Log Structures in Finnish Architecture – Continuing the Tradition

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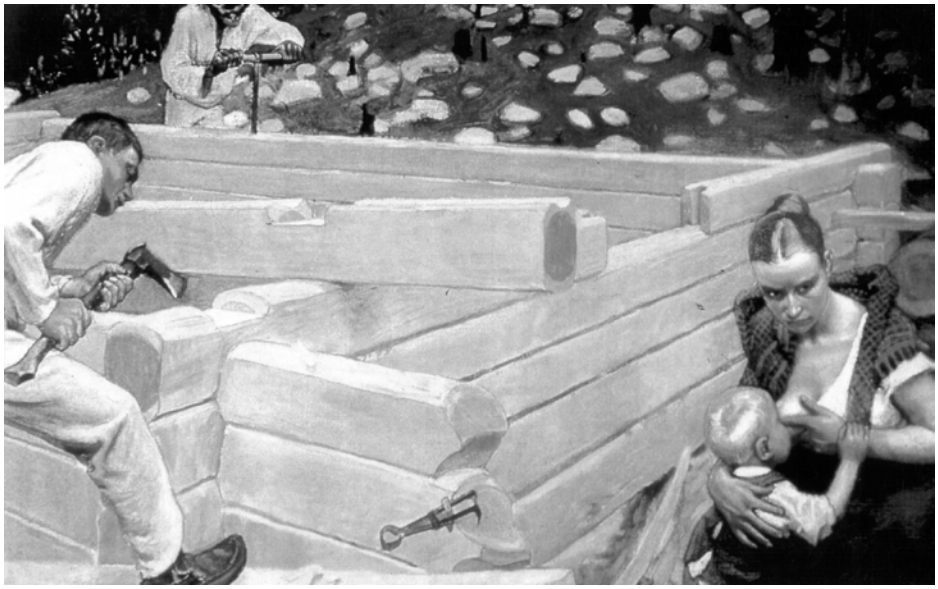
1. Introduction

Wood has always been a natural construction material in the northern coniferous zone. The entire construction heritage of Finland up till 1930s is mostly based on log construction. The simplest way to build from wood was to use entire tree trunks, or logs.



Picture 1. A Finnish log farm house under construction. Materials are taken from the nearby forest. Everything is done by hands. The hole family is taking part in the building process. Painting by Akseli Gallen-Gallela early 20th century.

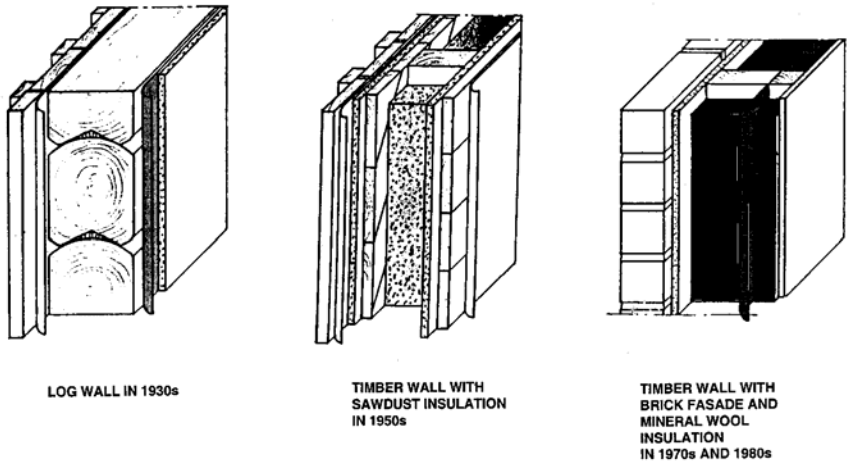
Construction methods were the same both in towns and the countryside. This included the finest wooden churches and the smallest cottages. From the 1700s on, the facades were started to cover with boards. Churches, town halls, manors and parsonages got their clothes of boards first. Boarding demanded logs to be hewn straight and the projecting corners replaced by short cut corners. Boarding was both a protective and an architectural solution, which allowed for following up-to-date styles of façade design. Boarding of log houses became common very slowly. Not until the 1800s did boarding of log buildings became a prevailing practice.

Log construction has always been dominated by simplicity and clarity. The use of the horizontal log technique has been created into simple rectangular building volumes. The Finnish construction tradition has been characterized by the use of gently sloping roofs. In housing it was typical that a new log frame was always built for a new need. Simple cubic-like log buildings formed a rich and variable courtyard both in towns and in the countryside.

Same technique and material in big and small.

Pictures 2 and 3. On the left, a inside view from the wooden church of Petäjävesi, built 1764. On the right, a street view with houses from 18th and 19th century in Tammisaari, a small town established year 1546 in the west coast of Finland. Photos R.S.

During the first decades of the 1900's a new American style lightweight timber frame construction method was imported to Finland. In the beginning the timber frame method became common very slowly because logs were easily available and they were cheap. During the 1930's logs lost out to timber frame, and log structures were considered to be old-fashioned and laborious. It was argued that lightweight timber frames spared wood resources and sped up construction work. Log construction achieved its last flowering during the post-war reconstruction period. Due to the lack of nails and the good availability of wood material, logs were again an advantageous constructing material. Standardized single-family log houses were built from logs mostly in the eastern border rural districts. Since then, logs have succeeded in competing with timber frames only in saunas and summer cottages. Although the log construction tradition thinned out, it never completely broke.



Picture 4. Evolution of the timber wall[1].

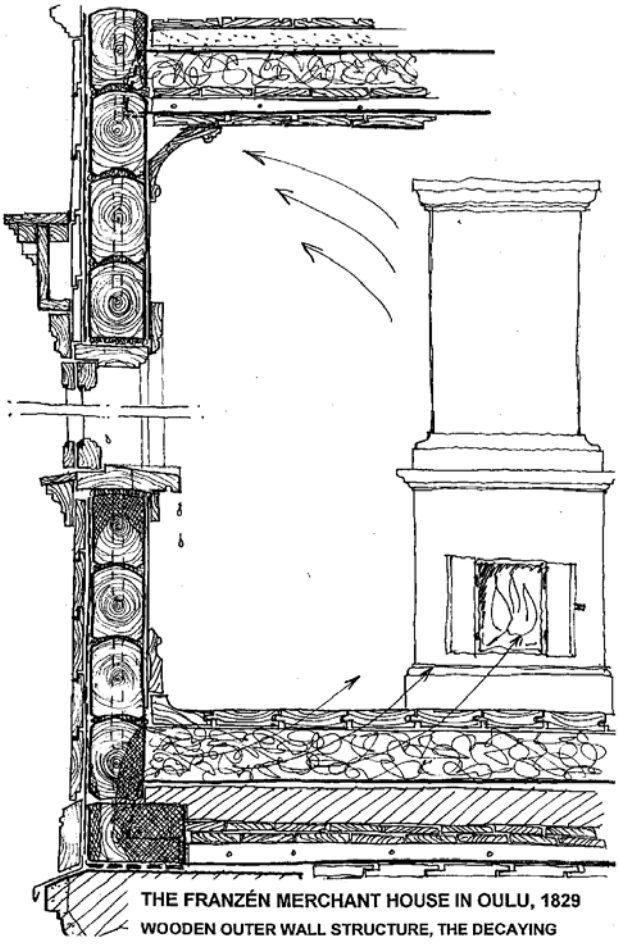
[1] Source: Prof. Unto Siikanen: "Perinteinen puutalo", in a book: Metsä ja Puu IV, edited by Prof. Eero Paloheimo, TKK, Tampere 2000.

Nowadays the number of old log buildings is relatively small. In towns most of them were demolished during the so called urban refurbishment of 1960s and 1970s. In countryside old log farm houses became also neglected because of their lack of modern conveniences – it was considered more easy to built a new modern building besides the old one than to repair and update the old one. Today the percentage of buildings built before 1920s (most of them log buildings) varies in different provinces only between 3 and 11 % of the total number of all buildings[1].

Recently the massive log structures have again become the objects of interest. Log buildings are considered to have some positive qualities. They are considered to be healthy, long term durable, beautiful, simple and ecological structures of high quality[2].

2. Old log structures and research

Usually the old log houses are in relatively good condition, if only the roof has been kept in order and if there has not been made any drastic renovations and changes of building materials. Problems and decaying of old log buildings is concentrated in the joints (picture 5). There are lot of opinions but not much research made trying to figure out the causes. The movement of moisture with the air flow and their effects to decaying has not been researched scientifically.



Picture 5. Typical places to find dry rot in an old log building. Drawing by architect Veikko Kotila.

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[1] Tilastokeskus 1990. Official statistics of Finland.

[2] E.g. Ritva Kuusisto: Teollinen hirsitalo - mielikuvien vanki (Industrially produced log house - captured by the images). Dissertation in University of Oulu, Department of Architecture, 2002.

In the picture above it is suggested, that there is connection between the air flow and rot, partly because of the ventilation air and replacement air for the oven coming through the lower part of the wall and partly because of the warm air is going to the attic via intersection of the upper floor and the wall. Maybe so, but this does not give a full answer to the causes of decaying. There are many variables involved, like: the origin of moisture (condensation water or leakage), convection, hygroscopic qualities of materials and differences of material layers, movement and pressure of the air, the temperature. All these variables have their effects on the three basic things rot needs to flourish: material, constant moisture and proper temperature.

Even though the construction of old log buildings is based on tradition and experience of well proven practical solutions, the physical function of the building still maintains unclear. Same goes with considering log structures as healthy structures (because they are breathing). This claim may have some truth in it, but still it is mostly based on image, not on actual research. Most of the research related to old log buildings is inventory work and art historic analyses.

Some research dealing with hygroscopic breathing timber structures has recently been made by VTT (Research Center of Finland). According to these tests, wood as a hygroscopic material balances remarkably the moisture peaks in the air inside apartment. The amount of carbon dioxide in the air is also diminished by breathing structure without moisture barrier but with an air flow barrier allowing the gas molecules to pass by. These things improve meaningfully the quality of air inside an apartment[1]. Another report indicates, that by using hygroscopic materials, the ventilation rate could be 15% lower and still have similar indoor air quality. This would mean 6% reduce in total energy used for heating buildings[2]. Same kind of results could probably be found when dealing with log structures.

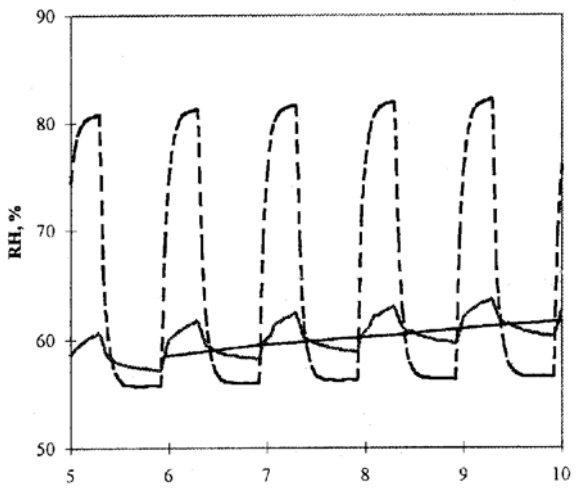


Figure 1. Relative humidity in the air of a bedroom as a function of time (days). The dot line indicates painted wooden fiber walls. Black line indicates unpainted wooden fiber walls. The amount of moisture varies considerably. Source: VTT, Erkki Kokko 2001.

[1] Erkki Kokko: Hengittävä puukuiturakenne (Breathing structure of wood fibers). Research report by VTT (Research Center of Finland), 2001.

[2] Carey Simonson, Tuomo Ojanen & Mikael Salonvaara: Effect of Hygroscopic Materials on Energy Consumption. VTT, Espoo, 2001.

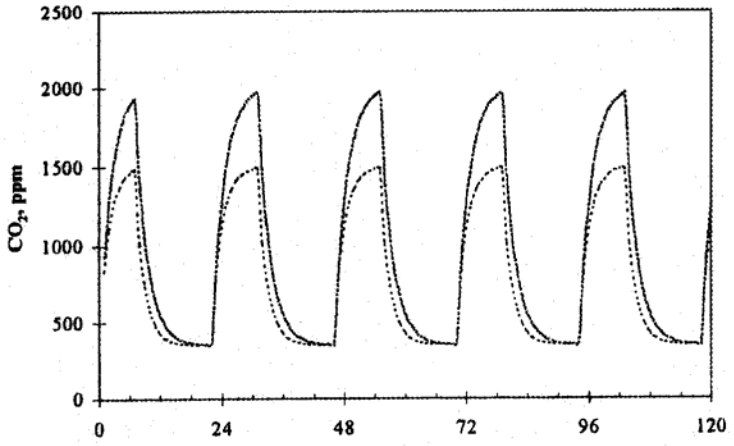
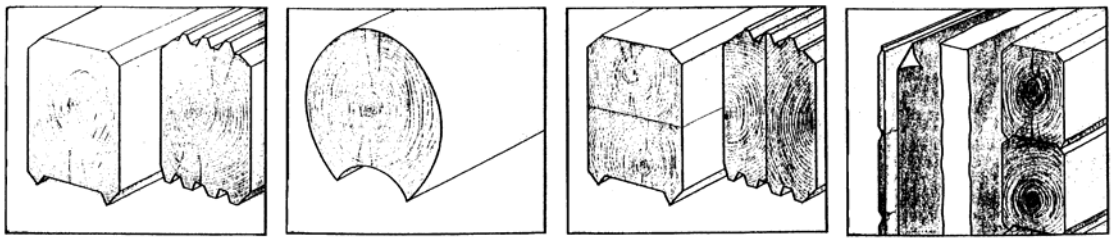


Figure 2. Amount of carbon dioxide in the air of a 12 m2 bedroom as a function of time (hours), when the air ventilation is normal (n=0,5 l/h). Upper curve indicates wall structure with moisture barrier. Lower curve indicates structure with construction paper holding the air flow but allowing gas molecules pass by. Source: VTT, Erkki Kokko 2001.

3. Industrially produced logs

Finnish log construction got new vitality in the beginning of the 1950's when log houses began to be produced industrially. In the beginning, log factories produced only hewed logs for sauna and summer cottages. Industrial round log production began in the middle 1960's. The staff at log factory companies often did the design for log cottages and competent designers were only seldom used. Log cottages became anonymous assembly line products.



Picture 6. Different types of industrially produced logs

Industrially produced logs have nowadays replaced traditional hand-hewed logs. Hand hewing has continued in home-district museums and in renovation of old log buildings. Handicraft schools all over Finland arrange hewing courses for interested people but mostly on hobby bases. The newest field of hand hewing occurred in the implementation of dead-standing logs. With the advent of downhill skiing, a new phase of tourist construction began in Lapland during the 1960's. Models for the use of dead standing logs were taken from the old stock cabins of Lapland. The design of dead-standing log buildings has been dominated by the wilderness romanticism, and the architectural quality of new buildings is not very high.

The production process of the log house industry has developed considerably after the unpretentious beginnings in the 1960's and 1970's. Modern logs are high quality, exact and technically functioning products. Industrial log production utilizes the newest CAD-based design technology. Industrially produced log houses have become the most important export product of the Finnish mechanical wood industry. More than 60 percent of Finnish log production is nowadays exported to more than 30 countries. The most important export

areas are Central Europe and Japan. Today Finland is the world leader in the industrial production of log houses. Finland also has the largest log companies and the largest log factories in the whole world.

More than 70 percent of new log houses today are produced industrially. The Finnish log house industry is leading in the world, and industrially produced logs are among the most important export products of the Finnish mechanical forest industry.

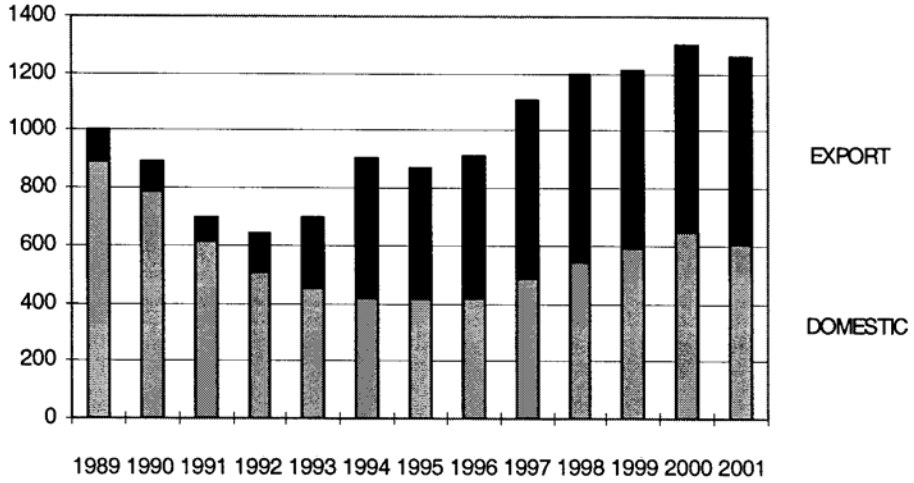


Figure 3. Net sales of industrially produced logs in Finland in Million Finnish Marks (1 million FIM = 168 000 euros). Source: Pientalobarometri nr. 1, Rakennustutkimus RTS Oy, 2001.

The domestic sale of log houses has expanded during the last decade from leisure-time housing to normal single-family housing. Of all new single-family houses 10 percent are nowadays log houses. The marketing of log houses is based on images of nature and tradition. The buyers of log houses defend their choice mostly by citing the genuineness, cosiness, and healthfulness of log houses.

New log houses are situated in rural areas. New log houses situated in towns or densely populated areas are scarce. Industrial log house models are still based on nature-romanticism. Some of the models look like normal single-family houses except that their material is log instead of boards or brick. If industrial log houses are to be a competitive alternative for modern town areas, a new architectural image must be found for them. The architectural handling of new log houses must reflect the possibilities of modern technology. It is inconsistent and conflicting that old-fashioned romantic houses are built from log components produced by the most advanced technology.[1]

Nowadays, a new demand for log construction has arisen. The industrial log house production has, however, been created for the needs of leisure-time construction. The most natural scope of log construction is in housing and especially in single-family housing, but with existing leisure-time products and models it has been difficult for the log house industry to spread into towns or densely populated areas. For these demands a new type of architecture is needed:

[1] Jari Heikkilä: Hirsi kaupunkiympäristössä – hirsiarkkitehtuurin kehittämishankkeen raportti (Log in town environment – report of a developing project of log architecture). University of Oulu, 2001.

4. Promoting log constructing in Finland

Timber construction in Finland and also in other Nordic countries has been strongly developed since the mid 1990's. Due to public financing and diversified research, a new era of timber construction has begun in Finland. Behind the popularity of timber construction are the more and more appreciated ecologic values. Wood is a renewable and local material, which binds the carbon dioxide of the atmosphere and cuts down the harmful effects of greenhouse gases. Timber construction has a huge national importance for Finland, which has the largest forest resources per inhabitant in the whole Europe. The additional use of timber is also possible because the use of forest resources has been less than the growth. The additional use of timber makes it possible to add to exporting and to develop the national economy. For this reason the state has promoted the research and development activities of timber in recent years.

The Wood Studio of the Department of Architecture at the University of Oulu has done research and development work for many years to create a modern town house made of logs. The development of log construction presupposes the knowledge of the history and the character of log construction. Only on this basis, it is possible to create new architecture.

In the common Nordic development work of timber construction and the research of massive timber structures has become more and more important during the recent years. The use of timber is also increasing because of ecologic reasons. The development work of massive timber structures is aimed at the huge construction market in central Europe, where massive structures are appreciated. New types of massive timber structures and components have been developed in central Europe during the last decade. Edge plank elements, crosswise laid plank elements, massive timber hole slab elements and massive composite concrete-timber structures are examples of this development. Massive timber elements can be used as horizontal and vertical structures of the building fame. Visible wooden surfaces are admired both in exterior and interior architecture. The success of Finnish log house exporting is based on the same admiration of massive timber. As a whole, log construction can be considered to be a Finnish massive timber construction method. Log construction has been until now outside the new development activities of Finnish timber construction. The better image of wood has, however, increased the value and demand of timber construction. In the beginning of the 2000's, logs have now made a comeback as an up-to-date building material. Ecological values and the promotion of timber structures have given log houses a high status.[1]

4.1 Log buildings in towns again?

It seems that a new interest in log construction has arisen during the last years. More than 20 percent of new home builders are interested in log houses. The most natural scope of log construction is in housing and the largest possibilities to add use of logs are in the housing areas of towns and densely populated areas. A new architectural image must, however, be found for log houses before they can be accepted in towns. The leisure-time log construction of the 1900's doesn't provide a solution to this demand. The problem particularly concerns architecture. Structural and technical means to produce modern log houses can be found from the long history of log construction.

The possibilities and borders of modern log architecture have also been searched in many projects of the Wood Studio of the Department of Architecture at the University of Oulu. Wood Studio has arranged several competitions for the students and some of the projects will be built.

The first architectural competition concerning modern log architecture was arranged for the municipality of Suomussalmi year 1998 to get models for a new log house factory. In the

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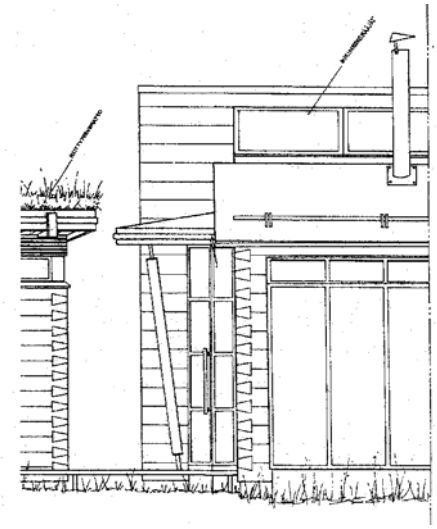
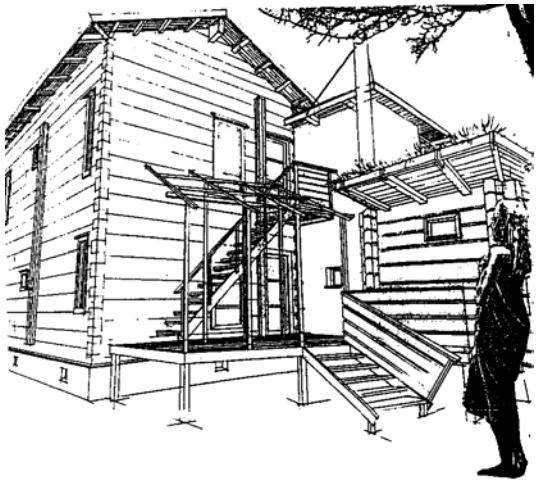
[1] Jari Heikkilä 2001.

entries of the competition students had searched for possibilities for modern log architecture. The solutions open new possibilities for log houses in urban single-family housing areas. In most entries the problems of general validity of standardized houses has been avoided. Architect student Anna Kaisa Laurila won the competition with her entry, “Kiefer”. The log volumes were clear and simple despite the richness of the courtyard milieus. The entry was structurally realisable and suitable for log construction. The openings were especially successfully composed.

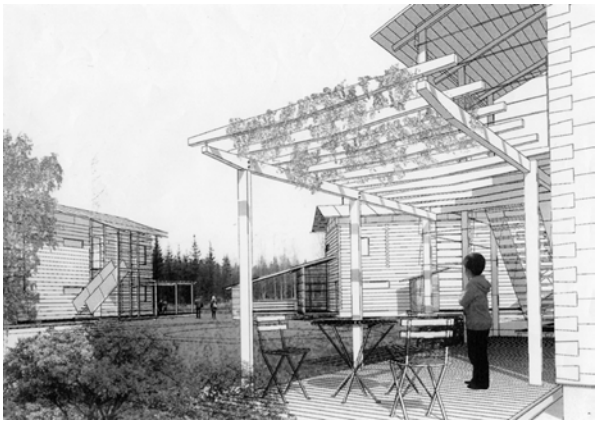




Pictures 7 and 8. Samples of prize winning entries of Suomussalmi log house competition. On the left, a fasade study by Anna Kaisa Laurila. On the right, a perspective view by Annaelina Isola.

An another competition was arranged year 1999 to design two-story high apartment buildings from logs for the Pyhäselkä municipality. The difficulty in the competition was to find new architecture for these types of buildings because in Finland there has not been earlier examples for over sixty years. The competition showed that log construction is also suitable for small-scale apartment houses. The entries were architecturally controlled and suitable for log construction. Log construction seemed to give no limitations for housing design. Architect student Riku Patokoski won the competition with an entry called “Illuusia” (picture). Although the basic volumes were clear the housing design was rich and varied. The simple building volumes had rich additional parts such as balconies, terraces and canopies. The dimensions of volumes and the openings were natural and controlled.

Both competition served their purposes showing guide lines for development of log houses in town environment, even though none of the entries has yet been carried out.



Picture 9. Court yard view from winning entry of Pyhäselkä log houses –competition. Drawing by Riku Patokoski.

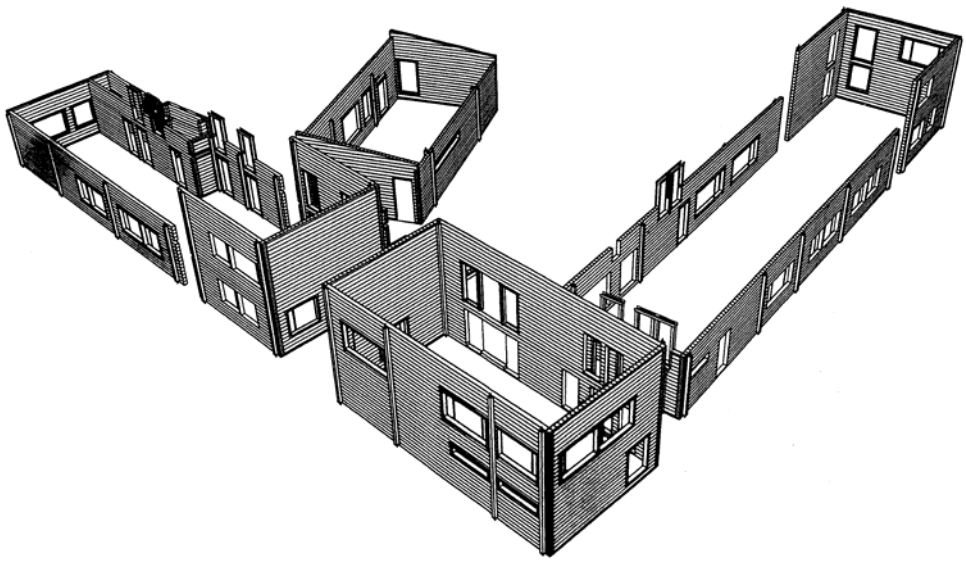
Quite recently there has been several new competitions organized for students. The Department of Architecture also arranged a competition for the design of an urban single-family house. In the best entries there was a suitable balance between tradition and modern architecture. In many entries lightweight materials and translucent wooden lattices had been brought in addition to logs. The competition showed that logs have good possibilities to become an alternative material for urban housing. Most of the entries displayed the image of a standardized house. The basic volumes in these cases were two-story high and narrow framed. It is easy to add canopies, terraces and balconies and other extra spaces to this type of volume. Architect student Marko Pulli won the competition with his entry, “Karbon”. The solution looked like a standardized house, which is suitable for many plots and different milieus. In the facades the balance between openings and closed surfaces was convincing. The light colouring of facades was considered to be suitable for urban areas. There is a good change the best entries will be carried out.

At present there is also consultation going on between Oulu university and the town officials of Oulu to get a large land area in use for experimental log housing.

4.2 Logs in modern public buildings

4.2.1 Polaria observatories

At the Department of Architecture, a new type of public log building have been designed as a diploma work. Architect Tanja Rytkönen designed the Polaria, main building of the Oulu University Geophysics Observatory and the Meteorological Institute’s Observatory in Sodankylä (pictures 10, 11 and 12). She has found the identity of the building from the local environment. The new main building is an independent public building but at the same time it is a village-like composition made from box-like log units. A protective continuous roof covers all the different parts of the building. The simple log volumes are combined with contrasting materials like copper, steel and glass. The detailing of the building is modern. Building was finished 2001. Total floor area is 1350 m2. Total costs were about 1,7 million euros (1180 euros/m2).

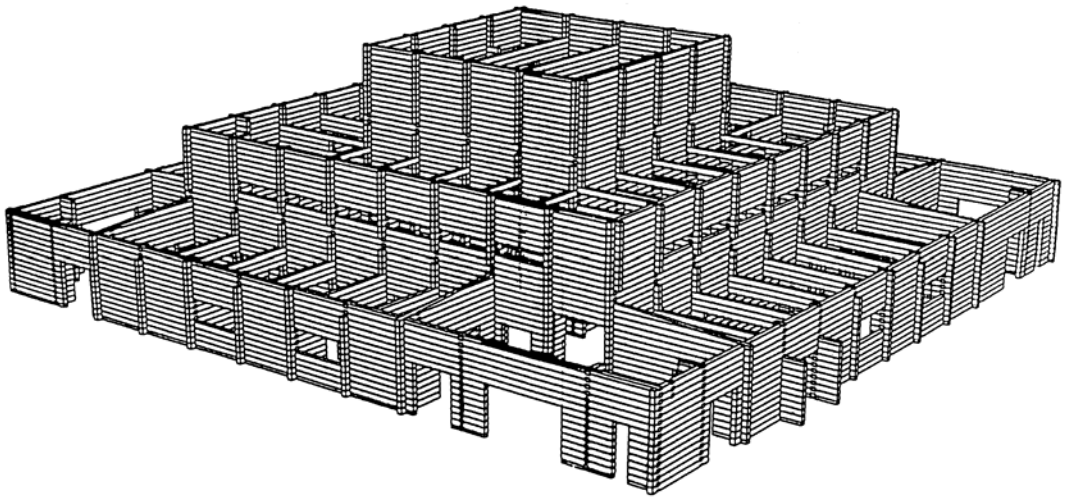


Logs in a publig building again.

Pictures 10, 11 and 12. Above, the log frame of the Polaria observatories in Sodankylä. Below views of the finished building, photos Tanja Rytkönen.

4.2.2 Kierikki Centre

The largest new log building in Finland (propably also in Nordic countries) has been built in Kierikki in Yli-Ii. The municipality of Yli-Ii arranged an open architectural competition in 1999 for the design of an activity and visitor centre for the unique archaeological treasures of the area. Professor Reijo Jallinoja won the Kierikki Centre competition with an entry called ”Miilu”. The competition jury considered the fortress-like log building as ingeniously simple and Finnish. In the Kierikki Centre industrial logs have been used in a modern way and on a huge scale. High log walls give an extremely strong feeling of massive wood to the interior of the building. Building was finished 2001. Total floor area is 1040 m2. Volume of the building is 6450 m3. Total costs were about 1,6 million euros, from which the costs of the log frame was about 740 000 euros. Follow-up research of the construction work was done in Oulu university by architect Janne Jokelainen[1].



Pictures 13, 14 and 15. The log frame of the Kierikki Centre. Below views of the finished building, outside photo by Jari Heikkilä, inside photo by Janne Jokelainen.

[1] Janne Jokelainen: Kierikkikeskus, rakentamisen seurantaraportti (Kierikki –center, follow-up research of the building process). University of Oulu, Department of Architecture, 2001.

4.2.3 An new church with old building methods

Another competition for the students was arranged for the design of the Kärsämäki wooden church. At the location there had been an earlier church which was built 1765 and demolished 1841. According to the ideas of the special researcher, architect Panu Kaila, the church had to be built with the construction methods of the 1700s but the architecture had to be modern. New architecture was wanted with old methods – not neo-old architecture with new methods. The wood material could be hand-hewn or hand-sawn logs or another type of timber. The best entries showed the kind of austerity and archaism that is typical for traditional wood architecture. Architect student Anssi Lassila won the competition with an entry called “Kantaatti” which was based on traditional log construction and shingle claddings. The structural and material solutions were a good basis to utilize the old constructing methods. The church has a heart made from hand-hewn logs and a black raincoat made from shingles treated with tar. For this purpose some 60 000 hand carved shingles are needed.

Picture 16. Official Logo of the church project, showing the form of the building designed by Anssi Lassila.

Building work comprises the following work phases:

- Resinating the trees
- Soil exploration

- Chopping down of European aspens for shingle making
- Forging of nails
- Chopping down of framework timber
- Hewing of logs
- Making of square timber and shingles, sawing of boards
- Tar burning
- Making of doors and windows of resinated wood
- Assembling of the building stage by stage
- Finishing the church
- Constructing the parking place
- Blessing of the church

Picture 17. View from the construction site of the Kärsämäki church in summer 2001. Photo, Risto Suikkari.

Work was started in the beginning of year 2000 and will be completed at the end of year 2003. The cost estimate is about 840 000 euros.

The church project has became a large cultural and educational project teaching wood handling and producing teaching material. Work is done by voluntary labor under guidance of few professionals. Everyone who is interested can take part in the work. Many foreign student groups has taken part into building process.

5. Problems and issues for further research and development, conclusions

5.1 Physical function:

The *breathing* of log structure, the behaviour of air flow and moisture, is an item which needs more investigation. At present there are only believes based on experience and image, not in actual knowledge.

5.2 Shrinking and depression:

In old log buildings, fresh logs were used because they were easier to pile. Depression and shrinking together of hand hewn log structure in vertical dimension is between 2 and 5 cm/meter of wall[1]. That caused no harm, because buildings were usually left without façade boarding for over two years. In industrially produced logs there is practically no shrinking involved, because the material is much drier. There is still some deformation in the structure, caused by depression of the joints. In modern log structure the deformation in vertical dimension is approximately 1 cm/m. The modern trend to make the building process more and more faster giving no time to the structure to depress before attaching the facade boards and additional building parts may cause some problems. Typical problem in modern log structure is, that the joints are made too tight to allow the hole structure to depress equally. Some parts of the wall may become hanging from the joints allowing air gaps to occur in the wall.

5.3 Deformation caused by changes in humidity during the building process:

Changes of humidity at the construction site has caused some problems with modern massive timber elements. The product is dry enough when coming to the site, but during the construction the elements may suck some moisture. Afterwards cracks become visible in the joints. This is more a cosmetic problem.

5.4 Energy economy of log structures:

Energy economy of log structures needs more investigations. Log structure is a massive structure which takes longer time to become warm but holds the heat inside material also longer. Standard u-value of insulation is not a reliable indicator when dealing with log structures. Some other measurement should be developed. Energy economy is also related to air flow, temperature and moisture in the building.

5.5 Architectural expression:

Architectural means, expressions of modern log building should also be developed. People are more and more concentrated in town-like environments. Expression of modern log construction in these environments can not based on images of leisure cottages and farm house architecture of past times.

Important factors dealing with modern log construction to be used in town environment can be put in a form of seven thesis[2]:

- Logs should be used as a simple massive structure so that the logs are both exterior and interior surface material, load bearing, and at the same time thermal insulating material. Logs must be thick enough to allow this.
- Logs should have straight hewn sides. Round logs should be left to leisure time products and to countryside buildings.
- Short corner joint adaptable to industrial production should be created.
- It should be possible to connect large openings and windows with log structures. These could be made between independent chest-like log structures. This way there can be variation of openings and solid walls characteristic to log structures.

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[1] Risto Vuolle-Apiala: Hirsitalo (The log house), Jyväskylä 1999.

[2] Based on a list made by Jari Heikkilä in Oulu University 20.5.2000, after experience and analyses of first student competition projects promoting log housing in town environment.

- Methods joining windows and openings to log structures should be developed instead of traditional boards put over the joints. Systems allowing some depression should be developed.
- In modern log construction combinations of light structures, like steel, glas and different plates, should be accepted. For this purpose joints allowing some compression should be developed.
- Massive wooden horizontal structures developed in Center Europe should be adapted to Finnish log structures. This would open a totally new view into marketing opportunities and export.

In addition, long term durability achieved by means of structural protection must be remembered when developing log structures. The house must have a correct roof, proper eaves and high enough base.

In spite of some development work and research still to be done, logs are an ecological and a usable material, which gives new possibilities for wood architecture. The technical skills of log construction have been mastered. With skilful and high-quality design it is possible to create modern log architecture. Modern single-family and row houses and small apartment and public buildings can be designed from logs. Modern log construction must reflect the