Today's problems of using wood as a construction material

Diploma project

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Abstract

This work contains problems of using wood as a construction material nowadays, mainly in the Czech Republic. In the work are mentioned several factors, which are affecting people’s decision for using wood as a structural material from the point of views like: economical, ecological, fire resistance, durability, load carrying, thermal insulating, architectonical, etc. These affecting factors are described and fulfilled with examples.

The necessary information to complete this work was gathered from book, websites, cooperation and communication with companies and teachers from various schools.
I declare that whole diploma project is my own work by using the mentioned literatures and resources in agreement with the Diploma Project coordinator.

In Halmstad 22nd May 2007                        Miloš Kobza
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1 INTRODUCTION

1.1 Aim of the research

In this research, I want to focus on the problem, why is there a lack of wood used on Czech Republic for constructing buildings. By utilizing wood, it can provide numerous benefits such as ecological, economical, fire resistance, and several other advantages that citizens of Czech society are unaware of.

1.2 Research methodology

In order to complete this research, the necessary information was gathered from many different resources. Mainly, it was obtained from books, websites, and cooperation and communication with companies and teachers from various schools. This information and technical assistance helped and led me to make and finish this research, which is what I hope to accomplish. Most importantly, influence readers to use wood as a building material.
2 WOOD AS A STRUCTURAL MATERIAL

2.1 Introduction

Timber has been used in the construction of buildings, bridges, and many other civil engineering works. Since mankind first learned to fashion tools, the unique properties of timber have made it a cornerstone to the advancement of civilisation and development of society as we know it today. (Kuklík, 2003)

From the earliest years of recorded history, trees have provided mankind with food materials from shelter, fuel and tools. Wood is one of the earliest building materials used by our predecessors, and most of us experience a strong affinity with the beauty and intrinsic characteristics of this natural material when timber is used in the places we work and live. (Kuklík, 2003)

Timber is the oldest known building material capable of transferring both tension and compression forces – making it naturally suited as a beam element. It has a very high strength to weight ration, it is relatively easy to fabricate and to join, and it often outperforms alternative materials in hazardous environments and extreme temperatures (including fire). It does not corrode and many species, if detailed correctly, can be very durable. The unique properties of timber have made it a cornerstone contributor to the advancement of civilisation and development of society as we know it today. (Kuklík, 2003)

Timber is truly remarkable material. Whilst most of the structural materials we use are processed from finite resources, requiring enormous amount of energy and producing significant green house emissions. Timber is grown using solar energy in natural soil which is fertilised by its own compost, fuelled by carbon dioxide and watered by rain. Since it literally grows on trees, timber is the only structural engineering material which can be totally renewed – provided that trees are replanted (plantations) or naturally regenerated (native forests) after felling. (Kuklík, 2003)
Forest, forest based industries, the services, goods and products they provide affect directly the daily life of any of the 450 M Europe’s Citizens. Within the EU 27 countries, the forests cover 140 million hectares which account 36 % of land area on an average, ranging from 1 % in Cyprus to 71 % in Finland. Europe’s forests are extending in area, increasing in growth rate, and expanding in standing volume. (Kuklík, 2003)

As already mentioned, wood is one of the oldest building materials which people have learned how to use for constructing buildings and making factories. While a major part of today’s building materials, it is made from non-renewable resources and produces a great deal of energy. However, a large amount of effort and time must be spent to be able to obtain the energy from the wood. Nonetheless, timber from well maintained forests is renewable resources and using them is environmental friendly, since it consumes carbon dioxide and produce oxygen. After Second World War, former Czechoslovakia had large amounts of wood and it was ranked closely with gold as an important resource for economic growth. But due to the mismanagement of this resource from the government in order to force start exporting, the Czechoslovakian economy was dealt a severe blow and the effects are still being felt today. Since wood was often exported as a raw material without value added, this along with intensive constructing panel buildings led also to the reduction of teaching design timber constructions in study programs at civil engineering departments which limited designing and restricted the use of timber as construction material for buildings. Although, the last few years has shown a growing interest from builders for adequate information on properly utilizing timber in building construction, nevertheless, many still view wood as an inefficient and weak raw material.

In majority (laic and specialist) of publicity in Czech still persists the deep rooted feeling that “bigger is better”. Meaning, it should be based only on traditions and references to “firmness and durability”. (www.rigips.cz)

Strong impulses to change are sequential with the rising prices of energy which leads to more economically thinking construction engineers. This idea should revolve around constructing houses that are cheaper and more serviceable for people to live in.
This is accomplished by adequate design of windows and doors, installing proper thermal insulation in the walls/roof/floors, and any methods that can help reduce the amount of heat that escapes. Most importantly, using timber as a building material since it is cheaper and durable.

Currently, there is strong emphasis on constructing houses as quickly as possible and that are economically and environmentally beneficial. This focus is reviving traditional technologies which will enrich new and modern materials and approaches.

One of the elegant solutions is to return to the principle of light wooden construction. Using the most modern technological procedures, it can fulfil the most sophisticated demands on low-spend energy buildings.
3 HISTORY OF TIMBER FRAMED HOUSES

3.1 Introduction

Timber has been used in the construction of buildings, bridges, machinery, war engines, civil engineering and boats etc. since mankind first learnt to fashion tools. Here it will only be possible to give some examples, generally limited to house to illustrate this development. These examples will be restricted to the European experiences.

Given that Czech Republic is situated in the centre of Europe, it is possible to see timber structures of South, North, West and East Europe here.

3.2 First timber framed houses

The first timber framed houses were constructed by the first farmers between 4500 – 3000 BC. The durability of these houses did not usually exceed twenty years. Since the first farmers did not know structural detailing very well, they had a lot of problems, particularly with trusses and bracing. Also, they did not know carpentry joints well. Nevertheless, they constructed a long-house. The reconstruction of the long-house is illustrated in Figure 1. (Kuklík, 2003)

The structure of all long-houses was the same. The width ranging from 5.5 m to 7 m was given by the structural possibilities. The difference was only in the length which varied from 20 m to 45 m. The back gable of the long house was usually oriented to the north or in the direction of prevailing winds. (Kuklík, 2003)

Long-houses were usually constructed in a gentle slope with the part for animals oriented down the slope. Long-houses did not have windows because the first farmers were not familiar with their construction and did not have glass or any similar material. (Kuklík, 2003)

The framework of the long-houses was made by four or five lines of logs set in the ground. The logs supported the purlins which carried the rafters. The outside lines of
the logs were usually interlaced by deciduous tree branches which were smeared by clay. Roofs were probably covered by sedges. (Kuklík, 2003)

In 400 BC, the Celts were on the territory of the Czech Republic. One tribe of theirs gave its name to one province of the Czech Republic, Boiohaemum (Bohemia). Houses constructed by the Celts were light with a stone pedestal. (Kuklík, 2003)

This type of house was used in Central and Eastern Europe over the centuries.

In the time of Roman Empire, the territory of the Czech Republic was mainly occupied by the Teutons. Only South Moravia was inhabited by the Romans, who built about twenty forts there. Houses constructed by the Teutons were primitive and small. Diameters of floor plans were approximately 5 m x 6 m or 4 m x 5 m. (Kuklík, 2003)

Between 400 – 550 AD, the first Slavs came to the territory of the Czech Republic. Houses constructed by the Slavs were the same as the houses constructed by the Celts. At the beginning of the Middle Ages, this type of house was gradually replaced by a log-house, particularly in towns. In the countryside, this type of houses was erected hereafter.

From the 13th century onward town houses were different from houses in the countryside. (Kuklík, 2003)

Figure 1: Long-house (http://www.nysm.nysed.gov)
3.3 Houses in the countryside

Between the 13\textsuperscript{th} and the 15\textsuperscript{th} century, countryside architecture came into existence and in this form existed till 19\textsuperscript{th} century. Between the 13\textsuperscript{th} and the 15\textsuperscript{th} century, countryside architecture took on different regional forms. Materials traditionally used at that time were timber, stone and clay. (Kuklík, 2003)

Stone was mainly used for foundations and the underground parts of houses. Stone was also used for walls from the time when the fireplace was moved from the centre to the corner of the house. (Kuklík, 2003)

Clay came into use as a structural material in the 15\textsuperscript{th} century. (Kuklík, 2003)

In thickly forested regions of Central and Eastern Europe, a different house building technique developed using the almost unlimited supply of logs (predominantly round) in which they were usually used laid horizontally one upon another to form walls (see Figure 2.) (Kuklík, 2003)

![Figure 2: Log-house (www.wikipedia.org)](www.wikipedia.org)
In Western Europe and some parts of Central Europe, the half-timbered house building technique developed using short logs (see Figure 3). (Kuklík, 2003)

![Figure 3: Half-timbered house, Warwick, England (www.wikipedia.org)](image)

This technique was developed in Germany in the 12th century and at first it was used in town houses. Beginning in the 15th century, this technique was also applied in country houses. (Kuklík, 2003)

Sometimes, the house structure was a combination of the log-house and the half-timbered house technique. Roof structure of country houses were very simple depending on snow loading. Bracing was usually constructed only in the longitudinal direction. (Kuklík, 2003)

### 3.4 Houses in towns

During the 12th and the 13th century, the log cabin was widely built in towns of Central Europe. In the contrast to the houses in the countryside, there was only a passage leading to the backyard. From the 14th century, stone and brick were used as structural materials for the construction of houses in towns. The main reason for their spread was
fire resistance of these materials. Floor structures of town houses were made of timber until the 16\textsuperscript{th} century. (Kuklík, 2003)

Roof structures have been made of timber till now. Since 14\textsuperscript{th} century, non-combustible roofing has been in use.

The development of town houses was more specific than the development of country houses. One of the reasons was colonisation of towns by people from different parts of Europe. From the 16\textsuperscript{th} century, town houses were made above all from bricks. From the 18\textsuperscript{th} century, it was prohibited to use timber as a building material in towns, except for floor, separating walls and roofs. (Kuklík, 2003)

3.5 Wood as a structural material

The development and formation of wood is one of the nature’s greatest achievements. World-wide, about 30,000 wood species are known with an extremely wide range of biological, chemical, technological and, moreover, decorative properties with development according to site conditions, tree age and cross-sectional position in the stem of the tree. While this requires great efforts during harvesting and processing, it also offers the possibility of expressly choosing the kind of wood that will fulfil specific consumer wishes and demands. (Kuklík, 2003)

The comparison of the most important technical properties with those of other building materials gives proof of the equivalence and, in some respects, the superiority of the natural resource wood. Wood is a largely porous composite reinforced by cellulous fibres and thus constitutes a natural “High-Tech” product. High quality wood is less heavy than steel, equal load-bearing capacity, and was therefore an important material in aircraft construction 50 years ago. Wood has approximately the same compression strength as concrete and moreover, in contrast to concrete, also shows resistance to tensile stresses in the same order of magnitude as in compression. (Kuklík, 2003)

Due to its great porosity wood has favourable thermal insulation properties. It has the greatest load-bearing capacity of all thermal insulating materials. This is a great help in design work, especially in the prevention of thermal bridges. (Kuklík, 2003)
As an organic material wood tends to burn and is prone to fungal and insect attack if its moisture content is high. However, suitable design can lead to almost any required fire resistance duration and prevent attacks by insect and fungi. (Kuklík, 2003)

The extraordinary technical properties of wood are only one of its assets. There is, moreover, its character, its beauty and the atmosphere it creates to be considered. All our senses react to wood and we feel comfortable in surroundings which feature wood. It is interesting to note that, today, wood construction is particularly successful in housing and reconstruction, i.e. specifically in places where we spend our spare time and like to relax. (Kuklík, 2003)

3.6 New engineered wood-based products

The strength of timber is determined more by the weakest cross-sections having defects than by the clear straight grain wood itself, which normally has two to four times higher strength than commercial sawn timber. Large defects can be avoided when logs are first cut into thin sections and then glued to a reconstituted product. Especially the tensile strength is increased. (Kuklík, 2003)

Glued laminated timber has a higher strength than its raw material. Still more benefits of the redistribution of large defects into several small ones is obtained in the fabrication of plywood, in which logs are peeled to veneer with thickness of 1 to 5 mm. Plywood veneers are glued usually in right angles to each other. (Kuklík, 2003)

Laminated veneer lumber (LVL) is a product close to plywood, except that (most) veneers are parallel and larger dimensions are available. The idea of LVL came from the 1960’s and the production has expanded in the 1980’s. (Kuklík, 2003)

Parallel strand lumber (Parallam) is a beam-like product made of long wood strand, which was developed in Canada in the 1970’s. Another new structural wood product is Intrallam, which is made from large parallel chips. (Kuklík, 2003)

LVL is being used as beams, plates, members of trusses and shells. This is done in new buildings as well as in renovation for beams, joists, truss chords, vehicle decking, concrete formwork, scaffold planking and prefabricated housing. The largest structure made of LVL in Europe is Oulu-dome with diameter of 115 m (Figure 4). (Kuklík, 2003)
The uses of Intrallam are similar to those of LVL.

Parallam is used for beams, headers and columns. In residential building construction in America it is often used in beams when a material with higher strength is needed. It is suitable also for hall structures and the appearance of material is considered warm and suitable for interior architecture. Both LVL and Parallam are competing with steel in large span structures. The advantages of the wood-based alternatives are good architectural appearance, longer resistance in case of fire and the easy techniques for fastening of the secondary structure. (Kuklík, 2003)

Beam and post structures can be built in Parallam and in LVL (Figure 5).
4 TODAY´S PROBLEMS OF USING WOOD AS A STRUCTURAL MATERIAL

4.1 Introduction

Endeavour of modern European society move to foreground problems of environment, exhaustibility of raw materials etc. (Kuklík, 2006)

In the interest of environment in Europe is key question to reduce amount of carbon dioxide in atmosphere. One of the ways to solve this problem is effective use of forests as a liquidator and at the same time producer of renewable ecological material like a wood. (Kuklík, 2006)

Increasing the use of timber in Europe is currently connected almost with construction.

Experts are currently discussing about question of possibly increasing annual consumption of wood per person in Europe from 0,2 m$^3$ to 0,5 m$^3$ which is common in USA and Japan. (Kuklík, 2006)

It is possible to establish, that the process of rehabilitation wooden construction in the whole world have started already at the break of 70´s and 80´s years of twentieth century. It happens thanks to big lumbering companies, which have started close cooperation with first of all chemical industry (new glues, protective means for timber, chemical modification of wood), machine and electro-technical industry (machines and devices for sorting lumber, new sawmill technologies, computer-operating drying kilns, machine technology for making new wood-based materials etc.). (Kuklík, 2006)

Conditions for using wood in wider way in construction have been created also within the scope of several activities from European and world organisations that are participating in research and normalization in field of wooden construction. (Kuklík, 2005)

It was prepared new designing methods for designing timber constructions inclusive of methods for designing timber construction affected by fire. (Kuklík, 2006)
4.2 Solutions for constructing wooden houses

One of the elegant solutions is the return to principle of light wooden construction combined with the most modern technological procedures can fulfil the most sophisticated demands on low-spend energy buildings.

4.2.1 Sandwich construction for wooden buildings

Principle of sandwich construction for wooden buildings is a skeleton construction consists of wooden scantling, filled in thermal and acoustic insulation, coated with plaster boards. On the ground of dry process of constructing, there are not compared with brick building volume changes of construction. This is caused by an influence of moisture during hardening and most of the time for erection which is disproportional shorter. (www.rigips.cz)

Sandwich wooden constructions are made in various systems and performance:

4.2.2 Completion of large area sections

Title of the method and its appearance by no means implies that the method is uniform for constructing the house. Unified is the only system and principle of solving the construction details. Manufacturing plants are made separately from structural elements, forging generally the entire wall. Every structural element is made according to its own individual documentation. From structural materials (wooden planed joists, plaster boards and mineral insulation), it is made in manufacturing plant structural elements that are transported to construction site. With the help of a crane, it is placed on the right place and fabric of the house is finished during few days. (www.rigips.cz)

From technical and structural view, it is the most exacting, but most sophisticated method.
Advantages of large area completion:

- High accuracy of construction
- High stability and stiffness of construction (high face-stiffness construction of walls, accurate and fixed connecting of several elements)
- Propitious thermal and acoustic properties
- Building under construction is practically not expose to weather conditions (it is only a few hours of not covered construction during assembling)
- Construction details are solved before and there are no complication on site
- Speed of erection (fabric of building is finished on prepared slab mostly during three days)
- Advantages come out especially with right coordination and supplies on construction site

Production of boards and prefabricated elements place high requirements for material, technical and designing equipment of supplying firm. Efficient assembling on construction site is conditioned by accurate-made foundations and substructure. (www.rigips.cz)

4.2.3 Sandwich construction assemble on construction site

Construction system is not so much different from previous method. The main difference is that the construction sites are not taken in finished construction elements, but construction of walls and other components are assembled from separated materials directly on construction site. (www.rigips.cz)
Advantages of construction assembled on construction site:

- Relatively massive constructions of structure with high resistance reserve of individual elements (according to designer or producer determine the density and profile of the columns)
- Possibility to assemble in areas with bad access for heavy erecting machinery
- Requirements for accuracy in foundations – particular elements is possible modify on site

Assemblage of sandwich construction and elements allow directly on site compensate contingent inaccuracy or bigger tolerance in substructure. It is also important during erection to check the quality of used materials and technologies of assembling. In comparison with completion of large area sections, it is important to count with longer time for erection inferential requirement of protection construction against weather conditions. (www.rigips.cz)
Figure 6: Structural system of wooden house (www.rigips.cz)
4.3 Contemporary trends

To contemporary trends in using wood in Europe and also in Czech Republic firstly behave:

- prefabricated dwelling houses
- multipurpose buildings (apartment houses, administrative houses, schools etc.)
- light roof constructions
- halls for physical and agricultural purposes
- special construction
- footbridges and bridges for cyclists

For reaching high technical level which is equivalent to other constructions are these constructions designed as composite constructions from wood, steel and concrete without suppressing wood properties in these constructions. It is expecting, that during realisation of multi-storey buildings based on wood would have important part composite wooden-concrete ceiling construction namely from view of spatial rigidity and fire resistance. (Kuklík, 2006)

In the interest of using wood in widely way in construction in Czech Republic, it will be necessary to surpass out of focus conceptions of publicity for using timber as a construction material. (Kuklík, 2006)

For widely applying wooden houses in dwelling and civil construction in Czech Republic are these priorities very important:

- Speed and simplicity of erection in all seasons
- High possibility of light prefabrication and reducing space requirement on site equipment
- High efficiency of work during production and assembling
- Lower load acting on foundations thereby lower cost for realisation
- Disposal flexibility
- Dimensional accuracy
- Thermal efficiency
Lower expenses for using building in compared to brick and concrete buildings
- Good estimation of purchase costs
- Short-term binding of capital
- Good thermal insulation properties
- Good sound properties
- Variability of construction system
- Possibility of own design or standardized project
- Good properties from environmental view (using renewable resources, decreasing wastes and energy consumption)
- Healthy living
- Bigger inner area in compare with classical house due to smaller thickness of external walls and better using built-up area

Wooden houses are also capable of fulfilling growing requirements for thermal insulating properties of buildings, where practically zero expenses for heating are not a mere vision. It is also important to take into consideration that only wooden construction creates only part of quite sophisticated systems where as other parts are exceptionally higher quality than thermal insulations, windows, including dormers, special vapour barriers and also vapour permeable folio, systems of roof covering etc. (Kuklík, 2006)

It is also important to mention, that wooden constructions offer a huge possibility for using quite a number of before mentioned building materials, whose producers have already understood which possibility of development in wooden constructions and quality realisation they provide. (Kuklík, 2006)

Average consumption of timber and timber-based materials on realization 100 m² housing floorage in wooden construction is circa 18 m³ of sawn wood, 200 m² (2,5 – 3 m³) of timber-based boards (plywood, chipboards etc.) and further 300 m² of plaster boards or gypsum boards and of 30 m³ of thermal insulation from mineral fibres. Although in these days, purchases costs for wooden buildings are approximately the same level as silicate constructions, but wooden buildings have in compared with them about 10% higher floorage area on the same built-up area and of course lower energy spent consumption for heating. These days, the quality for making wooden constructions in
Czech Republic are in every contractors interests and the recognition of wooden houses from brick houses is quite difficult (Figure 7). (Kuklík, 2006)

Timber is also suitable solution for solving penthouses on existing dwelling houses due to low weight of new construction and therefore increased load to the foundation is almost insignificant. Timber consumption for penthouses is probably 0,03 till 0,06 m$^3$ for 1 m$^2$ of penthouse’s ground area, it depends on chosen type of construction system. Nevertheless, implementation of penthouse for example on one panel house of 615 m$^2$ area takes approximately one month. (Kuklík, 2006)

The best proof of durability of wooden construction is traditional architecture in Scandinavian countries (like Sweden, Norway, and Finland) and South-East Asia. On the other hand, hardly anybody feels natural erosion by burned and cement materials. (Kuklík, 2006)

Problem of “eternity” of constructions is often in these days discussed, because traditional principle of buildings as a thing carrying persisting funds is in direct contradiction with “virtual” conception of today’s world. “Endless” durability of constructions also interferes to problem of availability of functional properties that are changing due to owners requirements. Inconsiderable question for these types of buildings is also problem of liquidation after survival. (Kuklík, 2006)
5 FIRE RESISTANCE PROBLEMS OF MULTI-STOReY BUILDINGS

5.1 Introduction

It is commonly known that housing construction is in decrement from the year 1991 in Czech Republic. Nevertheless, wooden constructions could rapidly contribute to solve this problem. It is interesting, that year timber harvesting for one inhabitant of Czech Republic is almost the same like in Sweden. But in Sweden, wooden construction dominates housing construction, whereas in Czech Republic it covers only 1 - 2 %. (Kuklík, 2006)

From among European counties takes CR 12.place in forest coverage, in supplement of wood per one hectare is on 4.place and in annual increment for one hectare is on 6.place. Especially last two data document that the condition of forests in CR is not so bad, like is unfortunately and laically presented.

Common annual increment is 18 million m$^3$ and timber lumbering 13 – 14 millions m$^3$ of timber. (Kuklík, 2006)

If we will compare annual increment and timber lumbering we can see, that increment possibilities have been used in Czech Republic for 75%. Therefore forest managers can suitable increase harvesting without endangering interest of society expressed by certification of forest. (Kuklík, 2006)

On condition favourable economical and social development accordant with activity of constructing and wood manufacturing industry and state, respectively regional support, it is real to increase during flowing years the amount of wooden buildings especially in housing construction in Czech Republic. (Kuklík, 2006)

The model for using timber in building construction should be among others Great Britain, which for all have small own timber resources, but they use it in housing construction in high-level. In Scotland, it is approximately 50% and in England and Wales roughly 15%. (Kuklík, 2006)

On behalf of using timber in housing construction in Great Britain, extensive research was made for fire resistance of multi-storey buildings made from timber, which is an important benefit for all-European endeavours for better using timber in
construction. Below I want to describe some facts about this research, which will show, that fire resistance of wooden houses is comparable to brick houses etc. (Kuklík, 2006)

5.2 Description of the experimental building

Tests of the fire resistance of wooden construction came true, Timber Frame 2000 project. On six floor light skeleton housing building made in Platform system (Figure 8 and 9) have been made except fire resistance tests according European norms also tests of entirety of construction after crashing car into the building and of explosion too. (Kuklík, 2005 and www.ijm.ie)

On every floor were designed four flats. Everyone consisted of living room, hall, two bedrooms, kitchen, and bathroom with WC. In the building were a wooden staircase and also an elevator shaft. (Kuklík, 2005 and www.ijm.ie)

Figure 8: Experimental building TF 2000 before tests (www.ijm.ie)
Externals load bearing walls are made of two layers of gypsum boards (thickness 12.5 mm) and of OSB boards (plywood) of thickness 9 mm. For wall columns (38/89 mm) is used sawn wood with compression class C16. Distances between columns are 600 mm. Space between columns is fulfilled with thermal insulation. Behind outside load bearing walls was in distance 60 mm bricked-up brick veneer from facing masonry. Internal load bearing walls are made in the same way like external load bearing walls. Cover of internal forms only one layer of gypsum boards (thickness 12.5 mm). Walls between flats are reduplicated and space between them is fulfilled with thermal insulation. Ceiling beams (38/225 mm) are designed from sawn wood with compression class C16. Distances between joists are 600 mm and gap is fulfilled with thermal insulation. On the joists is made shut from OSB boards of thickness 15 mm and on him consists thermal insulation of thickness 25 mm, gypsum board (thickness 19 mm) and chipboard (thickness 18 mm). All rooms were for veracity fully equipped (Figure 10). (Kuklík, 2006 and www.ijm.ie)
Aim of these tests on the building TF 2000 was determination of behaviour of six storey wooden building, which was exposed to high fire load-influence (Figure 9 and 11). Below I want to describe two main fire resistance tests: test of resistivity of fire cell and test of staircase. (Kuklík, 2006 and www.ijm.ie)
5.3 Test of fire cell

Separated fire cells were tested on 60 minutes fire resistance. Fire was established in living room; therewith that fully-extended fire occurred after 24 minutes (Figure 11). For creating the best properties for fully-extended fire was broken window-pane in the kitchen. It happened in 21.minute and 30 second after establishing fire. Maximal temperatures raised in flat approximately to 1000 ºC and this temperature stayed there till the end of test in 64.minute from establishing fire. Maximum temperatures in the structural voids forming the boundaries of the compartment generally remained below 100°C with the exception of the localised areas where the timber members were exposed to fire for a period of time. The test data indicated that the TF2000 fire was approximately 10% more severe than a 60-minute fire resistance test exposure. In spite of this, there was little charring of the joists observed after completion of the test. This test provided that wooden skeleton construction of building satisfied functional requirements inside building from view of spreading fire inner building with keeping of construction integrity. (Kuklík, 2006 and www.ijm.ie)

5.4 The staircase fire test

One of the main advantages of Timber Frame in the construction market is the speed at which buildings can be erected and commissioned. If a significant part of the construction involved the construction or casting of masonry elements then such benefits would be largely lost at cost to both the developer and client. This gave rise to a research proposal, supported by the timber construction industry, to carry out an experimental programme investigating the actual fire performance of timber stairs in a timber frame building. (Kuklík, 2006 and www.ijm.ie)

Wooden staircase TF 2000 was fixed to do walls, which had wooden skeleton. At the beginning of the test were defined requirements of staircase’s product using qualities during the fire. The stair has to remain usable for firefighting after initial evacuation of occupants immediately at risk and for subsequent evacuation by the other occupants of the flats who are initially advised to remain in their dwellings. Staircase TF 2000 was
designed of special non-toxic fire resistance surface protection and stairs were underdrawn with a single layer of 12.5mm gypsum wallboard. Fire development was very rapid following ignition. The fire lasted for approximately 31 minutes. At this stage the fire load had reduced to a few smouldering embers. The Fire Brigade attended the test but did not have to intervene to suppress the fire. For verification of functionality of staircase the Fire Brigade fully equipped used the staircase and ascended the highest floor. Designed staircase with above mentioned requirements confirmed the reliability during fire. (Kuklík, 2006 and www.ijm.ie)

Figure 12: Staircase during fire (www.ijm.ie)

5.5 Main findings

It was verified fire resistance of wooden building R 60 during the test and obtained findings from area of construction integrity and fire extending between separated fire cells. For realistic fire load in fire section it was possible to obtained objective information about expanding fire in multi-storey buildings made in light weight system. It was verified fire resistance of wooden staircase. Results of tests TF 2000 were projected to legislation. In these days it possible to use in Great Britain combustible materials for dividing and external load bearing walls tilt the height of 18 m of the building in lieu of 11 m as before. (Kuklík, 2006 and www.ijm.ie)
Project TF 2000 confirmed, that it is important by multi-storey wooden buildings to take care of connection between gypsum boards of cladding namely multilayer. A non-performed procedure leads to decreasing of fire resistance of construction. In the gaps of cladding of building are designed fire indentations to prevent fire spread and disturbance of entirety of cladding. It is important to take special care of fire spread on façade between windows and other openings on building. (Kuklík, 2006 and www.ijm.ie)
6 ECOLOGICAL AND ECONOMICAL VIEW

6.1 Energy saving

Houses built in wooden structure system feature of high standard of thermal insulating properties, which solve one of the most important problems these days – all the time growing expenses for energy. External wall for structural system design for dwelling houses reach and exceed value of thermal resistance $R = 5.2 \text{ m}^2\text{k/W}$, which in practise means reducing 30 - 50% of spent energy in compare with classical technologies (which were used twenty years ago). (www.chytredomy.cz)

Used materials for walls have sufficient insulating properties, which guarantee stability of inner temperature in house. During winter time, it is easy to heat the house and in summer time the walls protect the inner space against heat coming from outside from sun shining. (www.chytredomy.cz)

Insulating properties

<table>
<thead>
<tr>
<th>Thermal properties of common materials</th>
<th>Width of walls in cm</th>
<th>Thermal resistance $\text{m}^2\text{W/k}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hebel, Ytong</td>
<td>37</td>
<td>2.2</td>
</tr>
<tr>
<td>Porotherm CD blok</td>
<td>45</td>
<td>2.3</td>
</tr>
<tr>
<td>Square brick</td>
<td>100</td>
<td>1.2</td>
</tr>
<tr>
<td>Wooden walls system - sandwich constr.</td>
<td>Typically only 26</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Table 1: Thermal properties of different materials

6.2 Price of houses built from different materials

The cost of houses built from wood, bricks and concrete based materials is quit the same. It differs only in some percent units. But the main difference is in construction time, which can be different. For example, the time spent for building wooden house varies from one and half month to three months, the same building made by bricks eight to twelve months like a concrete based buildings. This time values are not accurate and
can be used only as an example. These values differ from the size, shape, structural system, etc. of the house.

6.3 Ecology of wood and wooden houses

Designing and realisation of buildings at the beginning of 21st century, in effort conditions of creating balance between environment quality and economical development, it is necessary to accept also ecological view between common architectonical and engineering access. (Bílek, 2005)

This view can be quite various from an ascetical views of deep environmentalists, through unflinching posture of environmentalists till pragmatic solution within the scope of sustainable development. It is also access of flowing brief analyse, which sees environmental motivation together with a functional and economical aspect of wooden building, specially wooden dwelling houses in behalf of decisive motives and his development. (Bílek, 2005)

It is efficient to mention, that harvesting and treatment of building materials for constructing buildings in conjunction with theirs mounting and manufacturing of theirs technical equipment, presents substantial part of total consumption of energy (cca 25 %) and big part in road and railway transport. Subsequently these activities are negatively exerted in emissions, particularly in carbon and sulphur dioxide, dusty aerosols and nitrogen dioxide, but also in production of unworkable waste. As well as to these requirements approaches of demolition and devastation of buildings. (Bílek, 2005)

Tiber as a construction material presents in this way very important benefit to progressional limitation of mentioned impacts both in traditional appearance – proved materials, constructions and technologies and in new-alternative possibilities. (Bílek, 2005)

Unambiguously positive effect of application of wood generally on environment in natural economy, in housing construction especially, is possible briefly draw down to these factors:
- Economically used forest represent natural cycle of sun energy, water, carbon (and minimum added energy), which in periodical cycles products wood and biomass (Figure 13).

![Figure 13: Cycle of harvesting pine forest – 80 till 110 years (Bílek, V., Dřevostavby, 2005)](image)

- Timber is one of the renewable raw materials with versatile utilization and it is a considerable bearer of energetic potential of cca 5000 kWh/m³ wooden biomass from sun radiation. (Bílek, 2005)
- Intensive development of using timber as a renewable raw material has a positive influence on landscape conversation, it declines demands on mining of non-renewable raw materials like lime, clinkers, brick clays, aggregate etc. and extend their exhaustion period of theirs deposits. (Bílek, 2005)
- During the growth of the trees – photosynthesis, are carbon substances from atmosphere and earth transformed and stored in biomass – wood (Figure 14). Each 1 m³ of wood whether in grown or in utility state bounds – storage cca 225 kg of carbon. Forests and wood products conduce to decreasing of emission CO₂
in atmosphere and subsequently to stability of temperature and climate in the Earth. (Bílek, 2005)

Figure 14: Scheme of growth – photosynthesis (www.skogsindustrierna.org). The plant absorbs carbon dioxide from the atmosphere, draws water up through its roots and uses light to photosynthesize sugars, which it uses as food. It excretes oxygen as a by-product of the process. Without water, photosynthesis cannot take place.

- Wood upon his sophisticated processing is raw material with minimum waste. If the waste from wood is not used for production of agglomerated boards, paper, it could be used as an energetic resource with essentially lower emissions during burning than coal. (Bílek, 2005)
- Energy costingness production of entering materials and constructing wooden houses is in comparison with other material-technological variants essentially lower. It is positively shown in energy budget and in other decreasing of pollutant emissions, included carbon dioxide. (Bílek, 2005)
• Relatively low weight of overground part of multi-storey wooden houses means lower requirements for transport, energy, lower emission of nitrogen dioxide, carbon dioxide, hydrocarbon and lower level of noise. (Bílek, 2005)

• The construction conception of wooden houses and subsequently lower thickness of walls largely facilitate regulation of thermal loses and energy consumption for heating. (Bílek, 2005)
7 WHAT MATERIAL IS SUITABLE FOR CONSTRUCTING NEW HOUSE?

7.1 Introduction

Czech society has created, due to historic development in the last decades, a unique relationship to wood as a construction material. Under the thumb of ideological pseudo-signs, people like wood as a material, but they do not want to use it, because they think it harms nature, forests, and trees, which they have to harvest to get wood. One of the areas, which are mainly affected by various notions, is construction engineering. I have asked some people from the Nadace dřevo pro život for explanations. The amount of constructing wooden houses presents in some mature states a large percent of built constructions (70% Scandinavia, 65% USA and Canada, 10% Germany). In Czech Republic, it is less than 1%. This fact is mainly influenced by lack of information, myths, and superstitions, which are circulating between laics, but what is worst, also between professionals. (www.rdrymarov.cz)

Following questions will be discussed in this chapter:
1. Is wood house’s durability lower than brick house’s?
2. Wood is combustible. It means, that house constructed by wood more easily burns?
3. Can fungi and wood-worms destroy wooden house?
4. Wooden houses are rumoured to have worse thermal insulation properties again for example brick houses. Meaning, that in wooden houses, it is colder and harder to heat?
5. Have wooden houses look like loghouses or gamekeeper’s houses?
6. Lot of people can imagine wooden house only like a cottage or provisional house? Is it well-founded?
7. Do you think that using timber for housing construction is harmful to the environment?
7.2 Durability of house

Wooden houses carry through centuries and from in light of durability they are fully comparable with buildings made of different materials. Consist in purpose for which we build them and also in maintenance during using-time. We have to take care for all things, which are serving to us – lot of people forget on it. Also modern wooden houses have to obviously satisfy strict and norm requirements for strength, stability and durability properties. (www.rdrymarov.cz)

Wood, like any other material really burns in definite temperature, but technical norm claims, that wooden constructions are fire resistant. It sounds as a paradox, but it is not so complex. Sooty surface layer rising during fire on bearing constructions (beams) protect to another spreading of fire (by massive wooden items fire penetrates roughly to two till three centimetre into the deep and therefore spreading of fire is slowed down or stopped, because surface layer carbonificate and defend excess of oxygen). During the fire the most dangerous for inhabitants is fire if interior, furniture, textile and appliances. It is possible to say, that wood burns in predictable, numerable, to some measure controllable way. This is big advantage by quashing of fire. This fact include all technical norms, according them are all wooden houses built. Modern wooden constructions are highly fire resistance. Steel constructions break down suddenly, unexpectedly and practically at a blow. Parameters of all wooden buildings have to assure sufficient time for people evacuation – always around tens of minutes. It is widely known by firemen. In the USA after 11.september, there are in some cases steel framed structural buildings protected by timber facing. (www.rdrymarov.cz)

They can – if the house is designed and realized without satisfactory experiences, often self-help, and subsequently there is missing right maintenance. All houses, also brick, without maintenance dilapidate and fall into disrepair. Construction of modern wooden house we have to realize with specialists. Quality knowledge and experiences of architect and also constructing company are fundamental prerequisites. Perfectly
mastered construction detail and knowledge of principles so called “constructival wood protection” are big priorities, to prevent rising of moisture into construction and protect construction units again agitated air. Constructional protection is priority again chemical protection. Wood and wood-products have not to be designed to places, where they cannot, from their character, wear, for example under the ground level. Necessary is also technical subordination during realization. (www.rdrymarov.cz)

7.3 House’s properties

Reality is opposite! When you make a fire in wooden house, there will be comfortable clime during a few minutes. While brick house you have to heat for some hours, because the heat is primarily accumulating in walls. Most of houses, and also catalogue projects, have without compare better thermal insulation properties than brick houses. Flow from principle of construction – usually wooden frame contactly fulfilled by insulation. There is so integrated bearing and thermal insulating component. Wooden constructions are lighter and they usually worse accumulate heat. We can rate it as advantage – we heat economically in wooden houses only inner volume of the air, heat is not deposited first to heavy constructions like in brick houses. If we want to deposit the heat, it is possible in wooden houses too – we have to insert there brick or concrete unit. (www.rdrymarov.cz)

7.4 House design

Timber based modern house looks always like in agreement with imagine of enlightened client (constructor, contractor, investing firms) and functionality of house, with graphic potency of architect, which has experiences in wooden constructions and practical skills in designing. Traditional form of loghouse or casing house is technologically and graphically overcame. (www.rdrymarov.cz)
It is connected with weekend cottage tradition, from which we have to as fast as possible unbend. This imagine of using timber is so hard to break for people living in panel building. Experiences from other countries show, that there are not buildings, which are not possible realize in advantageous way from timber, including large administration buildings, shopping centres and sport halls. (www.rdrymarov.cz)

7.5 House and surroundings

It is unique, that for people it is worse to see logged area, on which grows new forest, which will variegate landscape mosaic, than stone pit, which deface landscape from long distance and no new stones grow there. To product one clay brick, one kilogram of cement, lime, glass, concrete, steel we spend more energy than for one timber beam. Wooden buildings are made only from one inland renewable raw material. In these days, we have got in Czech Republic two times bigger are of forests, than 80 years ago. Nevertheless, the amount of usage of wood in construction in Czech Republic is worse than in Portugal, which is nearly without forests. Annual increment of wood in our forests is higher of one third than is annual harvesting plan. So that it is impossible to say, that there is wastage of environment by immoderate harvesting. The problem is that we cannot find consumption on our market. (www.rdrymarov.cz)
8 ADVANTAGES OF WOODEN HOUSES

8.1 Speed and simplicity of erection

Average time for building-up brick dwelling house is about 13 and 18 months. This time is hard for constructor because he has to order the building materials, schedule supply or to manage labour force. Another important factor is that the prices in construction business are changing from day to day; these consequences can finally raise the final price for some percents. Construction of prefabricated units take about 2 till 12 week, this time is influenced by the preparation time for erection (finished foundation and foundation slab), size and type of house. (www.drevstavslovakia.sk)

8.2 Good thermal insulation properties

Good thermal insulation properties in external walls of wooden houses have proper thermal comfort in interior, therefore during winter time thermal loses are minimized, comfortable climate without excessive thermal gain in hot summer months. This house saves energy in winter for heating and in summer for cooling. (www.drevstavslovakia.sk)

8.3 Good sound properties

Due to sandwich structure has wooden houses good acoustic properties, which helps to create dwelling place where prevail silence and peace without influencing of surrounding are. Thanks to physical properties of used materials and right combination it is possible to achieve better acoustic insulation, which have massive building constructions. (www.drevstavslovakia.sk)
8.4 **Variability of construction system**

Construction of wooden system for houses ensures high variability, which can solve any disposition together with different changes to galleries, loggias, winter gardens etc. At least it is quite easy to change disposition during full operation due to mounted elements. ([www.drevstavslovakia.sk](http://www.drevstavslovakia.sk))

8.5 **Possibility of own design or standardized project**

In the case, if we have got idea of particular shape, disposition, or if we have finished project of our house a lot of companies in the market have possibilities and experiences to realize prefabricated units for the construction. ([www.drevstavslovakia.sk](http://www.drevstavslovakia.sk))

8.6 **Possibility to construct in every season**

During construction of wooden houses are used materials for which is not in the way cold weather, therefore, it is possible to make realisation also in winter season. Constructing in this season is suitable due to lower expenses, because a lot of building companies are not so busy in this part of year. Because wooden houses are realized by using “dry method” materials, which does not need ripe-time, it is possible to inhabit them after completion. ([www.drevstavslovakia.sk](http://www.drevstavslovakia.sk))

8.7 **Environmentally safely system**

Main material used for constructing this type of houses is wood, wood as construction material is completely renewable material. Also other components in the construction of wooden houses are based on natural materials, where recycling is possible and therefore they burden environment on the lowest level. For theirs production and also liquidation is spent minimum amount of energy, which together with saved
energy during the usage makes from these houses buildings, which are ecological and they save you non-renewable resources. (www.drevstavslovakia.sk)

8.8 Healthy living

Right chosen constructions and materials insure, for the whole usage-time of building, healthy living. Due to timber, which is the main material, used in these buildings, it is ensured comfortable, not only thermal, but also moisture climate. With high moisture content in the air in interior wood is absorbing this moisture respectively in the case with too dry air is gradually slacking it to the surroundings, these feature protect moisture cumulating hence creating moulds and micro-organisms. (www.drevstavslovakia.sk)

8.9 Low weight of building

Every house needs to have good foundations, solid base on which is built, water insulation, thermal insulation etc. In this case, it is not wooden house different, but due to low weight of used constructions, it is possible to use lighter foundation slab and therefore lower price for its realization, but the rigidity of construction is still ensured. (www.drevstavslovakia.sk)

8.10 Bigger inner area in compare with classical house due to smaller thickness of external walls and better using built-up area

Due to lower thickness of external walls investor saves approximately 10 % of worthy space, which will be in “classical” brick building fulfilled only by walls (I have to mention, that the space is not saved again thermal insulation properties of external walls). Meaning, that in a house of 100 m\(^2\) area you will get approximately one room that is 10,5 m\(^2\) compared with brick houses that give you much less. (www.drevstavslovakia.sk)
8.11 Reasons

- Speed and simplicity of erection
- Good thermal insulation properties
- Good sound properties
- Variability of construction system
- Possibility of own design or standardized project
- Possibility to construct in every season
- Environmentally safely system
- Healthy living
- Low weight of building
- Bigger inner area in compare with classical house due to smaller thickness of external walls and better using built-up area
9 CONCLUSION

This work contains facts that can influence people’s decision for using timber as a construction material.

Wooden houses can nowadays from the architectonical view be very impressive and equivalent to brick houses. Using timber in housing construction very well conform to contemporary functionality requirements, to financial availability of living and to sustainable development in construction from the view of exhaustibility of raw materials.

With the possibilities of using timber in building construction in Czech Republic, it is necessary to get over the imaginings of professional and laic publicity about wood as a material, which is not only useful for temporary buildings, roofs, ceilings, smaller engineering works, columns, hoardings, windows, doors, floorings, facings and other construction-joinery works.

I think that without support of government and private companies it will take a long time to change the view on wood as a structural material. To change this view the construction companies has to have information about timber properties and wood resources ability in Czech Republic.

In my opinion from the economical and ecological point of view, wooden houses are nowadays, with using modern technology, more suitable for housing than bricks and concrete based houses, nevertheless, the prices for erecting are almost same. These buildings are friendlier to the environment, due to energy savings. The energy spent for heating (cooling), building, demolition and recycilation are more times lower in comparison to traditional way of building houses.

If I will have got the possibility to make a decision or to recommend someone which material is suitable for building the dwelling house, I will choose or recommend timber as a main construction material.
10 REFERENCES


Links:
- [http://www.krnovice.cz](http://www.krnovice.cz)
- [http://www.rigips.cz](http://www.rigips.cz)
- [http://www.rdrymarov.cz](http://www.rdrymarov.cz)
- [http://drevene-stavby.cz](http://drevene-stavby.cz)
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