From industrialised single-family homes to urban multi-storey housing

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1. Research objectives

In the industrialised construction of single-family homes, there is currently a trend shift towards the construction of bespoke properties. This type of construction is attractive because it allows fast response times regarding configuration and production. It is largely found in the building of commercial and single-family detached properties. But with technical progress, there are now huge potentials to apply it to urban multi-storey housing.

Today's industrialised construction of single-family homes is almost exclusively limited to prefabricated timber systems, while timber-based buildings with up to five floors are also appearing in urban areas. The introduction of building class 4 in the new 2002 model building code and the 2004 M-HFHHolzR model directive have created a framework for the construction of 5-floor timber-based buildings in Germany. As a result, use of timber as a sustainable building material need no longer be limited to low-rise buildings, i.e. detached and semi-detached family homes in suburban areas; it can be extended to multi-storey construction. While being able to specify their individual planning requirements, builder-owners can now also enjoy the benefits of industrialised production regarding construction quality, and cost and schedule reliability.

Due to demographic changes, we can see a trend shift towards new urban forms of living emerging. Modern city dwellers have high standards and expect to be able to custom-design their living space, but in urban multi-storey housing projects, end users tend to have little influence on the design. This is why more and more city dwellers unite to form homeowners' associations, which will allow them to implement their individual living concepts. These urban homeowners' associations are the modern equivalent of single builder-owners in rural areas.

This sets the context for this research project, which focuses exclusively on multi-storey prefabricated timber construction. It attempts to match up the demand for modern custom-designed homes in urban areas with the new high potentials of multi-storey timber construction, to develop a new concept for urban living: the 5-floor timber urban building – in short, the "urban prefab".

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2. Implementation

This research project aims to analyse the conditions for an "urban prefab". Based on this research, the concrete concept for a housing project will be drawn up in parallel in the integrated research programme "fertighauscity5+". The research focuses listed here will form the basis for this work:

Analysis

Urban vs rural housing developments
Traditional vs prefabricated construction
Industrialised prefabricated housing today – single-family homes

Outlook

The future of industrialised prefabricated housing – multi-unit housing

Recommendations

Presentation of recommendations

Documentation

Project documentation for multi-storey
timber buildings in Germany, Austria and Switzerland

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3. Summary of findings

3.1 Analysis

Urban vs rural housing developments

An analysis of the two types "single-family rural home" and "urban multi-unit housing" shows that
1. urban infill provides the only basis for a sustainable use of land as a resource;
2. because of demographic developments, the demand for urban forms of living will rise, while the demand for single- and two-family homes will fall;
3. in growth regions, there is scope for urban infill in city centres.

Traditional vs prefabricated construction

An analysis of the two construction types shows that
1. traditional types of construction lag far behind today's technical alternatives;
2. today's flexible manufacturing methods allow bespoke prefabrication and can thus replace standardised prefabricated construction;
3. timber-based construction is the most advanced area and has the highest rate of prefabrication.

Industrialised prefabricated housing today

An analysis of the prefabricated building industry shows that
1. products available are limited to single-family, semi-detached and terraced houses and do not include multi-storey properties;
2. the product range targets almost exclusively the traditional nuclear family;
3. the product range has shifted from standardised to bespoke prefabricated housing;
4. it is a high-tech sector within the timber construction industry.

3.2 Outlook

A number of very different new construction projects of prototype character have shown that there is a demand for urban housing. There is currently a lack of urban concepts that systematically match end users' requirements with housing types, and of suitable strategies that facilitate planning and construction. There are at present no practical concepts for urban industrialised prefabricated housing. The term prefabricated housing is used here as a label that represents the benefits of industrialised construction.

New builder-owners

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People living in urban housing developments represent a cross section of a new type of potential new builder-owners. They often live in household structures other than the traditional nuclear family. A new form of organisation, the homeowners' association, has emerged, which is an association of individual owner-builders or investors. Some of these are ideologically motivated, whereas others are interested in the investment. There is an equally wide range regarding the desired level of participation: some associations want to have their say in key issues, while others merely want to choose from a catalogue of possible designs.

Organisation

An analysis of the prefabricated housing market shows that there is a shift among manufacturers towards bespoke production. Manufacturers are becoming increasingly flexible to respond to customer requirements. At the same time, an increasing number of properties are being built, yet manufacturers do not supply multi-unit properties. Planning large-scale housing is complex, and adapting the terms of a contract to a group of several builder-owners means additional time and cost, which manufacturers are not used to and therefore reluctant to invest.

Timber construction

With the availability of efficient timber-based building materials and new construction methods, multi-storey timber construction is no longer a technological problem. Such housing projects can easily be implemented using flexible industrialised production. In the long term, manufacturing should aim for a higher level of automation, such as is predominantly found today in the industrialised construction of single-family housing.

Legal framework

There are general fire safety regulations for multi-storey timber buildings with up to 5 floors in Germany, Austria and Switzerland, with Swiss legislation even providing for up to 6 floors. In Germany, the model building code (MBO2002) together with the model directive for timber construction permits the construction of timber-based buildings with a maximum FFL of 13 m. The directive for timber construction only covers timber-frame constructions. And although solid timber and timber skeleton-frame construction are in fact more effective for multi-storey timber construction, the directive can only be applied to them as a rough guideline. Moreover, the MBO does not apply in the whole of Germany, so there is no uniform basis for planning.

Given these findings, the development of a new timber-based "urban prefab" with up to five floors, as proposed earlier in this paper, would appear to make sense.

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4. Recommendations

A new state subsidy for urban housing

The construction of new urban housing in the form of infill housing on vacant plots, the redevelopment of derelict land, or the addition of extra floors to existing housing has many benefits. Key benefits include the limitation of urban sprawl, the use of existing infrastructure, and the cutting of CO_2 emissions due to a reduced mobility requirement. With this in mind, legislators should be interested in attracting housing development projects to urban areas and should thus actively encourage urban multi-unit housing projects. Financial incentives should be given to support urban infill developments as described above.

One possible tool could be a "state subsidy for urban housing" – a subsidy that no longer funds single-family homes in suburban areas, thus promoting urban sprawl, but instead the formation of property "in the city".

Alternatives to sale by tender of property owned by local, state, or federal governments

The sale of property owned by local, state, or federal governments normally takes the form of a public invitation to tender, where the property is sold to the highest bidder. From a purely financial point of view, such a procedure makes sense, because it obtains the highest price for a property. However, it does not take urban-sociological aspects into account, although they are a key factor in the strength of a local community. These aspects should be considered when a property is sold, and not only the sales price.

Since plots in urban areas do not become vacant again once they have been built up, we would strongly recommend selling them in future not to the highest bidder but on the basis of the best building concept.

Need for uniform national legal provisions for multi-storey timber construction

The model building code MBO was amended in 2002 and subsequently almost all German states amended their state building regulations. Of the 16 states, 9 introduced building class 4 and fireproofed timber construction in line with the MBO.

This does not mean that it is generally impossible to erect multi-storey timber buildings in the remaining German states, using the MBO as a basis, but approval would be required on a case-by-case basis, with the appropriate proofs having to be provided. There is no uniform legal framework and thus no reliable basis on which to plan – which would be required for multi-storey timber construction to become established nationwide. State-specific variation represents a major obstacle for planners and manufacturers.

We urgently need a uniform legal framework for the whole of Germany.

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Building class 4 and fireproofed timber construction in line with the MBO should be introduced in the remaining German states by the earliest possible date.

Height restriction of building class 4 to FFL ≤13m

The new MBO building code introduces a building class 4 with a maximum of 5 floors and FFL of between 7m and 13m. In terms of fire safety requirements, supporting elements and modules that prevent or slow the spread of fire are classed as highly flame retardant in building class 4. With this scope, it will for the first time be possible to erect 5-floor timber buildings, thus taking timber-based construction into the city centre. This is a step in the right direction – but it is not enough if one takes a closer look at how many floors buildings in city centres normally have. In medium-sized and large German towns and cities, buildings are often 6 or 7 floors high. Five floors are therefore not enough to preserve the character of a town or city as required under Section 34 of the German Planning Act.
Building class 4 should be amended to permit not 5 but 7 floors, and the height restriction FFL ≤ 13m should be raised again to FFL ≤ 22m.

Amending M-HFHHolzR to include solid timber and timber skeleton-frame construction

The M-HFHHolzR directive applies to timber-based construction such as timber panel, timber frame and half-timber construction. It does not apply to solid timber construction such as brettstapel or log construction. The reason why the directive applies exclusively to timber panel construction is that this is the most commonly used type of construction in German-speaking countries, namely Germany, Austria and Switzerland. However, current knowledge suggests that solid timber and timber skeleton-frame construction are particularly suitable for multi-storey construction. It is possible to gain approval for individual projects "loosely based on" the M-HFHHolzR directive, with a fire safety certificate and other certificates; however, this is unnecessarily time-consuming and costly and obstructs the use of solid timber construction.
The M-HFHHolzR directive should be amended to include solid timber and timber skeleton-frame construction by the earliest possible date.

Need for development of fire-stop systems for multi-storey timber construction

There are no fire-stop systems on the market that are approved for highly flame-retardant timber construction, which is why systems for solid and dry construction are currently used.
The development of fire-stop systems that are approved by the building inspectorate for use in multi-storey timber construction is desirable. We recommend sponsorship of a joint research project involving the industry.

Current legal measures for cutting CO_2 emissions from buildings

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Within the context of the Kyoto Protocol and Agenda 21, legislation aims to reduce CO_2 emissions, also from residential properties. A number of legal measures have been established to achieve this.

Grants of the KfW banking group:
The KfW banking groups offers a number of grants for the refurbishment of existing properties and for new developments.

Energy passes for residential properties:
The EnEV 2002 energy saving regulation introduced energy passes for new developments. With the new EnEV 2007 energy saving regulation, these will be step-by-step extended to apply to existing properties from 1 July 2008.

New legal measures for reducing CO_2 emissions from buildings

Both KfW grants and the energy pass for properties only consider the annual primary energy consumption of a building, not its entire lifecycle and eco balance. To further reduce CO_2 emissions from buildings, the factors resource extraction, manufacturing, disassembly and disposal of the building also need to be taken into account.
An effective procedure should be developed for assessing buildings in terms of their complete lifecycle. Buildings with a positive CO_2 balance (timber buildings) should be taxed less, whereas buildings with a negative CO_2 balance should be taxed more.

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