# Timber Framing

A practical Guide for Beginners

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# Introduction

Timber framing is a traditional building method in which the structural framework is crafted from timbers connected by mortise and tenon joinery, fastened with hardwood pegs. This technique has been widely used for thousands of years, owing to its durability, accessibility of materials, and relatively easy design.

In Europe, timber framing has long been a well-established craft, particularly in the British Isles, Germany, France, Holland, and beyond. In forest-rich regions such as Scandinavia and the Baltic countries, where log material was more abundant, log construction historically became the more prevalent building method. However, timber framing has also been extensively applied, particularly in the roof structures of larger buildings such as townhouses, manors, and churches. The rafters of traditional farm buildings were also typically joined with half-laps and pegs, making them fine examples of local vernacular timber framing.

This study material introduces the fundamentals of timber framing, offering beginners an overview of basic techniques and outlining a feasible project featuring common joints. It also provides an introduction to wood as a building material and the essential tools used in timber framing.

This study material was created through the collaborative efforts of Estonian and Latvian carpenters, who love and practice this beautiful historical building method and would like to pass on these skills.

*Figure 1. Timber frame construction of the Kolga-Jaani church tower.*

# 1. Wood characteristic

Wood is a demanding building material. To achieve a lasting and high-quality result, it is necessary to know the properties of wood as a building material.

## 1.1 Tree growth

The tree grows in length from the ends of the branches and in thickness from the outer surface of the trunk. Between the wood and the bark is a layer of cambium, i.e., cells that divide during the growing season, producing wood cells towards the inside and bark cells towards the outside.

Water and minerals rise towards the branches of trees through the outer layers known as the xylem, the so-called sapwood. At the top, leaves or needles use water and light to create carbohydrates. These sugars travel downward in the phloem layer, out to the root system. This means that if you peel off the bark around the perimeter of a growing tree, the roots of the tree will starve to death.

Tree growth starts in the spring when the amount of light and heat are suitable. In springtime, large and thin-walled cells, called early wood, are formed, which facilitate the transport of fluids needed for growth. Towards the end of summer, the growth of the tree slows down and the resulting cells are now smaller and with thicker walls - the so-called latewood is formed. In autumn, growth stops and the tree prepares for winter dormancy. Within one year (the duration of the growing season is approximately from May to August), a new growth ring forms around the trunk. The share of winter wood in the width of the entire annual ring of a coniferous tree is on average 20-25%.

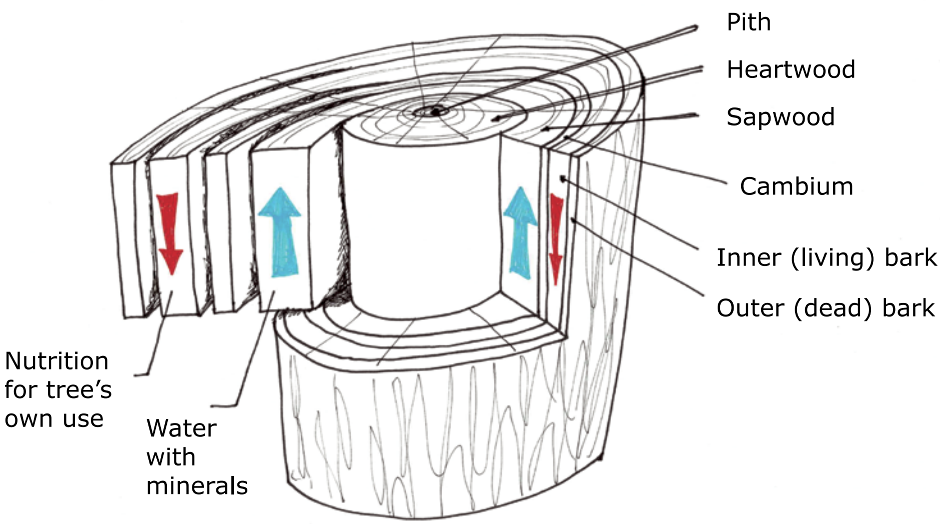


*Figure 2. Movement of fluids in the tree trunk.*

Sapwood is the outer, lighter-colored part of the wood of the tree trunk. It consists of fluid-conducting cells. In the sapwood, water is delivered from the roots to the top. A young tree consists entirely of sapwood. Heartwood is the inner, often darker part of the trunk. It consists of dead cells and therefore does not take part in the transport of fluids. As the tree ages, the sapwood in the middle of the trunk begins to turn into heartwood starting from around the pith. Along the rays, several substances such as resins, dyes, and the tree's self-produced anti-aging substance - pinosylvin - accumulate in the middle of the trunk. The heartwood is chemically transformed and no longer delivers fluids. Compared to the outer sapwood, the inner heartwood has a higher resistance to fungal decay and insect damage.

The three main directions of wood are:

- the longitudinal direction of wood fibers,
- the radial direction running from the middle of the trunk towards the outer layers,
- the tangential direction along the annual rings.

The physical properties of wood in these directions are different. For example, when wood dries, it shrinks in the tangential direction twice as much as in the radial direction.

Wood as a material is:

- Heterogeneous, i.e. the various parts of the material have different properties, for example, early and late wood, trunk and branch wood;
- Anisotropic, i.e. variable physical properties in different directions, for example, shrinkage-expansion, strength variations, and in processing;
- Hygroscopic, i.e. wood changes and harmonizes its moisture according to the moisture content and temperature of the surrounding air;
- Rheological, i.e. under the influence of a long-term external force, the shape and dimensions of the wood can change, the wood "shifts".

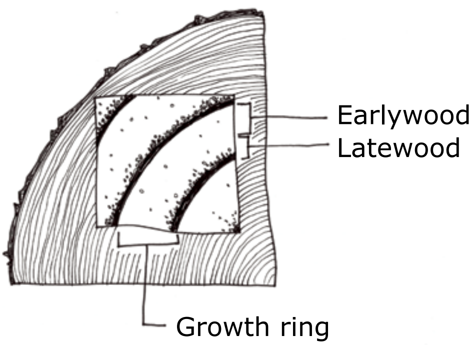


*Figure 3. Early wood and late wood.*

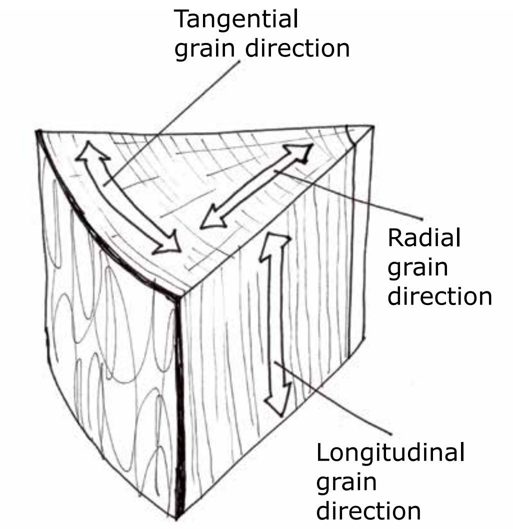


*Figure 4. Tangential, radial and longitudinal grain directions.*

## 1.2 Chemical properties of timber

Wood consists mostly of organic compounds, which include 50% carbon, 43% oxygen, 6% hydrogen, 0.4% ash, and 0.1% nitrogen, plus a small amount of mineral compounds.

The main components of wood are cellulose (40-50%), hemicellulose (25-35%), and lignin (20-30%). Cellulose acts as a fibrous stiffener like reinforcement in a concrete beam. Hemicellulose is an intermediate. Lignin is the glue that binds everything together (compared to a concrete beam, lignin is like cement). In color, cellulose is light gray and lignin is yellowish and brown when decomposed.

## 1.3 Physical properties of timber

The density of wood is the mass of a unit of volume, i.e. the quantity of matter, with the unit g/cm$^3$. As timber is a hygroscopic material, there is always some water in the wood. Therefore, it is important to know the moisture content in the context of wood density as it is highly variable depending on the humidity.

The bigger the density the higher are following properties:

- strength
- hardiness
- durability
- thermal conductivity
- calorific value
- expansion and shrinkage

## 1.4 Moisture content

Wood moisture content is the amount of water in wood, i.e. the proportion of water mass to the mass of dry wood. The walls of the tree cells absorb water until the point of saturation.  In most wood species, the fiber saturation point is around 28-30% moisture content. When the moisture content increases, excess water accumulates in the cell cavities or lumen. The strength of wet wood is about half of dry wood.

The moisture content of each piece of wood eventually finds equilibrium according to the relative humidity and temperature of the air around it. For example, when storing undried pine wood at 60% relative air humidity, the moisture of the piece of wood balances at about 13%.

The easiest way of drying the wood is in the open air, but it requires a long drying time. To achieve resistance to damage, the moisture content of the dried wood must not exceed 18-20%. Depending on the type of wood, the cross-section of the material, and the drying conditions, it can be achieved within a relatively long time - from three months to a few years. For example, the production of furniture requires significantly drier material and a very careful drying method. Kilns can be used to dry material, but this is an energy-intensive process.

Due to the anisotropy of shrinkage, the form and shape of a plank or board sawn out of a log change irregularly when drying. It also depends on the direction of the annual rings in the wood. Boards and planks are typically milled slightly larger than the final product. Due to the differences in shrinkage in different directions (shrinkage anisotropy), cracks often occur in the material.

Shrinkage ratios in wood in all three main directions are tangentially : radially : longitudinally accordingly 2 : 1 : 0.1.

Bear in mind:

- heavy tree species shrink more than light ones;
- latewood shrinks more than early wood;
- heartwood shrinks less than sapwood.

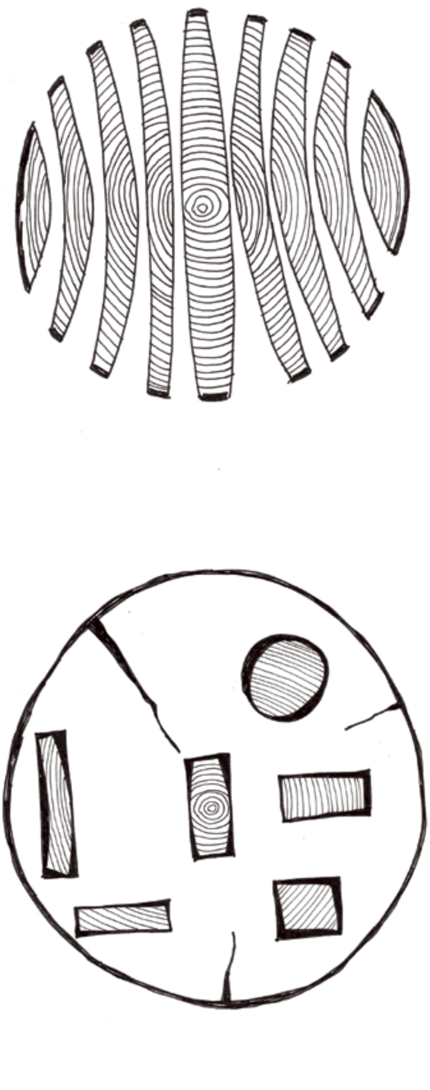

*Figure 5. Characteristic shrinkage and distortion of flat, square, and round pieces as affected by the direction of growth rings. Tangential shrinkage is about twice as great as radial.*

# 2. Preparatory works

## 2.1 Storage of logs

Common tree species used in timber frame construction in Baltics are Norway spruce *(Picea abies)* and Scots pine *(Pinus sylvestris)*. European oak *(Quercus robur)* is also used, although significantly less. Oak heartwood resists rotting well and its wood is denser compared to pine or spruce, but unfortunately, there is not enough oak in Baltics for use in construction. However, oak is a good material to make wooden pegs and wedges to lock the joinery into place. In southern Europe, oak is commonly used in timber frame buildings.

To find good spruce or pine logs, one needs to take the time to look around in the forest. The trees with the required quality might not be found in just one corner of the forest. The annual rings need to be even and not too wide. This means that one has to look for an environment where the growth of trees is not too sudden: for example, places with poorer soil, edges of swamps, the shady north side of a hill, etc. In pine trees, bark can be a good indicator - a mature tree develops a rough bark that grows higher and higher as the decades pass.

Before cutting a tree for construction, one must make sure of the characteristics of the selected tree. Among other things, the following should be noted:

- Construction material should come from a living tree;
- The construction log should have straight growth (if the goal is not specifically to use curved spacers or other material);
- The construction log should have a round cross-section;
- The wood should be healthy – avoid trees with various defects such as insect damage, rot damage, elk damage, or growth defects;
- On spruce, the resin flow can indicate hidden problems, such as bark beetle damage;
- The construction log should not have many large branches;
- Log with severe spiral grain should be avoided, as it tends to be "restless" in the wall. The grain can be observed by the branches and bark. The right-hand spiral grain should not be more than

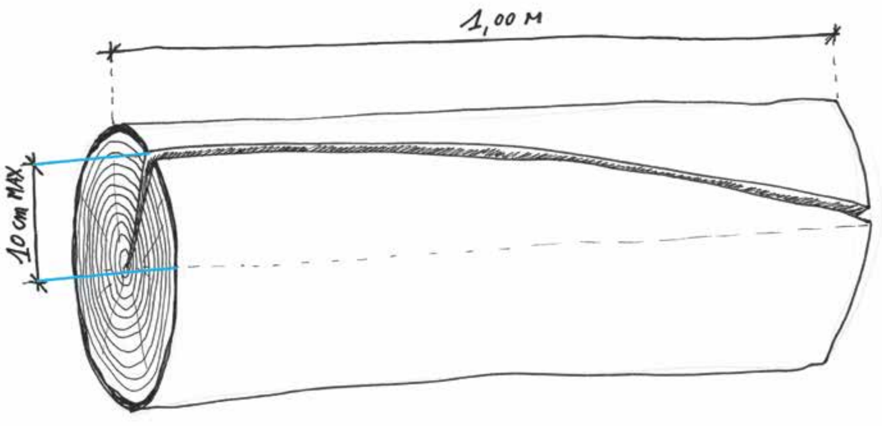


*Figure 6. Measuring the right-hand spiral grain.*

1:10, the left-hand spiral grain should not be more than 1:20. The already spiral logs tend to twist further while drying;
- The construction logs with a strong eccentric pith (with a deviation of more than 3 cm from the center) are not recommended.

Construction logs are cut in winter when trees are dormant. Tradition also follows the folk wisdom that building logs were cut during the waxing moon's "hard time", during the first quarter. It is also least harmful to the forest soil and the logs if the material is harvested and transported while the ground is frozen and snow-covered.

To find suitable logs, the trees need to be measured in the forest. For that purpose, the tree caliper is a good tool. The measurement is generally made at 1,3 m above the soil (at breast height). One can expect the tree tapers approximately 5-10 mm per meter.

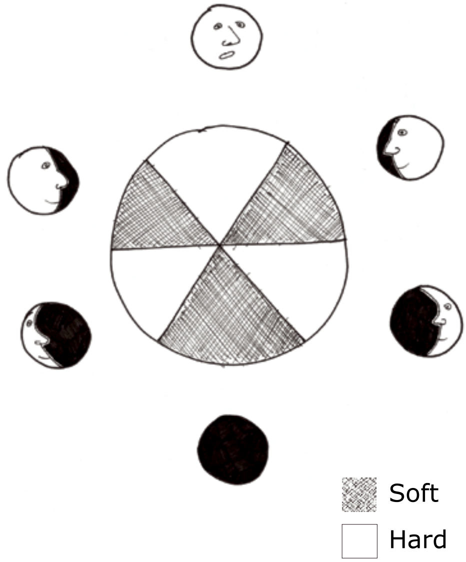


*Figure 7. Soft and hard times of the moon.*

*Figure 8. Felling the tree in a traditional way (picture from the short film "Logging day").*

*Figure 9. A tree caliper, axes, two-man saw.*

*Figure 10. Nowadays logging set: a logger tape, a felling bar, a chainsaw, a helmet.*

Traditionally felling the tree, the notch cut is made first to a depth of approximately one-third the trunk diameter. A handsaw or an axe can be used for that. The second cut is the felling cut - made on the opposite side of the tree from the notch cut and cut through the base of the tree leaving a narrow strip like a "hinge". If the hinge is made properly, the tree will fall perpendicular to the hinge itself. For that cut a two-man saw is the best tool. To help direct and push the tree, additional felling tools can be used such as a felling bar (breaking bar), wedges, and push pole.

To optimize the work done in the forest, it is useful to make a list consisting of the length and diameter of the logs needed. The size of timbers used for building timber frame structures depends on frame measurements and the function of the building. In the case of small frames, the dimensions are usually 15x15 cm or 20x20 cm. In the case of larger frames, the dimensions are also larger.

To find a proper log for a certain size of timber, the ratio 1,6 is used. If a 20x20 cm timber is needed, then the suitable round log for that would be 1,6x20 cm=32 cm. If the logs are even and straight, the ratio can be reduced to 1,5. Surplus material length should also be considered. 50 cm extra would be optimal as it leaves the possibility to cut away cracked ends or move the timber to exclude the knots from the joint. Knots have much more dense wood and therefore it's harder to process them with hand tools. Leaving surplus length increases material cost, so one must balance between different factors. If dried material is bought from a lumberyard, surplus length can be reduced by inspecting the timber beforehand.

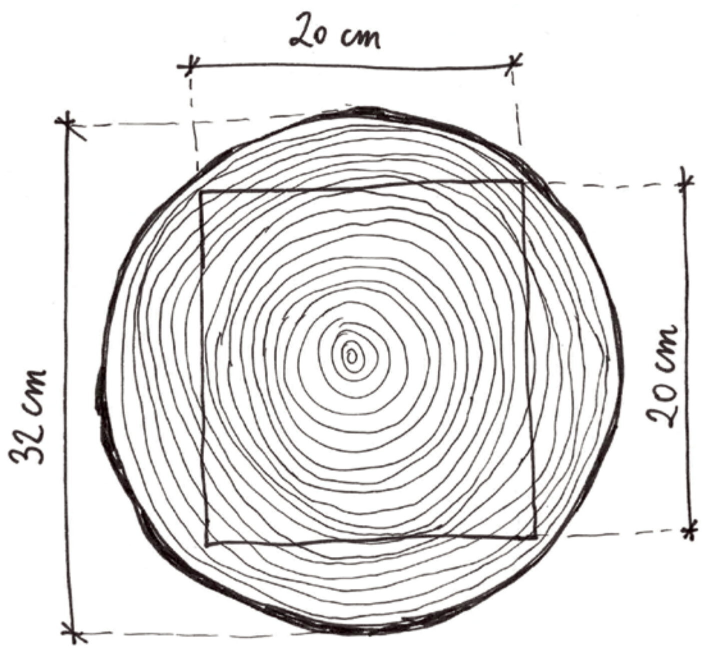


*Figure 11. The suitable log for cutting a 20x20 cm timber should be 32 cm in diameter.*

## 2.2 Debarking and using the fresh timber

After the logs are taken from the forest, they should be debarked. The best time to debark the logs is when the daily temperature is slightly over 0 degrees C. Then the logs are already slowly defrosting and it's easy to peel the bark off. When the days are getting too hot, then the bark can dry firmly to the log and it's harder to peel it off. The longer the bark is on, the greater the risk of getting logs infected with the blue stain fungi. Pine logs get infected rather quickly, whereas spruce logs take a bit longer. When the logs are milled immediately after felling, debarking is not necessary.

For debarking there are several tools: digging spade, log peeling spud, or drawknife. For bigger bark, the digging spade and log peeling spud can be used. The drawknife is more suitable for debarking thin bark on young trees, such as those often used for roof battens.

Historically, buildings have been built from green timber. Trees were felled in the winter and construction was carried out in the summer. Today, building from raw logs is justified only when hand tools are used during construction because raw logs are easier to work with and the wood is softer. However, one must consider the possible negative effects occurring while the prepared construction elements are drying. These effects can be relatively severe - twisting of the material, large cracks, etc. If the plan is to hew the logs with hand tools, the log should preferably be debarked and dried for a few weeks in the spring. The fresh resin is then no longer so sticky and the material is easier to handle. The hewing can also be accomplished with bark on, but the bark makes it more difficult to mark the lines.

*Figure 12. A plumb bob, carpenters pencil, chalk line, tape measure, log peeling spud, drawknife.*

*Figure 13. Broad axes, carpenters axe, log dog.*

A chalk line is used to mark the lines for hewing. If more than 5 cm of wood needs to be hewn, slight axe chops or saw kerfs are scored in every 30 cm to make the work easier. For hewing it's wise to use two axes. First, the majority is knocked down with a larger and heavier broad axe, and then the finishing is done with a smaller and lighter carpenters axe. The most common hewing axes in Estonia are currently of Swedish origin.

Rip cutting is rarely used these days, but it is an enjoyable task with a sharp saw.

If green timber is used for the frame, it is important to erect it as soon as possible after the parts are finished. The joinery and pegs locking the frame together help to minimize the warping and twisting of the timbers as they dry. The frame should remain open on the sides during the drying period. Covering the facade should be done after the drying process is over.

*Figure 14. Rip cutting the timber.*

## 2.3 Drying and stacking the logs

When building with modern power tools, it is reasonable to first pre-dry the logs as round material and only mill them into the necessary dimensions just before the start of construction. This reduces the extent of twisting and checking. If the raw material is cut into timbers and then left to dry, the material should be initially milled to a larger dimension, (1 inch in each direction). This allows for re-milling them into straight, square timbers just before joinery begins.

When drying as round material, the logs must be stacked after peeling. Logs must be properly stacked for at least a year to dry. The stack should be at least 50 cm above the ground. Log layers must be with more or less equal height, that is, logs of similar diameter should be in one layer. Each layer must be fixed and wedged so that the logs do not roll out. The stack must be covered with a waterproof roof with the sides remaining open. This avoids the risk of blue stain formation in the drying material caused by insufficient air movement.

The average moisture content in wood before construction should be less than 20%. Differences in moisture content in the material should be as small as possible.

*Figure 15. Stacked construction logs drying naturally.*


*Figure 16.*
*Bandsaw mill in work.*

*Figure 17.*
*Timber carts for transporting the material.*

# 3. Tools

Building a traditional timber frame does not require a lot of tools. The structure presented in this study material can be completed with hand tools, although power tools will speed up the process somewhat. Traditionally, a carpenter had as many tools as he could carry. In other words, it is not necessary to go to the store to buy expensive machines. However, in this study material, a wider range of tools will be introduced as they make the work easier and faster.

It is essential that the tools are properly sharpened. The cheapest way to get sharp tools is to make a sharpening set from sandpaper glued to a piece of glass. Sandpaper should vary from 60 to 2000. There are also useful tools like wet sharpening machines and sharpening stones found in a woodworking shop.

*Figure 18. Carpenter's tool box.*


*Figure 19. Sharpening set: sharpening stones, sandpapers, wet sharpening machine.*

## 3.1 Scribing tools

It is useful to have several **tape measures:** 8 or 10 m for measuring the length of longer parts and 5 m to mark the details.

The **pencil** for laying out the timber frame joints should be in a grade that is neither too soft nor too hard (for example, HB) and should be sharpened properly so it doesn't mark too thick of a line. **Erasers** can be used on wood to correct mistakes. If dry material is used, then it is good to use a **utility knife** for pre-scoring the surface fibers, which can help to avoid the tearout during the cutting of the joinery.

**The folding rule** makes many measurements easier, especially when a point-to-point measurement in the center of the timber is necessary. It should be 2 m long.

**The framing square** is specially designed for timber framing. It is used to check the squareness of the material, to find the timber's twist (using two squares, called winding sticks when used this way), to apply lines and measurements to the sides of the timber, etc. It can also be used to mark angles. When choosing a square, it should be ensured that it is metric, has the millimeter measure and the markings are engraved.

**Speed square (rafter square)** is a useful tool that helps to mark and find degrees, draw distance lines, can be used as a saw guide and easily marks 45 degrees.

**Try-squares** have different designs and are used to draw various lines and marks. Their advantage over the framing square is in compactness and ease of use. Less accuracy can be pointed out as a disadvantage because it is more easily affected by the roughness of the wood due to its short grips. Folding type of try-square is not recommended, as everything that moves, wears out and accuracy will most likely suffer.

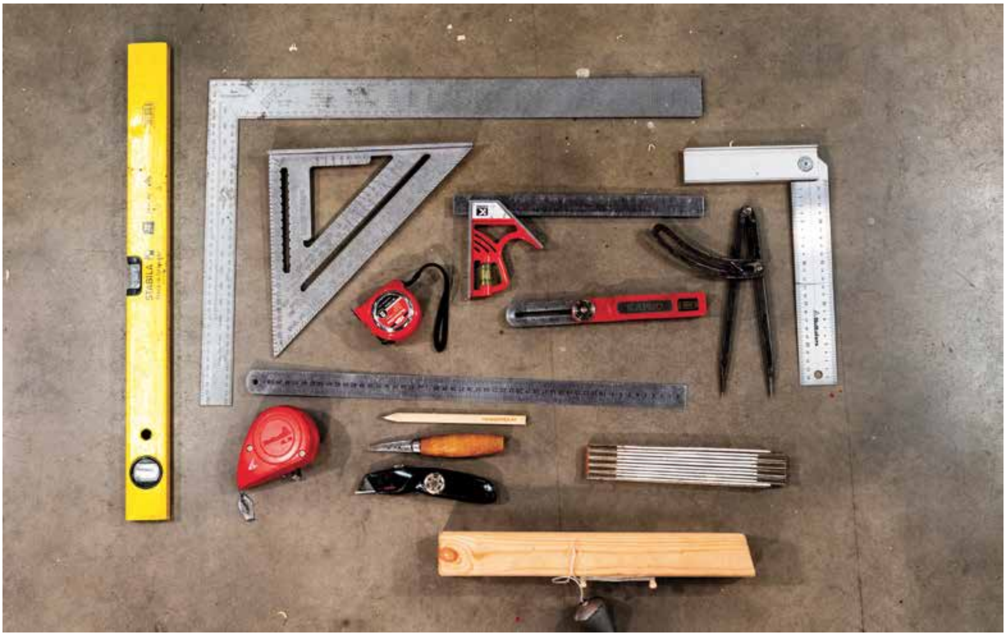

*Figure 20. A level, framing square, speed square, combination square, divider, try-square, tape measure, sliding bevel, steel ruler, chalk-line, pencil, carpenters knife, utility knife, folding ruler, plumb bob.*

**The combination square** is a marking tool with a sliding blade for measuring depths and checking the 90 and 45-degree angles and is an irreplaceable tool for checking mortise squareness.

**Sliding bevel** is used to check and transfer different angles.

If the frame holds many identical details (for example the braces), the work is speeded up using **templates.**

*Figure 21.*
*Using a speed square with the circular saw.*

*Figure 22.*
*Combination square is good for checking mortise depth and squareness.*


*Figure 23.*
*A 42 mm plexiglass template for scribing mortises.*

*Figure 24.*
*The brace template is made from plywood.*

## 3.2 Cutting tools

Hand saws and circular saws are typically used for cutting. Some cuts can also be made with a chainsaw. If there are not many tools available, the cutting can be done by combining tools. For example, a small circular saw can be used to make the first cut with the maximum depth, and a hand saw is used to cut the rest.

There are different types of **hand saws** - traditional crosscut/rip-cut saws and increasingly popular Japanese saws. Traditional Western handsaws work on the push stroke, requiring more power. Japanese saws, on the other hand, work by pulling and this allows for a thinner blade. In general, it can be said that pulling the saw toward you gives better control over the saw than pushing the saw. A saw with larger teeth is better for a large cut and a saw with smaller teeth for a more precise cut. If the right saw is used for the cut, the work is very enjoyable and fast. Important to remember that with a hand saw you only cut the lines that you can see.

When choosing a **circular saw,** the cutting depth and handedness must be considered. It is good to use at least two circular saws: a smaller cordless saw that cuts 5-6 cm and a larger one that cuts up to 10 cm deep. The larger one is also powerful enough to make rip cuts in wood. Circular saws with a ceramic (not metal) sole plate, are of higher quality. If an unfamiliar circular saw is used, it is recommended to start with a few trial cuts.

A simple **chisel** from the hardware store is fine to start with, but longer chisels are better for working on traditional timber framing joinery. There should be at least two chisels in the toolbox: a narrower one 1 inch (25 mm) wide and a wider one 1.5 inches (38 mm) wide. To make working with a chisel enjoyable, it must be sharp.

A **mallet** made of wood or some modern composite material must accompany the chisel. A metal hammer will break the chisel's head quite fast and is therefore not applicable.

*Figure 25. Circular saws in different sizes.*

Figure 26. Small hatchet, Japanese saw, common carpenters hand saws.

Figure 27. Two sizes forged chisels, a slick, two sizes chisels from hardware store (Bacho brand), a wooden mallet.

## 3.3 Tools for drilling holes

Figure 28. Historical boring machine for making mortises.

Older hand drills or augers can be used for drilling, but it is faster to use a **power drill**. It must be taken into account that when drilling mortise holes, the drill bit must have a wide diameter (e.g. 40 mm) and the drill must have lots of torque.

Self-feeding **auger bits** are generally used. The screw tip helps to pull the drill bit into the wood. When drilling a mortise, it is good to use **forstner** bits that allow cutting wider holes. When drilling a peg hole, the drill bit should be approximately 30 cm long, because with a longer bit it is easier to observe the drilling direction.

A **portable drill stand** is not an essential tool, but it simplifies and makes the work more accurate. The guide allows drilling at exactly 90 degrees.

The **plunge router** enables milling shallow recesses, called housings, with a fixed depth.

A **chain mortiser** is a machine that uses a chain mounted on a bar much like a chainsaw to cut a mortise into wood. It significantly speeds up the process of cutting mortises.

Figure 29.
Drill stand being used to drill peg hole.

Figure 30. Plunge router with guide.

Figure 31. A hand brace drill, T-auger.

Figure 32. A chain mortiser.

## 3.4 Tools for finishing the surfaces and making wooden pegs

A **beam planer** is not a necessary tool, but it simplifies many processes. Dry material is often planed to size before marking. Power planers of different widths are used for this purpose.

**Hand planes** are used for finishing the tenons and a **spokeshave** or plough plane is used for finishing the beam.

Wooden pegs are traditionally used to fasten the joints. They are usually made from a hardwood - in Estonia typically oak or ash. The diameter of the peg is usually 20-25 mm depending on the cross-section of the timber. Traditionally pegs are split from a tree trunk with splitting froe and finished with a drawknife.

*Figure 33. Spokeshave, block plane, rabbet plane, smoothing plane, bench plane.*

*Figure 34.*
*A bench plane, cordless 82 mm width planer, power planer 170 and 300 mm width.*

*FIgure 35.*
*Splitting froe, mallet.*

*Figure 36.*
*Simple jig for making wooden pegs with a thickness planer.*

# 4. Construction methods for the traditional timber frame

There are two common methods of timber frame construction: the scribe rule method, which was historically used in Europe, and the relatively more modern square rule method, which developed in the United States and is introduced in more detail in this study material.

## 4.1 Scribe rule method

The scribe rule method allows the use of curved or round material and enables building a frame from hand-hewn timbers.

When using the scribe rule method, the parameters of the section to be built are drawn full scale (a process known as lofting) on the workshop floor. Then, the framing timbers are placed at a height of approx. 20-30 cm above the floor, e.g. on timber blocks. The low marking height of the joints minimizes the error. Next, the timbers are set parallel to the lines on the floor surface, and the details are leveled longitudinally and transversely using a plumb bob.

The placement of all the details is re-checked and the joints are marked on the details using mainly a plumb line and a divider.

Several similar sections can be marked with one "map" drawn on the floor; therefore the details are marked and cut into sections.

Nevertheless, it must be kept in mind that when using the scribe rule method, all the details marked and joined in the construction are unique. Therefore, utmost attentiveness is required when making identification marks, known as marriage marks, so that the unique location of each timber in the frame isn't lost.

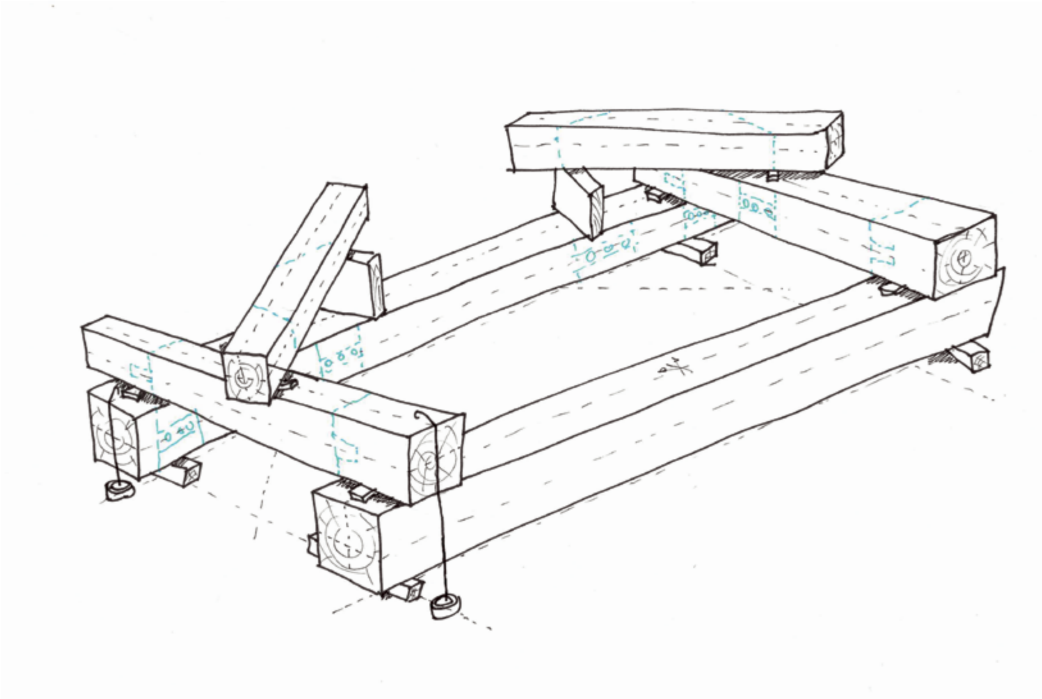

*Figure 37. Scribe rule method.*

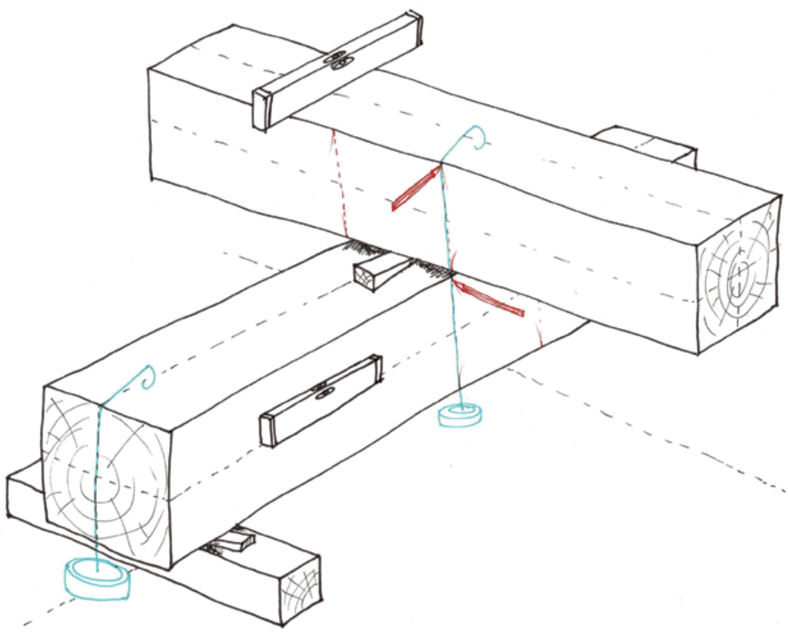

*Figure 38. Working with a plumb bob and dividers.*

## 4.2 Square Rule method

Square Rule requires pre-processed timber material. At least two close sides of the timbers are sawn, planed, or hewn square.

Using the Square Rule, the traditional timber frame is built timber by timber. All joints are marked at right angles, using the reference faces assigned to the timbers and a large framing square. Reference faces are marked with a ▲ (triangle). Using a framing square, the length and width dimensions of the notches and, if necessary, housings are measured from the reference surfaces. The purpose of the housings is to neutralize the irregularities of the timber in use, which result, for example, from the uneven cutting of the timber or the drying twists.

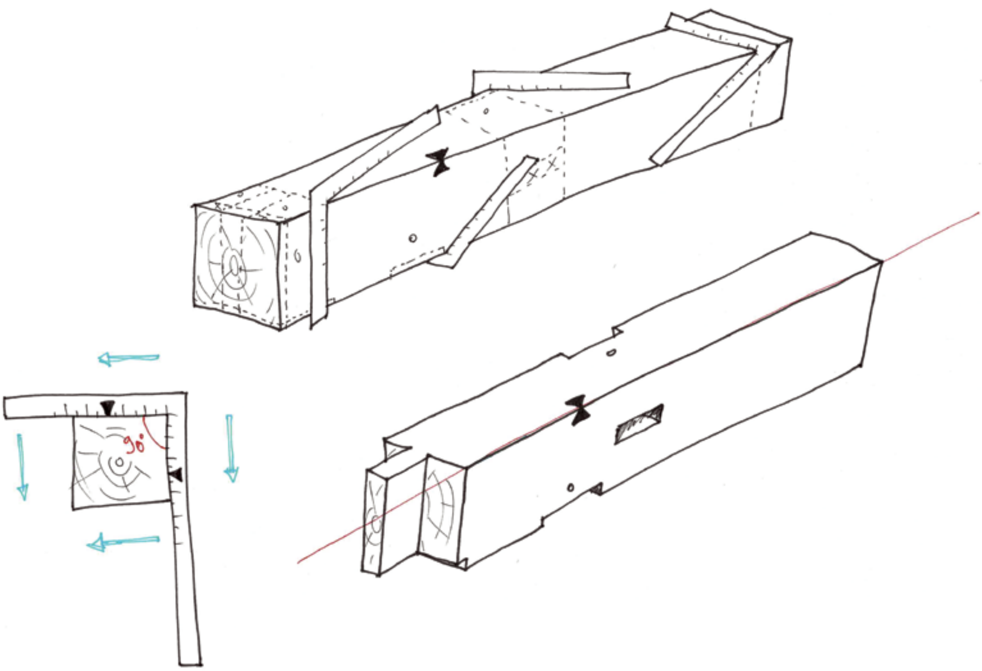


*Figure 39. Square Rule principles. Reference faces, the length and width measurement direction.*

# 5. Timber frame construction process with Square Rule method

In the following chapters, we describe the process of building a timber frame structure that we usually build with 6-8 men in a 5-day course. It covers a number of the most common joints and is feasible for beginners.

## 5.1 Details and sections of the frame

A traditional timber frame consists of framing members with specific names that come from its location in the frame or its function.

Based on the details, it is possible to divide the frame into larger sections, which simplifies the planning of the building process, e.g. material and work time calculations, price estimates, etc. Our frame is divided into three longitudinal sections and four cross-frames or bents.

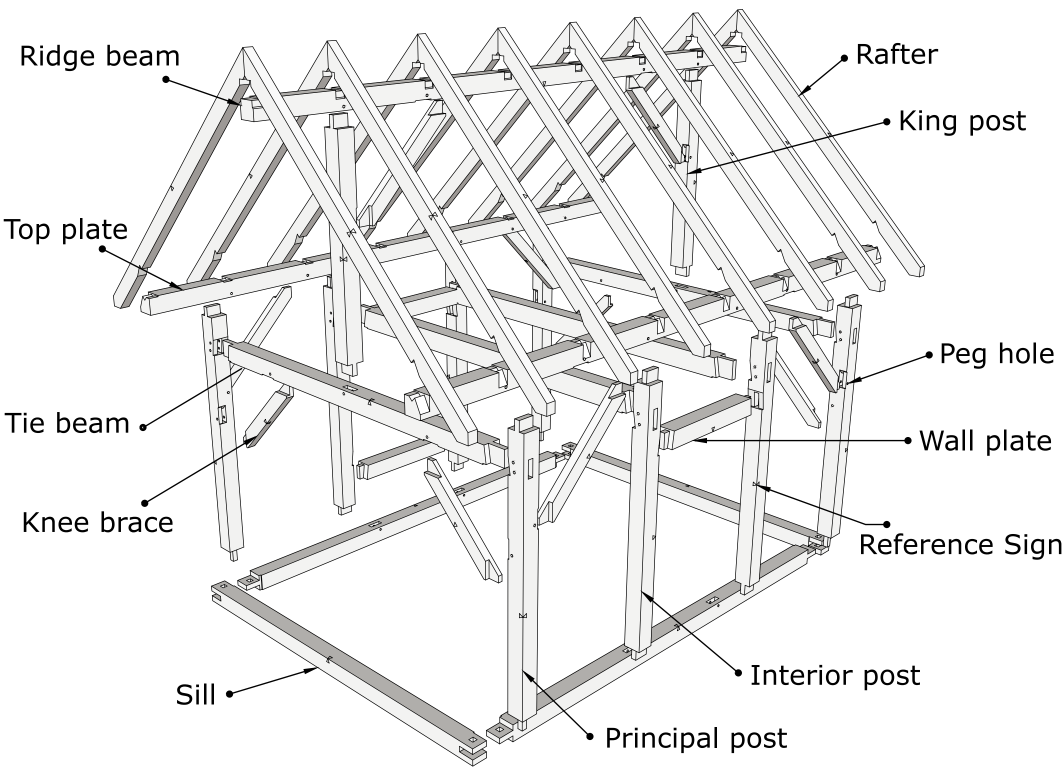


*Figure 40. Details of the frame.*

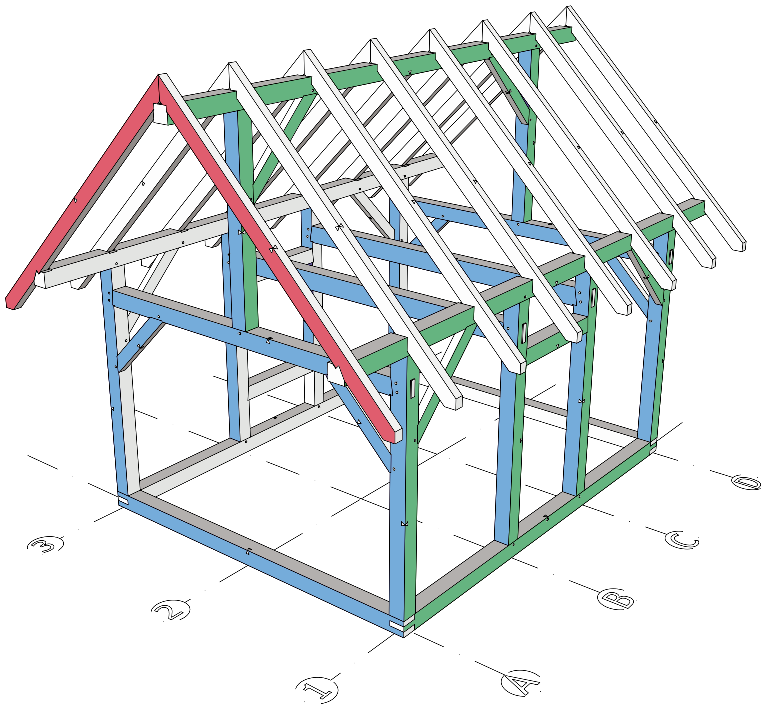

*Figure 41. The longitudinal section (green) is marked with numbers and the cross-frame or bent (blue) is marked with letters, the rafter pair is red.*

When the whole building is divided in this way, each detail can be uniquely marked. Each master may mark his pieces differently, but it is important that all the carpenters working on a project together understand the marking in the same way. After each timber is finished, it should be marked on both ends.

Historically, the section details have also been marked with Roman numerals, vertical or horizontal dashes, crescents, and combinations of them - so-called marriage marks. The number of dashes and crescents depends on the number of structural sections and details.

*Figure 42. Marriage marks on the details in the historical timber frame.*

## 5.2 Scribing and cutting the joints

Before cutting can begin, the joinery needs to be drawn, or laid out, on the timber in pencil. Marks are made with a sharp hard pencil to get a precise thin line. Identical timbers are marked and cut at the same time to avoid measurement errors and increase sawing efficiency. However, the parts can also be made in sections or from the bottom up (bottom plate and floor beams, posts and diagonals, top plate, ceiling beams, and finally rafters). It is recommended to make a list of all the parts, where the timbers that are already finished can be checked off so that it is always possible to keep track of progress.

First, the reference sides of the timber are marked. For this purpose, two adjacent reference sides (square to each other) are chosen and marked with a triangle ▲. If possible, it should be taken into account which sides remain exposed on the building and which remain inside the framework (e.g. later covered with planks or other material). Timbers with large checks, impurities, and punky knots should, if possible, be placed inside so that they will not be exposed later. Measuring and marking joints from reference surfaces is done with a large framing square, with the longer arm always on the reference face. It is recommended to mark the reference corner by painting the corresponding corner on both ends of the timber. The construction drawing shows the four sides of the timber. They are marked both in the drawing and on the timber with numbers (1, 2, 3, 4) or letters (A, B, C, D) starting from the reference sides.

All longitudinal measurements on the timber should always be taken from the same end of the timber, and all cross measurements should be taken from a reference face. For the sake of simplicity of the drawing, one point of the joint is at a given distance from the end of the detail. However, other points on this joint are measured from the first measured point. To do this, a straight line should be marked and, if desired, cut off the end from which the measurement starts.

*Figure 43. Scribed timber before cutting.*

Scribing is started from one reference face. Only one side is marked at a time - one does not go to the other side until all the layout on the current face is complete. When going to a new face, the measurements are transferred from the first side, so it isn't necessary to take measurements from the end each time. All four sides are scribed in this way.

Figure 44. Tenon with sliced cheeks (A).


Figure 45. Falling cut (B).

Before sawing, it is recommended to score the lines with a utility knife (or carpet knife) to prevent tear-out. The first cut is made from the reference side. There are two main ways to cut the tenon: A) the cheeks of the tenon are cut with a saw and later cleaned with a chisel, or B) a so-called drop cut is used and the tenon is cut out entirely with a circular saw.

When the tenons are cut, the mortises follow. There are two ways to cut the mortises: A) with a chain mortiser or B) with a drill and a chisel. The mortises should be finished before the housing is cleaned. In this way, a comfortable surface for working is ensured. The mortise is made approx. 1 cm deeper than the tenon to ensure that the shoulders of the tenon engage the receiving timber rather than the end of the tenon.

When all the cuts have been made, the peg holes are marked and drilled. As a rule of thumb, the distance of the peg hole from the corner must be at least 1.5 times greater than the diameter of the hole. For example, if a 22 mm drill is used, the distance of the center of the hole from the corner is 33 mm. Another option is to measure the distance of the peg hole with the grip of a carpenter's square (1.5 inches).

*Figure 46. Cutting a mortise with a chain mortiser (A).*


*Figure 47. Cutting a mortise with drill and chisel (B).*

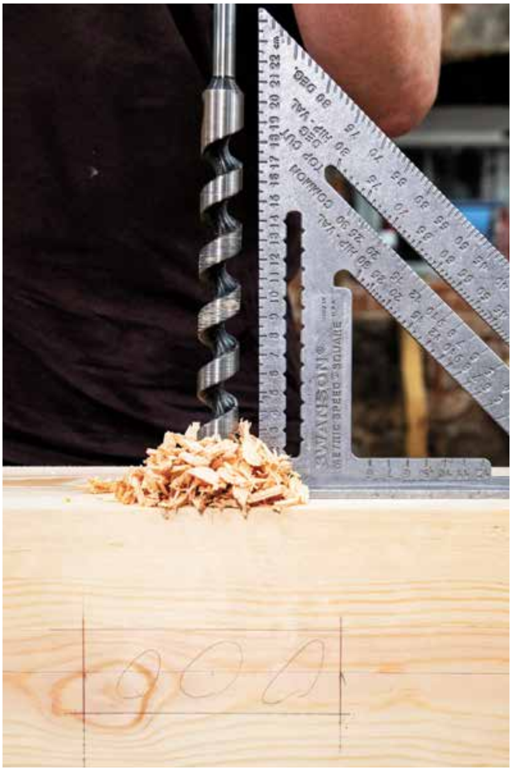

*Figure 48.*
*Drilling a peg hole into the joint using a square.*

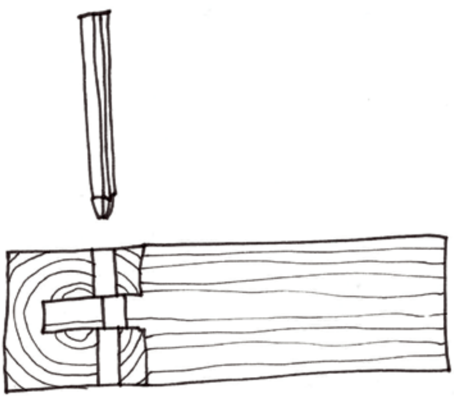

*Figure 49. Off-set marking.*

There are two ways to cut the peg hole.

A) Holes are drilled through the mortise. Later, the joints are connected in the frame, and tightened with, for example, ratchet straps, a hole is drilled through the tenon, and a peg is hammered in. This technique is recommended if dry material is used for construction. For drilling, a drill stand is used. Another option is to use a square to hold the drill at a right angle.

B) Another option is off-set marking, also known as draw-boring. Similar to the first option, a hole is drilled through the mortise. Then the tenon part is assembled into the mortise and the center of the hole is marked onto the tenon with the tip of the drill. Then the tenon is disengaged from the mortise, and from the center mark, a new dot is marked 2-3 mm closer to the shoulder, and a hole is drilled through the tenon starting from this new dot. When the holes are drilled in this way, the peg pulls the timber tightly into the mortise as it is hammered in. It is essential for the peg to have a long taper for the drawbore method to work. The tenon can also be marked according to the measurements.

All timbers are marked with their name and number at both ends so that when stacked there is a good overview of the parts of the frame. It is recommended to try to pre-assemble the finished details section by section in the shop as they are cut. In this way, it's possible to correct potential mistakes in the workshop and the raising of the frame will go more smoothly.

When the timbers are stacked for transport, it is wise to take into account the order in which they are needed. For example, the rafters could be in the bottom of the stack, because they are needed last. The sill should be in the top layer because they are placed first, and so on.

## 5.3 Raising the frame

The means of transport of the frame to the building site depends primarily on the size of the frame. The applicable traffic regulations and the carrying capacity of the trailer must be taken into account. Our frame fits onto a 5 m trailer and can be raised with 4-5 people; no lifting mechanisms are needed. In the case of a larger frame, it is more convenient to order a truck with a crane, so that all the parts can be delivered at once and the crane can also be used in erecting the frame.

To place the building on the plot correctly, it is good to have a location plan where the future building is precisely and accurately planned.

The foundation for our frame could be slab, post, and screw pile foundations. The choice depends on the purpose of the building and the soil.

Raising the timber frame structure requires sledge hammer, ratchet straps, and clamps to tighten the bents, crowbar, and scaffolding for the larger constructions.

*Figure 50. Prepared post-foundation.*

First, the hydro insulation is installed on the foundation to protect against moisture. For example, SBS roll material is suitable or in the case of some historical buildings birch bark is more appropriate.

Then the sill is installed on the foundation, it is checked if the diagonals are compliant with the blueprint, and the sill is attached to the foundation.

Second, four bent sections are connected on the ground. Usually, the section is first firmly fixed with the ratchet straps and fastened with pegs. If there is enough space around the building site, the finished sections can be placed close to their location along the building site. The raising starts from one end and moves forward in sequence. Already raised sections are temporarily fixed with diagonal supports. The girts between the two middle sections must be placed and temporarily fixed before the next section is erected.

Once the bent sections are erected, they can be connected with top plates. As the top plate is installed, the corresponding braces must also be fitted. Braces connect the posts and the plates and tie the frame into a single unit and provide stability. When both plates are in place, the braces can be fixed with pegs.

*Figure 51. Installation of the top plates.*

The next step is to put planks or scaffolding boards onto the tie beams to ensure a comfortable and safe next layer to walk on. The king posts with braces are installed and then the ridge beam is lifted on top. If there is machinery available, those parts can be assembled and fixed with pegs on the ground, and the entire structure can be lifted into place in one piece.

*Figure 52. Ridge beam is set.*

Next, the rafters are set. Since the rafters are all the same, the sequence does not matter. The rafters must be attached to the purlins with long nails or structural screws.

At the end of the raising, a symbolic wreath is traditionally nailed to the top of the gable rafter pair. The wreath honors the forest and the trees that make these buildings possible and symbolizes gratitude towards the builders.

If the frame is raised and the roof is not immediately built, it is important to temporarily cover the building with rain-proof material.

*Figure 53. The assembled frame.*

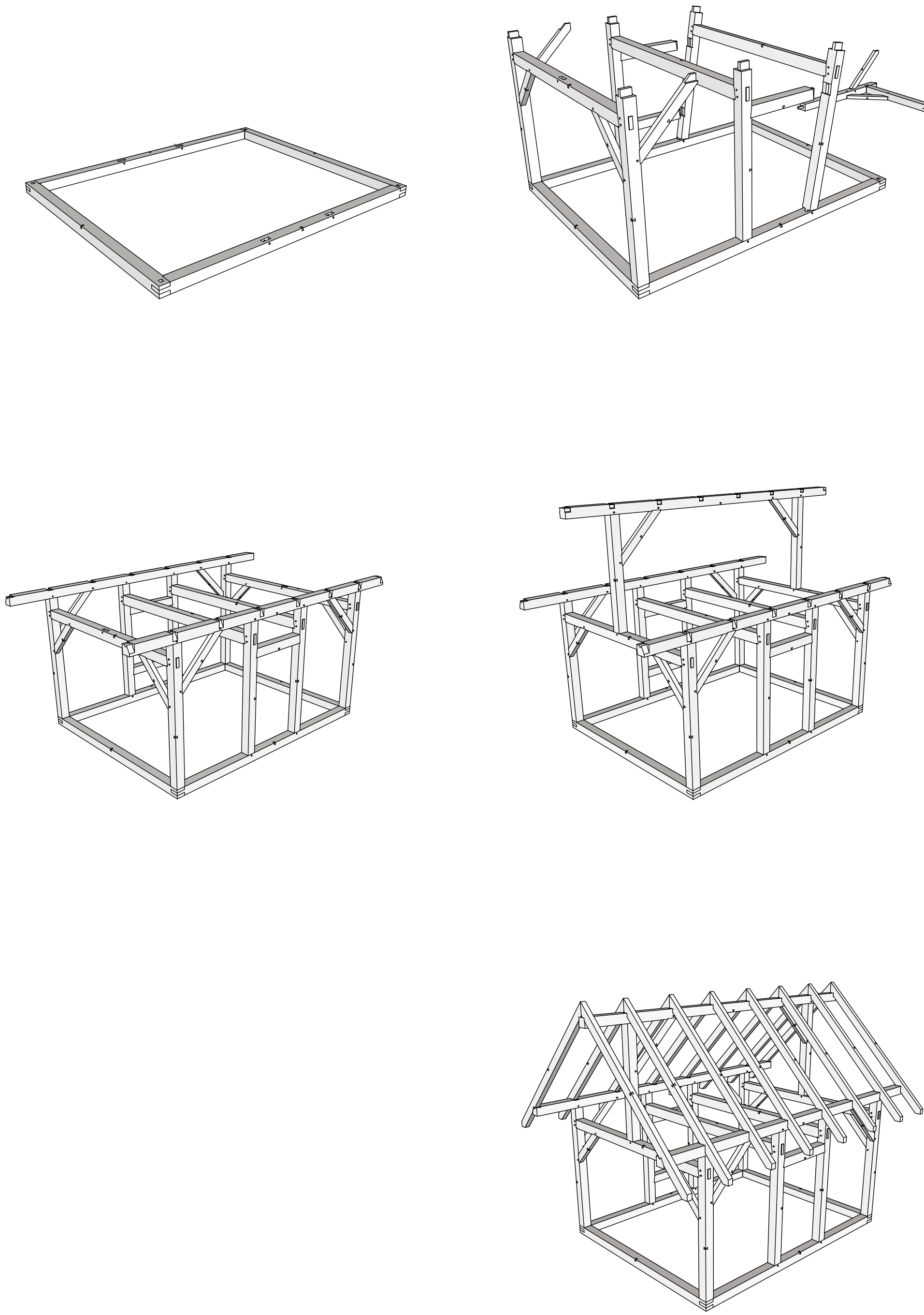

*Figure 54. Raising the frame.*

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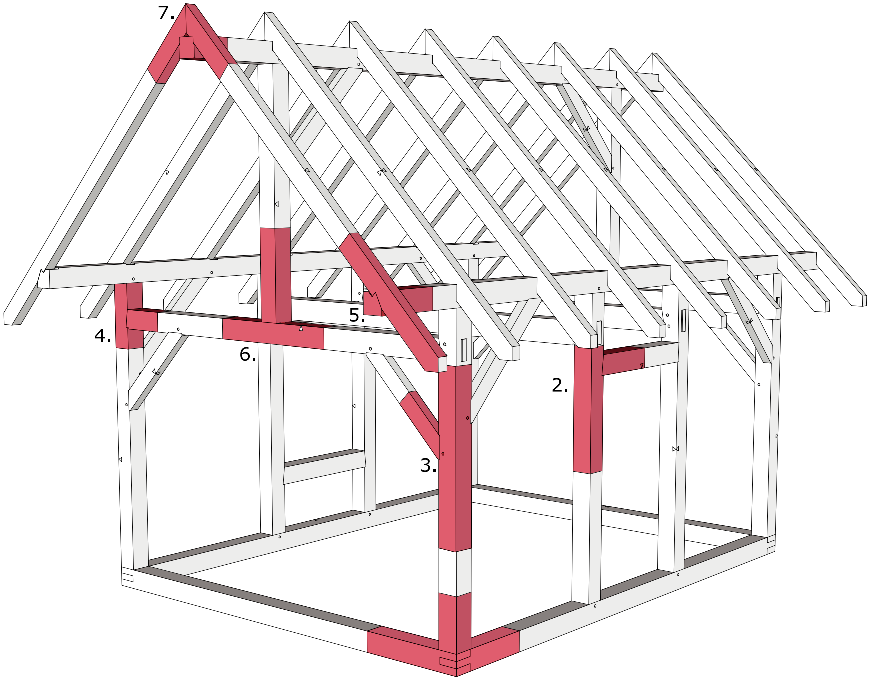
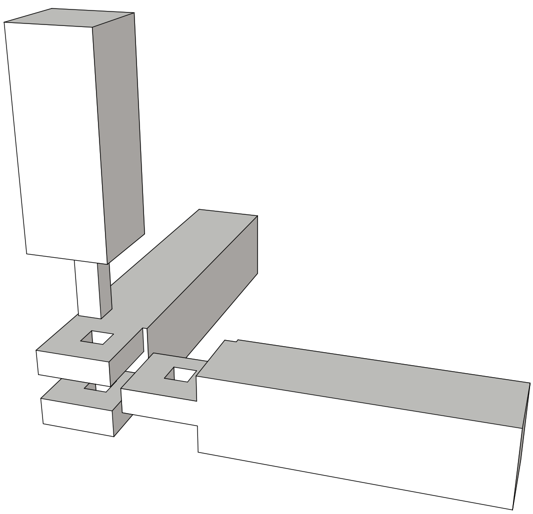
# Joints of the frame



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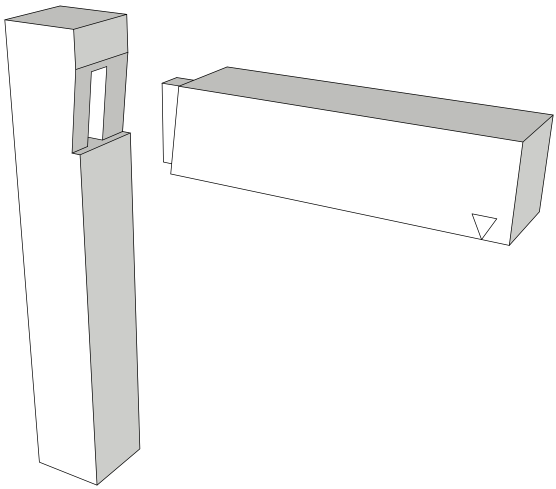

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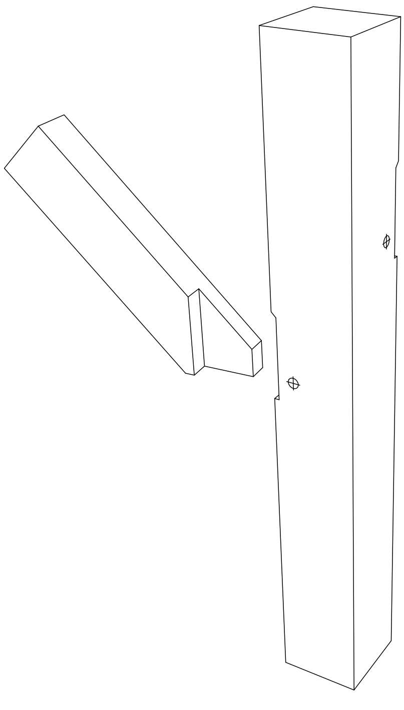

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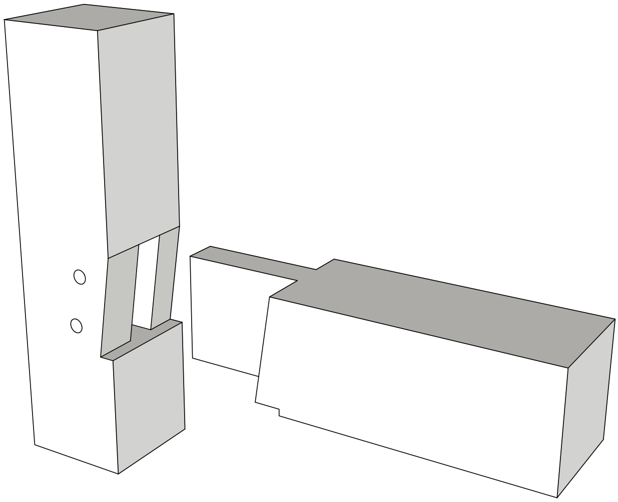

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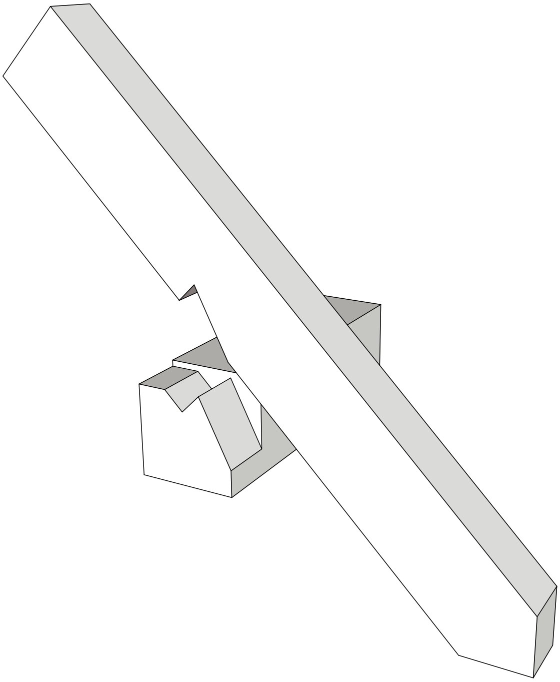

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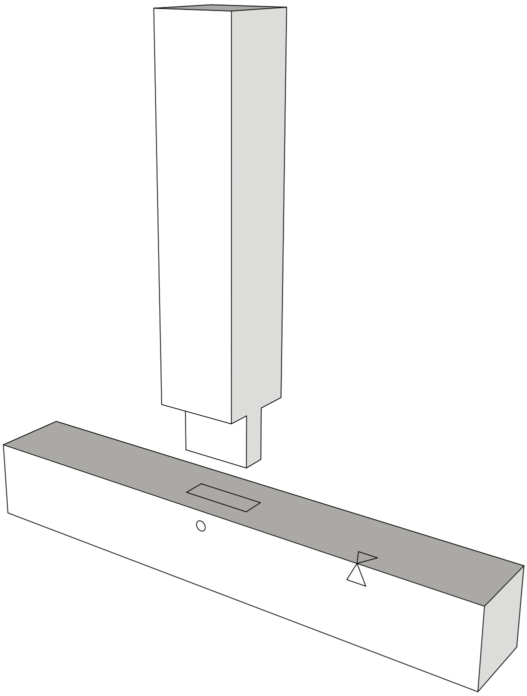

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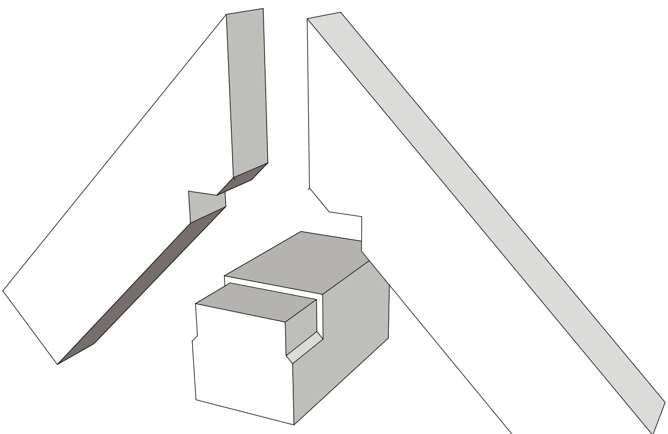

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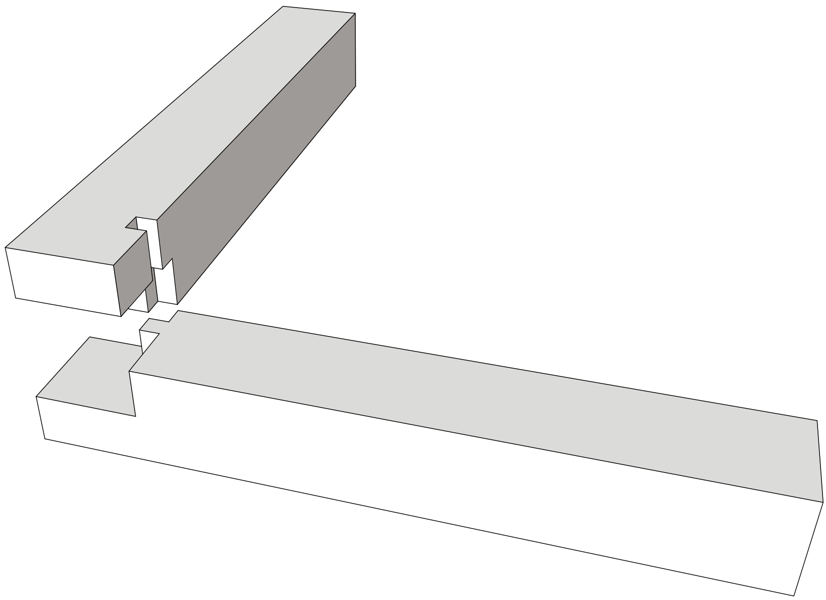
# Some more examples of common joints in Estonia



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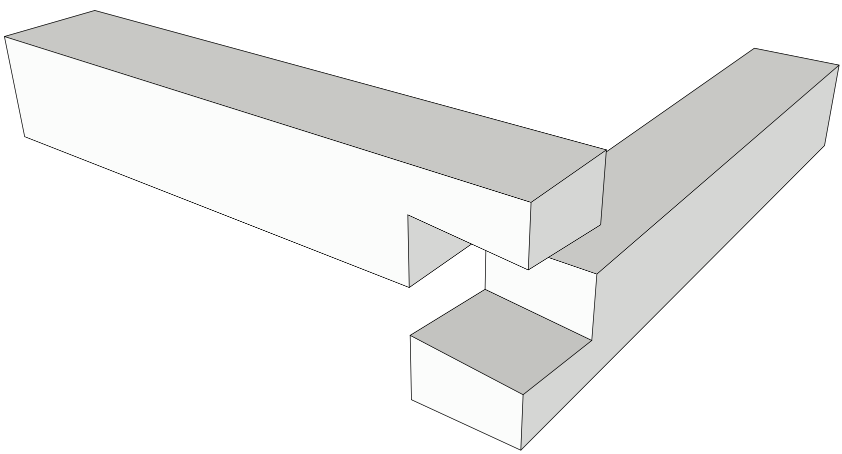

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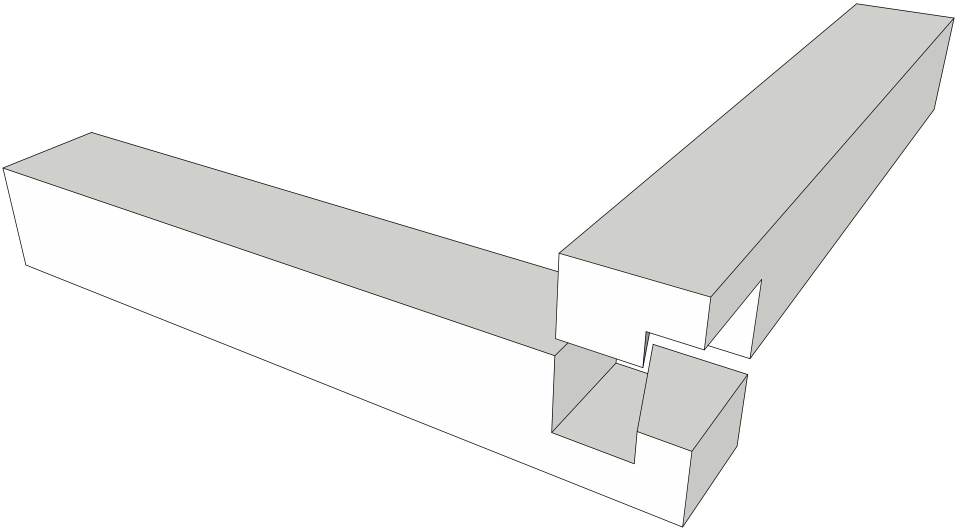

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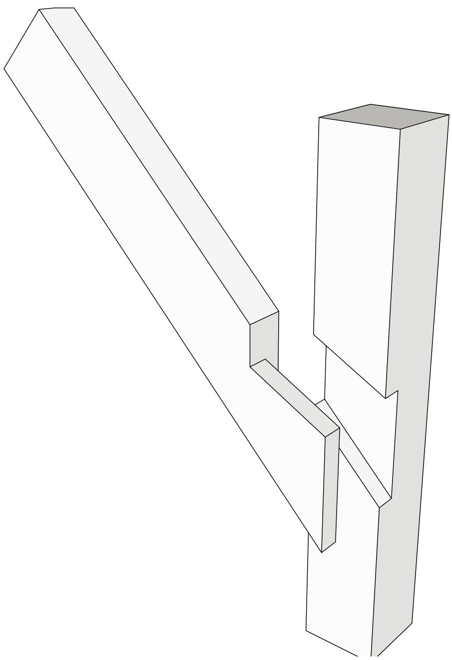

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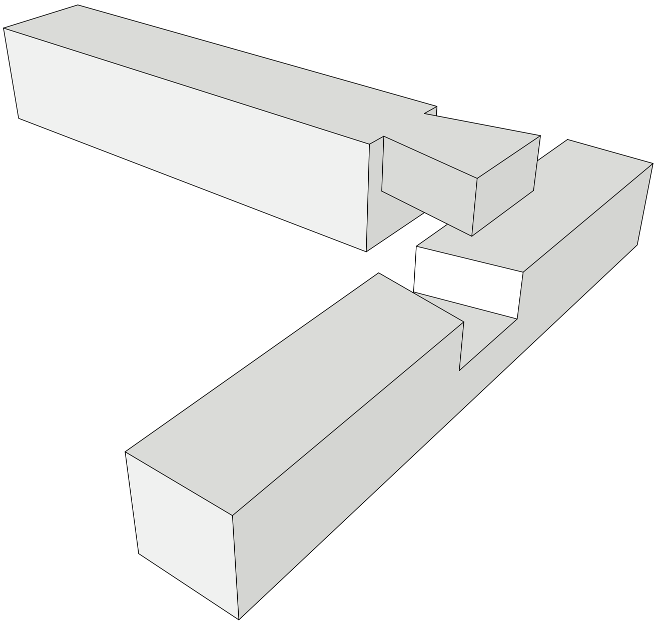

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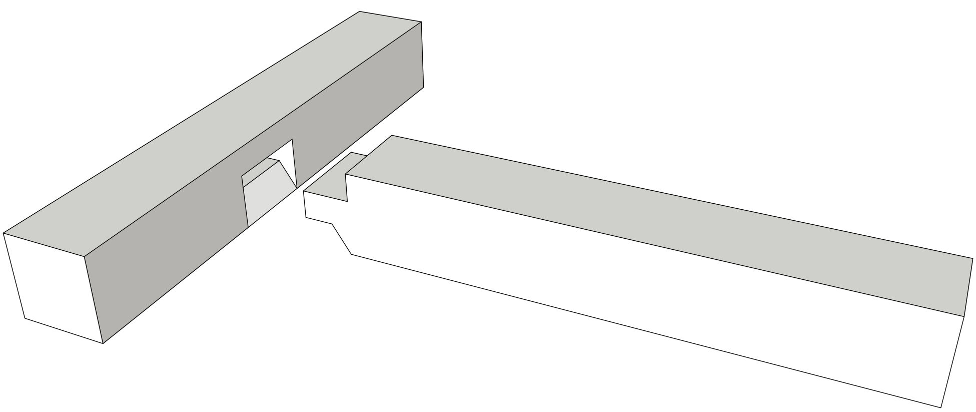

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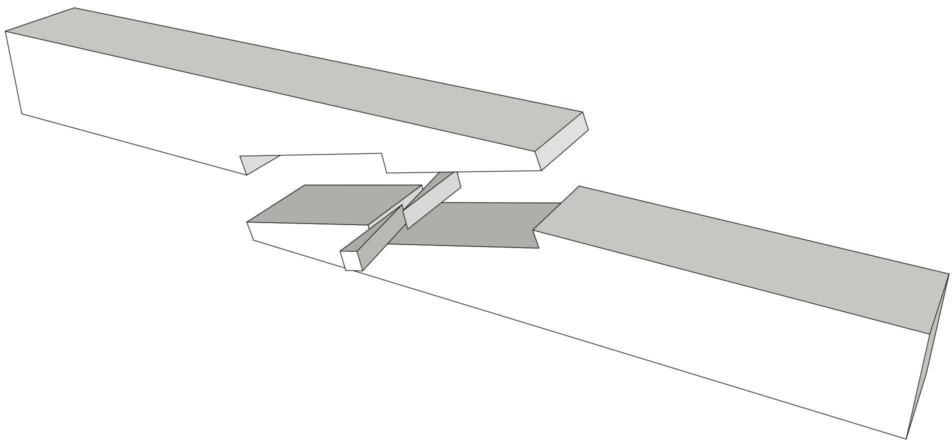

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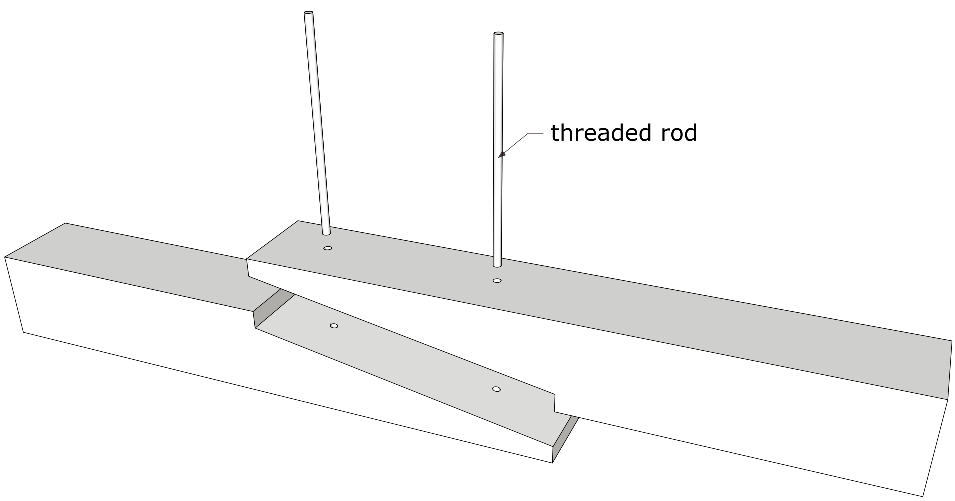


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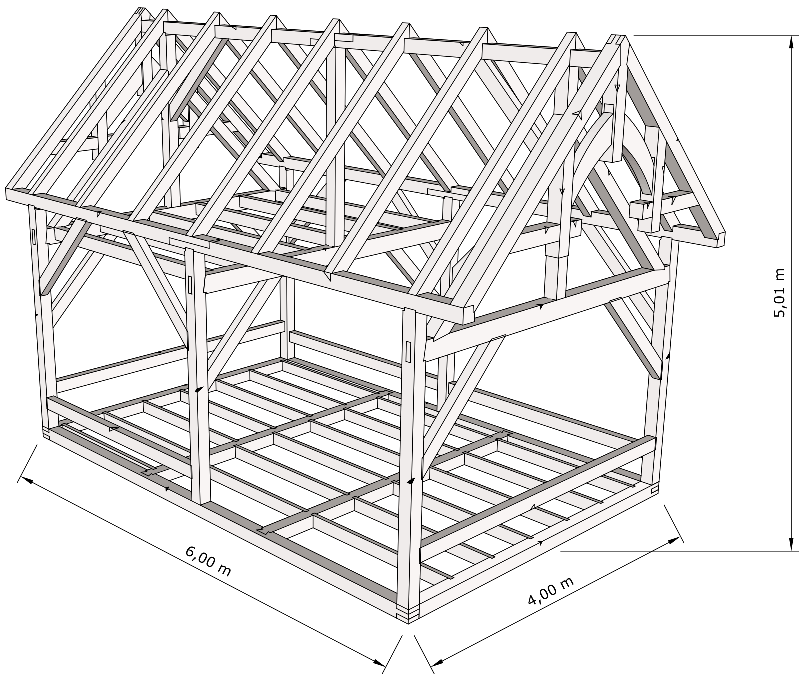
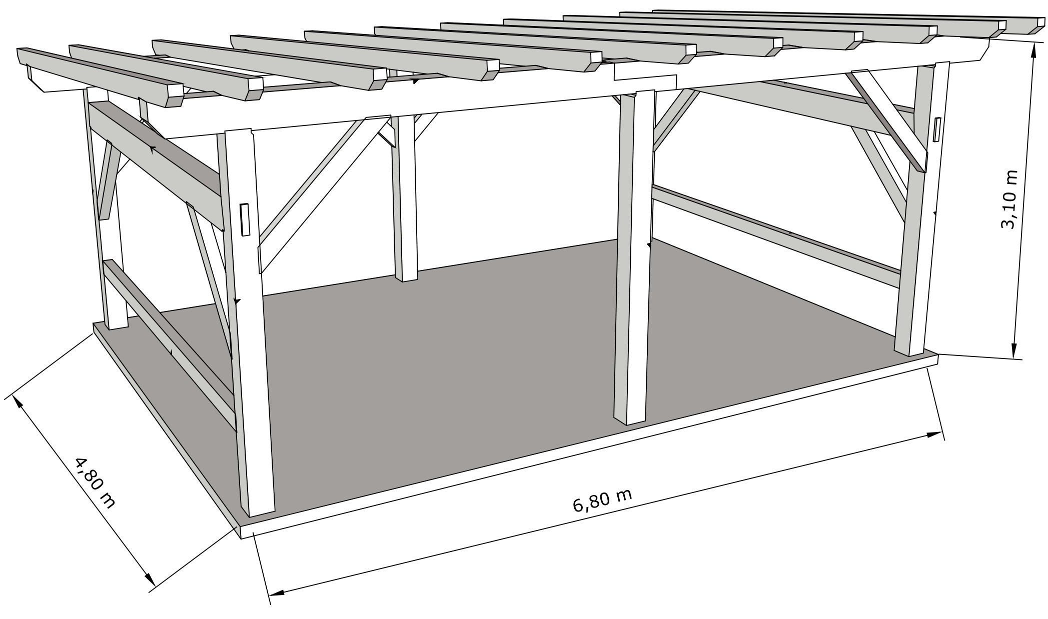
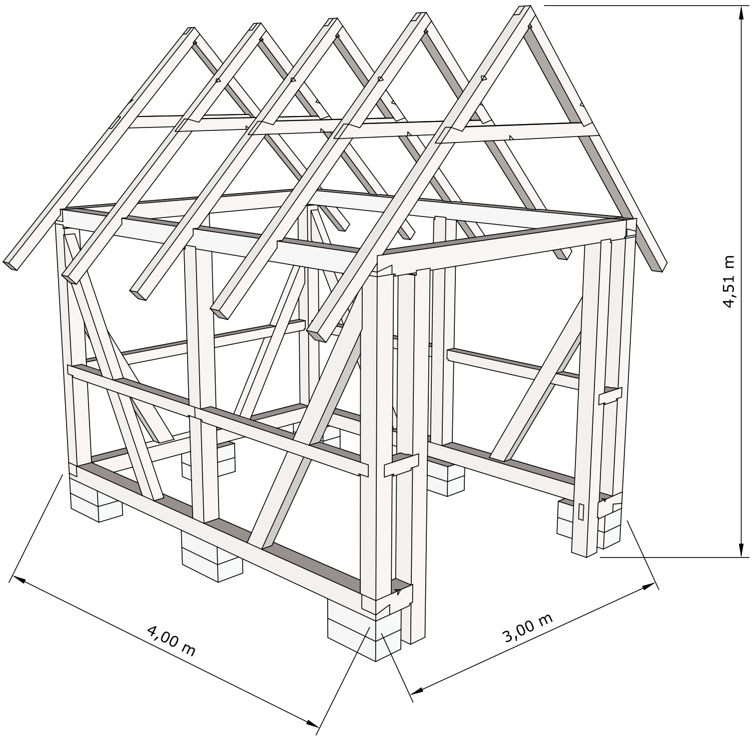
# Ideas for Timber Framing

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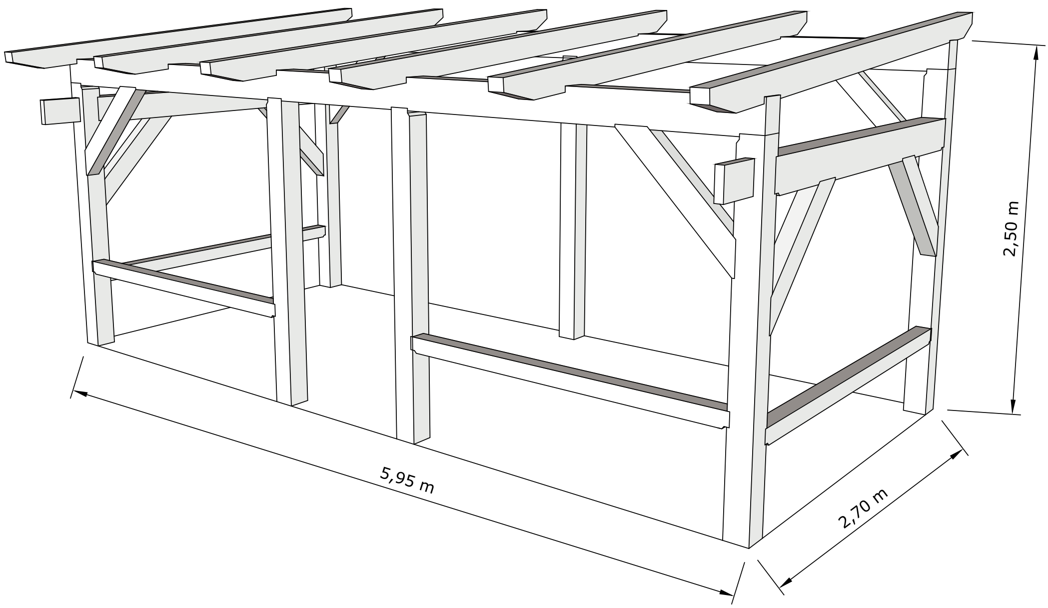
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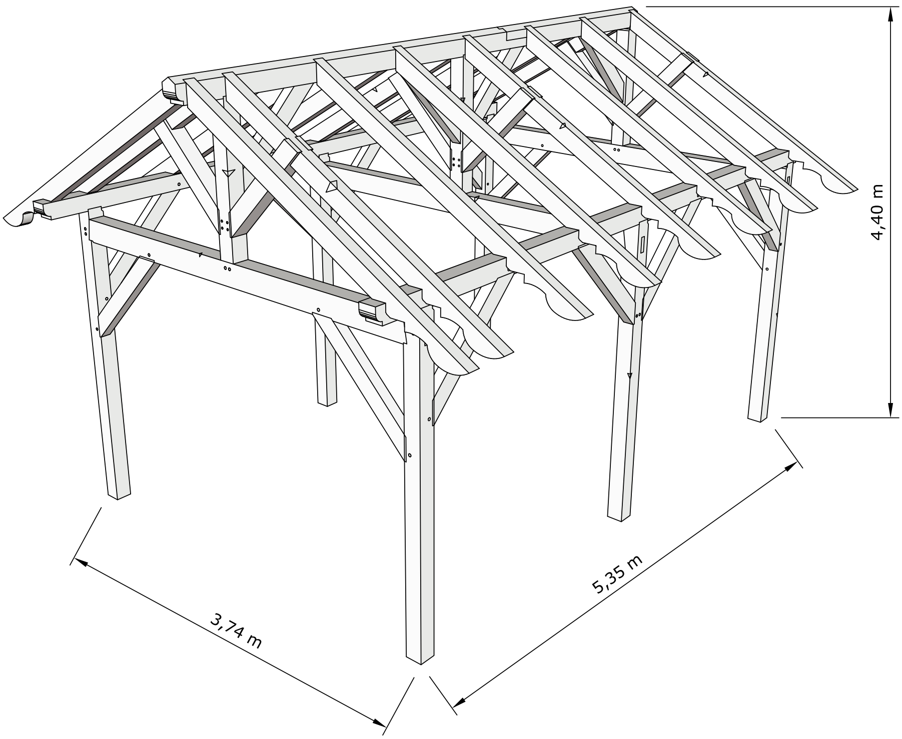
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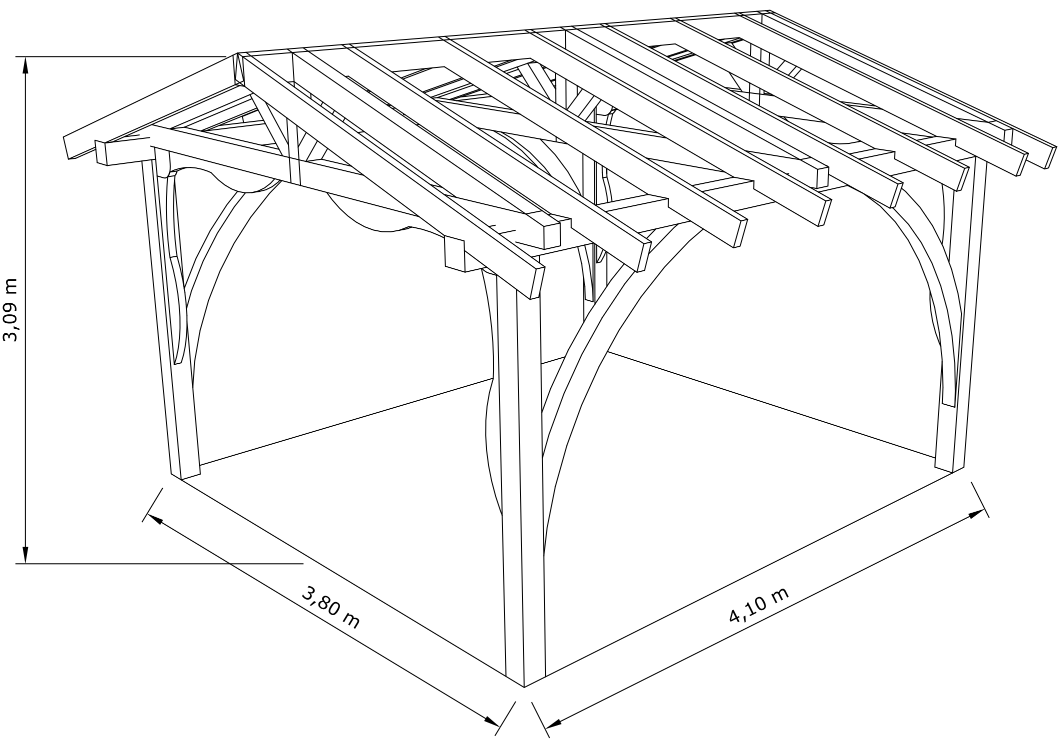
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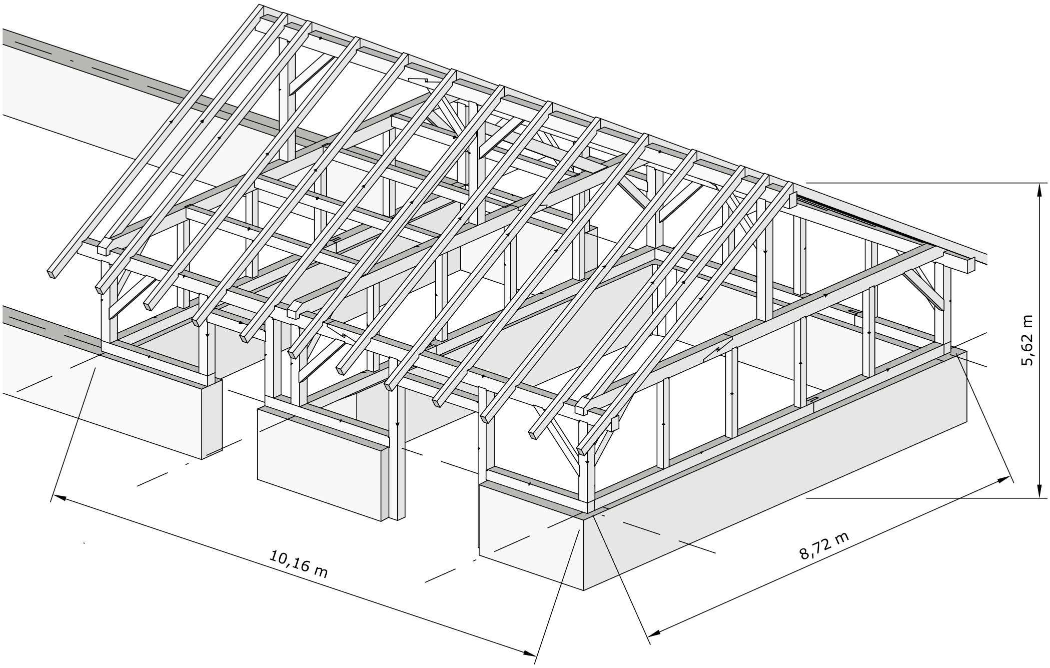
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