World Conference on Timber Engineering Oslo 2023

USING CO-DESIGN FOR DEVELOPING A NEW WOODEN FAÇADE SYSTEM

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ABSTRACT: The objective is to demonstrate the co-operative design (co-design) and production development process of a new wooden façade system.

Today, architects and designers are seldom involved in the development process when designing new products within the wood building industry. The architect and the actors in the wood value chain are far from understanding their respective standpoints in new product development, thus creating a gap. This gap between actors hinders innovation and can mean that valuable design knowledge and methods are not used that can promote innovation in the wood building industry.

In this paper we demonstrate how the development process of the façade system is profoundly influenced and improved by incorporating knowledge of the design process.

Product development is becoming more and more complex and therefore more knowledge intense. This was addressed by working in parallel with partners coming from different areas of expertise, resulting in a co-design process considering aesthetic and functional requirements as well as the industrial manufacturing processes, interactively, throughout the entire development process.

Using co-design when designing an adaptable facade system has proven to enable assessment of complex requirements, resulting in a sustainable system that can ensure good quality on material, aesthetics, and functions.

KEYWORDS: Façade design, Cladding, Heartwood, Design process, Co-design, Adaptable design

1 INTRODUCTION

There are many divergent wishes on what a facade system should fulfil. From building regulations, government requirements to societal perspectives, as well as aesthetic and functional requirements such as adaptation to existing contexts.

Architects and builders are showing an increasing interest in using wood as façade material in urban contexts. A modern facade system must be attractive and easy to use for architects to design, easy to manufacture and easy to mount and maintain [1].

New product development in the wood building industry is complex and therefore knowledge intensive. Wood is a complex material that requires many skills in the value chain from the forest to the creation of new products.

Society demands that future building systems provide a well-designed environment, are sustainable, reusable and circular, adaptable design wise to different environments and manufactured in an environmentally sound and resource-efficient manner. This complexity leads to a need for an increased number of involved experts in new product development. According to Perks [2], these rapid changes mean that the demands on design knowledge increase dramatically. Researchers acknowledge that knowledge about design and design processes takes on an increasingly prominent role in product development [3], [4].

Actors in the wood value chain are often far from understanding each other's driving forces and needs, which creates problems concerning new product development. Architects, who are responsible for design, are used to collaborating in collective processes and "raising their gaze" in design processes and thereby contributing to a more holistic approach. The gap between actors hinders innovation in new product development and can mean that valuable design knowledge and methods are not used that can promote innovation in the timber construction industry.

In the project " Facade of the city Swift, Stylish, Smart" hereafter called the project, it was identified how the gap,

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 https://doi.org/10.52202/069179-0511

more specifically between architects' and industry's perspectives and goals could approach these challenges [5].

Faced with an abundance of classifications of collaborative activities within design, so called co-operative design (co-design), here the definition presented by Saunders and Stappers [6] is used.

Working systematically together using co-design methods has proven to be of vital importance resulting in product innovation and exchange of knowledge between partners. De Vere and Fennessy argues that "If … design has a role to play as an agent for change, an inclination to working in participatory ways with a co-design mindset seems sensible "[7]. The project shows that the architect can have a decisive role in the development of new products within the wood building industry by using knowledge of design and co-design methods.

Adaptable design is a design paradigm aiming at creating designs and products that can be adapted for different requirements and influenced by users. An existing design of a product can be adapted to create a new or modified design based on changed requirements. Adaptive design enables manufactures to produce standardized products that are possible for end users to customize [8].

The objective with this article is to demonstrate the co-design and production development process of a new wooden façade system [9,1]. A co-design process was developed considering design and functional requirements as well as industrial manufacturing processes throughout the value chain interactively and in parallel with partners coming from different areas of expertise. The purpose was creating an adaptable, changeable and flexible design easy to use for architects and still economically viable.

The result is increased knowledge about design processes using co-design methods in new product development within the wood building industry.

2 METHODS

A new wooden façade system must be fast and safe to assemble, there must be a variation in the aesthetical expression, and it must be sustainable, adapted to regulations and possible to manufacture industrially.

An industrially manufactured wooden facade system here refers to a facade solution for buildings consisting of a set of components that are fully or partially ready-made and dimensioned regarding adjustment for specific dimensions of buildings. The components of the facade system are joined industrially to facade elements, corners, footboards, cornices, and connections at openings. On the construction site, the facade system is assembled and mounted on a building. The result is that the construction site becomes more of an assembly site, where finished elements of the facade system are assembled. This differs from the methods that are common procedure today; were wooden facades are assembled with a nail gun board by board on the construction site or in a factory on a prefabricated wall structure.

2.1 PROJECT VALUE CHAIN

The participating partners covered the whole value chain, including researchers, engineers, architects, constructors, raw material suppliers, manufacturers, builders, and property owners.

The engineer and architect were responsible for the architectural and constructive design, the raw material supplier for the manufacture of the components, the manufacturer for assembly of the parts, the paint supplier and the chemical industry for surface treatments and paint, the contractor and building company for mounting and the manager for care and maintenance.

2.2 PROCESS

Customer requirements, building regulations and the market for facade systems were initially investigated, analysed, and compiled. The aesthetic design was developed with the purpose of making the facade attractive and easy for architects and builders to use. Wood properties and surface treatments were studied and verified in scientific tests to achieve fire safety and long service life. Heartwood of pine and spruce were chosen because of its suitable material properties for facades.

Wood properties and surface treatments were studied and verified in tests to achieve fire safety and long service life. The facade system's functions were verified in lab tests and by small scale design prototypes. Full scale tests of the mounting of the facade system were executed on two buildings in Luleå, where mounting time and functions were evaluated. A full-scale fire test of the facade system was carried out with Teknos´ fire protection paint, which passed the SP Fire 105 test. Overall, the façade system was developed to be market-competitive and contribute to a sustainable bio-based economy. To assure this, durability and circularity have been considered both in the design and the choice of materials.

2.3 CO-DESIGN

In the project the term co-design refers to a process where the participants collaborated in a design process, including all the participants' knowledge and reasons for participating and enabling them to together create knowledge development, ideas, and concept generation when developing the product. It also meant creating a foundation of trust and understanding enabling participants who were not trained in design to be co-designers. Co-design methods can be used in all stages of the design process, though they are mostly used in the idea or concept phase. In the project several co-design methods have been used to facilitate participation and cooperative design, such as workshops, making prototypes, mock-ups, discussions of drawings and scenarios. To verify the prototypes aesthetically, discussions with partners in the

https://doi.org/10.52202/069179-0511

value chain including a reference group of architects were engaged.

3 RESULTS

The development of the façade followed an interactive development process with interaction between design, function, and production, figure1.

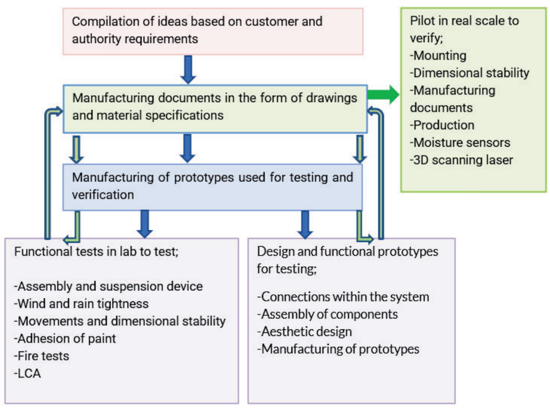

Figure 1: *Iterative development process in the project "Facade in the city Swift, Stylish, Smart", Development of the facades is based on requirements, laboratory tests and functional prototypes in an iterative process and thereafter verified as a pilot installation on two buildings [1]. (Image Karin Sandberg RISE).*

3.1 CO-DESIGN PROCESS IN THE FASADE PROJECT

The design was developed to make the facade attractive for architects and builders to use. The development process used in the project is described in full in a rapport [5].

3.1.1 Co-design in project managing, planning resources and anchoring decisions

Co-design enabled the partners to plan the project, asset manage, plan meetings and workshops alternating between including all participants and in smaller focus groups where specific tasks could be solved. The result of discussions, visualizations and prototypes were thoroughly documented in notes and the scientific tests, aesthetic tests, and functional verifications were described in rapports. The meetings with the partners were used to anchor decisions. The decisions were documented with meeting notes which were followed up by the project research leader who also distributed resources for implementation. Design choices and asset management were thus continuously updated leading to specification of the design criteria step by step.

3.1.2 Phases in the co-design process

The co-design process in the development of the facade system consisted of different phases,
-inventory phase
-analysis phase
-verification phase

The phases were developed in a semi parallel flow. The development took place iteratively where prototypes were tested and improved and adapted to production together with the partners in the project.

3.1.3 Inventory phase

Acknowledging the complexity and the nature of the scope at the very beginning of the project, the partners saw the benefit of establishing a common ground, thus creating engagement for the project. The common ground was the interest in the material, heartwood pine and spruce. The project established an interesting opportunity of understanding the material from different aspects, by reading it from the other partners perspectives, thus together creating more knowledge of its performance in a façade system including all aspects from design to manufacturing and mounting.

The design choices were based on an inventory that was carried out initially. It compiled customer requirements, building regulations and markets for facade systems and these were researched, analyzed, and compiled.
The engineers developed the scheme for verifying the performance through experimental design and appropriate test methods and technical equipment. The industrial partners gave input on production parameters important to consider.

Design criteria was summarized in a list of requirements on the product. The design criteria created a systematic and structured foundation for deciding on design, assessing criteria and discuss solutions. The design criteria enabled the partners to consider their own roles and connections with possible assets which was beneficial for the collective effort.

3.1.4 Analysis phase

In the analysis phase project drawings and visualizations were used, creating a foundation for testing the design decisions and further discussions. To verify the design decisions production feasibility and development of the manufacturing process design prototypes were built and tested. All prototypes were made of heartwood from Scots Pine (Pinus *Silvestris*) and Norway Spruce (*Picea abies* (L) Karts), figure 3.

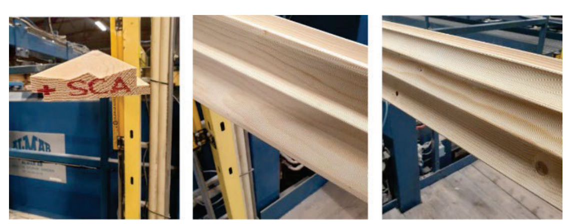

Figure 3: *Prototype testing of different design of the façade boards. (photo Camilla Schlyter RISE).*

https://doi.org/10.52202/069179-0511

The cooperation in the value chain, from choice of material to production method resulted in, for example in a series of new expressions of the surface figure 4.

Figure 4. *Example of one of the protypes built in the façade project. The milling of the boards was tested together with assembly of the boards. (photo Camilla Schlyter RISE).*

3.1.5 Verification phase

In the production phase full scale prototypes were tested. A pilot test was executed on a building in Porsön, Luleå. Full scale tests of the mounting of the facade system were executed on two buildings in Luleå, where mounting time and functions were evaluated. A full-scale fire test of the facade system was carried out with Teknos´ fire protection paint and passed the SP Fire 105 test.

The raw material supplier manufactured the components and the components were thereafter assembled by the wood industry partner.

3.1.6 Co-design process

The requirement on the co-design methods was that communication should be enhanced and enable interactivity between the partners and thus promote innovation.

The co-design process was based on building trust and an understanding of the partners points of departure. It was from the start considered crucial to build a common ground, a common language and a willingness to share competence. The methods of arriving to a result at first differed amongst the partners for instance; concerning the design of the product, the engineer relied on scientific results and validation, the manufacturer on efficient production methods and the architect from synthesizing design decisions by developing aesthetic design solutions. The different points of departure sometimes resulted in conflict in the beginning of the project. Opinions, ideas and thoughts could be ventilated in the co-design process and knowledge was exchanged concerning how to pursue the project.

In figure 5 the co-design process in the façade project is shown.

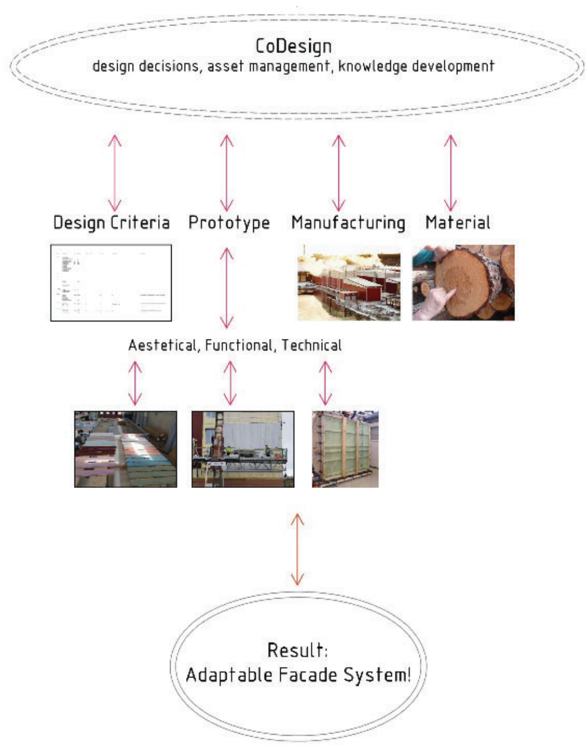

Figure 5: *Diagram over the co-design process. (Image Camilla Schlyter RISE).*

Attitudes, values, and expert knowledge was shared and communicated in the co-design process and conditions were created to enable tying together complex challenges in terms of design, materials, maintenance, and finances

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and at the same time ensure that all voices were heard. By understanding the partners knowledge and starting points, consensus was created concerning the product idea and assessment of resources.

3.2 THE ARCHITECTS ROLE

The architect's role in the co-design process was to ensure that the products architectural values and design quality was upheld thru the process and result in an aesthetically pleasing and functional product. The architect used design knowledge to negotiate design criteria by translating and mediating diverging information and transform this knowledge into form by sketches, drawings, and visualizations and create drawings for the prototypes. The purpose was to ensure that all project partners were part of the design and that their knowledge, values and perspectives were lifted into the project and addressed. The role of the architect changed during the course of the project, from being considered the decision maker of aesthetic design to facilitating for others to participate in making the design decisions.

3.3 SUMMARY OF THE RESULTS

Alternatives in aesthetic design, manufacturing process and functional/technical design were formulated and tested in an iterative process between project partners, where everyone contributed with their knowledge and intent. A continuous dialogue and compilation of experiences from design choices took place against the background of design criteria. The design choices were verified through a series of aesthetic, functional and technical prototypes. The design was changed if it did not deliver the results the partners anticipated. New design and new prototypes were created until desired result was achieved.

The aim with the developed co-design process was to ensure that all the requirements were identified, met, and processed. A result with the process was that the participants became co-designers, and the architect acted as a facilitator concerning design methods leading, guiding, and listening to the participants aiding the process of creating knowledge and making design decisions. This resulted in that the partners gained knowledge concerning design and design methods.

The co-design method enabled a discussion in which the project partners could work with technical and aesthetic solutions in parallel. This was ensured by the architect and the research leader working closely together thus giving scientific methods and design methods equal value.

• Of importance was that the project management consisted of an engineer and an architect, which meant that functional and design aspects were discussed in parallel and guaranteed that they were of equal value. The architect and the research leader acted closely together and enabled conflicting issues to be resolved by facilitating and mediating the design process thru co-design methods. An interesting result of this collaboration was that parallels in working methods emerged scientifically on the part of the engineer and aesthetically on the part of the architect.

• Through frequent meetings with the partners, consensus and common starting points were created. Any conflicts, values and purpose of the project could be raised right from the start, which enabled creating a synthesized target goal with the project together, in collaboration. The initial discussions concerning the partners' driving forces and respective positions were crucial to create trust and commitment to the project. By understanding each other's knowledge and starting points, consensus was created around the product idea. Attitudes, values, and expert knowledge could be shared and communicated in the co-design process.

• Another important result of the project was allowing time in the initial phase to create understanding regarding function and design to be of equal value. Using design knowledge and methods from the start to the finished result was of importance for the result. The projects specific co-design process enabled complex criteria to be solved. This contributed to understanding the benefits of involving design knowledge. The architect became an "insider" engaged in the development of a new product.

• This method of collaborating throughout the project enabled criteria to be met, discussed, and communicated in a continuous dialogue between project partners. In the project several specialists' engineers but also industry partners were involved and they all co-operated leading to the common goal. Partners dared to be open to different hypothetical solutions and not decide on a solution too early. Although it took time to collaborate with many partners, the result generated that more aspects than expected were solved and discussed and more questions were raised. It also resulted in that important issues and ideas were not overlooked.

• Understanding of the value of creating knowledge together already in the formation of the consortium. This made it possible for criteria to be met, discussed, and communicated in a continuous dialogue between project parties. It resulted in a wooden façade system in which all parties in the consortium were involved.

The project has resulted in commercialization of one of the components in the façade system, the developed boards with different surfaces are now in production by one of the partners see figure 6. Discussions on commercializing the entire system are continuing.

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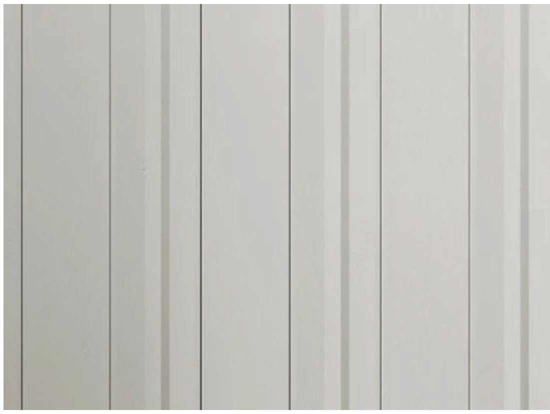

Figure 6. Image of one of the commercialized components in the façade system. (photo SCA).

4 CONCLUSIONS

Demonstrated here are the possibilities of using co-design methods when developing a façade system. The aim with the prolonged design process developed in the project was making all parties involved in the design of the new product.

The project result shows that co-design methods profoundly influenced the product development and were valuable for promoting interdisciplinary communication and innovation concerning new product development.

The architect worked closely with the project research leader in mediating and facilitating the development process ensuring the quality of the design decisions. Coming from two different paradigms in research, essentially using scientific methods on the part of the research leader and design methods on the part of the architect the negotiations between them guaranteed that aesthetic and functional qualities were developed in parallel. The architect and research leader created a solid ground for design decisions by using co-design to create trust amongst the partners in the development process.

The identified gap between the actors in the value chain was considerably diminished by using co-design methods. This was verified in interviews with the partners in the project. As one of the partners commentated, he had never really understood how design knowledge could be used in new product development in the wood industry but after the project he understood the potential of co-design methods.

The co-design method used in the project can be applied to the development of other adaptive product families in the wood industry. The design method enables criteria to be met, discussed, and communicated in a continuous dialogue between project parties.

ACKNOWLEDGEMENT

Thanks to the strategic program Bioinnovation Construction & Design, IPOS – Innovations in wood-based building materials and products, subproject "The facade of the city Swift, Stylish, Smart". The project is founded equally by Vinnova Sweden's innovation agency, the Swedish Energy Agency, and Formas together with the industry partners. Thanks to E2B2 Swedish Energy Agency concerning the project Climate smart renovation with innovative façade system. A special thanks to SCA and Hedlunda for industrial input and KBAB.

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