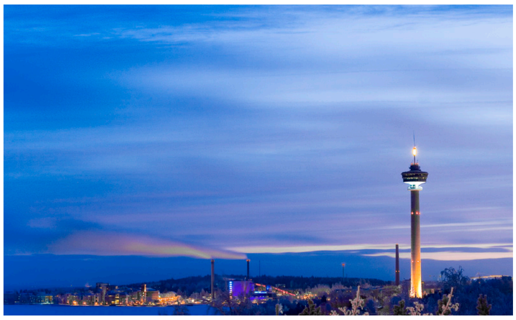
CEO 2015

Tampereen teknillinen yliopisto. Rakennustekniikan laitos. Rakennustuotanto- ja talous. Raportti 16
Tampere University of Technology. Department of Civil Engineering. Construction Management and Economics. Report 16

Kalle Kähkönen, Pekka Huovinen & Marko Keinänen

CEO 2015 - Proceedings of the 8th Nordic Conference on Construction Economics and Organization



TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

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Tampere 2015

Cover photo: Piia Huittinen

ISBN 978-952-15-3534-5
ISSN 1797-8904

Foreword

Nordic conferences on Construction Economics and Organization (CEO conferences) have been biennial events for academics and industry people. These events are bringing together experts globally and those particularly from Nordic countries for sharing and learning new knowledge, to meet colleagues, get new connection and to visit/see interesting construction case projects or companies. For academics these conferences are important publishing channels. The accepted double-blind reviewed papers are published using widely recognised academic media.

We are very pleased to introduce 8th CEO conference 28th – 29th May 2015, Tampere Finland. The overall theme of this CEO2015 conference is *Leadership for targeted change and proven advancements*. The following titles represent key areas for which the conference was planned to contribute.

- Gaining desirable changes in real estate and construction sector
- Change towards sustainable built environment and environmental friendly behaviour
- Processes and methods for realizing change initiatives
- Principles, methods and tools for the management of change in processes and projects
- Learning from change: challenges in change processes
- Change behaviour – methods and models to affect change processes
- Business and operations management under unceasing change
- Built environment, companies and projects as systems.

The CEO2015 conference comprises 79 accepted papers and their presentations. The special issue of Elsevier Procedia Economics and Finance (Volume 21, 8th Nordic Conference on Construction Economics and Organization) includes 76 papers. This publication includes three papers. The editors are grateful to all authors for their valuable efforts.

Tampere 20.05.2015

Kalle Kähkönen

Pekka Huovinen

Marko Keinänen

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Contents

A synthesis of studies on renovation profitability

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Abstract

Still, the building sector in Sweden repeatedly fails in using experiences from both fulfilled projects through feedback and existing research information. The use of earlier results would be beneficial for the process of developing appropriate and competing product and services, and would help avoiding crucial mistakes that risk the functionality of constructed buildings. It is also important to know the quality of the information to be able to make relevant risk assessments of constructions and decisions. Particularly because of the interdisciplinary nature of building renovation procedures, there is an urgent need for a comprehensive base of knowledge and a quality model, taking into account research and practical experience. As part of a five year research project on the interdisciplinary renovation of buildings, this paper proposes a start to synthesize existing research and experience of renovations. A synthesis of a number of profitability analyses of renovation projects was performed. It will give examples of existing information and how it is accessed. The result will function as a pre-study of a tool that will be continuously improved and extended over the coming years. It will be part of the work of Swedish National Renovation Centre with the aim to optimize the renovation process in an interdisciplinary manner.

Keywords: Holistic, profitability, renovation, sustainable

1. Introduction

Still, the building sector repeatedly fails in using experiences from both fulfilled projects through feedback and existing research information. Doing so would be beneficial for the process of developing appropriate and competing products and services and for avoiding crucial mistakes that risk the functionality of the constructed buildings. It is also important that the quality of the knowledge is known in order to be able to make relevant risk assessments of constructions and systems that will form the basis for decisions. Particularly regarding renovation of buildings, where an interdisciplinary approach is important at the same time as it creates constraints, there is an urgent need of a base of comprehensive knowledge and quality model, taking into account research and practical experience.

The aim of this study is to gather and structure experiences on the profitability aspects treated in renovation projects, to increase accessibility and manageability of the information. Some examples of data, based on existing research and experience from renovation projects is gathered in this study, with profitability aspects in focus. The Swedish National Renovation Centre, RC, works to optimize the renovation process, taking into account all relevant aspects. The long term aim is to create a more sustainable national renovation practice by learning from already performed renovation projects and introduce all relevant aspects of a sustainable renovation into the process. The result of this study will function as a pre-study of a tool that will continuously be improved and extended over the coming years, and it will be part of the work of RC.

This study includes larger renovations of Swedish multi-storey apartment buildings, where the whole building is being considered and several aspects are treated. Renovation projects for maintenance and aesthetic purpose are not included. Information on the planning phase of specific renovation projects was gathered without consideration of whether the execution of the renovation had been performed or not.

2. Economic aspects of renovation projects

Buildings are in need of renovation and society needs renovations, sustainable for both users and the environment. Sustainable development, as defined by the Bruntland commission is "...development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 1987). The definition generates questions on what the need is the time being and on the possibility for future generations to fulfil their needs. Narrowing down the meaning of sustainability in contexts and studies connected to building renovation projects show dissimilarities in the use of expression of sustainable renovation. A study from the technical University in Istanbul evaluate sustainability from two aspects, environmentally and economically (Cetiner & Edis 2014). An upcoming standard in Austria of evaluating sustainable buildings states environmental, social, economic, functional and technical aspects to be taken into account in order to achieve an holistically sustainable evaluation (Kreiner et al. 2014). The variation of sustainability content, expression and also of division of main categories with subcategories is evident in the studies. In Sweden the performed renovation project Brogården aimed for a sustainable renovation and treated the economic, ecological and social aspects (Alingsåshem & Skanska n.d.). In addition, an important conclusion, revealed during the renovation process, was the positive effect of the entrepreneur contract form 'Partnering', leading to a higher degree of partner involvement, resulting in higher quality and an efficient building process. The aspects of life-cycle cost (LCC), energy, indoor environmental quality and hazardous materials are treated in the report "Sustainable assessment of renovation packages for multi-family buildings in Sweden" (Brown et al. 2013). The expression of sustainability in this report is explained to be used for describing a method that involves more than "simply long-term environmental performance" (Brown et al. 2013). It is also stated that the purpose of using the term 'sustainability' is not to give it a definition. A common aspect, treated in the studies, is economic, as three of the studies state, and the fourth study partly includes life-cycle cost (LCC). By performing LCC calculations, it is possible to include an estimation of a project's profitability. In the economic aspects a wider view of, for example, accounting methods and financing options could be treated.

Reasoning about the different calculation methods and input data that should be used for profitability calculation is evident in several projects (Högdal 2013). The calculations should support decisions relating to investment. Several methods can be used such as payback time, net present value (NPV) and life-cycle cost (LCC) (Byman & Jernelius 2012) (Lind 2014b). Also internally developed methods by companies without references to earlier theories can be used (Hastig & Tapper Jansson 2014). Profitability can be calculated from the perspectives of companies or communities (Byman & Jernelius 2012). The companies' calculations can be performed regarding costs, expected income and invested capital. In addition to many companies' perspective, the social economic calculation includes also the social benefits. Societal benefits are for example reduced unemployment as well as lower criminality, and the use of local work resources can be considered. A web based tool for profitability calculations has been developed by BeBo (Energy agency's client group for energy efficiency apartment buildings) with the aim of being used at an early decision stage in renovation projects BeBo (2014). A function to include societal benefits is included in the tool. The input data required for the profitability calculation depends on the calculation method. Even with a clear methodology the calculations rely on realistic input values for e.g. energy price and lifespan. The article "Feasibility of energy saving renovation measures in urban buildings: The impact of energy prices and the acceptable payback time criterion" includes an analysis of the high impact of energy price alteration on profitability calculations (Papadopoulos et al. 2002). In 2009 the energy prices were too low in China for energy efficiency measures to be profitable according to a study published in "Energy Policy" (Ouyang et al. 2009). A study on the effect of different lifespans, which considered 40, 50 and 60 years, came to the conclusion that the impact of different lifespans are small or even negligible (Bonakdar et al. 2014).

3. Conduct of a review of empirical research on building renovation in Sweden

Publications on renovation projects were collected with focus on the treatment of profitability calculations. The data search was performed by the help of results from database searches and pearl growing in which references in **found** publications are included and through recommended literature from the collaboration within the strong research network called 'SIRen'.

A synthesis of reviewed studies was carried out, based on found information on specific renovation projects in publications. The used methodology and input values for profitability calculations in the renovation projects were collected and compared. A synthesizing qualitative study was performed on the projects where the needed specific information was accessible.

4. Result

Information on profitability calculations for renovation projects was found in publications regarding six specific renovation projects and in research projects which evaluated or analysed one or more renovation projects. The question whether a renovation project is profitable and how to determine whether it is or not, is widely treated. Table 1 presents general definition on profitability from six renovation projects.

Table 1. Project information and data for profitability calculations gathered from research projects: [1] (Byman & Jernelius 2012), [2] (Brown et al. 2013), [3] (Hastig & Tapper Jansson 2014), [4] (Dalenbäck & Mjörnell 2011), [5] (Lind & Lundström 2008).

	Hållbara Järva[1]	*Backa Röd[1]*	*Brogården[1]*	*Gårdsten[1, 4]*	*Two case studies[2]*	*Giganten 6[3]*
Calculation perspective	*Company and community*	*Company*	*Company and community*	*Company and community[5]*	*Company*	*Company*
Definition of profitability	*Future cash flow exceeds the investment cost*	*Future cash flow exceeds the investment cost*	*A positive result in 18 years was in this project considered profitable*	*A payback of below 20 years*	*Comparison is made with a base case (min. effort needed to keep the present function)*	*Decreased operational costs cover the investment cost*

In several cases information about method, definitions and input data is not specified. Table 2 presents examples of specified information from six projects on renovations and specific conditions for profitability used in the BeBo methodology for comparison. The table organizes the required information on profitability calculations.

Table 2. Project information and data for profitability calculations gathered from research projects: [1] (Byman & Jernelius 2012), [2] (Brown et al. 2013), [3] (Hastig & Tapper Jansson 2014), [4] (Snygg et al. 2014). (– information missing)

	Hållbara Järva[1]	*Backa Röd[1]*	*Brogården [1]*	*Gårdsten [1]*	*Two case studies[2]*	*Giganten 6[3]*	*BeBo[4]*
Profitability calculation method	*Net present value (with a residual value)*	*Net present value (with a residual value)*	*Prediction of future return*	*Payback-time calcula-tion*	*Life-cycle cost (LCC)*	*"Total cost"*	*Net present value*
Included costs	*Total project cost*	*Standard rising, energy efficient measures*	*Only investment (excl. maintenan-ce and energy measures)*	*Energy efficient measures*	*Investment, operational, maintenance, re-investments (incl. end-of-life-costs), energy*	*Total project cost*	*Energy efficient measures*
Calculation period	*10 years*	*10 years*	*30 years*	*-*	*50 years*	*-*	*-*
Internal rate of return	*5% (incl. inflation) Real discount rate*	*6.25% (excl. inflation)*	*5,5% discount rate*	*20 years*	*5% (incl. inflation) Real discount rate*	*7% was stated initially but 5% and 5.25% was used*	*5%*
Inflation	*-*	*2%*	*-*	*-*	*1.2%*	*-*	*0%*
Lifespan	*-*	*-*	*-*	*-*	*Building: 50 years*	*-*	*HVAC: 15 years Building tech.: 40 years*
Energy prices	*Following the inflation*	*Un-changed from the prices when the calcula-tion was performed (2009)*	*District heating: 3% Electricity: 5%*	*Un-changed*	*District heating: 1.4%/year (real price increase) Electricity: 2.5%/year (real price increase)*	*Current price for electricity and district heating in Halmstad at the time of the calculations (2011)*	*Electricity: 1.2 SEK/kWh 2%/year increase District heat: 0.8 SEK/kWh 1%/year increase*
Renovation and maintenance	*-*	*-*	*-*	*-*	*1.0%/year (real price increase)*	*-*	*-*
Profitable	*No*	*No*	*Yes*	*Yes*	*No for 3 out of 4*	*Yes*	*-*

In Hållbara Järva, Stockholm, the costs for maintenance that was performed during the renovation project was included with the rest of the investment costs even if these measures are not considered as investments. This was conducted in this way due to the complexity of separating them (Byman & Jernelius 2012). The performed profitability calculations in the renovation project Hållbara Järva, gave the result that the measures were not profitable. Some possible reasons for this are that the maintenance costs were included and that the assumed energy price was evolving in the same pace as the inflation but not more.

In BackaRöd, Göteborg the calculations did not result in the energy efficient measures being profitable (Byman & Jernelius 2012). If the energy efficient measures could count as raising the value of the buildings and therefore make it possible for the owner to increase the rent, the measures would have been profitable. However, this was not possible in negotiations with the tenants' association. Some of the reasons for the non-profit result are assumed to be found in the required high discount rate and the assumption that energy price would stay at the same level as when the calculations were performed.

In Brogården, Allingsås, the calculations showed that the energy efficient measures are profitable (Byman & Jernelius 2012). The owner of Brogården, Allingsåshem, considers the renovation profitable if investment costs and yearly costs, calculated for each year, will give a positive result within 18 years.

In Gårdsten, Göteborg, the energy efficiency measures are considered profitable according to the owners, Gårdstensbostäder (Byman & Jernelius 2012). The calculations for profitability were made for a pay-back time which was considered positive with a pay-back of less than 20 years. The calculation was performed for the energy efficiency measures purely with consideration on the cost for these investments and the yearly saving in operational costs. Deeper economic analyses of the renovation project, Gårdsten for Gårdstensbostäder were performed in the report "Affären Gårdsten" by H. Lind and S. Lundström 2008 and in "Affären Gårdsten en uppdatering" by H. Lind 2014. The reports present an economic evaluation firstly with a company perspective and secondly adding societal effects (Lind & Lundström 2008). The difference between the company's market value, with and without the effects from the renovation, is compared with the renovation costs. The project was to be considered profitable if the difference of the company's market value exceeded the costs of the renovation. This was not the case in the economic evaluation from a company perspective, and the renovation was considered unprofitable in 2008. The calculation performed in 2014 showed an increased market value for Gårdstensbostäder (Lind 2014a). A new profitability calculation based on re-evaluation of the uncertainties of market values and error margins resulted in the conclusion that renovation could be considered profitable. For both studies the societal benefits were analysed and valued to be added to the corporative calculation. Decreased unemployment, welfare effects, less criminality, less use of natural resources and positive impact on the surrounding neighbourhood were treated and included in the analyses. For the evaluation performed in 2008 the societal benefits compensate for the corporative negative cost results and therefore the renovation is considered profitable (Lind & Lundström 2008). The updated evaluation of the societal benefits showed a development that these impacts have a longer lasting effect than earlier assumed (Lind 2014a).

The multi-story apartment building, Giganten 6 in Halmstad was renovated in 2012 (Hastig & Tapper Jansson 2014). The building was in need of maintenance but the costs made the project unprofitable. By including energy efficient measures, the investment for the renovation could be covered. The profitability calculation included total costs of the project, increased income from rents and decreased operational costs due to reduced energy need. A method for calculating the profitability, called "Total cost" was developed during the project, where the total investment cost was compared to the decreased operational costs. The calculations were performed in the decision phase of the project but also as the project changed and developed. In the calculation no account for inflation, increased energy prices or calculation period is stated. Three renovation packages were evaluated from a profitability and energy saving perspective. The calculations resulted in all three suggested packages being both beneficial from energy and cost perspective. The "Total cost" method is not being used by the property owners any more due to the company's ambition to have a more long-term perspective.

LCC calculations were performed for two case studies of multi-story apartment buildings with three suggested renovation packages (Brown et al. 2013). One of the packages was the base case, meaning the minimum effort needed to keep the present function of the building. Life-cycle costs were calculated with the net present value method over 50 years period-of-analysis and included investment costs for year one, operational and maintenance costs, re-investments (incl. end-of-life-costs). Total bought-energy costs but no end-of-life cost were assumed for the building. Conditions and data for the LCC calculation were as stated in Table 3. With two different multi-story apartment buildings as case studies, each with two suggested improvement packages, and from the total of four comparisons only one showed itself profitable from an LCC perspective. The calculations show up to 26% higher LCC than the base case. The assumptions and input data in the LCC calculation are presented in Table 3.

Table 3. Source of the input data in the profitability calculation (Brown et al. 2013).

Calculation period	*Was assumed as a reasonable lifetime of interest for decision makers when the study was performed.*
Internal rate of return	*Together with the inflation the real discount rate was calculated with the assumed nominal discount rate. Analyses were made on 10-year government bonds for long-term nominal interest rates for the assumption of nominal discount rate.*
Inflation	*A general rate of inflation was calculated from the needed merchandise*
Energy prices	*The increase was assumed from a previous performed study on past trends of charges for electricity and district heating*
Renovation and maintenance	*Building costs were based on Swedish standards. Real price increase for renovation and maintenance was taken from Swedish statistic factor price index. Technical lifespans were assumed from earlier performed studies for Swedish cost for renovation and maintenances.*

5. Discussion

Gathered information from analyses of renovation projects' profitability calculations shows variation in presented input data, as summarized in Table 4. With different calculation methods the needed data varies and the interpretation of the used method can lead to misunderstandings if this is not clearly presented. To learn from the experiences on the performed renovations, all input data with origin and method should be showed in a transparent way for a fair comparison. As stated in Table 4 some data is not specified for all projects. Table 4 also shows the variation of which data is given in the projects. When looking at the internal rate of return a span from 5% to 7% was stated in the projects. It was also expressed as the discount rate or the real discount rate. There were methods found that are dependent on e.g. inflation, but these input data were not mentioned in the study. When analysing performed renovation projects, not only the found information should be considered but also the lack of information.

Table 4. Summarized data from table 2.

Profitability calculation method	*Net present value, Prediction of future return, Payback-time calculation, LCC, "Total cost"*
Included costs	*Total project cost, Standard rising, energy efficient measures, only investment, operational, maintenance, re-investments (incl. end-of-life-costs)*
Calculation period	*10 years, 30 years, 50 years*
Internal rate of return	*Real discount rate/discount rate, 5-7%*
Inflation	*Not specified, 0-2%*
Lifespan	*Not specified, building, HVAC, building technical*
Energy prices	*Following the inflation, specified prices in SEK, specified increase in % real or nominal*
Renovation and maintenance	*Not specified, real price increase, 1 %*
Profitable	*No, yes*

The gathered information in this study is mainly collected from academic reports, specifying only a few aspects of the total renovation process. To clearly benefit from the knowledge of performed renovations all relevant information needs to be easier to access. By collecting information, spread in different studies, the holistic approach could be lost. Found publications on renovation projects often lack information regarding origin of input data and method descriptions.

6. Conclusion

Information from profitability calculations for renovation projects is dependent on all project information being accessible to prevent the risk of misinterpretation. A description of the used calculation method and origin for used input data is essential for assessing the project. To make the information manageable a relevant structure and common vocabulary are needed. A standard of how to structure the methodology and input data, to be used when calculating profitability, would contribute to the process of disseminated renovation projects. More research is needed within this field to achieve a transparent calculation method that shows a realistic picture of the profitability of a renovation project with sustainable aspects taken into consideration. The need is clearly shown by the renovation project Gårdsten that has been analysed in different projects with a variation of outcomes of the investment profitability. Analyses have been performed with different methods and assumptions, which make it difficult to judge if the question of Gårdsten´s investment was effectively answered.

This study shows a number of inconsistencies, relevant when presenting a profitability calculation for a renovation project and these are some of the aspects that National Renovation Centre needs to consider and treat in further development. There is a need of new tools handling investment profitability together with sustainable aspects. This could be done by developing a tool for optimizing the renovation process in an interdisciplinary manner that can make it possible to end up with predictable and repeatable renovation work in the future.

The presented renovation projects were chosen due to the found information about their profitability calculations. Analysis of the missing information stated in this report is a matter of future research, which might result in deeper knowledge of the full process of profitability calculations.

Acknowledgements

In 2014 a strong research environment was granted by the Swedish Research Council Formas called SIRen, Sustainable Integrated Renovation. The research project is connected to the Swedish National Renovation Centre.

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Modeling industrial projects - barriers to innovation

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Abstract

In the field of industrial projects, diversity and number of clients' requirements generate a raising demand for process improvement and design quality. In the same scenario, the recent introduction of Building Information Modelling (BIM) in the design process of industrial projects has raised a discussion on how to improve collaboration in order to take advantage of the new technology. Moreover, to assure a collaborative environment with the implementation of BIM, the growth in the number of interfaces among players and tasks related to design development led to increasing responsibilities concerning the design manager and changes in the current management and communication practices. Using case studies carried out in Brazil, the aim of this paper is to evaluate the BIM implementation impact in the industrial projects sector, thus highlighting the main difficulties and critical points resulting from that technological change. The results of the above evaluation are presented as a set of specific recommendations to avoid the defeats found in the case study and reach the expected results and benefits of BIM implementation in industrial projects, based on the best practice of successful management.

Keywords: building information modelling, collaborative design, design management, industrial projects.

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1. Introduction

One of the main problems facing the construction industry and particularly the building sector is its high degree of fragmentation. A fragmented industry is one in which no player within it exerts enough power to influence the market alone (Zegarra et al., 1999). Moreover, in the building design process, that fragmentation exists in the division of responsibilities among design professionals and among professionals, clients and contractors. These conditions are the cultural basis of competitiveness among clients, contractors, subcontractors, suppliers and all other players, leading to a low degree of transparency and trustworthiness. Even if the purpose of the construction project is to deliver a quality product with good design and according to customers' needs, complying with the deadline and cost (Elmanuelim and Gilder, 2014), some management models are not really oriented to that. The construction project process is divided into four major phases, which refer to the main process parties: product idealization, project, construction, and use and operation. These phases are sequential and conceptually progressive and a greater level of detail of the solutions is added to each of them, as the possibility of choosing between design alternatives is reduced (Melhado, 1994), but the integration and coherence between two consecutive phases is one of the most defying challenges for project management in construction.

Current problems with the management of design and construction quality are clear calls for action to improve an industry that lags behind any other in its attempt to become more competitive and to provide a better service to clients and to society as a whole (Aranda-Mena et al., 2009). According to the authors, to reduce disputes, to share risks and to make the industry use a new building documentation, building information modelling technology (BIM) should be adopted. Therefore, in the recent years, building information modelling appears as a promoter of innovation from the integration of construction players and may potentially improve work processes in the four phases of the project and in the interfaces among them. It is expected that it provides efficient collaboration, data integrity, intelligent documentation, access and retrieval of data, high quality projects through improved performance analysis and coordination and multidisciplinary planning (Gu and London, 2010). Nevertheless, in a study conducted in the UK, Eadie et al. (2013) demonstrated that the most frequent use of information modelling happens in the design and pre-construction phases (detailed design). Next, the most common use was in the construction phase itself and, finally, the usage and operation phase. The same survey also concluded that the experience of building information modelling has been held within the project teams and few clients are able to use their full potential.

Industrial projects mobilize different specialties in the conception and design development of their projects. The particularities determine the actions of each part involved. They are: clients, design professionals, consultants and contractors, each with their own objectives and particular perspectives. Müller (2012) defines complexity in projects as a multidimensional concept, arising from the confidence in the ability to produce the result of the project, the amount of information to be processed, the dynamics and uncertainty of projects, besides the interaction among the persons involved.

Industrial projects also have a unique feature embedded. Given the rapid evolution of industrial processes, coupled with the diversity of products, each new project will present client demands and specifications which need to be quickly understood and satisfied. On the other hand, besides this dynamics the professional group traditionally involved in industrial design adopts procurement models that do not stimulate engagement and lead to poorly integrated solutions, thus reducing the potential for integration provided by the use of BIM (Silva and Melhado, 2014).

Using a case study, the aim of this paper is to evaluate the BIM impact on the industrial project sector, thus highlighting the main difficulties and critical points that result from that technological change. The results of the above evaluation are presented as a set of recommendations to attain the expected results and benefits of BIM in similar cases, based on the best practice of successful management.

The research methods adopted were: literature review on project and design management, building information modelling and other content that underlie the work and execution of the case study. One of the criteria to select the company studied was obtaining prior information about the organization considered, e.g., if the company had at least one project that had been developed on BIM and the availability of the necessary information requested by the research as well as the availability of the involved staff for the interviews. Once the case study company was selected, the necessary information was obtained from the professional responsible for design coordination, engineers and leaders of the disciplines involved, including technical interviews and analysis of documents such as contracts, designs, and meeting minutes. The study started to be developed in 2011 when the mainly information was collected. After that, the details and depth documental study were performed at the end of 2013. A semi-structured questionnaire was developed and used to carry out the interviews.

2. BIM – Building Information Modelling

The choice of construction information modelling as an alternative to project representation models is justified by its systemic and integrated approach to all the stages of the life cycle, presented in a single and shared model of information, leading to better results and less interference between production and the information used by the various parties involved in the process (Abaurre, 2013).

According to Underwood and Isikdag (2011), although the main role of BIMs is acknowledged to facilitate the design phase of a construction project, BIM can have a wide range of functions such as linking indoor and outdoor urban spaces, facilitating information sharing among different stakeholders and the software applications they use, enabling the use and management of shared building information, facilitating the simulation of construction processes, and supporting emergency response operations.

Because it is a single database for project development, the BIM technology allows making dynamic changes in the graphical modelling that are reflected in a positive way, as this can be viewed in real time by all the technical areas involved. Among several benefits and advantages offered by BIM, some of them highlight increased productivity, improved quality in presentation graphics, improved interdisciplinary communication, reduced data redundancy, rework and errors, among others. However, the implementation of the BIM strategy has a long way to go to reach maturity, and has to be continuously improved (Underwood and Isikdag, 2011).

The use of BIM in project companies has really benefited the design process. However, the culture of the companies in the sector, the informal flow of information and documents between the parties involved, the use of inadequate IT tools and the lack of designers' training for the new IT tools affect the projects process and, consequently, the projects quality (Ito, 2007). The use of BIM requires a new way of thinking. Professionals used to developing projects using traditional methodologies and processes applied to 2D platform see the need to change their concepts when using BIM. Teams that were traditionally fragmented and controlled become one integrated and collaborative team.

Khosrowshahi and Arayici (2012) describe the framework of BIM maturity level in terms of stages. The maturity stages that are briefly described below provide means for systematic classification of BIM implementation.

Pre-BIM – refers to the practice of traditional design process comprising significant barriers and inefficiencies. A lot of project information is communicated through paper-based documents (drawings and written documents), which can be easily lost or damaged. A poor process information management leads to incomplete understanding of the design solutions, functional inefficiencies, clashes between design elements and inaccurate work.

BIM Stage 1 – refers to the migration from 2D to 3D and modelling. Documentation is now based on digital objects. The BIM model is made of real architectural elements that are correctly represented under all viewpoints. The BIM model is still developed under individual disciplines and deliverables are mostly CAD files.

BIM Stage 2 – from individual modelling to collaboration and interoperability. Building design and management are highly complex processes that require evolution in communication and collaboration among all project team members. The maturity of Stage 2 requires integrated communication and data sharing between stakeholders to support this collaborative approach.

BIM Stage 3 - this step is the transition from cooperation to integration and reflects the real BIM philosophy. The model of Stage 3 becomes interdisciplinary, allowing complex design reviews since early design stages. At Stage 3, the content of the model goes beyond information of semantic objects thus including business intelligence and clear construction principles.

Even if each continent, region or country is going through different stages in making progress, it can be assumed that those stages above are still a universal reference to be used. The implementation of BIM in a long-term perspective will change not only the work practices, but also the contractual relationships between parties (Manzione, 2013). The author states that thanks to the technology involved in the construction of the BIM model, collaborative work with the various parties is possible; however, a high degree of maturity to reach that stage is required which will require changes in contractual relations towards a new goal, in addition to the change in practice.

An effective and positive use of BIM requires numerous modifications such as: contractual changes, service scopes and results formats; changes in the work environment seeking the integration of multidisciplinary teams and focus on the performance of the team as a whole and not as an individual for each discipline; change in the design process and in communication; among others. These changes are usually resisted to by professionals, mainly designers, and this may contribute to the difficulty in implementing BIM in an organization.

According to Jensen and Jóhannesson (2013), the key thing in the implementation process seems to be to conduct the transformation in small steps. The human resource part of the transformation toward BIM thinking can be very difficult. It is natural for some employees to feel that they are being threatened by the changes. This alone can be seen as a good reason for companies to implement BIM in small steps. The results from the research conducted by the authors show the importance of involving the top management in BIM implementation, because they say that the leadership must be convinced of the benefits of BIM and it must be looked at as a core business element, not just as another software system. Otherwise, it will be difficult to assign enough resources to the transformation process. If a company wants to implement BIM in the design and decision process, it means that fundamental changes are to be made in all the work processes. The transition period when moving from traditional working methods to BIM processes is a critical time for every company and it has to be carried out with regard to each company's own interests. It is necessary to spread knowledge to the company employees in order to make them aware of the potentials of these new processes and activities. Full acceptance, participation and exploitation of the possibilities will not take place until this occurs.

3. Case Study

3.1 Conduct of the case study

The case study chosen is an industrial project designed by an engineering firm that has its head office in the city of São Paulo, Brazil.

Through the case study, the authors identified some deficiencies in the design process in the use of the "BIM platform" that impacted activities development and, consequently, the quality of the project.

The case study comprised the following main steps: defining the firm and project to be investigated; proposal of the research protocols for the case study; scheduling and performing the technical interviews; compilation of all the information obtained.

3.2 Case firm

The engineering firm analysed in this study is a Brazilian company, which deals with design, management, engineering and supply of EPC / EPCM services. It has a 25-year experience in the Brazilian market, operating through its head office in São Paulo, but it also has offices in other Brazilian cities, in addition to some task groups settled in other sites in Brazil but also abroad, in South and Central America, Europe, Africa and Asia. The engineering firm studied has a quite large staff with circa 2.300 professionals (out of which 83% work in technical activities and 17% in administrative ones), with clients in different sectors such as mining, metallurgy, steel, fertilizers, Oil & Gas, petrochemicals, infrastructure, energy, docks construction, site implementation and construction management. The management team of the company, supported by the design engineers and the planning department, performs design management. The four directors of industrial sectors and management directly supervise design coordinators and planners.

3.3 Case project

The project is the extension of a factory, comprising the development of its Schematic and Detailed Design. The plant includes three production units of cosmetics, fragrances and toiletries. The project scope that was hired includes the development of studies on new buildings and building extensions, production areas, filling, packaging and existing utilities on the site. The design team was intended to develop the project scope from consolidated conceptual design by the client, thus delivering design documents (drawings, memorials, quantitative spreadsheets) in the form of schematic and detailed design of buildings and areas of the site.

One of the main requests of the client was that all the design conceived should be developed with building information modelling technology since the beginning of the design phase.

3.4 Design process in by using the “BIM platform”

In the studied case, BIM Maturity Stage can be considered at the first level of modelling implementation (Stage 1). Even considering what is expected at Stage 1 some deficiencies in the design process in the use of the "BIM platform" impacted the development of activities and, consequently, the quality of the project:

- Inexperience in the development of three-dimensional models;
- Deficiency in the scope clarification at the design level of detail from the initial kick-off meetings (KOM);
- Level of detail and requirements for the BIM model.

Based on statements by the design company employees, the difficulties which have been identified came from the following factors:

a) Lack of time and planning for deploying the technology – these were the main difficulties pointed out by the company. In the case of the project studied there was still an aggravating factor, as a technical consultant was not hired for implementation, since the BIM culture did not exist in the company.

b) Lack of skilled professionals – there were few professionals with expertise in building information modelling (BIM), which led the company to provide training, but only to a specific group of employees.

c) Resistance to changes by the team – in the studied company, there was a higher resistance by older and experienced employees.

d) Lack of IT Infrastructure – the new software used by the company needs computers with a much higher processing power than those which were previously used only for CAD. The change in equipment was necessary in order to have a better performance, but the lack of available equipment in the company generated delays in the development of planned activities.

e) The software own deficiencies – inefficiencies and problems as to render the manufacture model of stairs with two levels have been detected, as shown in Figures 1 and 2.

f) Compatibility – the designer used software from different suppliers for the teams involved in developing the project (Figure 3 - Organizational Chart), as a matter of a political issue of the company. For example, architecture modelling used REVIT, mechanical used Solid Works, piping used AutoCAD Plant 3D and other disciplines were simply designed in 2D. Hence, problems regarding the compatibility of such software were detected, which can be seen in Figure 4, where a pipe is represented by lines, not solids.

g) Adaptation to Brazilian construction standards – the architecture team reported that, concerning REVIT, much of the existing library is foreign and in many cases adaptation to national standards is necessary.

h) Size of the files – the files generated are much larger/heavier than the CAD ones.

i) Management – designer failure regarding the lack of management and planning about changes necessary in the design process have been observed.

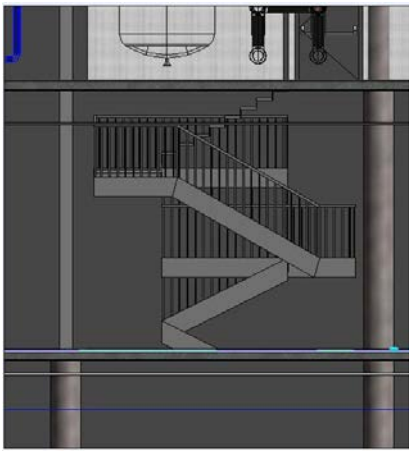

Figure 1. Problems detected in the stairs modelling with two levels – Wrong modelling showing additional elements (Source: case study data)

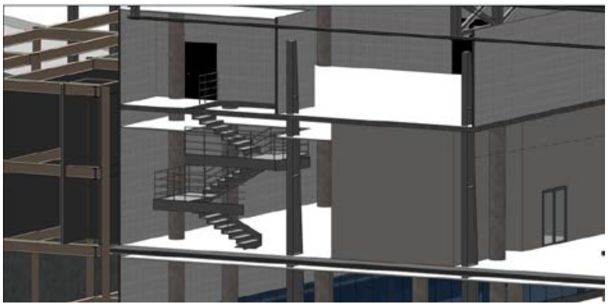

Figure 2. Problems detected in the stairs modelling with two levels –Elements missing in it (Source: case study data)

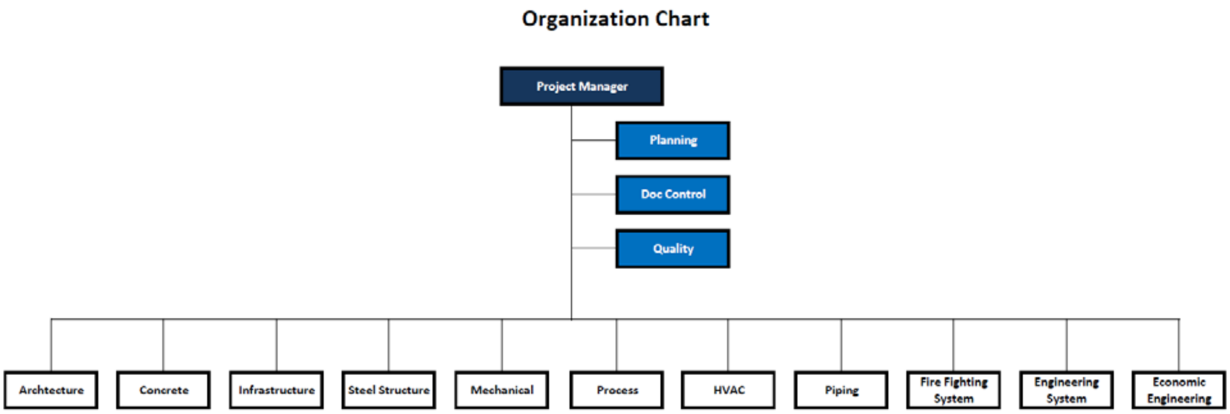

Figure 3. Organizational Chart of the project (Source: case study data)

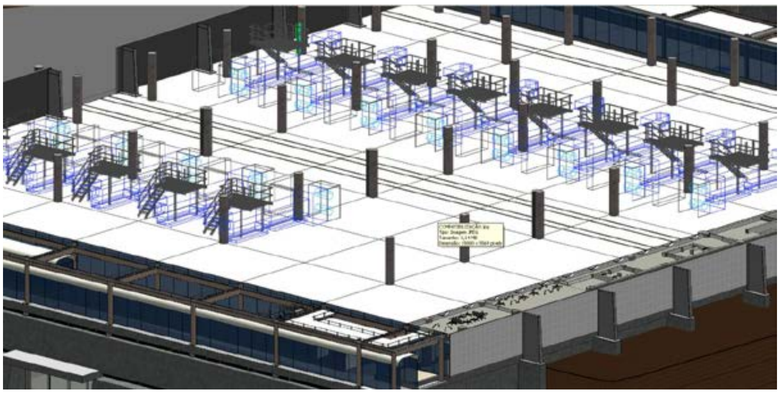

Figure 4. Compatibility problems (Source: case study data)

4. Conclusion

The difficulties identified in the case study (Section 3.4) can be divided into three main groups according to their nature: people, technological and management factors, which are individually commented below as well as the consequent recommendations.

People factors: difficulties described in (a), (b) and (c). In the Brazilian context, for most of the construction projects, the first experience using BIM has been guided by a hired consultancy which helps not only in the software and system training, but also creates a new teamwork, proposes a design process review and so on. It is recommended that working with BIM requires not only learning the necessary tools, but also a new way of thinking and a new design process.

Technological factors: (d), (e), (f) and (g). When implementing BIM in the design process, hardware and software requirements need a significant amount of investment which must be supported either by the project budget itself or by the design firm as a general initiative to ensure the conditions for modelling all the projects hired; it is recommended that investment concerns not only hardware, software and bandwidth supply but also the appropriate software selection including the interoperability issues.

Management factors:

(h) Since the proposal submission, i.e. really before the project initiation, it is recommended to consider the need for library which can be provided by a specialist hired for the specific project, a BIM consultancy firm or selecting a design office that already has the required library elements.

i) Working with BIM requires changes in the design process culture, changes in which planning and management are essential to a successful implementation and those changes, consequently, are highly recommended to make BIM benefits and advantages clearly distinctive ones.

Moreover, in the case study, several issues pointed out in the literature by many authors were equally found. The fragmented character of the construction industry and the lack of collaboration among actors, as well as the need for qualification of design professionals and new contract frameworks clearly produced their consequences. Clients' expectations were not satisfied and the information modelling did not help to achieve better and more integrated design solutions.

As an example on key points to achieve higher levels of BIM maturity, new contracting models should be adopted, oriented to stimulate collaboration, thus adding value to any effort to avoid modelling clashes and mistakes. Summing up, improved methods for design management, adopting KPIs (Manzione, 2013) are also a strategic issue to improve the level of BIM maturity in those projects.

In conclusion, as in any other construction sector, industrial projects can actually benefit from new information technology tools if properly implemented. However, without changes in the design process and an efficient qualification action previous to the introduction of modelling techniques, the expected results tend to be lost.

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Upgrading the business expertise of small and micro-sized companies

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Abstract

Small and micro-sized civil engineering contractors build small-sized projects as main contractors and operate as subcontractors on large projects. As they are among the key players in civil engineering, it is important that they make the most of the best available new technologies. This paper focuses on the questions of what and how to coach small and micro-sized civil engineering contractors to plan their businesses better and develop their skills to use new technologies as a competence advantage.

The aim of this research was to develop the content and form of the business training of civil engineering contractors. The research was carried out in close interaction with civil engineering contractors, masters and researchers. The content of the training was formulated by adjusting general business courses to the target audience. The business course was tested and developed to a final form with a series of six training sessions.

Keywords: Business plan, Civil engineering, Competitive intelligence, Small and micro-sized companies Training

1. Introduction

The formerly closed domestic public civil engineering market has opened up for private companies (Karjalainen & Pajakkala, 1985; Nippala & Petäjä, 2004; Nippala & Vainio, 2008; Vainio & Nippala, 2014). At the same time, the way contracts are carried out has changed to have a strong emphasis on using subcontractors. In Finland, subcontractors are typically small and micro-sized companies operating locally.

Today's leading customers, like the state and the biggest cities, involve their suppliers in the use of new technologies such as information modelling, machine automation and cloud services in their projects (InfraBIM ref. 13.2.2015). The use of these technologies is not only a huge challenge but also provides many new business opportunities for small and micro-sized companies

The added value of small and micro-sized companies is remarkable in civil engineering (Statistics Finland, 2014). The operation of small companies is based on good knowledge of the machinery and equipment used and hard work. The operation is hindered by strong seasonal fluctuations, rushes, insufficient financial expertise and rapid changes in the business environment.

The vitality of small and micro-sized companies is an essential part of the serviceable civil engineering sector, but changes in the operational environment and new requirements have increased the number of companies leaving the field as many face a change of generation due to the contractors' age structure. Instead of shutting down the operation, it is important to bring about a change of generation as well as enticing young people to start new companies.

The leading big civil engineering contractors and their clients were concerned about the situation. This was one outcome of a future study carried out by Tampere University of Applied Sciences and VTT (Nippala & Vainio, 2014).

In this research project, the main objective was to produce business development tools for small and micro-sized civil engineering contractors and to take these tools to the companies to use. The sub-objectives were 1) to recognise the most important business challenges for small and micro-sized companies, 2) to produce training material to support their business, and 3) to test the content and form of training and training material for different kinds of audiences.

2. Research process

During the first stage, five workshops were organised on future changes and the challenges facing civil engineering. They took a general look at civil engineering, examined it via three end product sectors and, derived from these, asked questions about the workforce. The end product sectors were chosen so that they divided civil engineering into three markets of similar size (Vainio & Nippala, 2013).

The first and fifth workshops were each attended by 20 persons and the other workshops by on average 10 persons each. The participants represented major corporations in the field, cities and trade associations:

1. The general challenges to civil engineering
2. Building traffic routes
3. Street, water supply service, energy management and communication construction
4. Civil engineering pertaining to industry and housebuilding
5. Workforce, training and expertise as a whole

The point of departure of the workshops was global changes. These led to concrete changes on a national level and, further on, in civil engineering. In order to include as many points of view as possible, the workshops were divided into PESTEL themes, i.e. political decision-making, economy, sociology, technology, ecology and legal (Vainio & Nippala, 2014).

Future changes and challenges were reflected on from the point of view of all the stakeholders, i.e. infrastructure owners and buyers as well as planners and contractors. Necessary measures were proposed to all the stakeholders. The measures proposed to contractors were complemented by the latest trends (Sitra ref. 13/02/2015) and a summary of the latest technologies (Sankala, 2014). A group of small and micro-sized company owners and representatives of their trade associations were invited to inspect this material. From a long list of proposed measures, the group chose the most essential measures to be included in the training (the short list).

At the next stage, the form of training and training material were also interactively developed together with the contractors. The key to the training was to develop a business plan concept that fitted the skills profile of micro-sized and small companies but was nevertheless sufficiently extensive. It was adapted from a general business plan model by focusing on the essentials of the civil engineering field and construing the concrete meanings of generic concepts. The final training material was developed in collaboration by teachers of construction engineering and business economics. The development of the training material and the planning of the training lessons were based on the theory of experience and interactive education (Dewey, 1930; Koro, 1992).

At the third stage, the training concept was put to test use in several localities to enable as many entrepreneurs as possible to take part in the training. Interaction was essential during the training sessions. The lecturers brought their own theoretical expertise into the training lessons, and the companies participating in the training brought their empirical knowledge of contracting. Project reports are usually only published on the Internet, but in this project, training material was also tested by organising test training courses. The course content and form were finalised after testing.

3. Results

3.1 Future changes and challenges facing civil engineering

From the long list of changes and challenges facing big construction companies and major customers, the following were chosen as vital areas of development for owners of micro-sized and small companies.

Market structure – The market structure has changed as a result of outsourcing and privatisation. Jobs that were previously managed by the public sector may now be the responsibility of companies. A good example of this is the maintenance of traffic routes in wintertime, which used to be managed by cities or the government. As a result of outsourcing, the jobs traditionally managed by cities may now be managed increasingly by private companies.

New markets – In addition to the traditional industries, many other industries can now offer work suitable for excavation machinery owners. Seizing these chances can be a way of levelling the business cycles typical of the field.

Following the markets – When it comes to markets susceptible to economic fluctuation, it is crucial to follow the market. History can show us many examples of situations in which heavy investments in excavation machines were made during boom times only for the machinery to become underutilised as the economic situation changed.

Online services – The realisation of the information society has moved services previously conducted in person or on paper to the Internet. Nowadays, the trade centre for invitations for tender, bidding, applying for planning permissions, procurement and many other services is the Internet. In order to stay in the market, it is essential to be where the trading takes place.

Technological development – The civil engineering field has benefited from generic advancements in technology. Part of the development is connected to digitalisation and data-intensive processes. Information technology has also increasingly been introduced to the Internet of Things and mobile work machinery. In Finland, the developers of the most important infrastructures require that plans be produced in digital data models. The implementation of data model-based plans utilising machine automation and positioning satellite systems (for example GPS) enables significant improvements in productivity and the production of ‘as built’ information for owners for maintenance purposes.

Competences and certification – The competence requirements for companies and professionals set by the government and large municipalities have become stricter. On civil engineering sites, many different competences are required of companies and individual workers alike. The competences are not permanent: they must be renewed periodically. A new requirement comparable to competences is the use of certified materials (CE markings).

Energy- and eco-efficiency – When it comes to energy- and eco-efficiency requirements, civil engineering lags behind housebuilding. It is catching up, however, and this is emphasised in the congested areas of Finland where there is a lack of natural resources and the transport distances are long. Projects involve environmental licences, for which the application process is long and arduous.

3.2 The content of training

The business environment themes pertaining to civil engineering are structured as follows:

- Civil engineering markets and the economic situation
- New civil engineering technologies and online services

These two headlines contain topics identified in Section 3.1.

The conceptualisation of business resulted in the following programme:

- Earning model/business idea
- Products and services
- Core expertise
- Customers and markets
- Competitors
- Marketing, sales, distribution channels
- Relationships with other stakeholder groups
- Personnel and organisation
- Logistics and procurement

A business idea refers to the acquisition of income for the company. Key questions in this context include what the customer is prepared to pay for and whether it is worth offering contracts at a unit price or a total price. ‘Products and services’ aims to identify the key products and services of one’s own company. Will the work be conducted by oneself on a ‘key in hand’ principle, using subcontractors or perhaps as part of a network of companies?

‘Core expertise’ considers the strengths of one’s own company compared with the competition. Is it a question of a general ability to produce value or a speciality? ‘Customers and markets’ examines one’s own key customerships and considers the qualities of an ideal customer. ‘Competitors’ considers the strengths and weaknesses of the competition and the possibilities of collaboration.

‘Marketing, sales, distribution channels’ looks at ways in which customers can find the services a company is offering. Are they available via a website or solely through the Yellow Pages. ‘Relationships with other interest groups’ examines material suppliers, investors, the authorities and also machinery servicing.

‘Personnel and organisation’ includes the company’s own employees, temporary workers, business partners, subcontractors and administrative work. ‘Logistics and procurement’ analyses the capital tied to the transfer of equipment, sensible operating ranges, warehouse maintenance, premises and inventory.

The end of the training day included familiarisation with the basics of inventory calculation together with the companies.

3.3 Test training sessions

The lecturers planned the tentative contents of the training package. The companies involved in the project acted as a test audience in the first training lesson session. The content and form of the training (Figure 1) was developed further and tested with a new audience in five different localities around Finland (Figure 2). These training lessons were timed for winter, which is the low season in civil engineering. A total of 56 persons participated in the test-training sessions, which makes an average of 11 persons per training session.

Opening **Civil engineering market and challenges** • Where to get information on market size and business cycles • Changes and challenges of the near future • New technologies
Break
Business plan • What is the company's earnings principle (business idea) • Strategy, what will the company be doing in 5 years • Core competence and customers
Break
The Internet as an information source **Financial calculation** • Production factors (equipment, labour) • Pricing of machine work (exercise) • Pricing of small contracts (exercise)
Break
• Financial calculation continues (breakdown of exercises) **Closing words** • Business plan materials (online) and support for making the plan

Figure 1. Content of the training

 

Figure 2. Training in Vaasa January 2014 (left) and in Lappeenranta March 2014 (right)

The lesson on the civil engineering market and challenges was planned by a lecturer in construction technology. The lesson consisted of the present civil engineering market situation and the forecast for next year's market development. New ways of working such as eBusiness were discussed. A small and micro-sized company must also learn to use e-tools. The first step is to have an e-mail address. The second step is to follow the public sector call for bids published on the Internet. Machines and machine work can also be bought or sold via the Internet.

New competence requirements, such as for construction quality, need to be trained. The third market challenge was environmental matters. As the permission procedure is difficult and time-consuming, companies have to pay attention to it early enough (Nippala, Ala-Myllymäki & Kolehmainen, 2014).

The business plan lesson was planned by lecturers in business administration. The idea, needs and practical examples of the business plan (Enterprise Finland, ref. 13.2.2015) were explained very carefully to the entrepreneurs. Most of participants were skilled workmen. They did not have any bachelor or master degree studies. It was extremely important to teach them in considerable detail what each topic really meant and why they needed it. After the business plan, theory was discussed, and many of the entrepreneurs told their own stories. This kind of peer group discussions was an important part of the training. Participants could compare their ways of doing business and learn from each other. All the participants were encouraged to start preparing their own business plan.

The financial calculation lesson was planned by a lecturer in business administration. First, the participants had to learn about budget estimation. It is the opposite of a profit and loss account. In it, the company's target profit was calculated. After that, the company's annual expenses were calculated. The easiest way to prepare a profit and loss budget is to estimate the profit at zero. Doing it this way, the entrepreneur finds out how much is needed with minimum contracts just to make an annual zero profit.

Secondly, the company's cost structure and capital structure were discussed. That is where the money comes from and where it goes. Thirdly, the hourly cost (euro/hour) estimation for machine work was taught (Oja, 2011). The calculation was done using a spreadsheet program. The teacher asked for examples of how much a machine cost when it was bought, how much the repair costs were and how many hours the machine worked at the construction site during one year. The driver's salary and net earnings were of course an essential part of this calculation. After finalising the calculations, very lively discussions began about the unit prices paid by different clients.

At the end of the training day, discussions continued for a long time. The discussions showed that quite a limited group of participants is ideal. People quite openly shared their business and problems with each other. The small group also enabled personal advice. This kind of local training is an effective but expensive way of giving new skills to the entrepreneurs. As an alternative to training sessions, many e-tools, new technologies and traditional reports are available to companies, but they are not used to these. The entrepreneurs said that the developed tools are too complicated to take into practice on their own without help. This project produced some new tools and a training lesson taught them how to use these new tools.

Entrepreneurs' comments on the training:

"The unit price templates have been on the association's websites for years, but I didn't know how to use them. Excel does the trick!"
"Beforehand, I thought that the time would go on repetition, but even the more experienced participants learnt new things."
"It was worth going to the course. I had good tips on marketing and its meaning in business."
"The whole course was tailored to civil engineering contractors, not just general information."

After six pilot training sessions, self-access material was developed. For every topic, a short introduction was made about the material and purpose of each slide. This material was also tested with contractors. After feedback on the slides, their content was updated and the explanatory text edited.

4. Summary

The project was aimed at helping small and micro-sized civil engineering companies to develop their business by means of a tailor-made training package. The project started with expert workshops in which future changes and challenges facing the civil engineering field were holistically identified. Out of these, the most pertinent topics to micro-sized and small companies were chosen. In tandem with the companies, the content and form of the training focused on business was created. The training package resulting from the project was also tested and implemented. Testing was done by arranging six training days in different cities in Finland. The training days also explained why many project results have not reached small and micro-sized companies. The content of the training package was as follows:

- Business environment
- Business planning
- Financial calculations

This kind of training is useful for young new contractors who are entering the civil engineering business. Instead of old ways of working they become open to appropriate new business models.

The training will form part of Infra Contractors Association's education supply. The course will be organised annually. The course will be approved by the Finnish Construction Quality Association (RALA) as a promise that that the contractor's business is responsible.

Acknowledgements

This article is part of a project financed by Tekes – the Finnish Funding Agency for Technology and Innovation – and national civil engineering branch organisations. Start main text for paper here using "normal" style (and use for subsequent main text).

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ISBN 978-952-15-3534-5
ISSN 1797-8904