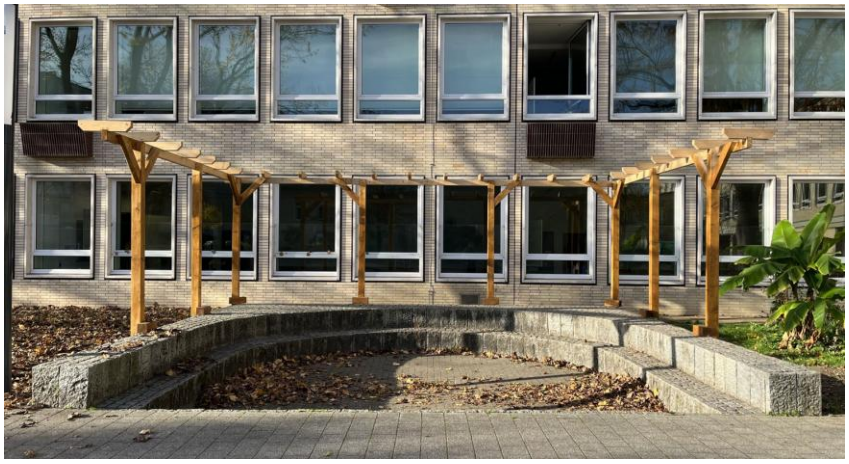
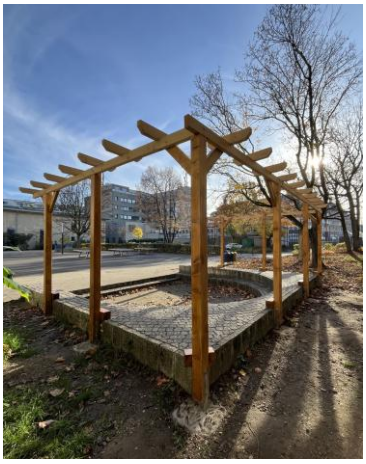
Rectangular Pergola





Key data

- LOCATION: Outdoor
- TYPE OF GREENING: Vertical greening, ground-based
- VEGETATION: Climbing plants
- CONSTRUCTION: Wooden pergola, built against a natural stone wall, with trellises
- IRRIGATION: None

Important preliminary remarks

This document describes a specific project implemented at the Friedrich-Wilhelm-Gymnasium in Cologne, Germany. The pergola was built onto an existing small amphitheatre. Therefore, the construction instructions will need to be adapted for use on other sites.

The pergola is inherently stable. However, it is explicitly **not** designed to bear heavy loads. In particular, it is **not** suitable as a climbing frame for people, and there are also limitations regarding planting. Details can be found in the safety instructions at the end of this document.

The entire construction project was planned and executed in such a way that the pergola could be erected in a single project day. Approximately 15 students and several adult supervisors participated, allowing for the formation of small groups, each with a supervisor.

All the preparation of the structural timbers was carried out by a carpenter, so no sawing or chiselling was required on the project day. The protective coating of the pergola, the installation of the ropes/climbing aids, and the planting will be carried out later.

We thank the carpenter Sascha Unger, who prepared and supervised this construction project!

Co-funded by the European Union

Table of Contents

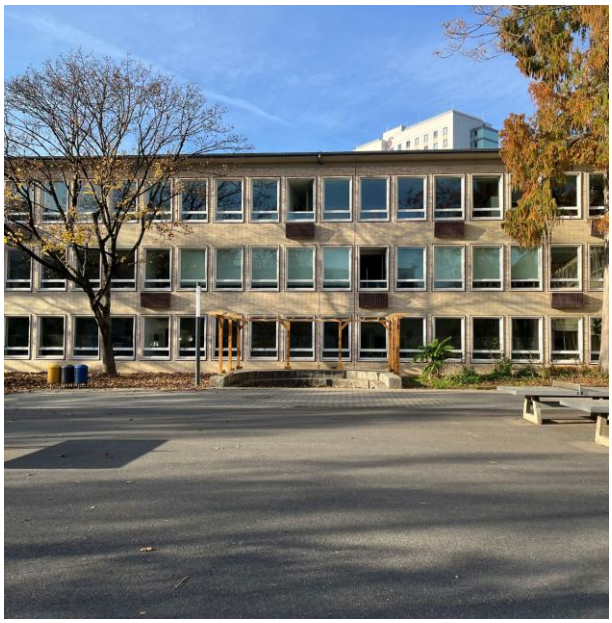
Co-funded by
the European Union

Location selection

The school specified the location for the pergola: the small amphitheatre in the schoolyard. It was to be transformed into a green space, providing shade in the summer, which could then be used as an outdoor classroom and break area.

Specific features of the location include:

- outside the accessible area of the schoolyard – therefore no conflict with fire lanes, etc.
- partially (temporarily) shaded by large trees
- relatively close to a window front of the school building – with implications for the landscaping (see there).



Material

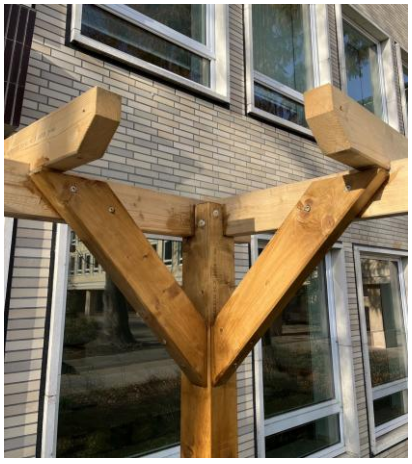
The following list provides an overview of the materials required, including approximate dimensions and quantities, for a rectangular pergola structure measuring approximately 5.00 x 7.50 m and approximately 2.70 m in height.

Structural timber (spruce) was used. It is dry and has a smooth, untreated surface.

Wooden Pergola

- **Square timber ~ 120/120 mm ~ approx. 25 linear meters**
  - 8 pieces of 2.70 m length (posts)
  - 8 pieces of 30 cm length (auxiliary timbers)
- **Rectangular construction timber ~ 120/60 mm ~ approx. 40 linear meters**
  - 2 pieces of ~ 5.00 m each (sill – short sides)
  - 2 pieces of ~ 4.00 m each (sill – long side)
  - 10 pieces of ~ 73 cm each (braces)*
  - 24 pieces of ~ 60 cm each (short rafters) *

Measurements refer to the longest side of the component.
See photo for cutting and installation of the braces and rafters.



- **H-shaped ground anchors**
  - 8 pieces (one per post), height ~ 40 cm, opening ~ 12 cm

- **Metal brackets**
  - 2 pieces approx. 8 x 8 x 8 cm

- **Concrete max. 0.8 t**
  - Construction sand/gravel, cement, and water to produce up to 0.8 t of concrete

- **Screws**
  - 16 wood construction screws 8x180 mm with hexagonal head + matching 6 cm anchors
  - 64 wood construction screws 8x120 mm
  - 16 carriage bolts 8x140 mm, including nuts and washers

Trellis

- Twisted steel wire, 4 mm diameter, ~ 50 linear meters
- Fastening materials (e.g., twine, clamps, wire)

Plants

- Climbing plants (twining) – e.g., grapevines, wisteria, and trailing vegetables.

Due to the specific location – close to a window front of the school – deciduous plants should be used. This will prevent the classrooms behind the pergola from being shaded in winter when the sun is lower in the sky and sunlight is scarce.

The plants will be planted in the ground, so they will remain outdoors year-round – therefore, they must also be frost-resistant.

Tools

- Cordless drill/driver + bit set
- Wood drill bits
- Masonry/concrete drill bits
- Utility knife
- Wrenches (for ground anchors, cable clamps)
- Cable cutters
- Garden shears
- Buckets
- Shovels
- Trowels

- Watering can or garden hose
- Ladders, approx. 2 m standing height (2 pieces)
- Spirit level
- Hammer
- Rubber mallet
- Wheelbarrow
- Spade
- Builder's tub
- Concrete mixer (forced-action mixer)

Step-by-step

Planning Sketch and measurements

The pergola's footprint was determined by the existing small amphitheatre. The height was freely selectable.

The carpenter developed a plan for the structure beforehand, procured the materials, cut the timbers to size, and made initial markings and drill holes. He also developed the work schedule.

Once all the materials had been procured and prepared by the carpenter, assembly could begin.

To ensure efficient installation in just one project day with the students, many work steps could be carried out simultaneously. Three work groups were formed for this purpose:

• Preparing, erecting, and securing the posts (Post Group)

• Anchoring the posts in the ground (Concrete Group)

• Constructing the frame (Frame Group)

Preparing, setting up and securing the posts (post group)

The amphitheatre is surrounded by a rectangular natural stone wall. This allowed the posts to be first screwed to the stone wall and aligned; the anchoring in the ground was done afterward.

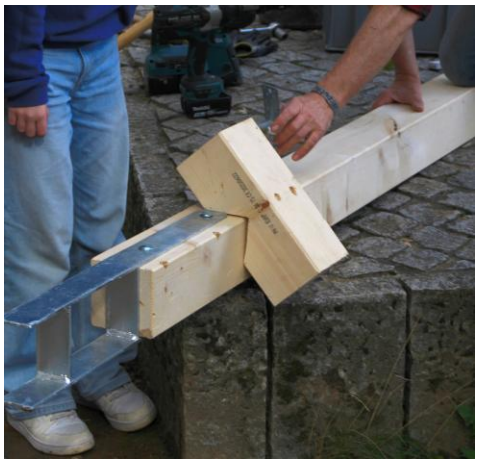
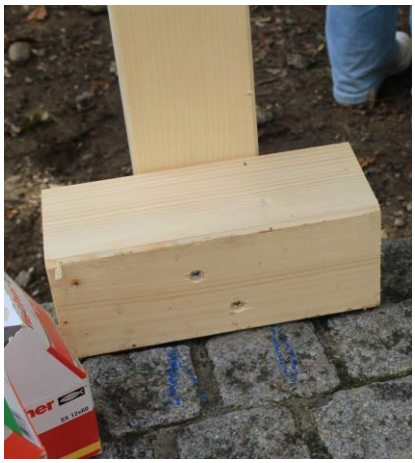
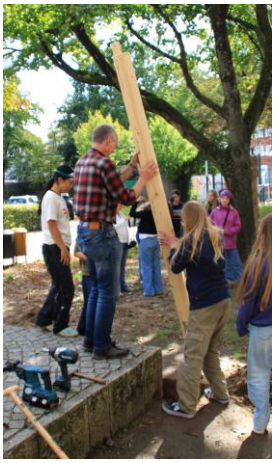
The post locations are marked on the stone wall with chalk.

The auxiliary timbers are screwed to the pre-marked positions on the posts

Each post is also screwed to an H-shaped ground anchor. The ground anchor is positioned against the post so that the base of the post touches the top horizontal strut of the anchor. Two holes are drilled into the post, one through each of the opposing holes in the ground anchor. An 8 x 140 mm carriage bolt is inserted through each hole and tightened with washers and nuts. This securely connects the post to the ground anchor.

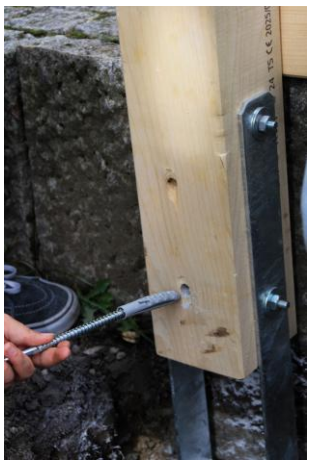
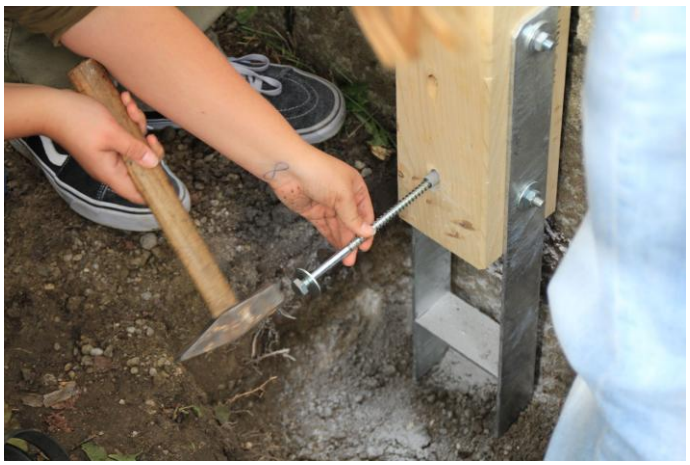
Once the concrete crew has dug the holes in the ground, there is sufficient depth to erect the posts and ground anchors.

Each individual post is positioned against the outside of the wall in such a way that the support timber rests on the top edge of the wall.

The posts already had two pre-drilled holes at their lower ends. A hole is drilled through one of these holes into the stone wall using a masonry drill bit.

A wall plug is inserted into the wall through this hole.

A screw with a washer is screwed in – but not yet tightened.

Now the post is aligned vertically using a spirit level. Two people hold the post in this position.

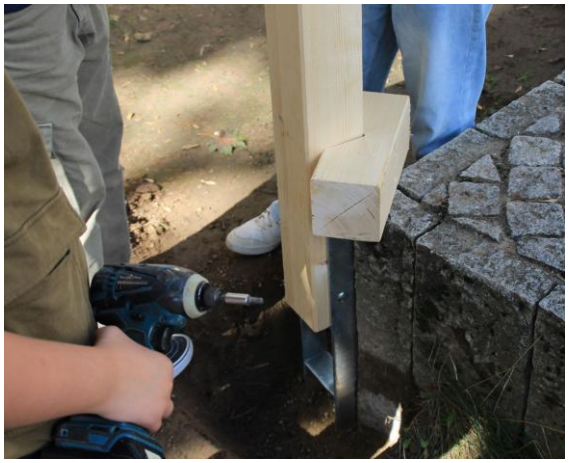
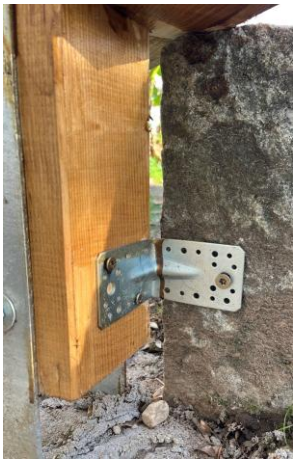
The second attachment to the stone wall is also carried out as described above – drill a hole, insert a dowel, and screw in a screw with a washer.

This aligns the post "in the direction" of the wall or the wooden structure.

The alignment perpendicular to this is achieved when the two screws are tightened. Since the stone wall has unevenness, wedges or flat strips of plastic may need to be inserted between the wall and the post.

Now the post "hangs" vertically and securely on the wall; it also "stands" on the auxiliary piece of wood attached to the side.

Six of the eight posts are attached to the stone wall in this way, face to face. The two corner posts are attached differently, namely edge to edge. They are pre-drilled differently for this purpose – diagonally through the square cross-section of the wood. Once screwed to the corner/edge of the stone wall, they are not yet secure enough to stand on their own. Therefore, they are stabilized with two battens, which are screwed to the sides and then angled outwards onto the ground. Additionally, a metal bracket is installed between the post and the stone wall.

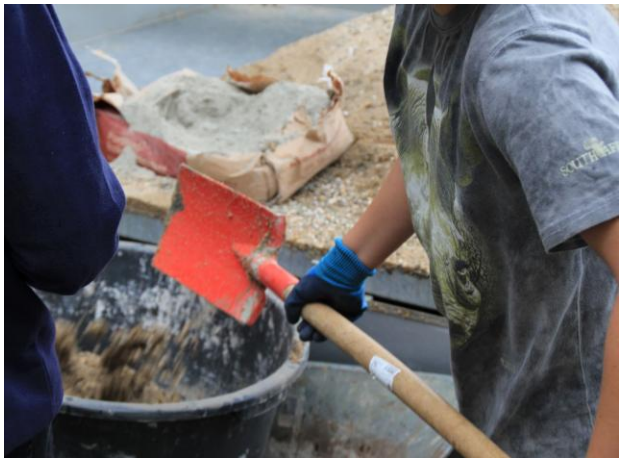
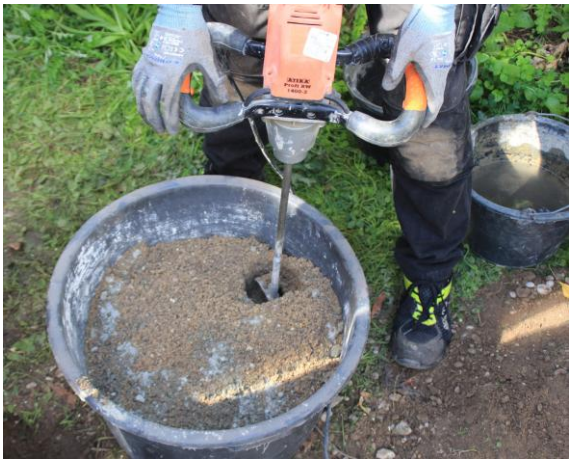
Finally, all posts are erected and secured. They only become permanently fixed through connection to the frame and concreting in the ground anchor.

Anchoring the posts in the ground (concrete group)

At the locations where the posts are to be placed, holes approximately 40x40x40 cm are dug in the ground. This work is laborious because the soil is mixed with stones, gravel, and construction debris. This work begins concurrently with the erection of the posts; ideally, both groups work in separate areas.

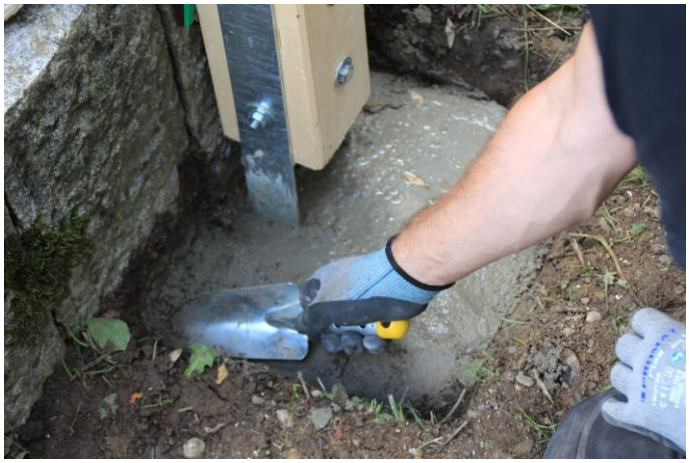
After the post-erection group has erected the posts and secured them to the stone wall, and after the sill-erection group has attached the sill, the concrete is mixed.

To do this, 4 parts sand/gravel are first mixed dry with 1 part cement in a mortar tub. Then, enough water is added to create a thick, non-runny concrete. An electric forced-action mixer is used for mixing.

The concrete is poured into the holes in the ground – up to about 3 cm below the end of the post.

The surface of the concrete is smoothed with a small shovel/trowel. This increases its strength and also creates a slight camber, allowing rainwater to run off as efficiently as possible.



Finally, the concrete hardens into a foundation that firmly encloses the ground anchor and thus supports the post.

Assembling the frame (frame group)

Once all the posts on one side of the pergola are in place, the top frame can be assembled.

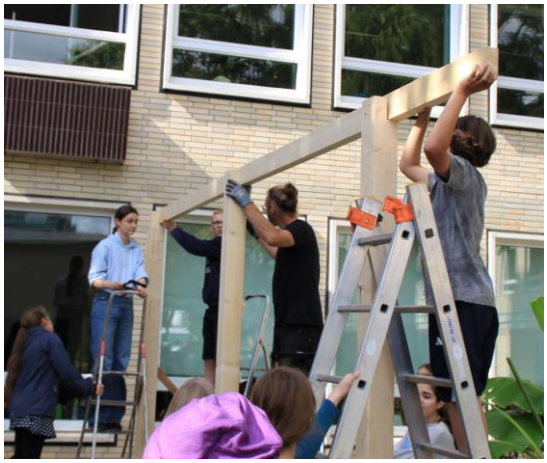
This means that the frame group can begin their work on the structure slightly later than the other two groups. They use this time, among other things, to unload all the lumber from the vehicle and transport it to where it is needed. The group also practices using the clamps that will be required later.

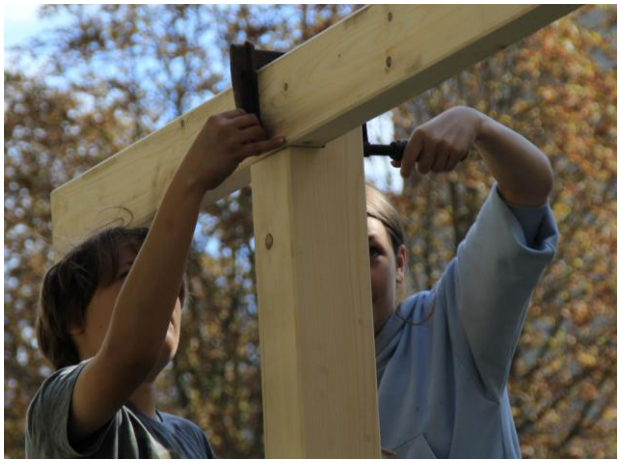
The frame is assembled as soon as all the posts on one side are screwed to the stone wall – and before the ground anchors are set in concrete. The screws securing the posts to the wall already provide sufficient stability.

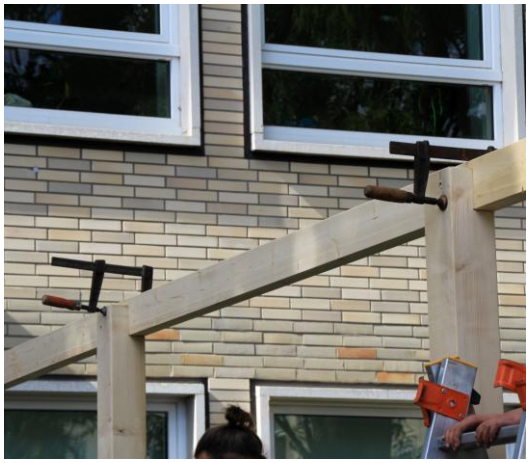
For the frame to fit properly, the posts must be positioned quite precisely. Deviations of a few millimetres are compensated for by the elasticity of the wood. If the deviations are larger, they must be corrected by adjusting the screws connecting the posts to the stone wall. (Therefore, the concreting of the ground anchors, and thus the final fixing of the beams, takes place last.)

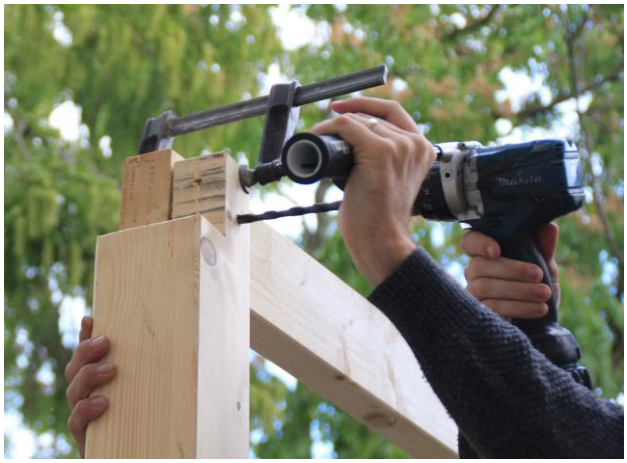
Two stepladders are positioned on each side, firmly erected, and held in place by one or two people while one person works on the ladder.

The squared timbers prepared as sills are placed on the posts and initially secured with clamps.



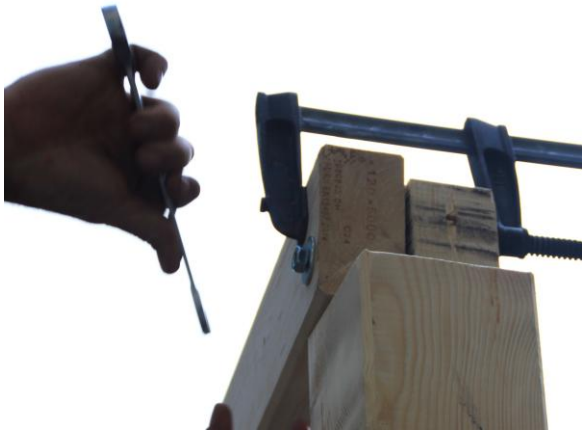


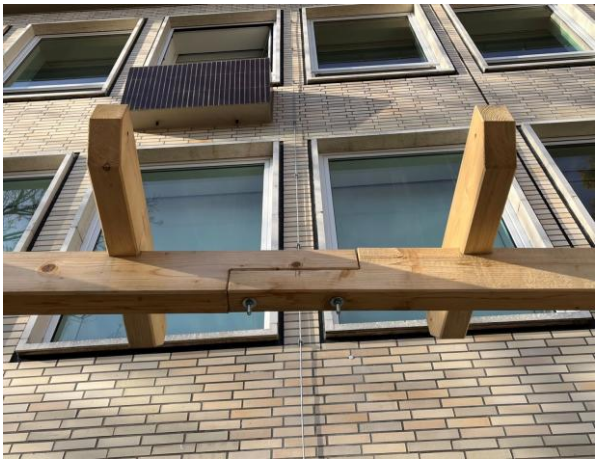




Then holes are drilled. The frame is securely bolted to each post using two 8x140 carriage bolts, including nuts and washers.

At the two corner posts, where two frames meet, each is fastened with only one carriage bolt.

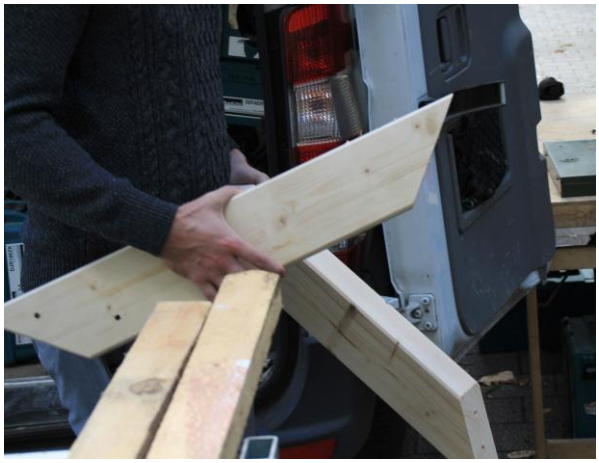


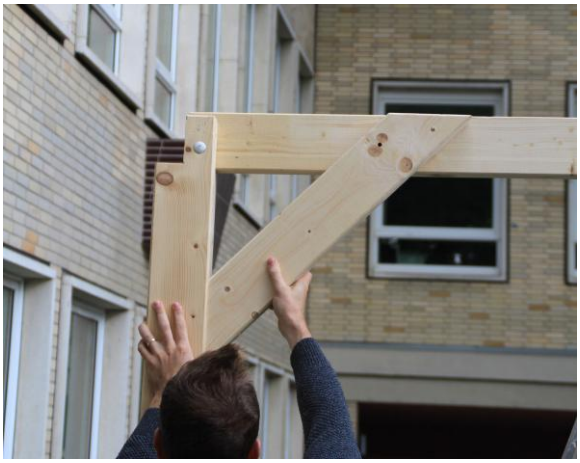


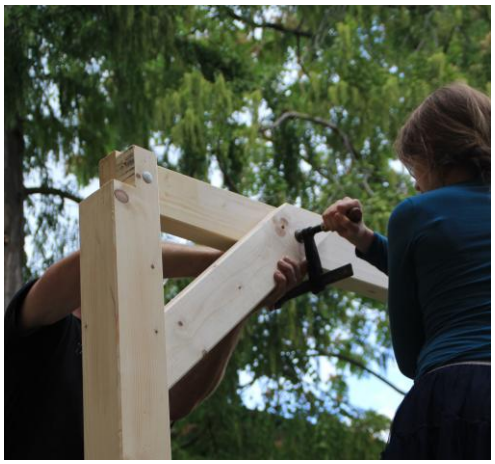
A special feature is the frame of the long side (7.50 m!). It would not have been practical to deliver it in one piece. Therefore, it was prepared and delivered in two pieces. These are drilled vertically at the joint and bolted together with two carriage bolts.

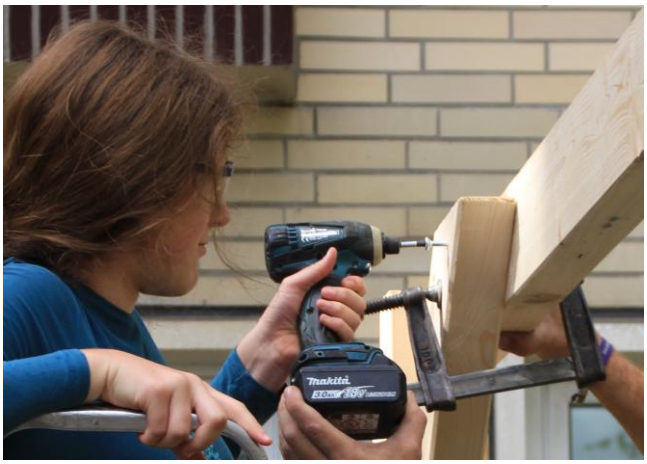
Now, the 10 braces are installed – two each on the corner posts and the two front posts, and one each on the two middle posts along the long side. A brace is a diagonal connection between the post and the frame, which stabilizes the structure.

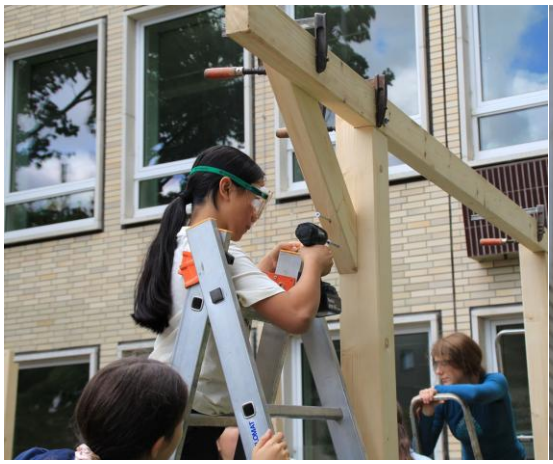
Each brace is first clamped to the frame with a screw clamp – the lower end should be flush with the post. The brace is then screwed to the frame and the post with two wood screws each; a hole is pre-drilled for each screw.

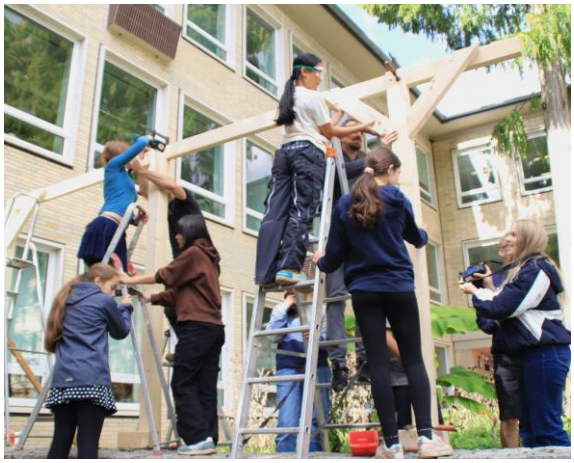


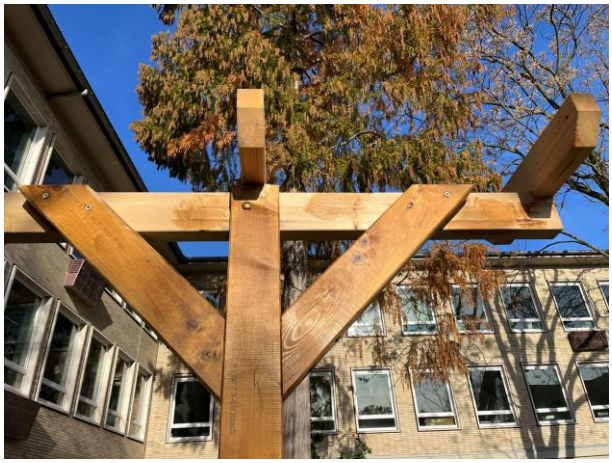





Makita







Finally, the short rafters are installed. They are first placed onto the frame, then aligned to the desired spacing, and finally screwed in place with a wood screw. Again, a hole is pre-drilled for each screw.

Tidy up, clean tools

After completion of the work...

- ...all tools will be cleaned – in particular, all tubs, spades, mixers, and shovels that came into contact with concrete must be cleaned quickly and thoroughly.
- ...any leftover concrete will be tipped into a pile so that the caretaker can dispose of it after it has hardened.
- ...all tools will be returned – to the carpenter's car or to the school's tool shed
- ...any small parts still lying around will be collected.
- ...power cables and water hoses will be disconnected.

Safety and wood protection, greening and maintenance

Safety and wood protection

The wooden structure described here is inherently stable. However, it is not designed for exceptional loads. Therefore:

- The pergola must not be misused as a climbing frame or sports equipment! This applies not only to the wooden structure itself, but also to any tension wires or climbing aids.
- Tension wires and climbing aids must be installed in such a way that they do not place excessive stress on one side of the rafters or frame.
- Tension wires and climbing aids must also be protected against unintentional overloading – in particular, against people tripping over them, exerting significant tensile forces, and injuring themselves.
- Greenery must be grown exclusively vertically. It is not permitted to install climbing aids horizontally from one side of the frame to the other to create a "green roof." The resulting forces would endanger the stability of the two front posts in particular.
- Lateral (diagonal) bracing, especially of the two front posts, should be considered. This involves running a wire rope diagonally to the ground on both sides of the post positions and securing it firmly with concrete or ground anchors.

- The entire structure must be regularly inspected for stability, wood condition, and tension.
- The vegetation is also relevant to safety, as plants can develop a significant mass and, in addition, create a sail-like effect in the wind. Therefore, the vegetation should be regularly inspected and trimmed back as needed. Vigorous climbing plants such as ivy or Virginia creeper are unsuitable.

Wood is a natural material that – especially when exposed to water – is gradually "eaten away" by insects and fungi, among other things. This causes it to lose not only its fresh appearance but also, over time, its strength. Therefore, wood protection is necessary for both aesthetic and, above all, safety reasons.

- The entire wooden structure should be treated with a suitable wood-protecting coating before planting – ideally when dry. The manufacturer's application and safety instructions must be strictly followed. - For "natural" wood protection using linseed oil-based coatings, there are separate instructions available on the Green Cool Schools website.
- The condition of the wood and the coating must also be checked regularly.

Greening and maintenance

The climbing plants intended for greening require trellises – (braided) metal wire is planned for this purpose. The short rafters for attaching the trellises are already mounted; they also have 8mm holes on both sides for threading the wires through.

The trellises are also secured at the bottom – using screw eyes in the natural stone wall or ground anchors/stakes in the soil.

Planting should take place in spring. The plants are planted in the soil. If the soil still contains a lot of rubble and stones, compost or potting soil should be added.

Maintenance then includes the following tasks in particular:

- During the first few weeks (establishment phase): check daily and water as needed
- Once the roots are well developed: check 2-3 times per week and water as needed
  - Arrange watering in advance for the summer holidays
- Ongoing care as needed:
  - Trin shoots on the trellis and tie them up if necessary
  - Remove brown leaves and dead shoots as needed
  - Prune plants if they become too vigorous
  - Fertilize as needed (spring/summer)
  - Remove and replace dead plants as needed.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or OeAD-GmbH. Neither the European Union nor the granting authority can be held responsible for them.