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01 Resource-efficient foundations

Soil excavation for the foundation. Due to the shallow foundation depth of 1.5 - 1.7 m and the slender dimensioning of the stepped strip and individual foundations, soil excavation can be reduced to a minimum.

STB is used for the base foundations, and the columns are made of reinforced formwork blocks with a vertical connection reinforcement into the base, a filling of in-situ concrete and termination of STB. The formwork blocks are not bonded, as the concrete filling provides the necessary stability.

Single and strip foundations completed and stepped. Compared with a conventional floor slab, approx. 45% of concrete can be saved in this way.

View of the foundations for the carports and the technical room; with partial basement for garbage room and general storage cellar/bicycle storage room. Each parking space also has a directly connected storage room. At the same time, the official requirement of a noise barrier on the station side is fulfilled.
All excavated soil will be stored on the construction site and used for site levelling and backfilling. The topsoil will be stored separately and re-applied at the end of the construction phase for the design of the outdoor facilities.

Aerial view of the construction site with the finished foundations for the buildings (semi-detached houses and apartment buildings) and the already insulated connection/supply shafts for the individual residential units. The finished modules can then be connected directly to these (plug & play principle). In the area between the apartment building and the semi-detached houses, the rainwater cistern and the additional retention basin required by the building authorities will be installed later.

Upper part and connection of the readily installed rainwater cistern (approx. 26 m3). Here, the roof water is collected and the service water is used for toilet flushing and garden irrigation.

02 Modular prefabrication of the multi-apartment house in the factory

Production of a floor element; floor panel made of HDF (high-density fiberboard), filling: 48 cm Iso-Stroh insulation and wooden ribs in between. The element is later closed with an OSB board. Elements for the floor and top floor ceilings are already equipped with the insulation in the factory.

A "raw module" for the ground floor with cross laminated timber walls (BSP) and ceiling support made of BSP, insulated floor element open with Iso-Stroh insulation filling.

Support of the top floor ceiling for an upper floor module in the factory in Kasten, without straw insulation yet. This is inserted directly after assembly of the wooden structure and then closed with HDF boards.

Interior view of a "raw module" with cross laminated timber walls (incl. milled holes for laying cables) and ceiling panel made of BSP. The floor element is closed with OSB3 panels, and the panel joints were provided with special adhesive tapes for airtightness. The advantage of the construction with BSP and OSB is that, from the point of view of building physics, no additional vapor retarders are required.

03 Series production of the modules in the factory

With the serial production of the modules in the factory, time and costs can be saved. The entire interior construction of the modules with all the trades involved (electricians, plumbers, carpenters...) can thus also be centrally controlled and handled in a time- and cost-efficient manner. Another major advantage of this construction method is the independence of the manufacturing process from the weather.

Factory hall of the general contractor in Kirchstetten (serial production of Top 1 - 4 = 14 modules, Top 7 + 8 = 4 modules were produced in the smaller factory in Kasten).

After prefabrication of the "raw" wooden modules, these are also serially processed by the various trades and fitted with the building services and interior fittings.

04 Building services and interior equipment of the modules in the factory

Interior walls consisting of a wooden stud construction and 3-layer spruce boards are erected and filled with a compartment insulation made of hemp insulation mats. Figure below right: The flexible partition walls are installed only after the floor is laid, in order to ensure a continuous floor covering, in case of displacement or removal of the partition wall. Finally, the interior walls are painted with natural and solvent-free white linseed oil glaze.

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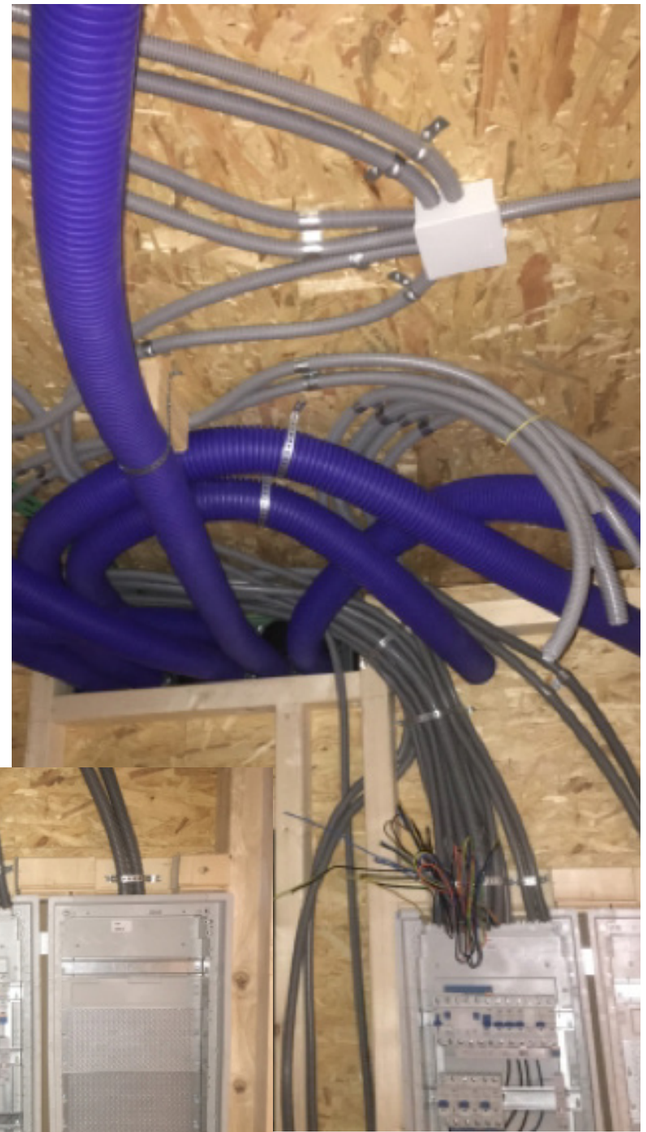
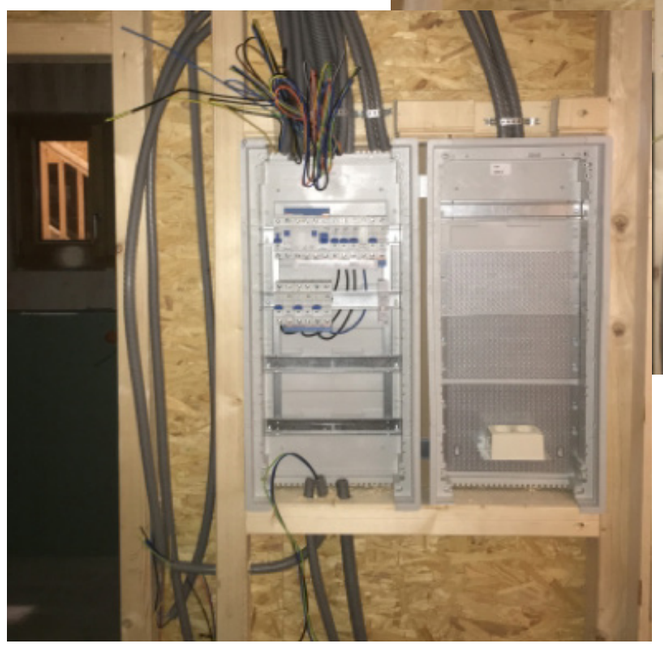
Interior sanitary installations from top left to bottom right: Installation of innovative hot water storage system Enerboxx (without its distribution module yet) in the bathroom; WC tiled and with installations, facing shell for the installations in the bathroom, installation of underfloor heating with a dry construction system made of gypsum fiber boards, underneath of which, an underlay board made of wood fiber. The advantages of the system are short installation time, low thickness (approx. 20 mm), low weight and easy dismantling (e.g. for renovation).

From top left to bottom right: Exterior connections and installations of decentralized living space ventilation (facade unit), supply and disposal lines for later direct connection to the supply shafts on the construction site prepared; factory prefabrication of building services lines (living space ventilation and electrical). In order to have good maintenance access, the suspended ceilings are also designed modularly as individual elements, which can also be easily removed individually (see pictures next page).





Interior joinery work from top left to bottom right: Assembly of the modular ceiling panels for the lower ceiling, installation of the frames for the interior doors, the installation of all windows and also the front doors are already done in the factory.

The finished modules are then prepared for transport to the construction site. The use of an innovative construction time sealant, which can be left on the modules due to its low SD value (Diffusion-equivalent air layer thickness), eliminated the need for the otherwise customary packaging of the modules in plastic film for weather-protected transport; this further reduced the volume of waste.

November 3, 2021, early in the morning: The four modules for the first construction phase (Top 7 & Top 8) are completed at the factory and leave the plant in Kasten for transport and relocation to Böheimkirchen. - Top 7 (ground floor) the first residential module is loaded and arrives at the construction site in Böheimkirchen.

05 1st construction phase on site - moving and assembling the modules Top 7 - 8

Preparation of the foundations for the support of the modules with support pads made of rubber granulate (moisture and friction protection for timber construction), the metal connectors for screwing the modules to the foundations have also already been pre-assembled on the foundations.

The first module (Top 7 residential module) is lifted onto the foundations by crane and precisely aligned.

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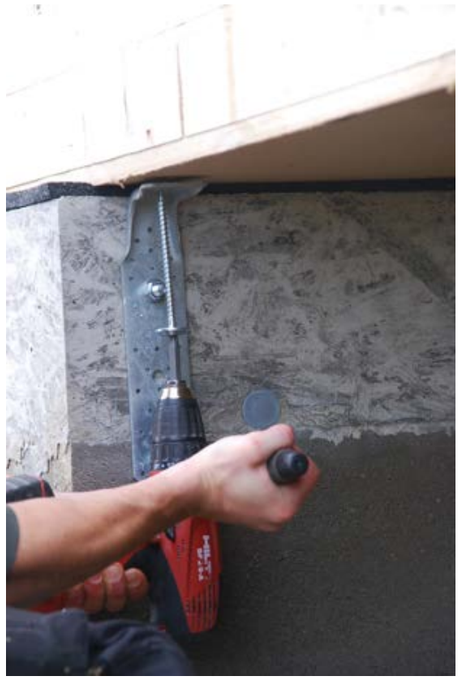
The individual modules are bonded to ensure airtightness and firmly screwed to the single and strip foundations.



03 November 2021, noon: - 2 modules are already in place;

03 November 2021, evening: all modules of the 1st construction phase have been moved and assembled.

The roof construction for the first construction phase was completed two days later.

06 Construction phase: Community center and staircase

The staircase and community center were built in lightweight construction with prefabricated elements. The staircase for Top 8 and Top 4 is the connecting element between the modular prefabricated units on both sides.
The interior fittings were carried out on site at the construction site. The prefabricated elements also ensured an extremely short erection time for the shell (2 days). The blow-in straw insulation was carried out after construction in the interior. The wood stud construction of the interior walls was erected not in the factory, but on site due to the height over two floors. The staircase was also constructed entirely of wood and wood-based materials.

07 3rd and 4th construction phase: Top 4 - 1

3rd construction phase: Moving and assembly of the modules for the units Top 3 and Top 4, each consisting of 2 residential modules and a building services module with a living area of approx. 84 m2.
All module joints and cable routing are sealed airtight with special adhesive tapes for wood materials.

For sound insulation and insulation between the floors, a layer of Iso-Stroh is placed loosely and covered with OSB boards. The modules of the upper floor are then placed on top of this.

Within one working day, all 6 modules were also moved and assembled in construction phase 3. The modules are screwed together horizontally. A vertical screw connection is not necessary due to the strong static friction of the modules to each other.

4th construction phase: Moving and assembly of Top 1 + 2 (terraced houses 2-storey), consisting of a total of 8 modules. Parallel to this, work on the insulation and façade has already begun in the first and second construction phases.

One module per row house will already be equipped with the finished interior staircase in the factory. The corresponding upper floor module is equipped with a precisely fitting opening.

Here, too, all 8 modules of the construction stage can be assembled within one day.

In the following days, the roof structure for the "flying roof" will also be completed and the scaffolding for work on the insulation level and facade will be pulled around the building complex. Meanwhile, the last two residential units will be connected to the central building services supply.

08 Insulation, facade and outdoor facilities

Directly to the outer wall of the modules, the wooden structure (compartment for blow-in insulation) is attached around the building on site.

The cavity is closed with DHF boards (= diffusion-open and moisture-resistant synthetic resin-bonded, medium-density wood fiber board). The 48 cm thick blown-in insulation made of straw chaff (Iso-Stroh) is inserted. The special preparation also keeps dust level well below the limits.

The ventilated wooden façade (vertical floor-ceiling formwork made of sawed larch) is installed on the counter-battening of the exterior wall and the terraces, balconies and house entrances, also made of wood, are installed. Meanwhile, the interior of the staircase and the community center is also completed

09 Completed multi-apartment building June 2021

South side with finished terraces and balconies

North side with house entrances, Top 4 and Top 8 on the upper floor can be reached via the staircase, all other residential units are accessed with an outside entrance via a small wooden walkway. All paths and driveways are covered with ecological flooring to keep the sealing as low as possible.

10 Erection of shell load-bearing straw construction

Prefabrication of the individual elements such as outer wall, floor, top floor ceiling in the factory

Exterior wall construction: The large straw bales are already compressed at the factory and inserted into the glulam frames with ribs (as settlement limitation and static support during load transfer). The elements are planked on the outside with soft fiberboard (as a plaster base) and on the inside with OSB as a vapor barrier. This creates a partial load-bearing straw wall structure combined with the advantage of prefabrication in the factory.
The floor element and the top floor slab are finished with Iso-Stroh insulation in a thickness of 60 cm. Due to the greater loads, the floor elements are planked with wooden laths made of rough-sawn larch in addition to the DHF board in the lower area.
The wooden stud construction for the partition walls of the semi-detached house are also already manufactured in the factory and planked on one side with 3-layer spruce boards.

11 Moving and assembling the elements on the construction site

In April 2020, the prefabricated elements for the first semi-detached house (Top 10) were moved and assembled on the construction site in 2 days. On the third day, the roof truss could already be erected.

Moving the first floor element and threading the lines from the installation shaft; view over the entire construction site with crane and floor and exterior wall elements of the first part of the semi-detached house (Top 10) already moved and assembled on this day.

Before the top floor slab was moved on day 2, the prefabricated interior walls were lifted into the open structure and assembled.

The individual elements were connected with screws and insulated with fleece between the joints. Here, too, adhesive joints were avoided as far as possible from the point of view of building physics. (e.g. to ensure the airtightness of the buildings).

View of the erected interior walls already prefabricated on one side, the open compartments (picture on the right) will later be filled with hemp insulation mats and closed with 3-layer boards spruce.

window fronts. Image above: Laying of the overlay, which is also insulated with blown-in straw insulation.
Figure right: Detailed view of the joint of the two overlays.

After the assembly of the overlays, the ceiling elements are moved and installed. Due to the prefabrication and the accuracy of fit of the individual elements, one residential unit (an atrium house) could be erected within one week including the roof structure.

The ceiling elements are constructed from the inside to the outside as follows:
OSB board; 60 cm blow-in insulation straw chaff; in between ribs;moisture resistant DHF board.
After installation, the elements are connected to each other with long special screws.

In order to minimize the use of construction foam for the air-tightness of the building envelope, fleece is used between the element joints. The joints are then sealed on the inside and outside with special adhesive tapes for wood materials.

Northwest view of the semi-detached house both residential units in the shell finished. The work on the roof truss and flat roof are being carried out.

12 Interior finishing load-bearing semi-detached house

Electrical wiring was installed in the interior walls.
The compartments of the interior walls were filled with hemp insulation boards and closed with 3-s boards spruce. Innovative wooden nails were used to fasten the wooden panels. These are shot into the wood with a compressed air nailer and the resulting frictional heat causes the lignin in the wood nail to expand, creating an inseparable bond with the material.

The east- and west-facing exterior walls of the two residential units of the semi-detached house were clad with clay building panels.
The picture also shows the façade ventilation unit (Top 9) and still packed hemp insulation boards for the interior walls.

The building panels are covered with clay plaster. The final top layer was made of clay plaster with an addition of light sand, which is finely rubbed with a sponge board, so a light, sandy hue and a smooth plaster surface. Keeping those walls unpainted preserves the sorption capacity of the clay for an improved indoor climate. Natural linseed oil with white color pigments was also used for painting the interior wooden walls.

The dry construction system for floor heating offers two advantages: During construction, rapid installation, since the long drying time of a screed covering is eliminated. During dismantling, simple and unmixed removal, as the individual panels are not glued to the subfloor.

Substructure for the suspended interior ceiling in the rooms; in the space between the ceiling and the top floor, there is enough space for the wiring and building services components (e.g. ventilation unit).
The exposed ceiling is made with individual, screwed panels of spruce, which allows easy maintenance access, but also, for example, to easily move the light outlet if necessary.

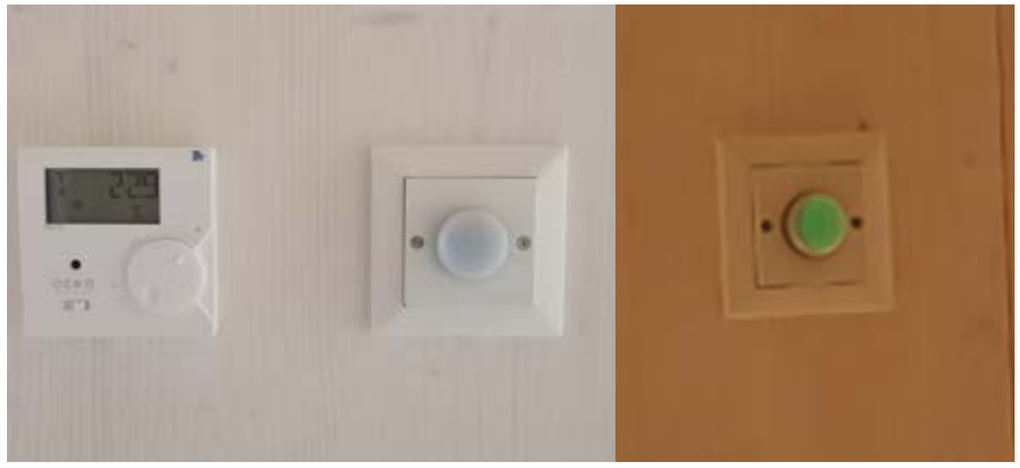
A cork carpet pad is laid over the floor heating system and a floating parquet floor is laid on top. The absence of adhesives ensures a healthy indoor climate and separation by type during renovation or dismantling.

The spacious terraces of the semi-detached house stand on screw foundations and are also executed in larch. All windows have passive house standard and are made with wooden frames.

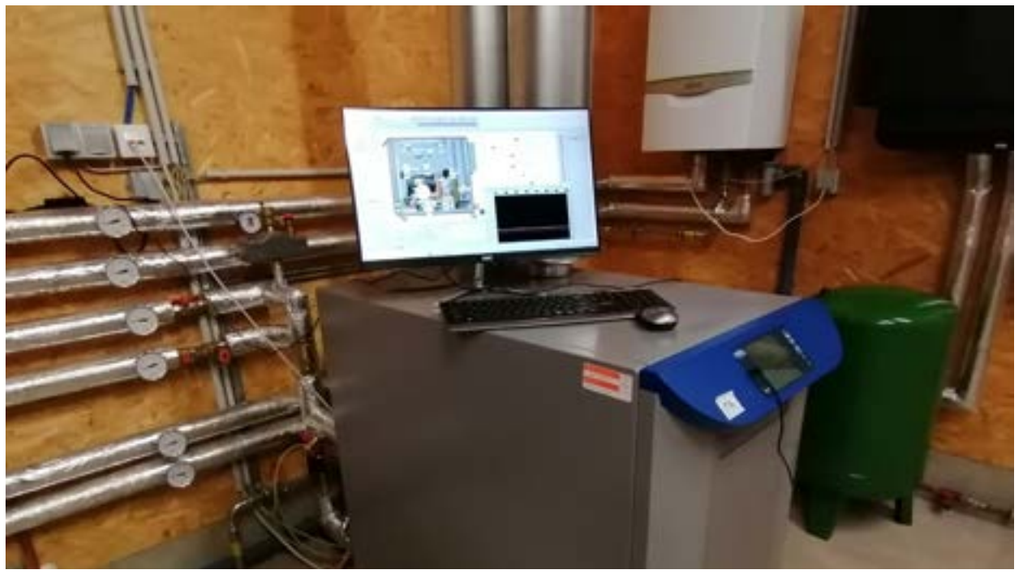
Views of the completed duplex. Image above: Garden side view from east to west; Bottom image: House entrance view on the north side (photo from west to east).

13 Renewable energy supply of the buildings

On the roof of the technical room (pitched roof in the background) is the solar thermal system with a total gross area of 33.4 m2.
On the roof of the carport, there are three rows of PV modules mounted in east-west orientation with a total output of 23.76 kWp. The PV system is set up as a community system and also supplies the residential units with energy.



All residential units are equipped with room sensors and an energy traffic light. The energy traffic light shows green when there is a surplus of self-produced electricity (PV + Enertwin).



The Enerboxxes (Hot water storage systems) in the individual units are loaded centrally three times a day from the 5000 l buffer storage in the technical room. This in turn is fed with hot water by the solar thermal system and the micro-CHP.

The Enertwin micro-CHP is operated with a low-maintenance gas turbine. It supplies 15 kWh of thermal energy and 3 kWh of electrical energy during operation. It is supplied with 100 % biogas.

Projektträger: GrAT, Gruppe Angepasste Technologie, Wiedner Hauptstr. 8 – 10, 1040 WienIdee, Concept Design, Projektleitung: GrAT / Dr. Robert Wimmer

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