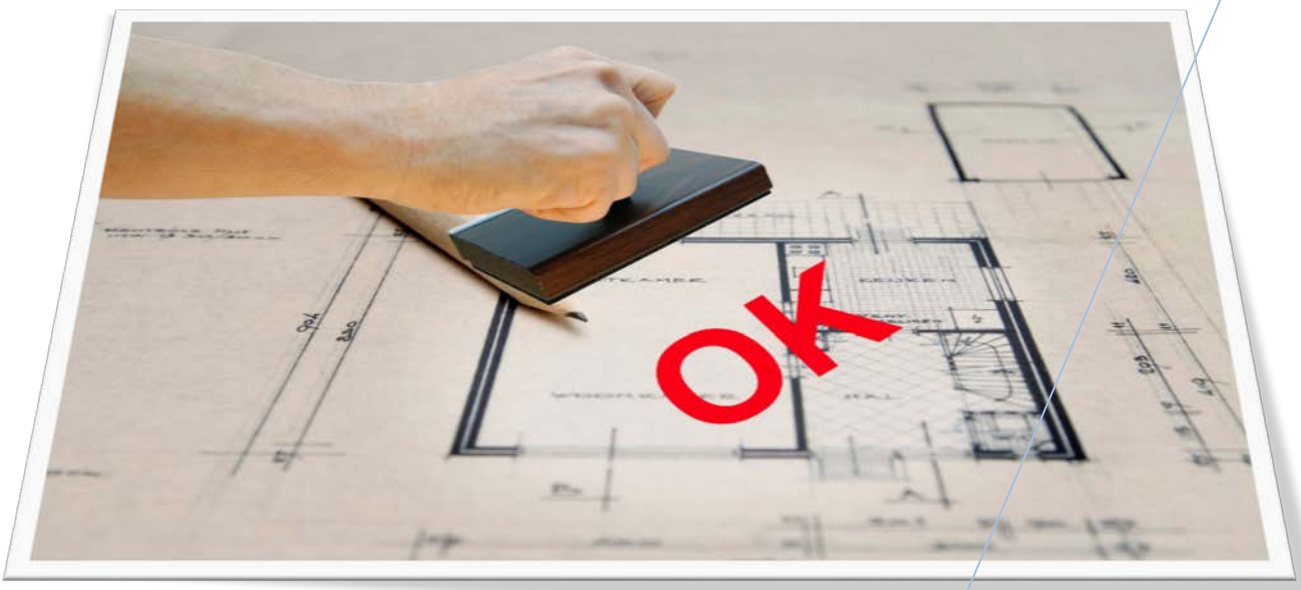
The Quality Assurance act for construction in the building process



Colophon

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Preface

This report is written as master thesis for the master Construction Management and Engineering at the Eindhoven University of Technology.
The thesis is conducted in cooperation with construction company Van Wijnen Group N.V.
The subject of my thesis is the new quality assurance act for construction (*Wet Kwaliteitsborging voor het bouwen*-Wkb) in the building process, which is a very interesting subject for my master thesis but at the same time resulted in also a lot of work.
With the help and support from my supervisors, family and friends I was able to finish my research. Therefore, I would like to make use of the opportunity to thank a number of people by name who made this graduation paper possible.
First, I would like to thank Henk de Jager, my supervisor at Van Wijnen, for his time and feedback on my research. During the research, his comments and support gave me new insights for my research.
I would also like to thank my supervisor Bauke de Vries from the TU/e for his inspirational guidance, advice and comments on my research. A special thank goes out to Aant van der Zee. He was asked last minute to assess my master thesis and was willing to do so. In the limited time left until the final deadline he was able to assess the thesis and provided me with valuable well-founded advice.
I would like to thank Wilbert Hilverda for providing practical advice and support during my research.
I would also like to thank my fiancé Nick Bredewold, who helped me with the little but important things during my research. He was the one who picked me up dragged me through it when I was feeling down.
Lastly I would like to thank my parents, especially my father, for their support and help during my research. Anneke and Harry always believed in me even when I didn't believe in myself and thought I wasn't good enough. My deep appreciation.
With this research I hope to give more insight in how to implement the Wkb in building process management systems.

Glossary

Systems Engineering
Systems Engineering is an interdisciplinary approach and means to enable the realization of successful system.
Quality Assurance Act for construction (Wet kwaliteitsborging voor het bouwen)
The quality assurance act for construction is a new law. This act changes the responsibility for meeting requirements of the Building Decree. The construction company becomes responsible for the compliance of the act instead of the local government (municipality). The construction company must show how he has meet the Building Decree.
Building Process Management System
The Building Process Management System (BPM) is the way a building process is organized. It starts with the Program of Requirements and ends with the completion of the building (sometimes with maintenance).
Bouw Information Model
The Building Information Model (BIM) is a set of data which represents a building structure.
Compliance
To meet the requirements of the Building Decree a part of the BPM system is equipped to show that the requirements are met. For this part of the BPM system a new quality system is designed.
Independent quality inspector
The independent quality inspector (KB) has the permit to use an admitted quality instrument (quality management system). He has to give the statement that the building meets the requirements (as-built statement).
Instrument
Instrument for Quality Assurance is an assessment methodology which has the purpose to determine whether there is a justified trust that building a structure meets the requirements which are addressed by or pursuant to a General Board Measures (*Algemene Maatregel van Bestuur*-AMvB) referred to in Article 2, first paragraph, preamble and under a, fourth paragraph or Article 120.
Instrument provider
natural or legal person which submits an application for admission of an instrument or tool in the system of quality assurance for construction to the Admission Organization.
Admission organization
Admission organization will issue permits to certain offered instruments and checks if the instruments are functioning in practice.

List of abbreviations

SE	Systems Engineering
KB	Quality Inspector
IA	Instrument provider
TO	Admission Organization
BG	Competent Authority (most of the time the municipality)
ZBO	Authorization Organization
Mvt	Explanatory Memorandum
KAM	Quality, Health & Safety and Environment
BWT	Local organization for construction and housing inspectorate
Cf.	Conform
BRL	Assessment directive
KV	Certified quality statement
QCL	Quality Checklist
CP	Control Protocol
BPM	Building Process Management
BPMN	Business Process Model and Notation
AMvB	General board measure

Summary

The Quality Assurance act for constructions (*Wet kwaliteitsborging voor het* bouwen- Wkb) is going to radically change the responsibilities and the building process. This research has provided answers to the main question *"Is it possible with systems engineering (SE) and Building Information Modelling (BIM) to efficiently deliver an as-built statement which the independent quality inspector can present to the building permit holder under the Quality Assurance for construction Act (Wkb)?''*

To be able to answer the main question a couple of sub-question are established and answered. Firstly, is has been established what the Wkb means and thereafter the in this act proposed approach is compared to systems operating in neighboring countries. The Wkb is an amending law which will change 3 laws. The position of the consumers is strengthened by the Civil Code (BW), the Environmental Licensing (General Provision) Act (WABO) is being amended to enable a large number of small constructions do no longer need be tested on the structural requirements (Building Decree), however the construction company remains responsible for meeting these requirements. The third law to be changed is the Housing Act (WW). In the current situation the municipality (BG) checks the construction plans beforehand, through this law the license holder shows with the help of an independent quality inspector (KB) that the requirements of the Building Decree are met. The KB drafts a so-called as-built statement attesting that the completed project meets the requirements. The as-build statement will together with the as-built dossier for structural and fire safety be send to the municipality by the license holders (for example; project managers). Thereafter the project may be put into use.
This new system has been compared to the systems used in Germany, England, France and Sweden in this thesis.
In those countries, the responsibility for showing that the building regulations are met lies largely by the private parties. The conclusion is that the new Dutch system has better (clear) roles and can work well. The reviewed countries however have more requirements on the qualities of the parties concerned than anticipated in the WKB. Systems Engineering is necessary to check effectively and efficiently and also to deliver what the customer expects. ICT support with the aid of BIM is necessary in order to limit the costs and to avoid failure costs. Through BIM Server it should be able to approach the quality management system of the project. The data which shows that compliance with the building regulations is met is systematically stored in the BIM server and can therefore be consulted by the KB and the parties concerned. The KB will have access to the BIM server so the KB is able to efficiently follow the project. In order to determine compliance with the Building Decree an existing building process management (BPM) of a medium size contractor is edited on the risk and quality management parts. The current BPM system consists of a matrix containing the indicated work per phase. Through this matrix, the underlying procedures can be found and used. For quality management a set of protocols is in use, including the so-called *'Keuringslijsten'*. The designed BPM-system is equipped with an extra step and the *'Keuringslijsten'* are adapted to align them with the Building Decree. From the matrix (step 1), are so-called quality checklists (QCL) controlled (step 2), the *'Keuringslijsten'* are controlled via the QCL which are called Control Protocol (CP) in the new system (step 3). The new system was tested on a realized project and proves workable. Next it is investigated whether the QCL's can be accessed via digital tools that are commonly used in the design, verification and validation process, namely Solibri, Revit and Relatics. This research has shown that these links can be made. An example is elaborated during this investigation. The 3D drawing (model) in Revit provides additional coding, and when clicking on a window-frame for example, the corresponding QCL will show and via QCL the CP's can be summoned, and any underlying data (BRL, NEN, KV). The QCL's and CP's will be completed and with data by in particular the work planners and executors. An important condition is that the design has been developed and tested carefully before work planning and execution starts. The answer to the main research question is that it is very well possible to deploy SE and BIM to efficiently prepare the as-built statement.

To reduce the cost of the new system's the use of BIM and SE is even more advisable. The WKB will reduce the costs of failure, because the construction process is carefully assessed in phases, which enables the detection and correction of errors. It is also recommended to prepare the implementation process very carefully and use professional change managers.

The expectation is that the digitalization of the design- and construction process will continue. It can be expected that in the future (within 10 years) for simple structures, such as houses and industrial buildings, the Building Decree Calculations and the checks on these calculations can be performed automatically. The deployment of qualified engineer’s stays necessary for complex structures.

Samenvatting

De wet Kwaliteitsborging voor het bouwen (Wkb) zal de verantwoordelijkheden en het bouwproces ingrijpend gaan wijzigen. Dit onderzoek heeft antwoorden opgeleverd op de hoofdvraag: '*Is het mogelijk Systems Engineering (SE) en een Bouw Informatie Model (BIM) op efficiënte wijze (de door de Wkb geëiste) as-built verklaring op te stellen die de onafhankelijke kwaliteitsborger (KB) moet aanleveren aan de vergunninghouder?'*

Om deze vraag te kunnen beantwoorden is een aantal onderzoeksvragen opgesteld en beantwoord. Eerst is vastgesteld wat de Wkb inhoudt en vervolgens is de in deze wet voorgestelde aanpak vergeleken met systemen die in de ons omringende landen worden toegepast. De Wkb is een Wijzigingswet die 3 wetten gaat veranderen. De positie van de bouwconsument wordt versterkt via het Burgerlijk Wetboek (BW), De wet Algemene Bepalingen Omgevingsrecht (WABO) wordt zodanig gewijzigd dat voor een groot aantal kleine bouwwerken niet meer getoetst hoeft te worden op de bouwtechnische eisen (Bouwbesluit), overigens blijft de bouwer wel verantwoordelijk voor het voldoen aan deze eisen. De derde wet die gewijzigd gaat worden is de woningwet (WW). In de huidige situatie controleert de gemeente (BG) de bouwplannen vooraf, via deze wet toont de vergunninghouder met behulp van een onafhankelijke kwaliteitsborger (KB) aan dat wordt voldaan aan het Bouwbesluit. De KB stelt een zogenaamde as-built verklaring op, waarmee verklaard wordt dat het gerealiseerde project voldoet. Deze as-built verklaring wordt door de vergunninghouder tezamen met een as-built dossier voor constructieve veiligheid en brandveiligheid verstrekt aan de gemeente. Daarna mag het project in gebruik worden genomen.
In deze scriptie is dit nieuwe systeem is vergeleken met de systemen die gehanteerd worden in Duitsland, Engeland, Frankrijk en Zweden. In die landen ligt de verantwoordelijkheid voor het aantonen dat aan de bouwregelgeving wordt voldaan ook grotendeels bij private partijen. De conclusie is dat het nieuwe Nederlandse systeem een betere (heldere) rolverdeling kent en goed kan werken. De beoordeelde landen stellen echter meer eisen aan de kwaliteiten van de betrokkenen dan voorzien in de Wkb.
Systems Engineering is noodzakelijk om effectief en efficiënt te toetsen en daarnaast te leveren wat de klant verwacht. ICT-ondersteuning met behulp van BIM is noodzakelijk om de kosten beperkt te houden en faalkosten te vermijden. Via BIM-server dient het kwaliteitsborgingsysteem van het betreffende project benaderd te kunnen worden. De data waarmee aangetoond wordt dat aan de bouwregelgeving wordt voldaan, wordt op de BIM-server systematisch opgeslagen en kan daardoor door de betrokkenen en de KB geraadpleegd kan worden. De KB zal toegang moeten krijgen tot de BIM-server, zodat op efficiënte wijze het project gevolgd kan worden door de KB. Om vast te stellen dat wordt voldaan aan het Bouwbesluit is het bestaande bouwprocesmanagementsysteem (BPM) van een bepaald bouwbedrijf aangepast op de onderdelen risico- en kwaliteitsmanagement. Het huidige BPM-systeem bestaat uit een matrix met daarin aangegeven de werkzaamheden per bouwfase. Via deze matrix worden de achterliggende procedures gevonden en gebruikt. Voor het kwaliteitsmanagement is een set protocollen in gebruik waaronder de zogenaamde 'keuringslijsten'. Het ontworpen BPM-systeem is voorzien van een extra stap en de keuringslijsten zijn aangepast om ook te laten aansluiten op het Bouwbesluit. Vanuit de matrix (stap 1), worden zogenaamde kwaliteitschecklists (QCL) aangestuurd (stap 2), via de QCL's worden de keuringslijsten aangestuurd die in het nieuwe systeem Controle protocollen (CP) worden genoemd (stap 3). Het systeem is getest op een gerealiseerd project en blijkt werkbaar. Daarna is onderzocht of de QCL's ontsloten kunnen worden via digitale tools die veel gebruikt worden in het ontwerp en verificatie en validatie proces, namelijk Solibri, Revit en Relatics. Dit onderzoek heeft uitgewezen dat deze koppelingen aangebracht kunnen worden. Een voorbeeld is uitgewerkt tijdens dit onderzoek. De 3D tekening (model) in Revit bevat extra codering en als geklikt wordt op bijvoorbeeld een kozijn dan wordt de bijbehorende QCL zichtbaar en via de QCL kunnen weer de CP's opgeroepen worden en vervolgens eventuele achterliggende data (BRL, NEN, KV). De QCL's en de CP's worden ingevuld en van gegevens voorzien door vooral de werkvoorbereiders en de uitvoerders. Belangrijk uitgangspunt is dat het ontwerp

zorgvuldig is uitgewerkt en getoetst voordat de werkvoorbereiding en de uitvoering start. Het antwoord op de hoofdvraag is dan ook dat inzet van SE en BIM om op efficiënte wijze de as-built verklaring op te stellen mogelijk is. Om de kosten van het nieuwe systeem te beperken is inzet van SE en BIM zelfs aan te raden. Door de Wkb zullen de faalkosten dalen, omdat het bouwproces fasegewijs zeer zorgvuldig wordt beoordeeld, waarmee fouten worden opgespoord en hersteld. Aangeraden wordt ook het implementatie proces zeer zorgvuldig voor te bereiden en daar professionele verandermanagers voor in te zetten.

Naar verwachting zal de digitalisering van het ontwerp- en bouwproces zich doorzetten. Verwacht mag worden dat in de toekomst (binnen 10 jaar) voor eenvoudige bouwwerken, zoals woningen en industrie hallen, de Bouwbesluitberekeningen en de controle daarop automatisch kunnen worden uitgevoerd. Voor complexe bouwwerken blijft inzet van gekwalificeerde ingenieurs noodzakelijk.

Table of Contents

Appendices:

1. Introduction

This chapter contains the research approach. The first section describes the context of the research. The second section defines the problem, questions, framework and the objective of the research. The third section outlines the approach of the research. In the fourth section the expected results are described. The last part of this chapter a reading guide is given for this report.

1.1 Context

The Dutch government is developing a new law for securing the quality of the AEC- industry. This new law is called Quality Assurance Act for construction(*Wet Kwaliteitsborging- Wkb)*.The new law contains two main topics: The first main topic is the system change of the Housing Act (*Woningwet*-WW), and the Environmental Licensing (General provisions) Act (WABO) (*Wet algemene bepalingen omgevingswet*) which are both public laws. The second main topic is the modification of the Civil Code (*Burgerlijk wetboek*-BW), a private law. A modification of the public laws is called the system change, which is the way the local government has to control the quality of the Architect, Engineer and Construction (AEC) industry. The second goal, the modification of the civil code is to reinforce the position of the consumers, for instance, when they buy a dwelling. Besides the modification of the three laws (two public laws and one civil law) the also so-called flanking policy has been developed with incentives for designers and contractors to deliver better quality.

1.1.1 Background

Since 1901 the Netherlands has disposal of the so-called Housing Act. This act had the goal to stop the disgraceful living circumstances mostly found in the big cities. A part of this act organizes the arrangement of a local organization for construction and housing inspectorate of newly built buildings (*Bouw en Woningtoezicht*-BWT). After the Second World War there was a great housing shortage and the Dutch government had to stimulate the construction of many new dwellings. There was a high demand for uniform technical requirements. The association of Dutch municipalities (VNG) developed a uniform requirements model (*Model bouwverordening)* which was adopted by the local governments. The model existed until 1992. Besides the uniform model the Dutch governments had their own requirements for granted dwellings (subsidy) ('Voorschriften en Wenken'). In practice there were many similarities between the National and local requirements, but the way the requirements were controlled was different in every municipality. In the eighties of the last century there was again a call for uniform requirements. The AEC industry also asked for performance based requirements. Their third wish was to cancel the building permit for changing the building layout. The Dutch government granted these wishes and on October first 1992 the Dutch Building Decree became law. For the AEC industry reading this Decree seemed to be difficult, because it was written as a law and only lawyers were able to read the context properly. Many books, seminars, courses, and brochures followed. But after the evaluation (by the Erasmus University, Rotterdam) in 2012 most of the AEC industry was satisfied with these regulations (Minister voor Wonen en Rijksdienst, 2013). In 2003 and 2012 important modifications of the Decree took place. Every year the minister of building applied small changes to the Decree, mostly on requirements for reducing the energy consumption of buildings. The regulations on the area of energy saving are controlled by Europe through the Energy Performance Building Directive (EPBD)[1]. The local government (municipality) carried out the quality control and checked if the requirements were fulfilled. Research of the Dutch government in 2007 showed that the quality of these checks are poor. After presenting the building plans many changes were carried out by the architect and nearby 50% of the building did not meet the building Decree. Therefor a committee with as Chairman Mrs. S. Dekker (a former minister) recommended to stop with technical checks of building plans. The role of every actor in the building process will become more clear. The responsibility belongs to the

[1] Besides the EPBD, Europe also tries to remove the barriers to trade. To remove these barriers, the CE marking has been developed. The norms are harmonized to enable the CE marking.

contractor and not to the local government. Since the first administration of Prime Minister Rutten the government is planning a system change. Minister Blok expects to send his law proposal to the parliament this spring (2016).

1.1.2 System Change

The purpose is to no longer perform the assessments by the municipal Building and Housing inspectorate on drawings and calculations on building plans, which in the framework of the environmental permit are being submitted at the Competent Authority *(Bevoegd gezag*- BG*).* The assessment beforehand by the BG was replaced by an as-built statement by the so called Quality Inspector (*Kwaliteitsborgen*- KB). This as-built statement is drafted at the completion and therefore is done afterwards. The KB drafts the as-built statement using an instrument for quality assurance (this is a quality management system) to ground his as-built statement. The criteria for this quality management system are stated in the Dutch law and recorded in a General Board Measure (*Algemene Maatregel van Bestuur*- AMvB). The Dutch government established a so-called Admission Organization *(Toelatingsorganisatie*- TO*)* who will issue permits to certain offered instruments and checks if the instruments are functioning in practice. Permitted instruments are also recorded in a managed register by the TO. An instrument is being offered by the instrument supplier, who will also look after the management of the instrument as a rule and select KB's authorized to work with the instrument. In the application of the environmental permit is indicated by the petitioner which instrument he wants to work and which KB is used. The BG checks whether both the instrument is included in the registry and is suitable for the particular building and that the KB is also entitled to apply the instrument. There are three so-called consequence classes defined, class 1 is the buildings and structures with the least risk (dwellings, simple utilities, renovation) Class 3 with the highest risk (hospitals, tunnels, stadiums, large stations, etc.) Class 2 are residential buildings, utilities such as offices, schools, factories, etc.). The new act will apply first to the consequence Class 1. The TO monitored tasks, and evaluate if the as-built statement is properly drafted and sufficiently substantiated. This foundation will be found in the dossier, which is compiled during the design and implementation process. The dossier consists of drawings, specifications, calculations, quality statements, measurements and assessments. The designing parties and the builder fill this dossier, supplemented where necessary with reviews of the KB. A part of the dossier (e.g. information on constructive- and fire safety) will be provided with the as-built statement (by the licensee) to BG in connection with the environment safety. A part of the dossier can also be used for the so-called consumer dossier (flanking policies).

1.1.3 Strengthening consumers position (modifications to Civil Code)

Resident organizations ascertain for a long time that the position of the residents (buyers, tenants, small companies) is weak compared with the position of the developers and the contractors and also (but less) housing associations (ECN, TU Delft, TNO en DHV, 2009). For example, in practice for a consumer it is difficult to prove that a complaint is a hidden defect. Also in the current right on retention (5% of the contract sum, on deposit with a notary, is released after completion of the second delivery) the buyer's position is not strong. In addition, the information given to the buyer and in which their decision is based to buy, is often very limited or opaque. The position of the consumer is therefore being strengthened by three changes in the Civil Code, the opposite burden of proof on hidden defects, an active act of the buyer with releasing the deposit and the obligation to provide information of the selling party.

1.1.4 Flanking policy

Besides the modifications of the laws the government develops flanking policies in corporation with the stakeholders. They work together to develop a clear benchmarking system and proposals are done for better information of the buyers. At present some formats are being developed in consultation with consumer organizations for the so-called consumer dossier, which will be made available to the market. It is customary to provide an information dossier at the completion of

construction with the instructions and warrantee statements. To optimize this process a format has been developed in coordination with a consumer panel and community organizations in the framework of the flanking policy for the so called consumer dossier. The idea is that everything needed to use and maintain a building properly should be described in a dossier which stays at the property, the same way a service book of a car stays with the car (until it is demolished).

1.1.5 Systems Engineering

Systems Engineering (SE) is a development in the construction sector which enables the optimization of designs (based on the Programm of Requirements (PoR) of the client). SE is an approach that allows for an integral approach and therefore connects the different disciplines in construction. This development fits well with the Wkb, because the intention of this act is to ensure that the consumers get what it deserves.

1.1.6 Building Information Model

The current construction market without BIM can no longer be imagined and ensures that information is shared and used correctly in the design. BIM is in development and the increasing IT capabilities increases the possibilities to develop an optimal design at lower cost. Much attention is paid to BIM in higher education, allowing more and more designers to use BIM and know the possibilities. Many construction companies are investing in BIM, especially in 3D drawing (with Revit or ArchiCAD) and checking these digital drawings (with Solibri). However, sharing information via a central BIM server is still not used optimally.
Van Wijnen (the graduation company) has also introduced 3D drawing, but does not use a central BIM server.

1.2 Research approach

In this section the research problem is given. The research problem is clarified and the research questions are formulated.

1.2.1 Research Problem

Most major construction companies have building process management integrated systematically into their business. Part of their process building management is quality management. The checks are carried out and recorded systematically in the execution phase. In the planning phase the risk analyses will be conducted per phase, which should underpin the GO / NO GO decision. Most construction companies are also working with a Building Information Model (BIM), linked with 3D construction drawings. For the as-built statement foundation should be provided, the builder has to show that the project complies with the Building Decree. This support should be established in an efficient and reliable manner and are therefore tailored to the construction process.

1.2.2 Research Questions

The main research question is:

''Is it possible with systems engineering (SE) and Building Information Modelling (BIM) to efficiently deliver an as-built statement which the independent quality inspector can present to the building permit holder under the Quality Assurance for construction Act (Wkb)?''

This statement will be forwarded to the competent authority (the municipality), together with the Municipal dossier (basically data on constructive and fire safety). When the municipality receives the statement and dossier, the project may be taken into use.

To be able to answer the main question the following sub-question must first be answered:

1. Is the Dutch control on the required building quality comparable to systems in other countries and we can learn from this?
2. How the construction process should be designed to use BIM efficient?
3. How control protocols can be linked to the Building Information Model and called via the 3D drawing?
4. What are the possible control protocols for Building Requirements?
5. What is the most efficient time to perform these checks?

Assumption: In practice a complete dossier is made, which shows compliance with the contract; a part will be to meet the Building Regulations. The Wkb is only about the Building Decree. The Building Decree is part of the Building Regulations.

1.3 Research design

In this section the way the research is carried out is given and the delimitation of the research is pointed out. Also the expected results before the start are shown, the realized results are more extensive (figure 1).

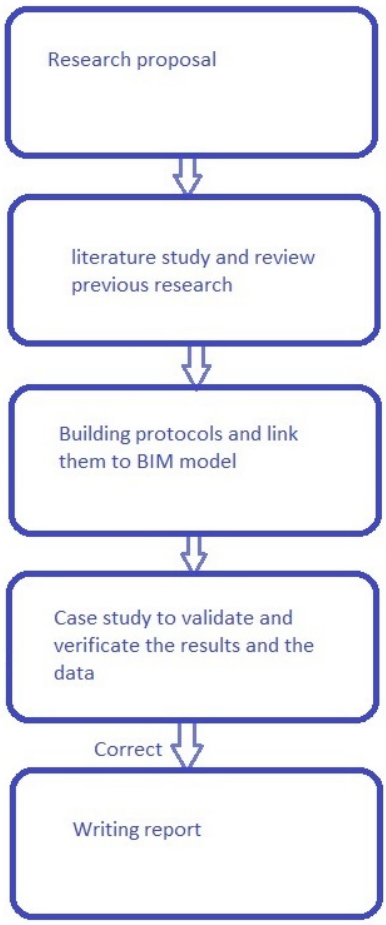


Figure 1: Research model

1.3.1 Delimitation.

The research is delimitated for the construction of houses. The designed system for quality control is tested in a case study of a housing project. The results however can be extrapolated to other types of building projects, such as offices, apartment buildings, schools, etc.
The new quality assurance act for construction (*Wet Kwaliteitsboring voor het bouwen*-Wkb) is chosen as starting point for this research. The act itself has not been investigated.

1.4 Expected Results

The expected results are a list of control protocols to demonstrate compliance with the Building Requirements, imposed on a detached house (ground-based). There is also a process which describes what the best moment is to carry out a certain process. The case study is an example of the use of the protocols and the process approach.

2. Literature review

This chapter starts with a introduction of the international comparison of building expectations. After the introduction a few selected European countries are compared, namely Germany, England/Wales, France and Sweden. All these countries have a form of quality assurance for building regulations by private parties. After that, the prospective system of the Netherlands is described. This chapter ends with the conclusions of the international comparison. Section 2.2 describes the purpose of the Quality Assurance Act for construction (*Wet kwaliteitsborging voor het bouwen*-Wkb). This purpose is to give the system the right stimuli to deliver the quality that the consumer is entitled to. In addition, the Civil Code (*Burgelijk Wetboek*-BW) will be amended in such a way that the position of the consumer with respect to the builder will be more balanced.

2.1 International comparison of building expectations

The Dutch system of quality assurance for construction will be drastically changed. The market is going, as far as it concerns the technical checks against the Buildings Decree requirements, organize its own quality assurance. The municipality will keep checking the permit request, however the local organization for construction and housing inspectorate (*Bouw en Woningtoezicht*-BWT) will no longer perform structural checks.
The public supervision of the new system will be centrally accounted by an Admission Organization (*Toelatingsorganisatie*-TO). The TO will become a so-called Independent Administrative Organization (*Zelfstandige Bestuursorganisatie*-ZBO) without a legal entity. The TO will check and –after approval – authorize and register quality assurance instruments developed by the market in any public register. The TO can revoke the admission of an instrument when the instrument does not function properly. The Wkb is almost ready and is expected for proposal to the Second Chamber of the parliament (*Tweede Kamer*) within a few months.

In the selection for the European counties different factors played a role. In the first place the countries should be comparable with respect to their legal framework and management model in regards to the Netherlands. Furthermore, the cost and price levels of these countries should not differ too much with the Netherlands.

Private quality assurance is new in the Netherlands, but in the most countries it is normal to hire a private party. The current situation, The Netherlands has disadvantages compared with the , the most important being unclear roles, many deviations from the regulations, unclear and high costs (Nipo, 2000).

The competent authority (usually the municipality (*Bevoegd Gezag*-BG)) checks construction plans and examines whether these plans meet the technical regulations. These regulations are set out in a general board measure (AMvB), controlled by the Housing Act). This AMvB is known as the Building Decree (*Bouwbesluit*-BB). The BB is normally adjusted annually. In addition to the Housing Act (*Woningwet*-WW), the Environmental Licensing (General provisions) Act (*Wet algemene bepalingen omgevingsrecht*-WABO) regulates the process of the building permit. The enforcement of the building code assesses in addition to the technical regulations also other laws of the environmental law, such as spatial planning and environmental safety. These tasks remain at the BG after the introduction of the new act, the Wkb is only about the technical building regulations. Van der Heijden (2009), compared different systems and their pros and cons in his PhD research.

The best model seems to be characterized by a combination of private and public parties. The public sector seems to connect best to the questions and expectations of the average citizen. The private sector seems to fit the best to the questions and expectations of professionals. Especially for

technical expertise it is meaningful to involve the private parties for regulation enforcement (Heijden, 2009).

The disadvantage or risk is that the assurance system is seen as necessary to protect the integrity of the private supervisors. Integrity problems by the introduction of private supervision are also mentioned. Risks are that private quality inspectors are under financial pressure and may have to deal with conflicting interests. Another drawback that is mentioned in private construction supervision is a reduction of accountability (Heijden, 2009).

In the Netherlands, various calamities occurred within the current system, such as the collapse of balconies in Maastricht with some fatalities and acute collapse danger in a residential building in Bosch en Lommer. The Inspectorate 'VROM' investigates many of these calamities. However, it appears that their reports 'Leren van instortingen' does not result in the desired improvements (CURNet, 2006).
In the explanatory memorandum (*Memorie van Toelichting*-MvT) attached to the Wkb is indicated why improvements are needed. In the MvT report from 2007 is referenced to 58 projects which are investigated on if the building plans where submitted at the municipalities, if the projects were build according to the building permits and if they complied with the Building Decree. The conclusions are clear, no project is built according to the submitted documents. This makes sense because after the documents are submitted at the municipality, adjustments will still be made to the construction plans and therefore the final construction plan will be different from the one submitted (De minister Voor Wonen en Rijksdienst, 2016).
The permit procedure is 12 weeks and runs parallel to the construction planning. The 58 listed projects are also assessed in practice and after the necessary recalculations the results show that still 50% of the projects do not comply with the Building Decree. There are in particular deviations on regulation for health and sustainability. The municipality takes no responsibility for the quality of their checks, however the permit provides the applicant certain legal assurance. This allows a builder to reach out to the municipality if something is not in order. However, this is not what the Housing Act intense, because in the Housing Act is indicated that the applicant and builder are responsible and liable for complying with the regulations. The conclusion is that through the checks of the building plan and the legal certainty of the permit a false sense of assurance is created which does not provide the quality that the Government aims for and which the consumer is entitled to. The Committee lead by former Minister Dekker proposed the removal of the check according the Building Decree requirements by the municipalities (Commissie Fundamentele Verkenning Bouw, 2008). A source of years of annoyance is the so-called legal fees (*legeskosten)*, these are established independently by the municipalities and amounts 2-3% of the construction cost, which are substantial amounts. The legal fees should cover the costs, however, from the legal fees of the larger projects cover the costs for the smaller projects. The way in which the legal fees are determined is often not transparent, and many lawsuits are the result. In the new system the legal fees will be substantially lower because the construction plan check disappears and a private party will be handling the supervision. The question then is whether the current legal fees system for construction should be completely abolished, since fitting a construction plan in a zoning plan does not have much to do with the actual construction plan, but more with the environment (Sira Consulting B.V., 2015).

Experiences abroad sometimes show unwanted developments. For example Ireland showed that private supervision has become extremely expensive due to the lack of private supervisors. Private supervision has been released and is now the responsibility of the builder. In Sweden, it turned out that the system was too open-ended and is now more strict (Meijer & Visscher, 2016). This knowledge is used to set up the Dutch system.

2.1.1 Germany

On national level the technical quality requirements are recorded in the model 'Building Decree' (Musterbauordnung – 2008). This federal model provides the framework within which the various federal States draw up their own construction laws. All 16 States have their own Building Decree that connects to the national level. These Building Decrees of the Federal States include the minimum requirements for construction works that should be met. They also indicate which construction permit procedures should be run through (Meijer & Visscher, 2016).
Germany makes distinction between two categories of construction works:

- License free construction works.
- Permit required construction works, which are eligible for a simplified authorization procedure or a regular authorization procedure (figure 2).

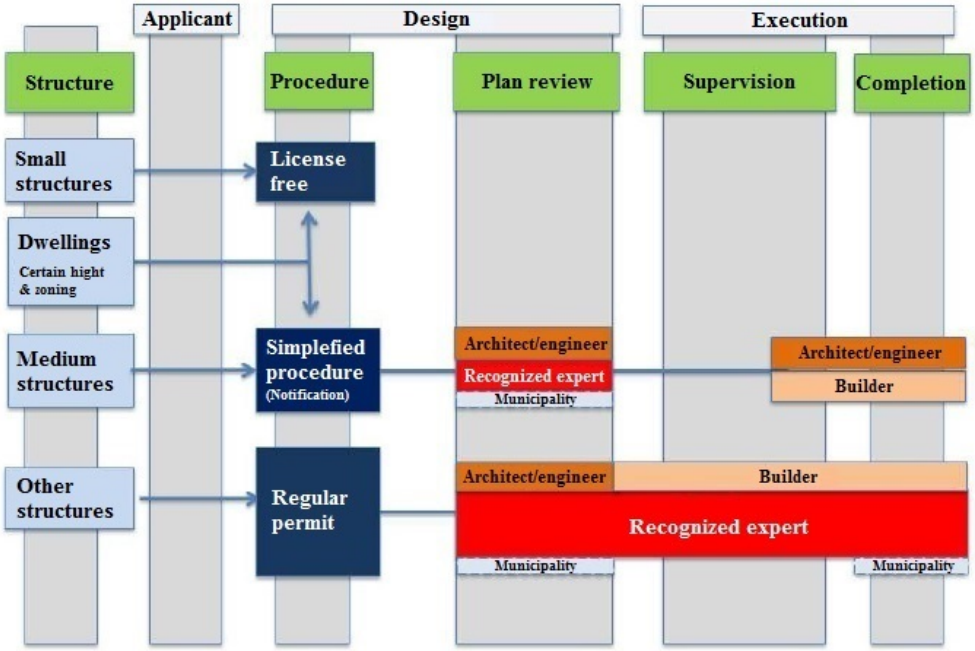


Figure 2: Quality assurance procedure Germany; (Meijer & Visscher, 2016)

In Germany a distinction is made between a simplified authorization procedure and a regular authorization procedure depending on the type of construction work and if there is a building professional involved. Because this study focuses on residential properties only the procedure of the medium size construction works is described.

The simplified authorization procedure will apply to the construction of low to medium level dwellings and, depending on the surface, agricultural buildings or other non-habitable ground-floor buildings. A licensed architect or engineer should be involved in order to qualify for the simple procedure. In the simplified procedure the local supervision (German version of the BWT) does not perform checks if the architect declares that the plan meets all the requirements. A certified engineer must draft the structural design and a State-recognized expert must check this design again. The architect or engineer is also responsible for the statement that the plan meets the requirements for noise and heat insulation. The municipality provides the permits. The building may only be taken in use when the Builder and architect concerned confirmed that it is ready. There is no certificate attached to this process (Meijer & Visscher, 2016).

Tasks

The tasks and responsibilities of the various parties (municipal, owner or client, architect or designer, consultant (building physics, structures), construction company, independently recognized expert)

are recorded in the German version of the Building Decree. The main rule is that when building, renovate, maintain, change of use or demolition of buildings, the principal/applicant and all other parties concerned are responsible for ensuring that the legislative requirements are met. The private parties who are involved in reviewing and monitoring are checked on independence and quality.

Municipality

In Germany the municipality is responsible for monitoring tasks and providing permits. There is also an important role in the quality assurance for registered architects, civil engineers and Government-approved experts for the permit application, plan review and inspection during the construction. When the expert (quality inspector) represents a municipality, they have the same liability as a municipality officer, and only in case of an 'Act of negligence' he or she can be held responsible. The overall responsibility remains with the Government.

Client

The client must be present at the preparations and execution of its building plans, a designer, a construction company and main supervisor/construction Coordinator. At the application, the applicant must (and in some cases the head overseer at the local Construction and housing (German version of the BWT)) prove that this is the case. When it concerns simple construction works it is not required. At work that is carried out by the applicant self, a construction company is of course not mandatory. Where the applicant fails, the municipal BWT can assign a Government-recognized expert to perform the applicant his jobs. For the start of construction, the applicant shall pass on to the municipal BWT who the Builder and main supervisor is (and if there are any replacement).

Construction company

The hired construction company is responsible for ensuring that the work is performed according to all applicable requirements and regulations (including in terms of technology, in terms of craftsmanship and safety). For special construction works, the municipality can ask the construction company for proof that the company is suitable and capable to carry out the construction. The BWT can demand the name of the construction company for some risky works in advance.
The company can also be asked to show that it is suitable to perform the construction and have the necessary equipment. This requirement is included in the general terms of the regulations. This gives the municipality the legal possibility to determine in advance whether a company is able to perform specific (and risky) work.
If the relevant experience data are not present, the company must hire professionals that meet the requirements. The regulation does not specify what measures the municipality can impose when they do not agree on the choice of company. The main overseer (project manager) must ensure that the construction process is according to all the rules of the construction law. He must have sufficient knowledge and experience. Apart from this, the construction company has its own responsibility that the construction progresses well.

Architects and engineers

The architect or engineers involved according to the permit should have sufficient knowledge and experience to develop the plan. They are responsible for ensuring that the design is complete and usable and meets the regulations in force. Architects and engineers who want to be involved when submitting a building permit must be registered at their respective professional association and they must be included in the list of professionals that can perform this task. The admission of the architects, engineers and the Government-approved experts runs via the professional associations in the German Federal States. Evidence should be provided at the application that the required training has been completed and experience is gained.

Quality inspectors

The building regulations of the Federal States contain the requirements of the quality inspector. This includes the educational level, practical experience and age (between 35 and 68 years).

There are general requirements regarding adequate knowledge of materials, economic and environmental problems, building management and building regulations. A thorough knowledge is expected of private consultants and government during the construction process. Furthermore, the requirements of experience and knowledge are specifically focused on the field in which the candidate wishes to be recognized. Candidates who wish to qualify for recognition as inspector for stability of structures must demonstrate that they have specific knowledge and experience. This experience should be demonstrated orally or in writing. The admissions committee can request additional documents and decides within 3 months of registration if the recognition is approved. The admission is valid for five years and can (after a check) be extended. The recognition ends when the quality inspector is no longer a member of his professional association, when he has achieved the maximum age, or resigns. The professional association can also remove experts from the registers, for example of serious dereliction of its duty.

2.1.2 England

In England and Wales a distinction is made in three categories of construction works:

- License free construction work
- Notification required construction works (building notice)
- Compulsory licensing construction works (full plan procedure)

In addition to the three categories mentioned above, England has a procedure to check afterwards existing buildings that are built without a permit (regulatory procedure). Applicants can go to the local municipal Building and housing (English version of BWT) for all procedures. Approved Inspectors only perform the regular procedures. The notification procedure is applicable to the construction of new homes and simple changes in existing homes. This procedure is widely used by construction companies, usually with standard design for which a permit is issued before at other locations. The applicant notifies the municipality that the plan meets the requirements (Office of the Deputy Prime Minister (ODPM) Publications, 2005).
There is no plan review in advance needed in this procedure. This prevents paperwork because it does not require detailed plans to be submitted. However, the BWT can demand that further information is provided before or during the construction, for example the associated calculations. The BWT may monitor during construction. At the completion of the construction the BWT does not have to publish a completion certificate (*gereedmeldingscertificaat*). The legal fees for a building notice procedure does not differ from a full plan procedure. Newly built homes and modifications will generally be dismissed with a building notice or can, when a certified company performs the work, be constructed without permit (figure 3).

In the sector for newly built houses the National House-Building Council (NHBC) plays an important role in reviewing and ensuring minimum quality of newly built houses. The NHBC has its own quality rules, checks and monitors as approved inspector and provides guarantees and insurance. Construction companies and project developers can be certified and be included in the NHBC registry. The by NHBC employees built houses must comply with the NHBC Standards. Buyers are only eligible for NHBC guarantees and insurances when the houses are built acording to the NHBC standards (Office of the Deputy Prime Minister (ODPM) Publications, 2005).

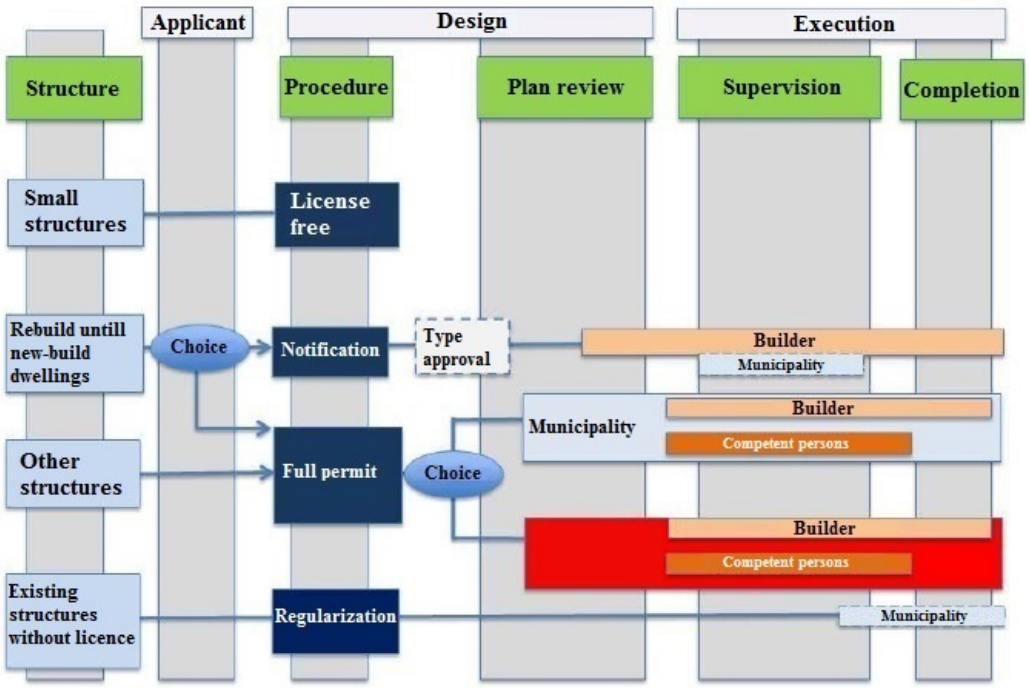


Figure 3: Quality assurance procedure England; (Meijer & Visscher, 2016)

Any construction can normally go through the regular procedure. It is up to the applicant (client) to choose. However in the case of major changes, alterations or changes of use of a building and in the construction (or changes) of larger structures (where the fire and structural safety requirements are an essential element), the regular procedure should be followed. The clients can submit the request. It is not required to have a registered architect or engineer to apply for the application.
The responsibility for the planning permission (does the plan fit within the zoning and, does it satisfies the aesthetic requirements) lies with the municipality. In the quality assurance of the technical rules in the regular procedure, an applicant can choose for private or public checks. Depending on the choice during the regular procedure, either public (BWT) or private (approved inspectors) is responsible for the plan review, the supervision during construction and reporting the completion. Both parties are responsible during the construction that the building eventually meets the requirements.

Tasks

There is a dual system. The applicant can choose between an approved inspector or for the municipality. For location-dependent aspects the applicant must always request a planning permission. Therefore, the tasks are always dependent on the choice of the client.

Municipality

The municipal BWT provides a completion certificate if they get the message of the construction company that the work is finished and they confirm that the technical requirements are met. The completion certificate indicates that the requirements are met.

Client

The client is responsible for the submission of the permit, the choice for the quality inspector and the executive construction company. During construction, the client shall notify the municipality of the progression so that at certain times (beginning of the construction, laying the foundation, and an estimate when the construction is completed) can be checked.

Construction company

The construction company must indicate when certain stages have been completed and can be checked. Each chapter of the English building regulations are requirements for all technical components on what materials should be used, the craftsmanship and skills of the executor (workmanship). The requirements are perhaps best translates as requirements for good and sound work (*goed en deugdelijk werk*). It is expected of each executing construction company that they meet the requirements.

Architects and engineers

The professions of architect and engineer are regulated in England. Registration in England is not directly related to verification and monitoring activities in respect of guarding the building regulations or the performance in a role as a quality inspector (KB).
England also knows the Competent Persons Scheme. Through this system construction and installation companies that specialize in e.g. glazing and installation technique can get certified. When a registered competent person (in principle notification or permit required) is executing construction activities, the competent person may certify his own work. A notification or authorization is then no longer required.
In the Building Regulations, construction works are appointed which can be carried out by Competent Persons. An example is the installation of central heating. A specialist should always perform the works on gas supply, regardless a permit required. There will be no supervision by the municipality or the approved inspector when the (installation works) are performed by a certified specialist. The building regulation gives specifics at which organization the Competent Person must be registered (the 'scheme operator'). In most cases this is a certification organization that specializes in the certification of certain types of work. These certification organizations must be accredited at the UKAS (United Kingdom Accreditation Service) and are also monitored by this organization.

Quality inspectors

There are no legally defined procedures for enabling a private inspector. Before the works begin, the Approved Inspector gives specific information on the project in a so-called Initial Notice and confirms that they will be responsible. They have no formal enforcement authority. Therefore if a signaled problem cannot be resolved the situation should be transferred to the local BWT. The BWT have legal powers to intervene. The Approved Inspectors should send a Final Notice to the municipality when, according to them, the building meets the requirements. This Final Notice has the same status as the completion certificate.

2.1.3 France

France has a combined public-private system for enforcement of the building codes. The bottom line is that the municipalities are responsible for providing the building permit and the completion certificate when necessary, while private parties are responsible for performing checks and supervision. Although in most cases the municipality can still play a (small) role in the spatial planning check, the smaller construction works (until dwellings) are not or hardly being checked. Larger projects are controlled by private inspection agencies, noting that as the risks are getting greater, the supervision becomes stricter (figure 4).
France also makes a distinction in construction works:

- License free construction work
- Notification required construction works
- Compulsary licensing buildings that have to go through the regular procedure

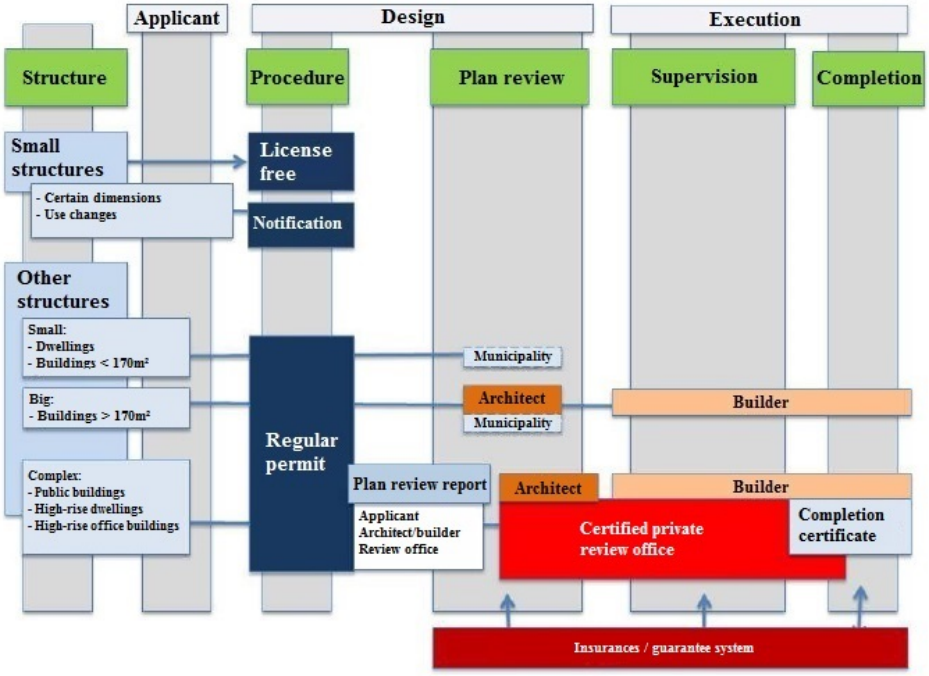


Figure 4: Quality assurance procedure France; (Meijer & Visscher, 2016)

For all new construction that are license free or require a notification, permits must be requested. For construction work on existing buildings, a building permit is generally needed if the modification covers a larger surface area than 20 m². For buildings within the urban area or an area subject to a zoning plan, a permit is needed if:

- More than 40 m2 of floor space is added or;
- The surface added is more than 20 m² but less than 40 m² and the floor area of the building after the construction is more than 170 m²

A permit is also needed when the (support) structure or the façade of the building is changed, the purpose is changed or when it is regarding a monument or a building that is located in a protected city area.

Even within the category of permit required buildings there is a distinction between simple and complex buildings. Within housing construction the spatial planning check is performed by the municipally. An application for a building project must be accompanied by a certificate indicating the proposed plan satisfies the technical requirements on energy performance (this is the tasks of the architect).

Regarding the supervision during the construction works, a quality inspector can be involved (on behalf of the construction company). The municipality can also perform checks, but usually this does not occur and if it does, it will be ad hoc. For detached houses there is barely supervision in practice. Applicants of a building with a floor area less than 170m2 can submit their own application. It is advised to first seek an architect of the Council of Architecture for a free architectural advice. This opinion is limited to the architectural value of the building. The assumption is made that the insurance and guarantee system ensures compliance of all technical requirements during construction. In this situation the municipality performs no supervision (or barely).
When the future floor space will be more than 170 m², a licensed architect must be involved in the permit request. The design (including calculations, materials) which is submitted with the application must be made by the architect. For the application, the architect must declare he possesses the required knowledge on the technical regulations. The designer must send as-built statement to the

municipality within thirty days after completion. Normal buildings may be used after the construction company has reported that the building is completed (Meijer & Visscher, 2016).

Tasks

There are experience and training requirements for all employees in the construction sector. At the end of the 10-year compulsory insurance the construction companies should provide detailed information about their company (number of employees, qualifications, solvency, and any problems with previous insurance).

Municipality

Municipalities are responsible for providing building permits and if necessary the as-built statement There are no legal requirements for the staff of the local BWT. However, the municipalities do have functional and voluntary requirements of their employees . The staff must have followed a specific training and have to meet the training requirements. There are also requirements concerning their independence.
Municipalities can follow a quality system on a voluntary basis. In most cases, the quality system deals with themes such as the inspection and test methods and the way of reporting of reviews and monitoring activities. The employees of the municipality do not need mandatory professional liability insurance. Though they work according a fixed code of conduct. Applicants who are wronged by an incorrect decision or act can appeal at the administrative courts. These remedies are recorded in the national public law.

Client

The current system has been developed in order to protect the client against errors in the construction sector. The consumer is insured for 10 years after the delivery against defects. A drawback is that compensation will be paid, but the defect will not be repaired.

Construction company

Construction companies must be registered or be recognized by an association, otherwise there is no guaranteed assurance on the quality of the construction. In addition, there are other professional associations where construction companies are registered. Applicants who want to build an individual home can best involve a member of an association. Construction companies who have passed a 'training in doing good business' must have a registration number. At the local Chamber of Commerce can be checked if the number is still valid.

Architects and engineers

The involvement of registered architects can be mandatory depending on the size of the construction. To act as a project manager of a project, the architect must have followed an accredited architecture training and must possess a 'project manager certificate'. Furthermore, the architect must be registered in the register of architects and have professional liability insurance. The architect should report in the permit application that he has knowledge of the relevant technical regulations for that request.

Quality inspectors

Private quality inspection offices play a key role in the inspection of the construction. There are about forty private control agencies in France. Of all new construction in France, about half is controlled by these offices. That is much more than the share of complex structures that are legally required to be checked by private quality offices.
The tasks and responsibilities of the private inspectors and the admission procedures are established in the French Building and Housing Act. The potential inspectors have to demonstrate their expertise and experience. These include the professional qualifications (professionals with an engineering degree), technical experience and independence.

A distinction is made in the approval of the type of construction for which the office may be active. In the area of their expertise the private inspectors should have a background in the field of construction engineering or civil engineering.

2.1.4 Sweden

For the categorization in construction work, Sweden makes a distinction between:

- License free construction
- Unlicensed buildings whose construction plans have to be first reported to the municipality
- Permit required construction

In Sweden it is possible to reserve a slot for submitting a prior information notice or decision of principle to find out if the in the building plan the appropriate location is feasible or not. If the municipality gives a positive decision on the notice, the applicant has two years to obtain the actual permit (figure 5).

For certain activities which are aiming to realizing a building that will be there for a limited time, a temporary building permit can be requested which is valid for a period up to 10 years (and can be extended to a total of 15 years) (Boverket, 2015). The municipal building commission forms the pivot at the quality assurance process. Applicants can go the municipal building commission for all information about the procedures. In organizational and procedural sentence, it starts and ends with the municipality. The municipalities also have the authority to tighten and relieve permit requirements in certain areas (however it is bounded to regulations). This applies to areas with a detailed zoning plan or where area regulations are in effect. These plans included the more and lesser strict requirements.

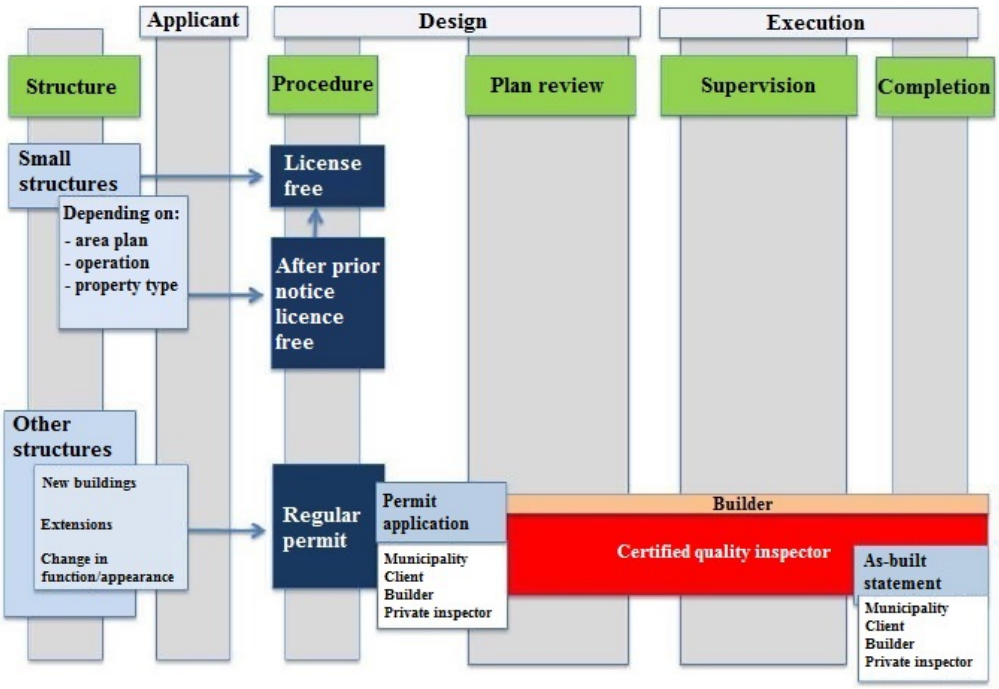


Figure 5: Quality assurance procedure Sweden; (Meijer & Visscher, 2016)

The regular planning permission procedure applies to the construction of homes, buildings, additions, external changes and user changes on existing homes and buildings. For the changes of smaller residential buildings the principle is the same, there is however more space to do this without a permit. In mid-2014 a specific arrangement came into force for the construction of smaller new property (up to a surface of 35 m^2). The goal is to simplify this kind of construction.

Functional changes of a building need a permit, even when no or hardly any physical modifications are needed. Also, for works like building walls and fences, storage facilities, water reservoirs, sports grounds and larger radio and telecommunications masts, a permit application should be submitted. In case of a building where a detailed development or spatial plan applies, a permit will be needed when changes are applied to the appearance of the building, for example by changing the color, the facade and the roofing material. For single-family homes or semi-detached homes are deviating (less strict) rules which are covered by the license free construction procedure (Boverket, 2015).

Tasks

The municipality is involved at the construction plan and holds a kick-off meeting and a final consultation. At the start consultation a monitoring plan is discussed. The documents will be sent to the municipality and issues the building permit. The client shall notify the municipality when the construction is completed. The quality inspector is an architect or engineer who meets certain qualifications and ensures the minimum required quality of a construction is met. If the client wants to obtain the assurance in advance that a building can be realized at a certain place, it is possible to make a preliminary application. If the conclusion is negative, the project may not be executed.

Municipality

According to the legislation, the employees of the municipal building Commission must be sufficient trained and have relevant experience.

Client

The client is fully responsible for ensuring that a building meets the requirements. The client should notify its intention to the municipality, after which a procedure will start.

Construction company

The hired construction company is responsible for ensuring that the works are performed in accordance to all applicable requirements and regulations (including in terms of technology, craftsmanship and safety). The Planning Act and Building Decree does not contain any requirements on professional or liability for municipal employees. In general, the conditions for professional liability of officials are governed by the Civil Code. The liability of the various parties involved in a construction project, are mainly adopted in the contract. Standard contracts are an integral part of the Swedish construction practice. A standard construction contract ensures a warranty on any defects for a period of five years and during this period the builder is fully liable for defects and damages that arise because of faulty construction. In case of negligence, the builder is liable for major defects till 10 years after the completion of the work. For private houses and residential buildings, the legal guarantee on buildings is 10 years after completion by default.

Architects and engineers

The architect or engineer concerned in the application must have sufficient knowledge and experience to develop the plan. The professions are not regulated, but there is title protection. According to (Meijer & Visscher, 2016), the architect or engineer plays no formal role in the quality assurance system. Though they can be certified as quality inspectors.

Quality inspectors

The certification associations in Sweden have established requirements on training, knowledge and skills and experience of the private inspectors and also formulated the requirements of the certification process. The certification association must be accredited by the Swedish Accreditation authority. As regarding the requirements for the private quality inspectors, a distinction is made between the supervision of regular construction works and complex construction works.
The quality inspectors shall prove in writing that they meet the training, experience and suitability requirements. Also an exam should be passed. Once certified, the quality inspectors are included in the register of the certifying association. Each year the quality inspectors report their activities and

completed assignments in writing to the certifying association. The certificate is valid for five years and can be revoked at any time by dysfunction.

2.1.5 The Netherlands

This section starts with a description of the current situation in The Netherlands which concludes up till 2017. In 2017 the Building Regulations are going to change. The second part gives a delineation of Netherlands from 2017.

The Netherlands till 2017

In the current situation a permit can be rejected based on article 2.10 of the Environmental Licensing (General provisions) Act (WABO). To prevent rejection of the permit, the request and the corresponding data should make it plausible that the construction of the building the permit is requested for, complies with the requirements of the AMvB. These requirements are included in article 2 or 120 of the Housing Act (WW). The BG supervises compliance with the structural requirements, the licensing and associated regulations including the structural aspects. The competent authority has the power to determine the intensity of this monitoring. The intensity of the monitoring may be larger as construction work more complex and riskier (Meijer & Visscher, 2016).

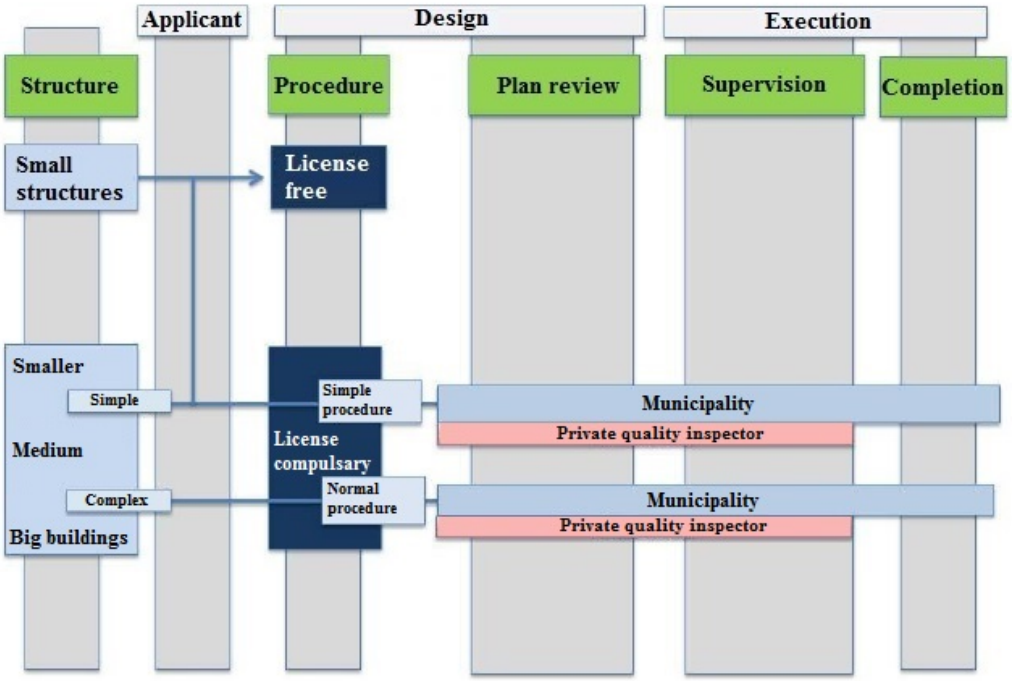


Figure 6: Quality assurance procedure the Netherlands till 2017 (Meijer & Visscher, 2016)

The Netherlands from 2017

Because the technical building regulations are complex and the authorities are on top on these regulations it is difficult to realize the implementations.
According to (Heijden, 2009), the direction of the solutions from the report the Commission Dekker (Commission Basic Exploration construction) are in line with how the general policy development over the last few years has been in Netherlands.

This new Dutch Act seeks to strengthen the position of the consumer and to make effective the system of quality assurance. The law has effect on three laws, the Housing Act (WW), the Environmental Licensing (General provisions) Act (WABO) and the Civil Code (BW) the first two laws

are public law (then the Government concerned) and the BW is private law (Government is not involved)

Public law regulates the supervision on the construction and the way in which a permit must be requested. The applicant for the building permit asks for permission to build on a certain place and certain activities. The municipality will review these plans and looks at whether the environment is adequately protected against effects of this plan and or the building plan fits into the environment (wealth). The technical building regulations are not checked by the municipality, the applicant indicates which tool for quality assurance (this is a quality management system) he wants to use (figure 7).

This instrument must be suitable for the project concerned. Construction projects are classified into three classes with an incremental risk result:

- Result class 1 properties, simple utility construction and large-scale renovation
- Result class 2 all projects that fall between 1 and 3. Consider, for example, residential buildings, schools, and larger offices
- Result class 3 concerning projects with major risks, such as stadiums, tunnels, hospitals and such projects.

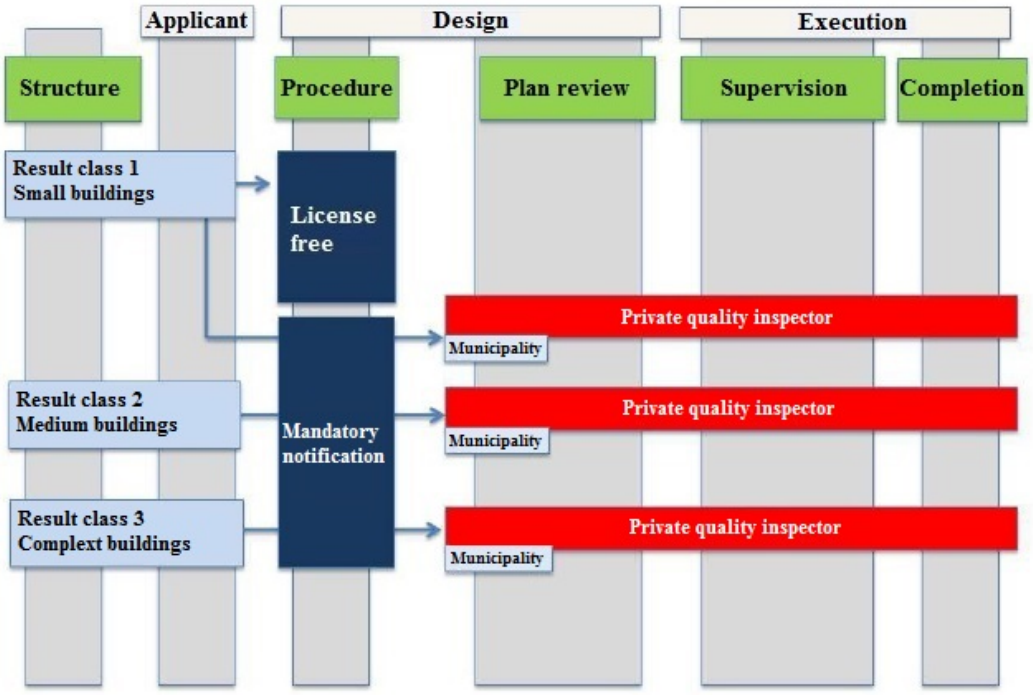


Figure 7: Quality assurance procedure the Netherlands from 2017 (Meijer & Visscher, 2016)

The municipality can consult a digital registry to verify that the instrument is approved and whether it is appropriate for the particular result class. At least 14 days prior to start of construction the applicant reports which independent quality inspector building guide goes. Also the quality inspector (QI) are found in a digital-register and in doing so is stated which instrument the QI may apply. The instruments are developed by the market and on the basis of legal criteria assessed by the Government. The instrument Manager shall turn in QI's and reports in to the registry.
The QI will the quality throughout the process, certain controls will take place in the design process, other controls at run time. As the building is ready, the QI gives a statement to the applicant that the project complies with the building regulations. This statement is forwarded to the municipality, together with the file that the municipality will need for its legal tasks (mainly that data about

constructive-and fire safety). The instrument administrator will regularly assess whether the QI does its job well. A QI represents a company. In practice, it will usually be team work, specialists are often required to assess the construction, and the same applies often for building physics, fire safety and installations.

The Government runs samples and allow instruments in practice to determine if a tool works. So the Government conducts system monitor. In practice, the QI shall in addition to the checks of the building Act also check the contract (and good-and sound work (*goed en deugdelijk werk*)). To determine that a statement by the QI is based on correct information, a complete file will need to be tracked and this file must therefore be available to the administrator, but also for the Government that performs samples. The Government can give out sanctions. This means that when the instrument is not used correctly or when a tool is not working properly, a yellow or red card is handed out after a formal warning. The consequences are large, for both the tool administrator and the QI. The Government will evaluate only the instrument; the tool administrator monitors the QI (Leeuwen, Barendregt, & Egmond, 2015).

Private law (BW) is adjusted in order to strengthen the position of the consumer. There are three measures. The concept of latent defect is adjusted, the burden of proof now comes at the Builder. All that is not written down with the delivery is seen as latent defect, so if something is not in order, the contractor should prove, that that is not his fault. The second is the lien, to release the depot (5% of the purchase price is stored at the notary) should the buyer should carry out an active act. If all complaints to the second delivery were fixed, the buyer gives free this last 5% by means of a message. This normally happens that within 3 months of the first delivery. The third measure is the so-called information obligation, the seller provides a kind of financial information leaflet to the buyer. The leaflet describes the financial risks for the buyer.

Besides the legal adjustments, there are the so-called flanking policies. There is a so-called consumer file, a format for the information provided by the seller to the buyer. All information, maintenance advice, drawings, etc. whatever the purchaser needs, will to be provided by the seller, through this file. Benchmarking is also stimulated, the Economic Institute for construction (EIB) has examined, that a good benchmarking system provides a lot of money to the society (Economisch Instituut voor de Bouw, 2014).

The Government should set up a so-called admission organization, this organization is set up as an Independent Administrative Organization (*Zelfstandig Bestuursorgaan*-ZBO). The organization reports directly to the Minister and will report annually on the State of the build quality in Netherlands.
With different organizations involved in building there can be care over this ZBO, has authority, such an organization causes no bureaucracy, and it remains affordable. Real concerns, which should be removed during a careful implementation (figure 8) (De minister Voor Wonen en Rijksdienst, 2016).

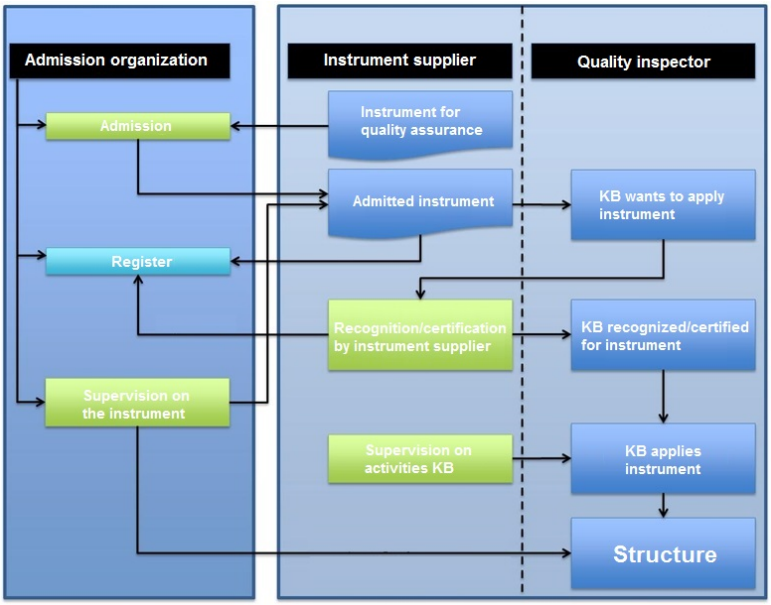


Figure 8: Admission organization procedure; (Leeuwen, Barendregt, & Egmond, 2015)

Tasks

A part of the tasks of the competent authority shifts to the market. The Government does not plan review and monitor the implementation. The competent authority remains responsible for providing the area permit. The market handles the monitoring task itself and delivers the competent authority an as-built statement.

Municipality

The Government provides the Environmental license (according to WABO), which means that they control if the building plan fits in the zoning plan. In addition they provide the assessment of whether the environmental safety is ensured. In the WABO are 26 laws, these laws are controlled by the competent authority (municipality and province), only the technical key disappears from their job responsibilities. For the more complex construction works consultation with the competent authority will continue to be necessary in their framework of their public tasks such as in occurrences like emergencies (e.g. fire) (figure 9) (Actieteam Routekaart naar Private Kwaliteitsborging, 2013).

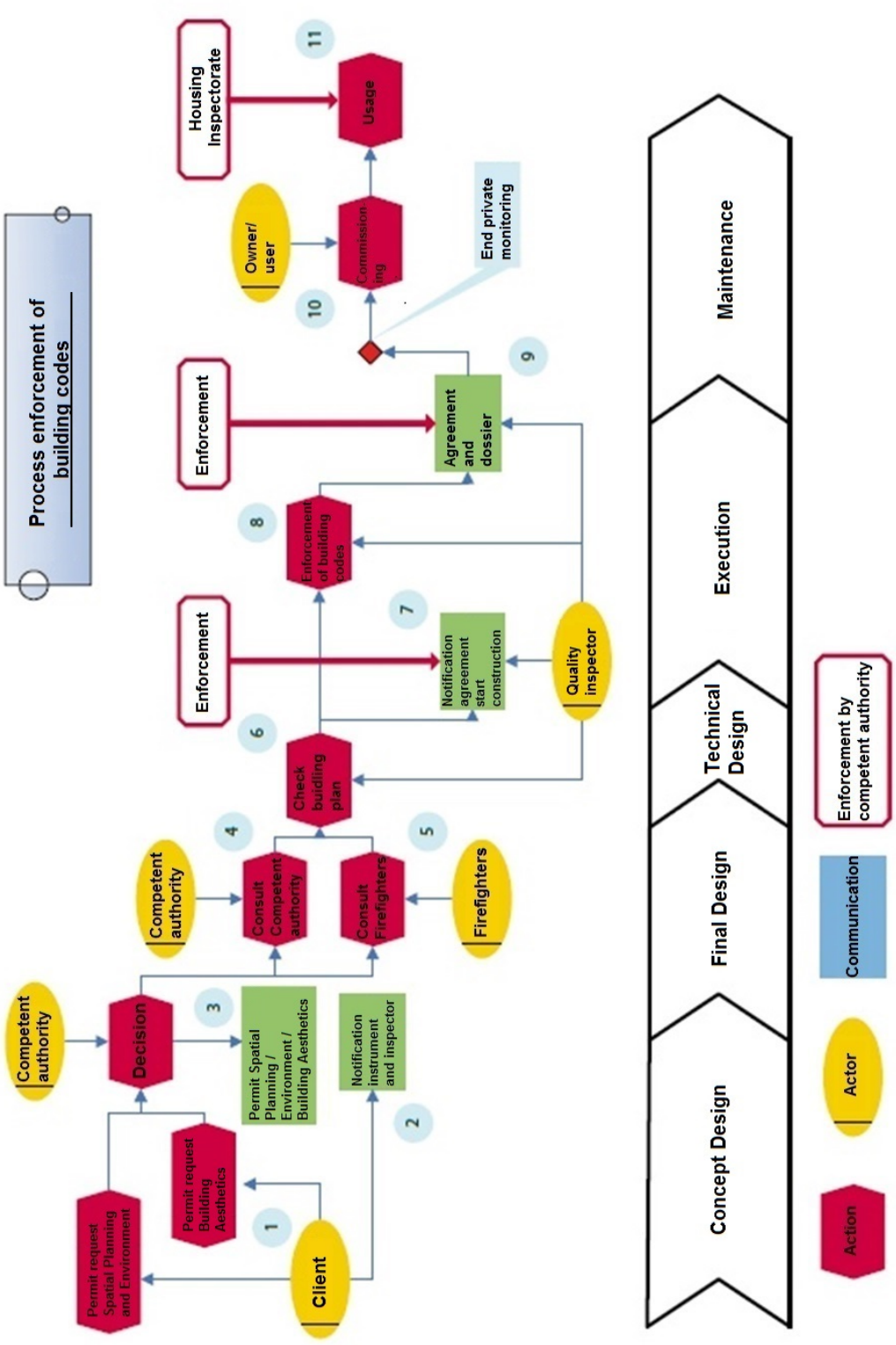


Figure 9: Procedure planning application; (Actieteam Routekaart naar Private Kwaliteitsborging, 2013)

Client

The client requests the building permit, indicates what instrument for quality assurance will be deployed. In addition, for the start of the building the name of the independent quality inspector is passed on to the municipality. After the building is ready, an as-built statement plus the file sent to the municipality. Without this statement the project cannot be put to use. If the building plan is not required to hold a license, the client does not to involve a technical audit office. Compliance with the building Act and the spatial aspects remains a requirement and is the responsibility of the principal or the owner of the construction work.

Construction company

The construction company may choose its construction process management in such a way that the checks carried out by the independent KB stays limited, which means investing in an improved building process including the digital support (tools). Meeting the technical building regulations becomes even more explicitly the responsibility and liability of the construction company.

Architects and engineers

Architects and engineers are especially active in the design process, they will also be able to fulfill roles in quality assurance and have to register as a quality inspector. Architects can on a voluntary basis be included in the Chambers of architects and manufacturers in a registry. It is expected that the quality of the people who participate in the building process are being registered transparently, possessing up-to-date knowledge and experience is then captured by the registers and so guaranteed.

Quality inspectors

The quality inspector should have sufficient knowledge to determine whether compliance with the building regulations is met. In the instruments, requirements will be set for the process, person and the products. For persons a number of scopes are defined in the assessment directive (*Beoordelingsrichtlijn*- BRL) BRL 5019, such as General architectural and coordination, structural, fire safety, building physics and engineering industry, which should be represented by a qualified person.

2.1.6 Sub conclusion

The comparison between four European countries and the Dutch situation provides a number of clear conclusions. The municipalities continue to grant permission to build, complying with zoning and environmental security is a task that is associated with the Government and a task that remains with the government.
Private parties carry out the technical part of the four evaluated countries. In England/Wales and also in Germany, there are options to choose a private or public inspector. The systems in France and Germany perform properly and are not adjusted recently. In England/Wales there are still discussions on the functioning. In Sweden, the system is adjusted and the criteria have become stricter. By mandating quality assurance in the evaluated countries, the size and risk profile of the project is taken into account.

Submitting a completion certificate or reporting a construction finished is common. The four countries have different systems of personal registration. Registering qualities of construction companies, architects, engineers and quality inspectors is common. The Government often plays a role in assessing these qualities, especially in establishing the qualifications. The independence of the inspector is required in most countries. The responsibility and liability is clearly defined in most countries.

The costs of the different systems are difficult to assess, the impression is the mandatory involvement of certain officials lead to substantial costs. In Ireland, for example, that has led to the release from the obligation for simple construction works (alterations, detached homes) to bring in a quality inspector.

When the evaluated countries, are compared to the proposed Dutch situation the following conclusions can be drawn. The clear division of roles between municipality and the designers, builders and the independent quality inspector is included in the Dutch system. The report of a ready project is also in the Dutch system. To make demands on the quality standards of the concerned officials and companies in the Netherlands remains limited to only the demands on the independent quality inspector. In the evaluated countries there are more demands on individuals and businesses than what is usual in Netherlands.

In the Netherlands there has been a lot of attention to the cost of the new system, it is expected that the cost in the Netherlands in relation to the current situation will rise limited for result class 1, but that the cost of quality assurance for result class 2 and 3 will decrease. That is mainly caused by the current fees system, because the cost of the quality assurance of smaller projects is being apportioned over the larger projects. The forecast and also the objective is that the quality of the projects will increase resulting in less failure costs. The EIB concluded from their analysis of the social costs and benefits that by accelerating the process important benefits can be booked, if also a functioning benchmarking system is introduced, than the benefits will be substantial (EIB, 2016). The position of the consumer ameliorates and that is also the ultimate intent of the law.

Table 1: Summary analyzed systems

Activities	Germany	England	France	Sweden	Netherlands[3]
Design Check	◔	[1] ● ○	●	●	●
Construction Check	◔	[1] ● ○	●	●	●
Permit to use	○	○	[2] ○	○	[4] ◔
Supervision plan	-	-	●	●	●
Supervision plan check and permit	-	-	○	◔	-
Qualifications designers and contractors	●	●	◔	◔	-
Qualifications check systems	-	-	-	-	◔

Legend	
●	Private
◔	Mix
○	Public

Remarks:
[1]: Choice between private or public inspection
[2]: Only high-rise and public buildings
[3]: New system (Wkb)
[4]: Obliged as-built statement

2.2 Quality Assurance Act (*Wet kwaliteitsboring voor het bouwen*-Wkb)

In this section the Quality Assurance Act for construction (*Wet kwaliteitsborging voor het bouwen*-Wkb) described. First the history and the cause of the law. The components of the law are described in section 2.2.2. 2.2.3 gives inside in the insurance and guarantees. After that the roles in the system are explained (2.2.4). The consequences of this law in practice are clarified in 2.2.5. This section ends with a sub conclusion.

2.2.1 Introduction

The construction sector is a dynamic whole. This includes the component of legislation.
The Ministry of Internal Affairs and Kingdom Relations (BZK) has been working on improving the quality assurance in construction for fifteen years.
The reason for this attention was the notorious NIPO study presented in Cobouw in 2000 with the headline 'Veel geld voor flutwerk' (Nipo, 2000).
This study was also partly the reason for the founding (in 2003) of the Netherlands Building and Housing Inspectorate (VBWTN).
One of the objectives of this association is to improve quality assurance in the work of the municipal building and housing inspectorate (BWT).
In 2008, the report of the Dekker Commission was released: 'Privaat wat kan, publiek wat moet'. This report made several recommendations for improving the quality in construction. One of the recommendations was to abolish the so-called building plan test by the municipality (formally designated as Competent Authority). This building plan test is carried out by the municipal building and housing inspectorate. If this test shows that the building plan adheres to the Building Decree, (a general board measure (AMvB), controlled by the Housing Act) and that the other requirements (spatial planning, environmental law, aesthetics, etc.) are also met, the applicant will be granted the building permit (Commissie Fundamentele Verkenning Bouw, 2008).
The audit process from the municipality took 13-26 weeks, depending on the purpose, and sometimes much longer.

Cause

The process described in the introduction does not suffice in practice. Firstly, a study from 2007 (see also the explanatory memorandum of the law) showed that submitted building plans were not realized in practice. Naturally, the building plan looks like the submitted building plan in terms of scope and purpose, but a lot of changes tend to be made during preparation and realization. It was also shown that in many cases (approximately 50%), the realized building plan did not comply with the Building Decree. Especially in the areas of health, usability, and energy efficiency, there were numerous deviations (De minister Voor Wonen en Rijksdienst, 2016).
Therefore, the consumer does not get what he/she is entitled to and has paid for. The current system does not offer the right incentives for delivering quality. If a deviation (defect) is detected, it appears difficult for the consumer to rectify this in his/her right. The permit (whether or not issued directly) had legal force, and the contractor could argue that the municipality had approved the building plan. However, the consumer cannot appeal to the municipality. In short, the 'roles' are not clear.
The Building Decree specifies the minimum quality that is deemed acceptable in the Netherlands. The Building Decree is a part of the Housing Law, which makes it public law (meaning the government is involved). In addition, the buyer enters into a contract with a contractor (or project developer), often in the form of a so-called sale-building contract. The government is not involved in this, which means it falls under private law (stipulated in the Civil Code). For a buyer, it is difficult to attain justice in case of flaws. The buyer often needs to prove that something does not comply and that is often very difficult if they are not an expert. The buyer is also often unable to understand drawings and calculations.
In short, with respect to the offering party, the position of the buyer is weak. These imbalances have often been addressed by consumer organizations. Recently, 3 consumer organizations published a manifest in which improvements are suggested (Ieder(in), VACpunt Wonen en de Nederlandse

Woonbond, 2014). In the coalition agreement of the Rutte 1 cabinet, the implementation of the Dekker Commission report is included. Since then, BZK has been working hard to legally define and implement the recommendations.
This has resulted on the 'Quality assurance act for construction' (Wkb). A consultation version of this act was presented in mid-2014. Over 80 responses were received, which have resulted in adjustments. After reaching an agreement in the coalition and after the Council of Ministers (*Ministerraad*) had accepted the act in mid-2015, the act was sent to the Council of State (*Raad van State*) for advisory purposes (De minister Voor Wonen en Rijksdienst, 2016). From that moment on, there was secrecy until Monday 18 April 2016, when ministers Blok and Van der Steur sent the law to the House of Representatives. In an interview minister Blok summarizes what the law entails and what objectives it pursues (Belzen, 2016).

2.2.2 Content of the Quality Assurance Act for Construction

The Wkb is a so-called amending law and consists of three parts: the amendments to the Environmental Licensing (General provisions) Act (WABO), the Housing Act (WW), and the Civil Code (BW). The first two laws are part of public law and the BW is private law.
The Wkb is often subdivided into two parts, the so-called system change and the improvement of the position of consumers. After these laws have been amended, several more AMvB's (general board measures) will be adjusted and there will be ministerial regulations for the remaining details.

WABO

The amendments to the WABO are limited and entail that the Building Decree test is no longer grounds for granting permits, meaning that the BG will no longer be testing. Via an AMvB (*Besluit Omgevingsrecht*-BOR) it will be indicated that from 1-1-2017, 60% of small structures, such as a dormer on the facade, will become Building Decree free and no longer involve a public role for the KB (De minister Voor Wonen en Rijksdienst, 2016).

Housing Act (WW)

The amendment of the Housing Act (*Woningwet*-WW) is about the process of the permit application up to the realization and commissioning. In the future, the applicant of the environmental permit will need to specify which authorized instrument (a system used for quality assurance) will be used to realize the construction. The municipality (the Competent Authority (*Bevoegd Gezag*-BG)) will check whether the specified instrument is permitted and whether it is suitable for the relevant project. At least 14 days prior to commencement of construction, the applicant will also pass on the information of the deployed Quality Inspector (*Kwaliteitsborger*-KB) to the BG, and the BG will check whether the KB is authorized to apply the relevant instrument. During these checks, the BG will use the Admissions Organization (*Toelatingsorganisatie*-TO). The TO only permits instruments, the KB will be admitted by the instrument provider or administrator. The so-called building plan test, the assessment of whether a submitted plan complies with the Building Decree, which would be performed by the BG in the current situation, will come to expire when the Wkb comes into force. There will be an as-built statement in its place. With this statement, the KB indicates that based on the applied instrument, it can be assumed that the project complies with the Building Decree. The KB drafts the as-built statement and provides it to the permit holder, which needs this statement together with the file the BG needs to carry out its tasks (such as monitoring the existing building stock). If the as-built statement is submitted with the file, the project can be used. For the BG, the simple determination of whether or not the as-built statement has been submitted is sufficient for enforcement and for prohibiting use where necessary.
The WW describes what an instrument is and what requirements it should meet. The general criteria are set out in the law, but will be further elaborated in a yet to be published AMvB, part of the WW (part of the criteria are known and included in Advice No. 8 of the Institute for Building Quality). The role of the instrument provider is also described. The tasks of the TO are described in the Housing Act, but will be further elaborated in the AMvB. The TO will become a so-called Independent

Administrative Organization (*Zelfstandige Bestuursorganisatie*-ZBO) without a legal entity. The ZBO will be managed by a board and is accountable to the Minister and therefore should draft an annual report (construction letters) on about the course of events and illustrate the state of affairs of the building quality realized in practice. This construction letter will be shared and discussed with the House of Representatives by the Minister (De minister Voor Wonen en Rijksdienst, 2016).

Civil Code (BW)

The BW strengthens the consumer's position. Three amendments have been provided. Firstly, the concept of a hidden defect has been defined differently; the builder must now prove that any defect is not attributable to them. The second change concerns the so-called right of retention. With the first completion, 5% of the contract value is withheld in a deposit controlled by a notary. In the current situation, this 5% expires after 3 months and is paid to the builder. In the new situation, the buyer (consumer) receives the request to release the 5% from the builder, because the builder is of the opinion that all complaints have been resolved and all obligations have been fulfilled. This is expected to lead to more debate, but this should only lead to a better understanding (and transparency) of the concept of good and sound work (*goed en deugdelijk werk*).
The third amendment concerns the obligation to inform the builder about the risks incurred by the buyer by entering into a sale-building contract. Obviously, the ways to hedge these risks should also indicated here (De minister Voor Wonen en Rijksdienst, 2016).
Many of these risks are hedged if the builder is affiliated to the *Stichting Garantiewoningen* (this foundation can be regarded as the continuation of the *Garantie Instituut Woningbouw*). The large guarantee institutions, such as *Woningborg* and *Stichting Waarborgfonds Koopwoningen* (SWK), provide certification, consultancy, testing, and monitoring of (housing) construction.

These measures bring more balance to the positions of the builder and the consumer. The consumer organizations, such as *Vereniging Eigen Huis*, are generally very positive about these changes. Moreover, the law permits professional clients to agree on different responsibilities with the builder. It should be noted that the usual standard conditions in construction UAV 2012 and the AVA need to be rewritten.

2.2.3 Insurance

Section 2.1 on international comparison describes the systems applied in countries surrounding the Netherlands. The French system strongly relies on the compulsory insurance, is expensive, and insufficiently leads to better quality. In the other countries considered, the emphasis is on the quality of the involved parties, such as the inspectors, the architect, and the builders. The responsibilities are clearly described, which means the consumer knows who to go to when there are complaints. Naturally, these parties will insure themselves against any mistakes they may make.

Guarantees

In the Netherlands, *Woningborg N.V.* and *Stichting Waarborgfonds Koopwoningen* were founded to protect the buyer against bankruptcy of the builder (completion guarantee), and a set of warranty rules has also been developed. In case of conflicts, these organizations can act as mediators. There are different views about the quality of these guarantees. They appear more like exclusions than guarantees. Certain developers and builders therefore provide more extensive guarantees, such as Timpaan, which resolves any faults up to 5 years after completion (Timpaan, 2014).
After introduction of the Wkb the foundation connected to the guarantee institutions, namely 'Woningborg', 'SWK' and 'Bouwgarant', will adjust their procedures. They continue the guarantee that in the situation of bankruptcy of the construction company the construction will be finished and the guarantees are met. Buyers can also submit complaint at the guarantee institutions in case defects are not corrected by the construction company. The new system will be expected to provide better-performing construction companies. The current methods of Woningborg and SWK differences (Bouwgarant is especially designed for renovations, while they are broadening their

scope). SWK mainly uses affiliated construction companies for the quality assurance (which are the larger companies in the Netherlands), Woningborg works more with medium and small builders, as they usually do not have a quality management system, Woningborg performs a building plan assessment before a project is insured and then inspects the execution (Aedes, 2015).

Tender

Because the construction company becomes responsible and accountable for the design and execution that by tenders there will always be a price will be specified based on the documents. The construction company does not have the time to check the documents. This means that afterwards, extra charges (*meerwerk)* may apply if the documents are incorrect. That will have unpleasant consequences for a client. Possible solutions are to give more time so that the builder can (or let) perform checks or conclude a design and build contract (with conditions UAV GC 2005 instead of the UAV 2012).

2.2.4 Roles in the system

As indicated, the building and housing inspection of the municipality (the BG) will no longer assess the technical quality, but focus on assessing whether the building plan fits the zoning plan (spatial planning), whether the plan meets the aesthetics requirements, and whether the project does not endanger the environment (environmental safety). In addition, the BG will assess whether the instrument proposed by the applicant is included in the register, and the same applies to the KB. Once construction is ready, the BG will check whether the as-built statement and the file will be submitted.
The municipality checks whether the file (dossier) they receive is complete, there is no substantive check. It is also not intended that there 'in use' permit is issued. However, enforcement by the BG should take place when the building is going to be used without an issued as-built statement and file.

The Admission Organization (TO) assesses the provided instruments, permits them, and registers the permitted instruments. This register will be public and will serve as a verification option for the BG. The TO will monitor the operation of the instruments on a periodic and risk basis. This monitoring includes two main activities:

1. office audits of the instrument providers
2. reality checks on the construction site

The instrument provider (*Instrument Aanbieder*-IA) will need to monitor the operation of the instrument and the way the KB is functioning. This KB first needs to be authorized by the IA before it can use the instrument. The TO assesses this by means of the office audit and checks whether the files at the IA are in order. By means of the reality check on the construction site, the TO checks whether the instrument is being used correctly, and whether there is compliance with the Building Decree. If the IA should be in default or if the reality checks show that an instrument is not working as intended, the TO will impose sanctions. Enforcement shall occur via a so-called escalation ladder (warning, public warning, suspension, and withdrawal). The consequences of suspension and withdrawal are very intrusive and have financial consequences for both the IA and the KB.

The instrument provider develops an instrument for quality assurance and provides it to the TO. If the TO allows the instrument, the IA will authorize the KBs to use the instruments. The authorized KBs will be registered in a public register by the IA, which should also be consulted by the BG.
The IA should also record its monitoring of the operation of the instrument in order to be offered with an office audit by the TO. The IA checks whether the building file that serves as the basis for the as-built statement for the KB is complete and transparent. Of course, this verification may result in a lot of 'paperwork', but if organized in an efficient and effective way, this additional load should be minimal. Therefore, this research project is aimed at determining what an effective, efficient, and reliable verification could look like.

The quality inspector will register with an instrument provider or will be asked by the IA to be registered to be allowed to apply the instrument. The KB will need to have sufficient knowledge and capacity to apply an instrument. The internal quality assurance of the KB will always need to be in order, as the IA will carry out periodic audits to determine whether the KB is performing its work properly and to see whether the instrument is working in practice. The amount of work the KB needs to carry out depends on the instrument and on what the builder can and wants to do themselves. To keep the costs proportional, it is expected that especially in consequence class 1, the demonstrability will mostly remain with the builder (Sira Consulting, 2015).

Given the fact that they are responsible and accountable, the builder has the primary responsibility to demonstrate that the agreed quality is delivered. Most builders have a quality management system; however, this study has shown that due to lack of time, many of the agreed checks never occur. The need to demonstrate that the 2012 Building Decree is complied with in a disciplined and knowledgeable way only becomes greater with this new system, and this has consequences for the construction process management of the builder. This is described in Chapter 4.

Consequence classes

In consultation with the House of Representatives, it has been decided to introduce the new system in phases. For this purpose, a threefold division has been established based on the risks run by the users of a building. The three classes are referred to as consequence classes. Consequence class 1 refers to the simple utilitarian structures, such as industrial halls with a small office, agricultural buildings, simple construction (such as bike bridges), small offices, as well as ground-floor single-family homes and large-scale renovation projects (figure 10). Consequence class 3 includes the projects with high social risks if things go wrong, such as stadiums, railway stations, tunnels, hospitals, and similar buildings. Consequence class 2 is somewhere in between; think of residential buildings, schools, offices, stores, and similar structures. Interestingly, politicians have chosen to start with consequence class 1, even though most experience with regard to quality assurance exists in consequence classes 2 and 3 (Instituut voor Bouwkwaliteit, 2015).

Figure 10: Consequence class 1; (Stichting Instituut voor Bouwkwaliteit, 2015) (own processing)

Role of the government

A system in which government and builder are both responsible for part of the supervision is already in place. This will remain, but the roles will change. In terms of technical assessment, the BG will limit itself to determining whether the right instrument is being applied by a suitable KB, and will ensure that the as-built statement is submitted together with the file the municipality needs. In the yet to be established AMvB, it will be determined what needs to be included in this file. Therefore, this file is a limited part of the total building file that will mainly be compiled by the builder and will need to be transparent to the KB, the IA, and if needed, the TO.

As previously mentioned, the central government will establish a Building Quality ZBO; the role of this TO is defined above and recorded in the Wkb.

The government has commissioned all sorts of studies, such as a Social Costs and Benefits Analysis (SCBA). For this law, the study was performed by the *Economisch Instituut voor de Bouw* (EIB), led by Mr. Drs. Taco van der Hoek. Among other things, this SCBA revealed that careful benchmarking has a major positive financial impact. Therefore, the Ministry (BZK) supports the establishment of a transparent and effective benchmarking system (for a comparable system, see www.bouwprestaties.nl) (EIB, 2016).
It has also been studied what information a buyer or tenant needs when a property is delivered (or moved into). Several consumer organizations contributed to this study (MARE Research, 2015).

2.2.5 Consequences of Wkb in practice

The consequences of the Wkb in practice are divided in the consequences for the construction company, their consumers and for the competent authority (BG) (most of the time the municipality).

Construction company

Accepting small deviations by the BWT, what is currently done in practice, will not be possible in the new system. The KB cannot declare that it almost meets the Building Decree. The designers will have to take tolerances and deviations more into account (Nieman, 2016).The construction companies will have to work more accurately, which is the intention the intention of the WKB. More quality, less failure costs, so that the consumer gets what he is entitled to. In the elaboration of the law is included that an inspection plan should be drawn up on the basis of a risk analysis. However, part of the build errors arise during the design phase, therefore checks will also be required during the design phase. These checks are also included in the developed quality system (Chapter 4). The amendments to the WW included in the Wkb is only regarding the checks for compliance with the Building Regulations. However, the assurance systems will also pay attention to the contract and good and sound work. The as-built statement which is sent to the BG deals with the Building Decree, however the consumer is entitled to everything he has paid for, and therefore also the BW is amended. All adjustments after the '*Koop-aannemingsovereenkomst*' with the consumer has been closed have to be well discussed and defined in order to avoid problems at the completion. This creates an incentive to develop a design as good as possible. Besides the law, flanking policies have been developed such as development of benchmarking, which will improve the customer's insight on the performance of the construction company and also prevents construction companies from playing it safe, which will cause the prices to rise.

Competent authority (BG)

As established by the Dekker Commission, the check on the Building Decree requirements performed by the municipality adds little value (Commissie Fundamentele Verkenning Bouw, 2008) . Also the fact that the building permit gives legal assurances above the Building Decree indicates that the current system is not clear about the responsibility and liability (Haan, 2016). In the new system, it will become crystal clear for the consumers who to approach when there is something wrong, namely the builder, not the municipality. The municipality remains responsible for issuing the

building permit (environmental permit), and will assess the spatial planning, environmental security and building aesthetics. The municipality also remains responsible for the existing stock (so after the completion the municipality will continue to assess the building to ensure it is safe and poses no threat to the environment). The enforcement will maintain with the BG. The enforcement grounds with the new grounds are simple, it is not allowed to start the construction when no authorized instrument is being used. The BG will also check whether the KB is entitled to use the specified instrument. As long as the as-built statement (plus the dossier for the BG) is not being issued, the building is not allowed to be used.

2.2.6 Sub conclusion

The new law (Wkb) has three chapters:

1. The amendments in the Housing Act, the manner in which the construction quality is checked,
2. Strengthen the position of consumers stipulated in the Civil Code
3. Adjustment of the WABO, small buildings are no longer assessed against the Building Act.

The new system places responsibility for the legally required building quality down to the builder. The national government will conduct system monitoring on the instrument for quality assurance. The license holder is obliged to involve an independent quality inspector, who will issue the statement that there has been built according to the building regulations (the Building Act), this statement will be accompanied by a confined records and will be made available to the competent authority, if the statement is submitted the relevant project may be taken into operation. The expectation is that through these adjustments the right incentives are given to deliver the quality the customer (the consumer) deserves.

3. Systems Engineering and Building Information Model

This chapter contains the description of Systems Engineering. The first section describes the context of the Systems Engineering and system engineering in housing, how it stands in relation to the Quality Assurance Act for construction (Wkb) and a Sub conclusion. The second section describes the relation of Systems Engineering at Van Wijnen followed by the integration of the Wkb in the BPM systems. Next the Checklist structure will be explained as well as the Monitoring Protocols structure. As last there is a Sub conclusion on the second chapter.

3.1 Systems Engineering

The projects in the construction industry are more complex than some years ago. Systems engineering is already implemented in the excavations, civil engineering and waterworks (*Grond-, Weg- en Waterbouw*-GWW) industry.

The construction industry also has more freedom and responsibility in the realization than for example infrastructure projects. With the complexity of the current building and more responsibilities, incorrect assumptions by specialists regarding the work of others and failures are common problems in construction. This results in increasing costs of failure (faalkosten). In 2008 it was already 11.4 % of the total turnover in the building industry in Holland (Rijkswaterstaat & ProRail, 2009). Several parties in the Dutch building-industry were already trying to reduce the costs of failure in construction. Implementing Systems engineering in the GWW-sector (ground, water and road construction) is one of those initiatives (Rijkswaterstaat & ProRail, 2009).

Systems Engineering (SE) as a work methodology in the Netherlands is best known in infrastructure. Large infrastructure projects were designed and implemented with this methodology in mind. Rijkstwaterstaat and ProRail encouraged this approach (for instance, SE was used for the Betuwelijn) RWS states: *'SE is essentially a structured specification and design method. SE has the purpose of giving structure and insight into the complexity of the object to be realized. Using SE, risks that occur due to incorrect or incomplete information and assumptions can be managed. What is important is that the system is considered as a whole, throughout the entire life cycle, including the relationship with its surroundings'* (Prorail, Rijkswaterstaat, ONRI & Bouwend Nederland, 2007).

SE has been applied in other business sectors for a very long time, such as in the aviation industry. SE is mainly used for complex projects.

There are many ways in which to define Systems Engineering (SE). According to Kossiakoff et al (2011), the definition of Systems Engineering is to guide the engineering of complex systems.
So SE is a guide to engineer complex systems in which the needs of different stakeholders are brought together over the life cycle of a product. SE is therefore not the same as other forms of engineering. Three aspects in which systems engineering differs from mechanical, electrical and other engineering are important in that matter (Kossiakoff, Sweet, Seymour, & Biemer, 2011)
SE is not focused on one aspect but on the whole Systems. SE is not focused on the technical production but on functional design reflecting the needs of the user. SE is not only for focusing on one aspect but bridges the traditional engineering disciplines.
INCOSE (International Council on SE), a leading international organization in the field of SE, provides a broad definition of SE: Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem: operations, performance, test, manufacturing, cost & schedule, training & support and disposal. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured

development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs (Incose, 2009). When comparing systems engineering with the traditional engineering disciplines it can be concluded that systems engineering is more complex. The main reason is that systems engineering is used over the complete lifecycle of a project, where several engineering disciplines and user needs are combined into one system. In traditional engineering, the diagrams show development, implementation and the relationship between systems and their requirements. Systems Engineering shows each intermediate step more clearly as traditional engineering, and gives a clean view of the sequence of different phases and the connection between them (figure 11).

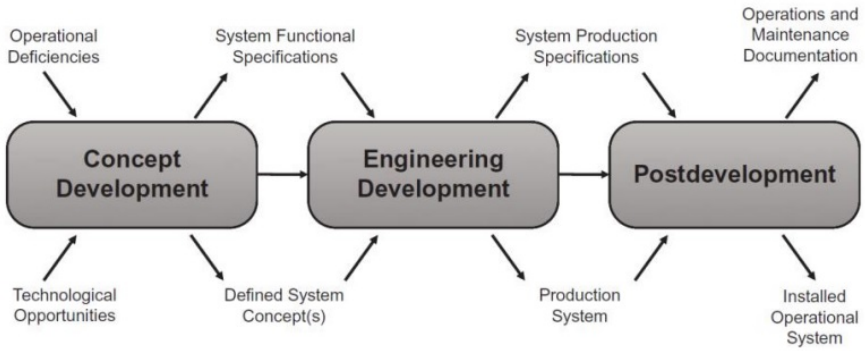


Figure 11: Systems Engineering Life Cycle; (Kossiakoff, Sweet, Seymour, & Biemer, 2011)

In the first phase the requirements of the user are analyzed, and the concept is described. Multiple tools can be used in this phase like, a Functional Breakdown Structure (FBS) and an Objective Breakdown Structure (OBS). In the second phase, an engineering development will turn up and the requirements will be translated to a design. In the final phase, the design is performed and the project is constructed. Further, operations and maintenance are included in this phase (Vries, 2015) SE is mostly used for big projects. However, it is also very useful for smaller projects. This kind of projects also starts with a definition and ends with recommendations for maintenance and use. This system thinking is propagated by many organizations in the Netherlands. For instance, SBRCURnet has issued many reports on construction process management, including about carefully defining the Program of Requirements (PoR) in advance. Carefully defining the question in consultation with the client is a prerequisite for a successful project. Thinking from ‘coarse to fine’ or from ‘abstract to concrete’ structures the design and implementation process. By repeatedly re-verifying whether the PoR is met during the process helps avoid disappointment of the client. Figure 12 indicates the start of a design process. First, the PoR is established, which is of course SMART (Specific, Measurable, Assignable, Realistic and Time-related) defined in a complete way; then, the three concepts are defined, including the fire safety concept, the energy concept, and the implementation concept (3 concepts) (Nieman, 2015).

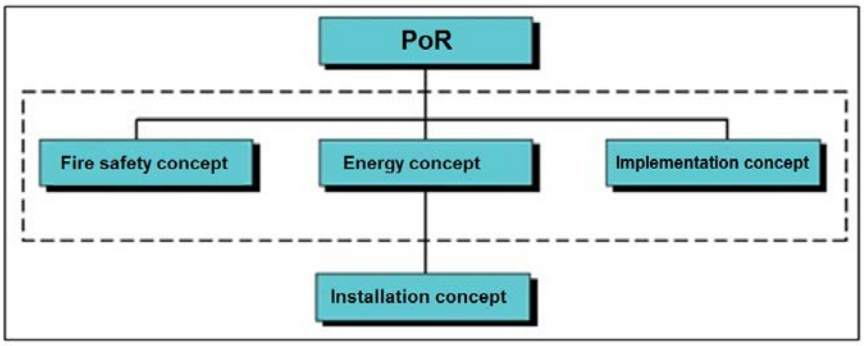


Figure 12: Start design process; (Nieman, 2015)

This established the structure of the design; for instance, the fire safety concept includes the escape routes and partitioning, the energy concept established the basic principles for the building envelop and the (sustainable) installations including the shafts, and the implementation concepts determined how construction would take place. Defining these concepts creates a 'timetable' for the rest of the design process, followed by a careful implementation process, and resulting in successful use. This approach is the basis of the building process management system (BPM) of a developing builder.
In commercial construction (with the exception of very large projects) and housing construction, SE is hardly or not used as a concept, but the description of how a good building process management system should work has the characteristics of SE. However, work carried out in practice is hardly ever in accordance with the principles of a good BPM system. The knowledge is available, but is often not utilized, and there is a lack of discipline to adhere to these principles (Koning & Elp, 2011).
It is also apparently not necessary to produce optimally. The client or insurance pays for the errors that occur, and it is estimated that the costs of failure in construction are 10-14% (PwC, 2012). Thus, the right incentives for delivering quality are missing in construction. There are various causes for this; firstly, it is not an open industry, there is no market from an economic perspective. The owner of the land determines who builds and they are often project developers, independently developing builders, or the government. In addition, the building permit provides an indemnity for non-compliance with the technical building regulations. If the municipality (the competent authority) has approved a construction plan, even if it does not comply with the Building Decree, it can still be built. Moreover, the municipality is not liable for any errors made. In short, the current situation does not lead to the delivery of an optimal performance. Measuring performances based on key performance indicators (KPIs) and comparing these via benchmarking is hardly prevalent in construction. There is a comparison site (www.bouwprestaties.nl), but given the fact that the consumer (with the exception of some situations, think of CPO) cannot select their 'own' builder, such a benchmarking system would only have a minor impact.

3.1.1 Systems Engineering in housing

Utilizing SE is not common in housing, but given its systemic thinking, the use of SE appears highly promising (Plegt, 2009). Defining the customer requirements as a starting point, considering the environmental aspects, thinking in concepts, working from 'coarse to fine', taking into account the use phase (TCO), in short, an integral (or holistic) approach leads to a business branch which (within the financial capabilities of the customer) can optimally fulfil customer needs. SE is a multi-disciplinary approach; optimal design results can only be realized in a design team. As shown in figure 11, the technical concepts need to be developed during the creative process; first designing and then implementing the installations leads to suboptimal solutions. Even during the realization phase, a multi-disciplinary approach is desirable, as the subcontractors and installers should want to achieve an optimal result together with the building contractor. Keeping to agreements, informing each other (good communication), and respect for each other's work are the basic principles. This way, chain cooperation occurs, in which all parties feel responsible for the result. As mentioned, little research

has been done in the Netherlands on the possibilities of SE in Housing; only housing corporation 'AWS Beter Wonen' has had a study carried out. This study yielded the following results:
Based on the developed structure, the four problem areas and the SE theory have been confronted with each other. All parts of the developed structure were included here: Environmental process, SE, purchasing process, SE management, project management, and organization. New roles need to be assigned for implementing the renewed process. The current employees are to be assigned different roles based on their competencies. The most important new roles are that of the SE manager (SE management team), the Systems Engineer (Requirements & Design team), and the Systems Integrator (System Integration & Verification team). If the required competencies for a role cannot be found within the organization, external parties need to be recruited. In addition, a supportive policy needs to be established in the field of process management (time, money, quality), and a clear procedure needs to be established for the development process, which should also include how the selection of market participants should occur. These adjustments to the development process can be based on SE, but there is no specific applicable method for this yet in housing. The results of a test may also give other corporations insight into how SE may improve the manageability of the development process and what SE can mean to housing projects.

3.1.2 Relation to the Quality Assurance Act for construction (Wkb)

The quality assurance act for construction places the responsibility (and therefore, the liability) with the builder, which means the consumer has one 'desk' for filing any complaints. The burden of proving whether a complaint is justified or does not lie with the builder. Furthermore, the consumer (which can also be a business that is having an office or workplace built) will receive the necessary information about the (financial) risks the customer runs and in what way these risks are or can be hedged. The customer will also release the completion deposition (5% of the contract value) registered with the notaries themselves, once any potential complaints have been satisfactorily resolved. These are the changes in private law. The changes in public law (compliance with the civil engineering regulations) become a responsibility of the builder; the builder needs to prove its compliance or have it proven by a third party. This is called the system change; in the new system, the builder is expected to provide an as-built statement. This means the actual (realized) project must comply with the regulations. In order to keep the new system affordable, it is necessary for the builder to prove their compliance themselves as much as possible. This practice needs to be integrated into the BPM. In nearly every phase of the construction process, matters need to be recorded and checked. By allowing the independent quality inspector to monitor the process (granting access to the BIM server), rejection at a later stage that required the work to be redone can be avoided. Even during the implementation, the builder can keep doing most of the work themselves and the role of the KB is limited to a number of samples. The KB needs to gain confidence in the BPM system (specifically, the quality management system) of the builder. The KB will (based on their system or instrument) check whether the system is being used properly and can then largely base their as-built statement on this system. Because the builder integrates its checks and data collection into its method, additional effort is limited. The builder is expected to make use of existing systems where possible, such as certified quality statements (*Kwaliteitsverklaringen*-KV). Quality statements are now mostly issued by manufacturers (product KV), but the expectation is that assessment guidelines will also be developed for application and assembly, based on which Certification bodies can start issuing process certificates or a process KV.
Demonstrating compliance with the civil engineering requirements is expected to make up a limited part of the total quality care, as compliance with the contract and good and sound work (customer requirements) are at least as important. This broad approach thus requires a good system, which is why SE fits very well with the Wkb.

3.1.3 Sub conclusion

SE is systemic thinking, a total approach, of the early definition or customer requirements and the technical integral approach (not only determining what activities should be carried out, so that the

traditional project management aspects (money, organization, time, information, quality, and safety and risk: GOTIK+VR) but also indicating how these activities can be carried out up to the use, maintenance, and demolition of homes and buildings). The Wkb can easily be implemented within SE and the Wkb can be applied in Dutch construction with minimal costs. The task at hand for construction industry is to improve (expand) their BPM and, even further down the line, transform their PBM into the principles of SE.

3.2 Systems Engineering at Van Wijnen

The section 3.1 on Systems Engineering indicates that in order for the new quality assurance system to remain affordable, integration into the Building Process Management (BPM) system of the builder is necessary. The builders will need to demonstrate compliance themselves as much as possible. The alternative is a quality inspector (KB) (a company that can assure all disciplines) fully taking over this task, which results in high costs. Moreover, the purpose of the Wkb is to stimulate the builder to deliver quality, and that should start with the builder ('building like it is your own'). The Wkb shows that an independent KB must prepare the as-built statement and provide it to the permit holder, who then submits this together with the file for the Competent Authority (*Bevoegd Gezag*-BG) to that BG. This KB may base its judgment on the quality management system of the builder. This system is a part of the overall BPM system. As such, the KB will need to make agreements with the builder about what matters should be demonstrated and recorded. This will happen in a transparent way, because even the instrument provider needs to be able to check whether the KB is performing their work properly and using the instrument correctly. Lastly, the Admissions Organization (*Toelatingsorganisatie*-TO) will need to monitor whether the IA is performing their work properly (by means of an office audit) and that the instrument is working as intended in practice (reality check) (figure 13) (Leeuwen, Barendregt, & Egmond, 2015).

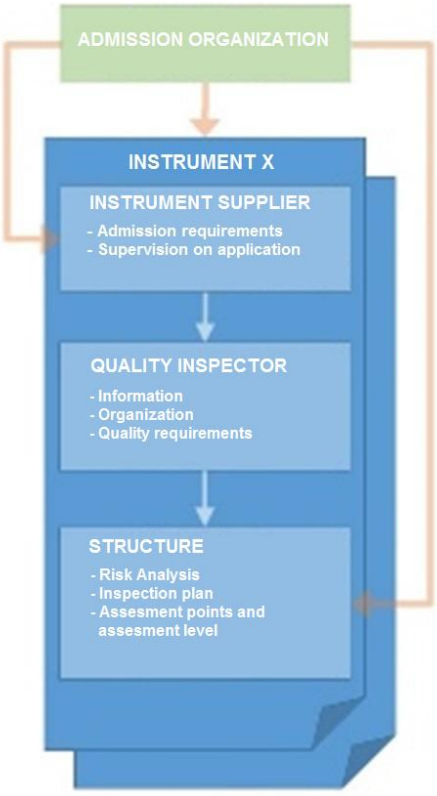


Figure 13: Admission Organization; (Leeuwen, Barendregt, & Egmond, 2015)

3.2.1 Building process management at Van Wijnen

Van Wijnen uses a BPM system in its business process, which indicates which activity should be implemented in which phase of the design and building process. The BPM system is displayed in a matrix (figure 14) each box represents an activity, and the way in which this activity should be carried out is defined in a protocol.

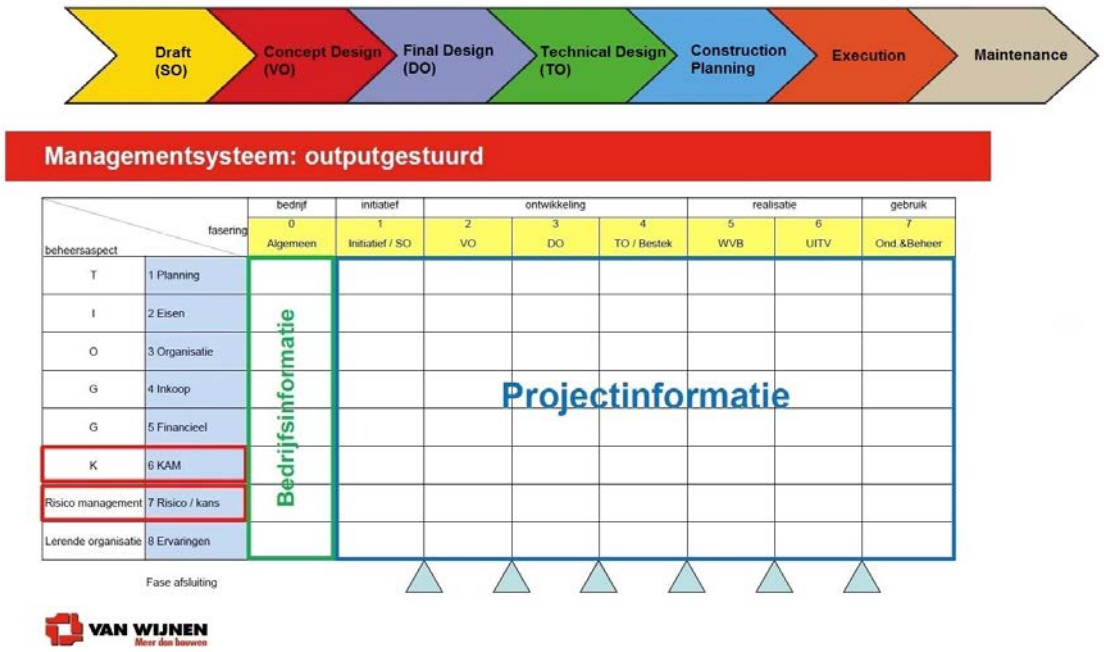


Figure 14: BPM system van Wijnen; (own processing)

The matrix is performed from left to right, and the risk analysis is important as the final activity in each column. Here, the risks are defined and analyzed, and it is considered how the risk can be eliminated or controlled. These activities are called risk management activities (Well-Stam, Lindenaar, Kinderen, & Bunt, 2008) (figure 15).

If the risk analysis and the associated measured are reviewed by the responsible manager, they will take a GO or NO GO decision. If the risks are deemed too great, the project is cancelled and the order will not be accepted. If the decision is a GO, the activities in the next phase (the next column) will be carried out. This phase is also finished by a risk analysis; of course, the risk management measures carried out are assessed in the relevant phase, but new risks can again be identified in this phase, which must then be eliminated or managed. This approach is used throughout the entire process. The filled matrix also includes the building regulations activity (Annex 1).The responsible project manager ensures that the design process occurs within the building regulations and that the necessary building decree calculations are performed. A consultant will often be hired to perform a Building Decree test. The guarantee institution will also perform a building decree test. If it is decided that the project will be implemented, a number of documents, such as reinforcement drawings, will still need to be submitted to the BG during implementation. In the future, these documents will need to be provided to the KB.

Once construction has started, the basic principle is that the implementation team can rely on the contract (specifications and drawings) to be correct (and therefore comply with the Building Regulations) and that their task is to build in accordance with this contract. At Van Wijnen, inspection lists have been developed, which the implementation team can use to check whether agreements are being fulfilled. These inspection lists are completed during planning and implementation. In total,

Van Wijnen has developed 22 inspection lists. In this study, these inspection lists were used as a basis for control protocols, which demonstrate and record compliance with the building regulations.

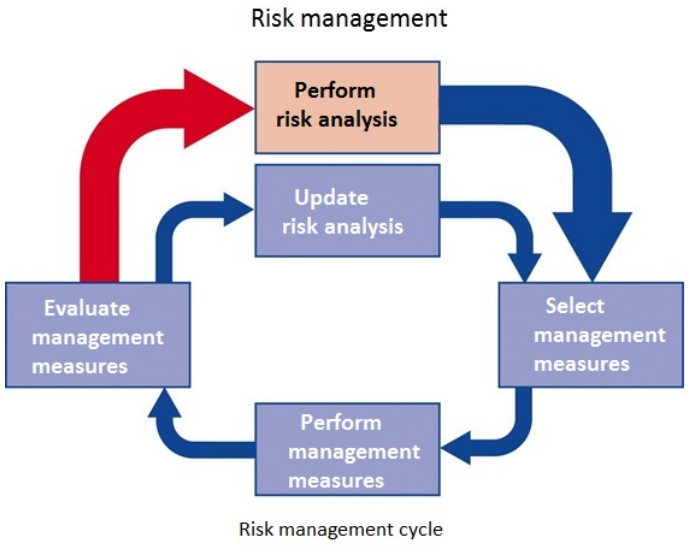


Figure 15: Risk management cycle; (Well-Stam, Lindenaar, Kinderen, & Bunt, 2008)

Based on the BPM system (annex 1) a Business Process Model and Notation flowchart (BPMN) is created to visualize the information flow (figure 16).

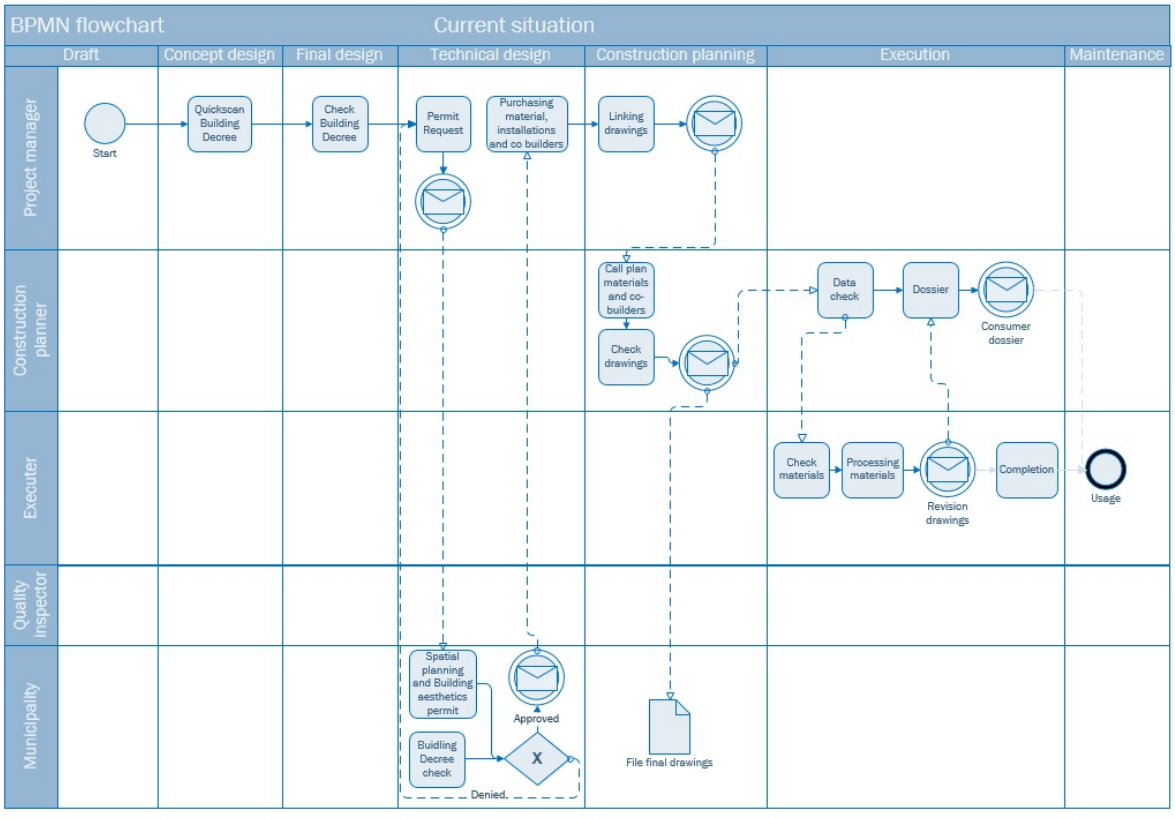


Figure 16: BPMN flowchart for current situation; own processing

3.2.2 Integration Wkb in the BPM system of Van Wijnen

As stated in the conclusions of the chapter on SE, an integrated approach will be necessary to determine compliance with the regulations. It should always be clear what needs to be done, how it should be done, who is responsible, and when it should be done. This results in a complete system (chapter 4).
In this study, a three-step plan was developed, which was tested in a practical situation (project Groevenbeek, Ermelo), see chapter 5.

Step 1: in the basic scheme (matrix), the quality management system is indicated as a separate topic; the building regulations activity is still a separate part of the matrix, but is limited to spatial planning, environmental safety, and aesthetics (these topics do need to be completed to obtain the environmental permit).
In all phases of the design and implementation process, certain activities need to be carried out for the purpose of quality assurance.
Step 2: new are the so-called checklists, which are arranged in such a way that the building process is followed. The total set checklists therefore cover the entire design and implementation process. In this study, 10 quality checklists (QCL) were created. This set will need to be expanded for other types of projects, such as residential buildings and commercial buildings.
The QCL define, in addition to the criteria above (what, how, who, and when), in what phase the check needs to be performed. It is also clear which Building Decree article is concerned and what the method of determination is. The method of determination is usually the Dutch standard (NEN) set out in the 2012 Building Decree. By linking the matrix to the checklists, during the assessment (risk analysis) or when the activities defined in the matrix have been carried out in the relevant phase, it can be determined whether the activities in the framework of quality management have been carried out.
Step 3: the person performing the check will make use of the control protocols. Checks are performed for each phase; the work planner and executor will perform most checks, and will rely on quality statements (KV) of the manufacturers and the subcontractors and installers. These checklists will be need to be filled out digitally and included in the project file.

The role of the KB is limited in the SWK instrument, the construction company is responsible for the correct assessment and recording. The employees therefore have to be instructed properly (see section 5.5). The KB will ensure that the quality system is used properly, important checks are the, risk analysis, design checks, the inspection plan and the measurements (e.g. blower door test).

3.2.3 Checklist structure

The QCL are arranged in such a way that the building process is followed. Annex 2 includes all the checklists. As an example, number 5,6,7 of the QCL 301 (front closure (window frames) and part of CP 303 (synthetic window frames) has been elaborated (figure 17 & 18). The design of the complete system is described in chapter 4. All the QCL's and CP's can be found in the appendices.
In this example has been chosen for QCL 301, in which the recordings for window frames are established. In the 'Who' column is indicated who is responsible, during the construction planning and execution are mainly the planner and executor responsible, they use the CP's. In these CP's (see example CP303) are also process agreements defined, it is important that the work planner or the executor verifies that the previous actions such as checking of the lintels is executed, otherwise it may not be ordered.

QCL 301: Façade locks (windows frames)								
N.	**Phase**	**Building Decree article**	**Component**	**What**	**How / Norm**	**Who**	**With / what**	**When**
5	4	2.2 /2.4	Calculation lintels (supplier)	Requirements: Do not collapse	NEN-EN 1990 & 1992-1996	Constructive assessor	Check calculation	
6	5	5.3	Thermal transmittance (U-window)	Requirements: Uavg. : ≤1,65 (c.q. requirement EPC) W/m2K and Cf. BRL 0801	NEN 1068/ KV + delivery receipt	Work planner (constructor)	CP 303	
7	5	5.3	Manufacturing window frames & doors	Cf. BRL 0801	KV + delivery receipt	Work planner (constructor)	CP 303 + 304	

Figure 17: Number 5,6 & 7 of the QCL 301; own processing

VAN WIJNEN
Meer dan bouwen

CP303 Synthetic windows frames

Van Wijnen Deventer
Project :
:
Location :

Projectnumber :
Drafter :
Date :

Component	Approval			Clarification/action	Handled
General (phase 4)	**Y**	**N**	**N/A**		
KOMO-certificate present					
Is the 'politiekeurmerk' applicable					
Construction planning (phase 5)					
Preparing and monitoring drawing procedures					
Sampling hinges and locks i.c.w. assembly by manufacturer					
Protecting windows during execution phase					
Planning en routing discussed					
Making and checking windows frames					
Dpc foil applied on windows frames					
Measuring syntactic window frames					
Execution (phase 6)					
Supply check windows frames					

Figure 18: CP 303; Van Wijnen

As a first check, the calculation is checked; the structural safety assurer checks the manufacturer's calculation using a test calculation. This calculation is made in the DO phase, which is when the check should occur. Based on the weight calculation and the cone penetration test, the numbers, length, concrete quality, and diameter of the piles are determined and recorded on the pile plan.
Based on this pile plan, the piles will be purchased during the work planning phase. The manufacturer generally has a quality statement (KV) which provides the basis for the contractually agreed quality. The work planner checks whether the KV is current and appropriate for the delivery. The KV indicated what way the piles should be stored on site, the contractor checks this and records it (e.g. with a photo). The surveyor sets out the stakes and establishes a control measurement to ensure this is done correctly. Then, the pile driver appears at work, the builder has indicated what rammer should be used, and the contractor checks and records the statement of the pile driver. The builder has also indicated what calendar should be realized before the pile is sufficiently fixed. The calendar state serves as evidence. Finally, the piles need to be cut correctly, which is also recorded by the contractor. The CP's will also need to record any pile deviations. Any pile deviations should be passed on to the builder, who will then determine the necessary measures. By carrying out acoustic measurements, it can also be recorded whether pile fracture has occurred.

3.2.4 Monitoring protocols structure

As indicated, existing inspections lists were reused as 'Control Protocol' as much as possible. Therefore, there is only limited deviation from the current method.

In addition to testing compliance with the Building Decree, the control protocols also contain checks to determine whether contractual agreements are being fulfilled and to check for good and sound work.

3.2.5 Sub conclusion

SE has become the new method to design and prepare projects. SE starts with recording of the functional design based on the wishes of the client. A second important aspect is that integral design is used as starting point. The coordination between the different components of the design is essential. Working systematically from coarse to fine is a feature of SE. SE is rarely used in residential construction, but it is well applicable. The application of SE would connect very good to effectually and efficiently secure quality for the new quality assurance law. The share moments with the KB during design (control phases) is efficient, but access to all information on for example a BIM server is necessary. Van Wijnen uses a good working building process management system (BPM). In this BPM-system risk management is an imported. This risk thinking is in line on the Wkb. The current BPM-system is used as basis for the design of a new assurance system, with which it can be demonstrated that at least compliance with the technical construction regulations is met.

3.3 Building Information Model

In the construction sector the importance of BIM is already widely acknowledged. BIM will be the future for the whole building industry. (SBRCURnet, 2015).
There are many definitions of Building Information Model (BIM). The National BIM Handbook use several terms. For BIM it is: 'A set of data which represents a building structure'.
Building Information Modelling (BIM) integrates all of the geometric model information, the functional requirements and capabilities, and piece behavior information into a single interrelated description of a building project over its lifecycle (figure 19). It also includes process information dealing with construction schedules and fabrication processes (Beetz, 2015).

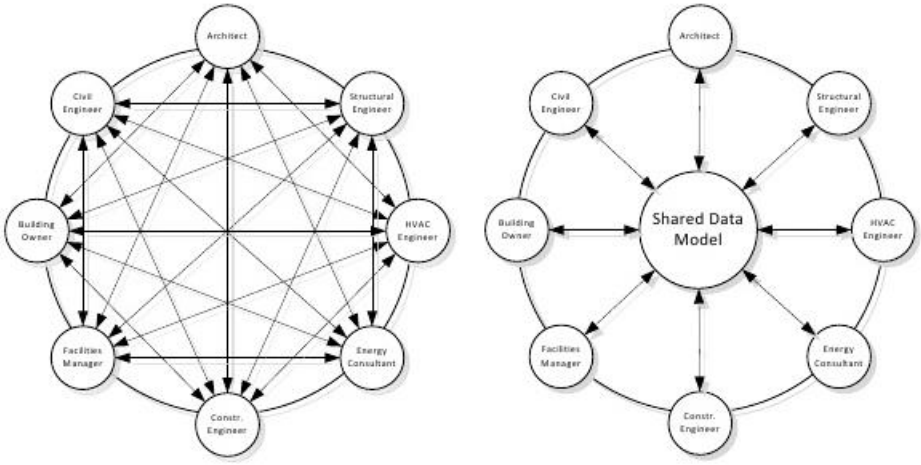


Figure 19: Shared data model; (Beetz, Berlo, Bos, Hendriks, & van Tongeren, 2012)

Building Information Modeling (BIM) processes have helped countless firms in diverse industries operate more productively, produce higher-quality work, attract more talent, and win new business (Autodesk, 2016).

In contrast to the traditional design and construction process, it is possible to work with one model (server) in the BIM process. All the data required for the design, construction and the maintenance of the building is linked to the server. This server is used by all the parties involved in the realization of the construction like client, architect, consultants, construction companies and engineers. In this research this server is called a BIM server.

The BIM server can be used to share and merge data from different specialists from the AEC industry. This tool fits in the technique Systems modelling. System modelling is part of the concept definition of the concept development stage. This is often considered the 'real' design (Vries, 2015).
The focus of this study is to share the results of the checks (including the check of the Building Code). So the BIM server is a way to communicate and exchange data in line with the general idea of The Shared Data Model. The data, in this case quality checklists (QCL) and control protocols (CP) are shared in one data model.

Van Wijnen does not use a BIM server to share all information yet. However, drawing in 3D software has already been introduced. In the continuation of this research a description will be given on how Van Wijnen can utilize a BIM server in their new quality assurance system.

4. System Design

Chapter 4 describes the newly designed Quality Assurance System. The introduction can be found in section 1. Section 2 will give more information on the link with digital samples. This is done via examples of Piles and Hull's. In section 3 a description of the system itself is given and includes the elaboration, processes and a sub conclusion.

4.1 Introduction

In chapter 3 (Systems Engineering) it has already been pointed out that within the current building process management system the consequences of the new law can be implemented. The BPM matrix of Van Wijnen is large and complex, for the study a simplified model is used which represent the current BPM matrix of Van Wijnen (figure 20). The complex BPM matrix can be found in Annex 1. The simple model which is used, has been limited adjusted (figure 23). From the matrix step 2 (QCL's) is being actuated. These checklists are developed for this research. Using the QCL's step 3 can be actuated. For these control protocols the current '*keuringlijsten'* are used as starting point. There was not a *'keuringlijst'* available for a number of Building Decree requirements, and these have been drafted. With these 3-steps procedure (described in page 47) evidence is delivered for all of the Building Decree requirements. Besides the checklists and the control protocols a check table has also been developed, with enables it to check if all the BB-articles are covered (Annex 4).

Figure 20: Simplified BPM matrix; own processing

4.2 Link with digital systems

The QCL's are created in 'W*ord' and 'Excel'.* This is done using the Building Decree and the related KEURINGSLIJSTEN at Van Wijnen. The CP's are also '*Word'* files and have to be filled in separately.

The ideal situation for Van Wijnen is that the checklists, for the QCL's and the CP's, can be linked to a 3D model. For Van Wijnen this will be a link with 3D modeling/drawing software.

For example, converting a 'Word' and 'Excel' to an open source file can create a link with a 3D-model. The open source files that are commonly used in the construction field are the so-called IFC files, which stand for Industry Foundation Classes. The IFC files have been developed to make it easier to share model information like walls, doors and windows and their properties. This in opposition to the file formats like DWG, in which only graphic entities are stored (lines, circles and shadings etc.). IFC is an open standard and available for all parties in the building process (Kubus, 2016).

This enables the possibility to link these '*Word'* documents to a 3D-model, for example a pile. When a specific pile is selected the software will present a lists with the requirements of this pile (QCL). Every part in the 3D model is unique and has its own specifications and therefore their own QCL. Because the focus of this thesis lies with the Building Decree check all of the piles have to satisfy the same check. But the check for a properly build house does not start nor end with the Building Decree calculations and if these or correct. Therefore there are also checkpoint added to the QCL for the execution phase which the parts have to meet.

To be able to show that the requirements are met evidence should be added to the checks. The evidence can for example exist of photos and statements. This evidence should be easily accessible via links so that with only a few clicks the as-state dossier can be composed.

In the most ideal situation it would be possible to click on a part, which triggers a pop-up of all the specifications of that part. The requirements that should be checked and the tool with which these checks have to be performed will be available in the drawing just by a few clicks.

Example: Piles

Part dimensions. The dimensions shall be conform to the pile plan. The surveyor who needs to check this, click on one of the piles in the drawing, see section dimensions, clicks on it, sees that these dimensions must be conform the pile plan. The surveyor can clicks on the section conform pile plan and the document of that pile plan will show with the measurements. The surveyor should verify this, and can click on the header protocol so that the control protocol shows with which the surveyor can check the dimensions. The control protocol is simple for this situation. The surveyor checks the position of the pole and determines the deviation. This information is then provided to the manufacturer for review.

Example: Body (casco)

Component fabrication walls. The manufacture of the walls must comply with BRL 1004. If the work planner click on the link, the BRL comes forward. In addition, there must be a quality certificate (*Kwaliteitsverklaring*-KV) from the manufacturer. The work planner can see by clicking on the header if this statement still meets the requirements (current / right product). In addition, the delivery receipt has to be added to the hull part that states when it has been manufactured and has been delivered.

The ideal model is that there is only one drawing required and within this drawing all the information can be gathered by simple clicking the links so it can be proved that the building meets the Wkb requirements. Last it would also be ideal when from the drawing easily an as-built record can be printed.

4.3 The system

The system consists of three components, step 1 (or phase 1) : the matrix, step 2 (or phase 2): the checklists (QCL) and step 3 (or phase 3): the control protocols (CP), the design is based on working from broad to fine.
The matrix (Annex 1) with the main concept of the construction process management system, which activities should be carried out, in which phase and in which manner. Every phase (the columns within the matrix) concludes with risk analyses, the corresponding management and the GO/NO GO decision. A row is reserved within the matrix for the Quality, Health & Safety, and Environment activities (*Kwaliteit, arbeidsomstandigheden en milieu*–KAM) activities. Part of the KAM is the quality managements, in every phase certain activities should be verified, approved and recorded. When these activities have been executed a checkmark is placed and the next phase can be started as regarding to the quality management.
To be able to place the checkmark in the matrix, the checklists (the checklists are the 2nd phase or the 2e step in the quality system) need to be completed, and 10 checklists are developed in context of this research. These checklists are included in Annex 2 The checklists are on their turn also matrixes. The checklists are numbered as follow:

- QCL 000 : “integrale aspecten”
- QCL 100 : “heipalen”
- QCL 102 : “funderingsbalken”
- QCL 104 : “prefab begane grondvloer”
- QCL 200 : “casco (hoofddraagconstructie)”
- QCL 300 : “gevelsluiting, dichte gevel delen”
- QCL 301 : “kozijnen, open geveldelen”
- QCL 400 : “dak sluiting”
- QCL 500 : “afbouw”
- QCL 600 : “installaties”

The columns of the quality checklists indicates the following:
Column 1: The sequence number of the corresponding checks
Column 2: In which phase the check has to be performed. To be able to place the checkmark in the main matrix the checks have to be performed in the corresponding phase.
Column 3: The relevant Building Act Article which is being verified.
Column 4: The component which is being verified, for example the calculations, the manufacturing, the transport and storage, dimensioning, the production or the delivery and any final inspection, for example with a measurement.
Column 5: The “**What**” or the demands the requirements that need to be checked.
Column 6: The “**How**” or the manner in which is monitored, for example, in accordance with a standard, an assessment directive (*Beoordelingsrichtlijn*- BRL) on which a issued quality certificate is based, a visual inspection, a statement from a subcontractor, a check of the dimensions, and such.
Column 7: “**Who**” performs the check (and thus places his signature).
Column 8: **‘With what”** is the check being performed, often this column refers to the check protocol (CP), these check protocols are often based on the check tables which are already used at Van Wijnen. These check protocols are used to perform the actual verification. The control protocols are therefore the 3rd phase (or step) of the quality management system. Not every protocol has check tables available, and have been developed in context of this research. There are in addition check tables in use at Van Wijnen which have no relation to the Building Act, but which are necessary to ensure a proper process, to ensure compliance to the contracts or are needed in the context of providing good and reliable work.

In the checklists and the control protocols there are incidentally checks included which are not required according to the Building Act, but which obviously should be performed at that moment, that the development of separate checklists and check protocols would lead to a rigid separation of the Building Decree and would mean good and reliable work. That is precisely not the intention, proving the minimum quality of the Building Decree should exactly be part of the total quality management system and should thus be an integral part of this system. This should prevent that it is seen as a separate and stand-alone activity and is seen as government enforced actions.
Column 9: "When" is or will the check be performed, for certain projects a planning can be drafted with the checks, the actual date and the approval included.

4.3.1 Elaboration

In this section a number of columns further is elaborated. Columns 1 to 4 and 9 need no further explanation, because they speak for themselves.

Column 5 : The Requirements (What)

In het the Building Decree of 2012 the so performance requirements are included to which a certain structure has to comply. These demands are listed in the so called control tables which states which article (and requirement) is applicable for the concerning user function. Sometimes the requirement can be found in the article, but sometimes there can be a separate column in the control table.
For example, main supporting constructions may not fail at certain loads, the constructor calculates these loads and these calculations are made according to the Eurocodes (international norms). These Eurocodes are called '*bepalingsmethoden*' in Building Decree jargon.
A second example is to limit the heat loss, and therefore constructions are being insulated. In the Building Decree are requirements, for example a facade shall have a heat resistance 'Warmte weerstand' (RC) of 4,5 m2.K/W compliant to NEN 1068 (national norms). The manufacturer or a building physicist calculates these resistances.
In practice, the requirements are being transformed into concrete demands, for example piles should have a certain calendar (number of strokes per 25cm of pile) before they are considered to be on the decisive low. The constructor issues the instruction how many blows and with which ram are needed, and the constructor shall perform checks to make sure the requirements of the Building Decree are met. In the Column Requirements (What) are therefore the requirements and the concrete demands, and references are made to the BRL (with the included translated requirements) a drawing of an instruction.

Column 6: The method (How)

The pile is used as an example again. The constructor determines, based on the Building Decree requirements, the quality of the pile, the measurements, the placing and the application process of piles.
It is therefore logical that the control process is based on the same requirements. To verify the calculations a controlling constructor shall make a verification calculation, this calculation will be, if done correctly, be a global calculation to be sure that the calculation is correct and on the other hand make sure that no double work is being performed (because of the costs)[2]. After the approval of the calculations it shall be verified during the continuation of the building process that the manufacturing, the application of the pile and the connection of the foundation bar have been realized within the framework of the approved calculations. An important assessment methodology is the assessment of details, as reference for the verification the SBR reference details can be used.

[2] Starting points at the checks is that it is plausible that there is compliance with the requirements. The KB is not responsible for the calculation. The concept of proportional stood central during the development of the WKB, the new system should stay affordable.

On the basis of a standard protocol engineering details are being verified and if agreed on these should then also be put into practice. By using these reference details in the indicated way it can be that measurements are not necessary.

The control methodology can therefore have differed manifestations:

1. Compliant a Norm (the relevant standard is defined in the checklists)
2. Compliant the concept “visual control”
3. A statement of the subcontractor (whether or not based on a BRL) of a conducted process.
4. A quality statement (*Kwaliteitsverklaring-KV*), (based on a BRL) with the delivery receipt of the delivered product.
5. A filled checklist, for example a ‘kalenderstaat’, a check on a detail or a measurements verification

Column 7: The responsible (Who)

The responsible person who performs the checks and declares digital that he/she has performed this check correct is being filled in this Column. These are for example the controlling constructor (now there is a separate constructor registry established where registered evaluative manufacturers are recorded), the building physicist, the work planner, the executor, the pile supervisor, a carpenter/surveyors who performs checks, in conclusion a summary of functionaries who are considered to perform and record these checks thoroughly and with knowledge.

Column 8:The instrument (With what)

There is a demand for the possibility to reproducibly and correctly prove the requirements are met. The so called instrument providers (IA), who are anticipated to also maintain their instruments for quality assurance (quality management system), are likely going to make a set of control protocols mandatory. In this research the preliminary instrument of the ‘Stichting Waarborgfonds for Koopwoningen’ (SWK) is used as starting point. The idea behind the instrument is that the executor can perform and record the assurance activities himself. The independent KB checks if this is done correctly and then he draws up the as-built statement, which then is sent to the municipality (BG) together with the requested dossier gathered by the license holders.

The methods with which the responsible are going to work are:

1. Verification calculations
2. Control protocols
3. Measurements and
4. Information collection and verification

Verification calculations will be calculations that can be performed in a quick manner (Maybe even a rule of thumb), which should prove that the calculation, which for example is performed by the involved constructor, give a reliable result. Control protocols (CP) are at Van Wijnen based on known ‘keuringslijsten’. The involved responsible persons is often the work perpetrator or the constructor, who will fill out the lists after the work preparatory or constructor has determined that a certain actions has been performed or that the work has been performed correctly and according the agreements. The numbering follows the QCL numbering. The control protocols indicate which QCL rule has been checked. For this research, extra control protocols have been developed to be able to make an assessment on the whole Building Decree. The third possibility is to (let someone) make the embodiments of measurements, often it is the assessment methodology which has been pointed out in the Building Decree, for example the noise measurement conform NEN 5077 or the ‘Blowerdoortest’ conform NEN2686. The results should prove that the test has been completed. In practice the test will be put to use incidentally because of the costs, but by building according to the

metered situation it can be established that it is plausible that the requirements are met[3]. Constructional reference details reference can also be used, which is well known that if properly carried out, the performance in that detail is realized.

As last resort a sub instrument used for a section of the process is mentioned the requesting and verification of information. In many cases the manufacturers, subcontractors and installers will put their quality check systems to use. You can assume that the quality checks have been performed. The most established form is the so-called quality statement of the manufacturer. The manufacture will let his quality system be verified by a certified institute and on that basis there is a justified trust that the requirements are met. De KV, which is issued, is based on a BRL. This BRL is drawn up by a certification institute, this BRL is being published for criticism and after processing the criticism being established. Every BRL is connected to a 'College van Deskundigen', which ensures that the substantive aspects of the BRL are correct. In addition the committee of Stichting Bouwkwaliteit is procedurally assessing the harmonized BRL. The roll of SBK is now partly public and partly private, but the expectation is that a fully private institute will be established and will survey the BRL. The responsible person should then request the KV, check if these are still current and belongs to the delivered product or process, and then check the delivery receipt. In the checklists it is indicated that certain components should be processed according to a specific work instruction, which is recorded in the product BRL. Only then does the product meet the requirements. This means that the constructor should add the work instruction to the relevant control protocol. In principle all of the four mentioned methods are control protocols, but because of the differences between them the sub instruments are mentioned separately. In some cases requesting and checking of the KV and statements that a process or activity is correctly executed is part of a control protocol. When this is the case, the control protocol is included in the checklist as a sub instrument. The mentioned control protocols indicate what should be looked at and in which way this should be recorded, for example taking a picture in filling in a lists.

All proofs that the requirements of the Building Decree are met will be gathered together with drawings and calculations in an as-built dossier. The KB will use this dossier as a bases on which he issues an as-built certificate and the IA will perform 'reality checks' if the concerning instruments works and if the KB performs his work correctly. The admission organization should have access to these 'reality checks'.

[3] Parties which continuously deliver good performance will be monitored less during a risk analyses that unknown parties. This is now standard practice, and this will not change in the new system. However, the KB will never take over the responsibility (basically, the municipality does not do this in the current situation either).

4.4 Process

In the QCL is specified in which phases a certain check has to be performed. Table 2 shows how many checks of a QCL should be performed in certain phases.

Tabel 2: Checks in QCL

QCL	SO	VO	DO	TO	Construction Planning	Execution
000		3			1	
100			1		1	5
102			1			6
104				1	2	3
200			3		2	5
300					6	4
301			2	2	5	5
400				1	9	5 (+2)[4]
500					7	15
600				3	2	10
TOT	**0**	**3**	**7**	**7**	**35**	**58**

In phase 1, Draft (*Schetsontwerp*- SO), are no checks specified, in this phase the PoR is established. In phase 2, concept design (*Voorlopig ontwerp*- VO) three checks are planned. The checks in the final design (*Definitief ontwerp*- DO) and technical design (*Technisch ontwerp*- TO) phase are also still limited, in both phases 7. The most checks are being performed construction planning- (35), and the execution phase (58). This system is designed for the project "Groevenbeek". For other projects and building systems additional QCL's and CP's should be drafted. An inspection plan should be drafted for every project in compliance with the law based on risk analyses. It means that for example the KAM-coordinator together with the project manager put together a set of QCL's and CP's with which the checks are being performed. Naturally this should also be digitalized to enable an efficient en flawless trajectory.
For the new situation (improved BPM system) a second BPMN flowchart is made (figure 21).

[4] (+2) Optional (if necessary, include in inspection plan)

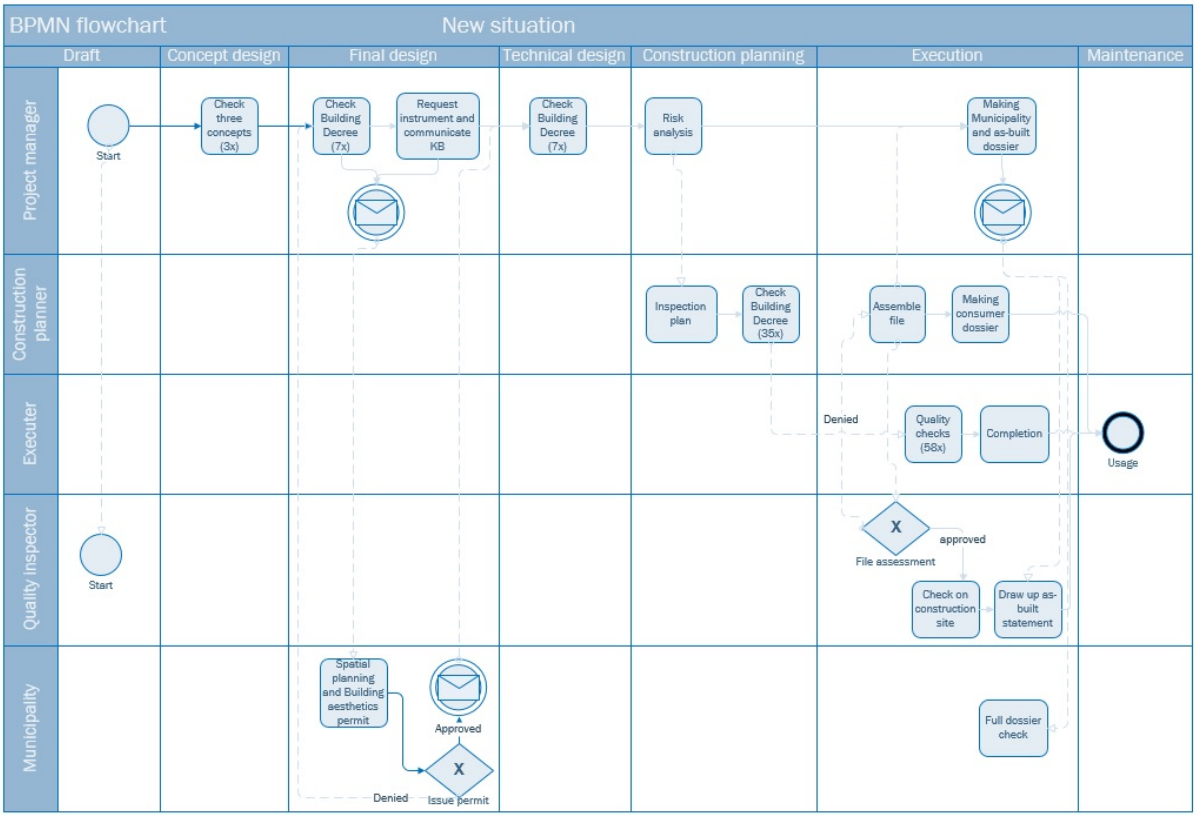


Figure 21: BPMN flowchart new situation; own processing

4.5 Sub conclusion

This system ensures that at least an agreement and a basis for this agreement for all Building Decree requirements is available. The system is developed for the Groevenbeek project. The system shall be further extended to other building systems and building functions. Because the system is based on the current systems, the adjustments are limited. By linking the QCL and the CPs to 3D drawings and store these on a potential BIM server in the near future, it is possible to limit the additional load (effort) for the company.

5. Case Study: 'Groevenbeek' Ermelo

This chapter contains the report of the case study. The developed assurance system, see chapter 4, was applied pro forma to the Groevenbeek project. In the first instance, the project, with respect to the process, construction technique, and persons involved were analyzed. Then, it was examined as to what the consequences would be for the quality management if the developed assurance system had been used. It is also assessed as to which digital tools are possible and desirable for limiting the additional work.

5.1 Introduction

The Groevenbeek project is the first zero-on-the-meter construction project in the Netherlands within this price category, scope, and energy concept.
The attractive village of Ermelo is located on the edge of the Veluwe. Not far from the Randstad, but surrounded by nature. Beautiful forests, heathlands, and estates, with the Veluwemeer right around the corner.
The homes of Groevenbeek North have the energy label A (+++). The zero-on-the-meter concept was achieved in Groevenbeek North by applying the passive-energy principle (passive buildings). Part of this is the thick, insulating shell. The thick peel keeps the heat out during the summer and keeps it in during the winter. As many as 23 solar panels have been placed on the roof. The home is equipped with a balance ventilation system with heat recovery, which ensures that there is a constant, comfortable temperature in the home while the air remains healthy and pleasant.
The homes do not have a gas connection. An electric water heater provides hot water. The use of energy-saving and low-maintenance materials further decreases the costs for the resident. This makes it both sustainable for the environment and ''good for the wallet'' (Van Wijnen, 2014).

5.1.1 Method

For this study, it is important to describe the building process, regarding how it was carried out in the current situation, as carefully as possible. Because the project has already been completed, interviews with the project manager and the work planner of this project were used. The file of this project is also available. With these sources, it was possible to properly describe the project itself and the building process. After that, the building process was rewritten using the checklists that were made.

5.2 Results

First, a general description of the project is provided. Then, the energy concept is explained, followed by an explanation of the building process management system (BPM); the implementation phase has been elaborated separately. After that, based on the new Quality Assurance law, it has been analyzed as to what changes should be made to the BPM-system. The proposal for efficiently demonstrating (compliance) the required building quality has been presented to several employees of Van Wijnen and assessed by them. Finally, conclusions were formulated.

5.2.1 General

To visualize what the consequences of the Wkb are, a case study has been elaborated. A relatively small housing project that was recently (2015) completed was chosen for this. This project was chosen because it is a so-called zero-on-the-meter (*nul-op-de-meter*-NOM) project. This project was very carefully prepared and supervised because of this standard. The available building file is very complete, which makes it suitable for this case study. An interview was also conducted with the responsible work planner to determine which individuals and organizations have carried out the quality checks (Deen, 2016).

The following documents were available for this project:

- Project plan (based on the BPM – matrix)
- Program of Requirements (PoR)
- Agreements regarding the drawings (BIM)
- Quality plan (and completed inspection forms)
- Drawings (including details) and buyer information
- Building Decree calculations
- Passive house calculations
- Air tightness advice
- Starting meeting reports (both with the team and with the subcontractors)
- Schedules (purchasing, preparation, implementation)
- Reports of the independent supervision (gBou)
- Reports of Health-Safety-Environment (KAM) checks by Aboma
- Photos of the agreements made during LEAN meetings

The project was built in Ermelo and includes 39 homes (see situation drawing figure xx). The target group for these homes is the starter category. The prices (deed in hand) were €161.000 - €179.000 (everything included). The project was built in the period from January to August 2015. The homes are so-called NOM homes, which means there is no energy consumption on an annual basis. Therefore, the residents only pay standing charges (for connection to the electricity grid).

5.2.2 Building system

Concrete strip foundation (on solid sand), upon which a lime sandstone (SL-stone) wall is placed on which the ground level floor is laid. The ground level floor comprises insulated precast slabs. The building envelop and inner shell elements of the façade are made of SL-stone (adhesive work). The upper floors are composed with precast slabs. The roof starts on the second floor. The cap is a prefabricated rafter with four included skylights (on the second floor, two in the front façade, and two in the rear façade). On the ground floor, two layers of Kingspan Kooltherm KB insulation plates are applied to the SL-stone inner shell elements, after which the ground level façades were finished with masonry.
The aluminum window frames on the ground floor are equipped with triple glazing. The inside walls are so-called Metal stud walls (lightweight construction).

5.2.3 Energy concept

The energy concept is based on the Passive Building concept, which means the heat demand is very limited due to heavy insulation. What is still needed in terms of energy is generated by 23 solar panels. The following insulation values have been achieved (table 3).

Table 3: Energy data

Ground level floor	Rc = 8.06 m^2.K/W
Facades	Rc = 7.88 m^2.K/W
Roof	Rc = 11.12 m^2.K/W
Window frames	U = 0.8 W/m^2K
Heating & hot tap water & ventilation	Electric element in ventilation system, electric boiler for hot water balanced, ventilation with heat recovery (HRS). Additional infrared heater in bathroom.

The air tightness of the building shell is of a high level.

5.2.4 Building process management (BPM)

Van Wijnen uses a building process management system which gives the management a good overview of the activities that need to be performed during each phase. The BPM system is laid down in a matrix (for each design & building phase, a column of activities is defined which needs to be performed before the next phase can be started, (Annex 1). The matrix includes a row for Quality, Health & Safety, and Environment activities (*Kwaliteit, Arbeidsomstandigheden & Milieu*-KAM) .
Within the Van Wijnen organization, a so-called KAM coordinator is active, who takes care of the central system management of these activities. For the Groevenbeek project, both a preparatory and implementation planning was created (Annex 6). The preparatory planning begins in the DO phase. The preceding building phases have been determined in accordance with the protocols laid down in the BPM system matrix.
The energy concept and the implementation concept had already been determined at this point. The costs and revenues were developed prior to the DO phase. The preparatory planning was mainly intended to optimize the DO by performing 'clash checks' on the 3D models and then produce the final work drawings. These drawings were then also submitted to the municipality (BG).

The involved consultancy firm has made a number of Building Decree calculations that were included with the construction application.
The following Building Decree calculations were submitted:

- Ventilation (air conditioning and purge ventilation)
- Daylight
- Energy performance

An overview of the surfaces has also been developed to show that there is sufficient residential area within the home. Interestingly, the calculations of the dilution factor were not made. The outlet and inlet of the ventilation are located very close to each other in practice.
There was no construction data present in the available pieces, it is to be expected that these were submitted in full to the BG and that based on this, the structural safety was realized.
In the structural-physical advice, a very carefully prepared advice for achieving the necessary air tightness was present.
This advice was used in the implementation and has proven its value, as the blower door test (in accordance with NEN 2686) showed that the required value (from the EPC and Passive Building calculation) has been realized.
During the preparatory phase, in addition to the aforementioned documents, a Program of Requirements (PoR) was also created and the Checklist Safe Maintenance (Building Decree requirement) was completed.
The conclusion can be drawn that this project was prepared very carefully.

5.2.5 Execution

According to the preparatory planning (Annex 6), the construction planning of the project started in October 2014. The initiative, Draft (*schetsontwerp*-SO), concept design (*voorlopig ontwerp*-VO), final design (*definitief ontwerp*-DO), and contract phases were carried out before that. For the layout and activities phases, which were carried out in the contract phase see Annex 1). In order to check whether all the activities were carried out, and specifically the activities in the field of quality assurance, an interview was conducted with the work planner Mr. P. Deen (Annex 5).
This project was won in a special way, namely via a competition organized by the municipality of Ermelo. Based on the PoR provided by the municipality, Van Wijnen made an offer and acquired the project as a result. The interview revealed that all involved parties performed their checks. The project planner had guided and guarded this project. The risk analysis included in the BPM system as well as the drafting of monitoring measures (row 7 of the matrix) have not been performed, and have, therefore, also not been recorded. However, a list of special details for the planning has been found in the documents. This list may be considered as the result of a kind of risk analysis.

The design of the architect was checked by the project planner. The project planner checks the design on the basis of:

- The Building Decree,
- The other construction regulations,
- The usual work methods at Van Wijnen, and
- The client-related agreements used by Van Wijnen

The transition from the DO phase to the specifications and work drawings has been checked by the project planner. The project team then carried over the project to the implementation team. Before the project is transferred, a so-called project plan is drawn up (according to a fixed format). This project plan includes a project description and the agreements which apply to this project have been fixed.
The work planner then checks the documents. For this project, 3D drawings have been made and 'clash checks' have been performed with Solibri for different building components. A so-called BIM coordination plan has been compiled for the creation of the 3D models. Two 'clash checks' have been performed and after approval, the final work drawings were completed. The work drawings are subdivided into structural and constructive work drawings. The constructive work drawings were submitted to the BWT of the municipality of Ermelo (BG) with the associated drawings. After that, the reinforcement, precast concrete upper floor, and LS hull were ordered.
The other building components with long delivery times, such as window frames, plastic frames, stairs, roof elements, and interior walls have been purchased and ordered. The work planner and executor check whether the purchased components comply with the contract.
The monitoring of whether construction occurs in accordance with the contract is performed by the work planner, executor, project manager, and the executors or foremen of the subcontractors (co-builders).

In addition to these checks, a monitoring agency has also been hired to monitor the quality. The agency in question (gBou b.v. from Heerenveen) has visited the project twelve times. A report was created for each visit, containing comments and agreements for adjustments and improvements. The documents of gBou showed that they made a prior risk analysis (design assessment) based on which they attended initial meetings and carried out inspections. Van Wijnen has had measuring agency Invent perform a Blower Door test on two occasions. The results of the first measurement did not meet the requirements. The Invent report, which indicates the present air leaks via photos, was very useful for the improvement process. The results of the second test were in accordance with the EPC and PHPP adopted air tightness requirements. The documents of gBou also stipulate that a sound measurement would be carried out, but the documents do not indicate whether this measurement was performed and what its results were[5]. The reports of gBou also record the progress, which is probably intended for the arrangement of a return visit. The report of the first visit includes a Building Decree checklist; however, this was not used in the continuation of the process. Thus, there is no record of whether the requirements of the Building Decree were met. gBou has mainly provided instructions in writing, although the reports show that photos were also taken. The general impression is that gBou monitored the project carefully and with expert knowledge. In addition to gBou, Aboma has also made a number of visits and performed the so-called HSE checks (health, safety, and environment). However, the main focus of Aboma was safe working conditions. The scaffolder has also contributed to work safety by drafting scaffolding transfer forms. Part of the quality assurance system (quality plan) of Van Wijnen is the initial meetings and the inspection lists.

[5] A noise measurement was desired by gBou, but is unlikely to be performed (because of the cost). The detailing of the project is as such that it would meet the requirements. In the new situation gBou will not accept the absence of a measurement and therefore will also not issue an as-built statement. Thus the quality inspector his position becomes more 'firmly'.

The agreements made during the initial meetings were recorded in a report. The initial meetings were held with the main subcontractors and installers. The following reports are included in the file:

- masonry
- caps
- frames
- scaffolding
- cement screed
- tiling
- paintwork
- installations (heating and ventilation)

Van Wijnen has a large set of inspection lists, but only the inspection list ‘masonry’ was found in the file. The reason for this may be that gBou was hired to take care of quality assurance. The project plan contains agreements regarding project organization, consultation structure, and the agreements to be made. A start of project checklist also needs to be completed. In chapter 6 of the project plan, a so-called risk analyzes overview is included. This overview records the activities that must be performed to ensure the quality and safety (Woudenberg, 2015). The following inspection lists needed to be used:

1. earthworks
2. reinforcement
3. masonry
4. scaffolding
5. frames
6. tiling

The possibility exists that the executor has recorded all their inspections in the diary.
The LEAN approach was chosen for this project, and all the parties made agreements regarding the implementation process during the LEAN meetings. The agreements were recorded via 'post-its.' Photos were made of these 'post-its' (figure 22). 'Lean approach' is a philosophy and methodology aimed at improving the entire construction process. The customer comes first and there is equivalent cooperation and transparency from first contact with the customer until the (points-free) completion. The lean approach is also called 'Chain Collaboration' or 'Smarter construction’. The shortest definition is: ‘Learn to build without waste’ (Lean support, 2015). The LEAN approach was selected by Van Wijnen because of the challenges in this project (first NOM dwellings).

Given the documents that were found in the file, it can be concluded that the project was managed carefully. Even so, it appears that the amount of administration was so large that not all forms were filled out due to lack of time.

Figure 22: Lean approach Van Wijnen

5.3 Quality assurance in the current building process

As explained in 4.1 the current BPM system is summarized to the main topics to show clearly the adjustments. The current BPM system is analyzed with a case study. The main activities per phase are:

In phase 1

- The environmental aspects are covered; it is not clear what is meant by this.
- The PoR was established (In this PoR the indoor environment is mentioned).

In phase 2

- The quality plans are drawn up. These were not found in the file.
- The constructive design and installation design are also not elaborated.
- A Building Decree quick scan is also performed (in this quick scan is also assessed the technical equipment

In phase 3

- The so-called Building Decree test is performed, although a quick scan would also suffice. The Building Decree test includes an assessment of the:
    - Safety requirements
    - Health requirements
    - Using requirements
    - Energy and sustainability requirements
    - Technical equipment requirements
- The KAM activities are identical in phases 2, 3, and 4, but it is unclear whether more information is added here or what exactly is checked in the respective phases.

In phase 4

- The specifications and specification drawings are ready (together the contract).
- The FSC/PEFC registration takes place in connection with the QHSE activities.
- The contracts with the installers are concluded.

In phase 5

- The dilatation advice, mortar advice, technical paint advice, adhesive advice, building safety plan, and roof advice/anchoring plan are drafted.
- In the work drawings the technical equipment is integrated.

In phase 6

- The quality inspections are performed and reported.
- The technical equipment are adjusted.

The basic principle with regard to compliance with the Building Decree is that the design is tested for the Building Decree, after which the drawings and Building Decree calculations are submitted to the BG (BWT).
The idea here is that the rewarding of the environmental permit means that the design complies with the Building Decree. The inspectors of BWT are to ensure that the design is implemented correctly. Due to the fact that plans are approved and inspections are carried out, it appears as though the project complies with the building regulations.
The environmental permit provides the builder with legal certainty. Even if there are errors in the approved design, these cannot be attributed to the builder. In 2007 the 'Tweede Kamer' has decided that a building permit provides legal certainty. Even if things are overlooked by the municipality. The municipality cannot expect the construction company to make changes when they find out that they have made a mistake. Formally, the construction company does not deliver what he should deliver the customer. The customer however does not possess of the knowledge to notify the contractor and demand restauration. This situation becomes better in the new situation (Haan, 2016).
However, the WW states that the builder is responsible. Thus, the roles and responsibilities are not clear, and consumers run the large risk of not getting what they are entitled to (research has shown that 50% of housing projects to not comply with the Building Decree (De minister Voor Wonen en Rijksdienst, 2016).

The new system provides clear roles and, therefore, ensures a clear division of responsibility and liability.
The current quality management system of Van Wijnen is mainly focused on meeting contractual obligations and assuring work safety. This system will need to be adjusted to a limited extent for the new situation.

5.4 Improved BPM system according to the Wkb (adjustments)

The number of adjustments in the BPM is limited. For each phase, it is indicated where adjustments are necessary to demonstrate to the compliance with the Building Decree to the KB (figure 23). The expanded matrix is recorded in Annex 8. The work planner of this project examined if the system was practical for the work preparation and the construction and easy to understand. In combination with ED-controls, a tool for the construction, the system is directly useable. For "Groevenbeek" the total check count was 110.

	1 - DRAFT	2 - CONCEPT DESIGN	3 - FINAL DESIGN	4 - TECHNICAL DESIGN	5 - CONSTRUCTION PLANNING	6 - EXECUTION	7 - MAINTENANCE
1 PLANNING							
2 REQUIREMENTS							
3 ORGANIZATION							
4 PROCUREMENT							
5 FINANCIAL							
6 KAM	VERIFICATION PROGRAM OF REQUIREMENTS	3 CHECKS IN QCL	7 CHECKS IN QCL	7 CHECKS IN QCL	35 CHECKS IN QCL	58 CHECKS IN QCL AS-BUILT STATEMENT BG	
7 RISKS AND OPPORTUNITIES	RISK ANALYSES AND MANAGEMENT MEASURES				INSPECTION PLAN		
8 EXPERIENCES							

Figure 23: adjustments to the BPM system; own processing

In phase 1

- No adjustments are necessary. The important PoR is drawn up in this phase and that needs to remain the same. The PoR should be arranged in such a way that the requested performances can be demonstrated unequivocally. An assurance for the check of the PoR is included in phase 1.

In phase 2

- The principles for the implementation concept and the energy concept are recorded. It is recommended to also compile a fire safety concept in addition to these two concepts. It is also wise to always develop several concepts and make choices that are backed up by a multi-criteria analysis (MCA). The concepts should be checked by an expert.

In the other phases

In the newly developed assurance system, the checks to be performed are divided over the different phases. The checks in the different phases should be carried out and recorded.
If these checks are not performed and recorded, the GO decision to proceed to the next phase should be adhered to. In phase 2 (VO), the check of the concepts is performed (so 3 check protocols are completed), 7 checks are provided in phase 3 (DO), 7 checks are also provided in phase 4 (TO), 35

checks are included in phase 5 (construction planning), and in phase 6 (execution), in accordance with this assurance system design, most checks are performed, namely 58. In total, 110 checks will be performed for this project to determine compliance with the Building Decree. These checks are spread over 29 check protocols, and in addition, a number of check protocols will be completed for topics not related to the Building Decree. As previously indicated, the existing inspection lists were used as input for the check protocols. Because the existing inspection lists do not assess all Building Decree articles, protocols have been added. In the protocols, the relevant Building Decree article and the determination method (usually a norm) are indicated. Row 7 indicates the risk analyses, because the Quality Assurance Act for Construction requires an inspection plan to be drafted based on a risk analysis, which is indicates in phase 5 row 7 of this inspection plan. Of course, this can also be included in the QHSE activities.

In phase 6

- As soon as the first homes are completed, the as-built (partial) statement by the permit holder must be submitted together with the BG file to the BG. The as-built statement cannot just be submitted with the last home (or project component), which means the homes (or parts of buildings) are vacant for a very long time.

The assurance system uses the existing inspection lists as much as possible. These inspection lists are now called control protocols, have been modified to a limited extent, and the relevant Building Decree articles have been named.

The matrix and inspection lists are existing documents; new to the system as the so-called 'checklists,' indicated as Quality Checklists (QCL). These lists provide the connection between the control protocols (inspection lists) and the overview matrix. It is very easy for the responsible manager to determine for each phase whether the agreed checks are being carried out. Digitalized means that the manager clicks the relevant box in the matrix, after which the relevant checklists are displayed, and by clicking the desired line in the checklist, the control protocol is shown.
See chapter 4 for the operation of the system (all checklists are included in annex 2 and the control protocols are included in Annex 3).

5.5 Consequences for employees

It has become clear from discussions with several employees that the use of the current quality management system is sometimes difficult. Completing inspection lists, having initial meetings, and recording these do not always receive priority, which means they are not always completed, held, or made. The concern of the employees at Van Wijnen is that even more 'administration' will be added. However, the Groevenbeek project shows that good preparation and execution (LEAN building) pays off. The quality is good and the client received the NOM home.

The new law has come at a good time. The building crisis has done well for the construction sector. Processes have been improved, the client now comes first, and the quality improved. At Van Wijnen, there is the belief that they are able to implement this law into their business processes. An important point of attention is the knowledge necessary to be able to assess whether the quality in design and execution meets the requirements and agreements (contract).

Besides knowledge, the culture in the building industy will also need to change. Marketing expert Marjet Rutten has written three books (Van Yab Yum naar Dim Sum, 2010, Van Kannie naar Passie, 2013 en Van maken naar raken, 2015) that illustrate where the building industry should be headed. The world is changing and the building industry must change with it. Building homes should become cheaper. Homes (and many commercial buildings, such as schools, warehouses, and offices) should no longer be developed and built uniquely. Another thing that no longer fits with the times and

generates unnecessary burdens is the approach of local governments, who continue to ask for a fully documented environmental permit application for many constructed objects, such as bike bridges, cell towers, and transformer houses. The very detailed requirements of the Building Aesthetics are now often in the way of building concept dwellings. In the end the consumers bears the brunt of it. The 'new' construction also requires a restructuring of the role of the contractor (Rutten, 2010). Homes and buildings either do or do not come out of the factory (nearly) fully assembled. In the book 'Van maken naar raken', the author illustrates a different sector structure (figure 24). This new structure requires a different business operation (Rutten, 2015). A clear vision is necessary.

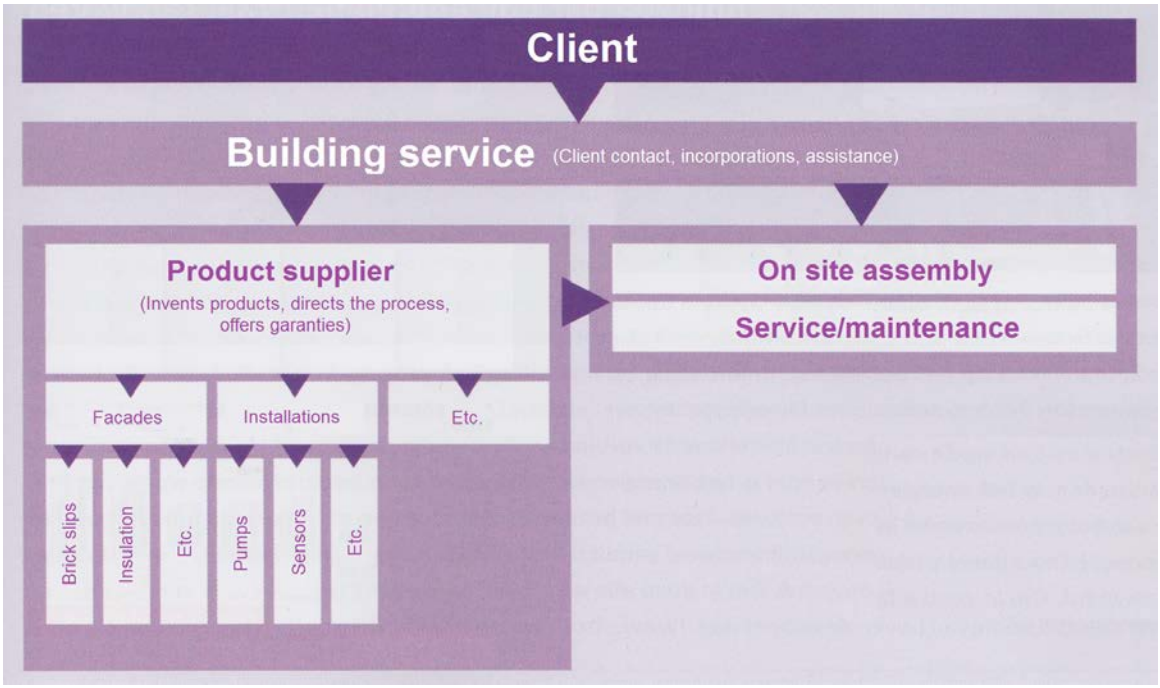


Figure 24: The future sector structure; (Rutten, 2015)

Rutten (2015), brings up the golden circles from Simon Sinek. A company needs to ask three questions:

- Why?
- How?
- What?

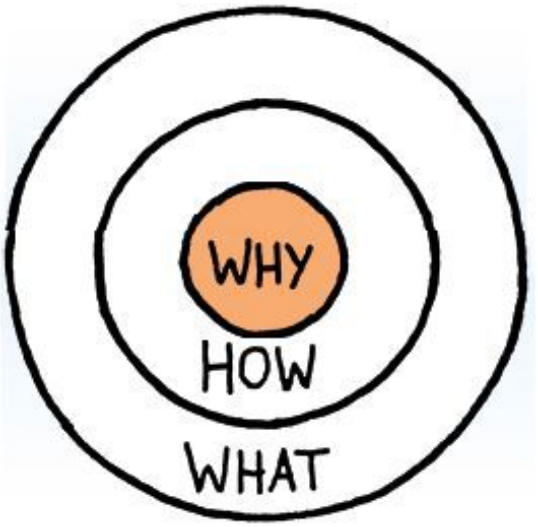


Figure 25: Golden Circle; (Sinek, 2011)

The questions need to be answered and these answers need to be shared and implemented into business operations.
With the first question (why?), why do we do what we do, concepts such as driving forces, values, involvement, right of existence, and motivation come to the fore. The second question (how?) “How do we do that?” is meant to provide answers that describe competencies, that identify the necessary means, and that determine procedures and skills. Means and procedures are described in chapter 4. It goes without saying that the third question (what?) “What do we do?”, requires solid objectives and necessary results as an answer, and that this is important for the survival of the company (figure 25).
The competencies and skills are important for employees. In higher professional education, not only skills such as constructional design, creation, and calculation are taught, but there is an increasing focus on competencies such as cooperation, communication, and listening as well.
Developing competencies requires self-knowledge; reflecting on behavior in both normal and special situations is a condition for learning and improving competencies. Construction companies train their middle and higher tiers to gain self-knowledge. Well-known formats in terms of people types such as that of professor Caluwé (yellow, blue, red, green, and white people) help employees and companies to develop competencies and create successful teams (Rutten, 2010). In order to successfully implement the new law (Wkb), the efforts to develop competencies and skills will need to be intensified.

These activities should not be limited to the main contractor, but the co-builders (suppliers, subcontractors, and installers) should also participate in this. Once the sales process has been completed, the buyer mainly comes into contact with the people on site, such as the executor, planners, carpenters, tilers, and employees of installation companies. The behavior of these employees should also comply with the policy of the organization to put the client first (figure 26).
The fact that ‘construction’ is extremely fragmented demands a broad approach and great effort. Fabricating a home of part of a building in a factory will resolve some of the current communication problems (which result in failure costs).

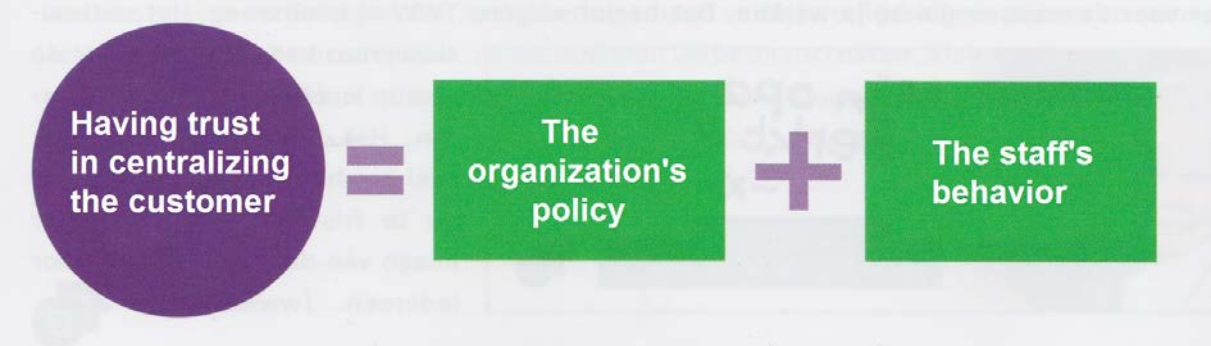


Figure 26: The sum of trust; (Rutten, 2015)

The challenge is to also realize the desired customer-orientation and provision of construction quality in the current mode of production.
As indicated, a clear vision is needed. This vision should be developed both top-down and bottom-up. The new quality system will only be successful if all parties and individuals involved consider it to have additional value and not as an additional administrative burden. Being allowed to provide the initials or tick for agreement should generate a feeling of pride in the sense of***: ‘I have done a good job’.***
What is important here is that demonstrating the delivered quality becomes part of the work process. It needs to ‘just’ be a part of it, which means the load should be minimal. In the section 5.6, the idea is further elaborated to link the QCLs and control protocols to the digital 3D model of the home or the building. If this 3D model and the quality system and the file are centrally managed, it is

possible for all those involved to follow and see the progress, the situation with regard to quality, and all information.

By granting the independent KB access to the server where all project information can be found, then the KB can follow the project without much physical effort (such as project visits, meetings) and report immediately if something goes wrong. This way, the costs for the KB remain very limited. This way of working does require the transparency and the trust that the employees and co-builders do their job properly.

Employees should be trained to adequately perform and register the quality checks. This requires a sophisticated training program. In the initial phase, coaching is very important. At a later stage, an internal helpdesk led by the QHSE coordinator will suffice, supported by a digital intranet with good and bad examples.

Parallel to this, the internal communication about putting the client first (and the trust the client have in this) needs to be developed. Rutten (2015), states that internal communication is essential for realizing and maintaining involvement. Managers should be role models in this. Everyone throughout the organization should be on the same page regarding this topic. This way, all employees of Van Wijnen will be proud of their company and proud of their own contribution.

5.6 Implementation

The expectation is that the law will take force on 01/01/2018 (Stichting IBK, 2016). This means Van Wijnen has eighteen months to prepare for this. Meanwhile, a national working group is already active to analyze and streamline this process.
In section 5.5, it is indicated that the employees should be trained to use the quality management system. It will also need to be checked what knowledge employees need to be able to explain that a part of a building or a building (home) complies with the Building Decree.
A number of checks require high-level knowledge; think of assessing the structural calculations, building physics calculations, and installation technique. This knowledge can also be obtained externally, but these experts should then be able to immediately enter their findings into the system.
This study illustrates a 'paper' form of the quality management system. This system should first be tested to determine its effectiveness. If the system works, it will be digitalized in order to be able to deploy it efficiently.

5.6.1 Digitizing

This section describes the manner in which software tools can be used to carry out the checks efficiently (and effectively). With the checklists and the underlying information which can be accessed, filled and assessed by clicking, the system becomes transparent. Completing these checklists and protocols and collecting information to prove compliance should become an integral part to all parties concerned. By using digital tools errors are (wherever possible) avoided and the administrative burden remains limited.

Tools

The digitization of the quality management system has been described by means of three programs how it could look like when implemented. The three programs describe how the QCL can be linked to a 3D model. After the description the process after the QCL appears is described.
In this manual KOZIJN B is taken as reference. The procedures described in this manual can be used for every item.

Solibri

Solibri Model Checker is an indispensable tool in any BIM process and unique in its kind as the only BIM quality assurance system on the market. It provides insight into the quality of your model and exposes issues in detail before even one stone is built. Solibri Model Checker analyzes the quality of BIM information. In addition, the 3D views (through Solibri Model Viewer) can shared with others including the annotations. This way the design team, construction company and future users of the building can get a good impression of the design choices and the parties can work together smoothly to an optimal end result (Kubus, 2016).

'Practical Test Solibri

From the starting screen select the 'Switch to Component Hierarchy' in the 'Model tree'.
Then, in the upper right corner, select the 'add view' window and select 'Hyperlink manager (and when preferred dock the screen) (figure 27).

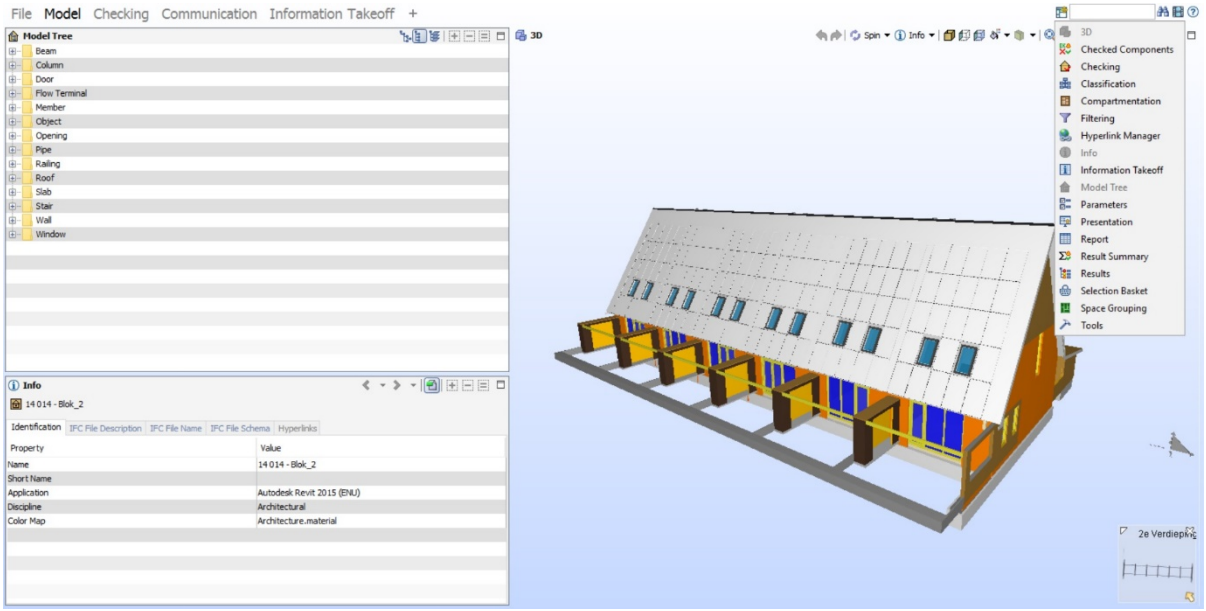


Figure 27: Solibri starting screen

From this point, you can select de elements you want to link to a QCL. In this example we used Kozijn B from the Windows folder to link to the appropriate checklist. First you select all the elements in the selected folder (note: select the elements separately instead of the folder will give you the option to enable the QCL by clicking on the part in the drawing. This will be explained later). Next pressing the right mouse button will pop up a new window with the option "Hyperlinks" at the bottom followed by "New Hyperlink" (figure 28).

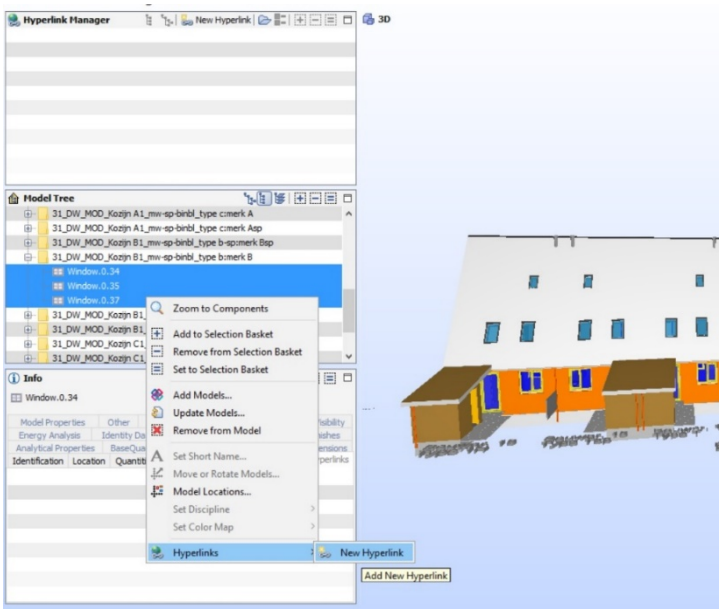


Figure 28: Solibri model tree

A new screen will appear where it is possible to select the path or URL were the appropriate checklists is located. Also a description of the path/URL can be inserted. Two Options are given, Absolute and Relative. Select Absolute if the QCL or hyperlink files are on a fixed location on a network drive or local drive. When the QCL files are in a folder with the Solibri or IFC file and the destination path changes from time to time but the files are kept together then Relative might be a good alternative. However with many companies having network attached drives, we go with absolute for now (figure 29).

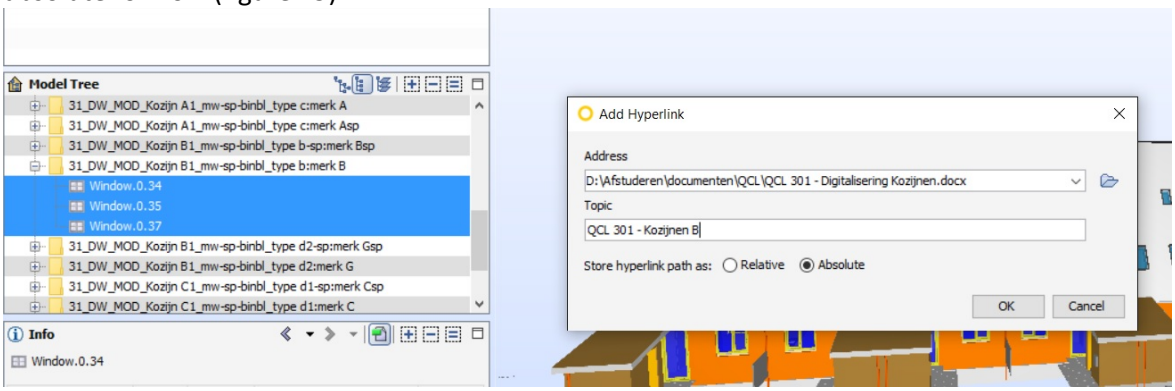


Figure 29: Solibri Add Hyperlink

If correctly done, the new Hyperlink should now show in the Hyperlink manager. When leaving the mouse pointer on the link for a few second will pop up a message stating when you press CTRL and left click on the mouse, the link will take you to the QCL (figure 30).

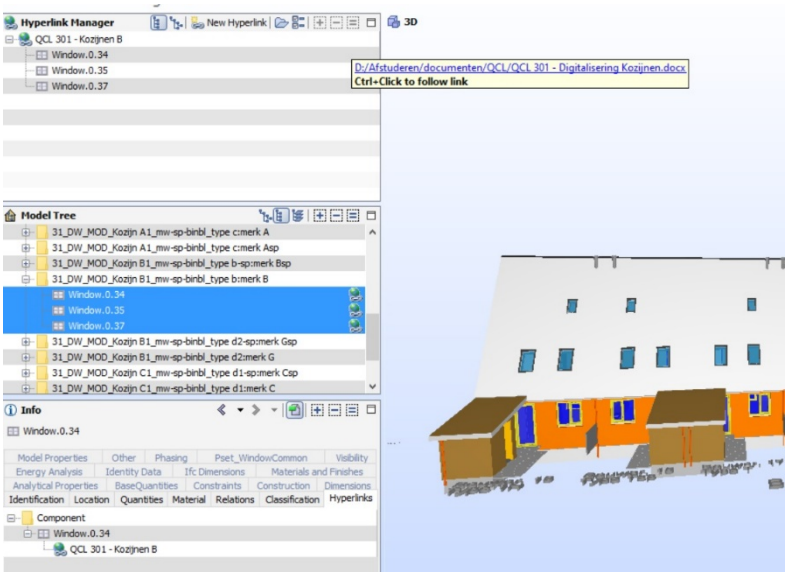


Figure 30: Solibri hyperlink manager

Because we previously selected the items separately, we can now click on one of the items in the drawing. Clicking the Hyperlinks tab in the info field will show the Hyperlink as well, and by pressing CRTL + left mouse will again bring you to the correct file. This last feature enables to show the appropriate checklist for every item in the drawing with ease (figure 31).

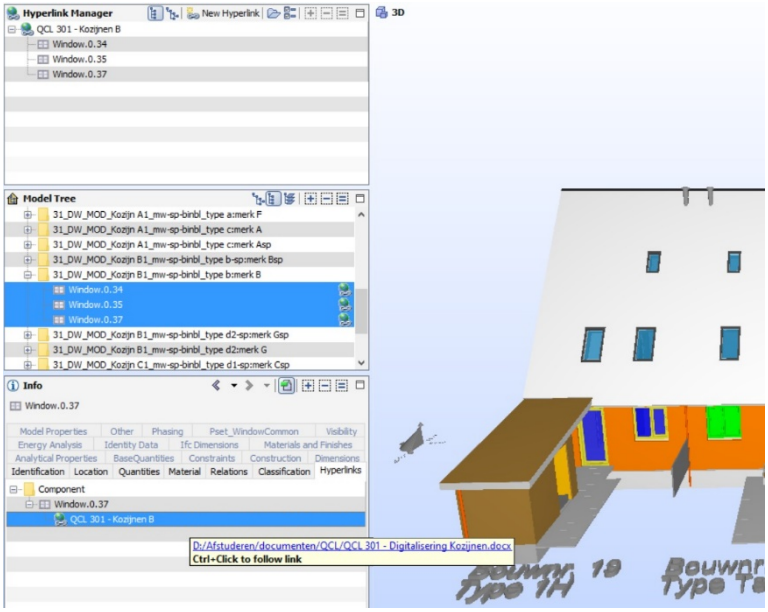


Figure 31: Solibri info field shows hyperlink

Solibri opened the QCL (figure 32).

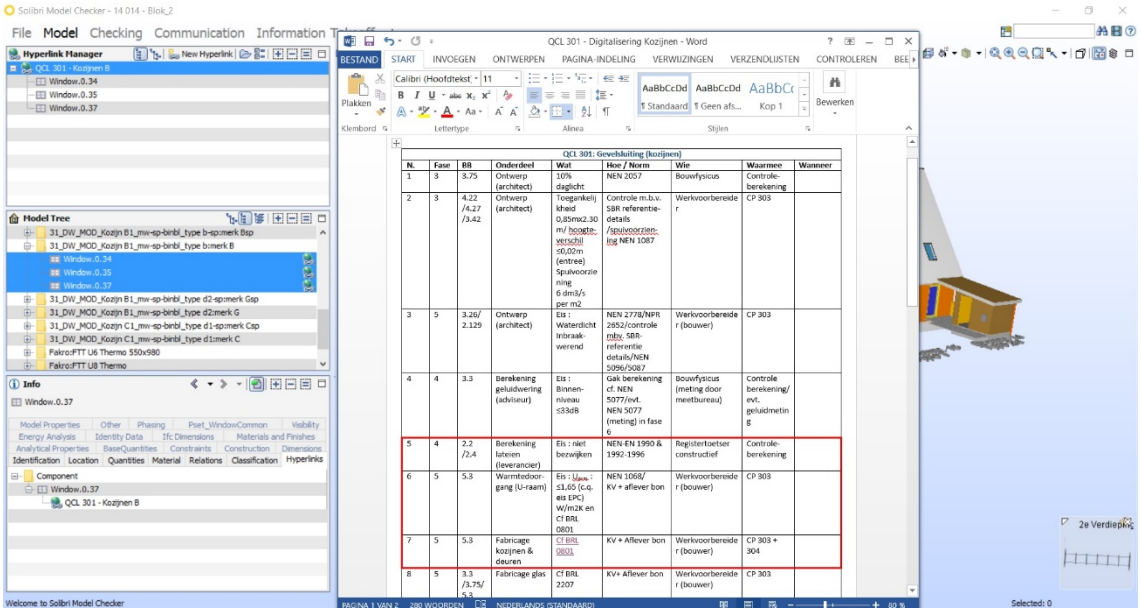


Figure 32: Solibri and QCL

Revit

Revit is a single software application that supports a BIM workflow from concept to construction. The software makes it possible to make drawings on the basis of parametric models. The IFC data can also be exchanged with external tools so that the model can be adjusted if necessary. A modification to the model is directly changed in all related areas. In this way, the complete presentation of the model remains current (Autodesk, 2016).

Practical Test Revit

For Revit a similar procedure can be applied as Solibri.

After opening an IFC file in Revit it is possible to select an item (properties) by clicking on it (In this example Window - Kozijn B is used in 3D view option) (figure 33).

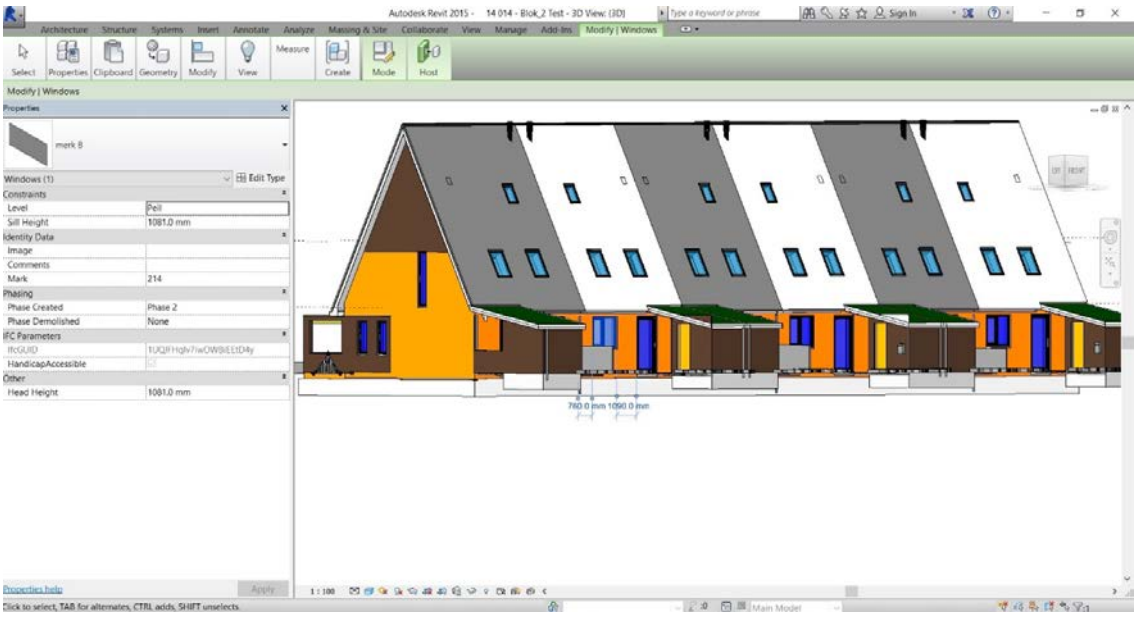


Figure 33: Revit select properties

After kozijn B is selected the properties window automatically appears on the left side of the screen. When the “Edit Type” is selected, certain properties can be modified or added/removed from the element in the “Types Properties” screen (figure 34).

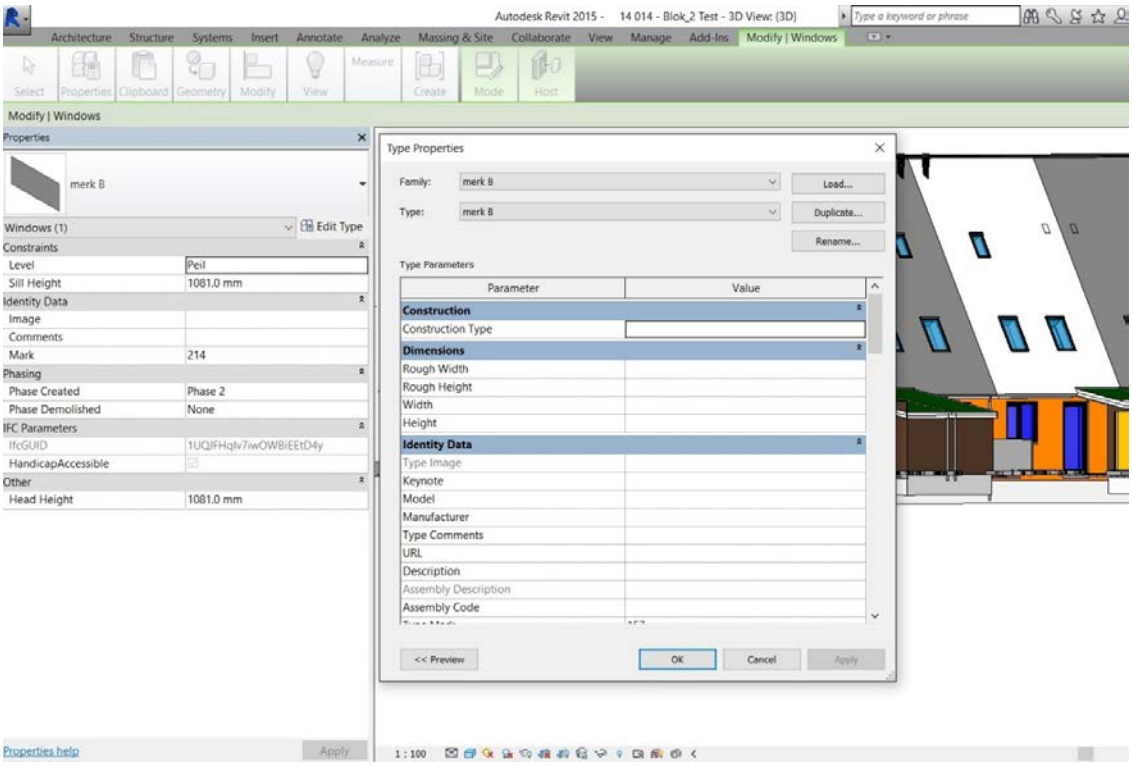


Figure 34: Revit screen 'type properties'

In the “Types Properties” screen under “identity data” is a field with “URL”. This field can be edited/filled with the (network) path of the QCL (figure 35). (Note: the file extension of the document like “*.pdf*” or “*.docx*” has to be entered as well).

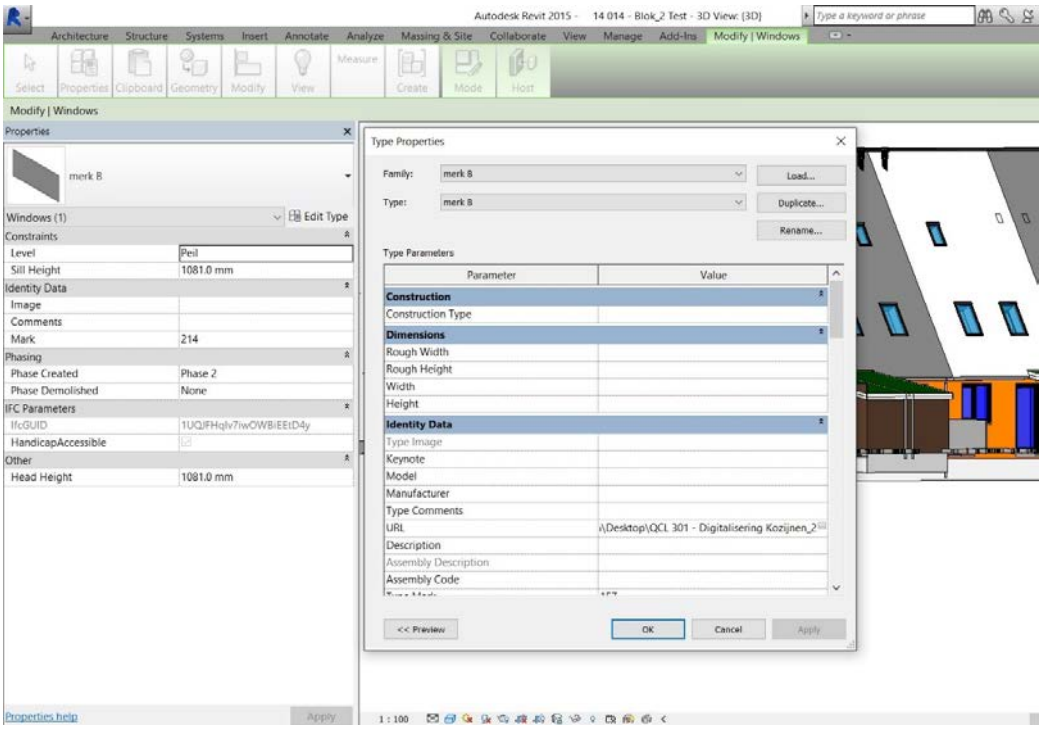


Figure 35: Revit URL

When the URL is inserted in the corresponding field, a three dot symbol will appear on the upper right side of the URL. Floating over this symbol will show the path entered in the URL field (figure 36).

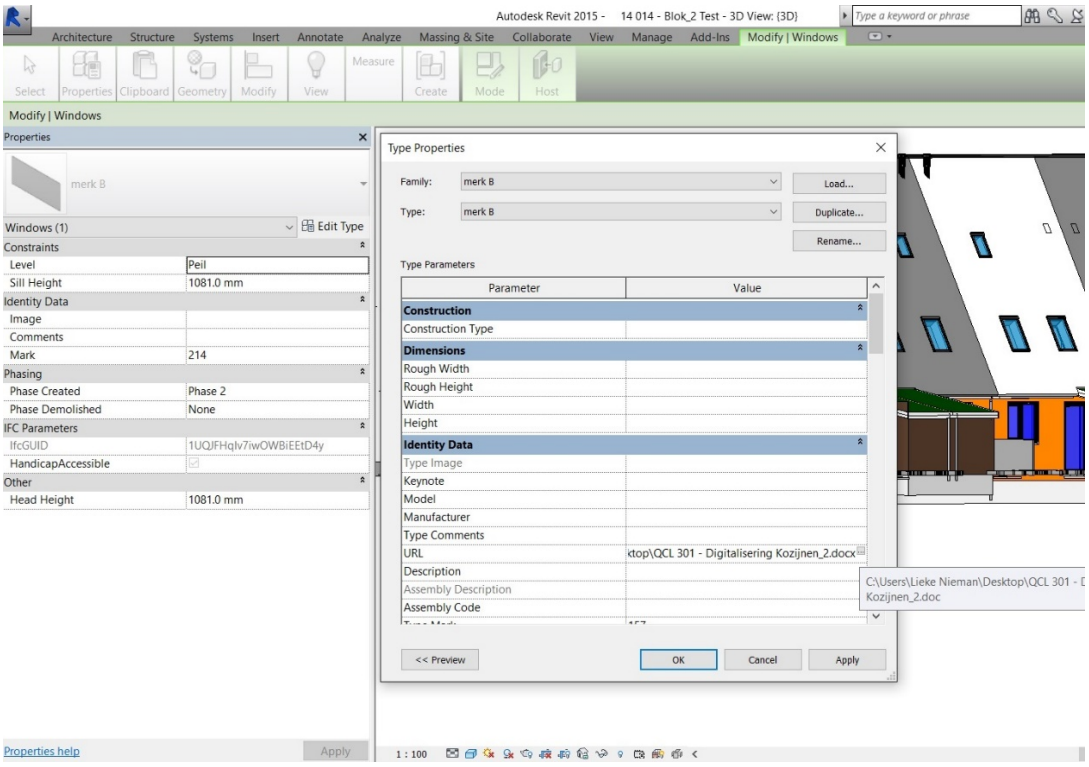


Figure 36: Revit shows the whole URL

By clicking on the 3 dot symbol the QCL can be opened (figure 37).

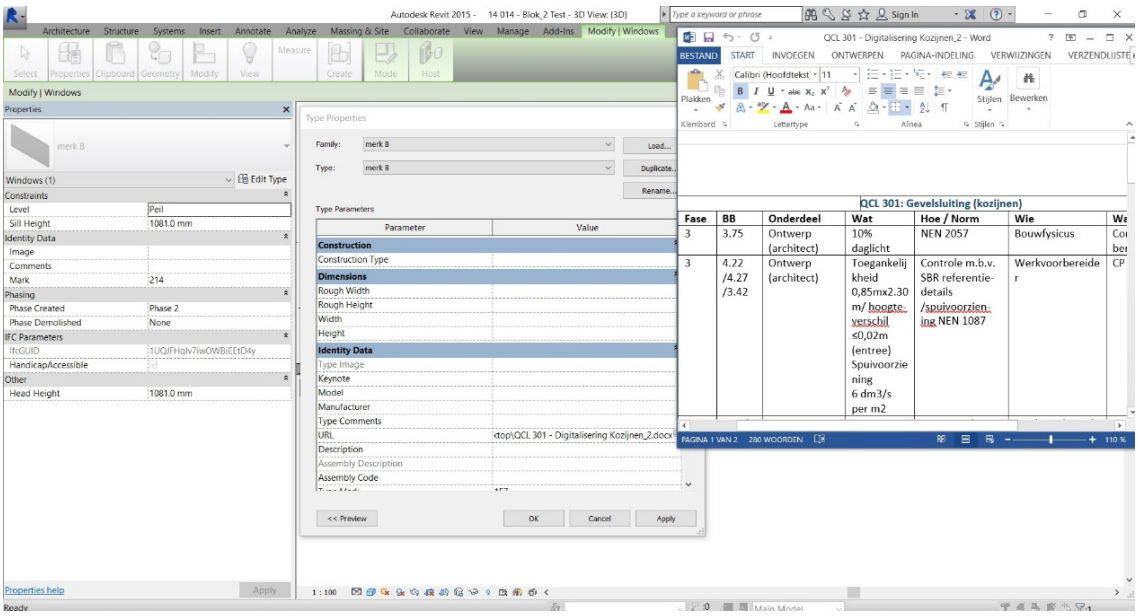


Figure 37: Revit and QCL

Unfortunately opening the QCL from Revit itself is a cumbersome operation. It requires the user to select the item, edit the data, find the URL field en then click the dot symbol. Revit however allows external plugins to be programmed with the software. A trained and skilled Revit user who is familiar with Microsoft® Visual C# programming can program a more easy and user friendly method of showing/implementing the QCL in Revit. The above tutorial can be used as a basis of the plugin.

A possibility for a plugin is the creation of a annotation in Revit. By creating a annotation it is possible to click on an item or link and the QCL can be opened directly or even shows within in Revit.
An example for an annotation is shown in figure 38.

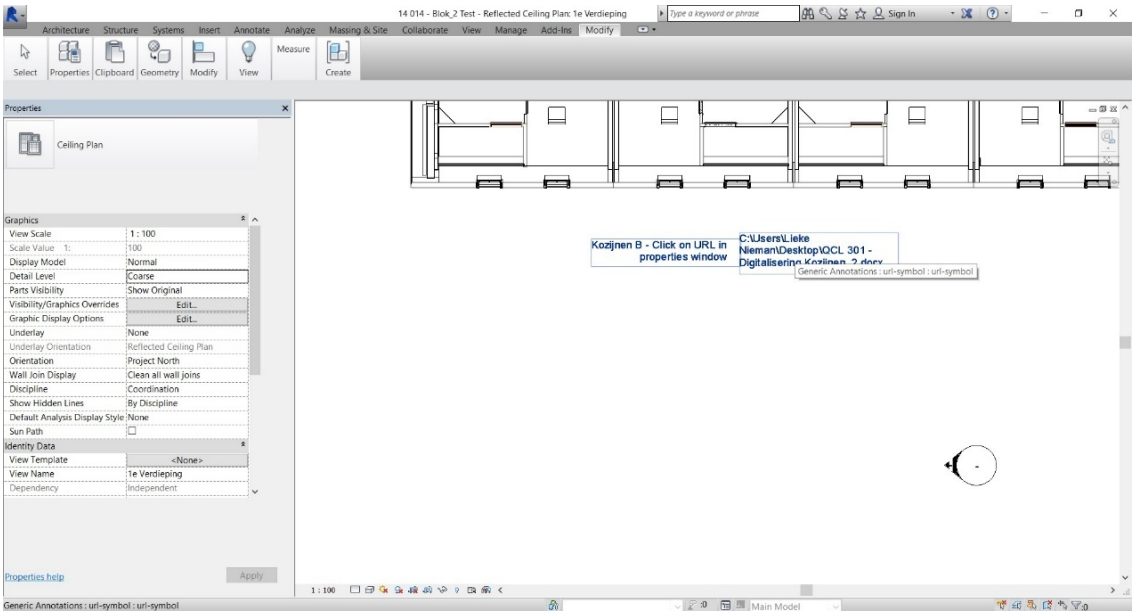


Figure 38: Revit annotation

When the link within the draft screen is clicked the path of the document is directly shown and by pressing the 3 dot symbol it takes you to the corresponding checklist (figure 39).

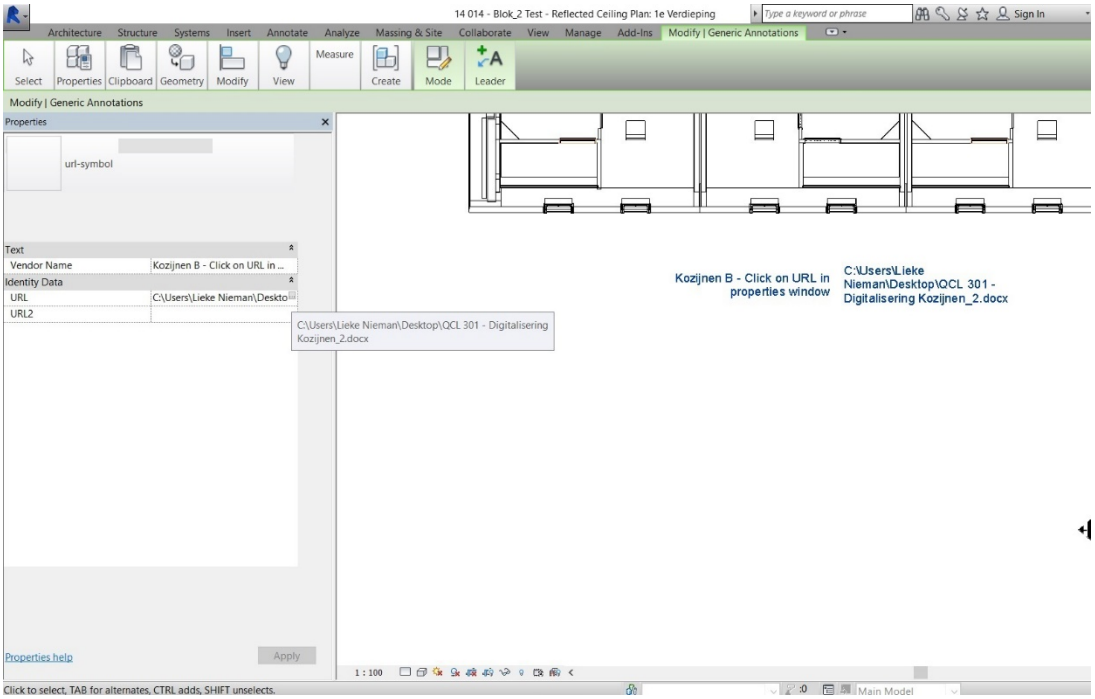


Figure 39: Revit link to QCL

Even more ideally would be showing the checklist directly within the properties screen. In this case the link should display the checklist instead of redirect. An example within Revit is shown in figure 40. In the left screen the QCL is now shown.

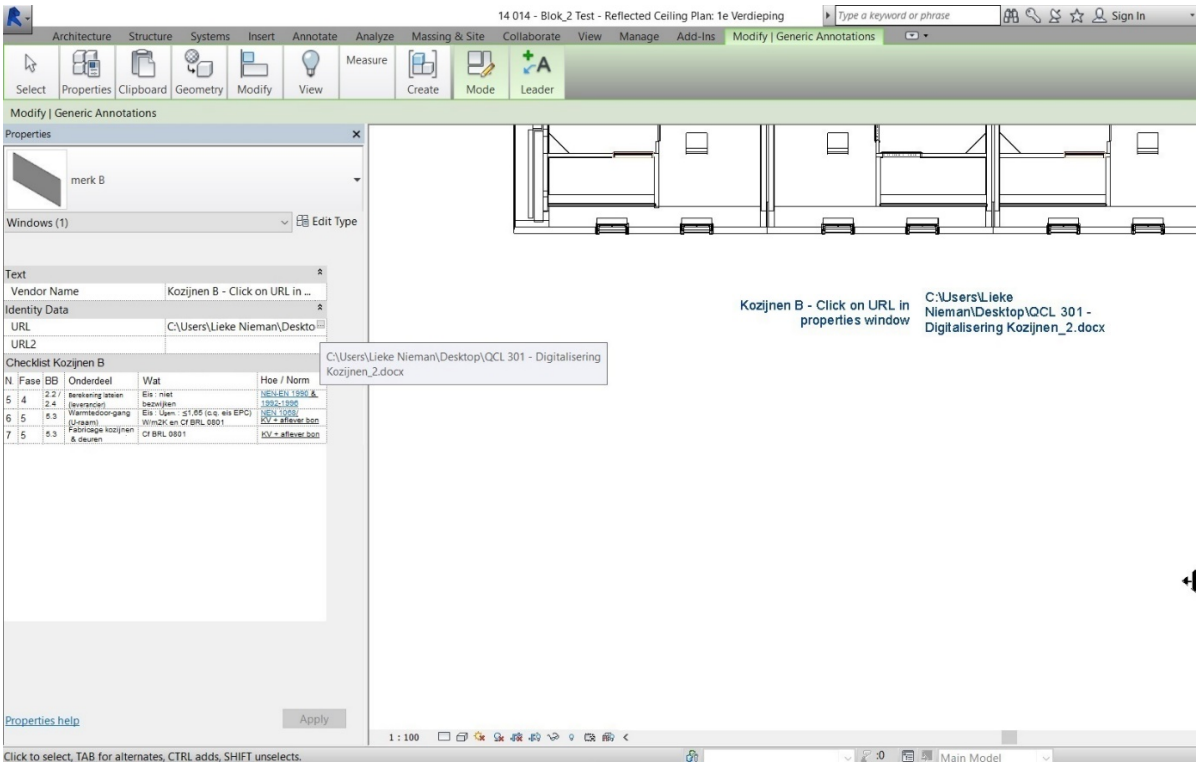


Figure 40: QCL in Revit

Relatics

Relatics is a cloud platform used by large projects in the construction, infrastructure and civil engineering industry to control all information within a project. It frees the project of numerous spreadsheets and isolated applications. As a result, Relatics has proven to regain project control, reduce project risks, and decrease failure costs. Relatics is used by governments, contractors and consultancy firms for buildings, roads, bridges, etc. (Relatics, 2016).

Practical Test Relatics

Relatics is a verification and validation web-based software package. Relatics runs parallel to the building process. Also Relatics has the option to link File server or weblinks to the elements.
First the user needs to create a model tree, which contains the structure and the elements. For this example a dwelling is created containing the façade (IfcFacade), window frame (IfcWindowFrame) and a window (IfcWindow) under the PhysicalObject (figure 41).

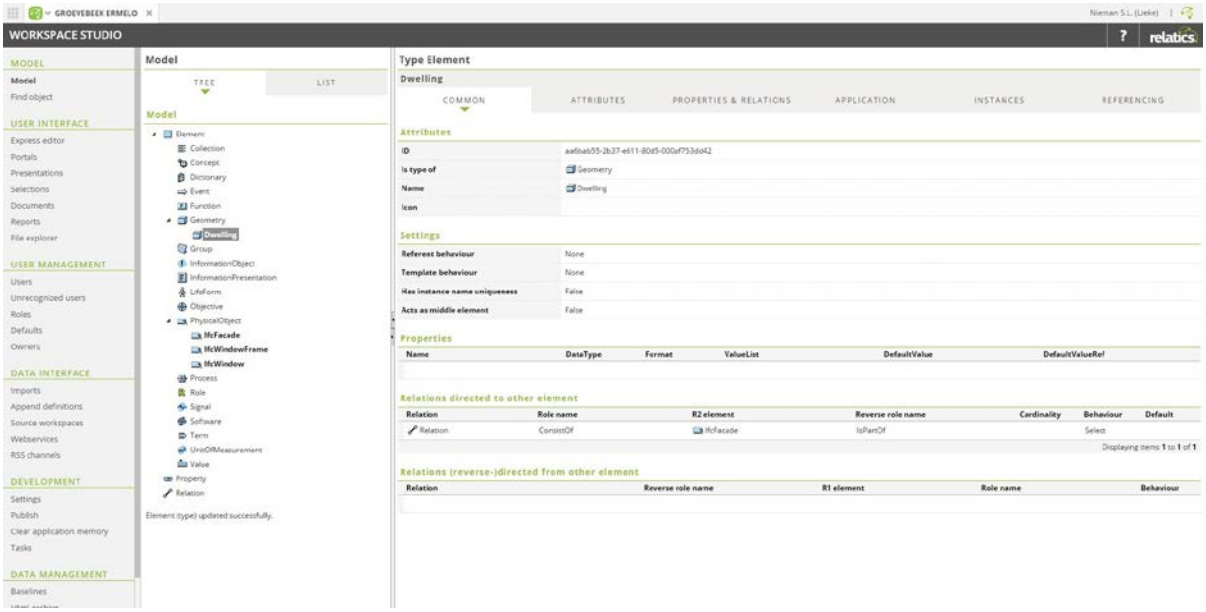


Figure 41: Relatics model tree

In this example the different IFC elements are linked to each other. As mentioned before this guide uses the QCL - Kozijnen B. When the IfcWindowFrame is selected, the properties are displayed. A new property can be added by right click → add (figure 42).

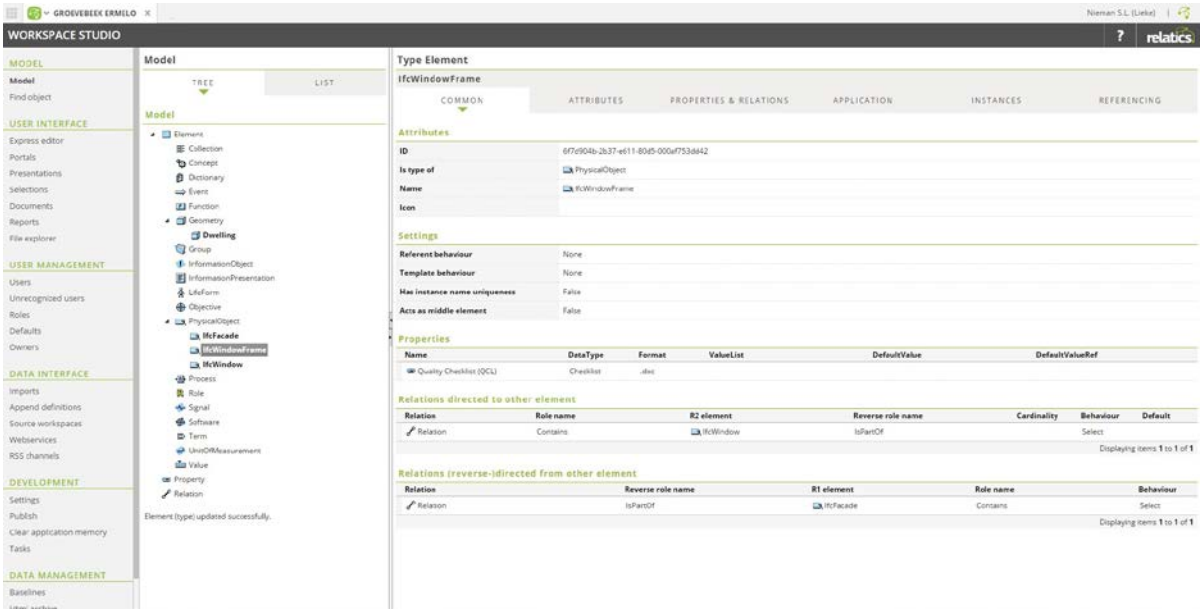


Figure 42: Relatics new property

When adding the new property the DataType and Format can be inserted. When selecting ATTRIBUTES in the upper screen, more information can be provided. This also includes the position for an URI. In this section the URI toward the fileserver can be entered (figure 43).

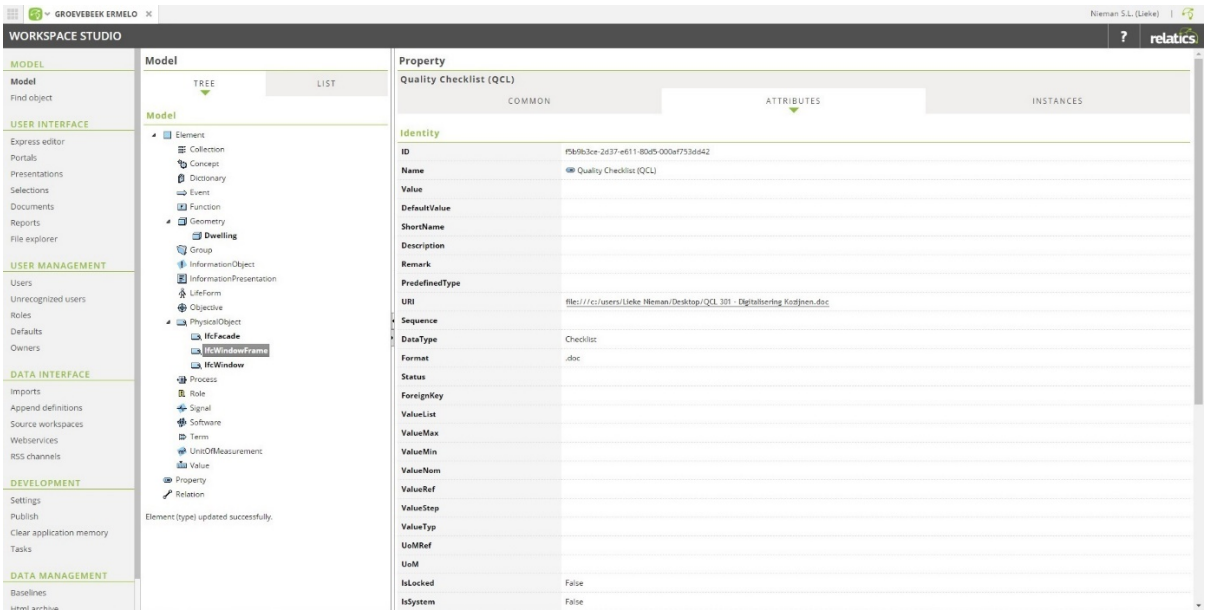


Figure 43: URI in Relatics

When this URI is clicked, it will open the appropriate QCL (figure 44).

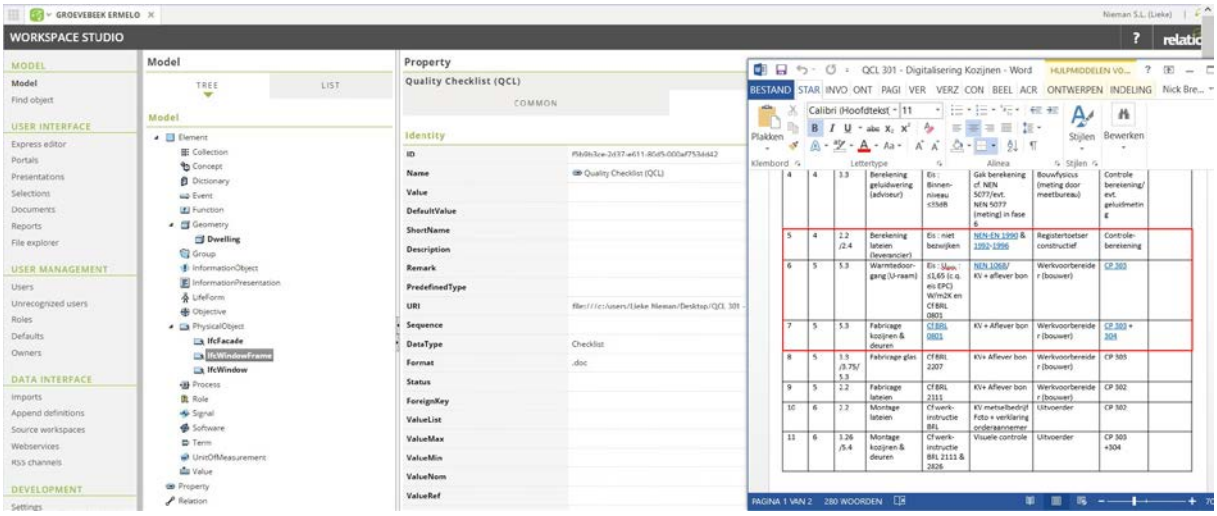


Figure 44: Relatics and QCL

There is also the availability to upload the QCL's into Relatics itself via the Data Management. In the subsection Files of the Data Management files can be uploaded towards the Relatics server (figure 45). However, the Relatics used for this research was provided by the TU/e, which is a student copy of the program. Therefore the needed function for further investigation within Relatics were disabled. The assumption can be made that the full QCL can be inserted into Relatics and be linked to a drawing via a Revit Addin (Berg, 2016) (Annex 7).

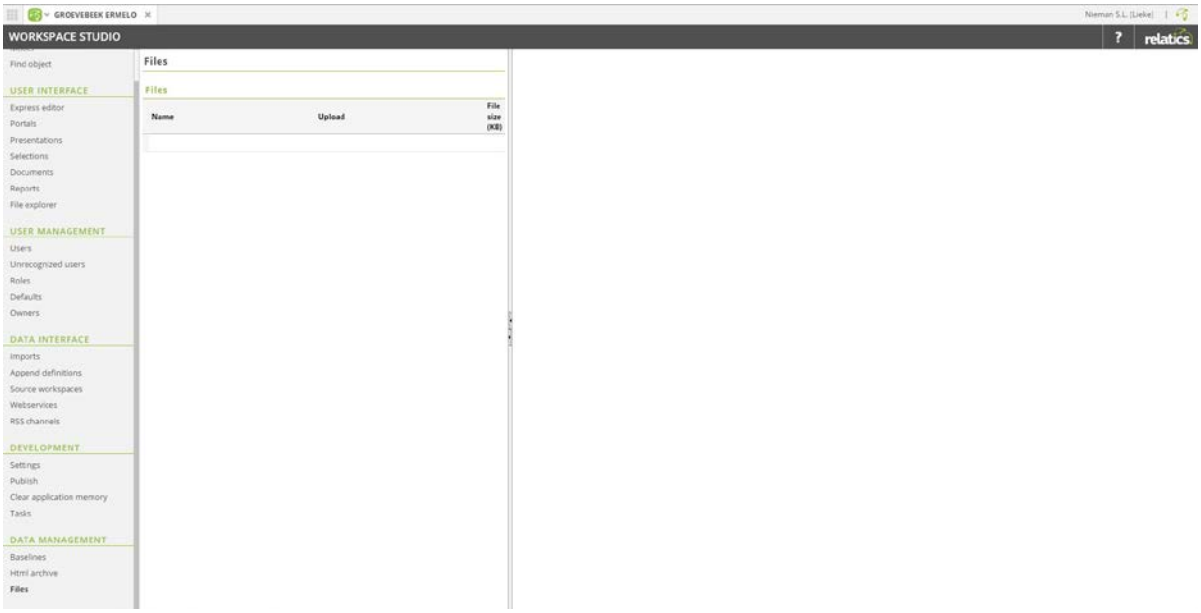


Figure 45: Relatics Data management

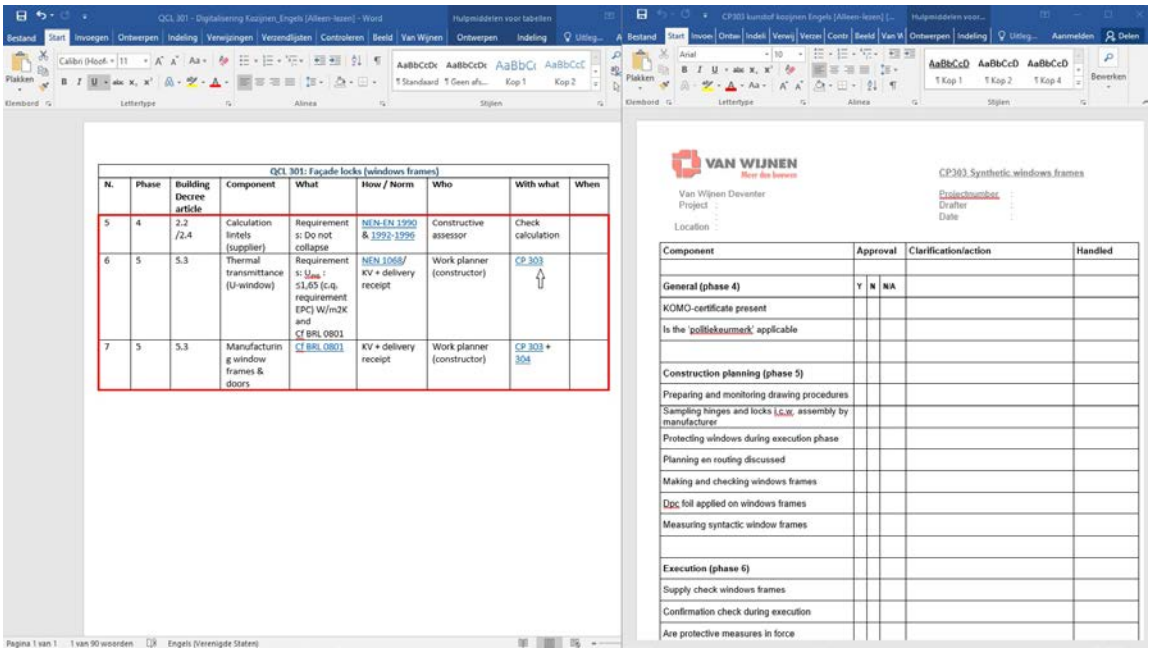
QCL

When the QCL is displayed it can be checked if all other documents are present, up to date or for example still have to be retrieved. When the column 'What' displayed a BRL code, the BRL code can be clicked and the actual BRL will be shown. The same applies for example the NEN norm (figure 46).

QCL 301: Façade locks (windows frames)								
N.	**Phase**	**Building Decree article**	**Component**	**What**	**How / Norm**	**Who**	**With what**	**When**
5	4	2.2 /2.4	Calculation lintels (supplier)	Requirements: Do not collapse	NEN-EN 1990 & 1992-1996	Constructive assessor	Check calculation	
6	5	5.3	Thermal transmittance (U-window)	Requirements: U_{waarde} : ≤1,65 (c.q. requirement EPC) W/m2K and Cf BRL 0801	NEN 1068/ KV + delivery receipt	Work planner (constructor)	CP 303	
7	5	5.3	Manufacturing window frames & doors	Cf BRL 0801	KV + delivery receipt	Work planner (constructor)	CP 303 + 304	

Figure 46: QCL contains several links

The column 'With what' often contains a CP. If the text of the CP is clicked, the corresponding CP shows and can be ticked off (figure 47). It is for example possible to upload photos to a server as evidence (for example by using ED controls) (ED-controls, 2014). In the same 'With what' column those pictures can (for that particular part) be requested when the word 'photo' is clicked.



QCL 301: Façade locks (windows frames)

N.	Phase	Building Decree article	Component	What	How / Norm	Who	With what	When
5	4	2.2 /2.4	Calculation lintels (supplier)	Requirement s: Do not collapse	NEN-EN 1990 & 1992-1996	Constructive assessor	Check calculation	
6	5	5.3	Thermal transmittance (U-window)	Requirement s: U_{max} : 1,65 (c.q. requirement EPC) W/m2K and Cf BRL 0801	NEN 1068/ KV + delivery receipt	Work planner (constructor)	CP 303	
7	5	5.3	Manufacturing window frames & doors	Cf BRL 0801	KV + delivery receipt	Work planner (constructor)	CP 303 + 304	

VAN WIJNEN

CP303 Synthetic windows frames

Van Wijnen Deventer
Project
Location

Projectnumber
Drafter
Date

Component	Approval			Clarification/action	Handled
General (phase 4)	Y	N	N/A		
KOMO-certificate present					
Is the 'politiekeurmerk' applicable					
Construction planning (phase 5)					
Preparing and monitoring drawing procedures					
Sampling hinges and locks (c.w. assembly by manufacturer					
Protecting windows during execution phase					
Planning en routing discussed					
Making and checking windows frames					
Dpc foil applied on windows frames					
Measuring syntactic window frames					
Execution (phase 6)					
Supply check windows frames					
Confirmation check during execution					
Are protective measures in force					

Figure 47: QCL linked to CP

As mentioned before a tool such as ED-controls can help to proof the 'with what'.

For the new situation with the use of a BIM server (assessable for the KB) another BPMN diagram is made to show systematically the information flows between the different players (figure 48).

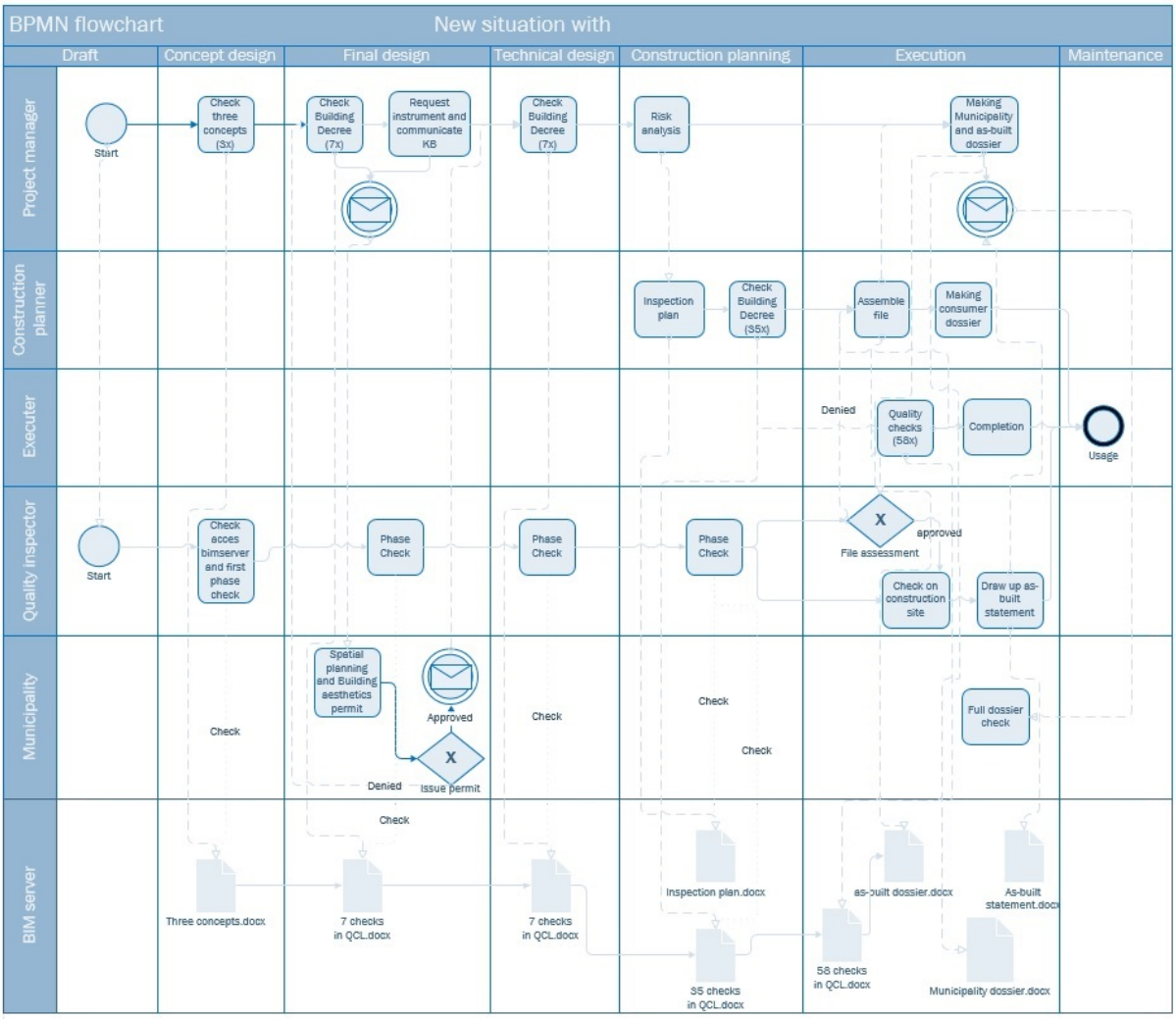


Figure 48: BPMN flowchart new situation with the use of a BIM server

Figure 49 visualizes the alignment between the client (environment), the strategy, the process, and the project. The company is focused on the client (consumer), as that is where commissions come from and what allows the company to exist (Nieman Raadgevende Ingenieurs, 2008). The management develops a strategy to meet the needs of the client. It is important that the company actually starts to deliver in accordance with this strategy. To manage this, a building process management system (BPM) will be developed; the approaches to the projects are often identical. However, within this process management, the project must come first. What are the specific wishes of the client and what are the specific risks (location and design). The Pareto analysis suggests that 80% of the operations are not specific and 20% are (Schreuder, 2015). These specific (project-based) operations or activities therefore require 80% of the effort. It is therefore important to draw up a risk analysis in each phase of the design and building process and to develop management measures. The Wkb also states that an inspection plan should be drawn up based on a risk analysis. In the matrix (figure 22), this inspection plan is included in phase 5, but it could also be created in an earlier phase and, if necessary, updated in a later phase.

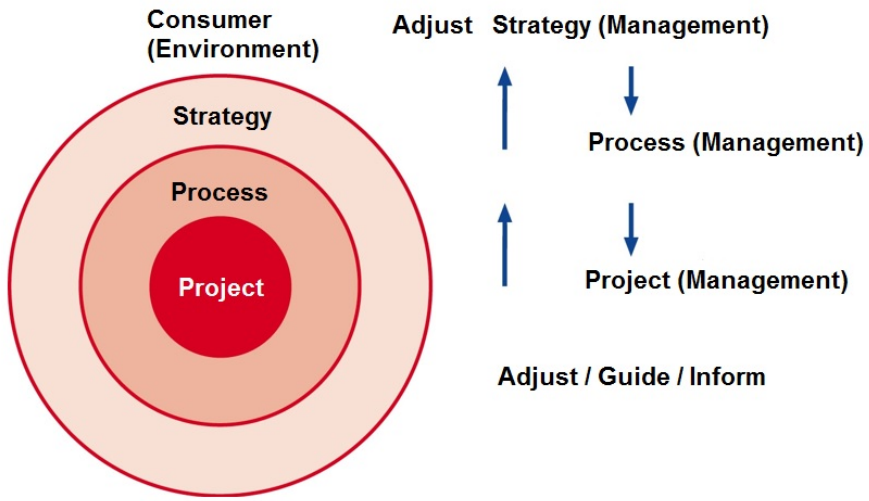


Figure 49: Alignment with consumers; (Nieman Raadgevende Ingenieurs, 2008)

5.6.2 Process automation

The Wkb will require additional efforts from the market. The additional costs for this should be limited and in addition, the law must not lead to bureaucracy and therefore the monitoring of the design- and construction quality element should become part of the construction process. This study indicates how checklists and the associated foundation can be linked and accessed. This forms the building dossier. Many of the actions described must be entered manually. Automatic checks are presently mainly conducted with regard to dimensions. To perform these automatic checks, the software program Solibri is used.

Checks of the Building Decree are primarily manual conducted actions so far, although support with for example the "BRIS-toets' is widely used. Checks using 3D models has been under development for more than 10 years. Software companies like the 'Twee Snoeken' and 'Kubus' are expanding the possibilities of automatic calculations against the Building Decree and test this further and further. The 'Twee Snoeken' have automated several Building Decree calculations (De Twee Snoeken, 2016). Currently (2016) the following calculations are available:

- Building Decree chapter 3- health: Daylight conform NEN 2057;2011, ventilation (also purge ventilation) and sound resistance (noise from outside).
- Chapter 4: Usability: the measurements of the building, useable area, surface residential areas and lounges, height and width dimensions (accessibility)
- Chapter 5: Energy-efficiency, conform NEN 7120 (energy performance).

Mr Willigenburg of the 'Twee Snoeken' reports that the Environmental Performance calculations (chapter 5) are under development. The automatic generation of the Building Decree calculation is obvious, because for most software there is also a calculation module available which is able to calculate the cost price. The environmental performance calculation also takes the quantities of construction materials into account, which are linked to environmental data from the National Environmental Database, after which the environmental performance is calculated.

Mr Nouwen of 'Kubus' reports that the developments are going very fast. Much more can be tested by adding extra 'Rules' to Solibri, however, these checks are global, but can be important in order to determine whether or not there is compliance with the Building Decree (assuming as a rule of thumb). 'Kubus' works much for suppliers who want to bring in their product data in the 3D model in

such a way that a faultless end product arises. At the Hogeschool Windesheim (Zwolle) a BIM lector ate is active. Several students have graduated on this subject, the results are similar, the information from the 3D model must be adapted via different protocols, for example, to create an Energy performance calculation, an environmental performance calculation or a daylight calculation. A direct link is not possible yet. This corresponds to the information from both 'Kubus' and 'Twee Snoeken', they indicate that the generation of the Building Decree Calculations is never automatic, there should be additional information entered into the 3D model, or data need to be made suitable via protocols for the Building Decree calculation. When for example an Energy Performance Calculation is made, the party who makes the calculation must insert a lot of additional information (e.g. installation technical specifications) in order to correctly perform the calculation. Most of the Building Decree Calculations will require expertise in order calculate and check properly. The question is whether the illustrator of the floorplans can acquire the necessary expertise to be able to declare that a design meets the Building Decree requirements. Expertise will always be necessary, however, automation will ensure that the costs of transparent and reproducible verification and validation remains limited (Het Nationaal BIM Platform, 2016) .

Developments are going fast and studies show that automation can be used excellent as design and evaluation tool (Kim, et al., 2016). By adding extra data, the design can be assessed on energy efficiency and can be determined which is the best HVCA design. However, this is independent of the by law required as-built statement. Perhaps the in the Netherland designated standards for calculating and determining the Building Decree requirements should be replaced by standards that better fit the digital-supported design and execution processes (Zibin, Zmeureanu, & Love, 2015). The verification and validation costs will decrease substantially. However, the chance that this will happen is small, because in general assessments the specific qualities of construction materials and installation techniques do not present itself sufficiently. This also reduces the need to innovate.
A development with great potential is 3D printing, perhaps in the future the digital model can serve as input for a 3D printer and thereby ensure a flawless execution.

5.6.3 Planning

Based on this study, an implementation schedule has been set up for the purpose of being able to fully implement the Wkb into the business operations by 01/01/2018 (figure 50). Incidentally, Van Wijnen does not need to limit themselves to consequence class 1, as the higher consequence classes can also be developed in accordance with the new quality management system on a voluntary basis. The system described in this study is based on the case study 'Groevenbeek.' For other construction methods, control protocols still need to be developed. Therefore, drawing up the inspection plan also means selecting the appropriate control protocols for the relevant project.

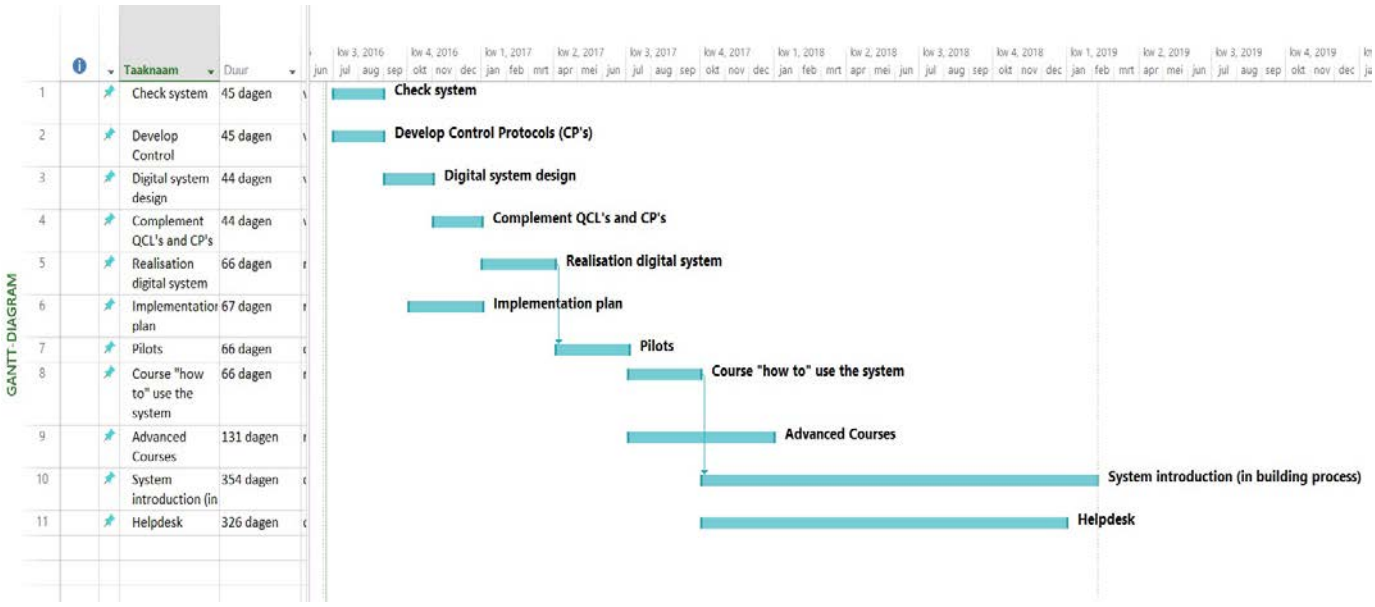


Figure 50: Gantt chart planning for implementation the new quality assurance management system; (own processing)

5.6.4 Insurance institutes and their instruments

Many housing projects are built under a guarantee (Stichting Garantiewoningen). Three guarantee institutions work together in this foundation, namely Bouwgarant, Woningborg, and SWK (see section 2.2.3). To cover the new law, these three parties are developing instruments for quality assurance. Bouwgarant lets a KB check the documents and the implementation (so no input from the builder).

Woningborg chooses to both develop an instrument and act as inspector, but these assurance activities are contained in a different company.

In their instrument, it is possible that the construction company also implements registrations, resulting in the limited deployment of the Woningborg KB (and therefore lower costs). Customization is possible. Woningborg ensures it that these registrations are done carefully and correctly by the construction company and they also do a number of registrations themselves (Instituut voor Bouwkwaliteit, 2015) (figure 51).

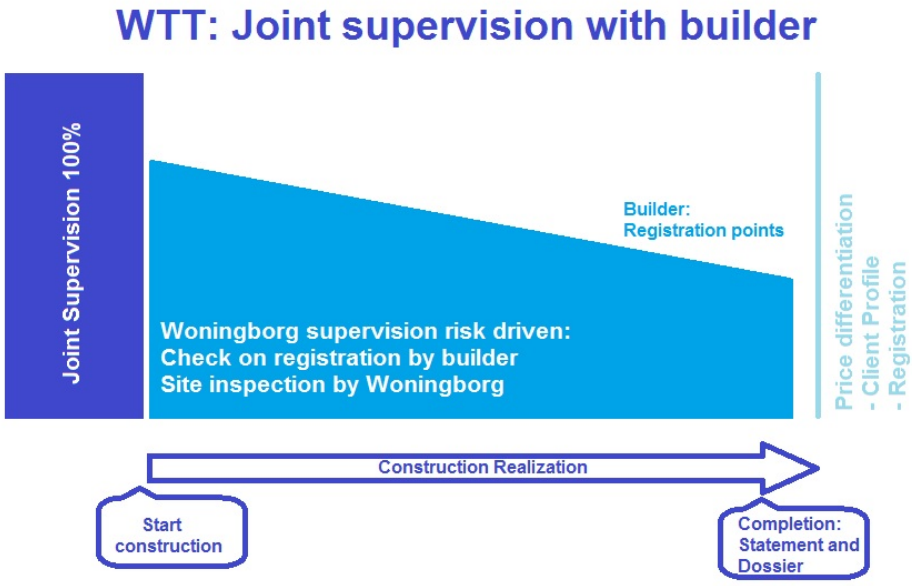


Figure 51: Woningborg Checking and Supervision (WTT); (own processing)

SWK, however, only develops an instrument and leaves the role of KB to a number of selected agencies. SWK mainly caters to large builders and their guarantee is already based on the quality management of their clients, which will not change under the Wkb. The idea behind their instrument is that the independent KB mainly bases their judgment on the information provided by the builder. The KB ensures that the construction company uses the quality assurance system in a good way and conducts samples (figure 52).
In further elaboration of the law it is likely for the higher result classes that certain inspections must be performed by the KB. In result class 1, the role of the KB can be limited to supervisor. The quality system developed in this study is based on the concept-instrument of SWK (this instrument is still in development). Van Wijnen is also affiliated with SWK (SWK, 2015).

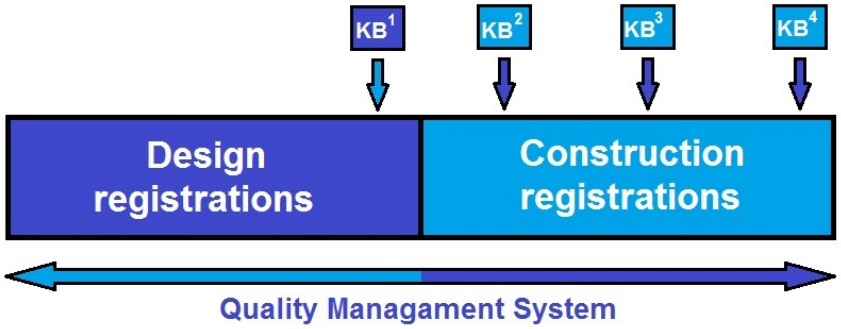


Figure 52: SWK quality management system; (own processing)

5.7 Sub conclusion

The case study was carried out based on the Groevenbeek project (Ermelo), a project that was completed recently and forms a good example of the correct use of the existing quality management system of Van Wijnen. The project is a so-called 'Zero on the meter'- project, which means its residents do not expect any energy bill. To achieve this high level of quality, an external quality inspector was deployed. The developed quality assurance system (see chapter 4) was applied pro forma to this project, and the differences with the current system were made clear. The modifications to the system are limited, but the discipline and knowledge necessary to determine whether the regulations are complied with need to increase. This requires a culture change, which should lead to the employees being proud of working for Van Wijnen and being able to deliver good work. To achieve this, a careful implementation project will need to be used. To minimize the load for both the employees and the external quality inspector, the quality system will need to be digitalized. Three tools are examined, Solibri, Revit and Relatics. It is possible to connect the new designed quality assurance system with these three tools. To minimize the physical effort of the KB it is necessary that the KB have access to the BIM server throughout the process in order to determine whether the system is being used correctly.
The lean approach does not stand in the way of the developed system. With the lean approach agreements are made in team meetings about the planning and execution. Harmonization's are being optimized and failure costs are being minimized. The lean approach also stands for the creation of customer value and continuously improvement of the production process. A learning organization arises. An additional condition for a successful implementation of lean is chain cooperation. By working with the subcontractors and installers regularly, the team knows where they stand with each other. Lean may also be of value to the Wkb. The law also intends to ensure that the customer gets what it deserves. Also for realizing and securing the agreed quality, the lean approach can be of value. By checking if the output of the predecessor in the process is correct (yield to each other), the foundation for a good result is created.

6. Conclusions

This chapter presents the conclusions on the results and findings of the research. The needed information gathered by performing a literature review, interviews, case studies and software programming (Solibri, Revit etc.) The information is used to answer the main question and sub questions of this research. The introduction is outlined in chapter 1. Chapter 2 comprises the scientific relevance including all sub questions.

6.6 Introduction

The research has provided answers to the following five research questions:

1. Is the Dutch control on the required building quality comparable to systems in other countries and we can learn from this?
2. How the construction process should be designed to use BIM efficient?
3. How control protocols can be linked to the Building Information Model and called via the 3D drawing?
4. What are the possible control protocols for Building Requirements?
5. What is the most efficient time to perform these checks?

The main question is answered on the basis of the answers of these five questions. The main question is:

''Is it possible with systems engineering and Building Information Modelling to efficiently deliver an as-built statement which the independent quality inspector can present to the building permit holder under the Quality Assurance for construction Act (Wkb)?''

6.7 Scientific relevance

The conclusions of the research are respectively found in Chapter 2 'Literature review' (question 1), Chapter 3 'Systems Engineering' (question 2), Chapter 4 "System Design" (question 4 and 5) and in Chapter 5 'Case study: 'Groevenbeek' Ermelo '(question 3).

6.2.1 Question 1

The main conclusions on research question 1 reads as follows:
The comparison between four European countries and the Dutch situation provides a number of clear conclusions. The municipalities continue to grant permission to build, complying with zoning and environmental security, the task that is associated with the Government and a task that remains with the government.
Private parties carry out the technical part of the four evaluated countries. In England/Wales and also in Germany, there are options to choose a private or public inspector. The systems in France and Germany perform properly and have not been adjusted recently. In England/Wales there are still discussions on the functioning. In Sweden, the system is adjusted and the criteria has become stricter. By mandating quality assurance in the evaluated countries, the size and risk profile of the project is taken into account.
The costs of the different systems are difficult to assess, the impression is the mandatory involvement of certain officials lead to substantial costs.

When the evaluated countries, are compared to the proposed Dutch situation the following conclusions can be drawn. The clear division of roles between municipality and the designers, builders, and the independent quality inspector, is included in the Dutch system. The report of a ready project is also in the Dutch system. To make demands on the quality of standards of the concerned officials and companies in the Netherlands remains limited to only the demands on the

independent quality inspector. In the evaluated countries there are more demands on individuals and businesses than what is usual in Netherlands.

In the Netherlands there has been a lot of attention to the cost of the new system. It is expected that the cost in the Netherlands in relation to the current situation will rise limited for result class 1, but that the cost of quality assurance for result class 2 and 3 will decrease. That is mainly caused by the current fees system, because the cost of the quality assurance of smaller projects is being apportioned over the larger projects. The objective and the forecast is that the projects quality will increase which will result in less failure costs.

Before the answer can be given to research question 1, the WKB is studied and analyzed.
The three conclusions are:
The new law has three chapters:

1. The amendments in the Housing Act, the manner in which the construction quality is checked
2. Strengthen the position of consumers stipulated in the Civil Code
3. Adjustment of the WABO, small buildings are no longer assessed against the Building Act

The new system places responsibility for the legally required building quality down to the builder. The national government will conduct system monitoring on the instrument for quality assurance. The license holder is obliged to involve an independent quality inspector, who will issue the statement that the building was built according to the building regulations (the Building Act), this statement will be accompanied by a confined records and will be made available to the competent authority, if the statement is submitted the relevant project may be taken into operation. The expectation is that through these adjustments the right incentives are given to deliver the quality the customer (the consumer) deserves.

6.2.2 Question 2

The main conclusions on research question 2 are:
SE has become the new method to design and prepare projects. SE starts with recording of the functional design based on the wishes of the client. A second important aspect is that integral design is used at the starting point. The coordination between the different components of the design is essential. Working systematically from coarse to fine is a feature of SE. SE is rarely used in residential construction, but it is applicable. The application of SE would connect very well to effectually and efficiently secure quality for the new quality assurance law. The share moments with the KB during design (control phases) is efficient, but access to all information, of, for example a BIM server is necessary.
Van Wijnen uses a good working building process management system (BPM). In this BPM-system risk management is an imported. This risk thinking is in line on the Wkb. The current BPM-system is used as basis for the design of a new assurance system, with which it can be demonstrated that at least compliance with the technical construction regulations is met.

6.2.3 Question 3

The conclusions on research question 3 are:
The QCL and CP are part of the quality assurance system and can be accessed via a server. By linking the QCL to a 3D-model the KB can easily monitor and asses the checking/verification process.

6.2.4 Question 4 and 5

The most important result of this study is the design of a quality assurance system, which can demonstrate compliance with the Building Decree.

As a basis the present process management system (BPM System) of Van Wijnen is used. This system has two main components, the in every recurring construction phase risk analysis and management, and the quality assurance in itself.

The BPM-System is summarized in a Matrix. “Behind” the “boxes” of the matrix are procedures and protocols included. There are for quality assurance at present checklists for quality assurance. At present there are ‘*keuringslijsten*’ for quality. The current system (the matrix and the ‘*keuringslijsten’*) is adjusted. The QCL’s are added to the system. The matrix indicates which QCL should be applied in the respective construction phase. Also included in the matrix is that before the start of the construction a risk assessment must be conducted, and an inspection plan should be drafted based on the risk assessment. The so-called as-built statement is also adopted in the Matrix.

In place of the current two-step system, a three-step system has been developed.

Step 1:

- The adjusted matrix (the summery of the total BPM-system). (het overzicht van het totaal BPM-systeem)

Step 2:

- The newly developed QCL

Step 3:

- The ‘*keuringslijsten*’, these are now referred as CP. Wherever possible, existing CP’s are used, however for a number of Building Decree requirements there were no CP’s available. These are developed in the framework of this study.

The new system has been applied to a recently completed project (Groevenbeek, Ermelo) and has proven to be practicable. It is important to note that the system is not yet usable everywhere. The system is complete for ground-level houses with a sand-lime shell, traditional facade brickwork, prefab roof elements with roof tiles. The system has been developed fort his user features and construction method.
The system should be extended for other user features and construction methods. The risk analysis should determine which user features a projects includes, which construction method is adopted and on that basis the inspection plan should be determined, so the necessary QCL and CP are then selected with the core file.
For the case study ‘Groevenbeek’, 10 QCL’s have been developed and via these QCL’s, 29 CP’s are selected. These CP’s need 110 checks. These checks are distributed over 3 checks in the concept design, 7 checks in both the final design as the technical design, 35 checks in construction planning and 58 checks in the execution phase.

The focus to determine that the requirements of the Building Decree are met are thus in the construction planning and execution phase. However during earlier construction phases (design) of a well prepared project checks are needed to prevent that the requirements ultimately cannot be realized.
Checking of calculations, such as for the structural safety and the energy performance, should be carried out at the earliest possible stage of construction.
Also checking the developed details of the building should be carried out in earlier stages, in which is worked procedurally from coarse to fine.
Checking the calculations will usually be done by specialists to eliminate errors in the technical design, which can then be marked as a reliable document for the construction planning an execution.

Research question 3: How control protocols can be linked to the Building Information Model and called via the 3D drawing?

Is elaborated during the case study. At this time Van Wijnen does not use BIM server where all the information of a project is compiled and many suppliers and subcontractors do not work with the BIM-systematics. For the future, the use of a BIM Server which includes the 3D drawings will be essential. For controlling and managing the quality in the execution phase the deployment of, for example, ED-control is necessary to efficiently perform the quality insurance to deliver the evidence. The three selected tools which are important to demonstrate that the Wkb can be implemented in an effective and efficient way, namely Solibri, Revit and Relatics, can be digitally linked to the newly developed quality assurance system. When the Kb acquires access to the server which holds all the information, the physical involvement (the effort) can be minimized.

Using the conclusions (results) on the five research question above the main question can be answered.

Systems Engineering in conjunction with a BIM-system is a prerequisite to efficiently and effectively deliver the by the Wkb required as-built statement. The developed quality assurance system can theoretically be used without digital support. The costs (time spent) will be high with the risk that checks will be omitted, in which case the independent KB needs to spend extra time (costs).

6.8 Social relevance (risks)

It is important to prevent the new law from becoming a bureaucracy. In interviews with planners and executors it has become clear that there is a concerns about that. The role of the KB must be clear for all parties, the KB is only responsible for the correct use of an instrument, the builder stays responsible and liable to the consumer. Especially in the beginning the expectation is that the BWT will look for errors made by the KB (and constructor) and seek publicity on these mistakes. The KB will have to mind that they are not going to fulfill an advisory (consulting) role, because then roles will become unclear again, the KB should just perform checks. Another point of concern is that commonly used general terms (UAV 2012) no longer fit. Towards to the consumer, only the builder responsible (including design defects), what this will mean for procurements is not clear not yet clear, perhaps it will result in more use of the UAV GC 2005.

6.8.1 Liability

The construction company can never hide itself from the consumer, the construction company will off course try to recover damages at the designers and subcontractors. In the contracts with these parties, agreements will have to be made on this subject. The KB is required to properly apply the instrument, when he fails to do this it, is likely when any damaged is observed, that a claim will follow. The correct use of a tool means that it is likely that there is compliance with the building regulations. An instrument will in practice have a broader scope than just the Building Decree, also securing contractual agreements and good- and sound work will be assessed by the KB. A KB cannot give advice, otherwise he will be assessing his own advice. This will be difficult in practice, because it is easy to for the KB to say ‘If you do it this way, then it is fine’. The KB has to stay away from giving such hints and tips and should refer back to the designers or the construction company. The culture in the construction sector is such that hide behind or pointing is commonplace, this law attempts (to break or culture) this attitude, the idea is that you are proud of your work. It is common culture to hide behind or point to the municipality. The new law must change this culture. Employees have to be proud of their work

6.8.2 Insurance institutes

The insurance institutes will continue to exist and are for the consumer of high value (source: Mulder, 2015). In case of bankruptcy the construction of the houses will be finished and any

complaint will be resolved. Developing an instrument is costly and will only be developed by larger parties (IKOB / BKB, KIWA, TIS organization Woningborg, BouwGarant, SWK), a private party will not be able to develop an instrument, both in terms of required knowledge and budget. Of course, it is also possible to build without a guarantee, however, it will be become mandatory for the construction company to provide information what the (financial) risks will be for the consumer. There is a concern with some parties that the insurance institutes are going to achieve a kind of monopoly position, for example, the situation in which the Woningborg and SWK will insure 80% of the new building together and are both going to use their own instrument. This causes other instruments to be excluded from the market. The question is whether this is a healthy development, or if it would be better if the guarantee institutions do not own instruments, but only require to use an approved instrument. The danger is then that the guarantee institutes are going to perform a second check, regarding a risk analyses on their risks. The quality will then become very expensive.

6.8.3 Finance

Woningborg (Klaver, 2016) has calculated that if the current fees will decrease by 20%, the new quality management will not lead to additional costs. The share of the Building Decree checks in the work of the BWT ranges from 30-45%. The new system does not have to lead to higher costs provided that the fees are reduced. Both the construction companies and the Second Chamber expect that the fees will be reduced substantially, however, municipalities are autonomous. One solution that several parties proposed the is the abolishment of fees, as it is the question of whether the fees are still attributable to the project, what remains as a task for the BWT is in fact setting environmental security and prosperity. Instead of fees the cost of BWT should be paid from the general funds (municipal funds). These funds are then made available by the government. It is expected that the cost of the new system will be higher (the KB will check 100% of the Building Decree, because he has to declare that the Building Decree requirements are met, the BWT now primarily checks the constructive- and fire safety), on the other hand, the authorization process will go faster and that the costs of failure will reduce. In the Social cost-benefit analysis, ((*Maatschappelijke kosten en baten analyse*- MKBA)(EIB, 2015)) it has been estimated that each year there will be significant savings. These savings will also increase substantially if a benchmark system is introduced. In the developed flanking policies, the market and government are working on a transparent, buyers focused, benchmark system (for examples of current benchmark system see: bouwnu.nl en bouwprestaties.nl). Van Wijnen (De Jager, 2016) anticipates that the competitive position of the larger construction companies in relation to the smaller construction companies will improve, because the smaller construction companies are now required to enable a quality inspector will need to use a quality management system.

7 Recommendations

An effective implementation is very important for the intended changes to be successful. This chapter gives an idea of how the recommendations could be implemented. This chapter starts with an introduction in section 1. Section 2 describes the recommendations for change management. Section 3 presents the recommendations for Van Wijnen. Section 4 describes the idea about the future.

7.1 Introduction

The implementation of a new BPM system has major consequences. The roles of the people involved change the developed quality management system and shows that most assurance activities (and recording) will take place in the construction planning and execution (figure 22). A precondition for a successful and efficiently captured as-built certificate is a well prepared building process. This means that contracts, drawings, calculations and constructional details are correct.

This also means that in principle all risks are eliminated. It cannot be expected that work planners, executor, and how people work at the construction site. Should evaluate the design and adjust as necessary. Van Wijnen therefore faces a process of change and they are well aware of it (De Jager, 2016). The employees in the execution of the construction are concerned that there will be even more paperwork (Deen, 2016). Checking and recording are still seen as “ballast”, which needs to be changed. Therefore, recording and checking should become an important task in everyone’s job. The responsibilities shall change (Chapter 2), not only for the company but also for the employees. It must therefore be clear for all employees at all levels in the organization what is expected of them. The new quality management system therefore clearly states who is responsible for a certain check. The change process comprehends three important components.

1. Culture change
2. Learning to apply the quality assurance system.
3. The ability to apply the quality assurance system.

Cultural change is needed to develop the “pride in your work” feeling. The organization, competences and the knowledge of all employees should make this possible. Change is difficult and often unsuccessful, which is why careful preparation is necessary. In the book "The 7 V’s van ‘*verandermanagement*’ practical instructions are given for a successful change process (Cozijnsen, 2015).

7.2 Change Management

Cozijnsen (2015), defines four building blocks of change management, which must be appointed integrally. He makes the following distinctions (blocks:

1. The organizational context
2. The improvement concepts
3. The behavior
4. The control (strategies, approaches, interventions)

In figure 53, the four building blocks are visualized and positioned relative to each other.

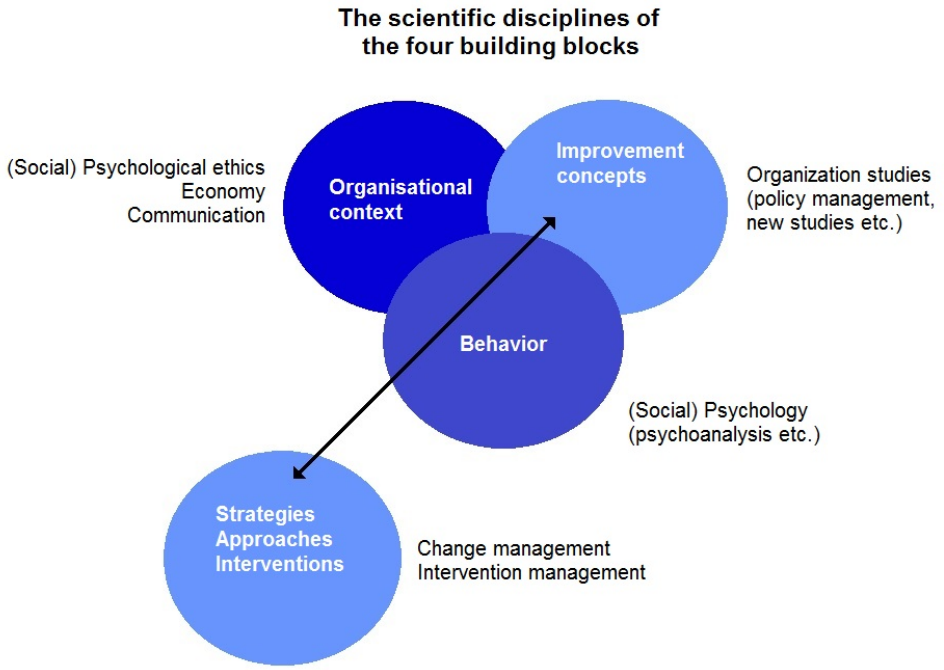


Figure 53: The scientific disciplines of the four building blocks; (Cozijnsen, 2015)

It is crucial that a clear vision is being developed, what direction do we want to go as Van Wijnen, who do we want to be and how do we want to achieve it as Van Wijnen. The messages have to be clear and must provide certainties, because uncertainties will lead to resistance (Cozijnsen, 2015). Change is a process, and therefore the four building blocks are also presented as a process (figure 54).

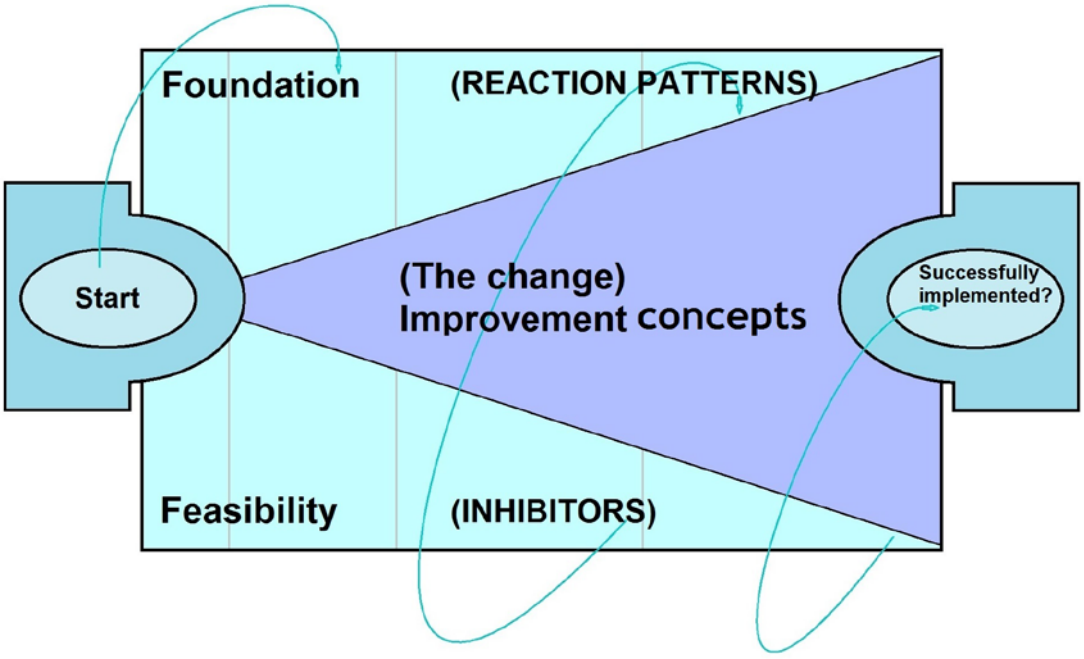


Figure 54: Vision on change; (Cozijnsen, 2015)

The inhibitors are from the block 'organizational context', the 'improvement concepts' is building block 2, the reaction patterns originating from building block 3, 'behavior'. The control (Building block 4) ensures the integrity within this process.
Cozijnsen (2015), defines 10 major risks:

1. Change capacity
2. Necessity to change

3. The trust
4. Positive or negative change properties
5. Complexity
6. The amount of threats
7. The increase of uncertainties
8. Harming interests
9. Increasing mistrust
10. Negatively affect the willingness to change

The necessity to change, the vision of the company and clear characteristic values should be clearly formulated. Once this is done the following question follows: 'Can the organization realize the vision and the additional goals in practice?' (Cozijnsen, 2015). Insight in the qualities of the organization and her employees is essential. Cozijnsen (2015), thus defines four blocks and 10 high-risk factors. He also suggests that ICT should be an integral part of the change processes (Chapter 5). For the change to be carried out successfully the seven V's are introduced:

V1- Accelerate (*versnellen*)
V2- Trust (*vertrouwen*)
V3- Imagine (*verbeelden*)
V4- Demonstrate improvements (*verbeteringen aantonen*)
V5- Clarify (*verduidelijken*[6])
V6- Associate (*verbinden*)
V7- Embedding (*verankeren*)

Embedding means for Van Wijnen recording in the BMP-system, securing competences and knowledge of the co-operation and structural monitoring of the delivered quality. Cozijnsen (2015), summarized the four building blocks, the 10 risks and seventh V's in a model (figure 55).

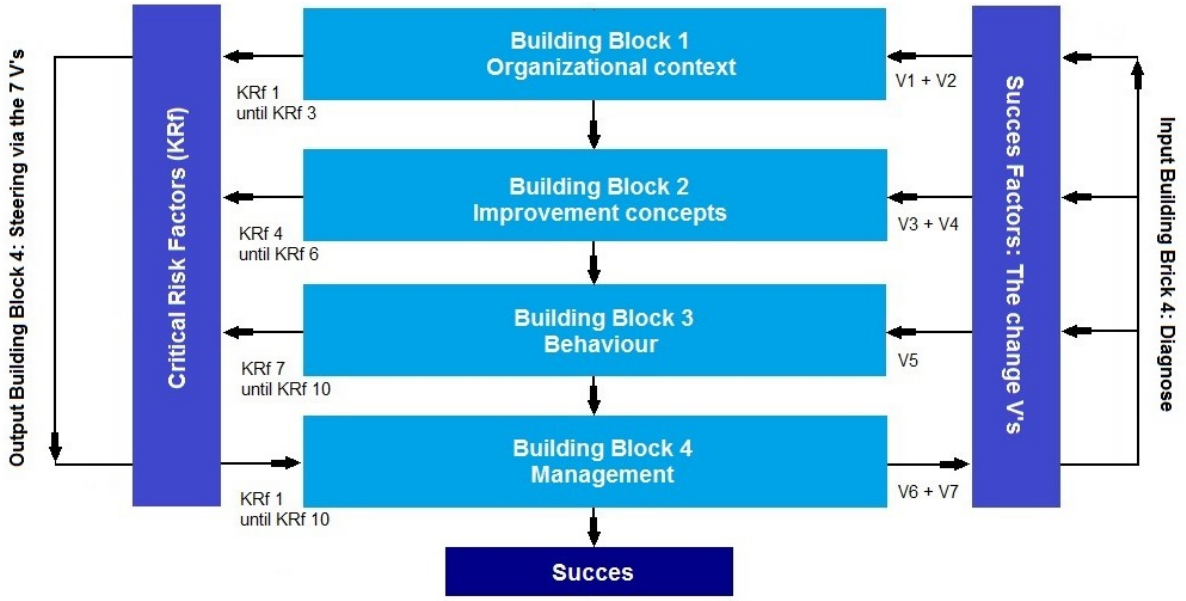


Figure 55: Summarized the 10 risks and the 7th V's; (Cozijnsen, 2015)

[6] N.B.: geen vaagheid, abstracties en onzekerheden

7.3 Recommendations for Van Wijnen

In sector 7.2 is plotted that a thoroughly designed and executed implementation is a prerequisite for success. A number of issues are important for this research follow-up. First of all a number of motivated employees should make and assessment whether this quality management system works in practice. If it works the system needs to be digitized. As stated in 7.2 IT support is necessary. In first instance, a IT design is needed. In Chapter 4 and 5 some pre-designs are presented. Based on the Van Wijnen realized projects the QCL and CP should be expanded and complemented for other user functions and construction methods. Once the system is complete, the IT support should be arranged. It is important that BIM is more integrated into the building process such as Autodesk BIM 360. A BIM server where all the information is placed and where the designers and co-designers have access to is important. To build this complete building file this central server is important. The project manager can check whether all "construction documents" are available with which can be demonstrated that good and sound work has been delivered and that the compliance with the contract and requirements of the Building Decree are met. In order to carry out the control process efficiently and effectively access for the independent KB to this server is advisable. All employees must be trained to use the system properly.
Instructions for storing data, using the QCL's and CP's and dealing with disorders should be developed and practiced.

It should be inventoried whether the employees have the necessary knowledge and competencies (skills) to use the system effectively and efficiently. Subsequently a training plan should be drafted and then carried out. It is important to test the system with a few enthusiastic employees on a limited number of projects. Once it can be established that the system works it can be implemented in the organizations. Sharing the success, giving out tips and supporting an internal helpdesk will encourage enthusiasm for the new system.

7.4 Future

The implementation of the WKB will lead to that structured work (SE), digitally supported with drawing software (for example, Revit), Building Information Modelling (central and structured storage of information in a so-called BIM-Server), digital control protocols (e.g. Solibri) and Relatics will be commonplace. Not only in the preparation (design phase) but also during the execution phase digital support will be needed to be in "control". The verification and validation should not lead to more workload. Provided an assessment of foundation in a quick manner should be 'fun' to do and be an integral part of the work processes. In addition to the digital techniques, to check information and streamlining, the attitude of the employees (from high in the organization to low) also need to change. Trying to evade responsibilities should be 'not done'. The acquisition and application of current knowledge should be a standard part of everyone's job.
Surgeons, pilots, lawyers repeatedly have to demonstrate that they master their profession, why is it not (yet) common in a very important and risky sector such as construction? The construction company will have to upgrade to continue delivering added value. The role of coordinator (director) will otherwise be taken over by for example supply companies, wholesalers and engineering companies.

7.4.1 Developments

The requirements for buildings are getting stricter. The energy consumption is being reduced to zero, which means that first of all the demand is being minimalized by carefully insulate the building envelop, and that heat recovery is being applied where possible. Next the installations and lighting need to be more energy efficient. Naturally there is also the use of energy, which should be from sustainable sources. Another development is the use of materials, materials should be re-used an endless amount of times (cradle-to-cradle), by for example building flexible. Flexible structures are

constructed like Lego blocks put together and can be dismantled so another building elsewhere can use the materials again. The adaptive construction method will also have to increase. In a building multiple functions should be possible. The industrial construction is expected to greatly increase, the quality is better, the speed of construction is increasing and therefore the price will decrease. Also development (design) and control processes are increasingly being digitized. By using a central BIM-server where the information is stored in orderly manner and can be accessed, ensure more efficiency and higher quality, and therefore also causes decrease in the costs (and simultaneously increase profit margins). Calculations will be faster (cheaper) and are better implemented when drawing models and mathematical models are linked. Automatically verify the fulfillment of the PoR and the Building Requirements will in my view be developed within the next 15 years. The national government, provincial states and municipalities must also join this process. Too often the government is a disruptive factor in the building process. Demands for buildings and homes need to be better monitored and the necessary land and zoning should become proactive available. This will be to the benefit of the businesses and consumers. The construction sector there is economically seen not really been a real "market". The owner of the land and the government decide when and what can be built. I do not expect that this will be resolved, however, the reduction of unnecessarily long procedures, and barriers (for example, unnecessarily building aesthetics supervision which is in the way of standardization) should be possible. The WKB is a good step forward in this case. Construction should develop into a modern industry with the consumer who lives in buildings, works, participates in education, and recreates as starting point of every process. An industry that fits within Corporate Social Responsibility (*Maatschappelijk Verantwoord Ondernemen*- MVO) and thereby provide positive contributions to human and environment.

There is still much work to do in this important and inspiring industry!

7.5 Finally

The new system is a step towards a more modern industry which produces sustainable, healthy, useable and safe buildings for its customers. An industry that produces flawless, listens to its customers and where ‘you’ would like to work with.

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