The factors of a successful industrial construction process

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1. INTRODUCTION

In the late ’80s and early ’90s, people at HBG Woningbouw came up with the idea of changing the way the construction of housing projects was organised in order to respond to the market demand for cheaper rented and owner-occupied accommodation.

They found that this project organisation could generally be characterised by the following aspects:

2. CHARACTERISTICS OF THE TRADITIONAL CONSTRUCTION PROCESS

1. **Every new development is built up from scratch:**
   Every new project development is built up from nothing and ultimately ends up with a set of specifications, contract drawings and a contract price for the work in question. The composition of the construction team that starts on this assignment changes for each project, as do the agreements concerning responsibility for the various aspects of the project.
   All members of the construction team are expected to do their level best on each occasion to ensure a definitive set of specifications and a final contract sum. In the process, each member of the construction team makes full use of the knowledge and experience he or she acquired on previous projects and tries to incorporate the successful experiences into the new project.

2. **Choice of construction method is largely determined by the design:**
   The choice of construction method is largely determined by the architect’s design and to a far lesser extent by the specific techniques that the contractor commands. As a result, contractors have all-round proficiency in many construction techniques, but lack specialisation in a particular construction technique, thus losing out on the efficiency benefits that such a specialisation could yield.

3. **Projects are completed in varying team composition:**
   Construction work is done by people. Each project requires a team of people appointed to carry it out. The composition of the team will vary from one project to another due to a project’s specific requirements and problems of co-ordination with other projects running at the same time. As a result, those involved make working agreements that only apply to that particular project. People obviously try and take the same agreements with them to subsequent projects, but these new projects have different teams and each member has his or her own working agreements to offer, and they once again have to reach some kind of compromise.

4. **Projects are completed with varying subcontractors:**
   Construction requires collaboration with subcontractors. Whatever applies to the agreements between project team members applies to an even greater extent to the agreements between the main contractor and subcontractor. These agreements often only become clear to both parties upon completion of the project. There is very little chance of being able to use the same agreements for a subsequent project, however, since the composition of the main contractor’s team will have changed and selection for a following project is often only based on the price involved.

The conclusion was that in the case of the traditional construction process, each project is considered to be unique, so that process improvements hardly extend beyond each individual project. Staff at the former HBG Woningbouw housing corporation for the north-west region of the Netherlands ultimately came up with the idea of changing the way in which the construction process is organised in order to keep the loss of know-how, experience and agreements to a minimum.
This idea was put into effect in the early '90s as the W&R-Bouwstroom construction flow; since then, more than 6,000 homes have been completed on the basis of the new concept. The idea was never intended as a means to develop a standard residential unit and build it wherever possible in the Netherlands, but rather to put up a large variation of units based on the idea of a standardised process.

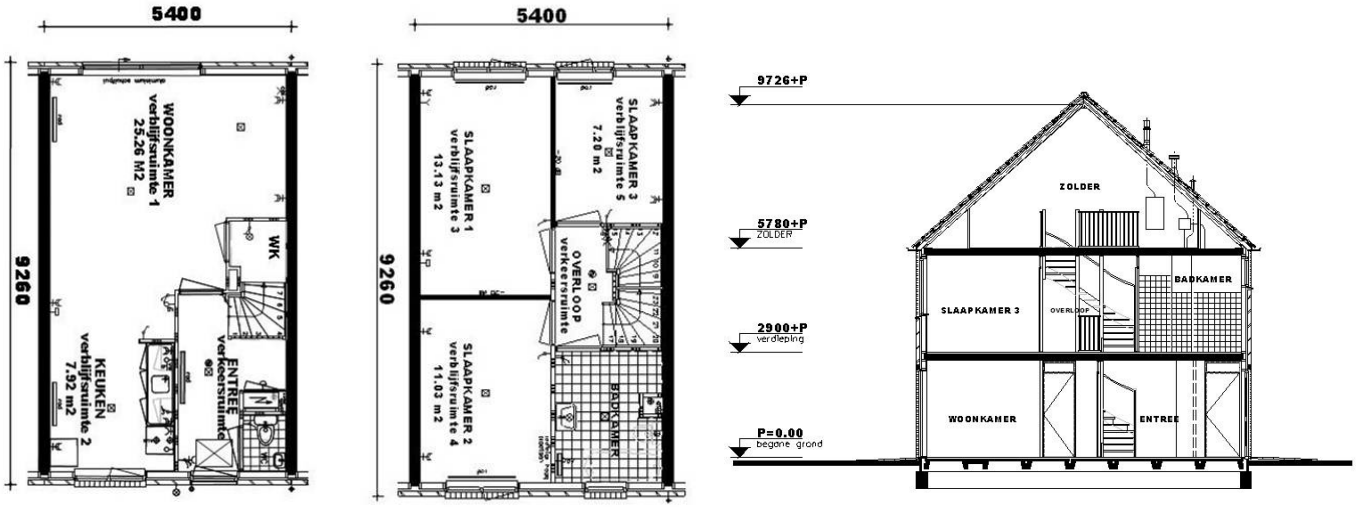
Now, ten years on, we can say that the W&R-Bouwstroom concept represents a standardised process that can be used to construct a large variety of products, as you can see from the photographs below.

3. INDUSTRIAL CONSTRUCTION

The critical success factors for the process are as follows:
- Development and construction using a reference building
- Production using construction flows
- Co-making

3.1. Development and construction using a reference building:

The W&R construction flow has a reference home that is defined in a set of specifications, a set of working and detail drawings and a budget. The reference home is a complete residential unit that meets the requirements of current legislation and has a plain but effective finish. By using the reference home as a starting point, it is no longer necessary to start every development from scratch because a lot is already known when the development begins.



Floor plans + cross section of the reference home

When a new development starts, the architect is commissioned to create a design based on the reference home. The architect is free to adapt the unit at his or her own discretion in terms of dimensions, extensions, rooftop structures and wall and roof finishes, provided these modifications can be completed using the standard process. The projects finished in the last ten years show that this has resulted in a large variety of home designs.
When the architect's design is compared with the reference home, any deviations from the reference point can be identified relatively quickly and easily. The W&R organisation is completely familiar with the reference and it requires no further attention, so that the organisation's full attention can be

focused on the deviations, from the first developments right up to the project's completion. The price charged to the client is based on the reference home and includes a list of the deviations and their consequences for the price. This gives both client and architect plenty of time to identify relatively expensive or cheap plan deviations and take appropriate measures.

3.2. Production in construction flows

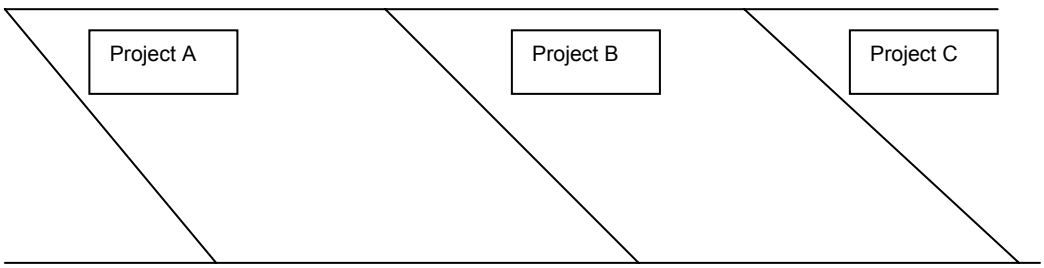
Each project carried out by the W&R organisation is scheduled into one of the 4 construction flows. A construction flow is the available production capacity; the organisation has to ensure that this production capacity is utilised to the full.
This available production capacity comprises a project team, a production team and various co-makers. The project team and the production team consist of staff employed by the W&R organisation. Each construction flow project team has a fixed composition comprising a project manager, a co-ordinating foreman and 2 or 3 project organisers. Each construction flow has 4 production teams, i.e. a tunnel formwork team, a rooftop team, a wall/roof team and a joinery finishing team. All other activities required for the completion of the project are carried out by co-makers.

In addition to a fixed team, there is also a standardised production process. The total production process of a W&R project is split up into 42 subprocesses. For each subprocess, there is a description of the condition of the object when the responsible party starts work, what activities are required in that subprocess and the condition the object should be in when that part of the work is finished. These 42 subprocesses occur on every project. Essential subprocesses of the W&R process are:

- Piling work
- Prefab foundation beams
- Prefab rib-slabbed floor
- Frame with formwork tunnel cast on site
- Wall-sealing wooden frame construction elements
- Prefab roof structure

Since every project has the same subprocesses, it is possible to make far-reaching agreements with all parties regarding the efficient and effective execution of the subprocesses. Now that all parties are quite clear about what they are expected to do, we see in practice that parties point out any deviations from those agreements to the person responsible.
Using this production capacity and the standardised production process, projects can be modelled on the reference home one after the other. The production process is always the same, but the location and actual product change from project to project. An activity on one project cannot begin until the same activity on the previous project has been completed. When projects are scheduled like this, under- or overstaffing is avoided and the available capacity is utilised as efficiently as possible.

Construction flow principle



The fact that the teams are always the same creates a situation in which the agreements made between the members of the team go beyond the project in question. This enables both the team and the organisation to progress to a higher level.

3.3. Co-making

The subprocesses that are not carried out by members of the organisation are performed in association with various co-makers, who assume responsibility for one or more subprocesses. An important reason for choosing co-makers is again that the agreements made between the main contractor and the subcontractor may go beyond the unique project, giving the process and the product an ever-improving price/quality ratio.

The co-makers are completely familiar with the reference home and each one has worked out what is required for his own subprocess on the basis of the reference. If a co-maker has ideas that can lead to optimisation of his process or product, he will notify the W&R organisation and the improvement can be incorporated into the annual update of the reference home.

Every year, a framework contract based on the reference home is concluded with the co-makers. Just as the W&R deducts the deviations from the reference home for its client, the co-maker indicates the deviations in each project in relation to his framework and a project assignment is drawn up. To make sure everybody involved is well aware of how the production process is progressing, a commencement meeting is held for each subprocess no later than on the starting date of each new project.

4. IMPLICATIONS OF AN INDUSTRIAL PROCESS

Continuous process improvement

By acting in strict accordance with these four success factors right from the very first projects, the existing four W&R construction flows have become a mobile factory with the conditions required for continuous process improvement, thus cutting the costs of failure. On each project, a progress meeting attended by the entire project team is held every four weeks. The ‘error cost list’ is a fixed item on the meeting agenda. This list is opened at the start of construction work and everything that goes wrong in the preparation or execution phase is put on the list along with the resulting failure costs. Keeping this list makes everyone aware of the consequences of the errors that are made and has a preventive effect for subsequent projects.
Splitting the process into 42 subprocesses with a clear-cut division of duties and responsibilities also has a positive influence on the reduction of failure costs. On the one hand, everyone is aware that any failure to fulfil agreements are pointed out to the party responsible. On the other hand, each respects the work of the other so that parties deal more consciously with the same failure situation. This prevents situations in which errors or shortcomings are concealed, only to be discovered at a later date or, worse still, after completion.

When the homes are handed over to the client, it is clear how the process progressed up to completion. In recent years, the W&R has managed to hand over homes with an average of no more than 4 flaws per unit in the hand-over report. Some projects have even been completed with an average of fewer than 1 flaw per home. These projects are characterised by easily manageable deviations from the reference, so the standardised process can be applied as efficiently as possible.

Changes for the client and the architect

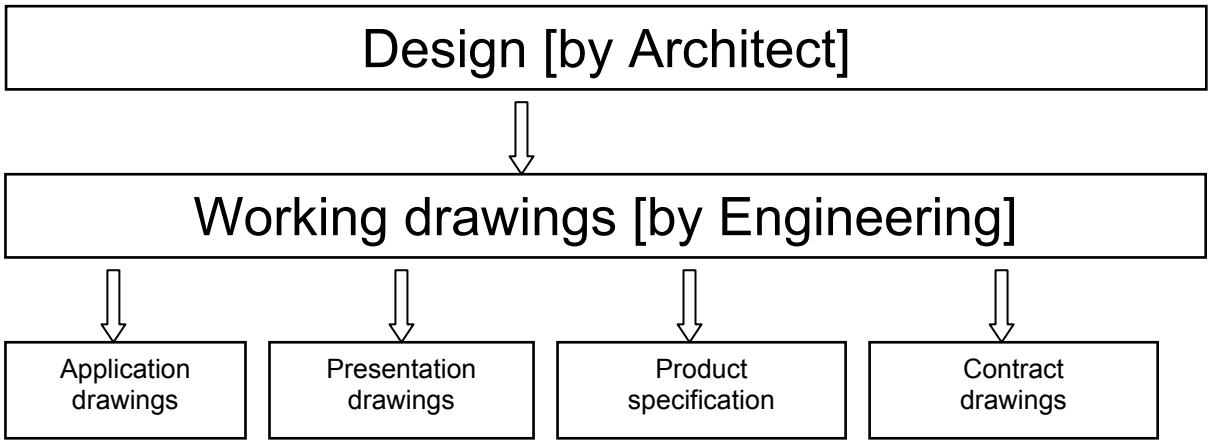
When a client wishes to use the development and production facilities of a W&R construction flow, this will change a number of aspects of the traditional development and production process.

To make optimum use of the advantages, clients are best advised to decide whether they wish to utilise the W&R concept right at the start of a project. If a client opts for the W&R concept, it is important to hire an architect willing to design according to the preconditions laid down for the W&R reference home.

Examples of designs according the W+R concept

The client then commissions the architect in accordance with the Standard Conditions Legal Relationship Client Architect (SR) up to and including the Final Design (DO) phase and the procurement of planning permission. The client is advised to give the job of drawing up the structural specifications to BAM Engineering, because BAM Engineering is fully aware of W&R's capabilities and they both know how the final documents should look. The same applies to the drafting of the structural working and detail drawings. The client is advised to call in BAM Engineering for the same reasons.

In close consultation with all parties concerned, the construction team then drafts the design for the specific project. Using the architect's initial sketches, the W&R can provide a quick indication of the consequences for the construction costs. Once the architect has completed the Final Design (DO) phase and a price has been agreed between the client and BAM Woningbouw, BAM Engineering starts with the draft of the working and detail drawings, also referred to as product specification. The client and architect are always best advised to wait until completion of the product specification and use these documents as a basis for the planning permission application and presentation documents. This procedure, which is shown in the diagram below, prevents a great deal of checking work for all parties concerned and makes it difficult if not impossible for any discrepancies to occur in these documents, because the product specification is worked out to the last detail.



- application drawings = working drawings -/- too much + what's missing
- presentation drawings = working drawings -/- too much + what's missing
- product specification = working drawings -/- other documents
- contract documents = working drawings + invoice [+ specifications]

- responsible for planning application: Architect
- responsible for the sale: Vastgoed
- responsible for the working drawings: W&R
- responsible for the contract: Vastgoed & Regio

Before starting work, a good construction team will always draw up a Preparatory Activity Schedule (abbreviated to VAS in Dutch) containing important milestones in the timeline. An important milestone for the W&R-Bouwstroom is the planned commencement of construction in relation to the required continuity of the 4 construction flows. Solid agreements concerning changes in the VAS are made during the development of the project. Once BAM Woningbouw have been awarded the contract, the W&R organisation can make a definitive decision on which construction flow the project in question is to be allocated to.

In comparison to traditional projects, once construction work begins, nothing much changes for the client and architect other than that they are now dealing with a seasoned team that can build the homes according to a schedule agreed on in advance. If the process runs smoothly, the homes will be delivered to satisfied buyers with a minimum number of flaws in the hand-over report.