

IMPROVING DEVELOPMENT PROCESSES IN HOUSE-BUILDING THROUGH IMPLEMENTATION OF BEST NEW PRODUCT DEVELOPMENT PRACTICES

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Abstract

Construction companies developing new housing projects have signalled an increasing amount of problems with their construction processes. In particular, the lack of adaptation of the current processes to a changing market environment result in unwanted failure costs.

This paper looks at the possibilities of improving development and construction processes in house-building by adopting ideas and practices from industrial new product development. To that end, the processes in both industries are compared to each other, and potential improvement areas are identified.

In this preliminary research the construction practice of one of the largest construction companies in the Netherlands has been used as a case study. This way, better insight in real world problems was gained, and both advantages and consequences of process changes could be checked.

Keywords: house-building, new product development, design practices

1 Introduction

Developments in the Dutch housing market, like changing consumer demands and regulations, are making the current development and construction processes in the building industry increasingly ineffective. In particular, failure costs in projects are seen as a major problem. Construction companies feel that there is a need for process innovation in the house-building industry, and that inspiration can be found in industrial new product development processes.

To that end, Ballast Nedam Bouw, one of the largest construction companies in the Netherlands, wanted to investigate which practices of the industrial product manufacturing industry can advantageously be transferred to the housing development process. As a first step, a preliminary study into this subject was carried out as a graduation project at the Faculty of Industrial Design Engineering of the Delft University of Technology.

The goal of this project was to identify ideas and practices in NPD that might contribute to the improvement of construction practice in house-building. Important questions were:

- What ideas and practices of NPD processes can be adopted in house-building?
- How do these ideas and practices relate to the near-future housing market?
- What are the consequences of these ideas and practices for the current business processes of construction companies?

This paper presents the results of this study, focusing on the outcomes as far as they are relevant for construction companies and development processes in general.

2 Methodology

Research into this subject was partly conducted at the large Dutch construction company Ballast Nedam Bouw. Their experience and development practice were used as a large case study, which served to compare actual construction practice with NPD-theory. It was observed that the findings at Ballast Nedam Bouw are highly comparable to the ways of working in other construction companies, and can thus be seen as representative to the house-building industry in the Netherlands in general.

As a first step, the current situation regarding working processes in construction companies was researched by means of conducting interviews, studying internal processes, and reading relevant literature. Also, the main problems in current building practice and their relationship to market demands were identified. This research was limited to the Dutch situation, so the conclusions cannot automatically be generalised to a broader international situation.

These analyses served as a basis for a comparison of real world development processes in construction companies with a more theoretical view of industrial NPD processes, based on best practices. Similarities and, more notably, differences were found, and possible improvements were identified, taking into account the weaknesses of the current construction practice. The comparison led to a series of recommendations to improve construction processes. Additionally, steps to implement these changes in current business processes were proposed.

3 Current practice in construction companies

3.1 Characteristics of development processes in house-building

For this project, research was carried out to obtain a good view of construction processes in house-building projects. Major construction companies carry out both development and building activities in these projects. The construction company coordinates all activities, but a lot of the actual work is outsourced to external partners in design, development and building phases (Figure 1)

The following main characteristics were found to be specific for these projects:

- Division of development and construction functions: even when development is carried out by the construction company itself, development and construction are separate processes, linked by an interface. This is the case in the functional organisation of the company as well as in the project organisation. Each of the functions has its own director.
- Project development is mainly a serial process [see 1] with design, sales and construction phases respectively. In this process, design decisions concerning housing are taken over a very long trajectory.
- External parties like suppliers and contractors have very limited influence in the project, although a large amount of the total work is contracted out to them. They carry out the work, but do not share responsibility for the end results.

- Construction companies are very project focused; they tend to view their production as a series of independent projects [2]. No connections are made between the various housing projects. This attitude affects the setup and execution of the development processes.
- Cost reduction is an important factor in the setup of the current development and construction processes, influenced by market circumstances. This results in a tendency to start the actual construction (the ‘primary process’) as quickly as possible.

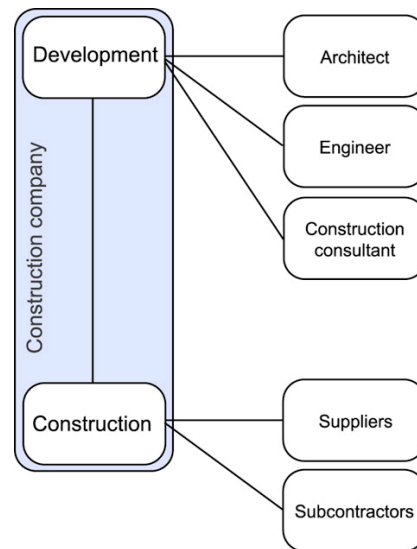


Figure 1. Construction team

3.2 Problems in current house-building projects

In current house-building projects, construction companies have signalled an increasingly higher number of unwanted results. The main issue is the increase of failure costs, which are associated with unforeseen changes in the construction during the building phase, a longer than expected building phase, and construction errors that have to be corrected afterwards.

However, interviews with employees and media articles signal more negative effects:

- Projects are delayed and exceed budgets because of legal procedures and issues.
- Construction companies offer buyers more freedom of choice in the configuration of their houses, but this generates problems in on-site construction planning.
- After development, houses unexpectedly turn out to be hard to sell in the marketplace.
- After the realisation of the housing project, construction companies face buyers with complaints about building quality, construction errors and configuration mistakes.

Although part of these issues is the result of external influences, it can be concluded from the preliminary study that the current construction processes are a major cause for these unwanted results. Studying the current practices the following causes were identified:

1. *A lack of adaptation of housing development to market demand.*

Although part of the problematic situation of supply and demand in housing development is influenced by residential zoning plans, development processes in construction companies are a major cause. Housing development projects have a time span of several years, so indicators

of market demand used to determine what to build are outdated by the time the project is realised. Moreover, the decision of what to build is influenced more by the profit rate of different housing types than by actual market demand.

2. A lack of integration and collaboration in the development phase

The architect, main engineer and construction advisors all have a very limited role in the design. They are all contracted by the construction company to do their part of the job, but this is not an integrated effort. In practice this means the architect delivers a concept design, which is then modified in a series of suboptimisations, resulting in design changes that have to be made during work preparation, a lack of attention to certain construction aspects, or even conflicting design decisions with regard to building components.

3. A lack of coordination in the total design process

As mentioned before, there is no single person or function that coordinates the design process from first development activities to the building phase, although design decisions are made during all phases of the process. There is a lack of direction from design to production. The current form of documentation, which does not allow for design decisions to be recorded unequivocally, augments this problem. This leads to different interpretations of design decisions.

4. A lack of process control in the construction phase

In the preparation and execution of the actual construction, planning, purchasing and work preparation, activities are executed parallel and under time pressure. A large part of the work is handed out to subcontractors and suppliers, who are responsible for making their own working drawings based on general documentation. Process control problems are caused by

- Wanting to start with the actual construction as soon as possible;
- The lack of a document management system to eliminate errors;
- A lack of attention to construction site logistics.

This results in construction errors and delays because subcontractors use outdated drawing files. Also, the building activities of different contractors are not adjusted to each other.

5. A lack of preparation in the project

In the house-building industry, prior to actual development activities, minimal attention is paid to risk analyses, coordinating the collaboration with external participants in the process or setting up a program of demands for the project.

In practice this leads to:

- Problems concerning the collaboration with contractors, or unforeseen complications with local regulations or properties of the building location;
- A lack of commitment and willingness to communicate among the involved contractors;
- Design changes in later stadia of the project because of unclear starting points.

In the construction process, the lack of preparation is caused by a tendency to start building as soon as possible. In practice, building often already starts while engineering is not yet finished, construction drawings are incomplete and subcontracted work has not been checked. This regularly leads to last minute design changes and construction errors.

The identified problems in the current construction practice are concerned with principles like preparation, integration, collaboration and control. These issues served as starting points for comparing construction practice in house-building with best practices in NPD.

4 Comparison of housing development practice in construction companies and NPD-theory

The current practice of construction companies has been compared with modern views on NPD in the manufacturing industry. This comparison has been based on generic models of the product development process, such as concentric or concurrent development [3, 4] and stage-gate progression [5], as well as on reported best practices in industry, such as Design for X [6], LCA and quality control systems. Comparing the two development processes on different levels with respect to process structure, activities and phases, and looking at the similarities of both processes, it was found that:

- In both cases the process consists of a series of consecutive phases, in which preparation, development, sales and production activities are represented in a comparable way.
- In the design phases the steps from first idea to detailed design are defined in a similar way (although they do not necessarily consist of the same activities).
- In both cases of development, a temporary project organisation is formed, in which different functions are brought together. Comparable issues with respect to collaboration, coordination and integration are relevant here.

For finding possibilities for process improvements, however, the differences between the two development processes are far more interesting than the aforementioned similarities. From this preliminary study, the following issues appeared to be the most significant differences with respect to the practices in both industries:

1. *Serial versus parallel execution of process activities*

In NPD, the preparation for production and marketing of a product is started parallel to product design. This approach reduces the total development time of the project, and thus shortens the time to market.

In housing development, the preparation to the actual on-site construction (including design detailing) is delayed until a large percentage of the houses in the project are sold. This reduces investments needed in the project, but also causes a delay in the total development time.

2. *Different sequences of design, sales and production*

In NPD processes, the design detailing and production preparation are generally completed before production and sales commence. Depending on the type of product it may be first produced and then sold, or produced on client order.

In construction practice, first a concept design for the housing is made, which is used to sell the houses. When the project is sold, the design is further detailed and production methods are chosen. This means that in the building phase there are lots of design decisions that still need to be taken. This causes time stress because the contractor wants to deliver as fast as possible.

3. Concentric development versus aspect design

In NPD and housing development the design of the ‘product’ is developed differently. In housing development, an architect creates the basic three-dimensional design, which is then elaborated by an engineer and construction advisors to make the design production ready and compliant with all regulations. The architect creates the aesthetics of the housing, but does not actively consider construction components of the design. The design of housing starts as an aspect design, which is then modified and optimised a number of times (Figure 2).

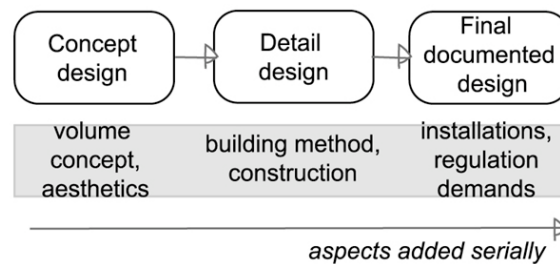


Figure 2. Design development in house-building.

In NPD best practices, all aspects of the new product are considered from the earliest design phases, and they are gradually detailed during the process. The design evolves in a concentric way from global to detailed. Optimisations are used to improve certain aspects of the design (Design for X methods).

4. Influence of the end user on the product design

In NPD processes of consumer products, it is common to consider potential target groups and research their needs by market research, either before or during the development process. Their preferences are considered in the development of the product, and possible configuration choices (as in cars) are largely predefined.

In housing development, market research is barely used; houses are being designed without end user involvement. Designs are based on general insights and the architect’s preferences. Buyers are allowed to specify individual preferences after acquiring the premises, in consult with the developer. These preferences are not pre-specified, and have to be individually planned in construction preparation.

5. Preparation activities in the development process

In NPD theory, preparation activities before the start of the development phase are more thorough than those found in house-building practice. NPD theory suggests forming a business case at the start of a development project, stating business possibilities, forecasts and risk analyses. This then results in a detailed design brief. In house-building projects, only a rough financial feasibility study is done, and a basic program of demands is made. Risk analyses exist in the building industry, but they are not used in housing development.

And, as mentioned before, while in NPD a marketing function employs activities to adapt the product to and introduce it in the market, in house-building this is non-existent. The commercial function is purely a sales activity.

6. Management of the development process

Compared to housing development, in NPD processes the responsibilities for the management of a project are more clearly defined and during the project more control measures are taken to ensure the project will deliver the designated results.

In house-building, several people are in charge of the project during the consecutive development and construction phases. From development to realisation, the design of housing is the responsibility of a project developer, a project manager and a project leader. Development and construction are separate processes, and despite internal meetings, there is no deliberation about design problems that need to be solved. In NPD, it is common to form a project team with a project leader who is responsible for the project from beginning to end. To facilitate internal communication, the multidisciplinary project team consists of members from all relevant disciplines.

Also, while in NPD best practices a project is monitored at regular intervals ('gates') to check if it fits strategic, business and financial goals, this is done more superficially in housing development. Usually management checks are purely financial go/no go decisions.

7. Supplying and contracting

Both in NPD and house-building businesses, suppliers are contracted to carry out production activities, but their position and responsibilities differ. In NPD it is common to involve suppliers early in the development process, contracting out the production of certain parts as well as the related development activities. These practices have led to the forming of co-makerships, where suppliers share a responsibility in the development process. In house-building decisions on components to be used and subcontractors to be hired are made in the work preparation phase (i.e. after the design and sales phases). In the development phase, practically no component decisions are made and no suppliers are involved.

8. Use of ICT in development and production

The use of ICT systems to support the development process is more extensive in NPD than in housing development. Particularly in businesses that develop complex products, ICT support plays an important role. Design, production and process control rely heavily on software applications. Integration of the various applications is an important characteristic, facilitating the exchange of data and the communication between departments and functions.

Although in house-building CAD systems are used to lay down the design and software is used to plan on-site construction, the integration between the various systems is insufficient. Since the various departments and suppliers use incompatible software, checking plans and drawings must always be done manually. Systems dealing with these problems have already appeared on the market, but construction companies do not make use of them yet.

5 Potential improvements to development processes in house-building

5.1 Recommendations

Based on the outcomes of the problem analysis on house-building development and the comparison of the two development processes, a number of recommendations were formulated to improve the development processes in the Dutch house-building industry.

Changes are necessary for construction companies to adapt to developments in the housing market and the building industry. To reduce costs and improve the quality in the construction process, a more integral development process is necessary, with more attention to preparation and development phases. Furthermore, to realise significant improvements changes in the current business processes are needed.

The following recommendations together form a proposal for an alternative setup of the development process in house-building (Figure 3) from a product designer's perspective.

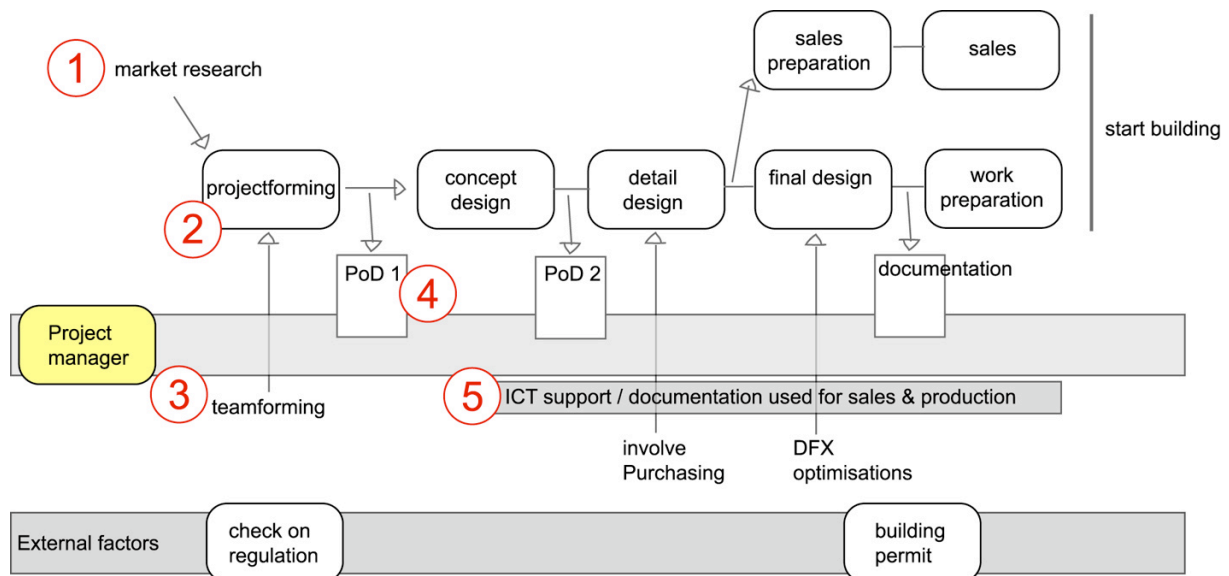


Figure 3. Proposal for an alternative setup of the development process.

1. Adding a market research function to the development process

In the case of construction companies who develop their own housing projects, the first step in the development process is determining the desired type of housing. Relevant indicators are:

- The type of housing that is in demand in that area;
- The needs of potential buyers in the relevant market segments.

Adding a market research function to the development process will help to gain insight into these questions. In collaboration with the involved architect, relevant consumer needs can be translated into a program of demands for the desired housing. Construction companies will thus be able to better adapt the housing development to the actual market situation.

2. Developing an integral development and building process

A development process in which all parties are more closely involved in the main process offers opportunities to reduce design and construction errors and shorten the time to market. Two measures are of importance here.

First, drawing the purchasing function from the construction process into the development process. This way design solutions can be found by using available knowledge in the supplier market. This approach will improve the integration of third party elements, like installation systems, into the design, and offers the possibility to lay down the complete specifications for the housing earlier in the process.

Secondly, starting the work preparation for construction parallel to the sales phase to reduce total development time. Fully planning and optimising the on-site construction work will reduce design and construction errors and ensure a better estimation of the construction time. By standardising buyers' options for personalisation, these individual configurations can be integrated in construction planning.

3. Management of the process by a multidisciplinary development team

To achieve an integral development process and facilitate communication between all participants, a multidisciplinary development team should be formed. This has to consist of members of all main disciplines, including an architect, an engineer, a constructional advisor and a project developer. The team will share the responsibility for the first concept of the housing, and for overseeing that attention is paid to all aspects of the design during the development process.

The development team should be led by a project manager, who will be responsible for coordinating and directing the development and building process. While in construction companies the project developer is responsible for the commercial aspects of the project, the project manager has to ensure the successful execution of the development task. This means:

- The monitoring of progress and checking integration of all aspects in the process;
- The coordination of decision making in the design process;
- The stimulation of communication between the involved departments and contractors.

4. Putting more energy into the preparation and reviewing of the design

Several measures should be taken to significantly reduce the risks and errors associated with the current execution of house-building projects. These are concerned with both preparation and reviewing activities in the development phase.

First, the current feasibility study can be made more substantial by carrying out a risk analysis. This way potential risks in a number of areas can be identified in an early stadium and measures can be taken to control them. Results of the risk analysis can be translated to the program of demands. Focus areas in the risk analysis can include properties of and regulations at the building location, financial pitfalls, and collaboration of the involved parties. By identifying potential problems upfront and taking measures against them, complications are less likely to arise during the development process.

Next, a more thorough program of demands should be used to direct and control the development process. This will serve to:

- Communicate the goals and guidelines of the project to all involved parties;
- Better guide the design development by checking the design with the program of demands during the process;
- Reduce the number of design changes during the process and improve the quality of the design.

Rosenau [see 7] opts to formulate the program of demands in two phases, which can also be done here. As a first step, results from market research and project analyses can be translated to a first idea of what type of housing has to be developed. The involved architect can assist the project developer to define the functions of the product qualitatively. After the first concept design is created based on these guidelines, the demands can be translated to specifications, to quantitatively define what has to be built.

Thirdly, to reduce costs in the actual building phase measures should be taken to speed up the on site construction. Since the building activity accounts for the largest part of the costs of the total development project, eliminating errors and delays during this phase is essential to substantially reduce failure costs. On the one hand this can be done by fully detailing the design before commencing the sales phase. This means defining upfront how to build the design, what components will be used, and which options are available to buyers to

personalise their new home. On the other hand, it is important to complete the building preparation phase before starting the actual construction. This means ensuring that all involved parties know what to do, and that all activities are planned and coordinated.

Finally, cost reductions in the development process can be achieved by introducing design reviews in the development phase. Design for X-methods as known in NPD can be used to optimize the design on several aspects. These should be carried out by a multidisciplinary development team to achieve best results. The design can be optimized in reference to:

- Ease of production and building logistics;
- Possibilities for individual buyer options;
- Performance demands as formulated in the program of demands, like ease of disassembly, isolation performance etc.

5. Supporting the process with an integrated software solution

To facilitate the exchange of design documentation, an integrated software solution should be introduced to support the development process across all phases. This software must be able to integrate the functions of 3D design documentation, data exchange and management, calculation and building planning. This way files from the design phase can be directly used for sales documentation, cost calculation and the planning of on-site construction.

Also, setting a drawing standard means suppliers and subcontractors will be forced to all use the same format, eliminating difficulties in data exchange.

5.2 Benefits

In the recommendations above, possible benefits of process changes have already been mentioned. Nevertheless it is useful to summarise in what way the proposed approach can improve the current building process.

Likely the most important motivation for construction companies to implement these changes is the possibility to realise cost reductions. These are possible because:

- The occurrence of design errors will be greatly reduced by using a more integral approach to the design process, including optimisations and design reviewing. This leads to fewer design changes during work preparation and building phases.
- Chances of construction faults and planning errors during the building phase are minimised by paying extra attention to work preparation and using electronic data management.
- A reduction of development time can be achieved by implementing 3D CAD systems in design and by specifying the exact components as early as during the development phase. Also, executing sales and work preparation activities at the same time and putting more energy into preparation of the building phase will shorten the realisation process.

However, besides cost reduction, an alternative setup of the development process offers more potential benefits. Firstly, by using market research and shortening total development time, construction companies will be able to better adapt to changing market demands and consumer wishes. Next, reduction of design and build errors means the quality of the final product will be improved. Thirdly, a more integral approach to the development process offers possibilities for improving the quality of the design. Multidisciplinary development

leads to better integration of functions and aspects in the housing design, and by involving purchasing in early design phases, product innovation at suppliers can be implemented more easily. To realise these benefits, the proposed approach to house-building development does require more discipline in completing each development phase, and a greater commitment to the project of all members of the development team.

6 Conclusion

This preliminary study showed that development processes in construction companies and industrial product manufacturing companies are comparable, although a number of key differences in current practice were identified. Several key differences offer opportunities for construction companies to improve development processes. Adopting certain practices in NPD may potentially improve processes and solve certain observed problems in house-building development.

Changes to current construction processes may lead to the following improvements:

- Reduction of the overall costs of projects, particularly in the building phase;
- Reduction of design and build errors, thus improving build quality;
- Reduction of the total development time;
- Better adaptation of the final product to market and consumer demands.

Some of the changes can already be realised within the current setup of development processes in house-building. However, full implementation of the suggested integral approach to the development process does require changes in the current business processes of construction companies.

The project reported here was a preliminary study based on findings in the Dutch situation; further research is required to get a more thorough view on the validity, benefits and consequences of the proposed changes to the development process in construction companies. As mentioned before, these findings cannot be automatically generalised to other countries.

On the one hand, further work should focus on the detailing of the process itself. If a more concentric and integral development process is adopted, what consequences will this have for the collaboration of the involved disciplines, and what activities should be carried out in the subsequent phases of the process?

On the other hand, further research is needed to clarify the consequences of changing the development process to the business processes of construction companies. Changing the order of certain activities and phases in the process does have consequences for the cash flow and required investments in the company.

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