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ARCHITECTURAL POTENTIAL OF NEW WOODEN MATERIALS & TECHNOLOGIES

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ABSTRACT: In this text, we like to showcase some of our more ambitious projects: The first high-rise in timber construction in Germany, our project SKAIO received the so-called DGBN certificate in gold, a proof of air quality, and a DGBN-Diamond award. In addition, it exemplifies our approach to design for disassembly—all materials can be clearly separated. SHAA, a university and office building we currently design in timber construction, advances some of the findings we gained in a recently finished university building: here, we develop a building frame at once simple and able to accommodate pipes and cables. In office areas, glued laminated timber slabs [Brettstapeldecken] span the timber frame, in corridor areas cross laminated timber elements span in two directions, so that we can dispense with bearers to incorporate wiring and plumbing. Another project of ours, NXT, is an attempt to design quite an ordinary office building. By that we mean a focus on comfort and flexibility for third party users. We devise a flat slab with integrated bearers. The timber–concrete composite slab spans from beam to the façade.

KEYWORDS: LAGERSCHWERTFEGER, Berlin, Germany, Timber architecture, housing, education

1 Introduction

Between 2012 and 2021, the architecture practice Kaden+Lager, the former office of Markus Lager, realized a large number of hybrid-timber construction projects in the so-called building classifications four and five, comprising all buildings higher than seven meters. Berlin's building code allows for such constructions since 22 March, 2018. Previously, architects had to have such constructions approved as departures from the norm and through individual exceptions, which required huge efforts both in terms of time and money. Meanwhile, four of sixteen state building codes in Germany allow for the use of timber constructions in said building classifications. In addition, since mid-2021, the federal states integrated what is called Musterholzbaurichtlinie MHolzBauRL (Construction Guideline for Timber Construction) into their administrative regulations on technical building codes. This regulation basically controls the use of timber in building classifications four and five, respectively, and it allows for superstructures already used in buildings between 2012 to 2021.

While this new guideline for timber constructions has been developed and introduced, an increasing number and size of realized structures helps to technically advance applied timber constructions: referring back to already existing structures makes the design and construction of new ones much easier. We can now simplify superstructures, for instance, by reducing individual layers in their buildup. And not least do we have to use materials according to their nature. Between 2012 and 2021, errors occurred during the planning and execution phases, both in our own practice and more generally. Statistically, an increasing number of timber-constructions will inevitably lead to an increase in water and fire damage. As a consequence, we need to take stock of our projects to date and the concomitant regulations they entailed. It is not a question of lowering our protection goals or of unconditionally reducing complexity; rather, timber constructions must become more robust. There is, for instance, still a lack of solutions for both temporary and permanent waterproofing of construction sites and bathrooms. Another example is the integration of building technology mainly in prefabricated wall and ceiling elements. This article aims to trace the above-mentioned developments through the lens of our own projects. In addition, this article offers an outlook on current tasks that are constantly changing.

2 SKAIO

SKAIO is Germany's first wooden high-rise and—at the time of its opening—the country's tallest wooden building. Measuring 34m in height, its timber-frame construction is to large extents prefabricated, comprised of supporting structures made of laminated timber, and wooden slabs which rest on steel ring beams that resonate to the slim design of the construction. The project is part of the recently developed residential quarter Neckarbogen, an urban district in Heilbronn. The residential block features ten storeys and offers 60 apartments, 40% of which are subsidized by the state.

The internal layout has been adapted to reflect the new urban realities, in which the nuclear family no longer represents the sole point of reference. SKAIO instead offers apartment types which are usually hard to come by in a contemporary city: 56 smaller studios and one-bedroom apartments. These individual units, however,

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can be easily combined to accommodate future changes in use. In addition, four shared apartments are dedicated to socially disadvantaged members of society, run by two of Heilbronn's social welfare organizations.

Above an underground car park, the ground floor features commercial spaces, common spaces—laundry room, communal kitchen—and ample bicycle parking. Common laundry rooms in Germany tend to be rare and save valuable surface area in each apartment. A central core made of reinforced concrete contains the safety-stairwell and an elevator, which allows for barrier-free access to all apartments. While the primary structure in the basement, ground floor, and first floor are made of reinforced concrete, all other load-bearing components are made of timber or wood-steel hybrids.

The studios start, in floor space, at 40 square meters; the largest flats offer 90 square meters. Every apartment has its own loggia, floor to ceiling windows to provide for a maximum amount of daylight, and energy-efficient underfloor heating. The roof has a common garden terrace, partly furnished, partly green, with produce gardens and stunning views across the city.

During the so-called Bundesgartenschau 2019, a biennial federal horticulture show held in Germany, SKAIO marked the entrance to the show, constituting one of three landmarks in the vicinity.

2.1 Structural Contribution

SKAIO's ceiling and wall structure can be dismantled into its individual parts, that is, all materials can be separated by type. What is more, all superstructures are dry to guarantee a fast and clean construction process. Floor slabs are smoke-proof, a property we achieved by using so-called panel bundles in conjunction with a continuous layer of Fermacell above the impact sound insulation. That part of the primary timber construction facing the apartments we did not cover with plasterboard, something the MHolzBauRL (the guideline for timber construction) commonly asks for. The underside of the 26cm thick cross-laminated timber ceiling remains visible. On top of this ceiling panel, we installed lighting and sprinklers which are then brought down through drill holes. A wall of 12cm thick cross-laminated timber panels on the inside closes of the living space. The degree of prefabrication of walls is quite common in many other timber constructions. Prefabrication of the ceilings, however, is limited to the joinery of the cross-laminated timber elements.
The dry floor construction can only be made in situ, as the high-pressure water mist firefighting system has to be installed first throughout all apartments and in the safety stairwell. Even though it is possible to use a dry construction method that does not impede construction progress with drying time or require the use of chemicals to accelerate any drying, the complexity of this method is rather high. SKAIO's shell received a total of around 26,400m2 of panel materials, which is equivalent to the size of almost four soccer fields, an amount that adds to the complexity of the construction site. In comparison, prefabricating the ceiling panels with dry construction in the workshop might have been significantly less complex. However, the installation of the sprinkler system in particular would not have been possible with prefabrication.

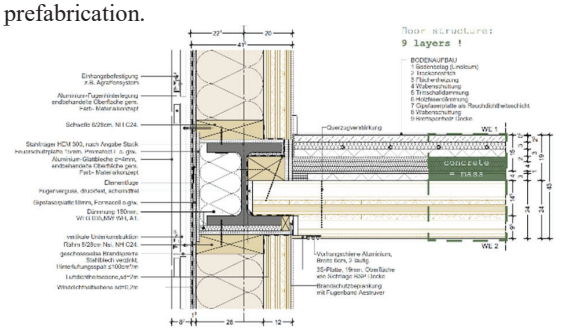

***Figure 1** – ceiling SKAIO, dry flooring, heating, beams*

***Figure 2 -** SKAIO MockUp of ceiling construction connecting walls*

2.2 Facts

SKAIO	
Planning	2016 – 2018
Realisation	2018 – 2019
BGF	5.685 m²
Amount of flats	60
SQM	3.300 m²
Costs KG 300/400	12.6 Mio €
Gebäudeklasse	5

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Figure 3: *view SKAIO: aluminiumfacade, skeleton construction, columns on public ground*

3 TzW, Hamburg

In 2015, Kaden+Lager won a competition for "Baakenhafen, Baufeld 89," with the design of a residential building in hybrid-timber construction eight stories high. The building group inhabiting this structure consists of 29 parties and is made up of families, couples, singles—younger as well as older residents. Our aim was to build privately-owned, affordable housing with a high standard of living in Hamburg's HafenCity, by virtue of sustainable, ecological, climate-friendly construction methods. Completed in 2022, the apartment building is located alongside the Elbe River on the west side of a new urban block offering direct vistas onto the famous philharmonic. Towards the river, the block is open, providing light and air to its courtyard. All apartments face westward towards the city, and east towards the courtyard, providing excellent conditions for light and ventilation. Through participatory workshops we developed individual apartments according to the specific needs of each user.

Thanks to the building's robust primary structure, we could ensure cost security in construction, as well as a high degree of flexibility for potential conversions in the future over the entire life cycle of the building, while also providing a great variety of individual floor plans. Two staircases—each one of them leading to two apartments on every floor—provide access to the building. Three cross walls run unbroken through the entire building, dividing it longitudinally into four units which then get stacked on top of each other, and which contain the individual apartments. Easily adaptable, lightweight walls respond to the specific needs of each party. The curtain wall features rear ventilation and consists of light, large-format ceramic elements. Two different window formats as well as balconies and loggias, offset floor by floor, subdivide the facade and give rhythm to it. The floor-to-ceiling windows and French doors provide very good natural lighting for the apartments while at the same time offering views onto Hamburg's harbor. The inhabitants can use the roof terrace collectively as a communal area and playground. The rest of the roof area is green and serves for rain retention, cooling, and to increase biodiversity. The building received the HafenCity Gold eco-label.

3.1 Structural Contribution

The building is constructed as a solid timber structure. For reasons of flood protection, we devised the two-story dwelling mound as well as the stairwells and fire walls as a solid construction in reinforced concrete to ensure both bracing and emergency exits with economic means. All other structural elements, ceilings, cross walls, exterior walls and balconies are made of cross laminated timber. Here, too, we exclusively employed certified timber and took into account that this building might have to be dismantled at one point, which is also why it contains no harmful substances. The interior atmosphere is characterized by an interplay of natural wood surfaces, reinforced concrete, and neutral wall surfaces. During the construction phase, the TzW suffered from significant water damage due to water entering through leaking, temporary balcony sealing. Defective or incorrectly installed sanitary objects bring about further water ingress. The resulting damage prompted us to scrutinize the so-called DIN 18534-2 (a building norm addressing construction waterproofing), and to publish a solution better suited than the existing two-layer sealing.

3.2 Facts

TZW	
Planning	2016 – 2019
Realisation	2018 – 2022
BGF	4.614 m²
Amount of flats	29
SQM	3.300 m²
Costs KG 300/400	7.2 Mio €
Gebäudeklasse	5

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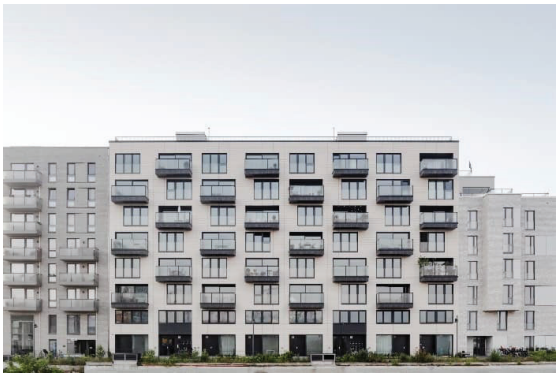

***Figure 4** – Tor zur Welt, Hamburg, west facade, grid of balconies*

4 UWH

The private university Witten/Herdecke in the southern Ruhr area is committed to teaching its students issues of culture and morality, as well as exposure to nature and production processes. Such concerns are fundamental to the relationship between people. Perhaps as a reaction to this, many students wanted to get involved in the design of a new central building, and in developing ideas about the arrangement of rooms and the materials used. The university opted for a timber construction able to bind carbon dioxide, thus contributing to the decarbonization of our planet.

The structure has many diverging tasks to fulfil at the same time: as a link between already existing, different buildings on campus, it also acts as an independent center that contains the library which spreads out across two floors. It also houses seminar rooms and work spaces. Rooms are used simultaneously or consecutively for different purposes. One can find silence and concentration side by side with lively discussions and teamwork. Many different parties require short paths out of different areas while in other parts of the building ask for much less circulation.

To make all this possible, we as architects subdivided the building into a square grid to keep the volume compact on one hand, while on the other to allow for individual rooms to contract or expand. Whether different functions remain separate or conjoin, things remain straight and simple.

Whereas to the south the building folds into the slope and adjacent park, towards the north it creates a new public square. The new building frames one side of a wide rectangle, while the large lecture and conference hall as well as a café open up towards the square. From here we catch a glimpse of the wide spiral staircase behind the main entrance, leading students and teachers into the first floor. This staircase is part of what we call ”aorta,” a central circulation area which not only opens up parts of the building, but which also offers niches to study and suites for discussion.

Materials can be experienced on the facade as well as inside: The open structure, walls and ceilings are made of wood, and large windows let in plenty of daylight. Towards the park, parts of the volume recede and thus create roof terraces. Of course, there is a bus stop directly in front of the campus, and those who come by bike can store it in the covered bicycle garage. Clear components for a climate-friendly future.

***Figure 5** – campus at UWH*

4.1.1 Structural Contribution

We applied the above-mentioned grid throughout the entire building. This allows for an efficient use of cross-laminated timber: within the grid, three fields in a row exactly match the length that can be easily manufactured and delivered to the construction site. From the onset, the manufacturer is involved in the process, which simplifies the planning in terms of optimisation and efficiency. Ecological balance sheets reflect both transportation and the CO2 emissions associated with it, which in turn drive of the cost of construction.

In a university building the units are larger than in a residential building. In the case of the University of Witten/Herdecke with a gross floor area of 6,880m2 there are a total of 14 units each up to 550m2 in size (compared to SKAIO with a GFA of 5,685m2 and 63 units). In general, the number of users per unit and in absolute terms is significantly higher in university or commercial buildings than in residential buildings of the classifications four and five. The large number of users is usually met with more powerful building technology. While the university’s own residential projects mostly manage without mechanical ventilation, this is impossible to maintain in lecture and seminar spaces as they are commonly used today. Here, the air is conditioned accordingly. However, the new UWH building features mechanical ventilation only in those rooms whose number of users does not allow for natural ventilation by means of simply opening windows. In office spaces without mechanical ventilation, we installed simple ceiling fans to lower the inhabitant’s sensitivity to temperature by around 2 degrees Celsius. In doing so, there is no need to further cool the building, a condition which helps significantly reduce the use of energy-intensive technologies.

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We designed the building as a simple timber frame structure. The posts connect with double tie joints to the beams of the ceiling, which is made of cross-laminated timber, spanning across three fields of the grid (which equals 13.95m/3 x 4.65m). The exterior walls are made of timber panels, in part of solid timber construction, and clad with an untreated larch wood facade, which features rear ventilation.

A column-free structure for the lecture hall spans across 15m, on top of which there are two floors with office space. Here, one can detect the truss system directing the loads of the office spaces on the ground floor to the outside, thus making posts unnecessary. UWH's design has been subject to repeated changes. To be sure, both the organizing grid and our construction method demonstrate a sufficient degree of flexibility to respond to changing requirements. It became apparent, however, that we could not consider the construction alone, without creating enough space for the HVAC and electrical installations.

***Figure 6** – Sprengwerk as classic carpentry*

4.2 Facts

UWH	
Planning	2018 – 2019
Realisation	2020 – 2021
BGF	6.880 m²
Timber volume	1.200 m³
Gebäudeklasse	5 / Sonderb.
Special rooms	
9 seminarrooms, 7 flex.	
3 storey library	
café and lounge	
room of silence	
winter garden	
3 rooftop terraces	
flexible eventspace	
100 office workplaces	
26 student workspaces	

5 SHAA

The university campus of Aalen, a city located in the eastern part of the German state Baden-Württemberg, is continuously expanding, and in the course of this expansion the Steinbeis Stiftung für Wirtschaftsförderung (foundation for economic development) wants to create an office building, the so-called SHAA, on the campus Burren. Exposed to an adjacent state road, the so-called Bundesstraße 29, the building serves as a landmark, thus completing the height development sloping down from the east Unclear to me and offering its future users distant views over the Ostalb. The office building, consisting of a three-story wing and a seven-story tower, is built in wood; only the two cores and the basement are made of reinforced concrete. Due to its construction method and delicate wooden facade design, the building blends into its vernacular neighborhood as much as into the overall layout of the campus Burren. While the lower floors will be open to the public—here the university will primarily accommodate lecture halls and spaces for leaning—the upper floors will house exclusive office spaces.

***Figure** 7 – view from campus on 7-storey timber construction and larch-façade with changing fins*

5.1 Structural Contribution

The SHAA project, too, is designed as a timber-frame construction. Based on the experience we gained from realizing the UWH project, this structure required that all HLS/E (in principal HVAC and electricity) ducts can be installed everywhere without having to cross or go below beams. Thus, we created a post and lintel structure with double tie joints Correct? based on a grid of 5,20 m. In office areas, glued laminated timber slabs span the timber frame across one unit of the grid. In corridor areas cross laminated timber elements span in two directions so that we can dispense with bearers to incorporate wiring and plumbing. As these elements structurally engage in two axes, here we can avoid the use of double tie joints and building technology can run through the entire structure without crossing any beams. One layer of beams spans two lecture halls, located on the first and second floors,

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the gaps of which we used to accommodate building technology which runs between individual beams.

***Figure 8** – HLS / E + pipes integrated in construction*

For the facade, we used prefabricated elements made of preaged larch that is treated with grey pigment. Below ground, geothermal probes extract soil heat for heating and cooling the building.

5.2 Facts

SHAA	
Planning	2020 – 2023
Realisation	in planning
BGF	6.345 m²
Gebäudeklasse	5 / Sonderb.

6 NXT

The first out of nine buildings of the NXT Airport Collaboration Village grouped around the village green is an office building we havedevised since 2021. Its presence and appearance point the way towards the future, as a harbinger for the village still under construction near Berlin's airport BER. Welcoming first users, this structure is a place for physical and virtual networking as it creates a vital environment to foster cooperation, creativity and growth.
A wooden frame used as a balcony and placed in front of the main facade Correct? welcomes the arriving users. Inside, the scheme offers contemporary office spaces, highly flexible and geared towards co-working. Public areas include a café and a multifunctional space connected to the central foyer located on the first floor, as well as outdoor spaces.

6.1 Structural Contribution

The design of NXT aims at commercial clients. Here our goal was to achieve the same level of comfort in the planning and operating phases one is used to from conventional construction. Due to high levels of vibration in the ground, we used timber-concrete composite slabs that are supported by glued-laminated timber posts and so-called delta beams, that is, composite beams of steel and concrete. This construction is akin to a flat ceiling and offers maximum flexibility with regard to the installation of building technology and potential changes to all non-load-bearing interior walls during the building's future use.

6.2 Facts

NXT	
Planning	2021 – 2023
Realisation	in planning
BGF	8.200 m²
Gebäudeklasse	4 / Sonderb.

***Figure 9 –** Kopfbau and facade NXT Berlin*

7 Silos - An Outlook

We currently develop a project on our own initiative. Instead of demolishing existing silos—as is proposed in the correlating master plan—we seek to preserve and repurpose this structure. Thus, we create residential and commercial spaces as we use the remaining volume of industrial buildings to store energy and potentially implement an indoor farm.
So far, we can share the following observations: The existing structures already cover the spatial requirements as laid out in the master plan. Furthermore, additional floor space can and should be created. By not demolishing the existing silos and doing without new structures we can save almost 70% of gray energy, evidence of which we provide by virtue of CO2 and life cycle assessment. Those building parts not dedicated to living and working can store electricity from renewable sources, which in turn can supply 18,000 households per day with power. We propose different options for energy storage and exchange these ideas with Flensburg's municipal utilities.

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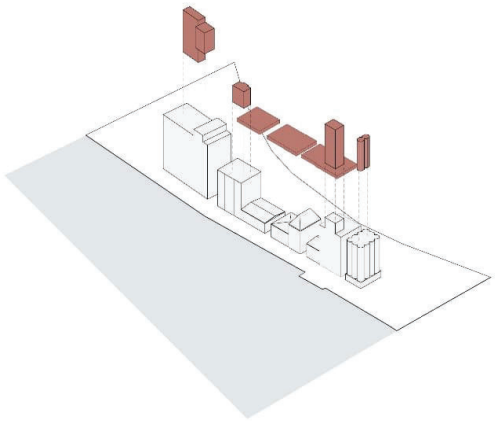

Figure 10 *– potenzial battery volume in Silos*

7.1 Structural Contribution

Here, the aim is to convert existing structures with as little effort as possible. To this end, we provide prefabricated wooden panels and solid wood elements that can be easily attached to the existing buildings and that already contain all necessary installations, so as to simplify the production processes on site.

8 Conclusion

During the time of this work, the design of timber constructions in particular has continued to develop gradually towards greater comfort and more simplicity. Above all, interdisciplinary planning processes from the beginning turn out to be essential and veryproductive. In order to keep the currently rising numbers of projects in timber constructions free of damage, we require proper planning solutions as much as manual dexterity in prefabrication and on the construction site.

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