 m deep. The ground heat exchanger is to guarantee that during the winter the temperature of the air penetrating the building will not fall below zero degrees. However, during hot summers the air going through the ground heat exchanger will be cooled to pleasant temperatures. Then a trained team performed ground works, and constructed foundations, a slab of reinforced concrete, and floors. A well designed and fixed insulation of divisions touching the ground is a very important aspect. The house has no basement which simplified its structure. The slab of reinforced concrete was insulated with a 30 cm layer of the waterproof polystyrene foam having very good insulation parameters (the thermal conduction coefficient λ = 0.035 W/mK, and the finishing casing around the building was added). It allowed the floor touching the ground to reach the coefficient of U = 0.11 W/m²K. A few days after the construction of the slab of reinforced concrete the walls were installed. The prefabricated technology of gravelite-concrete facilitated the fast construction of the external walls. We obtained the external partitioning whose penetration coefficient is Uo = 0.10 W/m²K by means of the additional polystyrene foam insulation. The prefabricated technology's advantage is its relatively thin supporting structure of 15 cm. It is particularly important for the general thickness of a wall insulated by a 30 cm insulation layer. The use of a thin supporting wall allowed to avoid the "bunker effect" possible to occur in passive buildings. The roof truss was built in the traditional manner. Then the works of thermal insulation, woodwork and insulation installation started. A layer of the special self-supporting polystyrene foam (20 cm) enriched with graphite and having the thermal conduction coefficient λ = 0.033 W/mK was inserted between rafters. Polystyrene foam boards (10 cm) were fixed under the rafters and polystyrene foam panels (15 cm), extruded to be inserted under roofing tiles and without additional laths, were placed over the rafters on the layer of the OSB boards. The total thickness of the roof insulation is 45 cm. As a result of the application of the three-layer insulation system the heat penetration coefficient reached U = 0.08 W/m²K, which is especially important, for heat losses through the roof can have a significant influence on the energy balance of the building. The windows were constructed of sections whose heat penetration rate is U = 0.7 W/m²K. The system obtained the certificate of the Darmstadt Institute of Passive Houses (Instytut Domów Pasywnych Darmstadt) selected in reference to the construction of passive buildings. A unique structure of the sections guarantees perfect thermal parameters and also the required tightness. It is especially important in the case of the front door. The front door of the coefficient of U = 0.8 W/m²K meets all the requirements of passive buildings in reference to the thermal insulation and tightness against air penetration. The window panes also have very good parameters. The set of insulated glass, whose heat penetration coefficient is U = 0.6 W/m²K, was used in the house. Such good thermal parameters were possible due to the application of the low-emission coatings and filling space between the panes with argon. The g rate of the total permeability of sunlight equals 0.52. The application of such a modern woodwork allowed for the average U coefficient for all the windows of 0.72 W/m²K. We used special bands for the building insulation. Tightness is essential in the construction of a passive house. The effectiveness of all solutions applied in the passive house, whose target was to limit the uncontrolled infiltration of the external air, was tested by means of the pressure test. We obtained a very good result of n5 0= 0.3 1/h. As a result of the application of complete solutions in reference to the house architecture and the structure, the heat requirement of that building was significantly limited.

Once the house was examined whether it lives up to Passivhouse standards during an energy assessment, the building obtained the certificate of PHI in Darmstadt. The certificate was formally awarded during a conference dedicated to passive houses – 11 Passivhaustagung 2007 in Bregenz. Our house was presented as the first passive building constructed in Central and East Europe. The house is the first certified passive building in Poland. The heat requirement in the standard heating season for the house constructed in Smolec near Wrocław is 15 Kwh/m²a. Such a house constructed in accordance with the valid Polish standards will need 123 kWh/m²a, hence over eight times more.

Showpiece Building

The legal regulations concerning the building energy ratings will soon come into effect in Poland. On the eve of this event only experts are aware of the influence such legal regulations shall have on the entire real estate market. Unfortunately, the average investor still builds the same houses, although the energy standards in the construction industry will soon change to such an extent that his or her house will become too expensive to maintain and hence to sell at a profit. It is worth constructing the buildings which meet the standards introduced by the European Regulation on Energy of 2002 and taking minimal energy requirements into consideration, for they will undoubtedly evolve to passive house standards. A house is an investment for many years. The first certified passive house in Smolec near Wrocław in Poland has become a showpiece building, whose role is to promote the concept of energy saving in our country. It serves as a presentation of materials and technological solutions for the energy efficient construction. Also trainings pertaining to this subject matter are organised for executors and individual investors. Everyone can learn how comfortable it is to live in a house without heating.

Ludwika Juchniewicz-Lipińska,
Translated by "Lector"

Fig. 5. Open space in the living room with additional light from large glazed windows

Fig. 6. What is more, the mezzazine enhances the effect of spaciousness in the living room.

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