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leanWOOD – towards resilient design and building processes

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Abstract. With the introduction of the concept of resilience in the discourse of building design, design and building processes have to react to complex challenges presented by the extension of the perspective from physical building structure to living space. Instead of conserving effort, resilience demands integrated and argumentative processes and interdisciplinary cooperation. Forerunners in industrialized timber construction have long-standing experience and are starting points for new advanced design processes. The international leanWOOD project (2014-2017) aimed at outlining the requirements for future timber building planning processes to put them on a broader base and thus contribute to advanced processes in the future. To achieve resilience in building design, rigid and sequential process-chains must turn into flexible, argumentative process approaches. The paper illustrates the key elements for resilience-oriented design processes, discusses procurement and cooperation models, identifies pitfalls in current development and outlines the impact on resilient buildings. Finally, the outlook shows the potential of the implementation of BIM to this change towards resilient design and building processes.

1. Introduction

Building stock and cities are increasingly challenged by the consequences of climate change, such as dwindling resources, demographic trends and migration flow, and must be able to react to diverse changes. Utilising scarce resources efficiently, creating favorably priced residential space whilst simultaneously doing justice to our affluent society's demands for sustainability, barrier-free design and increasing expectations regarding land usage, all present planners with complex challenges. The dynamics of change on the timescale of a building's life-cycle cannot be predicted and present those acting according to a rational planning model with tasks that are neither clear nor readily soluble. Models with a functional/technical focus deal with symptoms (like energy consumption for example), but are unable to accommodate societal, ecological or economic changes. This is exacerbated by short-term investment perspectives and how they are reflected in current procurement practice applied to planning and construction services. Planning models able to react to this must adopt an extended perspective: from the physical building to built environment. Consideration of life-cycle during planning would constitute a necessary first step towards long-term planning horizons, whilst a systemic planning approach must then follow.

2. State-of-the-Art

2.1. Systemic planning models



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It was in the 1950s that Burckhardt L was already criticising predominantly “*military-polytechnical*” planning approaches. Instead, his theories of planning react to the “*dynamics of urban realities*”. His demand was to “*accept the complexity and processual nature of the environment*” [1]. Like him, Rittel H also sees problematic scenarios holistically and the consequences of the planning process as not being clearly predictable. On the basis of this logic, Rittel speaks of “*argumentative processes*” in planning. Questions must be raised, diverse positions and points of view must be taken into account and arguments must be formulated. Here mere “*objective, scholarly*” action is not productive. He sees the solution on a «*political*» level. His planning theories are “*conspiratorial*” in the sense of sharing between all the actors involved and the cooperative manner of proceeding [2]. Habraken J also says that changing variations must be possible because of the unpredictable future within the planning horizon. He compares the rational planning models to military parades, where the greatest threat is presented by unanticipated disturbances. In contrast with this he describes a football game, which follows rules but does not obey a strict sequence: the unexpected can happen and takes place in a “*dynamic reality*”. [3]

2.2. Resilience as planning approach

As solutions were being sought, the term resilience entered the vocabulary of planning theory. The term resilience was coined and defined in psychology as “*a system’s capacity and ability [...] to respond to crises and disruptions*” [1] and the ability to recover from stresses. Resilience indicates sustainability and also implies the maintenance of identity and structure [5] though it is not a conserving factor but rather leads to self-renewal and opens up creative possibilities [1]. Within the discourse on planning, resilience belongs to the third generation of planning theories and, with a systemic orientation, interconnects planning processes with political, economic and social causal networks [6].

Consideration of this systemic planning model shows that resilience-oriented planning depends on the diversity of position and arguments from the point of view of the various actors, and on the possibility of discussing variations and flexibility in the running process permitting reaction to the unexpected. In contrast, inflexible, hierarchical and rationally-based procedural models are susceptible to disturbance and cannot deal either with complex problem scenarios or with the unexpected.

3. Outstanding issues

Thus resilience-oriented planning means integrative and discourse-oriented processes that offer scope for the debate of involved actors and a buffer for unplanned happenings. This results in the demand for more cooperation between disciplines. This is not new, at least in theory. Currently resilience is indeed in demand as a buzzword in urban and building planning (e.g. Brenet Status-Seminar, ETH Zurich, 6-7/9/18), albeit insufficiently represented in current planning practice. Either it is shifted into the area of soft skills and/or falls victim to rationalization in the course of raising process efficiency.

It is therefore desirable to put forward approaches for how this can also be effectively implemented in the planning process in future.

4. Proposition

In seeking solutions, the forerunners in prefabricated timber construction come to one’s mind. The timely integration of knowledge of construction and manufacturing processes is a prerequisite for any prefabricated timber construction. The actors in prefabricated timber construction are more or less forced into early interdisciplinary cooperation by the logic underlying timber construction design. Their experience and findings point out ways of implementing resilience-oriented design and building processes in the practice of future planning.

5. leanWOOD (WoodWisdomNet 2014-2017)

Forming the basis of this paper is the work done in leanWOOD, a project which was carried out from 2014 till 2017 [7] on the WoodWisdomNet platform.

The methodological approach of the leanWOOD project was based on detailed analyses of case studies realised in industrialised timber construction with high levels of prefabrication. The bottom-up-oriented approach taken in the project was based on intensive dialogues between theory and practice -

between research and business partners as well as a broad variety of stakeholders in the sector. The objective of the leanWOOD project was to establish a new understanding regarding prefabricated construction with timber and the foundations for process innovations still required. The central fields of work were the development of planning processes aligned with timber construction and the analysis of procurement and cooperation models in relation to their strengths and weaknesses regarding prefabricated construction with wood.

6. The timber-construction-aligned planning process

6.1. Results

However, analyses in practice forming part of the leanWOOD-project showed that exploitation of the technical as well as economical potential of prefabricated timber construction is limited because of inflexible, sequential, hierarchically organised planning processes and traditional procurement practices and cooperation models [8].

On the basis of these analyses, the leanWOOD-project team put together the «ideal» timber-construction-aligned planning process (as shown in Figure 1).

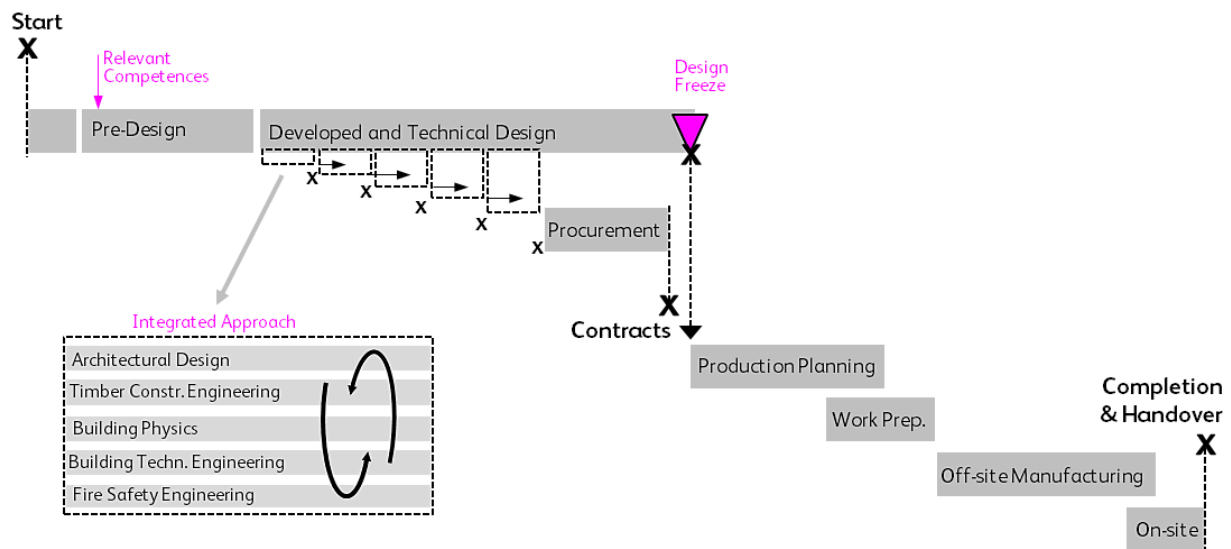


Figure 1. The elements of an “ideal” planning process aligned with timber construction

This ideal process offers many advantages with regard not only to confidence in compliance with timing and cost targets but also the far more extensive scope for decision-making for building contractors in comparison with “rolling” planning. This advantage is explained in the 2018 Brenet Status-Seminar contribution of Geier S and Zöllig S [9].

For it to be possible to profit from the advantages too, it is necessary to understand the logic underlying timber construction and to lay out the process accordingly: In timber construction, insulation, fire and noise protection are provided collectively by the primary and secondary structure, so all structural components and layers must be given collective consideration at early phases of design [10]. Thus the increasingly overly-differentiated range of products in timber construction, in combination with diverse construction options, which offer distinct solutions that are production and thus company-specific, demand a great deal of detailed knowledge which has to be integrated in these early phases. The process of technical and economical optimisation must begin at the same time as architectural design. Basically, recognising this is nothing new (cf. the McLeamy curve), the early design phases has the biggest influence on costs [11]. This integrative approach during design must be continued in a synchronised manner as the project progresses. It is necessary to open and close decision gates at appropriate times [12]. Here, each stage has a zoom factor (one might speak of a more finely resolved

“Level of Detail LOD”), which has to be reconciled within the individual disciplines. At each stage, decisions have to be arrived at through argument and finalised before the next stage. The “Design Freeze” constitutes an important milestone before the start of production planning, assuming a concluded and complete implementation planning process.

Decisive in this integrative approach is the discourse-based development of arguments. As mentioned earlier, fire protection and sound insulation can be achieved in a variety of ways. As to which solution can best be realised with reference to the tasks at hand, whilst being fault-tolerant in its execution and economical, this has to be determined within the field of activity covering architectural layout, design and structure, construction with reference to building physics, fire protection concept as well as the routing of building services. This covers not just fire protection and sound insulation, but given that humidity protection, ventilation concepts, installed components like solar protection and integrated ventilation components must be also designed and planned integratively. In these early stages, approaches that are isolated according to discipline can later result in far-reaching plan revisions or sub-optimal solutions.

6.2. Conclusion

One can say that the “ideal” planning process in prefabricated timber construction illustrates by example how disciplines must cooperate in an integrated manner, as distinct from “*poly-technical planning*”. The diversity of potential solutions demands an “*argumentative process*” that brings together all relevant competences in early design phases, preferably including the timber construction company too. Thus, forerunners in prefabricated timber construction are role models for integrative, discourse-oriented and systemic planning approaches paving the way to resilient design and building processes. Nevertheless, the question of whether this bringing together can, in organisational terms, also be realised in practice is discussed below.

7. Procurement and cooperation models aligned with timber construction

7.1. Selection of suitable procurement and cooperation models

Project team collaboration in the planning process is organised and regulated by procurement and cooperation models. During the leanWOOD-project detailed analyses were carried out regarding procurement and cooperation models aligned with timber construction [13].

It is evident that the decision regarding selection of the actual procurement and cooperation models (in the analysed projects) was reached essentially by the building owner/principal according to their own profile and/or corporate mission statements. The criteria for the decision were founded on confidence in cost and timescale planning, questions of liability, administrative outlay for contract and payment management, albeit also the possibility to take part in or withdraw from the design and building process themselves.

The criteria for selecting a suitable model, from the point of view of a planning process aligned with timber construction, differ from the above mentioned ones. Playing an important role here are the potential for early, integrative planning, i.e. cooperation between disciplines during early stages, ideally including a timber construction company, along with coordination of execution tailored to timber construction.

Thus, the selection of procurement and cooperation models is not straightforward, instead requiring recognition of the strengths and weaknesses for individual cases and selecting the best models with respect to building owner/principal and timber construction.

7.2. Classical procurement and cooperation models [13]

Figure 2 shows a comparison between differing procurement and cooperation models. The horizontal bars depict the course of the design and building process from project start to completion. A precise designation of individual project stages has been omitted, given that various models throughout D-A-CH-territory were analysed and discussed. The individual stages differ according to country, so the diagram only delineates the overall structure, without further resolution: preliminary design («pre-

design»), developed and technical design, construction. The message of the diagram focuses on the comparable approximate moment at which it is possible to cooperate with the executing companies according to model.

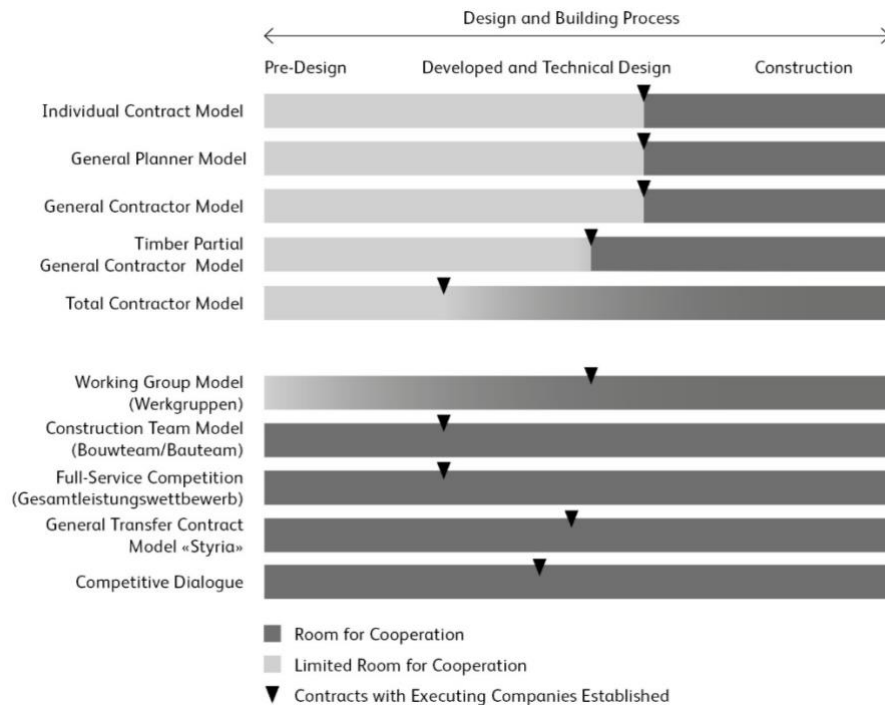


Figure 2. Overview of cooperation potential for businesses responsible for planning and execution in selected procurement and cooperation models. [14]

The upper group in Figure 2 depicts the primarily “classical” models. These are still highly respected, not only by building owners/principals but also by businesses. The Individual Contract Model, as well as the General Planner Model, offer good comparability of offers from the building owner’s/principal’s point of view, and a precise definition of work in relation to quality and quantity. In these models, businesses value the small effort required for calculation that results from the detailed performance descriptions. In both models, the choice of specialist planners is decisive. If choices are solely based on the lowest fee or the building owner’s/principal’s preferences, there is a great risk that the planning team will not be optimally aligned. The General Contractor Model is also very popular and often proves to be practicable, because one business coordinates the interfaces between the firms executing the work. This has led to the establishment of the Timber Partial General Contractor, because in this model the timber construction company can control execution of the work in a manner attuned to timber construction. The timber construction company takes on only the specialist work directly connected with timber construction (mostly being the “airtight building shell”) and not the entire construction (which is also advantageous regarding liability law). In both models, Partial and General Contractor Model, cooperation between the businesses depends on the General Contractor’s policy. Again, if price is the controlling factor here, the quality of cooperation also suffers.

The black triangles in Figure 2 mark the dates of the conclusion of contract with the businesses executing the work and indicate the split between the planning and implementation teams. Before that date, the inclusion of the timber construction company is not permissible (at least in public sector procurement). These models, which do not enable inclusion of the timber construction company before procurement, reach their limits when the necessary competences regarding product selection, manufacturing and assembly technique or logistics are not present (as a specialist planner or expert) in the project.

With the Total Contractor Model, these limits are removed. They bring together several disciplines and specialist planning departments within their corporate structure under one roof. Most often these are the market's big players. Opinions of the Total Contractor Model diverge: whilst it constitutes a "black box" for some building owners/principals, for others it is an opportunity to be relieved of contract and payment management as well as the coordination of all interfaces.

Yet, the analyses carried out in the leanWOOD-project showed that there are still few big players in the timber construction sector who could deliver total contractor services. However, the structure in the sector, as well as in the domain of architectural and specialist planning within D-A-CH-territory, is more often small-scale and also characterised by changing teams. Even though industrialisation in the timber construction sector demands structural change through capital-intensive production lines, one must ask oneself whether it is desirable for the characteristic elements of the culture of construction in D-A-CH-territory to be lost.

7.3. Alternative procurement and cooperation models [13][15]

In the lower group in Figure 2, alternative models for procurement and cooperation are shown. They offer more scope for cooperation with executing (timber construction) companies. However, the desire and search for alternative models is nothing new. For example, the idea of Working Group Models originated in Switzerland in the 1990s and, among other things, focused on better cooperation between those planning and those executing. In the Netherlands, the Construction Team Model ("Bouwteam") was established and also developed further. Here the intention is for the team of those planning and executing to develop commercially and technically optimised solutions. This model is less successful in D-A-CH-territory, the disadvantage being the lack of clarity in terms of responsibility for coordination within the team and also liability. Depending on the configuration, there is a risk that the architect may be confronted with joint and several liability. A solution for this was created in the form of the Full Service Competition in Switzerland, which is regulated in SIA 142:2009. The General Transfer Contract Model of the Styrian housing subsidy organisation also works on a very similar basis. Whilst the Full Service Competition directly addresses a consortium of architects, specialist planners and businesses, in the Styrian model it is only the architect and one timber construction company. Both need a very clear description of the tasks to be accomplished from the building owner/principal, neither is decided upon on the basis of a competition over simply price or design, but rather a jury evaluates the solution and awards on the basis of the fixed price. The great advantage of both models is that instead of the big players it is rather the large variety of businesses on the market, ranging from small to medium-sized, can become part of a team on the basis of trust and good experience in preceding joint projects. In both cases, the final contracting of planning and construction services is handled by the business charged with execution by means of a kind of total contractor service contract, which includes all the others via subcontracts. To avoid a mess with the reimbursement of fees, along with architectural aspects, good preliminary agreements are necessary. With the Competitive Dialogue of 2004, the EU created an instrument that does justice to the complex tasks at hand. The Dialogue includes the project team and the building owner/principal, with procurement taking place based on a solution and award criteria defined at the start. In Germany and Austria, the Competitive Dialogue can be used whilst, in Switzerland, currently only the federal government has this option. According to expert opinion, this model only makes sense for large (infrastructural) construction projects. However, there is some indication as to why models like Full Service Competition have spread even less: the effort that the building contractor must put into clear formulation of the task to be accomplished and the jury process is not insubstantial.

7.4. Pitfalls in current practice

The investigations conducted during the leanWOOD project highlighted the reality that current procurement practice mostly takes place according to the classical models, which offer limited scope for legitimate cooperation between planning offices and executing companies. What is altogether possible in these models is integrative collaboration between specialist planners. Yet here too, many building owners/principals hesitate to integrate the necessary specialist planners to a sufficient extent

(with corresponding payment) in the planning team before the official building permission is issued. The much more frequent practice is to include timber construction companies by means of informal (and hence cost-neutral) consultancy. Many architects and building contractors are too little aware of how they are thus operating in a grey area and risking procedural delays or stoppages.

Here a distinction is to be drawn between procurement practice and the possibilities afforded by EU directives and national legislation. It was already in 2014 that EU directive 2014/24/EU rang in a change of culture. The changes in the area of award criteria actually form the basis for the integration of sustainability aspects and requirement-oriented service procurement, and thus constitute a step towards quality-based competition [16]. These are thus anchored in Germany and Austria. In Switzerland too, currently with the revision of procurement law, not only price but also quality and sustainability have become decisive in procurement.

8. Conclusions

Implementing a resilience-oriented design and building process means having to worry about not only the process, its progress and the potential for raising efficiency in the process. In particular it means carrying over the process model via the organisational form, legal circumstances and also the actors' personal skills into the implementation. Timber construction with high levels of prefabrication has the potential to be a role model for resilient design and building processes. However, implementation in practice is largely hindered by traditionally rooted actors and organisational issues.

Hence, the task in future is to enable these in practice through legally secure procurement and cooperation models. The analyses in the leanWOOD project showed that models already exist, which make this possible. But in order to achieve the step to widespread implementation, there is still a need for efforts towards simplification of the outlay in these models and cultural change among the actors.

9. Discussion and Outlook

An aspect of the current roll over of Building Information Modelling BIM in the building sector is the change towards resilient design building processes. Similarly to prefabricated timber construction, BIM is committed to change in planning culture: methods, processes, and strategies must change with its implementation. Prefabricated timber construction is already very well positioned in the adoption of BIM. With BIM, integrative planning is also supported at early stages and technical/economical optimisation can be combined with architectural layout from the early design phases. If, as a result, one creates space for argumentative processes and thinking in terms of variations, one then enables flexibility in the process and a buffer for the unexpected. If, through visualisation, one also improves communication between experts and laypersons and thus enables the competent integration of building owners and users in the process, then prefabricated timber construction can make a great contribution to resilience in buildings and in cities.

If one closes the loop to those attributes of resilience-oriented design and building processes mentioned earlier, it is also necessary to cast a critical eye over the objectives of BIM implementation. If the focus of BIM implementation is directed towards further efficiency improvement in the process to reduce planning time, misusing BIM solely for economical optimisation, then planning is reduced to a polytechnical collaboration in planning models, which cannot coincide with the process of transformation to a resilient building stock.

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