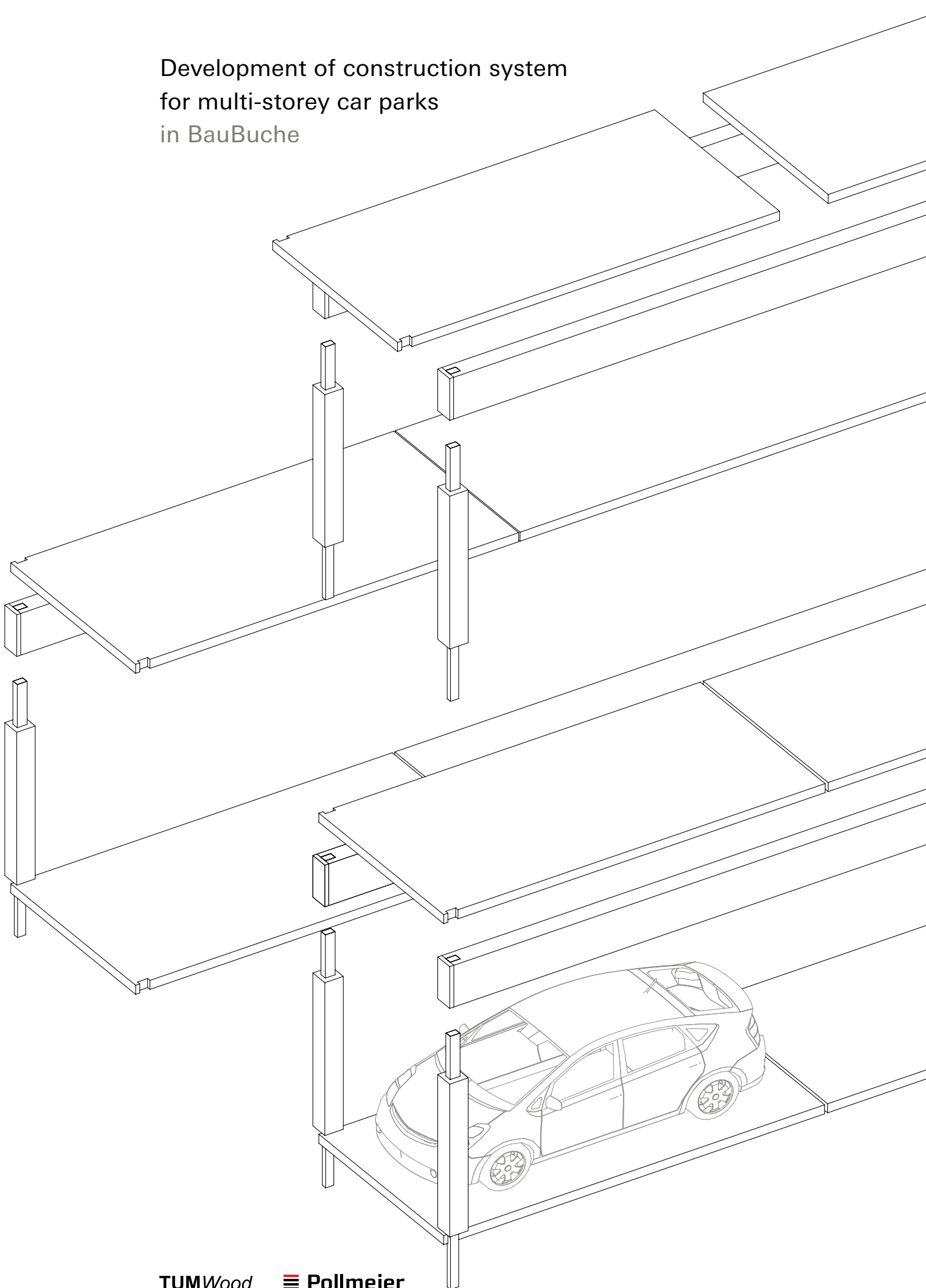


Development of construction system
for multi-storey car parks
in BauBuche



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Development of construction system for multi-storey car parks in BauBuche

About BauBuche

BauBuche is a product of Pollmeier Massivholz GmbH in Thuringia. The material is manufactured in a highly automated, cost-effective process from beech veneer. BauBuche offers excellent strength and other outstanding technical properties. After spruce and pine, beech is the third most common type of tree in Germany. Beech is much stronger and more stable than softwood. Thanks to the development of glued beech lumber products, beechwood is now used more and more in load-bearing timber structures. This is a welcome trend from the point of view of forest management and with regard to the protection of the environment. In the course of an R&D project at the Technical University of Munich, construction systems for multi-storey car parks made in beech laminated veneer lumber (BauBuche) were examined.

Use of BauBuche in multi-storey car park construction

Due to its exceptional strength, rigidity and dimensional stability, beech laminated veneer lumber is the ideal material for load-bearing construction elements. It allows for slender structures and therefore protects resources. In general, constructions in BauBuche are much more slender than those made in softwood. In addition, the attractive finish of beech laminated veneer lumber (LVL) makes the material extremely suitable for exposed construction elements. Mundane buildings such as multi-storey car parks can thus be enhanced without any extra investment in design features. With proper installation, effective protection against the elements and regular inspections, load-bearing elements made in beech LVL are expected to last for more than 50 years, which is in line with conventional solid construction materials.

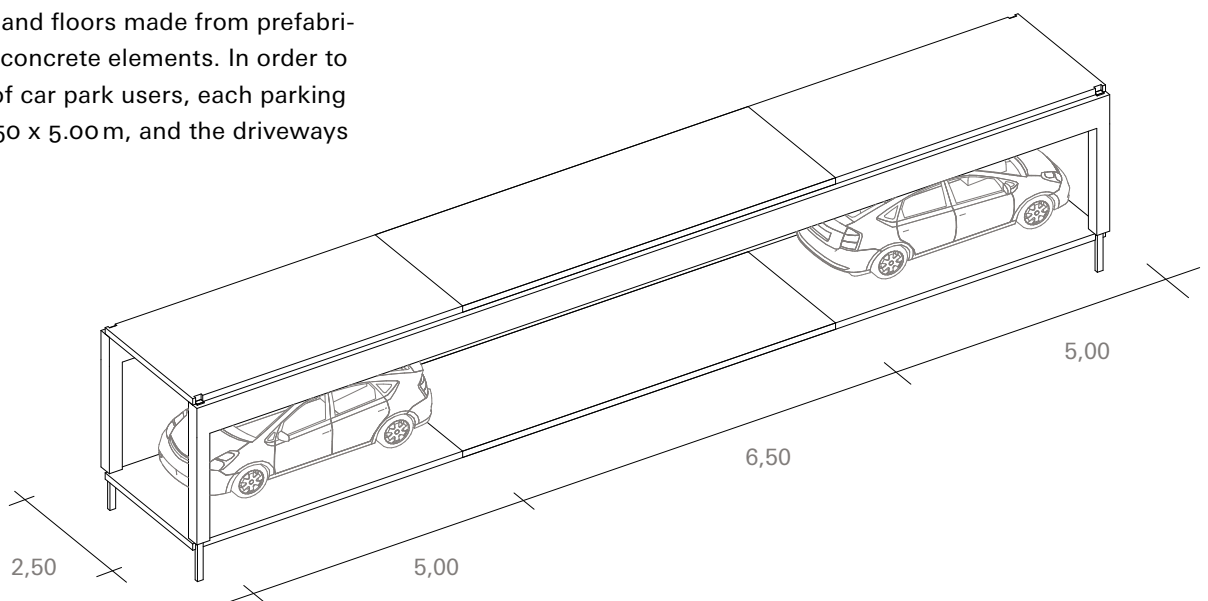


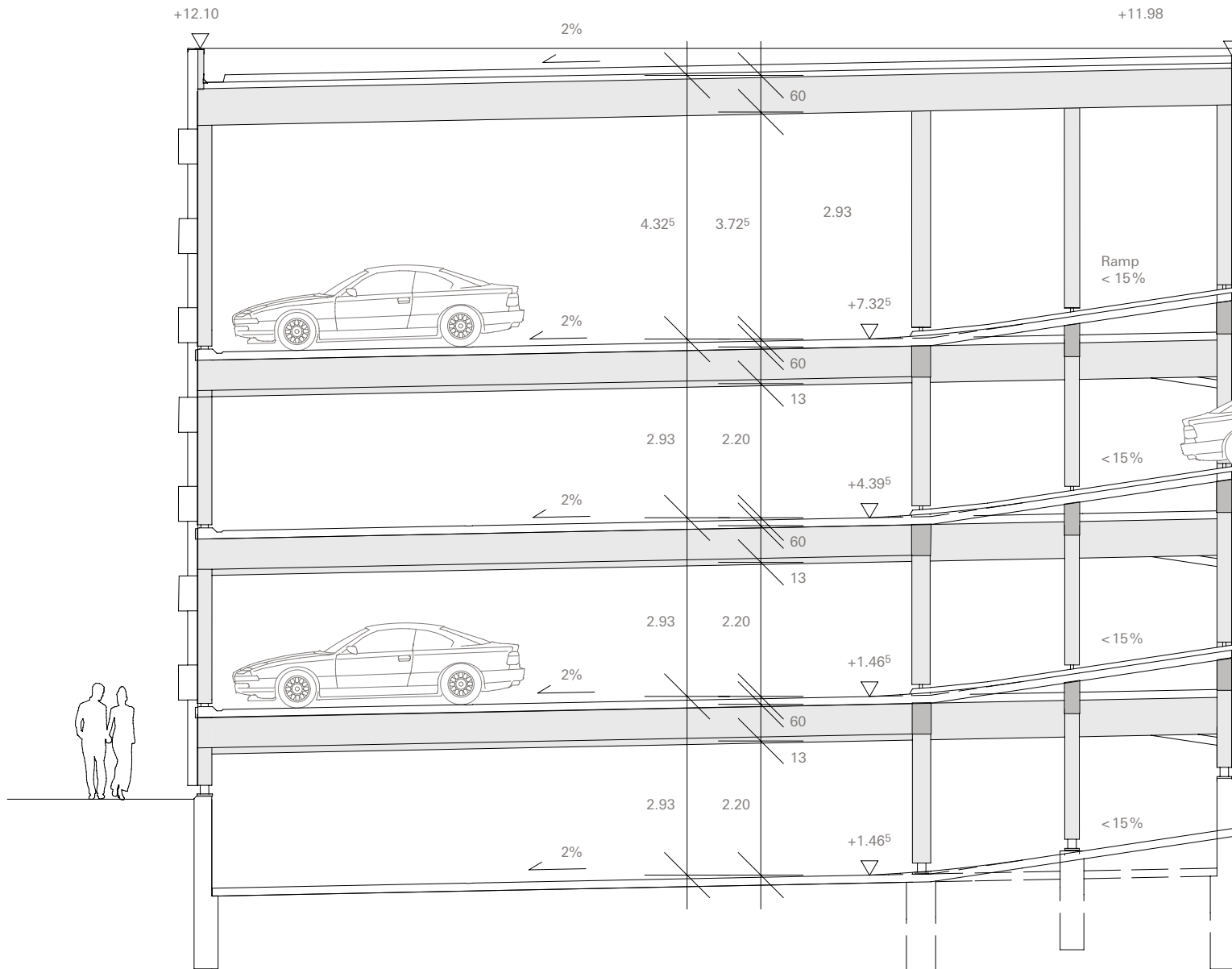
Fig. Visual impression of prototype design

Design of multi-storey car park

In the course of the project, a modular system for the construction of medium- to large-size overground, open multi-storey car parks was developed. It is based on a hybrid basic construction consisting of posts and beams made in BauBuche GL75, and floors made from prefabricated reinforced concrete elements. In order to meet the needs of car park users, each parking bay measures 2.50 x 5.00 m, and the driveways are 6.50 m wide.

Fig. Parking module





As the parking slots and driveways are not obstructed by posts, they can be arranged in any pattern that suits the site. The modular design also allows for the inclusion of parking spaces for disabled drivers, and caters for any future reconfiguration of the slots as car sizes change. The span between the supports measures 16.50 m at a load application width of 2.50 m. The clear height between the driveway surface and the lower edge of the supporting structure is 2.20 m so that there is sufficient space for lighting installations, sprinklers and similar equipment, as well as for any future driveway resurfacing. Each storey is 2.93 m high.

Flexibility in planning

For the design of the car park, the various modules can be arranged as required, which gives planners great flexibility. The basic parking, ramp and stairwell modules can be combined to cater for any type of car park facility and footprint, depending on the available site and terrain, the eaves height, surrounding structures, connecting roads, number of parking spaces, commercial considerations, etc.

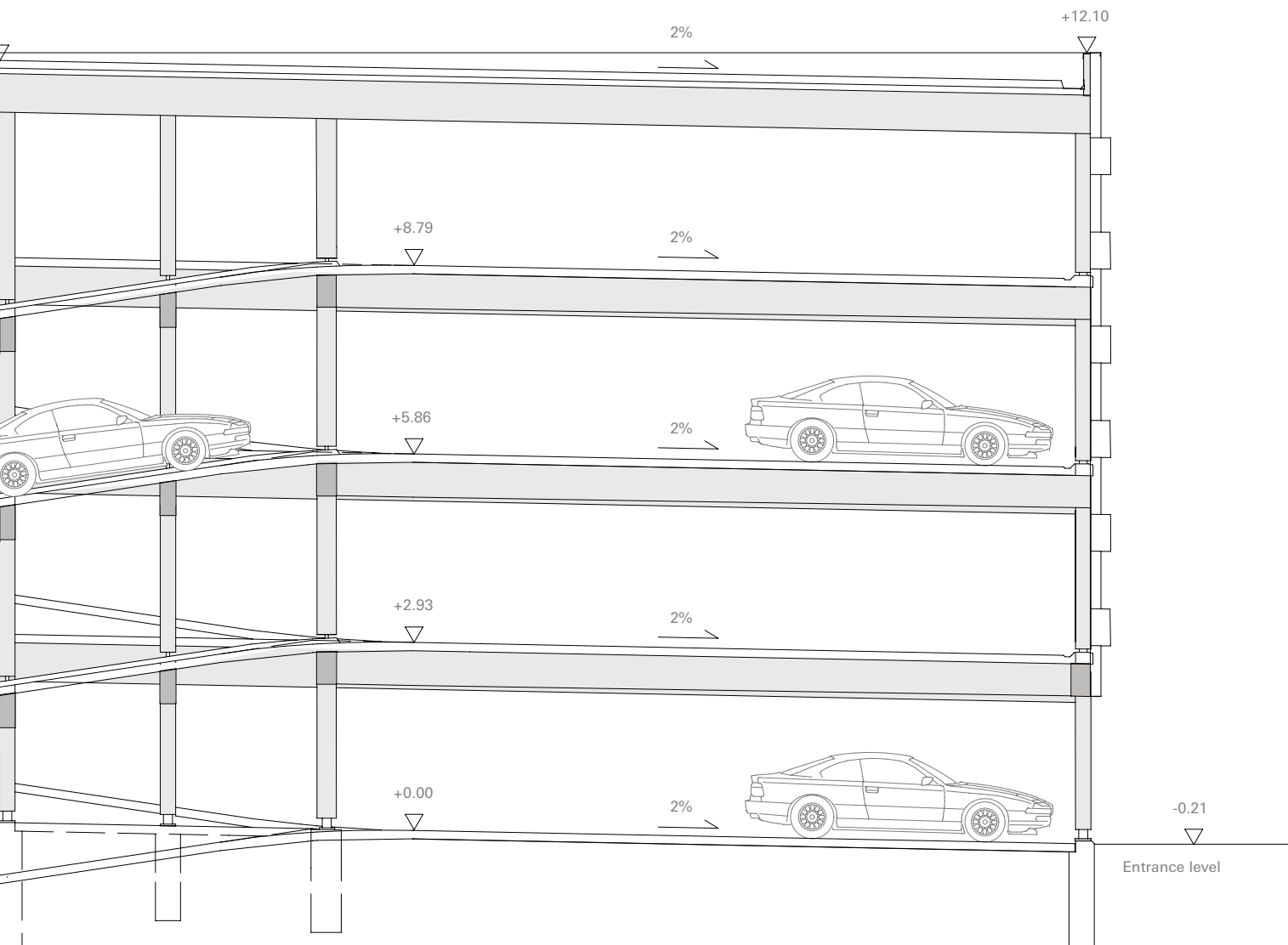
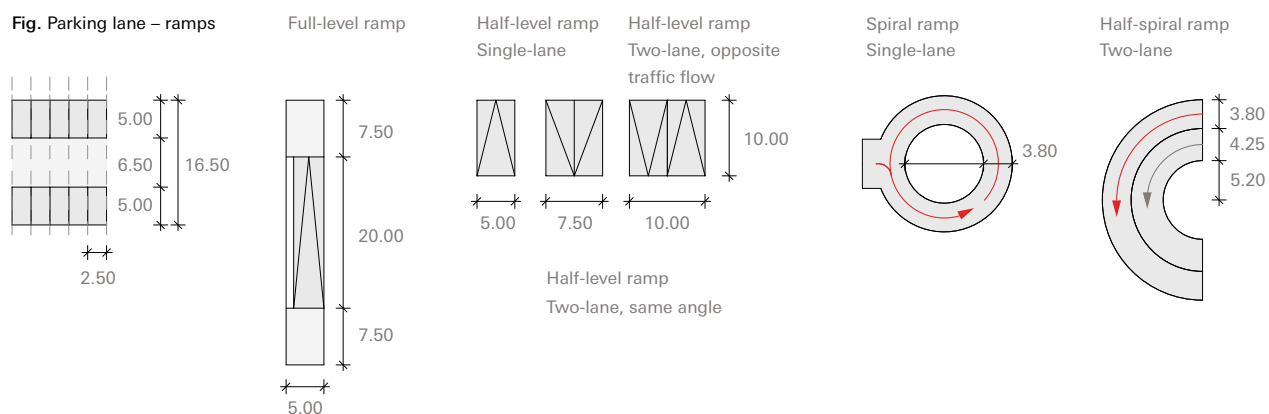


Fig. Cross-section of prototype model

Fig. Parking lane – ramps



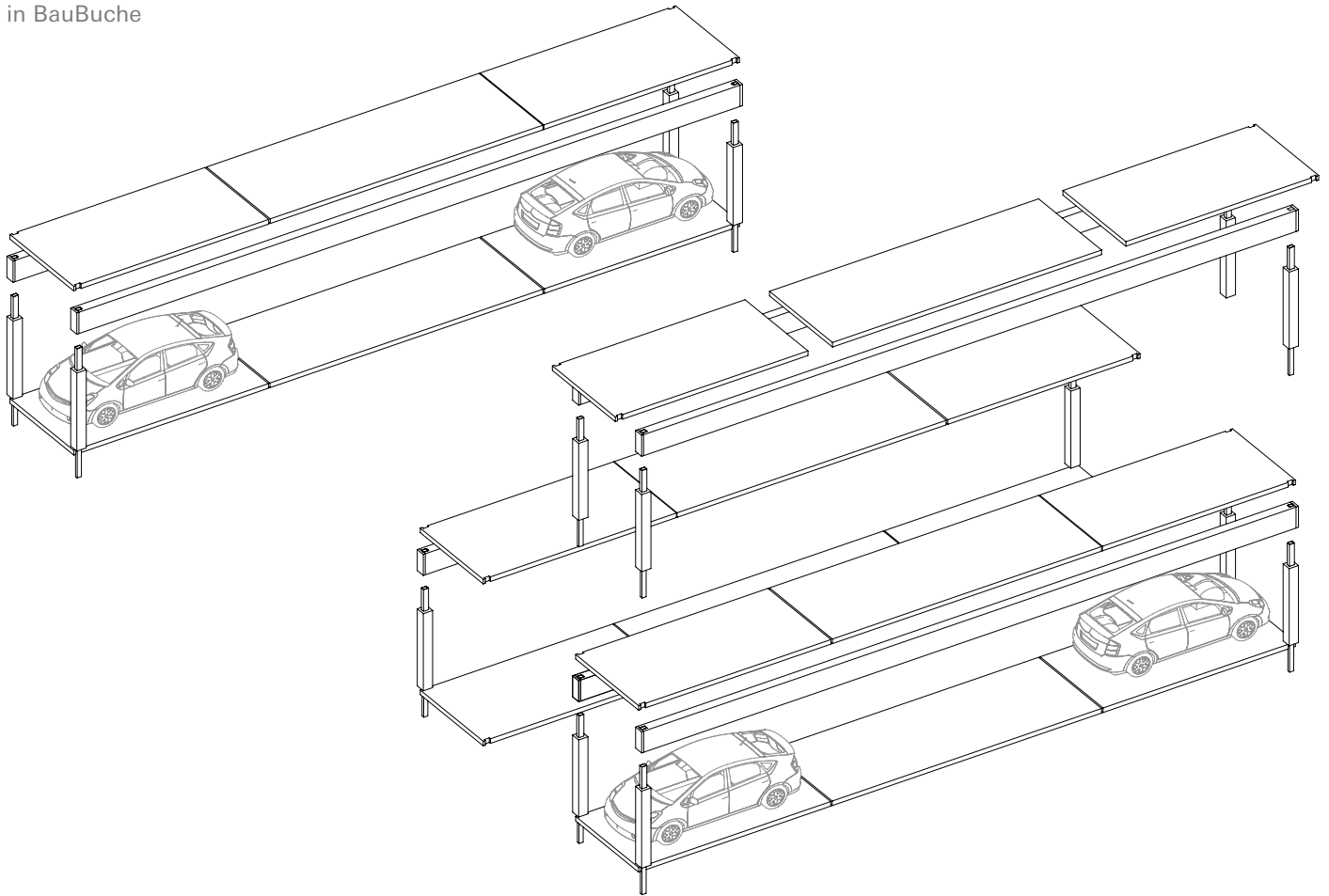


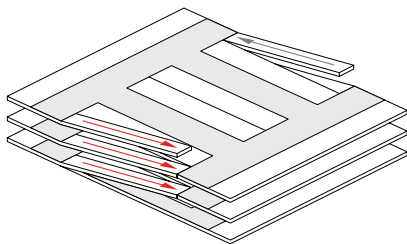
Fig. Basic construction – addition of modules

The basic modules can be arranged one beside the other to form parking decks of any length. In theory, the height of the construction is only limited by building regulations. The modular structure allows for the future addition of levels and the horizontal extension of the multi-storey car park. As the parking modules can be combined with various different types of ramps, there are virtually no limits as regards layout and design. Straight, full-level ramps for full-storey

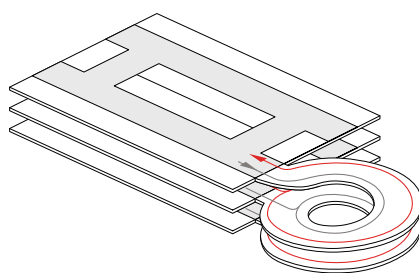
constructions as well as half-level ramps for split level car parks are constructed using posts and beams made in beech LVL. This type of construction is also suitable for car parks where the parking decks are at an angle of maximum 6%. Where there is a need for extra clearance, posts with a larger cross-section and suitable cross-beam connections can be incorporated.

The modular design also allows for combinations of full-level and half-level ramps with spiral ramps.

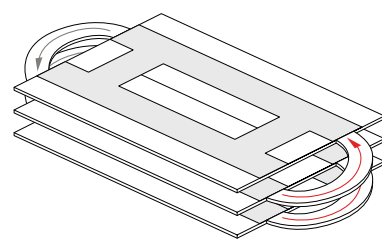
Fig. Types of car park ramps



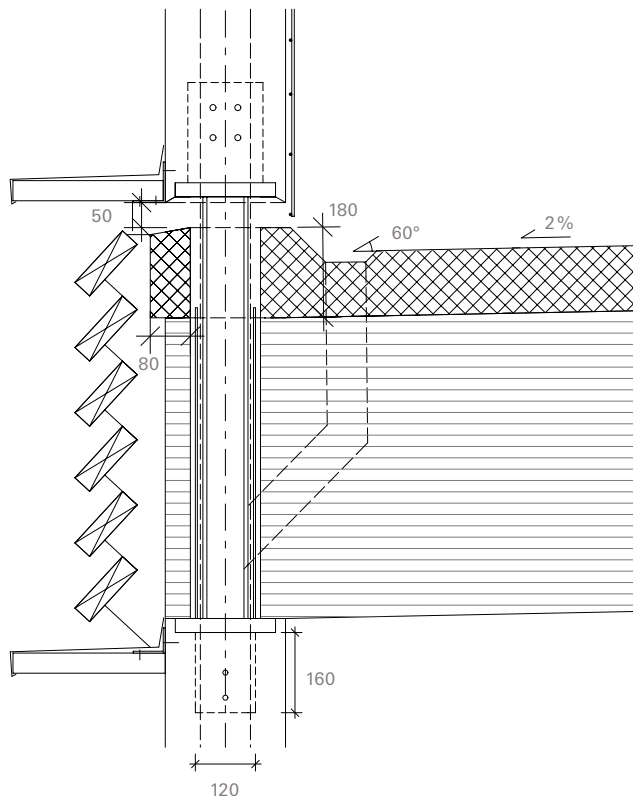
Full storey
Straight full-level ramps



Full storey
Spiral ramps



Full storey
Half-spiral ramp



Galvanised steel mat with impact barrier
+ fall protection
Slotted plate h = 10mm, 150/200 mm
Bar dowel d = 12 mm
Steel anchoring plate h = 28 mm, 200/200 mm
Rectangular tube 90/50/8 mm
Joint sealed with expansive mortar

Gutter connected to downpipe
of roof drainage system (optional)
Rectangular tube 120/80/4 mm

Beech LVL beam 600/240 mm,
40 mm, cambered

Slotted plate h = 10mm, 120/160 mm
Bar dowel d = 12 mm

BauBuche GL75 post, 240/240 mm

Fig. Longitudinal cross-section: connection between
post and concrete slab – SCALE 1:15

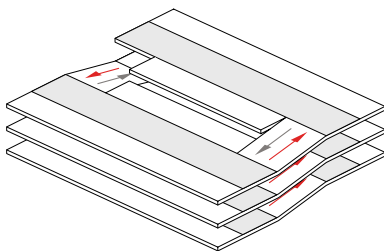
Construction

The timber-concrete composite floors consist of BauBuche GL75 according to ETA 14/0354 and pre-cast concrete elements that are connected to the timber sections with birdsmouth joints to form rigid structures. The timber beams are 240 mm wide and 600 mm high and are cambered. For extra durability, all timber beam elements are coated to protect them against moisture intake.

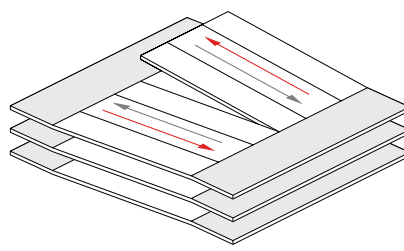
The beams span the entire parking deck and rest on square BauBuche posts measuring

240 mm x 240 mm. These posts extend over the entire height of the storey and are connected to each other by means of hollow steel profiles that are slotted into each other, filled with low-shrinkage expansive mortar and secured with steel dowels. This method allows for fast installation and separates the timber posts from the concrete slabs, so that water collecting on the concrete surface does not cause damage to the posts.

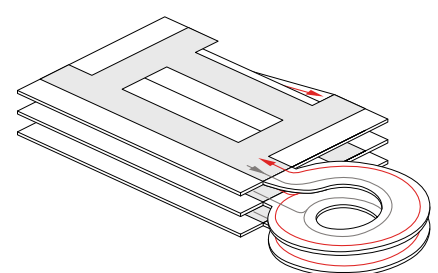
The posts supporting the split levels are screwed to each other.



Split level
Straight half-level ramp



Parking ramp



Special designs/
hybrid construction





Fig. Visual impression of ramp with parking deck

The parking decks are accessed over ramps constructed from BauBuche GL75 beams and prefabricated concrete slabs. The slabs are placed on the timber beams and secured with screws. A roof above the top parking level protects the entire construction against the elements. The parking decks are at an angle of 2% so that water brought into the building by cars can run off towards the shell where it collects in a gutter

integrated into the prefabricated concrete elements and is drained off through gullies into rainwater pipes. The building is stiffened in traverse direction by the walls of the stairwell made in reinforced concrete. For longitudinal stiffening, the construction features steel elements in the post planes. The diagonal steel elements are secured and tightened with overlapping flat steel eye plates to fin plates.

Prefabrication and modular structure

The higher the degree of prefabrication, the more resource-efficient the building construction. As the beech LVL load-bearing elements are manufactured at the factory, they are of an enhanced quality, as all details and features (recesses for birdsmouths, surface seals, etc.) are produced under stringent quality assurance conditions. Waste is reduced to a minimum and recycled at the factory. By using prefabricated building parts, construction on site can be standardised, saving time. The modular construction makes it easy to maintain and replace individual building components. The installation of the elements on separate levels ensures maximum wood protection as well as fire safety. Thanks to the factory production of the elements and the modular construction of the individual parking decks, the BauBuche beams are exposed to the elements for only a very short time. During construction, the individual parking deck floors (prefabricated concrete slabs) serve as roofs so that already installed beams and posts are protected against rain and snow.

As the concrete slabs extend across the entire floor, the modules are separated by fire barriers that prevent fires from spreading upwards along the supporting structure. As the beams are at a distance of approx. 2.30 m from each other, it is unlikely that flames will spread from one timber beam to the next. The use of solid timber elements eliminates the risk of fires spreading through cavities, and makes sure that fires can be extinguished quickly. The installation of linear load-bearing elements made in timber does therefore not increase the fire risk.

Disassembly and end of life

Thanks to the modular system design and the use of reversible steel connections (push-in tubes, slotted plates and steel dowels), the building or parts of it can be easily disassembled. As the construction features a limited number of joining techniques, disassembly can be automated. There are only three main materials, i.e. timber, concrete and steel, and the individual elements are relatively large, making separation for re-use and recycling easy and cost-effective.

Ecology

Timber plays an important role in sustainable construction. About a third of the material used in the proposed construction system for multi-storey car parks is renewable. By adhering to the constructive timber protection measures that form part of the system, there is no need for chemical treatment of the wood. To protect the elements during transport and installation, we recommend applying a hydrophobic coat (e.g. System BauBuche Primer/BauBuche Varnish from Koch und Schulte GmbH & Co. KG) and wrapping the timber in foil.

At the end of usage, the untreated wood can be reused, recycled, or used for energy. The concrete and steel components can also generally be sent for recycling. A parking garage made of BauBuche thus represents a large reservoir of potentially reusable or recyclable materials and creates favorable conditions for the resource-conscious use of building materials.

Beech laminated veneer lumber post 240/240 mm
Steel dowel $d = 12$ mm

Slotted plate $h = 10$ mm, 150/200 mm
Steel anchoring plate
 $h = 28$ mm, 200/200 mm
Rectangular tube 90/50/8 mm

Precast reinforced concrete element 130 mm
Joint sealed with expansive mortar

BauBuche GL75 post, 600/240 mm
40 mm, cambered

Rectangular tube 129/80/4 mm
Steel anchoring plate
 $h = 28$ mm, 200/200 mm
Slotted plate $h = 10$ mm, 120/160 mm

Bar dowel $d = 12$ mm
Beech laminated veneer lumber post 240/240 mm

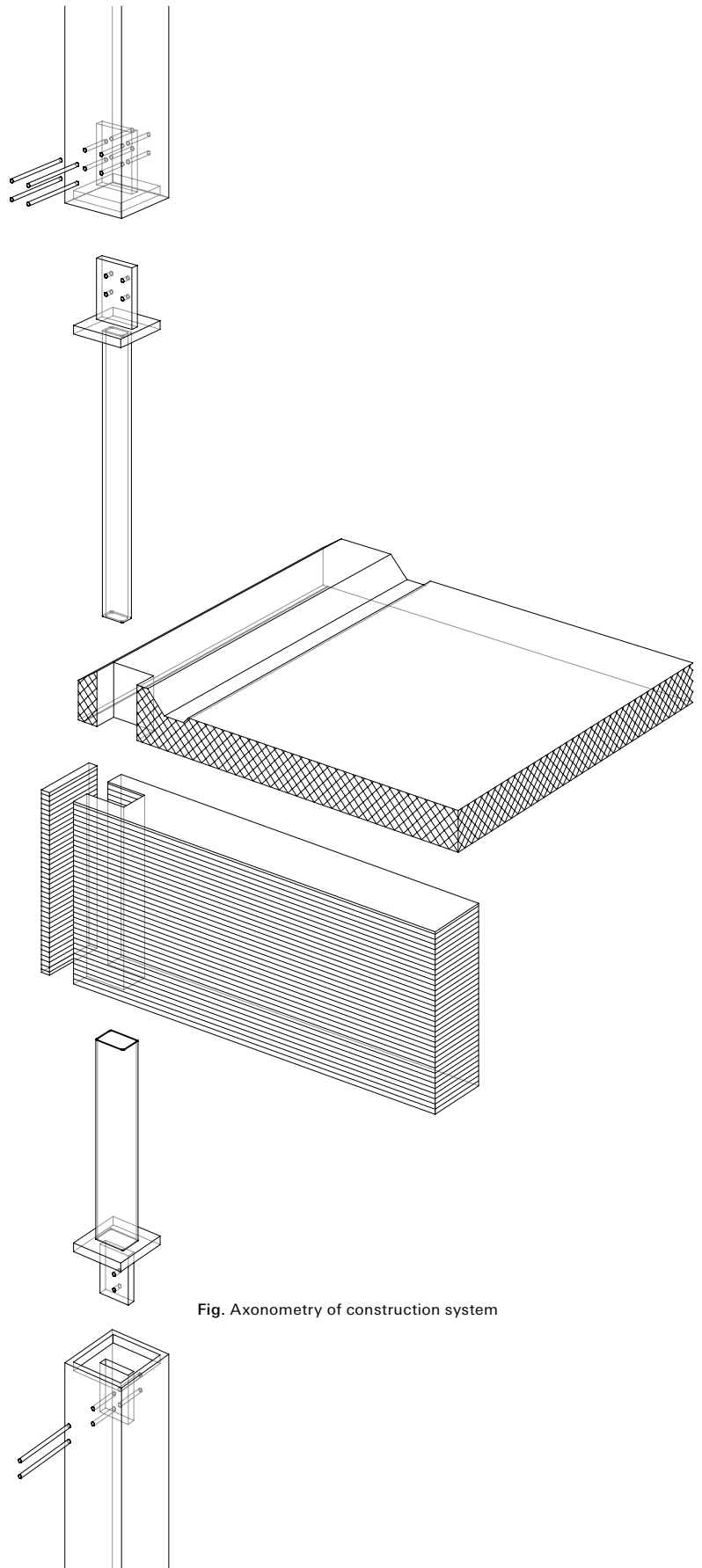
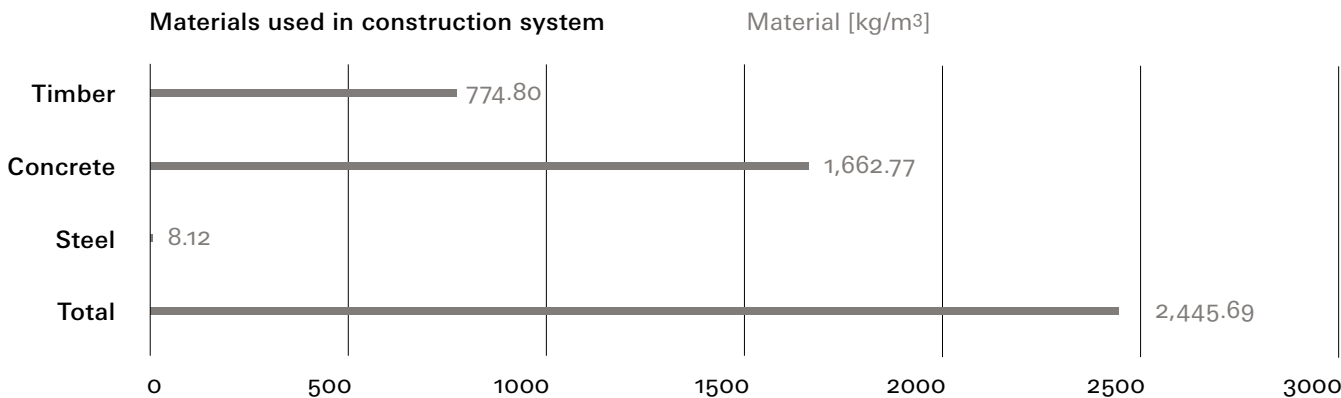


Fig. Axonometry of construction system



Thermal recycling

775 m³

BauBuche GL75 beam, 240/600
BauBuche GL75 post, 240/240

Recycling

1,671 m³

Mineral materials

Prefabricated concrete, expansive mortar

Steel

Push-in tubes, bar dowels, slotted plates, anchoring plates, concrete reinforcement, stiffening elements

Façade

The construction system for multi-storey car parks in BauBuche does not pose any restrictions as regards the design of the façade. To meet the requirements for an open multi-storey car park, the building shell must however be at least one third open. At the same time, it must provide adequate rain protection and good ventilation, as these are key requirements of the proposed construction system. The actual façade design needs to be approved by the building authorities, in particular with regard to fire safety.

For the prototype, the designers came up with horizontal fin cladding in larch combined with protruding circumferential timber planks. As the larch fins are at an angle, rainwater drains off quickly while there is ample daylight, which makes the parking facility more user-friendly. The planks installed at each level are secured to the posts and act as fire barriers while also giving the façade a consistent horizontal structure. As there are no solid walls, car park users feel safe and

can see reference points outside the building for orientation. The building is protected by 300 mm eaves on all sides. Alternatively, the car parking facility can be clad in a metal façade. By incorporating a back-ventilated intermediate layer, the car park can be constructed without a separate façade, or with facing that does not provide protection against the elements. The posts are protected against impact by board cladding on three sides, whereby the individual boards can be easily replaced, if necessary, which keeps maintenance and demolition costs low.

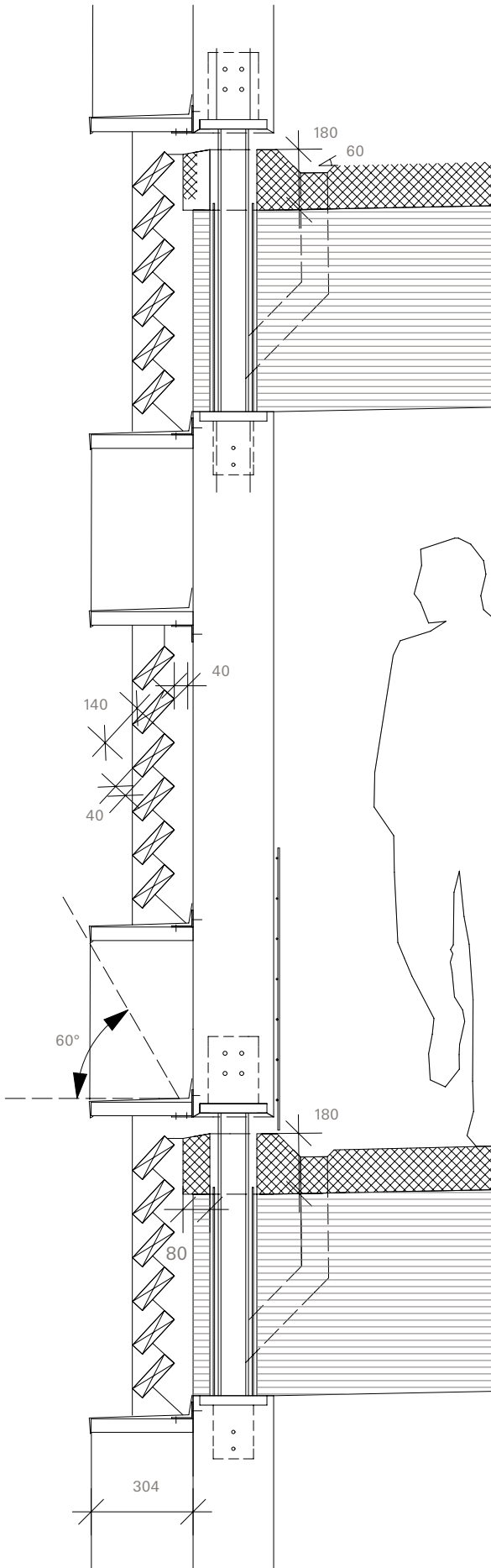


Fig. Façade cross-section – SCALE1:20

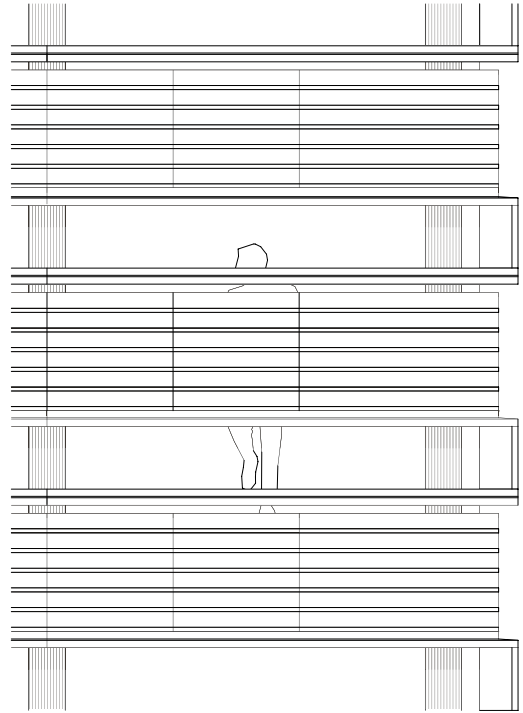


Fig. Façade front view – SCALE1:50

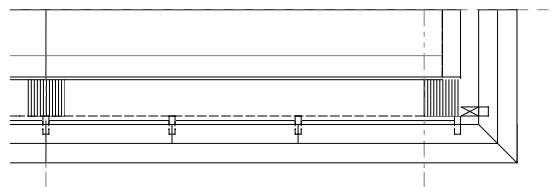


Fig. Façade floor plan – SCALE1:50

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