Hamburg ahead

INTERNATIONAL BUILDING EXHIBITION HAMBURG

Smart Price House
Case Study Hamburg

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A Introduction

A. 1 Smart Price Houses

The development of an affordable range of housing in inner cities that enables people on middle and low incomes to own or rent urban property is one of the key tasks of any forward-looking city policy. The "Smart Price Houses" are primarily well-designed and aesthetically sophisticated modular constructions or designs involving inexpensive materials, as well as supporting self-assembly and encouraging input from building associations and groups. In short, this approach marks the reinterpretation of the prefabricated building as urban housing.

The "Smart Price" concept is focused on the implementation of cost-effective construction strategies that draw on experience and assets from the fields of prefabricated building, modular construction, pre-production, automation, and self-assembly in order to come up with ambitious and contemporary architectural solutions. The resulting building must not only be "contemporary" in terms of its architectural expression; it must also make a vital contribution to addressing socially relevant issues such as ecology, sustainability, energy, and resource conservation, and the shifting of trends in community living, if it is to be considered innovative. Three "Smart Price" designs were completed by March 2013, all of which make their own contribution to the "Smart Price" approach.

A central aspect of affordable construction is the way in which its models can be applied to other sites, particularly those that feature problems that are common in cities. This approach informed the themes for the "Smart Price Houses". To what extent are the examples created here transferable without the additional assistance of IBA Excellence funding or other subsidies? The intention is that the development of the "Smart Price Houses" will set new standards and thus establish prototypes for constructing such buildings at other sites.

The architectural and building services concept behind the "Case Study Hamburg" will be set out in detail in this booklet. The building is an example of timber construction in an urban context. Another point of focus is the clear setting out of the planning process, as various changes were made between the design stage and the implementation of the model project. The reasons behind these changes were technical, financial, or functional, meaning that some original targets had to be adjusted.

Model projects are particularly liable to undergo planning changes; indeed, besides presenting innovative end products, building exhibitions also seek to test out construction methods and processes. Only when the planning process is examined is it possible to ascertain whether a model building project can serve as a good example for the use of "smart price" concepts in the twenty-first century, or whether the concept needs to be reworked. In addition to setting out technical details for experts, this White Paper is intended to provide an objective assessment of whether the model project fulfils this aim, and whether and to what extent it has ultimately succeeded in achieving the goals set out before the planning stage.

After this short introduction the "Case Study Hamburg" will be presented in brief, and then explained in detail. In particular, this presentation concentrates on the high degree of prefabrication involved in the "Case Study Hamburg" construction, as well as the choice of solid wood construction to reduce costs, and the feasibility of the concept when applied to this building and subsequent projects.

A. 2 Project Outline Case Study Hamburg

Features

- Innovative design with a high proportion of solid wood components, in a multistorey residential building
- Flexible and cost-effective construction
- Low consumption of resources due to the use of wood as a building material

Fig. 1: View of the north façade, March 2013

Fig. 2: View of the east façade, April 2013

Designed by Adjaye Associates, a firm with offices in London, Berlin, and New York, and implemented by planpark architekten, Hamburg, "Case Study Hamburg" demonstrates new possibilities for multistorey wooden buildings within cities, and follows the construction-kit principle: basic modules of equal size are "stacked" around a central area, forming housing units of different sizes with two to four bedrooms, configured as apartments or maisonettes.

The primary timber support structure for the project was largely prefabricated. The compact design and the 18 centimetre thick exterior insulation provide a high energy standard. Wood was chosen as a construction material for both ecological and economic reasons, while the prefabrication of the components reduces the assembly time and therefore the cost. It is possible to live over one or two floors in the building, as modules can be joined together horizontally or vertically. Due to the generous floor spans, the residents are left largely free to determine the design and layout of the ground plans, and can configure the rooms according to their individual wishes. The interior stairs, balconies, and terraces are mostly freely placed.

PROJECT PARTNERS

Idea, Concept, and Authorship

- planpark architekten, Hamburg (realization)
- Adjaye Associates, London, Berlin, New York (concept)

Investor

- Engel & Völkers Development, Hamburg

Technical planning

- Boll + Hauser Ingenieure, Itzehoe

Structural engineer/fire safty

- bauart Konstruktion, München

Partner building materials

- KLH Massivholz GmbH, Katsch an der Mur

Other project partners

- Hamburg Energie GmbH, Hamburg
- Haubrich Freiräume, Hamburg

PROJECT DATA

Project costs

- approx. € 2.7 million

Plot size

- 809 m^2

Gross floor area

- 1.118 m^2

Size of the functional units

- 47 - 124 m^2

Energy standard

- KfW-Effizienzhaus 55

Energy supply

- "Wilhelmsburg Central Integrated Energy Network"

Construction schedule

- December 2011 - January 2013

B Case Study Hamburg Project Details

B.1 Architectural Concept

The aim of the project is to find new prospects for multistorey wooden buildings in an innercity context, and to use designs that opt for a high degree of prefabrication to devise a cost-effective building model for urban living. Designed as a building with three apartments on each floor, and without a basement, the four-storey building now comprises nine apartments ranging from 47 to 124 square metres, all of them accessible from the northeastern side via a staircase. Two

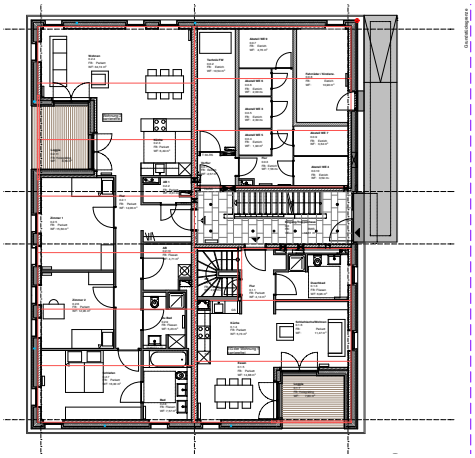

Fig. 3: Ground floor ground plan

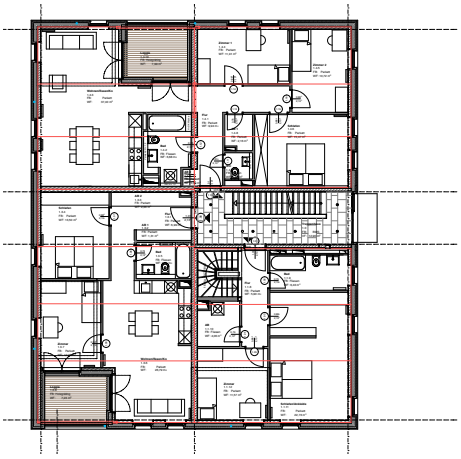

Fig. 4: First floor ground plan

southeast-facing apartments were built as maisonettes with two floors.

The building is arranged around the northeast-facing central area according to the construction-kit principle: basic modules of the same dimensions are "stacked" around this area, forming apartments of different sizes. The ancillary rooms are found on the ground floor. The layout and alignment of the residential units are based on four modules per floor, each measuring 7.5 x 9 metres, all adjoining the central area. The modules can be joined up with one another vertically to form maisonettes, or horizontally on the same floor, resulting in individual floor plans of

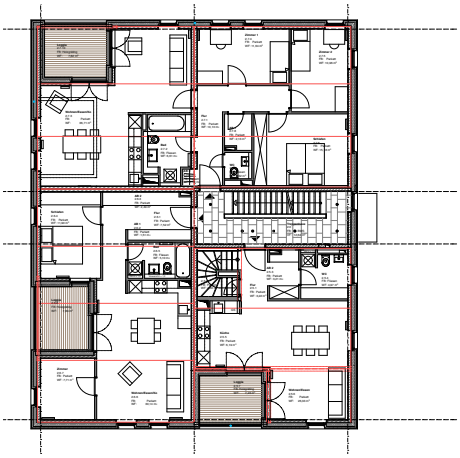

Fig. 5: Second floor ground plan

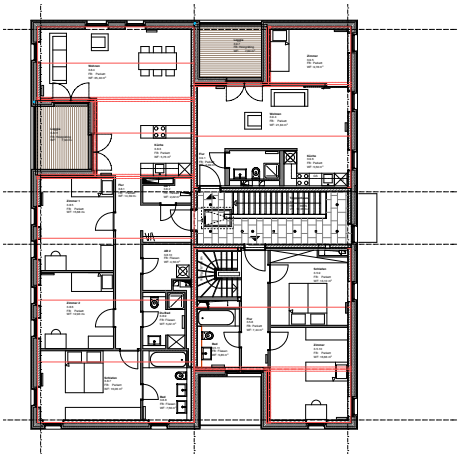

Fig. 6: Third floor ground plan

different sizes, comprising two to four bedrooms. The chosen design of the wood-concrete composite floor-and-ceiling structures is particularly important to the flexibility of the overall concept, as this means that the surfaces of the modules

do not require additional support.

Wood defines the building's load-bearing structure. All of the exterior walls are made of cross-laminated timber in a solid wood construction. This is accompanied by a standing larch wood casing with fire sections on every floor, visible through the recesses in the horizontal cladding. The dividing walls in each apartment are dual-layered structures, also made of 120 millimetre-thick solid wood. Wood thus gives the building its distinctive appearance, from the larch wood façade to the bare wood ceilings and wooden floors inside.

The cube-shaped structure receives its architectural tension from the recessed balconies, each

Fig. 7: Interior, first floor

covering eight square metres, that occur at intervals on the first and second floors, and merge into the roof area on the third floor. The careful integration of the modules into the building block concept results in a structure that is defined by notches and incisions over two storeys, and has a compact yet relaxed appearance. The narrow, vertical, floor-to-ceiling windows and the perpendicular larch wood cladding make the façade visually striking. In order to go ahead with the larch wood cladding it was necessary to obtain approval in relation to fire protection for this specific project, based on a test carried out by the Institute for Materials Research and Testing in Leipzig. This was necessary because larch wood

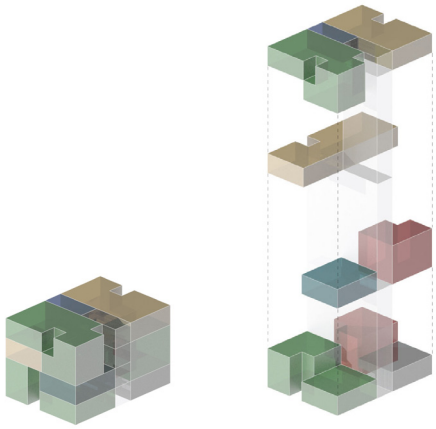

Fig. 8: How the units are stacked

is classed as "normally inflammable" according to the Hamburg building regulations. Horizontal bands that prevent fire from spreading run across each floor and give the façade its horizontal lines. At the top of the building is a flat roof with a large area of greenery.

The exterior design is not the only element of the building to use wood as part of its appeal. Large amounts of wood are also visible inside the building, giving it a pleasant and comfortable feel.

B.2 Smart Price Concept

The building features a high proportion of solid wood components. All of the load-bearing walls consist of cross-laminated timber, while the floor-and-ceiling elements are prefabricated timber-concrete composite slabs, and the roofing is designed as a pure cross-laminated timber ceiling. Only the staircases and landings are made of reinforced concrete. By using only prefabricated components, the timber frame could be constructed within four weeks. The "Smart Price" approach was achieved by reducing the construction time and ensuring that mostly prefabricated elements were used for the building's primary and secondary support structures.

Structure

Above the reinforced concrete floor, which rests on a pillar foundation, the building is made of pure wood. The outer walls and load-bearing inner walls and the walls of the staircases were built as solid wood constructions using cross-laminated timber elements. The non-load-bearing interior walls are conventional and lightweight. The floor-and-ceiling components consist of timber-concrete composite parts, also based on cross-laminated timber elements. The solid wood dividing and stiffening walls, with a K2 30 enclosure, were constructed to a standard that deviates from § 24 (2) of the Hamburg building regulations.

The outer and inner walls are made of solid wood, with cross-laminated timber. The outer walls are 410 and 415 millimetres thick. The outer casing consists of 21 millimetre thick larch wood as a

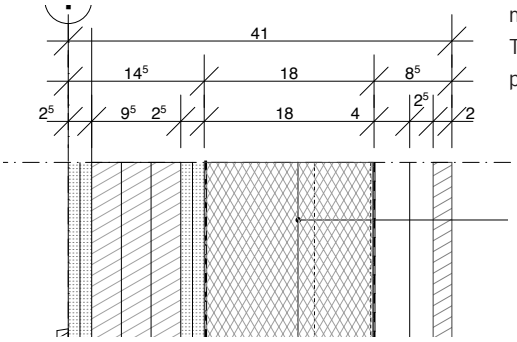

Fig. 9: Construction of outer wall

Fig. 10: View of terrace, second floor

closed tongue and groove structure, on a 25 by 38 millimetre substructure and a 38 by 38 millimetre batten. Behind this is the lining membrane with 180 millimetre type WLG 035 insulation, a timber structure, and a convection barrier that acted as a weather guard during the construction period. As with the walls dividing the apartments, the interior has 95-120 millimetre thick plywood board walls, encapsulated in 25 millimetre thick glass reinforced plastic (GRP) sheeting. The ventilated façade cladding formed by vertically mounted larch wood slats marks deviates from § 26 (3) of the Hamburg building regulations due to the use of solid wood components.

The apartment walls have a total thickness of 300 millimetres and consist of two plywood board walls, each 120 millimetres thick, with a 10 millimetre thick joint gap. The wood is covered on both of the outer sides by 24 millimetre thick GRP panels.

The floor-and-ceiling components are 400 millimetres thick, including the floor structure. The upper layer is made of 10 millimetre thick parquet, on a 45 millimetre floating floor, with

Wall construction (from inside to outside):
- 21 mm larch shuttering
- 25/38 mm slattet
- 38/38 mm counter slattet
- sealing sheet
- 180 mm insulation
- convection barrier
- 25mm plasterboard
- 95 - 120 mm glulam
- 25mm plasterboard

a dividing layer and 35 millimetre-thick impact noise insulation. Below this is 30 millimetre-thick insulation and 100 millimetre thick prefabricated grout topping, which is joined to the 182 millimetre thick plywood ceiling and acts as a load-bearing element, allowing large spans. This also deviates from § 29 (1) of the Hamburg building regulations.

The walls of the staircase are 265 millimetres thick in total, and consist of a 140 millimetre thick cross-laminated timber wall, framed by two GRP panels each 38 millimetres thick, and a 75 millimetre thick plasterboard facing formwork. Working from top to bottom, the 320 millimetre thick stairwell ceilings consist of 20 millimetre thick artificial stone, 40 millimetre thick screed, 10 millimetre thick impact noise padding, and 30 millimetre thick insulation, supported by the 200 millimetre thick reinforced concrete slabs.

The window and door elements were made of wood and installed after the encapsulation of the wooden components. Due to the way in which the elements were fitted, the windows were installed from the inside. In some places, it was necessary to fit baffle discs in front of the windows for noise protection. The windows have a lower crooked wing, sound-absorbing embrasures, and window-sills, in order to meet the high sound insulation requirements set out in the development plan.

Wood and Concrete Composite Flooring System
The floor-and-ceiling elements of the building were constructed as wood and concrete composite floors. A connecting system was devised by KLH Massivholz GmbH especially for "Case Study Hamburg". The flooring consists of the cross-laminated timber applied to the underside in the tensile area, and the concrete applied to the topside in the pressure area. The cross-laminated timber is 18 centimetres thick, while the concrete is 10 centimetres thick. The two are connected by notches and screws. The notches are 30 millimetres deep and 250 millimetres long. These are cut vertically into the cross-laminated timber elements. The benefits of using the completely

Fig. 11: Interior room view, second floor

dry and precisely crafted floor elements were proven during the construction phase.

High Level of Prefabrication

Due to the high level of prefabrication, construction of the primary supporting structure only took four weeks, which is remarkable given the size of the building. Each floor, including the precast reinforced concrete parts, was placed within a week. The encapsulation of the wood elements on site took longer than expected, and the experience gained should be applied to similar projects by ensuring that the first layer of encapsulation be done within the factory, in order to optimise the process.

Fire Prevention

Fire prevention is essential in the "Case Study Hamburg" project due to the large number of timber elements. Smoke detectors are installed in all of the bedrooms, children's rooms, living rooms, and corridors. A smoke detector is also fitted on every level of the staircase. The alarm is activated by smoke detection in the respective apartment. Load-bearing walls and supports have to be highly fire-retardant, and constructed in accordance with Hamburg building regulations. All load-bearing walls were encapsulated by a casing made of fireproof panels. Maintaining the visual effect of the wood on the interior walls would have required significantly stronger wooden cross-sections, at the expense of the apartment area, and would have meant a marked increase in the construction costs, so that the building would no longer fulfil the "Smart Price" approach.

B.3 Building Services Concept

The project is connected to the "Wilhelmsburg Central Integrated Energy Network", and is a long way below the IBA minimum standard, thus meeting the Efficiency House 55 standard. This shortfall is attributable both to the requirements for the primary energy demand and to the specific transmission heat loss in accordance with the reference building in Appendix 1, Table 1 of the 2009 energy conservation regulations (EnEV) for residential buildings.

The building's energy requirement is 57 kWh/m² per annum, and the primary energy requirement is 26 kWh/m² per annum. The energy needed for room heating amounts to 37.9 kWh/m² per annum, as this is supplied by the Wilhelmsburg Central Integrated Energy Network. Hot water, which requires 18.3 kWh/m² per annum, is also supplied by the district heating grid. The remaining 0.9 kWh/m² per annum is for hot water supply from the system current, which is supplied by the national grid.

The seasonal heat requirement is relatively low due to effective external insulation, with the result that most of the heat losses are primarily attributable to losses through air conditioning and through the window surfaces. The technical rooms that supply the building are located on the north side of the ground floor.

It is possible to upgrade the greenery-covered roof of the building with photovoltaic units, although this has not yet been done. The building has a good energy balance due to the high insulating quality of the solid wood used in the outer walls and the selective use of wood as a building material that does not produce additional carbon dioxide, instead absorbing it. Wood is also a sustainable construction material that can grow back and be recycled.

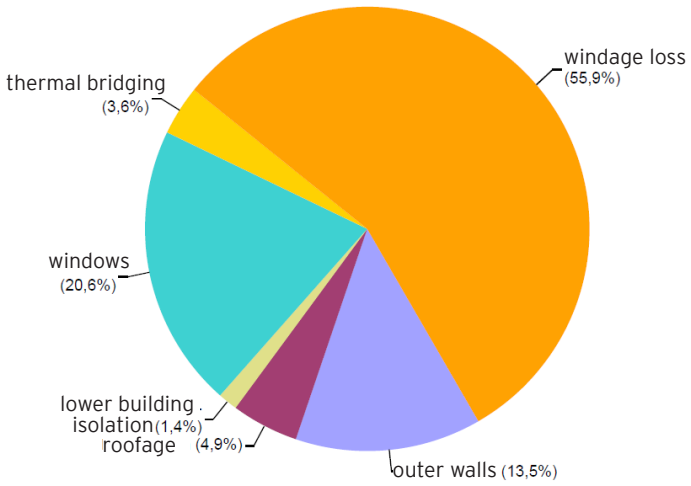

Fig. 12: Heat losses according to energy conservation regulatory information (EnEV)

B.4 Planning Process

For the two-stage competition launched in mid-2009, Adjaye Associates, based in London, developed a concept that envisioned the basic shape of the building as a compact, sculptural block. Four equally sized basic modules, each 7.50 x 9 metres, are "stacked" around a large central area according to a model kit principle.

The concept of load-bearing solid wood floor-and-ceiling components and walls was intended to enable all of the interior walls to be built as non-supporting elements, allowing the layouts to be configured in an individual and flexible way. According to the plan it would also be possible to stack and combine the elements in different ways. The staircase was to be made completely of wood so that this would be the defining material, giving the building an ecological quality. The "Smart Price" approach was largely to be

Fig. 13: Elevation from the second phase of the competition

achieved through a high level of prefabrication, and this remained the case despite revisions to the plan.

The design submitted for the competition and the construction plan were revised by the Hamburg-based firm planpark architekten, and the original concept of the building as a compact, sculptural structure with flexible ground plans, built according to a model kit principle with a large amount of wood and a high degree of prefabrication, was retained. Building work began in January 2013, but some changes were made to the project details of the competition design.

planpark architekten took over the further planning from the third phase. Due to legal requirements it was necessary to make adjustments to the ground plans: the staircase and apartments were made more compact, and scaled down in their ratio to one another, in order to achieve the best possible relationship between the living space and the common open area, while the maisonettes had to be given another entrance to the staircase for fire safety reasons, and the windows had to be optimised in order to ensure that the rooms received enough light.

Due to the large areas and for fire safety reasons, the planned solid wood floor-and-ceiling structure had to be converted into a wood and concrete composite ceiling. The exposed wood proposed for the underside of this structure remained, and the composite structure also afforded greater sound insulation.

Alongside the composite structure, KLH Massivholz GmbH developed a new connecting system between concrete and wood. This allowed the construction process to be accelerated, so that it only took four weeks to erect the shell of the building.

Steel beams needed to be integrated due to the high ceiling spans – which were necessary in order to implement the flexible stacked space principle – and the associated structural require-

Fig. 14: Completion of the building in spring 2013

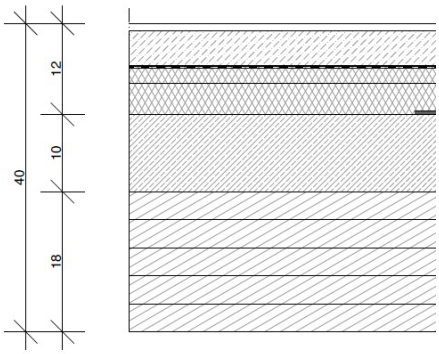

Fig. 16: View in March 2013

Floor construction (from top to bottom)

- 10 mm parquet
- 45 mm cement screed
- seperating layer
- 25 mm high-pass filter
- 40 mm insulation
- 282 wooden concrete ceiling, consisting:
100 mm ferroconcrete
182 mm glulam
fire safety F-60B

Fig. 15: Ceiling structure

ments for the balconies. The idea of using timber beams was quickly rejected by the architects, because, although this was the same material as the ceiling undersides, the higher volume would mean that they would be visible in the room, so steel was preferred as the same material used in the ceiling components. The original notion that the apartments would be rented was abandoned in favour of owner-occupied properties, as the building costs were higher than expected in comparison to conventional building methods, making this necessary from an economic perspective.

B.5 Assessment

As part of the International Building Exhibition, "Case Study Hamburg" is a model project that promotes the greater use of wooden buildings for inner-city housing, and is a significant building block in the authorised and technically appropriate construction of multistorey wooden buildings.

Due to the use of wood in the most important of the structural components in both the fitout and the façade, the project absorbs large amounts of carbon dioxide through its building materials. On balance, therefore, the construction process accounts only for low carbon dioxide consumption, while ensuring the long-term storage of carbon dioxide in its components. In this way, the building makes its very own contribution to the key IBA theme of "Cities and Climate Change".

Through its aim of becoming a "Smart Price House" and thus offering cost-effective housing, the building also makes a contribution to the theme of Cosmopolis and offers large strata of the population the chance to own their own property in a high-value housing development. The building also has lower heating costs that are normally found in new multistorey residential blocks due to its high energy standards.

Fig. 17: Horizontal bands on the north façade

demonstrated that solid wood constructions and composite wood and concrete structures are not yet popular, at least not in Northern Germany. This led to a limited choice of material suppliers, and low competition as a result. The material costs are still too high, with the scarcity of

Fig. 18: IBA opening, 24 March 2013

suppliers, resulting in high transportation costs. The Austrian vendor KLH Massivholz GmbH was chosen for "Case Study Hamburg". This meant that the goal of using raw materials from the surrounding region and thus reducing costs by buying from local suppliers could not be fully implemented.

With regard to the use of cross-laminated timber, the licensing-related aspects have shown that employing innovative materials and assessment by the building regulatory authorities are still largely at cross-purposes. The guidelines for timber constructions are lacking clear legal regulations on the use of cross-laminated timber or other solid wood building methods, which caused particular problems in relation to fire safety, as solid wood structures are not rated for their specific reaction to fire. The assumption, therefore, was that much greater encapsulation of the timber structure and the domestic technology was necessary, leading to increased costs, which acted counter to the "Smart Price" theme.

However, this had the positive effect that KLH were forced to develop a new connection between reinforced concrete and wood, as it was hoped that a large amount of wood could be used within the building for reasons of resource conservation, the indoor climate, and, last but not least, visual effect. This technological innovation also allows other wood-and-concrete composite structures to be built more quickly, thus shortening construction times and thus reducing costs.

Construction of the building as a prefabricated structure is not yet possible, despite the universally applicable model kit system, as it is Class 4 according to Hamburg building regulations, and the high amount of wood always calls for a fire safety survey, which means that re-planning is necessary on a case-by-case basis. The implementation of the concept with the same materials would, however, be possible for detached or semidetached houses. Once again, this shows that it is necessary to adjust the Hamburg building regulations and change the general way of thinking about how to approach multistorey wooden buildings. This project has demonstrated the hard way, with a number of different authorisations, that it can still be cost-efficient.

The apartments were sold at € 3000 per square metre. This price is € 500 lower than the Hamburg average in January 2013. In order to ensure that the model can be applied elsewhere, it should be mentioned that significant cost savings could be made to the model implemented here, which incurred additional expenditure due to its specific circumstances:

- High start-up costs resulting from the need to sink pillars due to the low load-bearing capacity of the soil; 50 per cent of the start-up costs could be saved if this were not necessary.

- Effective soundproofing was required due to the traffic noise in the area, and the requirements therefore set out in the development plan.

- More money could be saved by further simplifying the façade design (horizontal segmentation, change of casing).

The thin wall design saves costs due to low spending on materials, and allows greater availability of space. Key features of the project were the short building time – it took only four

Fig. 19: Urban buildings in the surrounding area

weeks to erect the basic framework – and the large amount of wood, as well as the use of a composite wood-concrete flooring system, a new development. This system consists of prefabricated drywall installations which are installed at the building site and then finished immediately, in order to save time and money. It would be possible to optimise the concept by opting for a greater mix of different materials, depending on their range of application, thus reducing costs and going even further towards fulfilling the "Smart Price" approach.

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