

Elements of Diagnosis - POLAND

1. Frame houses – introduction, basic definitions on an example Poland, Lithuania and Latvia.

Why frame houses? - health reason, social impact, financial and environmental impact

Main determinants are:

- lower costs of building house and its exploitation.
- wood is an ecological material
- short construction time

4 main reasons are:

1) health causes:

- microclimate of the house, material difficult to get in other technologies, created thanks to using the natural house in the structure wood,
- thermal comfort for users, because of good and long-term holding of the appropriate temperature inside the building,
- the respective parameters of the air humidity of ceilings inside the house due to the lack of problems with the moisture evaporation from structural members, e.g. built from walls, reinforced concrete and stairs.

2) social impact:

- better knowledge of potential investors in the scope of construction of houses in the skeletal technology,
- solid knowledge of specialists of houses in the structure in the skeletal technology,
- ability of effecting balance of the pros and cons, myths and facts in case of skeletal construction with reference to other technologies applied in the construction,
- greater awareness in the influence of applying different technologies in the construction on the environment.

On the other side:

- rather unpopular technology in Poland,
- the lack of knowledge and experiences in many persons professionally connected with wooden buildings (architects, building companies, or also persons from the building

inspection) what is causing problems both in the phase of the design as well as during construction,

- rise in the demand for wood not only for the construction, but as the eco-friendly fuel raw material also caused a rise in prices of wood used in the skeletal construction in the last period. In the future the continuing demand for raw materials can cause, that the skeletal construction will be less and less competitive for the traditional construction.

3) financial causes:

- time of the structure (apart from built foundations it is possible to avoid works of wet surfaces or to limit them for filling with plaster),
- possibility of carrying out work in every season, lack of weather restrictions,
- using almost exclusively dry materials for construction,
- friendliness for residents: finish in plaster lets for own, independent and simple making the modernization and repairs,
- heating up from the inside is taking place more quickly and longer a warm stays inside,
- possibility of achieving the standard of the passive house,
- alternative for typical (more expensive) of Polish built construction,
- economy of construction of the skeletal house, in comparing to the traditional construction built.

4) environmental causes:

- friendliness for the environment because of using eco-friendly materials for construction of the house (wood and modern building materials: plates from wood, cladding panels, eco-friendly materials for warming),
- smaller energy consumption towards the traditional construction due to the fact that wood is a renewable raw material, the construction process and producing building materials is calling the slight carbon dioxide emission to the atmosphere.

Definitions of frame houses

Frame house is wooden house with frame construction. The skeleton is the layout of the boards in the axial distance. The finished structure stiffened from the outside with panels. Frame house consists of a supporting framework and a filling. A supporting construction consists of a system of posts resting on a horizontal beam – a sleeper anchored to the foundation. The space between the posts is filled with insulating material.

Main definitions:

1. skeletal technology - it is an one among many of techniques of houses construction. Undoubtedly fastest. In the case talk through prefabricate relies on the assembly of ready structural members, to the earlier prepared foundation.
2. light wooden – carcass technology of construction of small and average single-family buildings, popular in Canada, the USA and Scandinavian countries.
3. skeletal house - it is a house, of which the supporting structure of the building is made of wood.
4. houses in the wood frame construction these are the modern houses, of which a wooden skeleton constitutes structures.
5. Canadian houses - these are built houses in the technology of the light wooden carcass.
6. Canadian houses, it's buildings built based on the long-lasting and flexible wooden outline, filled up with layers of the needled cloth and plates or plaster-carton.

Political and law regulations in each country and UE

In Poland, the construction of a frame house must implement all the requirements for building objects by the Construction Law.

Firms involved in the production of frame houses constantly control materials, which are used for construction and guarantee high quality and precise execution. The prefabricated elements of the frame house are made with great accuracy.

Frame houses manufactured in Poland also meet the requirements set by other EU countries. Many of them go to the German, English and Scandinavian markets.

Statistical data of frame houses in each country

About 5-6 percent. single-family housing is implemented in technologies based on wood. The lack of statistics in our country in this area makes it impossible to learn about the true development of this type of construction.

We can only base on statistical data from companies, which make houses in this technology.

Based on research done by “the Association of Wooden House”, bringing together about 750 companies, we know that about 5-6% of single-family houses are created in the wooden frame technology.

Based on the data from the companies that produce frame houses, we know that the demand for frame houses is constantly growing. For example, “Danwood S.A.” company, in 2018 built 1356 houses, or about 150 more by 2017. Of which about 100 houses a year are built in Poland.

Technical and assembly requirements for wooden construction

There are three ways of building wooden houses that can be distinguished:

- 1) from individual elements on the construction site,
- 2) from previously prepared prefabricated elements,
- 3) using previously made large-scale modules. The production process of residential modules is carried out in a factory. If only the design allows it, all the modules (including floor panels, installations, furniture, bathroom tiles, household appliances, etc.) are transported to the construction site where the whole building is assembled. After completing the finishing works, integration and testing of installations, the building is ready for use.

Technical and assembly requirements as well as humidity and heat conditions must be meticulously observed. For example, wood moisture should not be higher than 23% for external elements and 18% for enclosed elements.

The wood must necessarily be chamber dried, planed four-sided, with rounded or chamfered edges, with a maximum of 18% humidity. Wood for the construction of the house must meet the strength requirements contained in the standard PN-EN 338:2016-06. Constructional timber brought to production must always have a declaration of conformity confirming that the requirements set in the Polish Standard are met.

Prefabrication of houses in wooden frame technology

A house made of ready-made elements emerging in the production hall. Prefabricated elements reach the construction site in ready-to-assemble elements. The only pre-assembly work is pouring foundations. Prefabricated houses do not require wet works, so they can be assembled at any time of the year.

The wooden supporting construction consists of a system of posts resting on a horizontal beam – a sleeper anchored to the foundation. The space between the posts is filled with insulating material. Components of house including the walls, floors and roof panels are made in factory. The timber-frame components are precision-manufactured thanks to advanced digital software. Windows, doors, fire-resistant wall insulation, some service ducts and electrical connections are all installed at this time. The internal walls are either prepared for

application of paint, wallpaper or tiles, or are finished according to choices. Every component of the house is given a final quality-control inspection before it leaves the factory. All house components and building materials are shipped to site on special trucks, with a team of skilled tradesmen who are ready to start work. Massive cranes assemble individual elements of the house – typically the basic structure will be in place in one or two days. The house will be roofed and watertight within one to four days. When construction is complete, a team begins work on the interior. This includes heating and electrical installations, fitting doors, decorating, flooring and tiling to specified choices. In eight to 12 weeks house is ready to move in.

Renewable energy sources in frame building

Renewable energy sources and technologies currently taken into account in frame building are solar panels (for heating water), heat pumps and photovoltaic panels.

In skeletal houses, devices based on renewable energy sources can be installed. Nothing prevents a skeletal house from being heated by a heat pump, it has a mechanical ventilation system with heat recovery and it collects solar power from solar collectors to heat water.

Currently, more and more people decide to build an energy-efficient or even passive house. An example of a healthy energy-saving house can be a wooden house. Its unquestionable advantage is the ability to achieve good thermal parameters with a small wall thickness. Thanks to this, it is possible to achieve about 10% more usable area compared to a brick building, while maintaining the same external dimensions. Energy-efficient frame houses are often supplied with installations using renewable sources of energy.

One of them is heat pump, used to support central heating, hot drinking and sanitary water production or both. There are three types of heat pumps: air-to-air, water source and geothermal. They collect heat from the air, water or ground outside home and concentrate it for use inside. The most common type of heat pump is the air-source heat pump, which transfers heat between the house and the outside air. Today's heat pump can reduce the electricity use for heating by approximately 50% compared to electric resistance heating such as furnaces. High-efficiency heat pumps also dehumidify better than standard central air conditioners, resulting in less energy usage and more cooling comfort in summer months.

Solar collector is a device that collects solar radiation from the Sun. Its primary use is heating of water for personal use. Supporting the central heating is also possible but, due to the relatively low intensity of solar radiation in the winter, it is inefficient. There are many different types of solar collectors but the most widely used kinds are flat-plate and heat pipe collectors.

For our latitude, the most beneficial is the installation of solar collectors on the roof slope directed towards the south at an angle of 30-45 degrees.

Photovoltaic panels, on the other hand, capture the sun's energy using photovoltaic cells. The cells convert the sunlight into electricity, which can be used to run household appliances and lighting. The advantage of photovoltaic panels is, for example, cutting electricity bills. Sunlight is free, so once somebody paid for the initial installation, its electricity costs will be reduced. What is more, if the installation is connected to the electrical system (on-grid), it is possible to sell surplus electricity to the power plant.

Achieving the passive house standard is almost impossible to meet without the use of mechanical ventilation with heat recovery (MVHR). MVHR provides fresh filtered air into a building while retaining most of the energy that has already been used in heating the building. A heat recovery ventilation system properly fitted into a house provides a constant supply of fresh filtered air, maintaining the air quality while being practically imperceptible. The installation works by extracting the air from the polluted sources e.g. kitchen, bathroom, toilets and utility rooms and supplying air to the 'living' rooms e.g. bedrooms, living rooms etc. The extracted air is taken through a central heat exchanger and the heat recovered into the supply air. This works both ways, if the air temperature inside the building is colder than the outside air temperature then the coolth is maintained in the building.

2. Frame houses in vocational school curricula on an example school from Poland, Lithuania and Latvia.

Is there prefabricated timber-frame houses in school programs?

Is school teaching using prefabricated timber-frame houses challenges? Examples, professions

Prefabricated timber-frame houses are included in school programs. Prefabricated timber-frame houses should be discussed in detail in teaching for the profession of carpenters. All professions in the construction industry will learn the basics of building construction in this technology.

Our students have the opportunity to learn about the technology of making timber-frame houses during school practices, which they have in training center of company producing prefabricated timber frame houses.

In the school program in the field of construction technician there are no prefabricated frame houses.

We organize trips for pupils to production and construction sites of wooden houses.

There are plans for internships for students that would take place at Dan-Wood

The school in teaching in the profession the construction techniques isn't using ready prefabricated elements.

In school programs for techniques of the construction only in small part are included material connected with the scope of skeleton building.

In the programme base for educating the construction techniques concern the following effects of the education:

- distinguishing the structure of buildings and the technology of carrying them out;
- adherence to the principles of dimensioning of wood structures elements, steel and reinforced concrete;
- determining the structure of elements of load-bearing civil structures;
- drafting projects and technical drawings;

However in the classification: making and controlling structural-building work, in elaborating the individual of effects of the education concerning the assembly of wood structures it is possible to widen the scope of education in skeletal wood structures for the following effects:

- distinguishing types of steel constructions and prefabricate of reinforced concrete and wooden structures;
- adherence to the principles of dimensioning of wood structures elements, steel and reinforced concrete;
- using the project documentation, technical specifications of the workmanship and the acceptance of construction works, norms, catalogues and instructions of the assembly of steel constructions and prefabricate of reinforced concrete and wooden structures;
- distinguishing types of steel constructions and prefabricate of reinforced concrete and wooden structures;
- selecting materials, tools and the equipment for the assembly of steel constructions elements and prefabricate of reinforced concrete and wooden structures;
- applying technologies recommended in the project and steel constructions and prefabricate of reinforced concrete and wooden structures;
- selecting methods of steel constructions elements connections and prefabricate of reinforced concrete and wooden structures;
- performance of activities of building structures associated with preparation, preliminary fastening, protecting against loss the sedateness;
- making connections of building structures elements;

- controlling making connections of steel constructions elements and prefabricate of reinforced concrete and wooden structures;
- controlling the way of safeguarding the assembled structure against loss of the sedateness;
- performances fixed preliminary and of structural elements rectification;
- controlling preliminary fastenings and the steel elements rectification constructions and prefabricate of reinforced concrete and wooden structures;
- applying steel constructions recommended in the project to the technology of disassembly and prefabricate of reinforced concrete and wooden structures;
- performance of works of elements associated with repairs and disassembly of building structures;
- controlling the performance of the steel constructions works associated with the assembly and prefabricate of reinforced concrete and wooden structures;
- controls works associated with repairs and disassembly of steel constructions and prefabricate of reinforced concrete and wooden structures;

Mentioned above effects of educating in the programme base in the main aspects are concerning wooden rafter framings.

The school doesn't have ready prefabricated elements houses with wooden frame constructions. It is anticipated that wooden housing will be gaining popularity, hence the need for sound education of future professionals and engineers in the construction industry. Currently, the school program for technical secondary school of construction includes some issues about wooden constructions. According to the school program, student should distinguish between types of wooden structures, be able to choose materials, tools and equipment to assemble construction elements, decide on the method of connecting wooden elements and control the correctness of the connections. Nevertheless, the subject matter of prefabricated timber-frame houses is neglected.

In order to give students the practical know-how about wooden modular houses, the school has partnered with Danwood company, which is one of the most important suppliers on the European market of prefabricated wooden houses in a turnkey standard. In the last year our construction students took part in a study visit to the modern production plant in Bielsk Podlaski and to the construction site where they could see the technology of prefabrication and assembly of modular houses. Very interesting was the ability to see the show house, completely finished, equipped with all installations and furnished. It was a valuable lesson.

3. Prefabricated timber-frame houses of building on an example companies from Poland, Lithuania and Latvia.

Is people buy prefabricated timber-frame houses? How often, when, why? Examples. Good and bad practices on an example of real companies.

People buy prefabricated timber-frame houses more and more, because time of making house is very short in relation to the other technology of building. Usually, the most important advantages for the investor are the time of building the house and relatively low costs. The disadvantage of this system in Poland is often the use inappropriate wood. Only industrial dried wood should be used for the construction of a frame house.

Poles do not want to build prefabricated houses. In 2017, the company built only 47 houses in Poland. Wooden frame houses are not popular, they are believed to be less durable. For many customers, a short turnaround time is not an advantage, with cash payment you need to organize it faster. In traditional construction many works are carried out with own efforts due to savings

In 2014 the most building orders handed over via Oferteo.pl concerned the structure in the traditional technology built from the ceramic brick (40.9%). On the second place in terms of the popularity a technology built from the cellular concrete which the every third Oferteo.pl user chose positioned itself (33.2%). In the course of final years **we are observing the slow, but even increase in the technology of skeletal and Canadian houses** (appropriately the 8.5%, the 9.3% and the 12.4% in years 2012, 2013 and 2014).

In Poland, since years, vast majority of new buildings has been made as mason constructions. According to the official data given by Central Statistical Office (GUS), in the first three quarters of 2013, 51 685 new residential buildings were commissioned for use in individual construction, mainly single-family housing, of which only 222 in wooden construction technology (0,4%). Unfortunately, probably the data does not present the real scale of such a technology. It is known that many buildings, despite their inhabitancy, for various reasons, are not commissioned and consequently not included in the statistics. According to the data of the Wooden Construction Center, 750 companies working on construction of single-family houses in wooden technologies in Poland raise about 4 -5 thousand buildings each year in various wooden technologies. Moreover, by the year, an uptick in demand for frame houses could be seen. In a study commissioned in 2017, as many as 54% of respondents planning to buy or build a house or flat declared their willingness to live in a year-round wooden house.

The technical standard with the guidelines for designing wooden structures is Eurocode 5. As to technical and assembly requirements, although wooden construction accounts for 6% of single-family housing in Poland, no national construction and commissioning requirements have been developed.

A poor situation of wooden constructions may change as such technology of buildings is to be a part of the government program, Mieszkanie Plus. Within the confines of the Mieszkanie Plus program, the construction of thousands of apartments is planned for the less affluent, who would not get a loan for an apartment because of too low wages. The construction of wooden houses will be carried out by the company Polskie Domy Drewniane, founded in July 2018 with the effort of the National Fund for Environmental Protection and Water Management and the Bank Ochrony Środowiska. Taking all together, the forecast for frame houses is optimistic.

4. Analysis of the building in Poland, Lithuania and Latvia using prefabricated timber-frame houses.

Expert's opinions and contribution in project field.

Prefabricated timber-frame houses – challenge, impact, local activities and local culture.

Poles are conservative in the approach to building, but this should change over time. I think that with the development of this type of technology and its wider promotion, we will be more and more willing to use prefabricated houses.

As it was mentioned before, despite the fact that timber-frame houses cannot currently compete with traditional ones in terms of popularity, there is a constant increase in interest in wooden construction. There are many unquestionable advantages of such technology. Firstly, construction is faster than in traditional technologies. Work time on the construction site is only about 6 months. Secondly, thanks to the wide application of natural material – wood, the buildings have a healthy microclimate. Companies producing modular wooden houses assure clients of low heating costs considering low heat transfer coefficients and air tightness of buildings.

Nevertheless, due to the relatively short tradition of wooden frame and modular construction in Poland, there are some concerns about durability, fire resistance and comfort of use of such buildings. Finding a competent company specializing in timber-frame houses also turns out to be a challenge for investors.

Prefabricated timber-frame houses – course market expectations and teachers

The course will cover topics such as:

- materials used in wooden construction
- building structure
- covering the ceilings, walls and roof,
- external and internal protection against moisture,
- thermal and acoustic insulation,
- ventilation of the building,
- building thermography test

The training will theoretical and practical form be both.

Getting knowledge and experience in the time of the internship on the structure or the unit producing elements of skeletal wood structures in order to hand over to pupils at school. A lack of knowledge and experiencing at many persons professionally connected with wooden buildings (architects, building companies, or also persons from the building inspection), is causing problems both in the phase of the design as well as during construction.

In order to popularize wooden frame and modular construction, there is a great need to familiarize students of vocational schools and construction students with these technologies. The first step is to prepare teachers and widen their knowledge about it by organizing trainings and meetings with specialists from this industry. Only a well-educated group of teachers can pass knowledge to students. Moreover, schools should be equipped with such study aids as wall and roof models of modular houses with cross-sections of component layers. It is much easier to understand how something works when you can see it. What should also change is school program. Teachers are obliged in the first place to realize it. If timber-frame houses are not included there, this topic will be still slightly overlooked. Finally, closer cooperation between schools and companies involving study visits and training programs for students would result in better preparation of future contractors and designers of wooden structures.

To sum up, wooden frame and modular construction has a chance to become a competition for traditional construction, as it happened in the case of Scandinavian countries and Germany. However, changes are necessary in the education sector, national construction and commissioning requirements needs to be developed. There is also a need for reliable data on the number of wooden buildings made annually in individual technologies.