Chapter 5

Construction Process

5.1. TYPICAL WOODEN CONSTRUCTION SOLUTIONS

Petri Lento,
Häme University of Applied Sciences

Various systems for timber construction differ from each other. When looking at the two most used prefabricated element solutions used in more than two-storey wooden apartment buildings in Finland, we have:

- large timber frame elements (traditional from 1990…);
- and solid massive wood space elements (increasing trend from about 2015…).

We can find two very different kinds of approach in construction process. Main differences of these two systems are presented in Table 5.1.

Timber frame element is considered to be cost effective in lower, maximum four storey buildings, and in additional floor construction due to easy weather protection and lightness. Also, a building contractor whose business is based on traditional assembly methods on building site can easily adopt timber frame elements construction system. Timber frame elements has been a traditional method of building one to two storey private and detached houses since 1950s.

Mr. Kilpeläinen and others stated already 20 years ago that cost savings in construction are achieved due to shorter on-site phase and effective production conditions at nearby sources. Manufacturing elements at a plant is faster, and available labour resource is closer to raw materials and assembly site. Raw material use is more controlled in industrial conditions, and raw material waste is less. Material flow and work can be organised at the location where it is most affordable (Kilpeläinen et al., 2001).

Table 5.1

Different Approaches in Construction Process

Large timber frame elements	Space element with massive wood
Customer decision for architecture – more freedom for building layout and appearance	Customer decision for architecture is more limited (i.e. suitable for standard size smaller apartments, for example student houses) and schematic appearance
Design process is more traditional for prefabricated building process, design for prefabricated individual units for production is typically factory made	Detailed design readiness for complete apartment manufacturing early in process, longer design time
Logistics easy, light elements easy to handle on site	More challenging transport and logistics on site
Faster production time, longer site assembly time	Longer manufacturing time, short site assembly time
Tent or other weather shelter required on site	Typically, weather protection included in each unit
Faster than concrete, slower than space element	From foundations ready to move in fast
Finishing quality management on building site	Finishing quality management focus on production line
After elements assembly on site, all highly industrialized element products are finished on site – 10-year guarantee from the main contractor, typically, 2-year guarantee for large timber elements from the supplier.	After elements assembly on site, all highly industrialized element products are finished on site – 10-year guarantee from the main contractor, 10-year guarantee from the space elements supplier (typically, the main contractor)
Easy to renovate or even change some elements	Space modifications are not possible

5.2. QUALITY ASSURANCE

Petri Lento,
Häme University of Applied Sciences

Wood is an anisotropic substance, that means, its moisture life in different directions is different. In the longitudinal direction of the wood moisture content is small, but in the transverse direction the moisture content is larger. If wood is dried from totally wet to absolute dry, the tree shrinks tangentially about 8 %, in the radial direction about 4 % and in the direction of the causes about 0.4 % (Puuinfo Oy, 2020).

Changes caused by the moisture life of the wood must be taken into account in construction. For example, in log construction the drying causes the frame to pile up. In addition, drying causes pressure inside the wood that can cause more cracking to wood construction. The wood usually cracks at the point where the distance is shortest from the surface (Puuinfo Oy, 2016).

Trend on the construction market is to increase prefabrication and production of wood-based buildings. Target is also to speed up building works and move more work to be done in factories. One major advantage for industrial prefabrication is the diminishing importance of the seasons in year-around construction. Also, smoother quality is expected when educated workforce are working under steady conditions and quality monitoring is in place. Prefabrication brings along better work safety and schedule management. Project management and delivery chain management is more controlled and accurate. On site works are turning more into building assembly tasks.

In construction the quality of prefabricated industrial elements is exceptionally good. This is because elements are produced in exactly controlled conditions. Therefore, the dimensional accuracy is excellent and material losses and mistakes can be minimized in industrial conditions. This speeds up the construction process itself. Realizing the dry chain when elements are under production in a dry indoor environment has clear advantage compared with on-site construction. Wooden prefabricated units are light to transport, and logistics to the site and on site is effective and clean compared to some other materials. During site assembly of elements using tent above the construction gives opportunity to maintain the dry chain until the roof, and building envelope is completed. In the Nordic climate conditions maintaining dry

← "The Gipson tower" is a steady rising weather shelter lift by motors. Assembly crane operates above the building under the shelter. Photo: Rakennusliike Reponen Oy, 2016.

→ Additional floors construction, 7th and 8th floor, Tampere, 2018. Photo: P. Lento 2018.

← This project was a six-storey prefabricated large timber element project for housing fairs in Vantaa, Kivistö 2016. Total floor area of the project was more than 10 000 sqm. including about 200 apartments. The project was built by Rakennusliike Reponen Oy. Photo: Rakennusliike Reponen Oy, 2016.

→ Two more floors of wooden large elements were installed under the tent for a 100 years old downtown block in Tampere. Photo: P. Lento, 2018.

← Mansikkala School, the largest wooden school centre in Finland, Imatra 16 000 sqm, build in 2018–2020. Client: City of Imatra; Frame structure: Glued Timber by Versowood; Facades are large timber elements with massive panels and glued timber columns by Oiva Wood Oy; Roof elements: Oiva Wood Oy; Main Contractor: YIT Construction; Wood structure installation: Kymeenlaakson Rakennus Oy. Photo: Oiva Wood Solutions Oy, 2019.

→ Prefabricated wall, partition floor and roof elements installation inside the frame of one of the seven Mansikkala building blocks. Roof elements consisted of three separate units. Assembly works for one building block took about 4–6 weeks. Facade is coated with 'rautavihtrilli' ageing liquid at sawmill. This natural coating turns grey in few months under natural weather conditions. This natural 'ageing' keeps facades service proof for ages. Photo: Oiva Wood Solutions Oy, 2020.

Fig. 5.1. Dry chain construction under the tent (Saari, 2019).

chain in construction is essential. For the customer prefabricated wood construction allows for speed and building quality. In Fig. 5.1 there are examples of dry chain construction under the tent.

Wood building materials and elements must be weather protected as long they are installed in place. In storage, transport, and site logistics phase prefabricated wood products are covered with plastic packing. During storing air circulation must be ensured inside the transport packing. When storing packages outdoors, there shall be about 0.5-meter ventilated distance to the moist ground.

Assembly on site takes place under weather shelter until the building has water cover. Space elements are normally water protected at factory. Site assembly must be organised under good installation conditions. In some projects movable roof pieces (roof elements) are used as on-off principle. In such cases moisture penetration into structures is unlikely. Some additional costs, like tent or shelter rent, exist due to weather protection. Weather shelter would be a good quality assurance for the whole construction no matter what kind of building materials are used.

Construction quality is mainly up to the competence and attitude of the working group, site management and quality assurance procedures of manufacturing and assembling company. Factory selection, quality monitoring and LEAN kind of process management provides quality products. When the overall process is under control at the factory and on site, the entire production chain is proper, and project end result will be superb.

5.3. CONSTRUCTION PROCESS MANAGEMENT GUIDE

Per Sorensen,
VIA University College

It is absolutely vital for a good project process to get things start right by making the right decisions in the initial phases of the construction project. It is important to reflect upon the building process and carry out the right activities to increase the chances of success for the project participants and for the project as a whole.

This is about creating clarity about the tasks and interfaces for everyone in the project. From the very start there should be a clearly defined and effective organisation, so the right skills come into play at the right time. The project constraints should be well-known and balanced, so that everyone is familiar with the relevant assumptions and agreements. A clear framework and agreements provide the best foundation for good communication between the parties of the project and form the basis for an effective building process.

This chapter is based on the Danish guide prepared by the project called "Value-creating Construction Process" (Værdibyg, 2020). This guide focuses on the crucial parameters that need to be understood before the project design work starts. The specific tools and methods in the guide will help the project to get things right from the start and provide for a value-creating project process right through to handover.

5.3.1. Key principles

About the guide

The guide describes the key activities that the client organisation and the project design team need to manage proactively to provide for an effective building process.

The activities fall under three headings:

- Create clarity about the task and the process.
- Balance the project constraints.
- Bring the right skills into action.

Across these areas there is a general need for communication. Effective communication is a crucial parameter for the success of a construction project.

When and for whom?

The recommendations in the guide are aimed at the initial phases of the building process when the client has just identified the partners who are to handle the project design (and possibly also the subsequent construction). Before this, a process has taken place in which the client's ideas were discussed and clarified to provide a basis for the subsequent project design. Now it is about getting the project right from the start and laying the foundation for a value-creating building process going forward.

The target group for this guide therefore encompasses the client organisation, the consultants and the contractors who are involved early in medium-sized or large construction projects.

Checklist and toolbox

The guide ends with a checklist which the client and the team can use to ensure that they have covered all the key topics. There is also an appendix with specific tools for inspiration and practical use. We refer to these tools throughout the guide.

Communication – the key to the right start

Communication is a fundamental factor in a good building process, so it is crucial to make it clear from the start: how are we going to communicate? The client and the team should agree on a set of common ground rules for

communication in order to ensure that nothing gets lost 'between the lines' and that there is room for the necessary questions to be asked and answered.

This can be set out in a communication plan which is an overall script for the communication work through the building process – note the example in Appendix 5.1.

Preparing for the communication will provide the client organisation with a number of basic rules for how things should be communicated during the project. This plan is then converted into a document applicable in discussions with partners and providing a common understanding of how both internal and external communication should be handled in the actual project.

Internal and external communication

The client and the team should communicate internally to ensure clear areas of responsibility and interfaces and constant progress in the project. Procedures and guidelines should be drawn up and complied with, preventing the project from being flooded with unstructured information, which could give rise to misunderstandings and inefficiency. It is important that the project information is accessible, readable and up to date. There should be a clear strategy governing how things are to be communicated to whom, and how often. This is particularly important in relation to external communication concerning project progress to the public, the local area, future users, existing residents, etc. The communication plan should also address more mundane subjects such as the meeting structure, the 'tone' of the meetings, use of e-mails and other digital media, etc. It is important to agree on common ground rules and constantly evaluate and modify them as the project evolves.

Stakeholders and politics

A good basis for producing a communication plan is a stakeholder analysis identifying the stakeholder groups involved in the project. It is important to proactively identify the key stakeholders and interests and to pin down the areas where, e.g. political decisions could affect the progress of the project.

ICT

ICT (Information and Communications Technology) plays an important role for communication in a project team. The use of ICT offers great potential for knowledge-sharing across functions, which can provide for an optimisation of the project. But this requires that information and drawings are structured in order to prevent misunderstandings and duplication. It is important for everyone to use software systems that are compatible with each other for a fluent exchange of information and data. A project website is also a useful platform for exchanging files.

The ICT guidelines must not be decoupled from the rest of the process; rather, they should help to support the overall goals of the project throughout the process. The ICT guidelines will often be produced by specialists, but it is important for the ICT specifications to be written in a straightforward language and for the guidelines to be communicated and handed over to all new actors in the project.

It may help to look up the Danish BIPS directions for ICT specifications or the FRI and DANSKE ARK's supplement to the Service Specifications for handling ICT in the building project (A building component description is defined by BIPS and described in Danish publication B100, where BIPS stands for: Construction Information Technology Productivity Cooperation).

Disseminate the communication plan

It is essential that the communication plan is disseminated, and that management actively supports the implementation of the desired communication culture in the project. The communication plan will typically be part of an overall project plan or project handbook.

Create clarity

Before a building project gets properly started, all parties should be clear about the following issues:

- What are we building and why?
- What are the client's needs and wishes, and how should they be satisfied?
- How does the organisation appear?
- What should the process be like?

Clear values produce the right solutions

The client and the team should start by aligning their expectations, perceptions, and ideas about the forthcoming project, so work can continue on the right solutions to the right needs. The client organisation itself may be a complex entity made up of builders, lawyers, politicians, users, finance people, operators, etc., so clarifying needs and values is a process that demands some effort.

The design specification should contain the project's underlying visions, needs and values as well as the assumptions and requirements established in the early phases. The design specification alone cannot support knowledge-sharing from planning through to project design. The needs and values of the client organisation and the specified task should be compared with the conception of the job by the project team.

Value tree

To ensure that the values are adhered to throughout the project, a value tree can be used. The value tree is a discussion tool to establish coherence between the vision and more concrete criteria for the project design. It acts as a proactive compass and allows for the subsequent design process to be monitored and evaluated in a measurable way (Fig. 5.2).

The value tree should be completed jointly by the client and the team to arrive at a shared understanding of the fundamental values behind the project. It is important to give everyone a hearing and to challenge needs and solutions with the specific knowledge possessed by each member of the team. It is furthermore important for the value tree to reflect a series of measurable success criteria which the team can then incorporate in the project design process. The client kicks off with his needs and wishes, and then the team describes in specific and measurable ways its intentions of meeting these.

The value tree is thereby a discussion tool offering answers to how the overall vision and goals should be addressed as well as to why the chosen solutions are appropriate. A detailed value tree can be seen in Appendix 5.2.

It is essential to remember that the building process is a learning process, and that it may be necessary to modify the value tree along the way. The value tree thus becomes a dynamic tool that can be changed and expanded as further and more detailed decisions are taken.

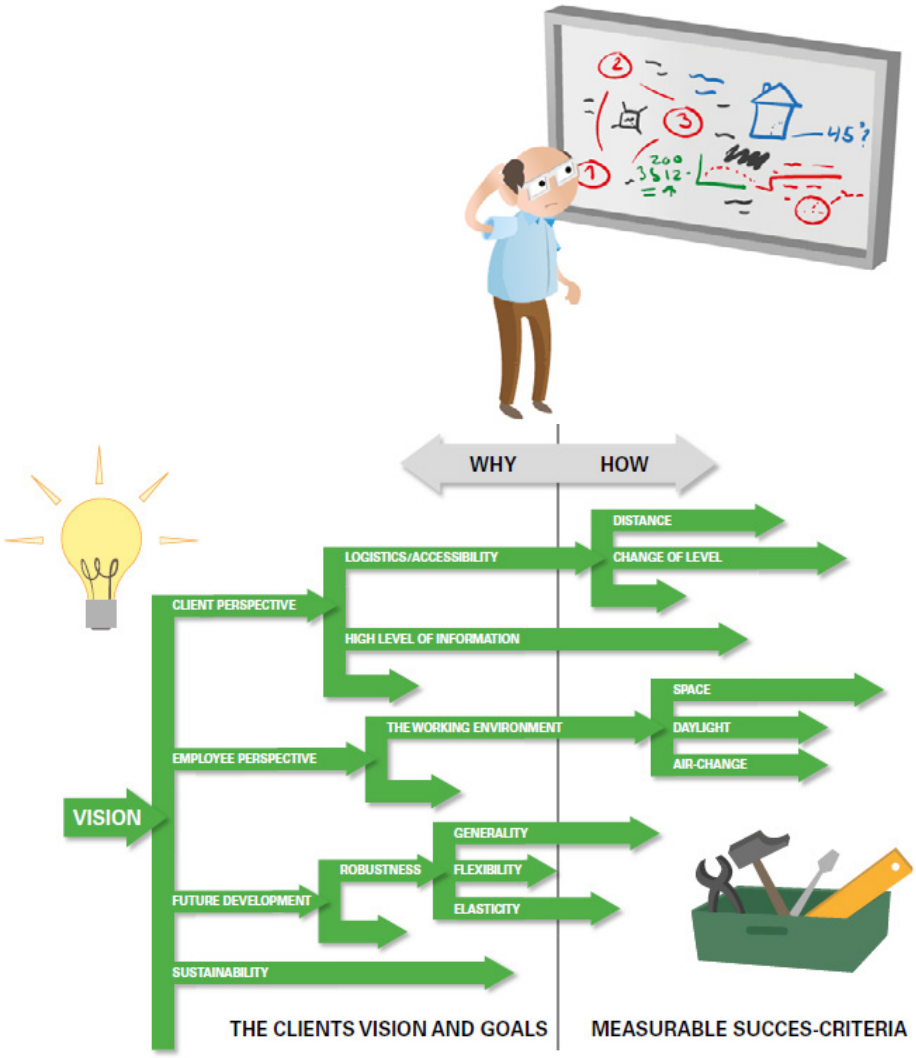


Fig. 5.2. The value tree (Værdibyg, 2020).

Routes towards a common understanding

There are many useful activities for the team and the client to undertake to ensure a common understanding of the content and scope of the assignment and of the needs of the client or future users:

- Study visits to completed or ongoing reference projects will give the team a better understanding of the client's wishes and may inspire thinking along new lines.
- Studies of the end-user's day-to-day behaviour and culture will enable the consultants to understand and challenge the specified needs.

Example of user studies

In connection with the expansion of Copenhagen University's Department of Veterinary Clinical and Animal Sciences, the consultants visited the vets, doctors and nurses at the existing hospital. The workflows that they observed made the consultants better qualified to draw up and propose suitable solutions for the extension of the hospital, including operating theatres, recovery, admissions, reception, etc.

- 1:1 mock-ups, which involve building a prototype of parts of the building (e.g. a bedroom or a flat), will stimulate practical dialogue between the team and the client. They also allow users, operation staff, contractors, etc. to get a better idea of the end-result and to uncover possible errors and problems.
- Scenario-building provides different views of directions, such as market changes, lifestyle trends and climate change, in which the context surrounding the building can evolve. It allows the team and the client to discuss needs and values in a longer-term perspective – what do we want for the future?

Organisation and Process

Apart from creating clarity about the needs and how they are to be met, it is important to be clear about the organisation of the project and the coming

process – who does what, and when?

A number of good tools are available for this:

- **Organisation chart**

A graphical depiction of the contractual relationships and of the decision and communication paths in the joint project organisation.

- **Service specification**

The client's description of the consultant's role and services.

- **Interface form**

Schematic overview of activities at the interfaces between the individual actors.

- **Terms of reference**

Description of roles, responsibilities, and decision-making authorities of various sub-groups (e.g. steering group, advisory group, project management, etc.).

- **Project plan**

Overall description of organisational and management structures and procedures.

- **Diagrams**

The placing of roles and responsibilities should be communicated clearly and precisely to the client organisation and the team. A sensible method is to distinguish between the following diagrams:

- Contract organisation – who has a contract with whom?
- Decision-making organisation – who can decide on what?
- Communication chart – what paths do we use to communicate?

Example diagrams can be found in Appendix 5.3.

We recommend that the organisation is simplified as far as possible to provide for a more straightforward decision-making process and to make it easier for everyone to understand the organisation and act in accordance with the specified structure.

The communication chart can be supplemented with more details via sheets

with the project participants' photo, contact details and principal function (e.g. ICT manager, project design manager, technical manager, etc.).

Terms of reference

The project organisation chart may be supplemented with terms of reference for horizontal sub-groups (e.g. steering group, user group, project management, advisory group, etc.). The terms of reference describe the tasks to be performed by the different project units and the constraints within which they can act. An example table of contents for terms of reference for user involvement is given in Appendix 5.4.

The terms of reference should be communicated widely across the project organisation, so that all parties involved know what functions and tasks each sub-group has, who has the authority to make decisions, and hence what each of them can expect from the others.

Services and interfaces

When producing the contract documentation, the client should be very precise about the services expected of the team. We recommend expanding on FRI and DANSKE ARK's specifications of services by adding an extra column containing additions and exceptions to the standard specifications. This will provide recognizability and also allow the specifications to be adapted to the project in hand. For example, see Appendix 5.5.

The problems often arise at the interfaces between the services of the different actors. Building installations are particularly prone to interface problems when, e.g. ventilation, heating and electrical installations are integrated into an overall automated control system for the indoor climate in the building (see also an example relating to doors). In these cases it is useful to produce an interface diagram; an example can be found in Appendix 5.6.

Example of services and interfaces around doors

There are many issues to be considered when designing doors:

- ***Functionality***

General design, illumination and visibility, flow, automatic opening and closing.

- ***Structures***

Structural coherency and dimensioning of walls and floor.

- ***Fire***

Location of fire doors, automatic closing.

- ***Risk of theft / access control***

Locking systems, security doors.

- ***Electricity***

Coherence between electrical components and general electrical supply to the building, monitoring and control. This area contains interfaces among the architect, fire engineer, security engineer and the overall electrical project. There may also be specific acoustic factors to consider requiring consultation with suppliers, carpenters, security and electrical contractors.

A door project often involves coordination among 8–10 different actors. It may give rise to serious problems if all the requirements for collaboration are not in place.

5.3.2. Project Plan

To provide an overview of the project organization and process, a project plan (Fig 5.3) should be produced. The project plan works as a handbook to the project and contains not just an overview of the various structures and procedures in the project but also an overall description of the project process right through to operation. The project plan unites the guidelines, diagrams, terms of reference, etc. It may also include a timetable and descriptions of procedures, for example for project economy, time and quality management, including critical milestones and risk management.

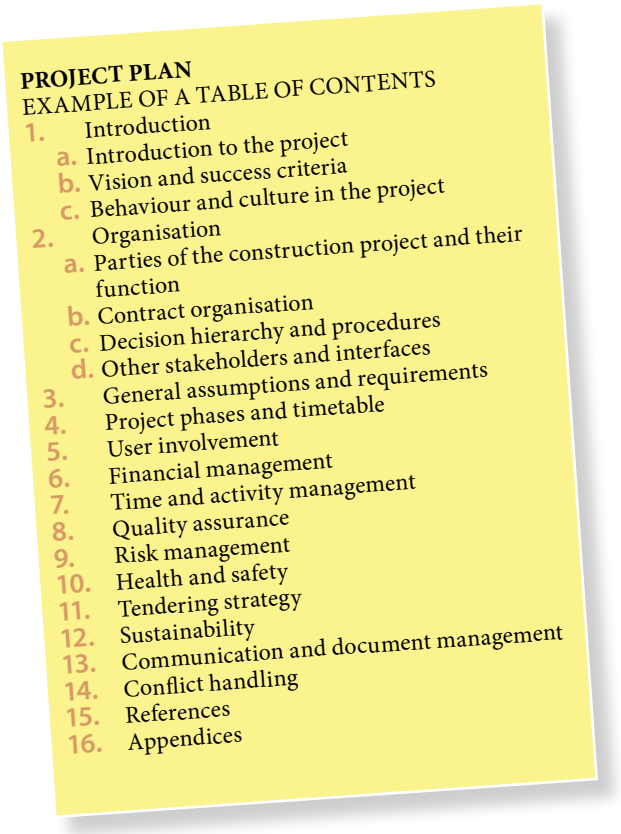


Fig. 5.3. The project plan (Værdibyg, 2020).

The project plan should give the team and the client organization a clear answer to how the process is to be implemented. It is a dynamic tool to be used and modified throughout the process. The individual elements of the project plan must work together, so that, e.g. the results of the stakeholder analysis are reflected in the interface charts, the communication plan, the organization chart, etc.

Preparation of the project plan should involve the parties who are to apply it. This will ensure that all parties know in advance how the project is going to be constructed. The process of creating the project plan is thereby another activity which provides for collaboration and coordination across the disciplines involved in the project.

The project plan should be concise but it should also contain the essential details of the project. When the project plan is handed over to new actors in

the project, there should always be an oral presentation and discussion of the content.

5.3.3. Balance of the Framework Conditions

Framework conditions set the boundaries for the task and are defined by the client and the surrounding community. Such boundaries to a building project may be legislation (e.g. governmental regulations for public buildings), municipal planning issues, the governing overall budget, geotechnical factors and deadlines.

Crucial balance

Balanced framework conditions are a fundamental requirement for a good project. With an agreed balance between the task, the desired quality, time, budget and risk, the building project can be implemented to the satisfaction of all parties. Good contracts produce a win-win situation for all parties, balancing roles and responsibilities. The balanced framework conditions and agreed expectations should be reflected in both the overall contracts and in the behaviour of the project participants and the management approach to the project. On this basis, the team and the client will be better equipped to handle the challenges that emerge in the course of the project.

Alignment of expectations and collaboration

Early in the process the client and the team should each clarify what they expect of the proposed project. It is important to be honest about the parties' different goals and to recognize that all parties have a good case in order for the project to become a success. The entire project team – including the client – must collaborate and be prepared to help each other if any party unintentionally gets into difficulties. And this, in turn, places demands on the underlying contract documentation, where early involvement and incentive structures can help to reinforce the parties' interest in achieving a common goal. It is a good idea to kick off the collaboration between the team and the

client organization with a start-up workshop, focusing among other things on the expectations of the project content and the process protocol. At the start-up workshop, the participants should draw up a joint declaration of intent describing the ground rules for collaboration in the project. The declaration of intent is not a legal document, but it represents ground rules for the process and can later be used as a basis for the regular evaluation of the collaboration.

Handling project changes

There may be many reasons why changes are required in the project along the way during design and production: new users may introduce new requirements; market developments may change the preconditions for the project, etc. With one-off buildings it is hard to predict time and budget and thus to achieve a balance between framework conditions. In these cases there will often be a need to make continuous adjustments to the project. Project changes are often a source of frustration for both the client and the project team and can cause conflicts and delays in the process.

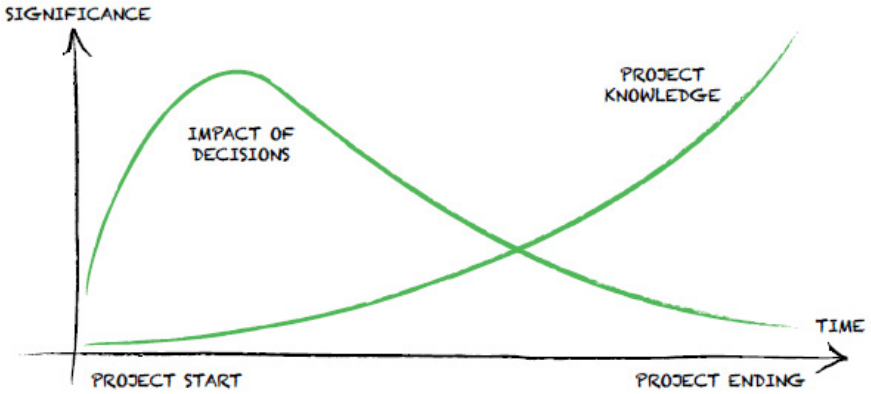


Fig. 5.4. The project paradox (Værdibyg, 2020).

The project paradox

The reason why it may be necessary to make changes to the project can be found in the 'project paradox'. When the project starts, we know very little about it but, paradoxically enough, this is when the most important decisions must be taken (Fig. 5.4). Many of the assumptions made at the beginning may turn out not to hold water. So, we must make continuous changes and adjustments, even if this calls for greater coordination and re-planning.

Tools for handling changes

Not all the suggested changes have to be implemented. It is important to thoroughly consider whether a change proposal is worth the necessary effort. When a change to the project is decided, there are various tools available to maintain a balance between the framework conditions:

- **Frequent estimates**

In projects with fixed budgets, it may be recommended to make frequent estimates of the overall costs of the project. In this connection the design should be constantly adjusted to the finances (and not the other way round) in order not to re-start the budgeting process. Estimates may be made, for example, by successive calculation (see, e.g. Steen Lichtenberg: Project planning in a changing world), which is a tool for risk management and cost estimation.

- **Decision process**

When there is a need for changes, it is important for the client organization to be geared for quick decision-making. Long drawn-out decision-making can kill any progress and cause both the budget and the schedule to slip. A decision plan should be drawn up in which the delivery team, the project management and the client commit themselves to deadlines with a process for efficient decision-making.

- **Flexibility**

A possible strategy is to work on a basic design with various additional options, so everything does not need to be re-designed if the budget comes under pressure.

Changes may lead to a slipping schedule, and extending the construction period will often entail substantial costs. Furthermore, handling ongoing changes to the content of the project is a demanding process. In this regard, it is crucial for clients to communicate how they prioritize time, cost, and quality, so any change is not made at random but according to a deliberate, structured, and well-considered process.

5.3.4. The Right Skills

A good project is heavily dependent on the right skills coming into play at the right time and being utilized in the most advantageous way. Continuity, relationships, skills, and leadership are keywords in this regard.

Permanent actors

In the transition from planning to project design it is important to ensure that there are a few permanent people who can carry forward the original ideas and visions, and that new actors are integrated as quickly as possible to maintain efficient teamwork. This process can be encouraged by assembling the project group so that relationships can be established – e.g. via workshops, kick-off seminars or team building events. Likewise, it is important that the appropriate skills are brought into play at the right time. Many architects' firms are very aware, for example, that it is mainly creative people who should be deployed at the start of projects, with more production-oriented staff joining in later in the process.

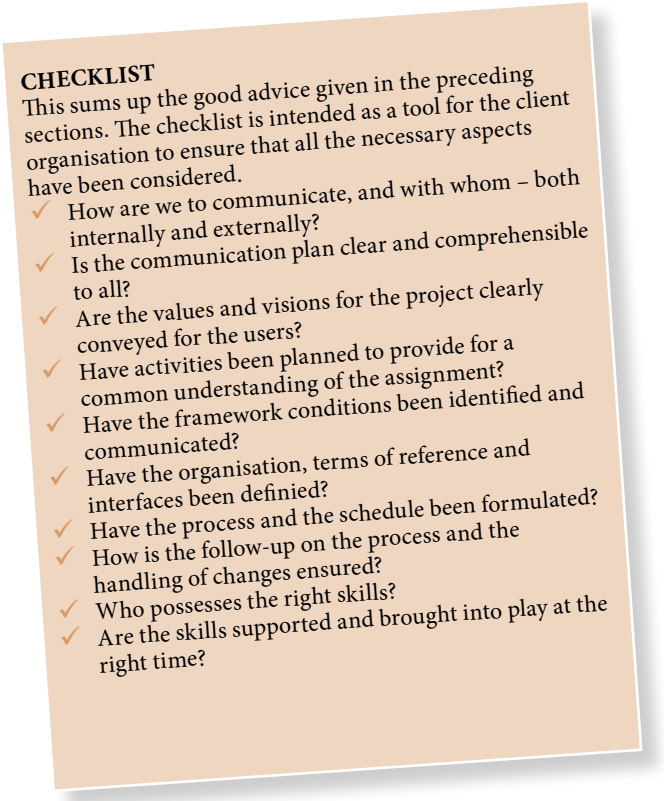
Start slow and build relationships

A project team will not perform 100 % from day one. To begin with, a new project team member will focus on finding his or her own place in the project and on forming an overview of relationships and roles, rather than focusing on the assignment. Many new actors may cause a temporary drop in efficiency. This represents another good reason for creating clarity around roles and services early in the process.

Building relationships through social events provides the benefit of creating better communication between the parties. It is simpler to call or write to someone if you have met one another. It is important to create a sense of confidence in the project group, so everyone dares to ask so-called 'stupid' questions and enter a discussion.

Make space for the skills

The right skills should not merely be in place at the right time; they should also have the time and space to develop. It is undesirable for the project manager to become absorbed in technical details, or for the architect to be spending all his time managing budgets. So, it is essential to create a structure in the project to allow all of the actors to do what they are best at.



CHECKLIST

This sums up the good advice given in the preceding sections. The checklist is intended as a tool for the client organisation to ensure that all the necessary aspects have been considered.

- ✓ How are we to communicate, and with whom – both internally and externally?
- ✓ Is the communication plan clear and comprehensible to all?
- ✓ Are the values and visions for the project clearly conveyed for the users?
- ✓ Have activities been planned to provide for a common understanding of the assignment?
- ✓ Have the framework conditions been identified and communicated?
- ✓ Have the organisation, terms of reference and interfaces been definied?
- ✓ Have the process and the schedule been formulated?
- ✓ How is the follow-up on the process and the handling of changes ensured?
- ✓ Who possesses the right skills?
- ✓ Are the skills supported and brought into play at the right time?

Fig. 5.5. Checklist (Værdibyg, 2020).

Chairing meetings

Bringing the right skills into play requires an overview from the people managing and coordinating the project. When it comes to solving a specific problem, a good project manager will be aware that the important skills may be 'hidden' in people who perhaps are not so dominant in meetings. So, good management is often a matter of chairing good meetings and getting everyone take an active part where it adds value.

In larger workshops you can make use of an external facilitator who has not only general knowledge of building projects but also special expertise in group dynamics.

An external facilitator can more easily create a space in which it is permitted to ask the difficult questions which the project participants cannot or dare not ask. A 'speak your mind' culture should be established early in the project, making it OK to question the project and the decisions that have been taken (Fig. 5.5). See Appendix 5.7 for good tips on chairing meetings.

5.4. PROCESS MANAGEMENT IN TIMBER CONSTRUCTION

Petri Lento,
Häme University of Applied Sciences

Chapter 5.1 describes the different methods and systems how to build from wood. It also introduces the most common wooden building materials and solutions that are used in factory assembly and on-site installation of prefabricated wooden elements. Some combined building solutions, so-called Hybrid solutions, are also presented as modern, more sustainable methods to build. To understand the entire wood construction process, one must be aware of the variations and solutions introduced in Chapter 5.1. In addition, Chapter 5.2 "Quality assurance" gives more aspects to pay attention to when any wood construction process is managed.

Chapter 5.3.2 introduces a collection of the latest thinking of Finnish wood construction segment entrepreneurs regarding use of wood in construction. This thinking includes ideas which are presented in the Finnish "RT Puutoteteollisuuden kehitysryhmä" (Construction industry / "RT Finnish wood products industry development group") in recent years. The undersigned has been a member of this development group since 2016 (Rakennusteollisuus, 2020; Puutuoteteollisuus, 2020).

The ideas about the process are also collected from the recent study published by the Ministry of Economic Affairs and Employment of Finland on 25 June 2020. The title of publication is "An overview of industrial wood construction – wood elements". The review examines the wood element industry, which offers solutions for large-scale constructions such as apartment buildings and public sector. There are about 30 companies in the sector, many of them are small and medium-sized enterprises established in the 2010s. The survey contains interviews with more than 10 entrepreneurs (Sipiläinen, 2020).

Wood construction process management has the following specific needs, least but not limited to (Sipiläinen, 2020):

- *Reasonable legislation*, norms and municipal planning for wooden construction realization.

- Wood construction segment`s *readiness and capacity* to operate competitively.
- Wood specific resources training and constant research and development.
- Customer support and technical awareness for elimination of prejudices.
- Customer training and procurement know-how to build wooden constructions (CO_2, etc.).
- Utilizing co-operation networks for complete wood construction value chain management.
- *Design know-how and capacity*, detailed 3D libraries for wooden construction solutions.
- *Project management* skills (new kind of value chain responsibility).
- Prefabrication and logistics, the *dry chain management*.
- *Quality assurance* during guarantee period.
- *Use and maintenance*, service manual and maintenance handbook.
- End of life cycle and *recycling*.

The process follows topics from 1–12 related to the wood construction process management scheme and it sums up some ideas about the society and industry approach to wood construction process and thinking in the value chain in 2020.

5.4.1. Reasonable legislation, norms and municipal planning for wooden construction realization

Wood construction in Finland was the most common form of building for a long time, but its popularity began to decrease in the 1950s. Some interest in modern wood construction arose again only in the 1990s when the Finnish government started activities in wood construction research & study to promote wood construction projects and new techniques. In 2010, emphasis on ecology of construction and life-cycle thinking promote the use of wood. New changes in building regulations came into force. Modern wood construction has increased remarkably after 2011. Many large wooden buildings have been built. Recently there are several intentions to develop norms for more favourable usage of wood in construction. Application of the EN Eurocodes regarding the design of load-bearing structures requires the establishment of national annexes.

Current worldwide sustainability thinking and CO_2 targets for societies operate as drivers for advanced legislation and norms. In Finland, most of municipalities and cities take wood construction into account in municipal planning. The targets set for public sector construction and the carbon footprint review regulation that will come into force by 2025. That will fuel the demand for wood construction in the domestic market. Similarly, the general attitude is also favourable for industrial wood construction.

The four main principles of climate-sustainable zoning are (Ymparisto.fi., 2020):

- Minimizing the use of natural resources.
- Enabling a sustainable lifestyle.
- Minimizing consumption emissions.
- Preparing for the risks of climate change.

5.4.2. Wood construction segment's readiness and capacity to operate competitively

Global competition is growing in the wood construction sector: in 2019, for the first time ever, the value of wood houses imported to Finland exceeded the value of exports. Industrial wood construction has great potential to grow in Finland in the near future and in export markets in the longer term. To efficiently support the use of wood in residential building and public sector construction, it is essential to pay attention to the business environment and the ability of the sector's companies to make a profit (Sipiläinen, 2020). The target of the entire construction market is to find more cost effective, fast and sustainable solutions for building. There is a tendency to transfer more and more assembly works to industrial manufacturing and under controlled dry conditions. Building sites have had to learn new kinds of installation methods and practices.

In recent years wood is considered to be equal to any other building material. Wood construction becomes more competitive after the field of competition is properly created, legislation is revised and the methods of construction and designing are unified. The greatest possibilities to increase wood usage in construction lie in the construction of blocks of flats (Sipiläinen, 2020).

5.4.3. Wood specific resources training and constant research and development

Educational institutions and construction industry organizations have begun to arrange education and training of resources. There is especially big demand for wood construction designers and site foremen. Nowadays several institutions develop specific learning content and plan wood-specific education. Industry organizations lobby for legislative matters. Research and development take place in many organisations, and plants are in search for more competitive and technically better solutions. Some of the research and development is supported by the state financing in search for sustainable solutions.

Some contractors have been developing, working and learning their own wood building concept in order to become forerunners on the market. For some companies making wood buildings is already a normal practice. Such companies have the best knowledge of the cost level and practice. It has been said that wood construction is more expensive than any other traditional building method. On the other hand, recently there have been a few articles which state that a normal cost level has been met. This shows that different construction systems are coming closer to each other in technical properties and cost wise. Still, there is some argument, especially in the freely funded market, about the cost of wooden constructions (Sipiläinen, 2020).

Other companies participate in contract competitions and make their first attempts to make a proper wood house. Obviously, only by making new kind of solutions one can learn. The same goes with wooden buildings installation. So far in Finland about 70 % of realized wooden apartment houses are three to four floors high. Such projects are not too big to jump in. The current trend is to build apartment houses by using a space element technique either with massive wood frame or timber frame. Another commonly used technique is to erect wooden houses by using large timber frame elements under the tent (Sipiläinen, 2020).

5.4.4. Customer support and technical awareness for elimination of prejudices

When asking for the arguments in favour of wood construction, the issues of ecology of the wood and green value come up. These are important for municipal builders and especially for big construction companies. Responsibility in construction business is a big deal. Ecological solutions, CO_2 neutrality and other sustainable issues are nowadays every responsible company's strategic key words. Sales of wood construction solutions utilize these modern time arguments. During the building process, real cost saving advantage comes from the speed of assembly and effectiveness of prefabrication. Customers are different. For example, student foundations are big builders and they have become forerunners in Finland with standardised high wood construction projects made of space elements. Student foundations appreciate green values and they have found a reasonable cost solution to fulfil their housing needs (Sipiläinen, 2020).

Green values demand will continue to increase in the future when legislation will focus more on life-cycle analysis and carbon footprint. Especially in municipal projects like schools, kindergartens and health care buildings good indoor air quality is given a special attention. The wish for having a wooden apartment building or a healthy indoor school building seems to be major mind-opening for many municipal decision-makers towards sustainability in municipal construction.

5.4.5. Customer training and procurement know-how to build wooden constructions (CO_2, etc.)

The argument that can make it easier to procure a wooden building is that many manufacturers and turn key contractors can offer the whole concept of realization. Wood or any material itself shall not be the main argument. Public tender can ask for a total solution for the requested criteria. Or it may be, for example, a negotiation competition where bidders may propose variations for open technical tender specification. Negotiation procedure is an excellent opportunity to learn when several candidates present their best solutions and values. Naturally, for many negotiations as such more time is

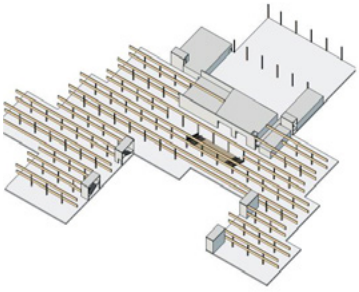
needed. Still, the learning aspect is remarkable. Let us not consider wood as a material but enabler.

Successful have been those cases where customer, architect, contractor and wood construction manufacturer sit down together early enough to fix the best possible realization variant. A good example of this was the Mansikkala School Centre project in the city of Imatra, Finland. This project got honourable mention in the yearly "Wood construction" prize 2020 (Fig. 5.6).

5.4.6. Utilizing co-operation networks for complete wood construction value chain management

For builders and construction companies the key question is to find reliable partners for the wood construction project. Each company has developed their own strengths and can manage processes by usual methods. New kind of materials and building solutions require new kind of operations and process management. There are new tendencies regarding the building site management and leadership (Sipiläinen, 2020).

New partners and processes must fit to the new kind of production strategy. Some contractors already have their own production premises, others are planning big investments for having capacity and adapting their own style of production. Project by project new alliances occur and subcontractor networks are developing. This gives opportunities for entrepreneurs to start new business and develop new strategies (Sipiläinen, 2020).



Mansikkala School Centre frame layout, 16 000 sqm

Photograph: Oiva wood Solutions Ltd, 2020

Fig. 5.6. Mansikkala School Centre project.

5.4.7. Design know-how and capacity, detailed 3D libraries for wooden construction solutions

At the moment wooden structures design takes more time than the traditional concrete or steel design. This is due to still under development normative base for new wooden solutions for bigger construction. It is also obvious that there are many wooden design standards due to several different wood construction materials, systems and prefabrication practices. On the other hand, there is advantage during construction because of typically shorter building time on site.

For the market we need more experienced designers who can make detailed drawings also for various wooden solutions. It is also essential that industry develops their own standards and detailed libraries for anyone`s use. In modern 3D design, it is crucial for the whole wooden building segment to have all the necessary data for general use. Designers, component suppliers and manufacturers shall not keep their secrets hidden. It will not develop the branch. Having proper design on time with standardised solutions can bring remarkable cost savings for wood construction (Sipiläinen, 2020).

5.4.8. Project management skills (new kind of value chain responsibility)

Many contractors have not yet joined the wooden construction scheme. One reason for this is the attitude: why change something that works? Business volume in wood construction is still smaller compared to some other more used building systems. That is why some well-established companies have not accepted the new variant so actively yet. Learning something new is not yet topical in strategy. If business is good, some companies may wait for more standardisation and experiences by the others before rushing into the genre. Anyway, it is obvious that all construction companies are following modern trends, and little by little they must form their approach to new ways of building. A well-considered process and new kind of project management skills may be the drivers for a new strategy (Sipiläinen, 2020).

There already are construction companies which have specialised in wood construction alongside with other solutions. Such companies are now

forerunners of the segment. Recently also the biggest companies in construction have expressed their interest in wood construction. Technically there is no big difference in project management, no matter which construction technique is utilized (Sipiläinen, 2020).

5.4.9. Prefabrication and logistics, the dry chain management

This topic is quite thoroughly described in Chapter 5.1 "Materials and Solutions" and Chapter 5.2 "Dry Chain Management". Prefabricated solutions and new building materials each have their own specialities. On the other hand, there is nothing too exceptional for any company to handle. In most of the cases material supplier or manufacturer is able to give the necessary information and handbooks and show how to manage. Most factories have their own technical department for clients' service.

5.4.10. Quality assurance during guarantee period

Guarantees in wood construction are typically the same as in any construction. There have been some hesitations earlier, for example, concerning facade coating service period. The contract-based responsibility for main contractors is 10 years. There were expectations that the main contractor's responsibility was to repaint the building during the guarantee period. The present experience shows that wooden buildings and their facades from ten years ago have proved to be durable and solid through the guarantee period. Normal maintenance is needed as in any building. Maintenance shall be done according to information in the service manual.

One of the forerunners in wooden construction has followed user satisfaction in wooden house. A practical follow up has shown that during the guarantee period there have been fewer reclamations in wooden house than in concrete projects listed in the database of the same company. It is obvious that managing dry-chain during construction and having accurate dimensions in element production keep the guarantee defects at minimum.

It has also been measured that acoustic properties of a wooden building

differ from those of a concrete building. In real life some residents sense that the sound atmosphere is more pleasant in a wooden house, on the other hand, some residents appreciate the sound of the concrete building. In 2017, Professor Markku Karjalainen published a resident satisfaction study in wooden apartments after minimum two years of living. The survey`s general result is a summary of 302 answers from 17 buildings, which is as follows: in wooden apartment "there were less annoying noises", "acoustics properties were pleasant", "comfort and beauty values were good", and "there was a warm feeling in the apartments". The feedback also summarises that more visible wood surface was on the residents wish list (Karjalainen, 2017).

5.4.11. Use and maintenance, service manual and maintenance book

When a new building is handed over, the contractor hands out a service manual to the housing company. The service manual is a guidebook for the building maintenance and service company. It includes instructions on the products and materials used in the building, maintenance instructions, description of repair methods, replacement of changeable parts, standard use of energy and water. In some cases consultants can prepare a more exact and long-term maintenance book for the needs of predicting coming renovations (Sipiläinen, 2020).

5.4.12. End of life cycle and recycling

After years to come and when a building's life-cycle is coming to the end, the following actions will follow: demolition of the building, waste handling and transport, material disposal, possible reuse of materials, recycling and energy recovery. There are still no final formulas for calculating the CO_2 and other recycling values, but indications already exist and it is clear that some building materials are more sustainable than other. The most essential thing on the whole is – which set of values will count.

APPENDIXES

One may retrieve appendixes from https://vaerdibyg.dk/

The Value Creating Building Process (VÆRDIBYG) is a partnership between seven most influential organisations in the building industry. VÆRDIBYG is developing a new best practice for the construction process covering the different actors in the industry. The guide discusses the activities meant to ensure that a construction project and a project team get things right early in the process laying the foundations for the subsequent process to become value-creating.

APPENDIX 5.1

DRAFT COMMUNICATION PLAN

Example of contents of a communication plan:

1. COMMUNICATION AND DECISION PATHS

Key people for the project

Telephone and e-mail details for all

'Who knows what?' form

2. INTERNAL COMMUNICATION (IN THE PROJECT TEAM)

3. RULES FOR COMMUNICATION VIA

Meetings

E-mail

Project web

ICT

- Formal and informal
- Handling disagreements
- Speak your mind and question the assumptions

4. EXTERNAL COMMUNICATION (TO THE OUTSIDE WORLD)

Organisation and procedures

Stakeholders and target groups

Channels

Media management

5. FOLLOW-UP

Meetings focusing on communication

Success criteria, evaluation and measurement

APPENDIX 5.2

VALUE TREE

The example is from the Teleparken project, a public housing project in Gladsaxe. Read more about the project on www.jonsson.dk
Parties involved: Domus Arkitekter (Architect), Jönsson (Contractor), Niras (Process Consultant), FSB (Client), Grontmij (Engineer), Lassen Landskab (Landscape Architect)

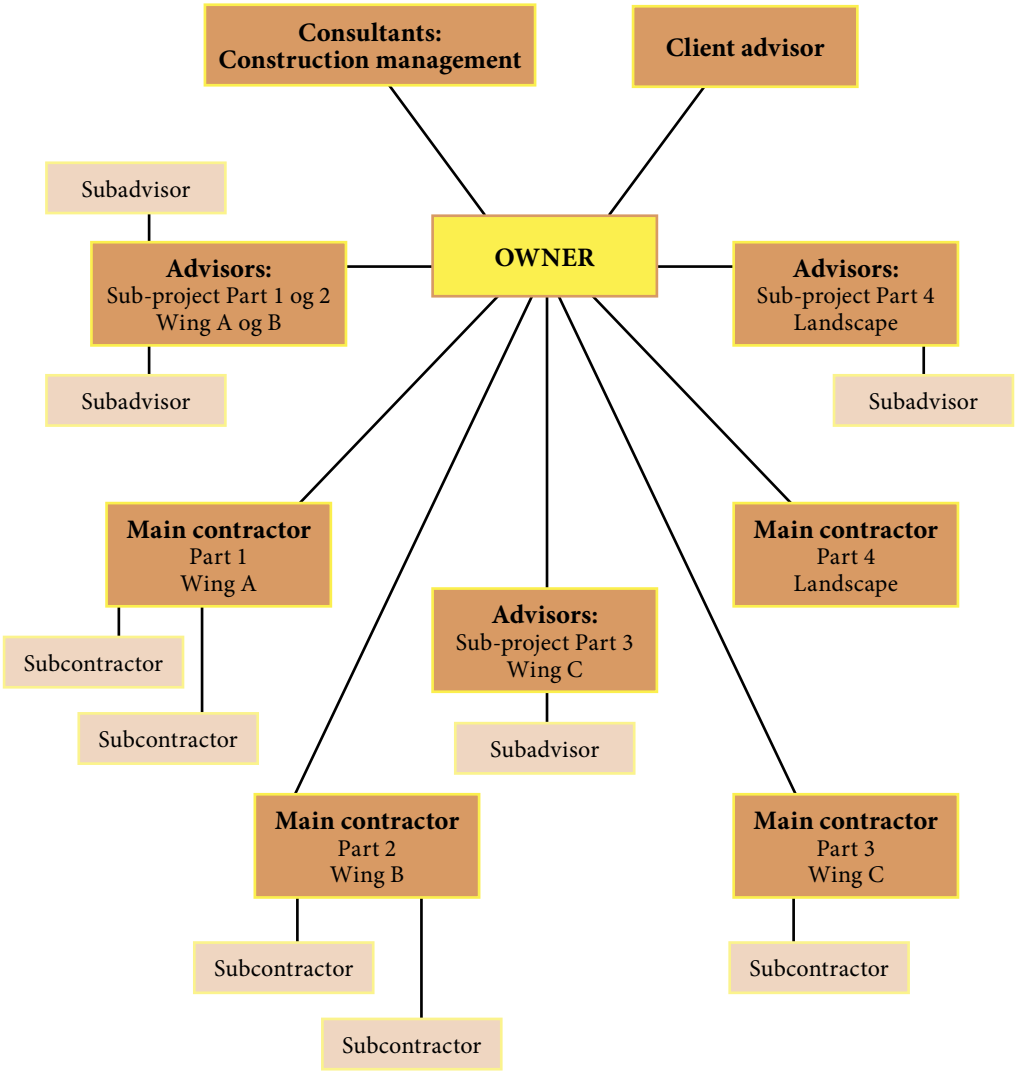
Basic value	Level 1 *Why?*	Level 2 *How?*	Comments
Beauty	Shape	Interplay with the other buildings	
		Consistency in the garden	The architectural motif should be consistent
	Expression	Simplicity 'inspired' by the works of Kaj Fisker	
		View of facades around e.g. balconies, entrances, etc.	
		Interplay between facade colours – 'the white city'	Representing some limitations
		Residents are keen to have finished surfaces	
	Materials	Robustness and consistency	
	Light	Lights is important – play and quantity	
		Illumination in flats	
Environmental impact		Low emission targets are linked to low operating costs	
		No basement, to avoid dealing with contaminated soil	Planning authority is contacted for instructions

	Consump-tion	Low consumption targets linked to low operating costs, including:
		• Good waste management
		• Rainwater collection
		• Low energy consumption
		  • Recovery in ventilation system
		  • Visible monitors (to encourage savings)	

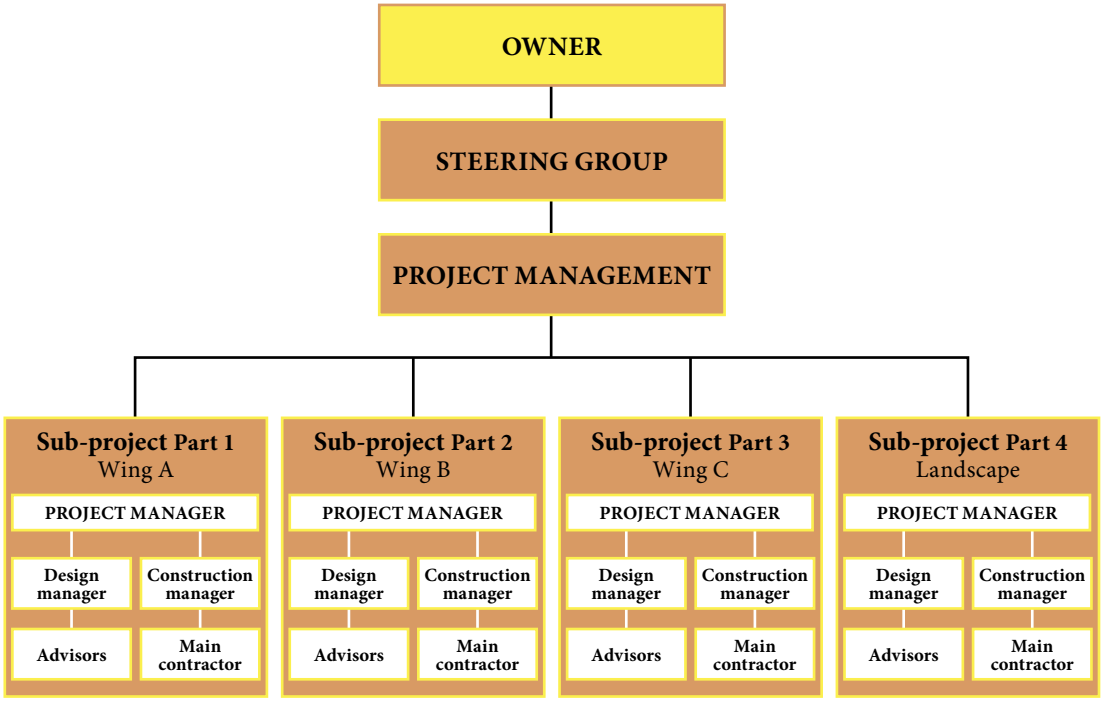
	Other	Use of suppliers operating with environmental management systems	
Buildability	Systems and deliv-erables	Prefab. bathroom modules	Should be considered in light of quality and fitting
		Concrete elements	Avoid odd shapes to minimise on-site casting
		Functional installation of ducts	
		Buildable balconies/optional system?	Should living rooms have balconies or be replaced by access to garden?
	Execution	Focus on a best practise installation process	
		Simple solutions and well-matched materials	
		Aim at zero-soil groundwork accounts to minimise contamination problems	

APPENDIX 5.3

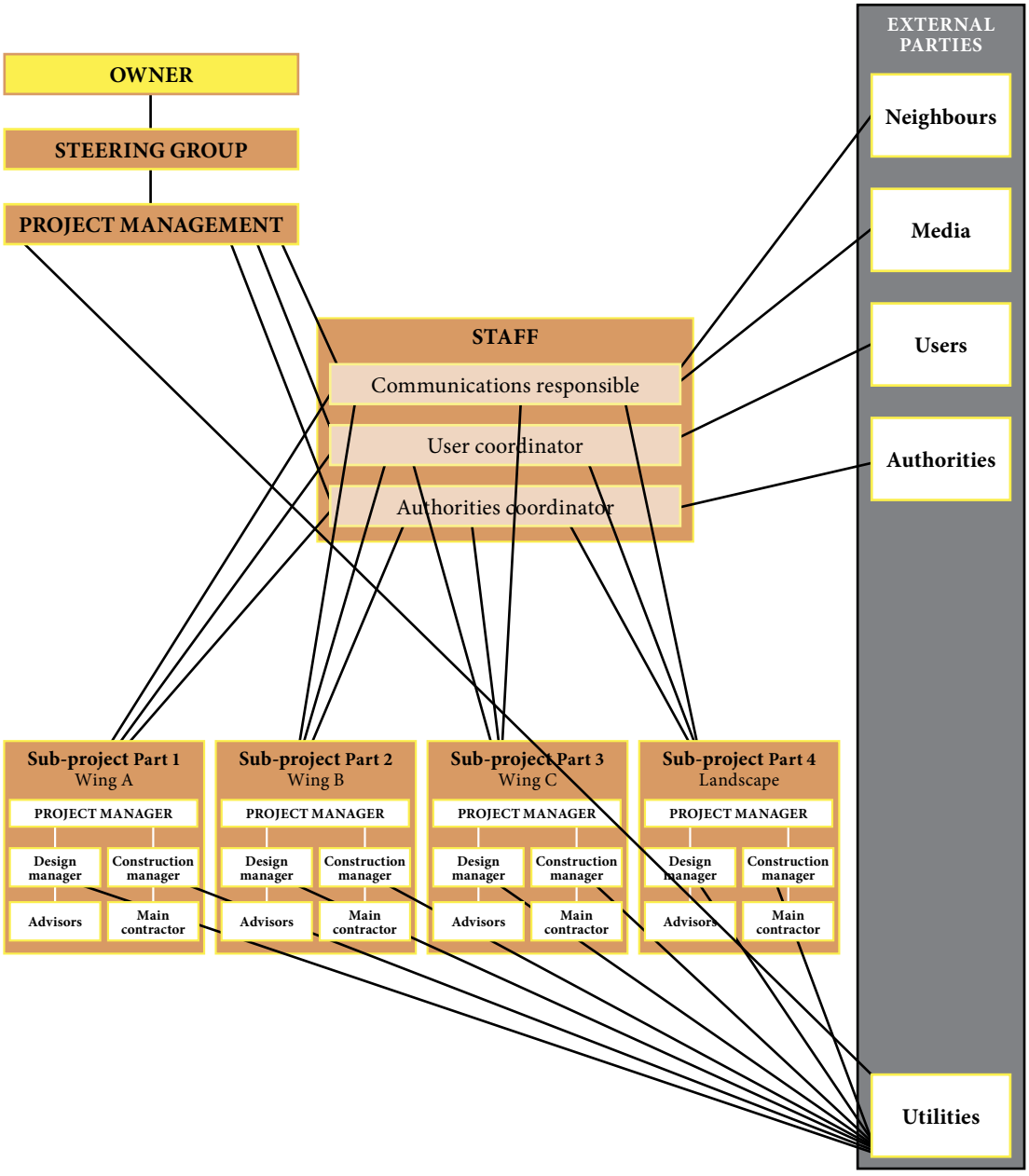
ORGANISATION CHARTS
CONTRACT ORGANISATION



DECISION-MAKING ORGANISATION



COMMUNICATION CHART (FOR EXTERNAL PARTIES)



APPENDIX 5.4

TERMS OF REFERENCE FOR USER INVOLVEMENT

Example of a table of contents for user terms of reference:

1. PURPOSE OF USER INVOLVEMENT

2. SUCCESS CRITERIA

3. ORGANISATION
- Organisation and decision plan for user involvement

4. ROLES AND RESPONSIBILITIES
- Political
- Administrative
- External consultants
- User groups
- Authorities

5. DESCRIPTION OF GROUPS AND TASKS
- User groups in general
- Handling feedback
- Total-consultant
- User steering group and consultative group
- Departmental groups
- Interdisciplinary subject-groups
- Other stakeholders

6. THE PHASES
- Start of process
- Design specification phase
- Outline proposal
- Project proposal
- Pilot project – authority project
- Main project
- Commissioning

7. PROCESS TO DATE

8. TIMETABLE

9. DOCUMENT OVERVIEW AND LINKS

APPENDIX 5.5

SERVICE DESCRIPTION

Extract from a service specification based on FRI and DANSKE ARK's Service Specifications (left-hand column). The right-hand colums contains the client's additions and comments for the consultant.

From the service specifications	Contents Yes	Contents No	Revelant additions/ comments
3.2.6 Quality assurance The consultant reviews the project proposal to ensure: • that the project proposal is consistent with what was determined in the outline proposal, • that the requirements in the design specification for the overall quality of the building (form, function, construction technology) and for costs and time have been met, • that the project proposal can act as a basis for preparing the pre-project and the main project. The consultant informs the client of any special or risk aspects found in the review. The consultant takes part in an interdisciplinary project review	×		Quality assurance is carried out in accordance with the agreed quality assurance manual.
3.2.7 The client While the project proposal is being produced, the client – and/or their appointed user representatives – should attend the necessary meetings on, e.g. detailed room layout, fittings etc. The client approves the governing budget and updates his own budget related to other expenses. The client approves the project proposal as the basis for further project design work.	×		The total-consultant provides an overview of the necessary meetings with the client and his user representatives for approval by the client up front. After 'updates', is inserted 'after input from the consultant'.
3.3 Pilot project (authority project) The pre-project (authority project) is a further revision of the approved project proposal to the point where it can serve as a basis for official approval. The pre-project (authority project) is an integral part of the main project.	×		

APPENDIX 5.6

INTERFACE FORMS
EXTRACT FROM INTERFACE CHECKLIST

× indicates who bears the responsibility, while O indicates further professional influence in the area.

Interface checklist (extract)	Client	Client consultant	Turnkey contractor	Architect	Geotechnical engineer	Sound consultant	Engineer Structure	Engineer HVAC	Engineer Electrician	Landscape architect	Interface agreed
…											
6. The building – Primary building components											
A Design principles			o	o				×			
B Loading requirements			o					×			
C Objectives, overall and detailed geometry			o	×				o			
D Tolerances (e.g. camber, temperature changes)			o					×			
E Expansion joints			o					×			
F Anchoring of roof			o	o				×			
G Steel reinforcement in outside walls			o					×			
H Window openings, stairs, risers, etc.			o	o				×			
I Installation bushings			o	o					×		
J Thermal insulation			o	o				×			
K Vapour barrier, poss. ventilation of structures			o	o				×			
L Soundproofing			o	o				×			
M Airtightness											×
N Installation bushings, light walls			o	o					×		
7. The building – For Completion											
Building components											
A Opening skylights, smoke release dampers			o	×					o		
B Sun screening			o	×					o		
C Window glass types			o	o					×		
D Suspended ceilings			o	×		o					
E Inspection hatches			o	o					×		
F Fresh air vents in windows and facade			o	o					×		
…											

EXTRACT FROM INTERFACE CHECKLIST

Subject	Consultants, contractors or sub-projects responsible for project design		
	Sub-project 1	Sub-project 2	Sub-project 3
Installations			
Ring main for water (underground)	×		
Branch pipes (underground)	×	×	×
Main distribution panel			×
…			
Connection between wings			
Concrete walls in module line C		×	×
Doors in module line C			×
Electrical installations (fire, security and supply) for doors in module line C			×
…			
Movable inventory	×		
Cross-disciplinary environmental coordination		×	
Signage – indoors		×	
Signage – outdoors			×
…			

APPENDIX 5.7

SERVICE DESCRIPTION – 10 PIECES OF GOOD ADVICE FOR CHAIRING MEETINGS

1. THINK ABOUT THE NUMBER OF PARTICIPANTS

Effective working groups should not exceed 15 people.

2. CONSIDER MEETING FACILITIES

Participants should all be able to make eye contact, the indoor climate should be OK and distracting elements (sound, light, etc.) avoided.

3. THE PURPOSE AND FRAMEWORK FOR THE MEETING SHOULD BE IN PLACE

Communicate the purpose (well ahead of the meeting), draw up a clear agenda, define and stick to the time frame.

4. BE PREPARED AND ARRIVE ON TIME

Insist that the participants do the same.

5. PROVIDE FOR BREAKS

... if the meeting goes on for a longer time. This will provide fresh energy, and informal chats in the breaks may open up for important questions which would otherwise not have been asked in the formal forum.

6. REMEMBER TO SUM UP DISCUSSIONS AS YOU GO ALONG

Close the meeting by gathering action points (remember to include this as an agenda item).

7. PAY ATTENTION TO ESOTERIC TALK

and technical terms. Ask clarifying questions.

8. RESTRICT DOMINANT PARTICIPANTS

and bring in those who are hanging back. Ask for comments from the whole group.

9. REMEMBER TO EVALUATE MEETINGS

that repeat over a longer period to improve them.

10. PRODUCE AND DISTRIBUTE THE MINUTES

in good time before the next meeting

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