Saimaa University of Applied Sciences
Technology, Lappeenranta
Double Degree Programme in Civil and Construction Engineering

Gennady Podolskiy

DEVELOPING THE LOG FRAME COST ESTIMATION TOOL

Bachelor's Thesis 2010

ABSTRACT

Gennady Podolskiy
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Saimaa University of Applied Sciences, Lappeenranta
Technology, Degree Programme in Civil and Construction Engineering
Tutors: Tero Liutu (SUAS), Aatos Keskitalo (Pellopuu Oy)

The aim of the thesis is to develop a program to estimate the cost of construction of external walls of wooden buildings at the stage of the tender. This work was written in Pello, northern Finland, commissioned by the Pellopuu Oy company.

The main reason for choosing this topic for the thesis is the reduction of time spent on the calculation of the cost of a log frame of the building. This means an increase in profits for the company. In the development of the program Microsoft Office Excel spreadsheets in conjunction with Visual Basic third-generation, event-driven programming language and integrated development environment (IDE) from Microsoft were used.

The program tool is able to determine the amount of running meters of logs for wooden walls and the cost for it. As a final result, the program displays the costs of log walls with different types of log profiles selected by the user. Therefore the user can easily compare costs and choose the best variant of a log profile to use. The tool was made according to the Pellopuu Oy's requirements: the high level of calculation accuracy and reducing the time spent in comparison to the manual method of calculation.

In the end of this thesis a comparative analysis of manual and automatic account methods was made. The differences in time spent was in average 30%. Using the log frame cost estimation tool Pellopuu Oy can increase their log house production from 350 to 455 houses per year. Also the company can save 33,000 € on the time spent for the production of 350 houses per year.

Keywords: cost, log wall, log house, programming, spreadsheets, time costs.

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APPENDICIES

1 INTRODUCTION

Lapin Punahonka Pellopuu Oy company gave me a place and an opportunity to write the thesis connected with the manufacturing of log houses, holiday houses, outbuildings, saunas, planned logs and laminated logs in various profiles. The company has long traditions in the field of log processing: over 50 years of experience in log buildings, and their traditional know-how stretches beyond 100 years.

Pellopuu is a modern log house factory located in the core of a red-hearted pine growth area. The house factory and company headquarters are situated in the village of Turtola, which lies on the banks of the Tornionjoki River, Finland.

The company uses red-hearted pine as a raw material for the production of the wooden buildings. That is why Lapin Punahonka - red-hearted pine, is the name of a trademark of the Pellopuu Oy company.

Lapland's red-hearted pine has grown slowly into tight-grained wood in northern Scandinavia; experts value this pine worthy of hardwood. Over the years, the red-hearted pine does not weather like pine that has grown quickly in lush areas, but reddens beautifully, as its name suggests. The slow growth rate and the large proportion of heartwood causes this effect. Even in extreme conditions, red-hearted pine cracks considerably less than an ordinary log. Moreover, the sagging of timber, which happens in log cabins over the years, is of minor effect in red-hearted pine compared to ordinary log. That is why it is a unique and a truly lasting building material.

Modern production lines, highly skilled personnel and knowledge of life of the northern forests make products of the company well known and having a great demand in both the domestic and foreign markets. Approximately 350 buildings are produced annually, and 80% of these are exported (Pellopuu Oy).

That is why the company is considered as one of the five largest woodworking companies over the Arctic circle.

To succeed in the field of timber production in the future Pellopuu Oy constantly raises the level of technical equipment, the quality of manufactured goods and professional level of personnel. Thesis' topic is related to one of these improvements.

By the time of writing the thesis the global economic crisis has almost passed. Therefore supply and demand for all kinds of goods and services has started to grow. Building industry has been no exception. It's turn, Pellopuu Oy has received more orders and has been increasingly involved in tender competitions.

Tender is "competitive form of placing orders for goods, services or works on pre-announced terms of documentation, in terms agreed on the principles of competition, fairness and efficiency. The contract signed with the tender winner…" according to (Wikipedia, Tenders, 2010). Thus, participation in the tender competition is not a 100% guarantee of a signed contract.

The chances of obtaining the contract mostly depend on the performance of cost calculations in the shortest possible time. The lowest cost of a log house does not mean that the contract will be signed. The effectiveness is supposed to be caused by usage of the modern methods and technologies in building industry. Changes of the building elements for being more modern and quality are being taken into account at the tender competitions. The time spent on the building is also of great importance. Due to all of these options only the best participant wins the tender competition.

The aim of this work is to develop such a program that will be able:

- to calculate the cost of a log frame for a short time

- to select and change building log profile

- to define the optimal price for a log frame.

To succeed the aim of the thesis the following tasks are made:

- researching problems of manual calculation of the building log frame

- developing a tool-assistant to make the cost calculation easier

- testing the software by making calculations of a new order

- making a comparative analysis of manual and automatic log wall price account.

In the development of the log frame cost estimation tool the Microsoft Office Excel spreadsheets program in conjunction with Visual Basic third-generation, event-driven programming language and integrated development environment (IDE) from Microsoft were used.

The main supervisor of this thesis is Aatos Keskitalo - a civil engineer and sales manager from Pellopuu Oy. Kari Pasma, Henrik Eero and Esa Virtanen helped with practical and technical issues. Also, Tero Liutu and Kirsi Taivalantti participated in this thesis work as supervisors from Saimaa University of Applied Sciences. Using the chance I would like to thank all above-mentioned persons and my chief - Armas Kristo for giving the opportunity to make this work.

2 OBJECTIVE

At the first phase of studying the problem of the cost estimation of log house external walls held acquaintance with the manual method of calculation. The account formulas, sources of used values for the calculation and normative databases were studied in the process of familiarization techniques of manual accounts.

Manual method of determining the cost of the log house frame was a compilation of tables in the Microsoft Access format (Figure 2.1), which were filled with the following columns, reflecting:

- "ID" (identification number of the calculated material) - this number is used to group materials by intended use. Depending on the ID materials are divided into:

    a. Logs

    b. Supplementary items for log wall

    c. ...

    r. Nails and screws.

- "Name of the material" - the name of the used material or purchased products, components, products

- "Unit" - a unit of measurement of the material

- "Number" - the physical volume of material, products, parts or production

- "Price" - calculated rate of money supply is determined by the formula "price multiplied by the number" in euro. Price of material, products and details contained in the regulatory databases.

All of these indicators, except for the column "Number", are filled in automatically.

There were normative values for calculating the cost of external wall frame of wooden houses, they were in electronic normative databases, presented in the form of spreadsheets. Such bases were designed to facilitate the preparation of the calculation, but only allowed the user to make the final document manually, selecting materials, product parts and products. They did not have an automated way of calculation, the logical connections - formulas between parameters, forcing the engineer to consider such links manually.

Figure 2.1 Access table example.

The process of cost estimation of external walls - hereinafter referred to as frame of wooden buildings, depending on the profile of log, is subject to drawings approved by the customer, and when all conditions pertaining to the configuration of the building specified. This evaluation for medium complexity objects is performed manually and takes approximately 2 to 6 hours. In the case of more complex objects, the amount of time spent can be changed up to several days.

In order to reduce the cost of the project, it is sometimes necessary to replace materials. In this case, the substitution of one material to another required a repetition of the manual recalculation with the new material.

Company's managers had to recalculate the cost of the object, when the customer changed the configuration of the building, which led to an increase in the use of time. Most of these changes touched the log parameters, the height of the log exactly.

One-third of the wooden house total cost is occupied by the external log walls. The calculation of the external walls cost is the most complex process, therefore time spent for such calculation is much more than the valuation of any of the remaining parts of the building. Over 50 percent of the time costs are expenses for the calculation of the external walls cost.

Therefore, time spent depends a lot on the following major factors:

- the complexity of the configuration of the building

- the replacement of building elements (critical in case of changing the log profile).

These factors are extremely important and should be considered in the development process of the cost estimation tool developing. It was also necessary to identify additional important parameters that could improve an existing manual method of calculation. Information about these parameters could be obtained only after consideration and the analysis of the log walls cost estimation of the wooden houses completed manually.

Considering an example of manual accounts external walls cost of the house model Kartano 1 the main stages of the assessment highlighted:

- The analysis of the existing drawings

- The designation of all walls of the building frame

- Selection of the type of main box frame

- Marking the heights of walls on the section drawings

- The separation walls on the simplest elements

- The measurement of dimensions of the simplest elements

- Running meters calculation

- Cost calculation.

These stages are common for calculating the log frame of any house. That is why each of them will be discussed more in detail in the following sections of this work.

3 MANUAL CALCULATION

3.1 The object of study Kartano 1

As an example for the manual cost estimation of log frame for the wooden building a simple object was chosen. The model of the building called Kartano 1 - one of the last projects of the Pellopuu Oy company. This example was reviewed to show the basic principles of the log frame calculation, the later used them in the software application.

Figure 3.1 Render of the Kartano 1 model house. (Pellopuu Oy's Brochure)

Model Kartano 1 (Figure 3.1) one-story wooden residential house, intended for one family. The plan is rectangular in shape. Building consists of a living room connected to the kitchen, two bedrooms and two bathrooms, one of which has a shower and sauna inside. Also there is a fireplace to heat the building inside.

3.2 Analysis of drawings

The manual calculation algorithm described in this section is based on an actual customer practice. Under the Executive the investigated enterprises are understood.

Assumed that the client provided only the drawings (Figure 3.2, Figure 3.3), with comments.
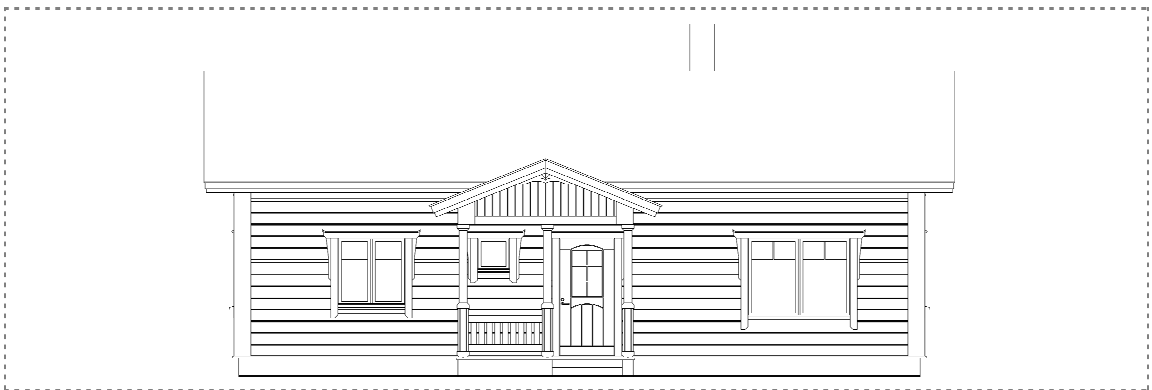

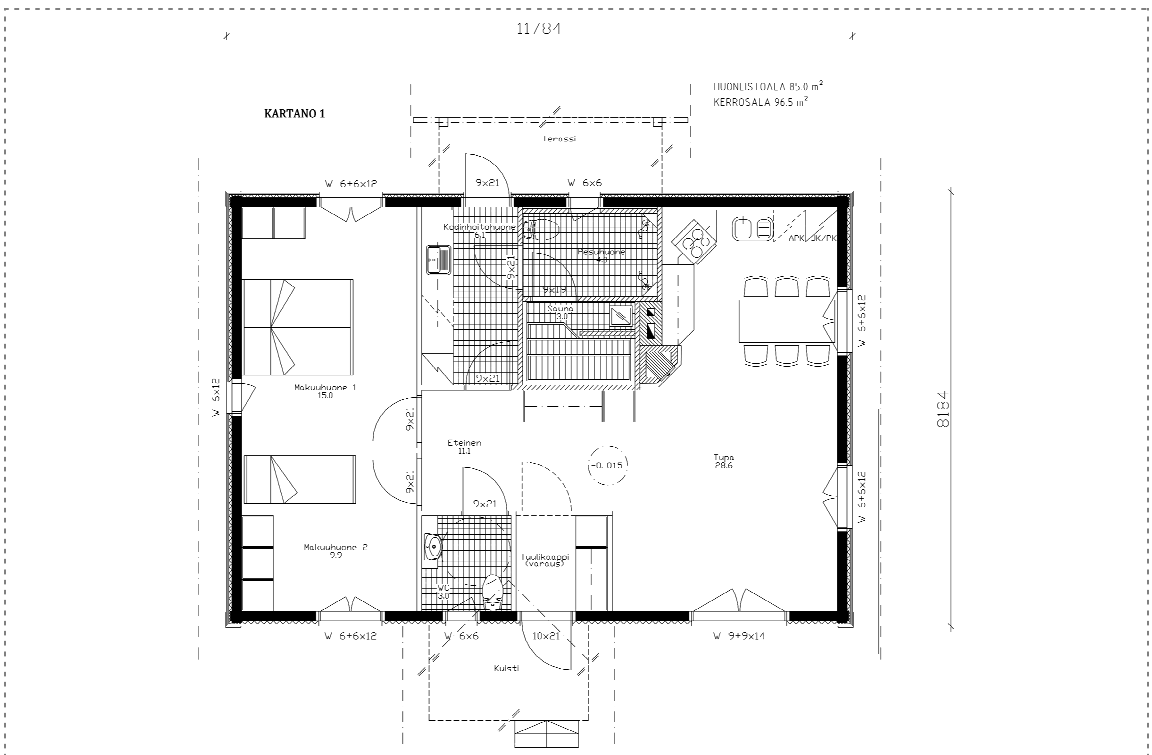Figure 3.2 Front facade drawing of the building Kartano 1 model.

Figure 3.3 Plan drawings of the building Kartano 1 model.

Often the customer sent an electronic version of drawings in a picture file with the extension JPG, PNG or PDF.

To estimate the cost a printed version of the electronic drawings was required. That is why drawings are printed in a certain scale. Often the printed scale does not coincide with the needed one. In this case the estimator changes the scale of the copy and prints it in the required scale.

It also happens that the customer has sent the drawings in a file with DWG extensions. This option is most appropriate, because for printing a drawing amendments is not required, which reduces the time spent for the work.

The most appropriate scales:

- scale drawings for the planned facility is 1:100 and 1:50

- scale drawings for the facades and sections is 1:100

3.3 Walls' designation

The designation of the walls was made to ensure that none of the walls or log areas have not gone unnoticed.

The marking was initially horizontal and then in vertical directions. In case if the building has a wall located at an angle differ from the right, such walls are indicated by latter. This process is performed on the drawing plan of the building. (Figure 3.4)

Pellopuu Oy has used only the letters of the alphabet for the walls designation. The letters' outline coincident or similar to the Arabic numerals was not used.
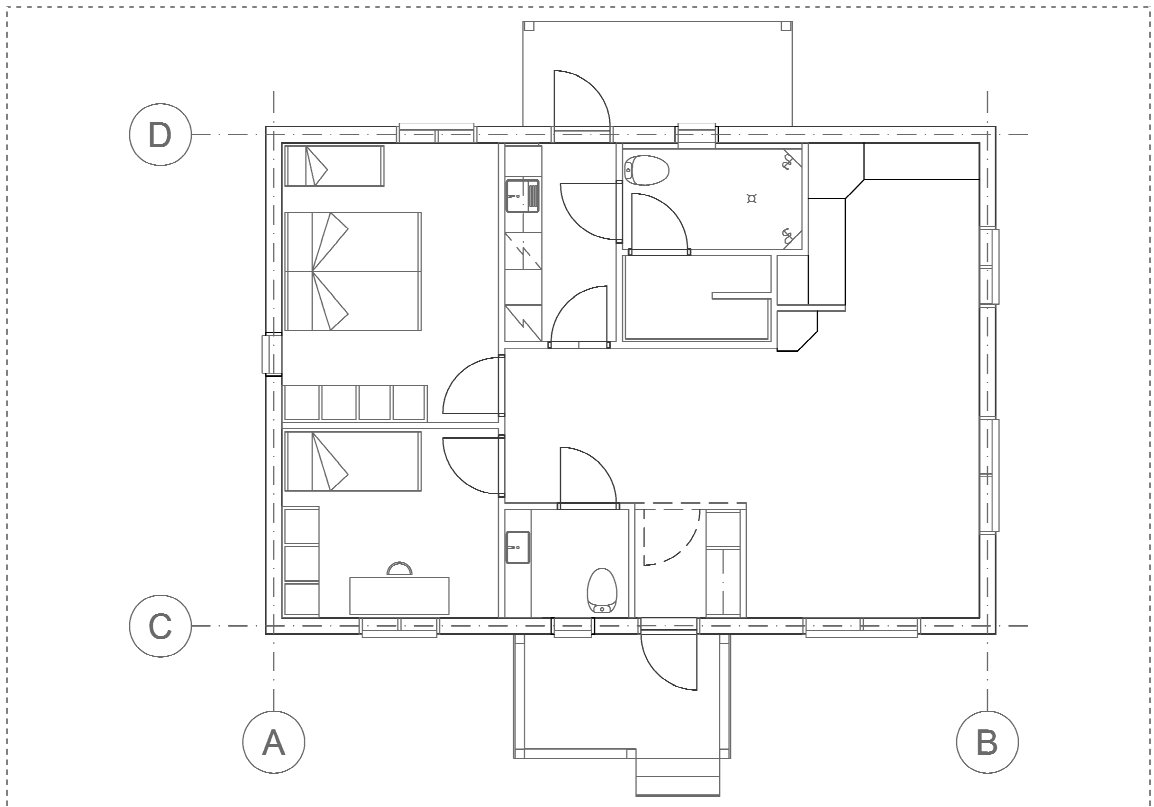
Figure 3.4 Walls' designation.

3.4 Walls' height marking

Marking the wall height used to determine the total number of logs used for the construction of the building.

At the request of the customer the log profile used in the example was Laminated log 88x170 mm. This log had a net height of 160 mm.

In this example an assumption was made. The lower part of the wall bounding the room and the upper portion of the wall bounding the attic was entirely built of logs. Such assumption was made to cover all possible configurations of the wall in the calculation using the developed program.
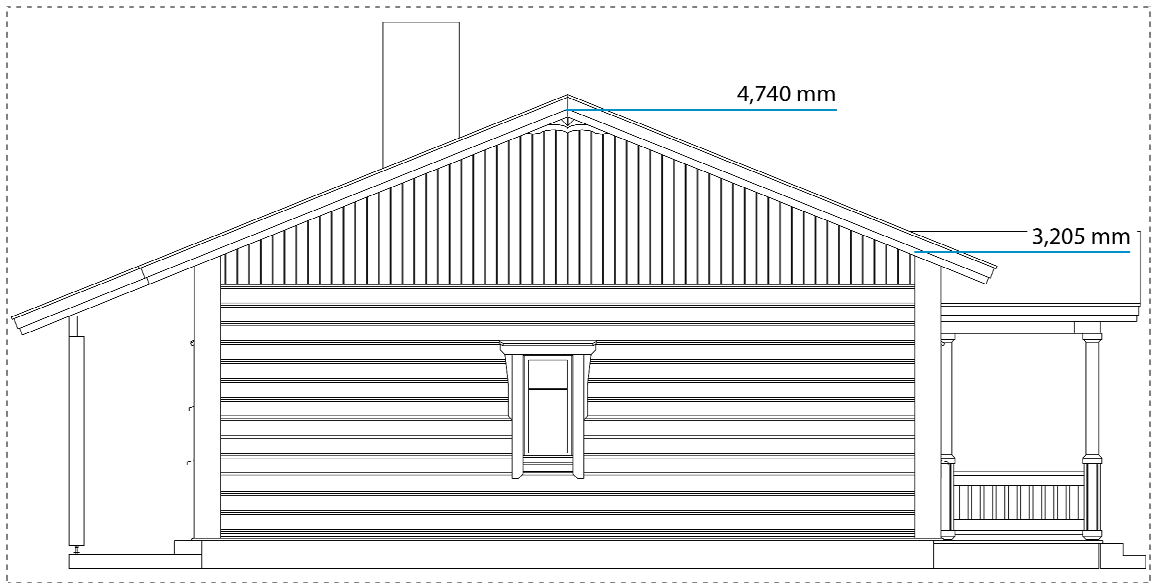
Figure 3.5 Side wall drawing of the building Kartano 1 model.

The height of the wall from the foundation to the ridge was 4,740 mm (Figure 3.5). The height of the rectangular part of the wall was 3,205 mm. Therefore, the height of triangular part of the wall was 4,740 - 3,205 = 1,535 mm.

- the height of the rectangular part of the wall $3{,}205/160 = 20.03 \; pcs$, rounding obtains 20.5 logs

- triangular part of the wall consists of $1{,}535/160 = 9.59 \; pcs$, 10 logs.

Thus, a result of 31 logs on the side walls was received.

3.5 Main box frame

There are two possibilities to build a log wall:

- Triangular wall part made of logs

- Triangular wall part made of wooden panel.

In the first case the cost of the logs running meters calculated with triangular wall part, otherwise the cost of wooden panel is not considered in running meters calculations.

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After selecting the triangular wall part type, the places and the number of half logs should be chosen.

To connect the walls and to ensure the rigidity of such connection during the house construction a log bonding is made. To make the log bonding possible, one of the walls must be started with a half log. Since the half log is a full log divided into two parts, then its cost estimates as for the full log.

The wall with the half log selection is based on economic considerations. If you select the shortest wall, in this case, taking into account the additional half log, the amount of running meters for the entire frame is increased slightly compared with the choice of a long wall. Most often, due to the buildings' rectangular shape the shortest walls are side walls, therefore a half log is arranged into them.

In this example of a manual method calculation each wall has one half log in their rectangular parts.

3.6 Wall simplification
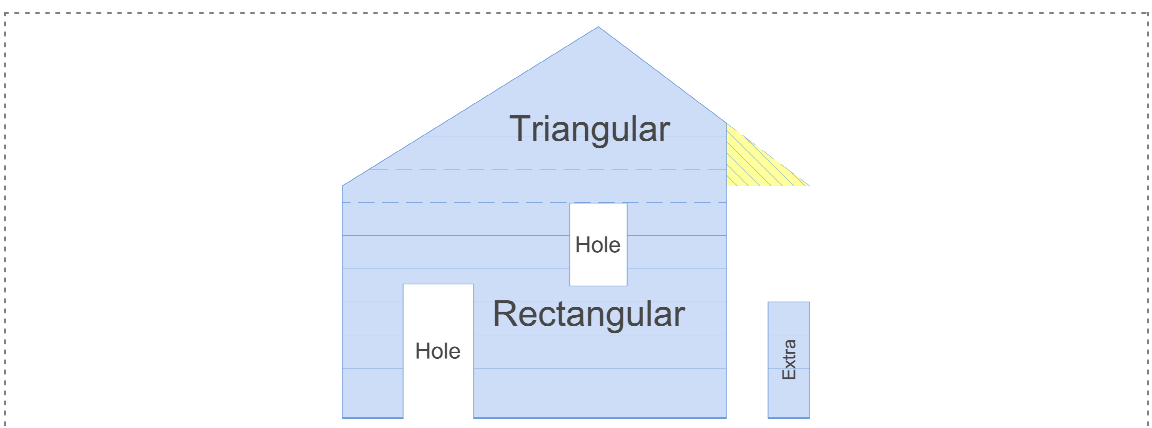
Figure 3.6 External wall separation.

After marking the walls and determining the number of logs, each wall separation is produced the simplest elements (Figure 3.6), such as:

- the rectangular part of the wall

- the triangular part of the wall

- holes

- extra.

3.7 Measurement

The measurement of the horizontal and vertical dimensions of each simple element of the wall:
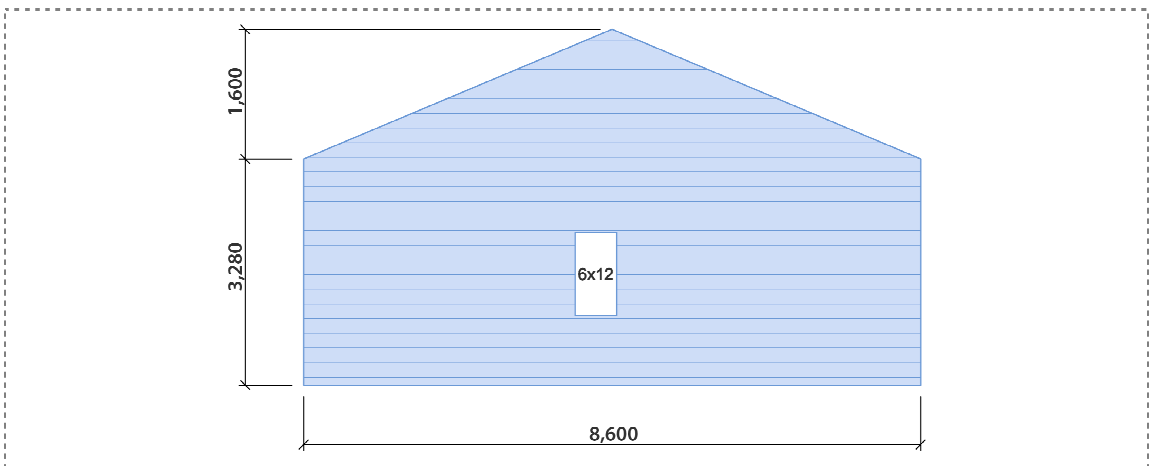
Figure 3.7 Side wall marked A.
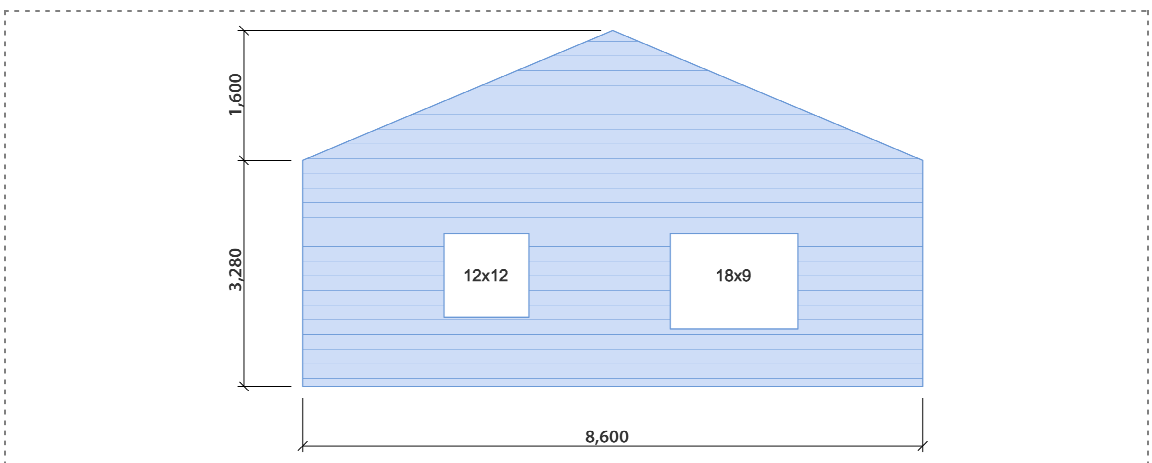
Figure 3.8 Side wall marked B.
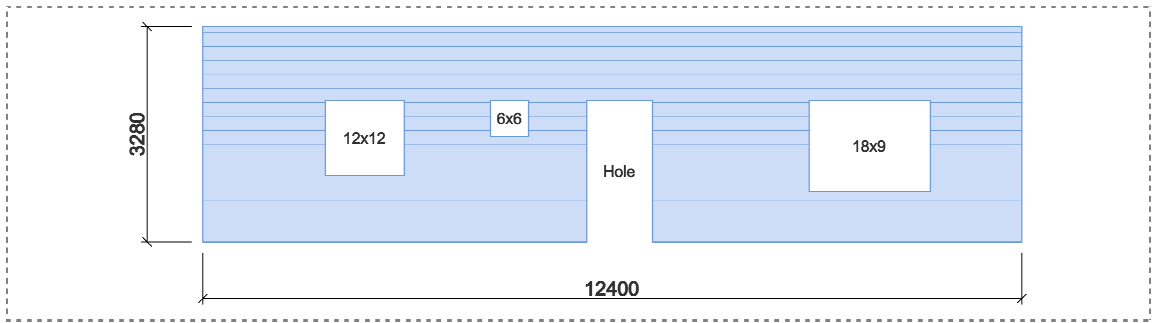
Figure 3.9 Face wall marked C.
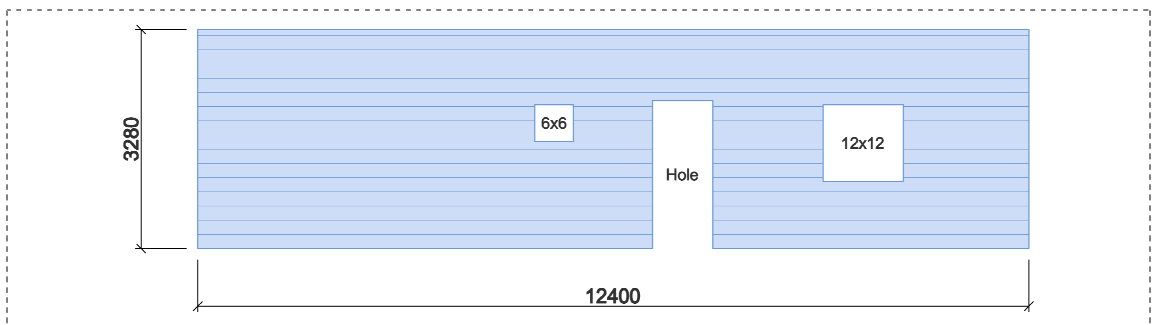
Figure 3.10 Back side wall marked D.

Note: The dimensions of the walls are in meters, the size of holes are listed in dm.

3.8 Running meters' calculation

The calculation of running meters of logs is produced according to the formula:

$$RM_{total} = \sum RM_n \quad (2.1),$$

$$RM_n = L_R \cdot A_R + (L_T \cdot A_T)/2 + \sum L_{E,i} \cdot A_{E,i} - \sum (L_{H,i} + D) \cdot A_{H,i} \quad (2.2)$$

where,

n - letter of the wall

RM_{total} - total amount of running meter of the n-th wall, rM

RM_n - amount of running meter of the n-th wall, rM

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L_R - length of rectangular part of the *n*-th wall, m

A_R - log amount of rectangular part of the *n*-th wall, pcs

L_T - length of triangular part of the *n*-th wall, m

A_T - log amount of triangular part of the *n*-th wall, pcs

$L_{E,i}$ - length of extra *i*-th part of the *n*-th wall, m

$A_{E,i}$ - log amount of extra *i*-th part of the *n*-th wall, pcs

$L_{H,i}$ - length of *i*-th hole of the *n*-th wall, m

D - T-molding width if required, m

$A_{H,i}$ - log amount of *i*-th hole of the *n*-th wall, pcs.

Note: Some summands in this formula may not be necessary in particular cases.

The amount of log running meters for walls is assumed to be 21 because the half log is ordered in the production as a full log. In the calculation, the amount of logs for building frame holes is carried according to the formula (4.11, 4.12), as specified in chapter 4.6.5.

$$RM_A = 8.6 \cdot 21 + (8.6 \cdot 10)/2 - (0.6 + 0.1) \cdot 7 = 218.7 \ rM$$

$$RM_B = 8.6 \cdot 21 + (8.6 \cdot 10)/2 - (1.2 + 0.1) \cdot 7 - (1.8 + 0.1) \cdot 8 = 199.3 \ rM$$

$$RM_C = 12.4 \cdot 21 - (1.2 + 0.1) \cdot 7 - (0.6 + 0.1) \cdot 3 - (1.0 + 0.1) \cdot 12 - (1.8 + 0.1) \cdot 8 = 220.8 \ rM$$

$$RM_D = 12.4 \cdot 21 - (1.2 + 0.1) \cdot 7 - (0.9 + 0.1) \cdot 12 - (0.6 + 0.1) \cdot 3 = 237.2 \ rM$$

$$RM_{total} = 218.7 + 199.3 + 220.8 + 237.2 = 876.0 \ rM$$

The price for one running meter of Laminated log 88x170 mm was 17.8 € according to the company.

Total price for 876.0 running meters was 15,592.80 €.

Time spent on the manual method of calculation 1 hours and 30 minutes.

3.9 Manual method summary

All data obtained as a result of the stages described in sections 3.1-3.8 of this thesis for the basis for the manual method of the cost estimation of external walls of the house model Kartano 1.

During the study the manual method considered the main stages of running meters amount calculation, the types of an existing main frames, wall and contemplated the simplified wall elements. All the data were analyzed for their subsequent use in the automated calculation.

The measurements of the actual time costs for the preparation of the cost calculation of the frame of the log house Kartano 1 model were carried out to the compared with the automated method.

These studies showed that 1 hours and 30 minutes were needed to prepare the final calculation. Revealed that the manual method of the existing calculation did not satisfy next requirements of the company:

- the company required calculation conduct in short time at the stage of tender

- a permissible error in calculations of the cost in monetary terms should not exceed 5 percent

- the method of calculation should be trainable.

The next chapter is devoted to the research and the selection of the automated calculation method, taking the requirements of the company into account. Getting the comparative characteristics of the manual and automated methods is only possible if it is chosen according to the automatic approach for calculating the cost of the log building frame.

4 SOFTWARE DEVELOPMENT

4.1 Definition

A development of a program is a challenge. To simplify and expedite the task a methodology have to be developed. To follow to the this methodology a programmer need to know what to plan next and to control the development process.

A software development methodology is a framework that is used to structure, plan, and control the process of developing information systems. One system development methodology is not necessarily suitable for use by all projects. Each of the available methodologies is best suited to specific kinds of projects, based on various technical, organizational, project and team considerations (Wikipedia, Software development, 2010).

There are several different approaches to software development. Some take a more structured, engineering-based approach to developing business solutions, whereas others may take a more incremental approach, where software evolves as it is developed piece-by-piece. Most methodologies share some combination of the following stages of software development:

- Market research

- Devising a plan or design for the software-based solution

- The implementation (coding) of the software

- Testing the software

- Development

- Maintenance and bug fixing

The above stages are the basis and used in this study as starting points of the program development process.

4.2 Market research of existing programs

4.2.1 General

A selection of an automated method of the object cost calculation was carried out in direction based on the analysis of existing software on the market, which are connected to the wood manufacturing sector.

Once the problem had been identified, the programs already on the market had to be found. They had to be programs which can calculate the cost of wooden buildings to obtain information about the program characteristics required by Pellopuu Oy.

The World Wide Web was chosen as a source of information for existing programs allowing the calculation of the preliminary cost of the log building. Programs of various types and purpose were found on the Internet. The most suitable ones were selected among them. The basic principle of selection was the ability of the program or application to take the cost of the frame of wooden buildings into account. As a result of the research and selection, programs were divided into two groups: "simple" and "complex".

Among seven found programs the most outstanding examples were identified and described in the following chapters. Other examples can be seen in Appendix 1.

4.2.2 "Simple" programs

A lot of the programs were based on the principle "enter the area of the house and floor number - get the price" were found. Such programs were named "simple" (Figure 4.1).

Figure 4.1 Log Home Cost Calculator (Log Home Advisor)

Description of the program:

Calculating the cost of building a log house depends on how much information you have to work with. In the beginning when you have little to work with, you may want only a rough estimate of final "turn-key" cost to know whether or not you will be able to afford the log home you are considering. That is the purpose of this log home cost calculator. More accurate estimates can come later, when you have more detailed information (Log Home Advisor, Log Home Cost Calculator - Estimate Log Home Construction Cost, 2004).

4.2.3 "Complex" programs

Some companies offered so-called "complex" programs that could make the calculation of structures a three-dimensional model of buildings in addition to the cost estimation. To get a price in this case it is necessary to create a model of the entire building first.

Figure 4.2 Structural calculation software for wood frameworks (Sema)

Structural calculation software for wood frameworks (Figure 4.2) was made by Sema company.

Description of the program:

Flexible software. The special requirements of log constructions also call for very flexible software. Here SEMA offers not only an easy and a fast definition of components and special processing but also the necessary automatic features to calculate the walls efficiently. The software also generates user-friendly production plans, piece lists and, if required, machine data (Archi Expo, Products, Sema, Structural calculation software for wood frame-works).

4.2.4 Comparison of "simple" and "complex" programs

A comparative table for both of them extreme types of programs was made to determine the advantages and the disadvantages of an application and to avoid the disadvantages in the program production.

Table 4.1 Comparative table of "Simple" - "Complex" programs

Features Program	"Simple"	"Complex"
Ability to estimate the number of items and price with high precision	-	+
Ability to calculate the order for the shortest possible time	+	-
Ability to replace the elements "on the fly"	-	-
Ability to calculate the order without basement	-	+
Possibility for visual inspection	-	+
Low cost	+	-
Ability to run the program on any computer configuration	+	-
Usability	+	-
Archiving	-	+

4.2.5 Research result

Each type of the program has the same numbers of pluses and minuses. Therefore, the choice of the best program to strive should be based on the basic criteria for the selection. These are time reduction and the accuracy of the calculation in this case.

"Simple" programs significantly reduce the computation time, but have essential inexactnesses in the cost evaluation.

The pluses of the "complex" programs are in their ability to evaluate the cost of the calculated building with the high precision, but at the same time, working time is only growing in comparison with the "simple" programs.

Due to the fact that the reviewed programs did not meet the above-mentioned requirements of the company, it was decided that an own program with less

cumbersome, more rapid than the "complicated" program and more accurate than the "simple" one should be produced.

4.3 Selecting the programming environment

Selection a programming environment depends on the complexity and the requirements for the future program.

To develop the program Visual Basic programming language was used.

Visual Basic (VB) is the third-generation event-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model. VB is also considered relatively easy to learn and use as a programming language because of its graphical development features and BASIC heritage (Wikipedia, Visual Basic).

The selection of the program language was based on the following criteria:

- Visual Basic is an integrated component of the most common program - Microsoft Office Excel

- Pellopuu Oy uses Microsoft Office products for everyday purposes

- The planned development program is mainly related to the calculations, in which baseline data are indicators contained in the databases

- Visual Basic programming language allows you to develop the macros, which makes it possible to write own formulas

- Since Visual Basic is built into Microsoft Office, there is no need to install it separately

- Access to information on the Internet network about Visual Basic programming language allows Pellopuu Oy company to exploit the program without the support of the developer.

4.4 Planning

The development of a program requires a strict sequence. Therefore, programmers use a mind map method for the planning of development programs.

By presenting ideas in a radial, graphical, non-linear manner, mind maps encourage a brainstorming approach to planning and organizational tasks. Though the branches of a mind map represent hierarchical tree structures, their radial arrangement disrupts the prioritizing of concepts typically associated with hierarchies presented with more linear visual cues.

The elements of a mind map are arranged intuitively according to the importance of the concepts, and are classified into groupings, branches, or areas, with the goal of representing semantic or other connections between portions of information (Wikipedia, Mind Map).

Mind map based on manual calculation example was made (Figure 4.3), reflecting the essence of the program and assisting in the program development.
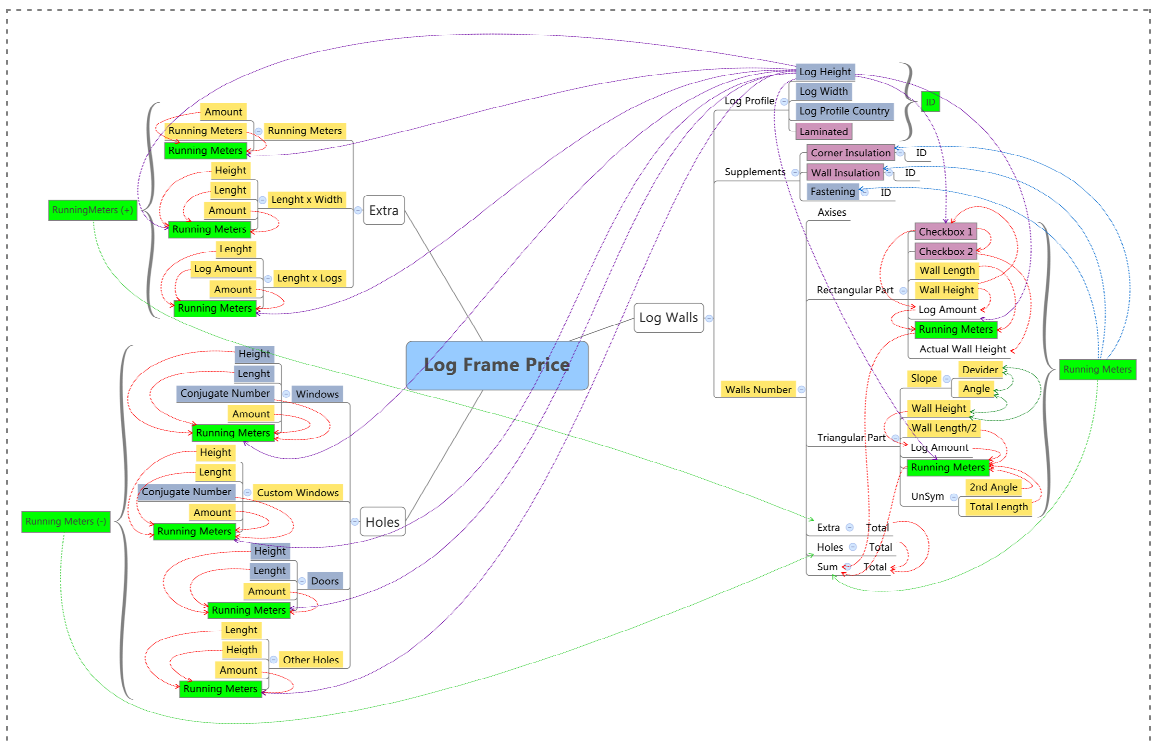

Figure 4.3 XMind mind mapping tool.

A developed mind map presented a dependency of input and output data, constituted additional connections and formulas between important characteristics.

Marking with different colors, the various forms of unilateral and bilateral relations improve the perception of a mind map and explain the relationship according to explanatory "Explanatory notes to the mind map" table.

Table 4.2 Explanatory notes to the mind map.

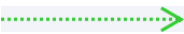| Topic	Explanation
Extra	value calculated by formula
Height	value entered by hand
Log Height	value chosen from the pop-up list
Laminated	checkbox
Running Meters	final value calculated by formula
Arrow	Explanation
·····················>	value depending by formula
·····················>	value equally transferred
·····················>	value calculated with entered data
<·····················>	mutually dependent values
·····················>	value calculated with output data

More detail mind map can be seen in the Appendix 2.

4.5 Development stages

After all introductory and preparatory works were finished the program creation process has started and have been divided into main stages:

1. Sketching stage

Sketching a preliminary user form on paper with a consideration the specifics of the interface.

2. Transferring stage
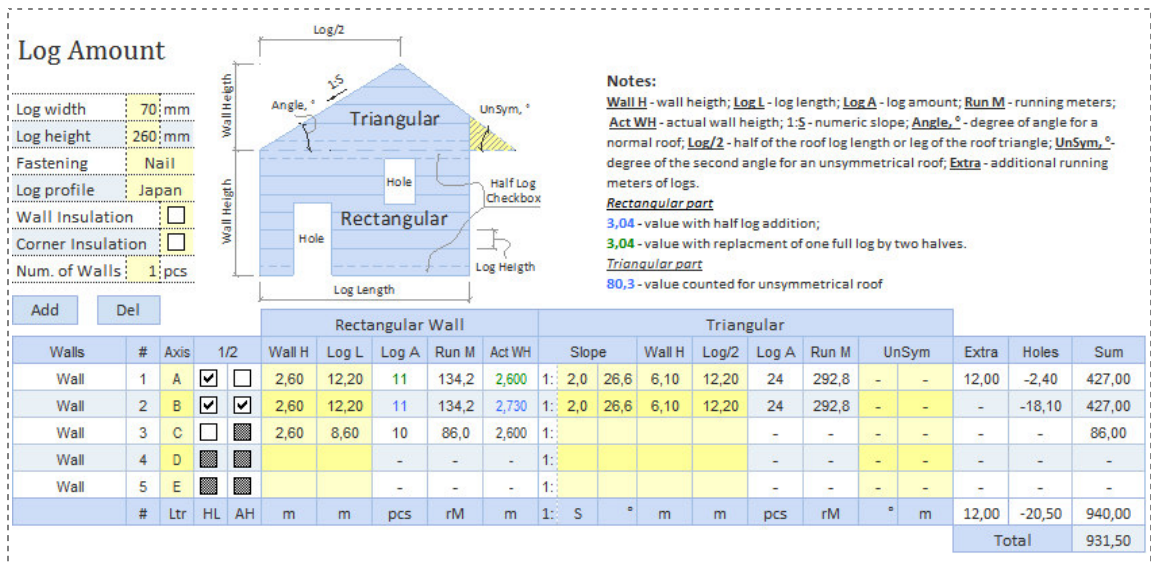
Figure 4.4 Transferring stage.

In transferring stage the main idea is to transfer preliminary sketch drawings into MS Excel program with possible corrections, entering all possible formulas and values into non-editable cells.

3. Coding stage
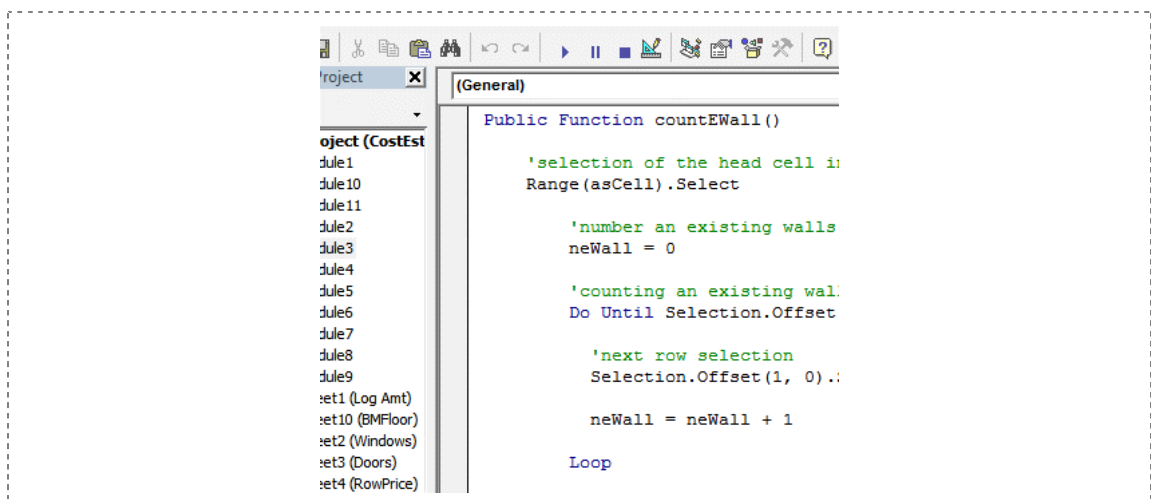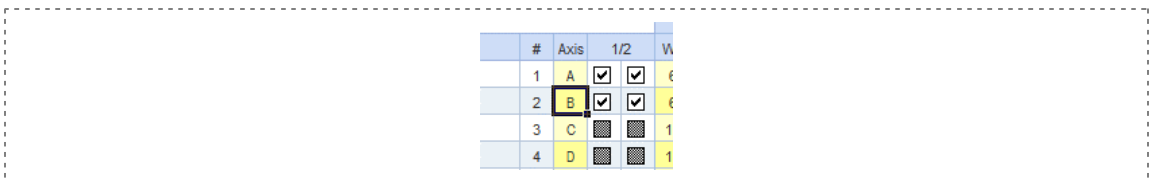
Figure 4.5 Coding stage.

Writing the code of the macros in the Microsoft Visual Basic program in accordance with the agreed plan.

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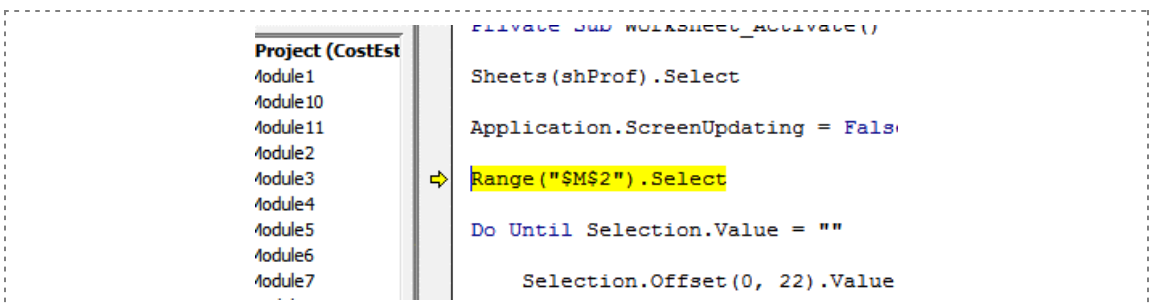
4. Testing stage

Figure 4.6 Testing stage.

The implementation of all possible actions which the user can do.

5. Debugging stage.

Figure 4.7 Debugging stage.

Error detection and correction stage.

4.6 Problems-solving methods

This chapter describes only the significant problems that have occurred in the program development process.

The main calculation spreadsheet was divided into five sections (Figure 4.6), each of which includes a certain specific partition problem and methods used to solve them.
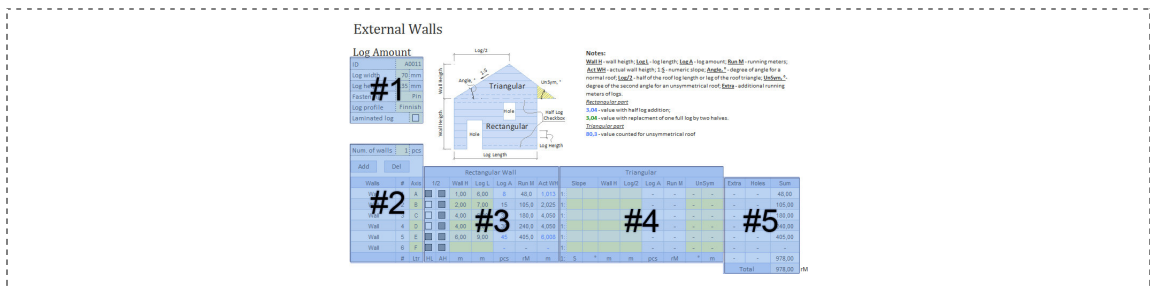
Figure 4.8 Main spreadsheet parts.

Most of the formulas in this chapter have been simplified to reflect only the basic calculations. The program formulas are more complicated, because of compliance with the integrity of the calculations and the program interface.

4.6.1 Log profile part (#1)

Section "Log profile part" provides complete information about the log profile and method of its selection.

ID number:

ID number cell has a mutually dependent relationship with log width, log height, log profile (origin) and log lamination parameters.

A cell with a value of ID number filled with the selection of values from the dropdown list, dependent on the database. In case of the ID number selection the program searches the database for available ID profiles and collects additional information about the log profile. Then the information is filled in the appropriate cells.

The program database (Figure 4.9) is based on existing databases available at Pellopuu Oy. The complete database of profiles can be seen in Appendix 3.

	A0038	HNx092x162	hirsi 92*170 Holl.prof.	14,30 €	
	A0039	HLx092x162	hirsi 92*170 L Holl.prof.	18,40 €	
	A0040	FNx118x162	hirsi 118*170	17,50 €	
	A0041	HLx088x162	hirsi 88*170 L Holl.prof.	17,80 €	
	A0042	JLx088x160	Lamellihirsi 88*170 L Jap.prof.	17,80 €	

Figure 4.9 Program database.

The reverse process occurs when selecting values from the drop-down menu for "Log Width", "Log Height", "Log Profile" (origin) cells and checking the "Laminated Log" checkbox. It means that the program looks for values of the ID number in the database and fills in the ID cell. In case of no detection of the selected values in the database, the cell ID is set to "None" value and the user should choose the values again.

This method of selecting the log profile was adopted for users who do not know the ID profile could define it by entering described information.

Problem:

To form the link between ID number and other characteristics of the log profile using VBA macros.

Solving:

To implement such a software search an additional column "Notes" was introduced in the database, which is used for marking each log profile. The method of marking is shown as:

$$FNx118x162 \qquad (4.1)$$

where,

F, H or J - first letter of the marking indicating the "Finnish", "Dutch" or "Japanese" type of the log profile respectively,

N or L - The second letter of the marking indicating Laminated or Normal log profile respectively,

118x162 - numbers show the width and height of log, respectively.

4.6.2 Wall information part (#2)

This section of the main spreadsheet concerns information about the number of walls. Also buttons "Add" and "Del" form main spreadsheet calculations described in the section.

Number of Walls:

The primary and most important cell is called the Number of Walls, because the number of walls of the building is specified and the main table is filled here.

Once the number of walls is put, the button "Add" should be pressed to run the event creating the main table with the number of entered wall-lines. The button "Del" serves to remove the walls-rows on the sheet. It removes a number of walls starting the countdown from the last wall in the table, as much as entered in the "Number of Walls" cell.

Problems:

1. Consider the number of existing walls by adding or removing the specified number of them in "Number of Walls" cell.

2. Fill or clear the table when adding or removing walls-rows, respectively.

3. To make the numbering and labeling of added walls.

Solving:

1. To take into account the existing walls by adding/removing such procedures was used as:

- "Do Until" procedure to count up the existing walls.

As a first step the selection of the first filled with "Wall" cell carried out. Afterward the next cell was selected and so on until the moment when the cell is empty. During such process the counting method was used by adding figure 1 to the counter each time when the cell was changed.

- "If" procedure used to compare the number of existing and removing walls.

If the number of existing walls is more than in the "Number of Walls" cell, then the program deletes the specified in cell wall number. When the "Number of Walls" exceeded the number of existing walls, the program deletes all the existing walls.

2. A special designation and pre-designed formula was appointed to every column in the process of filling the table. The program code allocates the cell in a new filled row and enter depending on the purpose formula. The deleting of the wall removes the row entirely.

3. To number and label marking the wall was used:

- The cycle "For" used for the numbering of the walls. The counter counted the number of walls and filled rows of the table, while its value is transferred into a column with the number of walls (with "#" label)

- The code for the alphabetic marking of the walls turned cumbersome due to the lack of distinguishing cycle. Therefore it was necessary to use the

linkage between the cycle "For", the condition "If" and the symbols of the ASCII table.

4.6.3 Rectangular wall part (#3)

This section describes the filling of "Rectangular" wall part group of the main table with the help of the program.

Checkbox 1:

Checkboxes are created simultaneously with the filling of cells by formulas. For each walls two checkboxes were created. The first checkbox is responsible for the replacement formula in a column with the "Log Amount" value, replacing the one full log by two halves. This means adding one to the value of log amount.

Program code colors for the "Log Amount" value is green for a better understanding of the formula changing.

Checkbox 2:

The second checkbox replaces the formula in the "Log Amount" column and "Actual Wall Height" of filled row in such a way that the value of log amount increases by one, that means adding a half log and "Actual Wall Height" value also increases by one half log height.

Program code colors for the "Log Amount" value and for the "Actual Wall Height" is blue for the user to notice the changes.

Log Amount:

The number of logs for a rectangular section of the wall depends on the height of this wall part, the height of the log profile and whether it is marked in the checkboxes. Calculated by the formula:

- in case the reminder of the division "*Wall Height*"/"*Log Height*" is more than zero, the formula takes the form

$$LA_R = WH_R/LH + 1 \qquad (4.2)$$

- if the reminder is equal to zero, the formula takes the form

$$LA_R = WH_R/LH \qquad (4.3)$$

where,

LA_R - log amount contained in rectangular part of the wall, pcs

WH_R - height of rectangular part of the wall, m

LH - log profile height, m.

Running Meters:

The number of running meters depends on the "Log Amount" and "Wall Length" value. Calculated by the formula:

$$RM_R = LA_R \cdot WL_R \qquad (4.4)$$

where,

RM_R - number of running meters for the rectangular part of the wall, rM

WL_R - length of the rectangular part of the wall, m.

Actual Wall Height:

The "Actual Wall Height" column reflects the actual height of the wall when "Log Amount" is recalculated. It is calculated by the formula:

- in case the wall consists only of full logs or from full logs and two halves

$$AWH = LA_R \cdot LH \qquad (4.5)$$

- if the wall consists of full logs and one half log

$$AWH = (LA_R - 0.5) \cdot LH \qquad (4.6)$$

where,

AWH - actual wall height when the "Log Amount" is recalculated, m.

Problem:

The main problem in this section was to disable the ability to mark the checkboxes in case the "Wall Height" value consisted of several number of full logs and one half log when the "Log Amount" is being recalculated. Because the wall contains the curtain number of full and one half logs, the additives are not required and the house consists of rectangular wall parts of equal height.

Solving:

This problem was solved by the method of comparison. The decimal remainder of the division "Wall Height" by "Log Height" rounded to the decimal values and number 5 (the value of half log) was compared. If these numbers are equal, the checkboxes became not active, otherwise active.

4.6.4 Triangular wall part (#4)

"Triangular" wall part chapter contains the information with which it is possible to calculate three different variations of the pediment.

<u>Slope:</u>

The slope of the roof, respectively, and the slope of the pediment may be entered in the table by several interdependent ways:

- entering the angle of the slope, °

- entering the value of steep of the slope in form of $1/S$, where S is divider entered in a table cell, dimensionless quantity

- entering the height of the triangular part of the wall at the highest point, m.

Each method is calculated only if the values of "Wall Length" are entered in the appropriate cell.

<u>Wall Height:</u>

The "Wall Height" value can be calculated by the program by entering the slope characteristics and the "Wall Length" value or it can be entered by the user who measured it from drawings.

<u>WL/2:</u>

The "WL/2" value, short for the "Wall Length/2", entered by the user and taken into account when calculating the "Log Amount", as well as slope and height of the triangular part of the wall. "WL/2" is the length of the leg of a right triangle.

<u>Log Amount:</u>

In case the pediment has same slopes on both sides of the ridge the "Log Amount" value is calculated the same way as the "Log Amount" value for the rectangular wall part by formulas 4.2 and 4.3. If the triangular part of the wall has an asymmetric roof, and therefore different slopes, then the "Log Amount" value is calculated by the formulas given in the conclusion of this subsection.

<u>Running Meters:</u>

The number of running meters for the triangular part of the wall is calculated with or without an asymmetric component. Calculation formulas are given in the conclusion of this subsection.

<u>UnSym:</u>

The "UnSym" columns reflect the additive of asymmetric part of the pediment. With the help of which it becomes possible to calculate the wall of virtually any configuration. The calculation formula and the types of possible types of the pediment was given in the conclusion of this subsection.

<u>Problems:</u>

1. The need to develop a method for various types of the triangular part of the wall.

2. The need to develop ways to calculate the interdependent characteristics of the slope of the symmetric triangular part of the wall.

<u>Solving:</u>

1. To solve this problem, at first the main possible types of the triangular part of the wall was determined:

- The symmetrical triangular part of the wall (Figure 4.10).
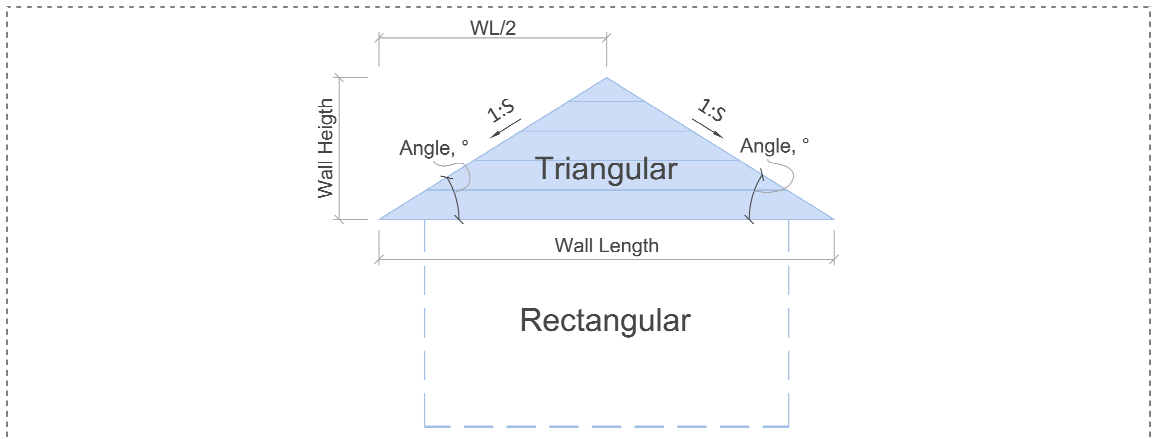
Figure 4.10 The symmetrical part of the wall.

This type of a wall has equal divider values of slope and symmetric about the vertical axis passing through the horse. The calculation of running meters of log for a such a wall are derived from the formula:

$$RM_T = LA_T^* \cdot WL_T / 2 \qquad (4.7)$$

where,

RM_T - amount of running meters for the triangular part of the wall, rM

LA_T^* - amount of logs for the pediment, rounded value of division WH_T / LH, pcs

$WL_T / 2$ - half length of the triangular part of the wall, m.

- The unsymmetrical triangular part of the wall.
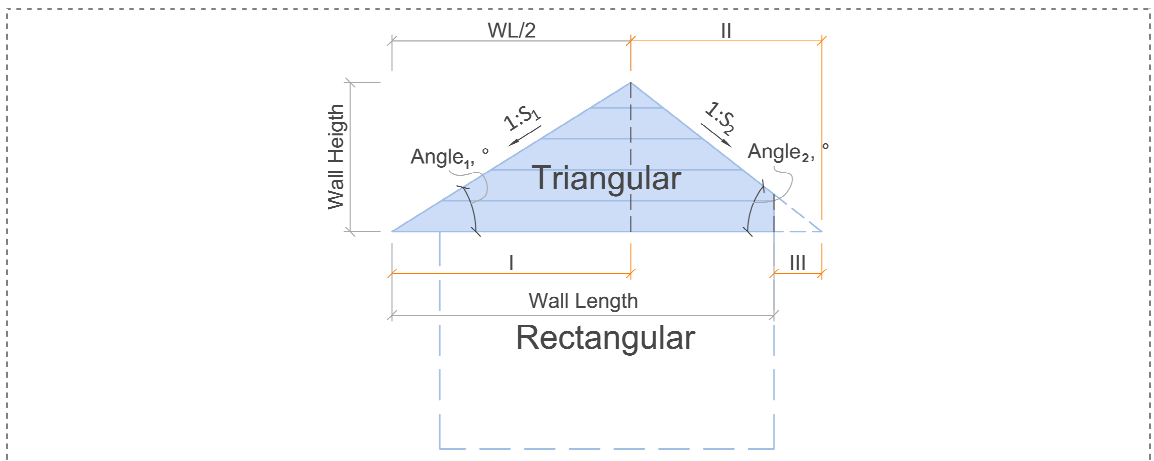
Figure 4.11 The unsymmetrical triangular part of the wall.

The unsymmetrical triangular part of the wall was divided into component parts (Figure 4.11). Then, running meters of logs for each segment were calculated, and the results were summarized according to the formulas:

$$RM_T^{Total} = RM_T^{I} + RM_T^{II} - RM_T^{III} \qquad (4.8)$$

$$RM_T^{I} = \left(LA_T^{*} \cdot WL_I\right)/2$$

$$RM_T^{II} = \left(LA_T^{*} \cdot WL_{II}\right)/2$$

$$RM_T^{III} = \left(LA_T^{III} \cdot WL_{III}\right)/2$$

where,

LA_T^{*} - amount of logs contained in pediment, rounded value of the division WH_T/LH, pcs

WL - length of the triangular part of the wall, m

WL_I - length of I part of the wall, equal to the entered in "$WL_T/2$" column value, m

WL_{II} - length of II part of the wall, equal to "$WH/tg(Angle_2)$" value, m

40

WL_{III} - length of III part of the wall, equal to "$WL_{II} - WL - WL_I$" value, m

LA_T^{III} - number of running meters of III part of the wall, calculated by the formula pcs;

$$LA_T^{III} = WL_{III} \cdot tg(Angle_2)/LH \qquad (4.9)$$

$Angle_2$ - angle of the unsymmetrical part of the pediment, °.

Using these formulas it is possible to calculate special cases of the unsymmetrical part of the wall, such as:

    a. Lean-to pediment (Figure 4.12)
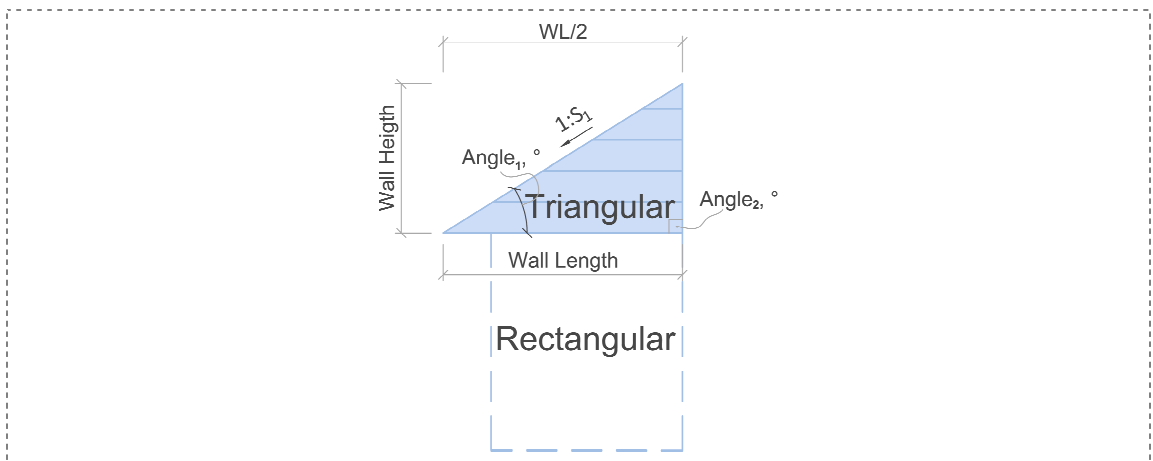
Figure 4.12 Lean-to pediment.

To ensure that the program could count the number of running meters for this pediment, information in the columns of the table on Symmetric part of the pediment must be entered, the value of the angle being $Angle_2 = 90°$ and the length of the wall $WL = WL_I$ must be specified in "UnSym" column.

    b. The unsymmetrical cutted pediment
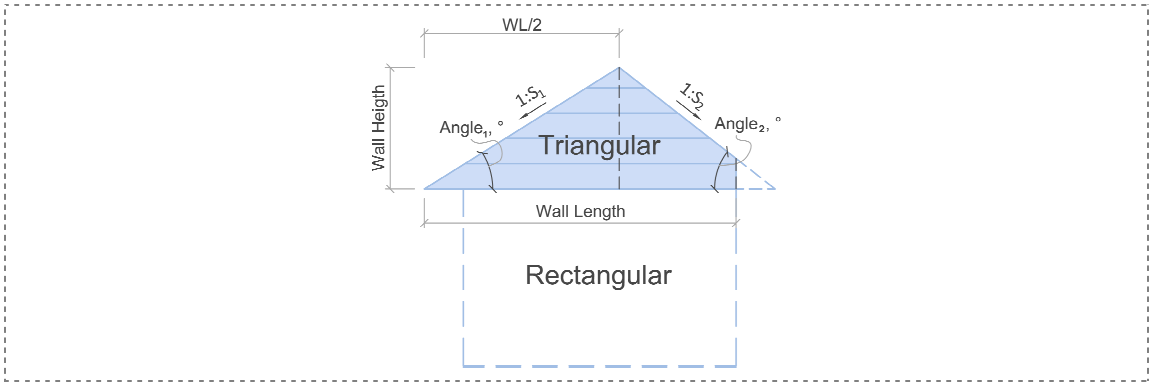
Figure 4.13 The unsymmetrical cutted pediment.

To calculate the pediment of this kind (Figure 4.13) in addition to entering information into the symmetric part of the table, it is needed to enter unsymmetrical characteristics with known boundary conditions:

- $WL < WL/2$

- $0 < Angle_2 \leq 90$.

c. The symmetrical pediment (Figure 4.14)

Figure 4.14 The symmetrical pediment.

With the unsymmetrical part of the table it is also possible to calculate the amount of running meters of logs used in the symmetrical pediment. For this calculation, the data $Angle_2 = Angle_1$ and $Wall\ Lenght = (WL/2) \cdot 2$ must be entered.

2. The solution was in the fact that the program code defines one of three cells, in which the change was made (value input) and replaced the formula in others.

- Entering a value in a cell with a steep indicator of slope $1/S$ leads to the substitution of formulas in other cells in this way:

    a. $Angle_1 = \arctan(1/S)$

    b. $WH = (WL/2) \cdot \tan(Angle_1)$.

- Entering a value in a cell with an angle indicator of slope $Angle_1$ leads to the substitution of formulas in other cells in this way:

    a. $S = 1/\tan(Angle_1)$

    b. $WH = (WL/2) \cdot \tan(Angle_1)$.

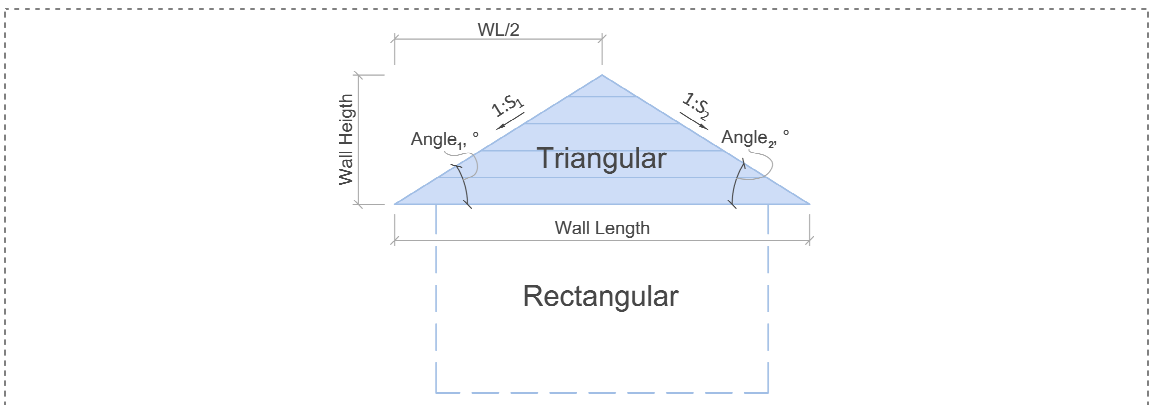- Entering a value in a cell with the indicator of height of the pediment WH leads to the substitution of formulas in other cells in this way:

    a. $Angle_1 = \arctan(WH/(WL/2))$

    b. $S = 1/\tan(Angle_1)$.

Such methods of input of the pediment slope accelerate the process of calculating the number of running meters, because it absolves the program users to calculate these parameters manually.

4.6.5 Summary part (#5)

Section "Summary part" shows the resulting number of running meters, counted, depending on the availability of the "Extra" and the "Holes" value in the configuration of the building. "Extra" logs and "Holes" are accounted on an additional sheet. Each wall has its own table for the calculation of "Extra" logs and "Holes".

Extra:

					add	del	
Wall #		2		Extra types	4		Running
Extra #			Extra		Extra Amt		Meters
1	D	1	x	0,5	3		9
2	rM		12		2		24
3	N	5	-	6	1		30
4	+	Length	x	Height	1		-
end	T	Length, m	x	Height, m	7		63

Figure 4.15 Extra table.

The table (Figure 4.15) was developed to calculate the additional logs, where key parameters are:

- "Extra" it is types of additional elements from the log, various configurations present in the wall

- "+" - allows to choose "Extra type" of the three available options:

  a. "D" - data entering in the form of length/height dimensions, m

  b. "RM" - data entering in the form of running meters, rM

  c. "N" data entering in the form of length/log amount, m / pcs.

- "Extra Amt" - amount of identical types of "Extra"

- "Running Meters" - number of running meters related to one of the types of "Extra" logs.

The total amount of extra running meters is later used to calculate the final value of running meters.

Holes:

					add	del	
Wall #	1			Hole types		4	Running Meters
Hole #	Holes					Hole Amt	
1	WC	3	x	8	1	1	0,9
2	W	9	x	14	2	1	11,4
3	D	6	x	21	-	1	6,3
4	O	14	x	6	-	1	2,8
5	+	Width	x	Height	1	1	-
end	T	Width, dm	x	Height, dm	CJ	5	21,4

Figure 4.16 Holes table.

Information about the presence of openings and their dimensions are filled in the tables on a "Holes" (Figure 4.16) sheet. The main required parameters:

- "Hole types" - number of hole types, present on the wall

- "+" - allows to choose the "Hole type" of four available options:

  a. "WC" - sizes of custom window entering, dm

  b. "W" - window sizes' selection, dm

  c. "D" - door sizes' selection, dm

  d. "O" - sizes of different types of hole entering, dm.

- "CJ" - number of conjugated windows.

Sum:

The "Sum" column reflects the amount of running meters for each type (rectangular and triangular) wall. Calculated according to the formula:

$$RM_i = RM_R + RM_T \qquad (4.9)$$

$$RM_{total} = \sum RM_i + \sum RM_{E,i} - \sum RM_{H,i} \qquad (4.10)$$

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where,

RM_i - number of running meters calculated for the i-th wall, rM

RM_R - number of running meters calculated for the rectangular part of the wall, rM

RM_T - number of running meters calculated for the triangular part of the wall, rM

RM_{total} - total number of running meters, rM

$RM_{E,i}$ - number of running meters calculated for extra logs of i-th wall, rM

$RM_{H,i}$ - number of running meters calculated for holes of i-th wall, rM.

Problem:

The main problem of this subsection was to develop a method of calculating the number of running meters which takes holes. Because the position of holes is strictly specified by the height in the drawings and the dimensions of the log profile and logs' banding may vary, the minimum number of running meters that can fit into the opening must be taken into account.

Solving:

The method of solution was to develop a formula that would take the minimum number of timber fits into the holes into account.

Two possible formulas have been developed, provided that the minimum distance from the log edge to the edge of the hole at which the board did not cut 30 mm:
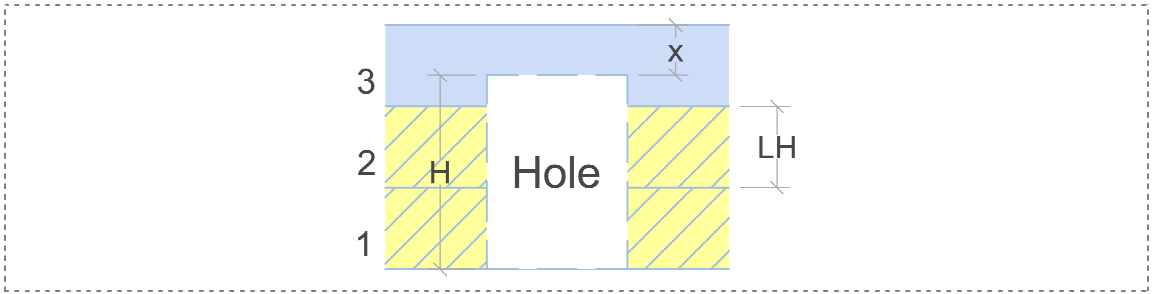
- Variant 1

Figure 4.17 Holes calculation variant 1.

In the first variant (Figure 4.17) it is assumed that the edge of the hole is located in the junction of the two beams. The remaining distance X will be determined by the formula:

$$X = 3 \cdot LH - H \qquad (4.11)$$

Thus, if the remaining distance is $X \geq 30\ mm$, the gap takes 2 logs. If the remained distance is $X < 30\ mm$, then the opening has 3 logs.

- Variant 2
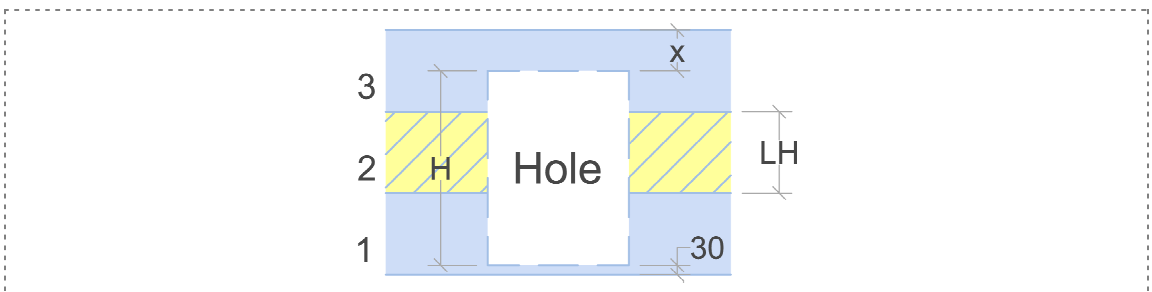
Figure 4.18 Holes calculation variant 2.

Variant 2 (Figure 4.18) describes a case in which it was assumed that the edge of the hole is separated from the junction of the two beams by 30 mm. This means that the first log is not cut. Thus, X is determined according to the following formula:

$$X = 3 \cdot LH - (H + 30) \qquad (4.12)$$

In this variant, if the remaining distance is $X \geq 30\ mm$, the hole has one log. If the remained distance is $X < 30\ mm$, the hole accommodates 2 logs.

Provided that the amount of log should be minimal, the second variant of formula was selected for usage in the program.

5 TESTING OF THE PROGRAM

Testing the program was carried out at the facility Kartano 1, the same example which was calculated by manual method, with the purpose of comparison and subsequent analysis of the number of running meters of logs and time-consuming.

The data required for the automated calculation of the cost of logs in the program was taken from the manual method and were used to fill the tables of the program.

The calculation was divided into stages:

1. Entering information about log profile.

ID	A0042	
Log width	88	mm
Log height	160	mm
Laminated log	☑	
Log profile	Japan	

Figure 5.1 Entering information about log profile.

Log profile with ID number (Figure 5.1) A0042 was selected by the customer. When selecting this ID number the other table cells are filled in automatically.

2. Entering information about walls.

    a. Number of walls.

Figure 5.2 Number of walls entering.

The calculated building contains four external walls, therefore the table is filled with four walls (Figure 5.2).

    b. The rectangular part of the wall.

Figure 5.3 Entering information about the rectangular part of the wall.

All the rectangular parts of the walls have a height of 3.28 m. The length of A and B walls is 8.6 m, and C and D walls is 12.4 m. All these data were entered into appropriated columns (Figure 5.3).

c. The triangular part of the wall.

Triangular							
	Slope		Wall H	WL/2	Log A	Run M	UnSym	
1:	2,8	19,6	1,54	4,30	10	43,0	-	-
1:	2,8	19,6	1,54	4,30	10	43,0	-	-
1:					-	-	-	-
1:					-	-	-	-
1:	S	°	m	m	pcs	rM	°	m

Figure 5.4 Entering information about the triangular part of the wall.

Only the walls A and B have the gable part of the walls. Therefore, the height and half length of the wall have been entered solely for these walls. The height of the walls is 1.535 m and half of their length was 4.30 m.

3. Entering information about holes.

Because walls did not have additional, extra log elements, only information about holes was entered for each wall in the "Holes" worksheet.

					add	del		
Wall #		1		Hole types		1	Running	
Hole #			Holes			Hole Amt	Meters	
1	W	6	x	12	1	1	4,9	
end	T	Width, dm	x	Height, dm	CJ	1	4,9	

					add	del		
Wall #		2		Hole types		2	Running	
Hole #			Holes			Hole Amt	Meters	
1	W	6	x	12	2	1	9,1	
2	W	9	x	14	2	1	15,2	
end	T	Width, dm	x	Height, dm	CJ	2	24,3	

Figure 5.5 Table "Holes" filling of A and B walls.

					add	del		
Wall #		3		Hole types		1	Running	
Hole #			Holes			Hole Amt	Meters	
1	W	6	x	12	2	1	9,1	
2	W	6	x	6	1	1	2,1	
3	D	10	x	21	-	1	13,2	
4	W	9	x	14	2	1	15,2	
end	T	Width, dm	x	Height, dm	CJ	4	39,6	

					add	del		
Wall #		4		Hole types		3	Running	
Hole #			Holes			Hole Amt	Meters	
1	W	6	x	6	1	1	2,1	
2	D	9	x	21	-	1	12	
3	W	6	x	12	2	1	9,1	
end	T	Width, dm	x	Height, dm	CJ	3	23,2	

Figure 5.6 Table "Holes" filling of C and D walls.

4. Result printing.

The output results of the calculation was performed on the worksheet "Print", intended for submission to the customer. The information about the total cost of the logs running meters amount and "Cost comparison chart", allowing to estimate the costs difference between different log profiles used in the same building are shown on this page. The page can be seen in Appendix 4.

Price for one running meter of Laminated log 88x170 mm was 17.8 € according to the company's price.

Total price for 876,0 running meters was 15,592.80 €.

Time spent on the manual method of the calculation was 1 hour 5 minutes.

6 DEVELOPMENT OF THE PROGRAM USER INTERFACE (UI)

6.1 User interface (UI)

The user interface plays an important role in the development and maintenance of the program. Therefore, considerable attention was paid to the user interface in this work.

Designing the visual composition and temporal behavior of UI is an important part of software application programming. Its goal is to enhance the efficiency and ease of use for the underlying logical design of a stored program, a design discipline known as usability. Techniques of user-centered design are used to ensure that the visual language introduced in the design is well tailored to the tasks it must perform (Wikipedia, User Interface).

In the industrial design field of human-machine interaction, the user interface is (a place) where interaction between humans and machines occurs. The goal of interaction between a human and a machine at the user interface is effective operation and control of the machine, and feedback from the machine which aids the operator in making operational decisions.

A user interface is the system by which people (users) interact with a machine. The user interface includes hardware (physical) and software (logical) components. User interfaces exist for various systems, and provide a means of:

- Input, allowing the users to manipulate a system, and/or

- Output, allowing the system to indicate the effects of the users manipulation.

Generally, the goal of human-machine interaction engineering is to produce a user interface which makes it easy, efficient, enjoyable to operate a machine in the way which produces the desired result. This generally means that the op-

erator needs to provide minimal input to achieve the desired output, and also that the machine minimizes undesired outputs to the human (Wikipedia, User Interface).

A series of elements conforming a visual language have evolved to represent information stored in computers. This makes it easier for people with few computer skills to work with and use computer software (Wikipedia, Graphical User Interface).

6.2 Benefits of well-made user interfaces

1. Increasing competitiveness.

Developers, paying attention to the interfaces of their applications, can leave their competitors far behind, by making their products simple and user friendly. If application development is done in accordance with usability requirements it increase developers profits by 80%.

2. Increase the training speed on how to use systems.

On average, utilization of the usability methods when planning and developing interfaces, reduces the training time by 25%, and decreases the number of technical support calls by 60%. The more convenient and the simpler the interface, the easier it is to train people and get them used to a new system, which accelerates the payback of investing into the system in the first place.

3. Increase clients' satisfaction.

Leveraging the approach, targeting to help users achieve their goals, authority can be assured that the application will address the needs of the users, making your business a success.

4. Increase the productivity.

Intuitive user interface improves user productivity, as a result for the task requires fewer people, or they spend less time at work.

5. Decrease the number of human errors.

Significant number of emergencies, caused by the human factor, could be avoided if interfaces of the systems, that caused incidents, would have prevented operators from taking wrong actions and helped steer them towards taking the right ones (eSector Solutions, Interfaces, 2002).

6.3 The user interface design process

Given the above information, implemented the following improvements of the user interface were taken into account:

▪ The marking of editable cells by color

ID	A0042	
Log width	88	mm
Log height	160	mm
Laminated log	☑	
Log profile	Japan	

Figure 6.1 Highlighted editable cells.

This improvement should help the user to understand which cells are editable.

▪ Used for large tables, line by line method for color separation of rows

Wall	1	A			3,28	8,60	21	180,6	3,280	1:	2,8	19,6	1,54	4,30	10	43,0	-	-	-	-4,90	223,60
Wall	2	B			3,28	8,60	21	180,6	3,280	1:	2,8	19,6	1,54	4,30	10	43,0	-	-	-	-24,30	223,60
Wall	3	C			3,28	12,40	21	260,4	3,280	1:					-	-	-	-	-	-39,60	260,40
Wall	4	D			3,28	12,40	21	260,4	3,280	1:					-	-	-	-	-	-23,20	260,40

Figure 6.2 Line by line rows highlighting.

Line by line highlighting should help the user to control the entering process.

- The logical separation and grouping of the input an output data

Figure 6.3 Data grouping.

- "External Walls" table was made in such a way that it can be easily printed on a A4 size paper to present this table to the customer
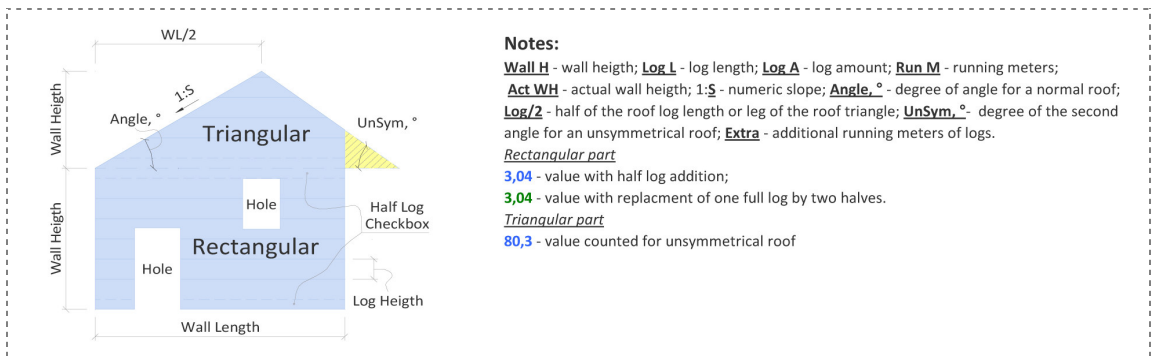
- Drawings and explanation notes.

Figure 6.4 Explanation drawings with notes.

Created accompanying drawings and explanations to them explain possible embarrassing moments in completing the table of the program.

7 EVALUATION

7.1 General information on Mathida object

In addition to the Kartano 1 model cost estimation a new model of wooden building was chosen to improve the accuracy of the comparative analysis.

As a new wooden building the object Mathida model was chosen for the second calculation. Company East Loghouse Tokyo Co., Ltd ordered the cost estimation of running meters of log from Pellopuu Oy company.

The Mathida object is a two-storey wooden building intended for year-round residence. The building frame is made fully from log. Several walls have the unsymmetrical part of the wall.

7.2 Manual calculation of Mathida object

Drawings received from the East Loghouse Tokyo Co., Ltd. contained all the required dimensions and details. Drawings and wall markings can be seen in Appendix 5.

The number of running meters of log calculation were produced by the manager of Pellopuu Oy.

Result of manual method of calculation

$A: \ 8.3 \cdot 29 + (8.3 \cdot 11)/2 = 286.35 - 32 = 254.35 \ rM$

$B: \ 8.3 \cdot 29 + (8.3 \cdot 11)/2 + 2.5 = 288.85 - 61.9 = 226.95 \ rM$

$C: \ 8.3 \cdot 29 + (8.3 \cdot 11)/2 + 1 \cdot 4 + 2.5 = 292.85 - 75.7 = 217.15 \ rM$

$D: \ 1.4 \cdot 3 = 4.2 \ rM$

E : $1.4 \cdot 2 = 2.8 \ rM$

F : $1.4 \cdot 3 = 4.2 \ rM$

G : $6.3 \cdot 29 + (8.3 \cdot 11)/2 - (2 \cdot 5)/2 + 2 \cdot 2 + 1 \cdot 4 = 231.35 - 29.2 = 202.15 \ rM$

H : $4 \cdot 3 = 12 \ rM$

K : $9.5 \cdot 30 + 1.8 = 286.8 - 77.1 = 209.7 \ rM$

L : $6.4 \cdot 16 + 4.2 \cdot 24 + 5.4 \cdot 3 + 1.8 = 221.2 - 15.4 = 205.8 \ rM$

M : $4 \cdot 35 + 5.4 \cdot 3 + 1.8 = 158.0 - 7.5 = 150.5 \ rM$

N : $6 \cdot 30 + 1.8 \cdot 2 + 1.8 = 185.4 - 14.8 = 170.6 \ rM$

N : $10.5 \cdot 3 = 31.5 \ rM$

$$RM_{total} = 254.35 + 226.95 + 217.15 + 4.2 + 2.8 + 4.2 + 202.15 + 12 + 209.7 +$$
$$+ 205.8 + 150.5 + 170.6 + 31.5 = 1691.9 \ rM$$

Log profile Lamellihirsi 114x190 for this building was chosen. One meter log price for this profile was 25.2 € according to the company.

The total price for 1691.9 running meters was 42,635.88 €.

Time spent for the manual method of calculation was 2 hours 15 minutes.

7.3 Automatic calculation of Mathida object

All input data used in the manual method of the calculation was used to fill in the tables of the program.

The result of the automatic method of calculation

ID	A0047	
Log width	114	mm
Log height	180	mm
Laminated log	☑	
Log profile	Japan	

Select log ID, enter number of
walls and press "Add" button
to fill the table.

Num. of walls	13	pcs

Figure 7.1 Log profile part of the table filling.

Walls	#	Axis	1/2		Rectangular Wall						Triangular								Extra	Holes	Sum
					Wall H	Wall L	Log A	Run M	Act WH	Slope		Wall H	WL/2	Log A	Run M	UnSym					
Wall	1	A	☐	▨	5,22	8,30	29	240,7	5,220	1: 2,1	25,5	1,98	4,15	11	45,7	-	-	-	-32,00	286,35
Wall	2	B	☐	▨	5,22	8,30	29	240,7	5,220	1: 2,1	25,5	1,98	4,15	11	45,7	-	-	2,50	-65,30	286,35
Wall	3	C	☐	▨	5,22	8,30	29	240,7	5,220	1: 2,1	25,5	1,98	4,15	11	45,7	-	-	6,50	-76,40	286,35
Wall	4	D	☐	▨	0,54	1,40	3	4,2	0,540	1:				-	-	-	-	-	-	4,20
Wall	5	E	☐	▨	0,36	1,40	2	2,8	0,360	1:				-	-	-	-	-	-	2,80
Wall	6	F	☐	▨	0,54	1,40	3	4,2	0,540	1:				-	-	-	-	-	-	4,20
Wall	7	G	☐	▨	5,22	6,30	29	182,7	5,220	1: 2,1	25,5	1,98	4,15	11	39,7	25,5	6,3	8,00	-29,20	222,35
Wall	8	H	☐	▨	0,54	4,00	3	12,0	0,540	1:				-	-	-	-	-	-	12,00
Wall	9	K	☑	☐	5,22	9,50	30	285,0	5,220	1:				-	-	-	-	1,80	-77,10	285,00
Wall	10	L	☐	▨	2,88	6,40	16	102,4	2,880	1:				-	-	-	-	118,80	-15,40	102,40
Wall	11	M	☐	▨	6,30	4,00	35	140,0	6,300	1:				-	-	-	-	18,00	-7,50	140,00
Wall	12	N	☑	☐	5,22	6,00	30	180,0	5,220	1:				-	-	-	-	5,40	-14,80	180,00
Wall	13	P	☐	▨	0,54	10,50	3	31,5	0,540	1:				-	-	-	-	-	-	31,50
	#	Ltr	HL	AH	m	m	pcs	rM	m	1: S	°	m	m	pcs	rM	°	m	161,00	-317,70	1843,50
																	Total		1686,80	rM

Figure 7.2 Main table filling.

add **del**

Wall #	2			Extra types	1	Running
Extra #		Extra			Extra Amt	Meters
1	rM		2,5		1	2,5
end	T	Length, m	x	Height, m	1	2,5

add **del**

Wall #	3			Extra types	2	Running
Extra #		Extra			Extra Amt	Meters
1	rM		2,5		1	2,5
2	rM		4		1	4
end	T	Length, m	x	Height, m	2	6,5

add **del**

Wall #	7			Extra types	2	Running
Extra #		Extra			Extra Amt	Meters
1	N	2	-	2	1	4
2	N	1	-	4	1	4
end	T	Length, m	x	Height, m	2	8

add **del**

Wall #	9			Extra types	1	Running
Extra #		Extra			Extra Amt	Meters
1	rM		1,8		1	1,8
end	T	Length, m	x	Height, m	1	1,8

add **del**

Wall #	10			Extra types	3	Running
Extra #		Extra			Extra Amt	Meters
1	N	4,2	-	24	1	100,8
2	N	5,4	-	3	1	16,2
3	rM		1,8		1	1,8
end	T	Length, m	x	Height, m	3	118,8

add **del**

Wall #	11			Extra types	2	Running
Extra #		Extra			Extra Amt	Meters
1	N	5,4	-	3	1	16,2
2	rM		1,8		1	1,8
end	T	Length, m	x	Height, m	2	18

add **del**

Wall #	12			Extra types	2	Running
Extra #		Extra			Extra Amt	Meters
1	rM		1,8		1	1,8
2	N	1,8	-	2	1	3,6
end	T	Length, m	x	Height, m	2	5,4

Figure 7.3 Extra tables filling.

In the picture Figure 7.3 only walls containing additional logs are shown.

Figure 7.4 Holes tables filling.

In the picture Figure 7.4 only walls containing holes are shown.

The total price for 1,686.8 running meters was 42,507.43 €.

The time spent on the manual method of calculation was 1 hour 35 minutes.

The resulted "Print" worksheet can be found in the Appendix 6.

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8 CONCLUSIONS

8.1 Comparison of the results

To compare the results and to estimate the automatic method of running meters a comparative table of cost calculations was made.

Table 8.1 Comparative table of manual and automatic calculation methods.

Building model	Characteristics	Manual method	Automatic method
Kartano 1	Running meters, rm	876.0	876.0
	Total cost, €	15,592.80	15,592.80
	Time spent, min.	90	65
Mathida	Running meters, rm	1,691.9	1,686.8
	Total cost, €	42,635.88	42,507.43
	Time spent, min.	135	95

The resulting numbers are almost the same in both calculation methods, respectively, the cost almost equal, but the time spent did vary. Therefore, it was concluded that a difference in costs can be caused by human error and the only way to estimate the benefits of automatic method of running meters calculations was to find the percentage difference between time spent.

Kartano 1:

$$\Delta_1 = \frac{90-65}{90} \cdot 100\% = 27.7\%$$

Mathida:

$$\Delta_2 = \frac{135-95}{135} \cdot 100\% = 29.6\%$$

Consequently it can be said with high accuracy that the automatic method of calculation decreased the time spent approximately by 30%.

8.2 Findings

The theme of this thesis was not chosen not randomly, because the topic is relevant for practical work at Pellopuu Oy.

The increasing demand for log houses in Finland and abroad requires that the management responds quickly to any changes in existing projects and in the development of new ones. The guarantee of successful relationships with customers is the timely and optimal calculation of the cost of log houses.

In this thesis, based on the theoretical study of the existing manual method of calculating the cost of running meters of logs for wooden houses an own version to solve these problems using an automated method of calculation was offered.

The importance of conducted pre-studies was large, because with the help of it, the aim of the thesis has been achieved an method of the automated calculation method of the running meters cost of logs in the wooden frame building based on the program.

The principles of the program management follow the requirements of the company Pellopuu Oy:

- performance and readiness for use

- minimal cost

- the ease of making changes in the reference

- the integrity of the system of calculation

- security and privacy.

The fourth section describes the algorithms and formulas on which the program was built. The appendix provides a user manual with detailed explanations on the operation of the program and technical requirements the program.

For the disclosure of the aim of the thesis tables, charts and figures were used.

Problems arising from the objective of this work were solved:

- development improving the process of determining the cost of logs for the log houses;

- significantly reduces labor and economic resources;

- the program is simple to use, requires no additional skills and knowledge from the user, thereby reducing the cost of training;

- this software has enough efficiency and a higher reliability compared to the manual one.

This was proved in a comparative analysis of the experiments, as reflected in the section 9.1. For the purity of the experiment two objects Kartano 1 and Mathida were taken. Each of these objects have been calculated with the old manual method and with the automated method based on the developed program.

In the implementation of the development program for calculations, considerable attention was paid on the economic substantiation needed for this work.

Analyzed data shows the economic appropriateness of the new development:

- reduced labor costs by an average of 30% in the calculation of a log frame for the wooden house

- with an annual demand of 350 log houses and considering the above mentioned, the usage of the tool increases the annual amount of the calculated houses by 105 pcs. per year.
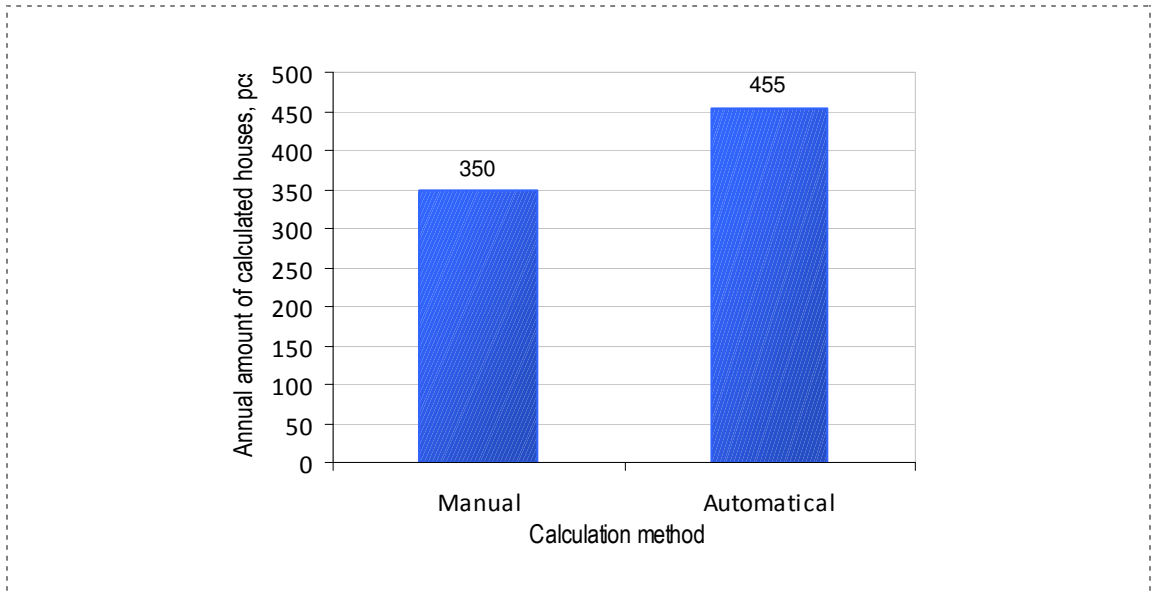

Chart 8.1 Prediction chart for the annual calculated houses.

- considering that the minimum manager salary of one working hour for the calculation of the cost of wooden log frame is 50 €, the amount of savings in monetary terms with an annual demand of 350 houses will be 33,000 € per year using the tool.
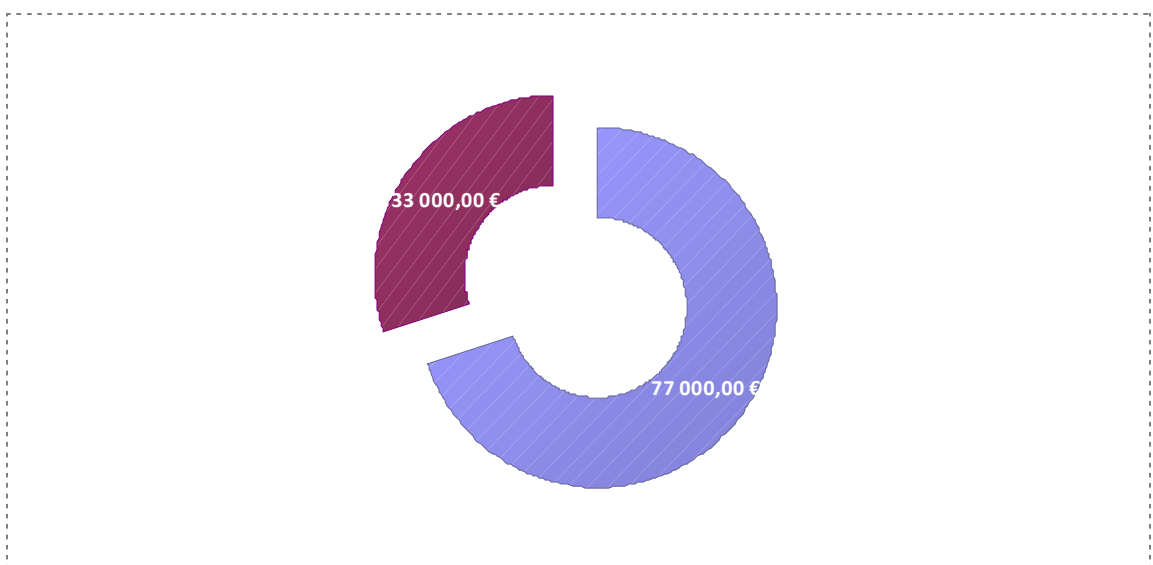

Chart 8.2 Money saving chart per year.

The above mentioned charts are preliminary calculated and shows possible changes which can be achieved using the developed program at Pellopuu Oy.

8.3 Writing a user guide

To facilitate the use of the program for users, on instruction manual was compiled. Instruction can be found in the Appendix 7.

This manual explains the procedure for completing the user input information for calculation in the form of a step-by-step algorithm.

Also the manual contains the system requirements for stable work of the program.

FIGURES

CHARTS

TABLES

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Home Pricing Calculator

We use a square footage cost to determine a ball park price of your home, which includes Golden Eagle's complete log home package. Every building lot is unique, which makes it difficult to price a log home without hours of estimating. The estimate also varies depending on how much labor you want to do yourself.

The log home industry pricing range for turn key construction should fall within $135 to $195 per square foot. The price can be affected by the type of home you are building, the options selected, the building site and the location in which you are building.

Home Price Calculator

Square Feet: 30   = $ 4,050   to $ 5,850

Calculate

[http://www.northernloghomesinc.com/home-pricing-calculator.php]

Maisons
CanadaLog & Hybrid Timber
Homes Inc.

Your New Log Home Calculator

Use this tool to get an approximation of the total costs to build your new home. This is an estimator only. It is designed to give you an idea of the costs and get you pointed in the right direction. Talk to one of our Project Managers for actual costs.

Home > Info Library & Links > Log Home Cost Calculator

1. Log Home Type:

What type of log home do you prefer?

○ Engineered Square Log
○ Full Length Round Log

Choose the type of exterior log wall you prefer. If you are unsure about the selections, please view our log profiles.

Wood Species?

○ Exclusive Appointments
○ Eastern White Pine
○ Cedar

Exclusive Appointments: mostly custom cabinetry, solid wood and cera Our log homes are generally offered in eastern white electrica pine however, we do get many requests for cedar. trim, mantles multiple fireplaces, large decks, radiant flooring.

Log Thickness / Diameter ?
Result

○ 6" X 8" standard square log
Based on your inputs, the cost to
build your home is:

○ 6" X 10" square log
○ 6" X 12" square log

Log thickness/diameter can impact the cost of your log home substantially. Remember that this is a standard 6 inch thi
$63,587.65
*

Remember that this is a conservative approximation of the cost to build your home. Using our managed project system and our custom tendering process, results are likely to be 10% to 20% lower. Find out more about our Project Management System.

And the cost per square foot is:
$178.12
*

Mortgage Cost
based on 25 years at 6% is:
$368.73
*

This gives you an approximation of your mortgage costs using a 6% interest rate and a 25 year amortization period.

* All figure are quoted in Canadian dollars

[Complete Calculation]   [Clear Form]

[http://www.canadaloghomes.ca/about/calcul.htm]

	Subcontractor, Supplier	Description	Original Cost Estimate	Adjusted Cost Estimate	Total of Previous Payment	Current Amo to be Pai
1		Permits, Fees, Surveys				
2		Utilities				
3		Excavation				
4		Foundation				
5		Rough Lumber				
6		Rough Labor				
7		Windows/Ext. Doors				
8		Roofing				
9		Concrete Flatwork				
10		Siding				
11		Plumbing				
12		Heating				
13		Electrical				
14		Insulation				
15		Water (Well)				
16		Sewer (Septic)				
17		Fireplace				
18		Drywall				
19		Cabinets				

Location
Name:
Address:

Builder
Name:

BYOH
www.byoh.com

can include temporary driveways, backfill, and rough & final grading, any needed sand, gravel, or stone. Get written bids.

[http://www.byoh.com/spreadsheets.htm]

Structural calculation software for wood frameworks

Flexibility in Timber Construction
Most important when designing a new project is to implement special customer requirements quickly and efficiently. Whether that is in traditional timber framing, log constructions, pre-fabricated constructions or massive construction. SEMA meets all these needs with a broad range of simple to use features on a modern user interface.

Working with a System
With our standard yet dynamic software you create building projects as you need them. The simple cataloguing system enables company-specific standards without losing flexibility and that makes SEMA to an indispensable tool. And the system grows with the requirements of the user.

Perfect Results
Practically oriented features to print drawings, flexible data-base features for calculations and parts lists as well as the integration of MS Office programs offer users a decisive advantage for their design process and material planning.

Master Data and Macros
Definition of single or multi-boarded wall and ceiling elements with up to 11 boarding and batten layers. Pre-defined members and groups of components that work across all projects guarantee standardisation in detail without limiting design possibilities.

Printout, CAD and Dimensioning
Printing of to-scale wall manufacturing plans by using layout templates. Auto-dimensioning of sectional views, wall views and top views. Free CAD and dimensioning features to supsequently add details to production drawings.

[http://www.archiexpo.com/prod/sema/structural-calculation-software-for-wood-frameworks-3369-153673.html]

Timber Frame Software

The Timber Frame Software used offers a number of key benefits:
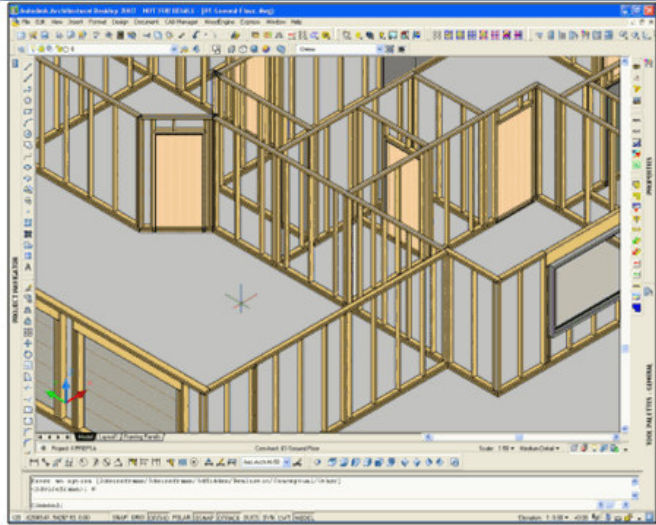
- Intelligent 3D computer models of framed buildings based upon standard UK building practices to aid compliance with relevant building regulations and standards.
- Rapid creation and manipulation of house-types to consider alternative designs and appraise cost implications.
- Automatic quantity take-off and scheduling for accurate cost analysis at any stage of the design.
- 2D/3D visual appraisal of a house-type from any viewpoint to avoid design errors.
- Rapid production and update of working/manufacturing drawings.

With the tool as our disposal and the ongoing commitment of our team we ensure a quality engineered design that in practice works.

[http://www.sydenhamstimberframe.co.uk/timber-frame-software.aspx]

The MiTek WoodEngine timber frame detailing package has been enthusiastically received by the timber frame industry in the UK and Ireland since it's launch in 2005.

Over thirty five timber frame manufacturers and design consultancies have invested in WoodEngine, which is based upon Autodesk Architectural Technology.

Industry leaders such as **Potton Ltd**, **Prestoplan**, **Taylor Lane Timber Frame**, **Walker Timber**, **Scotframe**, **European Timber Systems**, **Framewise** and **Howarth Timber Engineering** are amongst the manufacturers who have invested in WoodEngine.

The benefits for the timber frame designer are numerous. Rapid detailing tools are accompanied with rapid editing tools, enabling the timber frame panels to be edited in the plan view, model view or even at manufacturing drawing stage.

[http://www.mii.com/site/frameset.aspx?siteid=2&langid=2057&main=/page/open.asp%3Fpid%3D5143]

Running Meters (-)

Holes

Windows
- Height
- Lenght
- Conjugate Number
- Amount
- Running Meters

Custom Windows
- Height
- Lenght
- Conjugate Number
- Amount
- Running Meters

Doors
- Height
- Lenght
- Amount
- Running Meters

Other Holes
- Lenght
- Heigth
- Amount
- Running Meters
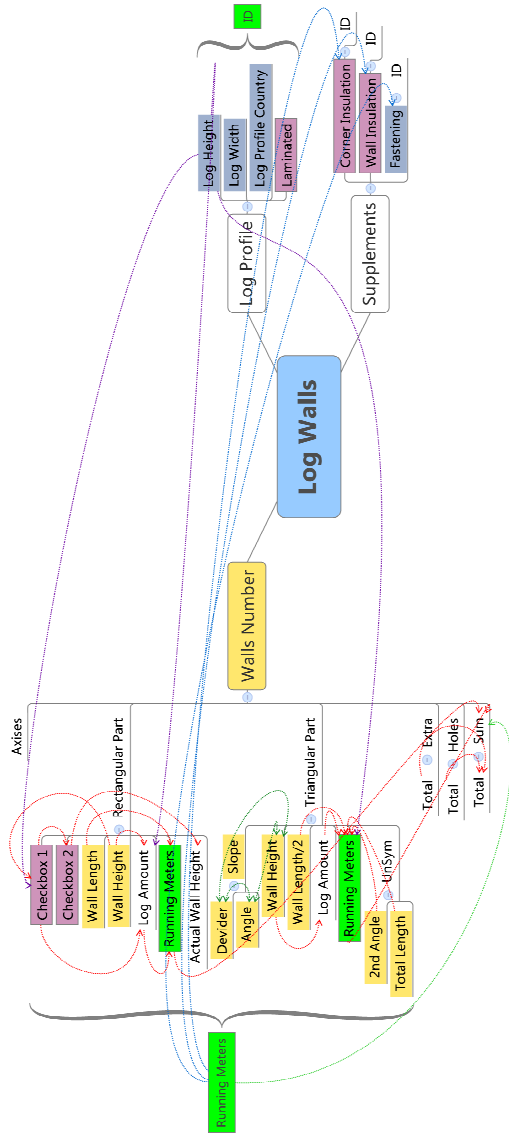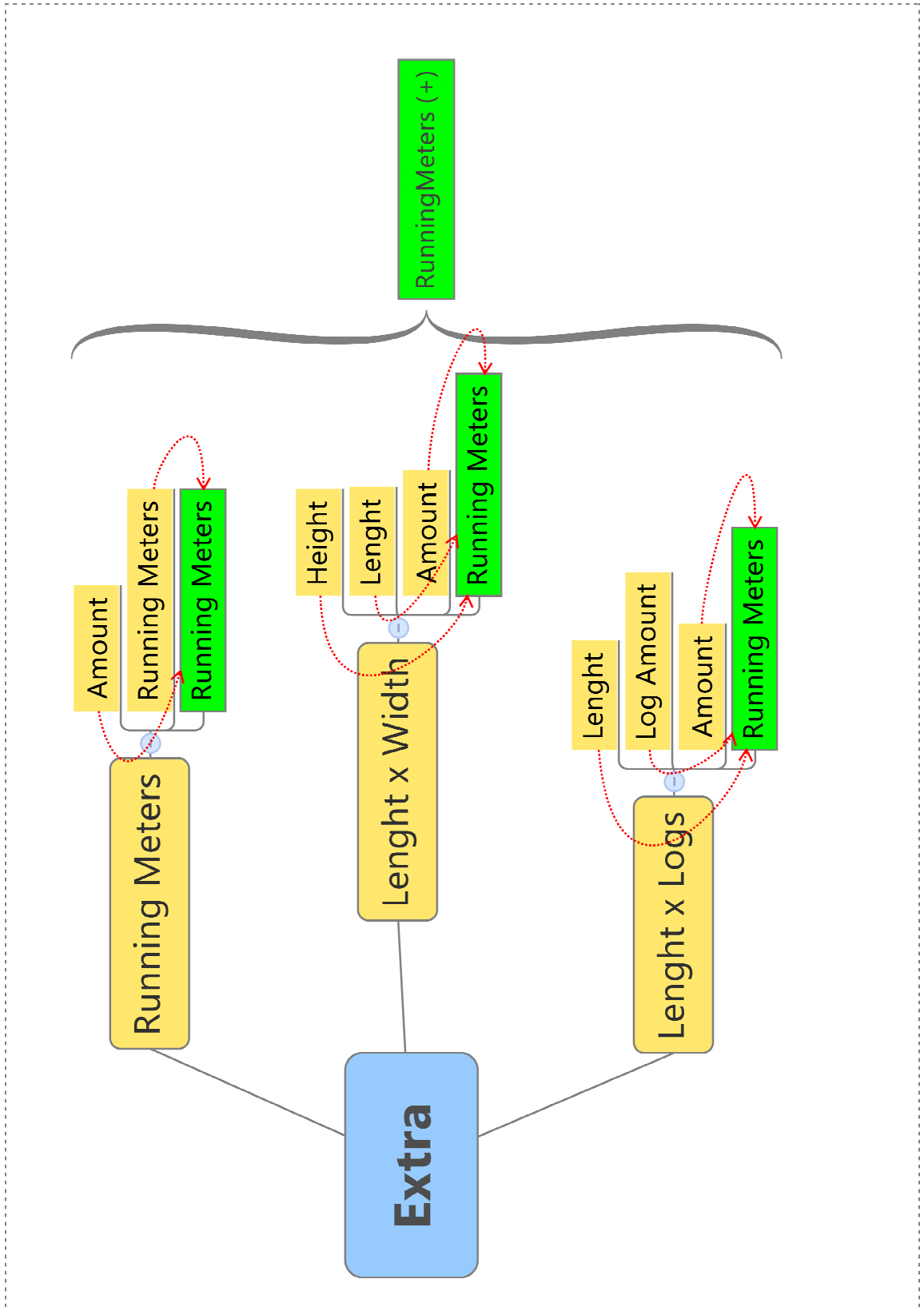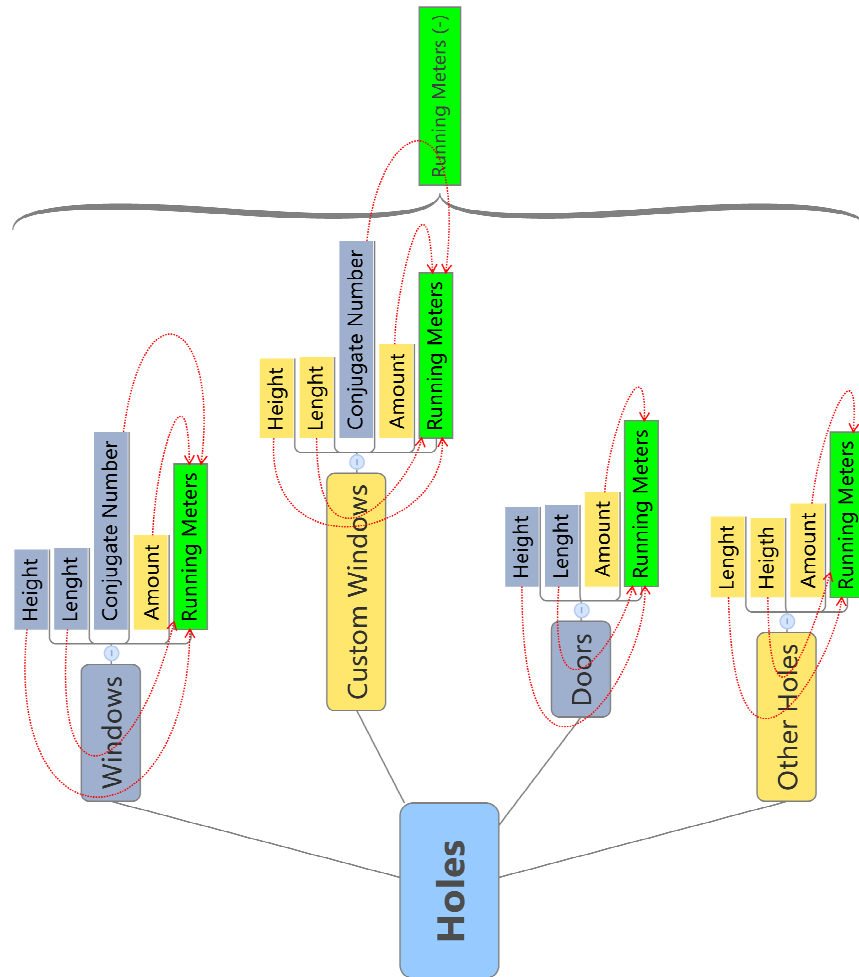
ID	Remark	Name (FI)	Price
A0002		Vinosalvostyö PP kapeat hirret	
A0003		Vinosalvostyö PP isot hirret	
A0005	FNx069x180	kevythirsi 69*190 II-laatu	
A0006	FNx069x208	kevythirsi 69*220 II-laatu	
A0008	FNx045x138	kevyt-"hirsi" 45*145	
A0010	FNx070x138	hirsi 70*145	
A0011	FNx070x135	hirsi 70*145 pontattuprof.	
A0012	FNx070x162	hirsi 70*170	
A0013	FLx070x135	hirsi 70*145 L pontattuprof.	
A0014	FNx070x182	hirsi 70*194 (182mm), erikoisprofiili	
A0015	FNx092x138	hirsi 92*145	
A0017	HNx092x138	hirsi 92*145 Holl.prof.	
A0018	HLx092x138	hirsi 92*145 L Holl.prof	
A0019	HLx088x138	hirsi 88*145 L holl.prof	
A0020	FNx092x162	hirsi 92*170	
A0025	FLx092x138	hirsi 92*145 L	
A0033	JLx088x180	Lamellihirsi 88x190 jap.	
A0034	JLx088x182	lamellihirsi 88*194 (182mm), jap.profiili	
A0035	FLx088x162	Lamellihirsi 88*170	
A0036	FLx088x208	Lamellihirsi 88x220 xxP	
A0037	JNx092x160	hirsi 92*170 Jap.prof.	
A0038	HNx092x162	hirsi 92*170 Holl.prof.	
A0039	HLx092x162	hirsi 92*170 L Holl.prof.	
A0040	FNx118x162	hirsi 118*170	
A0041	HLx088x162	hirsi 88*170 L Holl.prof.	
A0042	JLx088x160	Lamellihirsi 88*170 L Jap.prof.	
A0043	JNx118x160	hirsi 118*170 Jap.prof.	
A0044	JLx114x160	Lamellihirsi 114*170 Jap.prof.	
A0045	FLx114x162	Lamellihirsi 114x170 mm	
A0046	FLx114x190	Lamellihirsi 114x190 HUOM ei käytetä	
A0047	JLx114x180	hirsi 114*190 L Jap.prof.	
A0048	FLx114x208	Lamellihirsi 114x220 LH xxP	
A0050	FNx140x162	hirsi 140*170	
A0051	FNx140x208	hirsi 140*218	
A0052	FLx136x208	Lamellihirsi 136x220 LH xxP	
A0054	JLx136x160	Lamellihirsi 136x170mm Jap.prof	
A0055	FLx136x162	Lamellihirsi 136x170 mm	
A0056	FLx136x180	Lamellihirsi 136x190	
A0057	FNx180x208	hirsi 180x218 pontattuprof.	
A0058	FLx180x208	Lamellihirsi 180x218 mm pontattuprof.	
A0059	FLx164x180	lamellihirsi 164x190mm LH	
A0060	FNx206x208	hirsi 206*218	
A0062	FNx206x208	hirsi 206*218 pontattuprof.	
A0063	FLx204x208	Lamellihirsi 204x218 mm pontattuprof.	
A0065	FLx202x208	Lamellihirsi 202x220 LH xxP	
A0066	FLx220x260	Lamellihirsi 220x280 LH xx V	
A0070	FLx240x208	Lamellihirsi 240*220 LH xxP	
A0071	FLx240x260	Lamellihirsi 240x270 xVP	
A0072	FNx202x208	hirsi 202*218 pontattuprof.	

A0075	FLx202x208	Lamellihirsi 202*218 pontattuprof.	
A0079		BB 70 mm hirsi	
A0080		BB,hirsi 92*170,sydän halk.	
A0081		BB,hirsi 92*170, sydän kesk	
A0082		BB,hirsi 118*170,sydän halk	
A0083		BB,hirsi 118*170,sydän kesk	
A0084		BB,hirsi 114 mm L	
A0085		BB,hirsi 140*170,sydän kesk	
A0086		BB,lamellihirsi 136 *180 mm	
A0087		BB 88 mm logL	
A0088		BB 88*180 mm lamellihirsi	
A0089		BB 114*180 mm lamellihirsi	
A0104	FLx113x208	Lamellihirsi 113x220 (208)/HK	
A0106	FLx134x208	Lamellihirsi 134x220 (208)/HK	
A0108	FLx180x208	Lamellihirsi 180x219 (208) HK	
A0110	FLx202x208	Lamellihirsi 202x219 (208) /5 HK	
A0115	FLx202x260	Lamellihirsi 202x271 LH xxV	
A0150		hirsi erikoisdimensio, 274 mm	
A0200	FNx150x127	pyöröhirsi 150 mm	
A0220	FNx170x143	pyöröhirsi 170 mm,	
A0240	FNx190x158	pyöröhirsi 190 mm	
A0260	FNx210x174	pyöröhirsi 210 mm	
A0262	FLx210x174	lamellipyöröhirsi 210mm	
A0280	FNx230x190	pyöröhirsi 230mm	
A0300		pyöröhirsi 250 mm	
A0301		BB lamelli pyöröpilari 250 mm	
A0320	FLx230x190	pyöröhirsi 230 mm lamelli	
A0550		Liimahirsiaihio	
A1000		Sahatavaraa (m3)	

REPORT		Model #	Structure	Designer	Date
TOTAL PRICE:	**€ 15 592,80**	1500	LH 204 pak	Podolskiy	04.05.2010

Cost comparision chart represents the running meters cost estimation for selected log profile in comparision with the running meters costs of other five different log profiles used in the same log building
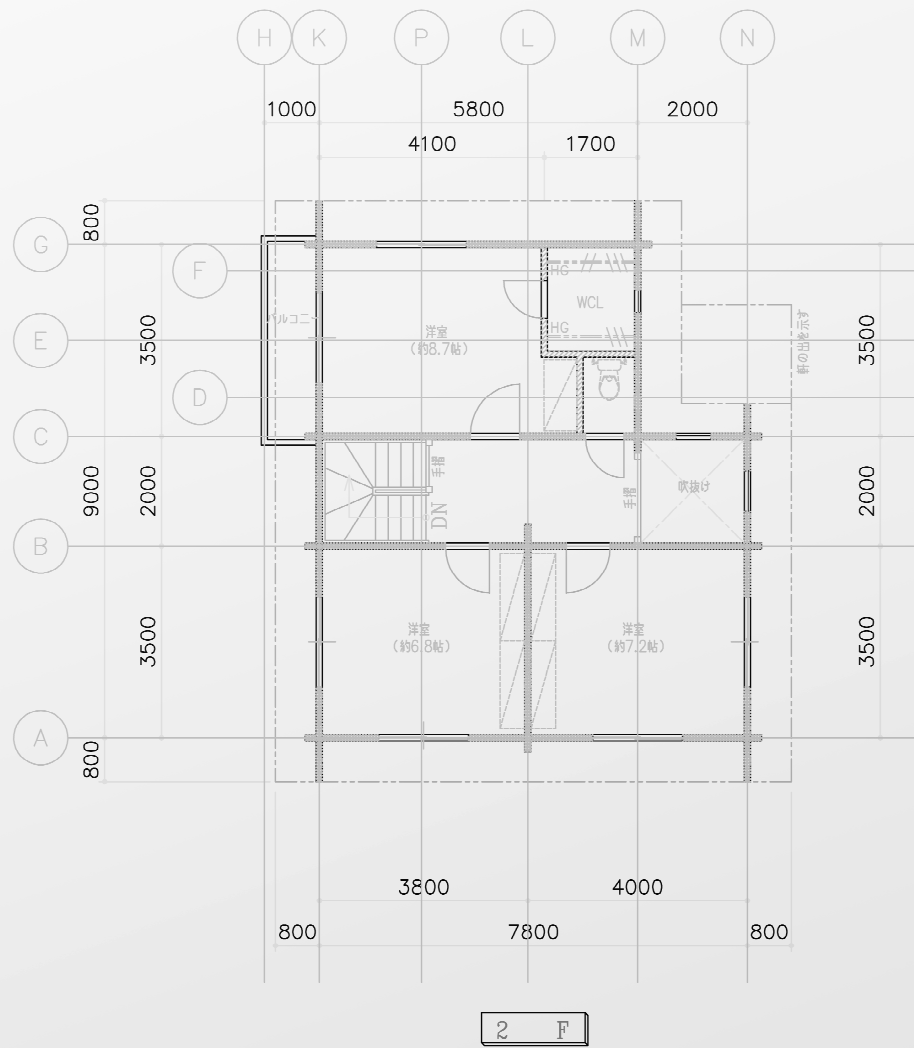
Cost Comparison Chart
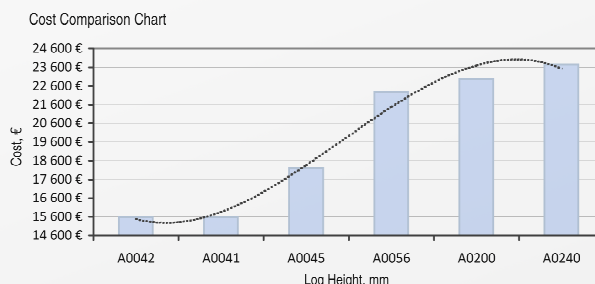
ID A0042

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
1	88	160	Japan	rM	876	17,8	15 592,80 €

ID A0041

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
2	88	162	Dutch	rM	876	17,8	15 592,80 €

ID A0045

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
3	114	162	Finnish	rM	876	20,8	18 220,80 €

ID A0056

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
4	136	180	Finnish	rM	795,3	28,00 €	22 268,40 €

ID A0200

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
5	150	127	Finnish	rM	1085,2	21,16	22 962,83 €

ID A0240

#	Log Width	Log Height	Profile	Units	Amt	Price per meter	Cost
6	190	158	Finnish	rM	876	27,1	23 739,60 €

H K   P   L   M   N

5800   2000

G

F

1700   3500

E   3500

D   1800

C

9000   2000   UP   2000

B   1250   5500

3500   DN   2250

DK
(約12.3帖)

玄関

L
(約8帖)

A

2150   1850

3800   4000

7800

1   F

2　F

9000

3500   2000   3500

9000