HOUSING DESIGN PERFORMANCE: HOW IS IT MEASURED?

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Industrialisation involves reoccurring tasks and interfaces, which enables companies to work with continuous improvements of the process. In order to determine the effects of undertaken measures as well as enhance the manageability of the process, it is important to find measurements for effectiveness and efficiency of the construction design process. The aim of this paper is to serve as a gap analysis regarding the differences between current practice and the characteristics of performance measurement found in literature. This study is based on interviews with middle-managers at six industrial housing companies and four construction engineering consultant firms in Sweden, in order to explore the current methods of performance measuring in the construction design phase. The result shows that the studied companies currently have a limited use of measures and that the present measurements do not serve as a means of control for the design process or enable follow ups of undertaken improvements. For extended control and continuous improvement of the design process additional methods for measuring are required.

Keywords: construction design process, design management, off-site production, performance measurement.

INTRODUCTION

The Swedish construction sector has in previous studies been reported to be inefficient and slow in adjusting to changes, in addition in urgent need of improved product quality and financial result (SOU 2000; SOU 2002). There are also reports indicating that Swedish construction companies generally overlook the opportunity to assimilate knowledge from previous projects with a systematic approach (Borgbrant 2003; Forsberg and Saukkoriipi 2007). Industrialisation of the construction process has been mentioned as one road forward in pursuit of improvements, wherefore companies have changed focus to prefabricated products with various degrees of specialisation (Lessing *et al.* 2005). This change in strategy transforms the construction companies from object-oriented, on-site construction firms, into process-oriented off-site manufacturers with increased control of the value chain (Höök 2008).

Being in charge of the entire value chain, from sales to completion on the construction site, in combination with a design organisation not altering amongst projects, enables these companies to work with continuous improvements of their processes and reoccurring interfaces (Jansson *et al.* 2008).

Still there is a lack of well defined, easy to implement sets of measurements that support work with productivity improvement. Therefore the construction industry is currently relying on the 'iron triangle', i.e. time, cost and quality (Haponava and Al-

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Jibouri 2009). In addition, a recent study, initiated by the Swedish government, concludes that some of the flaws in the Swedish building sector, might erupt from insufficient procedures for making research results available to construction companies (Stadskontoret 2009). Derived from the statements above, the following set of research questions has been developed:

Which variables currently serve as performance measurements within the construction design process?

How well does the current use of measurements correspond to existing theories for performance measurement?

To be able to answer the questions a set of constructs was developed using literature on performance measurement. The proposed constructs are explored in practice by evaluating ten companies within the Swedish housing trade. To identify any possible differences in practice between different segments of the industry, six of the companies are industrialised housing companies whilst four companies are "conventional" construction engineering firms.

The aim of this study is to serve as a gap analysis regarding the differences between current practice and the characteristics of performance measurement found in literature. This will lead to future development of performance measurements which is believed to be valuable to the construction industry.

This paper focuses exclusively on performance measurement within the Swedish construction industry, additionally demarcated to performance in the design stages of the construction process at six industrial housing companies and four construction engineering consultant firms.

METHOD

By examining the research fields of performance measurements and performance indicators in construction the authors have gained knowledge within this field. (Kaplan and Norton 1992; Neely *et al.* 1995; Kagioglou *et al.* 2001; Bassioni *et al.* 2004; Beatham *et al.* 2004; Chan *et al.* 2004; Costa *et al.* 2006; Haponava and Al-Jibouri 2009) are among the sources that have been studied. By combining the presented findings a set of constructs for evaluating the current use of performance measurement within housing design in the Swedish construction sector was developed. This study compares the current practice with what is suggested in literature, and gives an indication of how the studied companies are measuring their performance.

Data has been collected through semi-structured in-depth interviews with 10 persons in total. Focus of the interviews was placed on the current use of measurements in the construction design process. All interviewees were managers or middle-managers with responsibility for the design process at their company.

Questions were asked about both the nature and the use of measures and the interviewees' opinions regarding use of measurements for management of the construction design process were captured. To what extent measures were used to improve the design process and how connection between corporate strategy and objectives in used performance measurements was realised, were aspects of extra interest.

Examples of questions asked: How is the measurement collected and analysed? What are considered to be the strengths and weaknesses with the used measure? Can the

measure be used as means of control for the design process? It is possible to use the measurement through different stages of a project? How is the measure aligned to strategies and objectives? How is data from previous projects re-used in new ones? Can the used measures be used for benchmarking?

Company A to F are small to medium-sized industrial housing companies, meaning they internalise the design, manufacturing and assembly normally carried out by several different companies. Industrialised housing holds a share of approximately 15% of the Swedish construction market (Höök 2008). Company G to J are all among the largest construction engineering consultant firms in Sweden and all interviewees were representatives for construction design sector of the companies.

PERFORMANCE MEASUREMENT

The interest in using measurement for gaining further knowledge about a phenomenon is nothing new. Already in 1883 William Thomson held a lecture on the subject of "electrical units of measurement" saying:

"…I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be…"

The rationale for conducting performance measurement is to enable systematic learning from experiences and evaluation of gained results. As Helmrich (2001) puts it: 'without collection of data of previous performance, it is impossible to evaluate the outcome of one's performance'. This idea of evaluation of accomplishment is also found in the definition of performance measurement by Neely *et al.* (1995):

"The process of quantifying the efficiency and effectiveness of action"

Evangelidis (1992) includes the aspects of fulfilment of objectives and strategies to the definition of performance measurement:

"…determining how successful organisations or individuals have been in attending their objectives…"

Performance measurement has in previous research been categorised in various ways. A distinction of the time-orientation for measurements is made by Bashir and Thomson (1999), who distinguish between result and prediction oriented metrics. A result is a measure for a completed system such as design effort or development time whilst a predictor is a metric related to a future result, such as product complexity or design difficulty. Another categorisation regarding time is made by Ghalayini and Noble (1996) differentiating lagging (post-event measurement incapable of affecting the result) from leading indicators (real-time measurement that enables changes during the process). Evidently there are differences in having measurements to report previous performance from having measurements that can serve as a means of control during an ongoing process. Leading measures are recommended to serve as early warnings, identification of latent difficulties and indicate need for further investigation (Costa *et al.* 2006).

Kagioglou *et al.* (2001) emphases that organisations using lagging measures have ability to recognise their past performance but can not solely look at the data when trying to determine what contributed to the obtained performance. Therefore, is it recommended to, in addition to measuring 'what' the performance was, also identify

the 'how' that performance was obtained (ibid). Neely and Bourne (2000) highlight the lack of an improvement process connected to the gathered measurement data, wherefore it is not possible to determine the outcome of improvements made.

Robinson *et al.* (2005) divide performance measurement in terms of being either financial or non-financial measurements. The main pitfall for financial measures is that they are lagging metrics, representations of outcomes and decisions made in the past and therefore not of much use in improving current performance (Ghalayini & Noble 1996). Use of data for performance improvement is considered by Bashir and Thomson (1999) as one way possible to avoid severe schedule and cost overruns in construction design projects. Also Chan *et al.* (2004) state that gathered data can be used to forecast the performance level of a construction project in advance.

Since collection of data can be both expensive and time consuming to manage (Neely *et al.* 1995), is it of outmost importance that only well-considered measurements are implemented. It is also vital to have a clear objective for the intended use of collected data, since neglecting utilisation of gathered data has been described as "the ultimate management sin", which is still the case in many modern organisations (Neely and Bourne 2000). It is not just a matter of selecting the most suitable measurements, it is also about making a considerable change in decision making processes and learning approaches within an organisation (Costa *et al.* 2006).

As important as it is for performance measurements to serve as guidance for management decisions (Bassioni *et al.* 2004), it is as equally essential that management's visions of where the company desires to be, serve as the main input in creation of performance management systems (Kagioglou *et al.* 2001). By doing this, the performance measurement will serve as an evaluation tool when determining to what extent the result of the process meets the organisation's strategic goals. Figure 1 illustrates how strategy is related to goals and performance measures.

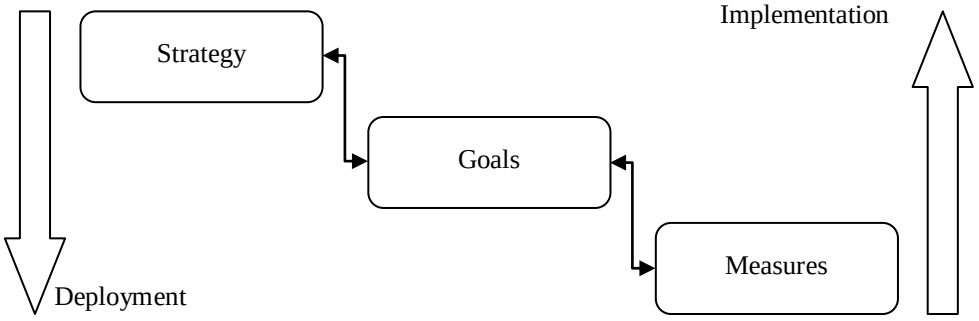

Figure 1: Deployment of strategy to performance measures (Kagioglou et al. 2001).

This opinion is shared by Kaplan and Norton (1996) who argue that the initial use of performance measurement should be to determine the success of implementation of the particular strategy. Another value adding aspect of performance measurement is that it makes benchmarking possible and thus allows a more well-grounded decision making process (Beatham *et al.* 2004).

MEASUREMENTS IN PRACTICE

Time consumption is a measure used by all studied companies. The way that the measure is represented differs in between different companies, where some put it in relation to how well the total time of a project correspond to prediction. Others, like

company B use a measure of spent time/square meter building area, whilst company D utilise a measure for time waste. Measures considering quality are usually provided as feedback from production, but only two companies document this systematically. Answering a question regarding measurement of customer satisfaction, several of the interviewees answered that it is not considered to be needed since a close interaction with the client is required throughout the entire project. One of the interviewees phrases it:

It is like a dance, and as one notices, it takes two to tango. If we deliver inferior results or ask questions that sticks the client up against the wall (...) we are perceived as a poor partner.

Collection of data is made easily for all of the studied companies, since employees' working hours are clocked in, usually into an enterprise resource planning (ERP) system, which also compiles the data. All interviewees believe that sufficient amounts of data are currently captured. As one of the interviewees puts it:

We have information about everything (...) but we are poor in making use of it.

The major field of application for measurements is currently for prediction of future projects and for analysis on gained results once a project is completed. All companies use data from previous projects in order to estimate time for upcoming projects when scheduling. One difference between the studied companies is to what extent these estimates are based on numerical data or on personal experience. Only two of the companies have measurements that allow collection and analysis during a running project. It is considered difficult to determine to what extent a project is completed, during it is running, and the measures of time and cost can only indicate how much of the allocated resources (i.e. time and money) that have been used.

None of the interviewed companies have a measurement that facilitates benchmarking. Several interviewees expressed their concern over identifying a numerical measurement to facilitate comparison of construction design performance between different companies, regardless of project- or company-unique aspects. All interviewees still express that they consider a possibility to make such a comparison as fruitful. One manager expresses the need for benchmarking by saying:

It is actually our raison d'être being determine.

Many of the interviewees encourage an extended openness regarding work routines and procedures, and the ability to learn from each other.

The interest for continuous improvement of the construction design process, and the use of measures for follow-ups on such progress is considered as important by almost all of the industrial housing companies. None of the interviewees representing a construction engineering consultant firm shared this opinion. One of the interviewees says:

Follow-ups consume time and cost money. Follow- up on the construction design process does not add any economical value, wherefore it is not done systematically.

One issue raised, considering the use of measures to improve results is that it can be difficult to determine how different factors in the process have contributed to the final result. One interviewee expresses this by saying:

The measurement is too general. Just looking at the statistics can be deceptive. You need more background information; there is always an underlying reason for the outcome.

Questions regarding what objectives and strategies the company have, resulted in widely different answers. Among the different objectives were “reduce the time for

construction design by 50 percent", "become more industrialised" and "become the client's number one choice" mentioned. The interviewees representing company A and F stated that their company do not have any explicit objective or strategy for development of their construction design process.

CONSTRUCTS FOR ANALYSIS

In order to make a critical analysis of the current usage of performance measurement in the studied companies, two constructs were created:

9. Nature of measurement.
10. Use of measurement.

Table 1: Analysis of studied companies' current use of performance measurement

	Conditions	Used measures correspondence to conditions									
		A	B	C	D	E	F	G	H	I	J
1. Nature of measurement	1.1 Scope of measurement is easy to understand	●	◍	●	◍	●	●	●	●	●	●
	1.2 Enables use throughout different stages of project	○	◍	◍	●	◍	◍	◍	◍	◍	◍
	1.3 Alignment to company strategies	○	●	○	○	●	○	○	○	○	○
	1.4 Enables benchmarking	○	○	○	○	○	○	○	○	○	○
2. Use of measurement	2.1 Easy or automated data collection	●	◍	●	●	●	●	●	●	●	●
	2.2 Support decision-making	○	◍	◍	◍	◍	◍	◍	◍	◍	◍
	2.3 Serve as a mean of control during an on-going project	○	○	○	◍	○	○	○	○	○	○
	2.4 Support process improvement	○	●	◍	●	◍	◍	○	○	○	○
	● = High ◍ = Normal ○ = Low										

Nature of measurement

1.1 The majority of the studied companies are considered to meet this criterion of easy understandable measurement to a high extent. The two companies that are considered to meet this criterion to a normal degree have, besides collecting data on spent time, constructed their own measurements which result in a normal correspondence to the condition. Measures of quality and customer satisfaction were all considered to be easy for understanding.

1.2 Only a few of the companies have measurements that allow collection and analysis during a running project. For this reason measures are only used in estimating the outcomes of coming projects and for evaluation of completed projects. Most of the

companies use measurement for prediction of outcomes and for analysis on gained results once a project is completed.

1.3 Even if all studied companies use time as their main factor for evaluation of performance, only company B and E have explicit objectives or strategies that include a quantity of time. This results in low correspondence to the condition of having measures aligned to company strategies and objectives. This is seen as an indication of the deficient use of measures for evaluating progress towards a desired future state for the construction design process.

1.4 None of the interviewed companies have a measurement that is found suitable for benchmarking. Since all used measures are regarded as being influenced by project- or company-unique factors, comparison with other companies is not possible.

Use of measurement

2.1 Collection of data is considered to be done easily for all of the studied companies, since employees' working hours are clocked in. Company B needs supplementary data besides time for calculation of their measurement, also added that the calculation is not automated, resulting in a lower correspondence to the condition in comparison to the other companies.

2.2 Most companies use data from previous projects in order to estimate time for upcoming projects when scheduling. One difference in between the studied companies is to what extent these estimates are based on numerical data or on personal experience. Company A is considered to correspond poorly to this condition by not using numerical data.

2.3 The lagging measurements prevent the companies to use them as means of control for the construction design process. Company D is the only company who has a daily follow-up on their performance measurement, and therefore can act swiftly on deviations on the process.

2.4 Having total consumed time as the major measurement for evaluation of project outcome does not provide the companies with identification of improvement opportunities. The measurement is rather used to display the result after the project is completed. With a plethora of factors differentiating one project from another, a measurement of total time spent will not facilitate the opportunity to identify potential improvement options. Company B is considered to meet the condition for identification of improvement opportunities to a high extent since measuring divided parts of the process increases the opportunity to identify potential areas of improvement. Company D can through their measurement on time waste work for obtaining a more efficient process, and is also considered to correspond to the condition to a high extent.

Connections between constructs

All companies are using measures that are easy to understand as well as also effortless to collect (condition 1.1 and 2.1). Also clear is that the prime use of measures is to enhance accuracy in estimation of future projects (resulting in ordinary correspondence to condition 1.2) not for enhancement of process control during ongoing projects (condition 2.3).

Comparison between different clusters of companies, points out a prominent disparity in the level of interest for construction design process improvement. None of the studied construction engineering firms, (company G to J), have in the interviews given

any indication of having incentives of working with continuous improvement of the design process, which is clearly seen in condition 2.4.

DISCUSSION

The Swedish construction industry has in several reports been described as inefficient and in need of improvement. One possible way to monitor performance and follow up undertaken improvement initiatives is through use of performance measurements. This paper focuses firstly on the current use of performance measurements in the construction design process, and secondly, on how well the used measurements correspond to previous research made within this field.

The survey shows that the main variable for measuring construction design performance is time. How the measure is expressed and represented in the studied companies differs. Some of the studied companies measure the total amounts of time spent in a project, while others compare actual time spent with estimated time for the project. Quality is also of interest for the studied companies, but little effort is made in documentation on this subject. This confirms that the "iron triangle" (cost, time and quality) still is the prevalent measurement of performance within the construction sector, also reported by Haponava and Al-Jibouri (2009).

The constructs created in order to analyse how well the current use of measures corresponds to existing theories for performance measurement highlight that the existing measures are easy to understand as well as collect, but are solely lagging measures which do not serve as means of control for the construction design process. It is also determined that the used measurements are not satisfactory in terms of monitoring process improvements, since they only report the outcome of projects, not how different factors have affected the result, a finding also reported by Kagioglou (2001) and Neely and Bourne (2000). The project-orientated measures also render difficulties in comparison between projects since all projects are considered to be unique and one-of-a-kind due to various reasons. This results in an inability to evaluate progressive performance which consequently excludes comparison with other companies wherefore benchmarking is considered to be impracticable for all the studied companies. Another finding is the weak correlation between objectives and strategies for the construction design process and the measures used.

The study also indicates a variation in interest in continuous improvement of the construction design process between industrial companies and construction engineering consultant firms. This might be explained by different initiatives for improvement among the studied companies: the industrialised housing companies (company A to F) are foremost focused on ensuring availability of correct production documentation for the production system, where the companies' product and customer value is created. The construction engineering consultant firms (company G to J) on the other hand, have the construction design as their final product and are therefore mainly interested in maximising profit from the number of hours invoiced in a project. It is therefore considered that the industrialised housing companies should have a greater interest in relating performance measurement to the company objectives regarding design process improvement.

Proposed future research is development of process performance measurements. The predominant project-focus on performance measurement, in practice as well as in literature, is not sufficient for use within industrial housing, where improvement of processes is of main interest. This gap has also been identified by Haponava and Al-

Jibouri (2009). Also suggestions of how excessive information of previous performance should be captured in order to facilitate experience feedback and lead to improve decision making is necessary.

CONCLUSIONS

The current used performance measurements (i.e. time, money and quality) are not considered to be sufficient in terms of supporting process improvement within industrialised housing. The current used measurements are lagging measures, reporting outcomes of previous projects and do not serve as means of control for the construction design process or enable follow up of undertaken improvement. The industrial housing companies are therefore in need of process-oriented measurements in order to increase control over their performance and enhance data used for decision making.

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