Construction process models – enabling a shared project understanding

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ABSTRACT

The search for improvement in construction continues, with many novel as well as longstanding initiatives applied to the process in attempts to drive down cost and raise quality. Success is often claimed, but it is not always possible to reproduce the same result elsewhere.

Research for the Swedish government on a 'design and build' housing project has examined the underlying process and has found a series of discrepancies between what is claimed and what appears to have happened. A comprehensive computer-based model was created in order to pinpoint inconsistencies and omissions in the process. Whilst this 'lean project' was judged overall to have been a success, questions remain not least in relation to the synchronisation of off-site production with on-site construction. Areas of concern include the project definition stage in particular the mismatch between the project programme and the detailed workings that lie behind it. The programme appears to present construction personnel with insufficient insight into the detailed steps that are needed to undertake some key activities.

The paper concludes by arguing for a much more detailed analysis of the process and one that integrates the efforts of specialist contractors and off-site production with on-site construction. By doing so, it would help to balance resources and increase the likelihood of achieving a project's cost, quality and time objectives.

KEYWORDS

Process modelling, project planning, supply chain

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INTRODUCTION

Improvement in the construction sector is a topic of current debate. Construction companies and consultants are looking at ways of raising quality, lowering costs and shortening project times. This work is not going unnoticed by the clients of the sector who see the potential benefits too. Expectations have risen and new ways of working are being promoted to emphasise teamwork and greater involvement of the client organisation. The nature of construction however makes it anything but a trivial affair. The number of actors involved, activities being undertaken and decisions to be taken contrive to make the process less than certain. Even the most basic of actions could very well fail unless the right information is communicated to those that need it, when they need it and in the form that they need it. One proposed solution – and the one covered in this paper – is the use of detailed process models to assist in managing construction projects. These models can show the entire process for the project down to a fairly detailed level, providing a hierarchical and integrated view of the project. Views to the contrary, that this is not achievable, are common, not least among practitioners in the sector. It is claimed that the process is far too complex to be modelled and that even if it were possible it would be of no use as every project is unique. However, research has shown that there are plenty of similarities between the projects, even across different countries (Atkin 1998) and detailed modelling of the process in different forms has already been conducted with many useful insights being gained (Kagioglou et al. 1998, Karhu et al. 1997)

BACKGROUND

In 1996, the Swedish government initiated an investigation within the Ministry for Industry, Employment and Education. The aim of the investigation was to create long-term reductions in the costs for construction and maintenance of social housing, thereby lowering the cost of housing and raising employment in the construction sector. A special committee of enquiry *Byggkostnadsdelegationen* (BKD) was created to undertake the work.

This paper is based on the findings from a case study conducted on one of the test projects initiated by BKD. The project in question consisted of the construction of three adjoining buildings with a total of 44 flats specially suited for elderly living. The work was undertaken as ‘design and build’ with the construction phase running over nine months. The main actors were a regular client of the sector and a ‘design and build’ company.

The project was initiated under the assumption that benefits would accrue from an open and transparent sharing of information between the actors. The main objective of this test project was to measure and evaluate how an increased collaboration between client–contractor–suppliers could influence the quality of the end product and the costs of production and maintenance.

METHODOLOGY

The method adopted for the research was based principally on a detailed analysis of the processes supporting the housing project. A single model of the project was created using computer software based upon functional modelling techniques. These were used to document activities, their relationships and associated inputs, controls, outputs and mechanisms (Feldmann, 1998). The computer software product, BPwin, was used. It is based on the US IDEF0 Federal Information Processing Standard for function modelling.

Interviews with key project personnel were conducted in order to obtain a complete (or as near a complete) picture of the activities that were undertaken, the information flows that these needed and generated, and the resources that were necessary for their completion. It was

assumed that the information flows and activities reported in these interviews had taken place in the manner described. To validate and refine the model, repeated visits were made to the site. These visits were observational and did not impede the work. Discrepancies from what was said in the interviews were picked up and errors and defects were noted. Furthermore, a review of the documentation produced during the course of the project, originating from both the client and the project team, was undertaken.

The model was compiled from a functional decomposition of the project as a whole. Views of parts of the model were generated and used to 'walkthrough' representatives from both client and contractor organisations. Where necessary, sections of the model were altered or adjusted and 'walked through' again to achieve as near a replica of real life as possible. The resulting model covered in excess of 80 A4 pages and took the form of an integrated set of hierarchical diagrams. From these it was possible to probe the detailed workings of the project and to identify areas in which further study was needed.

MAIN FINDINGS

The housing project was considered as a success overall and the main actors have agreed to continue their relationship in coming projects. However, a detailed analysis of the workings shows that large parts of the process not were adequately defined and assigned and that many of the time, cost and quality errors that occurred could have been avoided or kept to a minimum. In other words, further improvement could be achieved. Phases in the process where this was especially apparent were the project initiation and definition stages and the general management of the supply chain.

PROJECT INITIATION AND DEFINITION

Briefing

Briefing is probably the most crucial of phases in the procurement process. The actual need might be quite difficult to ascertain as the client's business plan may embody stipulated corporate, financial and other requirements and may not, therefore, have been drafted in a way that enables the project team to use it directly. Interpreting these requirements is an important exercise that has to be done in a structured and methodical manner. The basis of the brief will normally be determined by requirements stated as objectives and priorities. Objectives generally take the form of statements as to the cost, time-scale and some (but probably not all) aspects of quality. The funds available will be fixed, as might the time for completion of the building. These objectives set the main working parameters for the project and challenge the team to produce the required quality. Unrealistic objectives for time, cost and quality and, equally, impractical trade-offs between them will inevitably result in a less than satisfactory outcome. Priorities should be stated in terms of which objective is of the greatest importance and how the others relate to it.

Some of the performance failures on the case study project could be traced back to the inadequate definition of needs and the relative ordering of priorities. One cause being that the project objectives and priorities were not recognised and shared by all members of the project team. The parties came into the project carrying with them their specific ideas and standard procedures for how the work is supposed to be conducted. Not sharing the same view on how the project was to proceed and exactly what that was required of each of the activities in the earliest of stages meant that the parties were ill-prepared and could not exchange sufficient information with each other. Meetings were, on repeated occasions, forced to be held over again, effectively slowing down the process. Certain issues that were disputed by the parties during the project came as a direct consequence of misinterpretations in these early stages. One example concerned the facade.

The project team

None of the workings of the process should be the private affair of any member of the project team. Bringing transparency to decision-making and, at the same time, throwing light on the actions required of each team member enables the project team to concentrate upon doing the job to the best of its ability. The use of a project plan, such as was developed on this project by the author, would help in ensuring that this becomes routine. The project plan must define the process – from initiation to occupancy – in such a way that the client can see what is to happen on the project and thereby be able to impose constraints as to make as good as possible interface with his own business plan. Moreover, the project plan must show clearly and unambiguously the actions, their sequence and times that are needed to complete the project (Atkin, 1999). In the case study project it transpired that there were actors who had not recognised the full extent of the work that lay ahead of them. The effect was that they could not fulfil their commitments, which effectively impeded the performance of several other actors. A detailed project plan enables the full sequence of decision-making to be taken into account from the start of the project. This means fewer surprises and less risk exposure for the client through a more certain process.

Project success derives largely from the actions and interventions of the various members of the project team and those associated with them. This may appear to be a self-evident statement, but it is too important to go unsaid. Total commitment of team members over the entire duration of a project may, as became the situation on the case study project, be difficult to achieve. However, there are some simple steps that the client can take to ensure that the team remains focused on the project objectives and priorities. Decision-making should be as transparent as possible and timely. Awareness of what each team member does is of paramount importance if communications and actions are to be effective. An explicit project plan would help each organisation and person to establish the required mode of working. Team members can then be expected to act promptly and correctly. A plan would also ensure that members are fully conversant with their roles and responsibilities and, equally important, that others are aware of them too. The use of such a plan could also pave the way to a process of continuous improvement by defining a baseline from which to measure subsequent performance. This lays the foundation for benchmarking to begin.

Scheduling

Timing of key decisions is likely to determine the pace of the project more than anything else. Bar charts and other graphical representations show when decisions have to be taken, but during the course of the case study project it became obvious that they did not always help in understanding what must be done to enable those decisions to take place. It is therefore necessary to expand the role of project planning (i.e. method and time management) to incorporate decision-making. The project plan is intended to show where in the process decisions have to be taken, who will be involved and the information required. It can be extremely helpful early in the project's life by acting as a checklist. The implications of a change of schedule, or design, can only be considered properly if there exists an understanding of the underlying processes and the flows of information and actions needed to maintain integrity of the project plan based on a comprehensive model of the entire process. Programmes in the form of bar charts and precedence diagrams will be used in conjunction with the project plan. The use of a project plan, which is shared by everyone, will help to identify areas of risk as well as keeping track of which actions are required when and by whom. Overall, this is likely to ensure that fewer risk items are overlooked.

Coordinating the specialists

The case study project, as most other building projects today, required the services of several specialists. They were needed not just for constructing or assembling elements or components of the building, but also for undertaking parts of the design. Their work had to be integrated with that of others in, as is the nature of construction, a fast-moving and dynamic work environment. Managing the interfaces between various specialists requires close attention – certain failures in the performance of the buildings in the project resulted from mistakes made at the interfaces between components and/or the organisations responsible for them. Coordinating the work of specialists is a necessary task and one that has to be resourced adequately. Ensuring that the scope of work covered by respective specialists is complete is key to efficient development of the design – there should be no gaps. Visits to the design offices and works of specialists are highly recommended even though the specialist may only be responsible for a small part of the project. One such visit was made in the case study project. Representatives from both the client and the 'design and build' company visited the manufacturer of prefabricated modules. Even though it was meant as an information gathering visit, important weaknesses concerning both structural and functional aspects of the product were discovered and passed to the manufacturer. The findings show that telephone calls and verbal assurances are not sufficient substitutes for a physical presence to check the facts. Subsequent visits, once the project is underway, ensure that there is no deviation from what has been agreed. Surprises generally result from a lack of return visits. Moreover, simple calculations show that the cost of the additional supervisory and management resources will be amply repaid.

Partnering

There is no point in a client partnering with a contractor if the latter does not commit to implementing this practice throughout the supply chain (Baden Hellard, 1995). In the study, the 'design and build' company had difficulties in convincing a few suppliers of adopting the principles on which it based its work, one example being the application of Just-In-Time thinking. Reducing costs by eliminating inefficiency and waste comes about from a thorough understanding of how the present work is performed.

Quality failures

Tracking the cause of quality failures is routine in many industrial sectors. Knowing the real cause of a defect can lead directly to improvement in the product, process or both. In construction, however, this work is not always conducted in a satisfactory way. Elsewhere research has been conducted to quantify this problem in the railway sector, and has revealed failure costs in the region of 10% of the production costs (Nylén, 1999).

In the case study project quality failures were not sufficiently quantified and analysed. More could and should have been done. It is obvious that going back and putting work right costs more than getting it right first time. Tracking back to the cause of the failure (or defect) is a part of any quality system.

Delivery errors

Assuring the timely delivery of supplies and the arrival of specialists is an obvious factor in the success of any enterprise where materials, labour and machinery have to be coordinated. Even some fairly straightforward construction activity on the project went beyond the requirements of many industrial sectors in demanding the close coupling (or scheduling) of

these key resources (or factors of production). When one talks of waste on a construction site, this extends to all three factors – materials, labour and machinery. Greater effort can, as it was in the project, be put into the control of on-site activities to minimise waste. However, the same cannot be said of the 'hidden' off-site activities since they were generally viewed as being someone else's problem. Synchronising the arrival of the right components, at the right time, with the right availability of labour and machinery will reduce wasteful working and lead to lower costs for the client (Atkin and Leiringer, 2000). The way to ensure the correct synchronisation of deliveries with the demands on site is to regard this aspect of project management as a priority need. This turned out to be a difficult concept to sell to the actors involved, despite the obvious imbalance between the cost of consequential delays and errors and the part-time employment of a 'chaser' or 'expediter'. For the relationship to work and for the supply chain to function efficiently requires an organisational infrastructure that has checks built into it. Checks that, unlike those conducted in the case study project, must be based on more than spoken assurances by suppliers and assumptions made by the 'design and build' company that the work will be done properly. To say that failure of a trusted supplier will result in its not being considered for the next project is no comfort to a client who has a late and expensive building.

Construction companies need to ensure that not only is the delivery timely, but that the content is in accordance with the on-site production schedule. Delivery errors that occurred in the project included the quantity of components supplied, their conformance with the specification and their arriving in the wrong sequence. It happened that the suppliers delivered components to site in a sequence or batch that suited their own production, but which was at odds with the requirements of the construction site. The pursuit of zero delivery errors is only meaningful if there is action to follow this through. This requires that reasons be identified for the cause of the error. Simple causal analysis could be enough to ensure this happens, so long as the findings are recorded and implemented to avoid repetition. Once this practice has become routine – as in fact it must if one is working to a quality system – it is likely that many of the common, easily avoidable problems will disappear. One must, unlike in the case study project, avoid relying on individuals' memories and, instead, hard-wire error avoidance into organisational procedures.

CONCLUSIONS

The research discussed in this paper is based on the detailed analysis of a housing project in which the actors have gone beyond their established procedures to create an open, transparent and, above all, collaborative atmosphere. The findings show that even though the project was judged as successful there were still plenty of unnecessary procedures and wasted work. A more effective construction process comes out of all parties knowing what to expect and what to do. The use of process models, amongst other improvements, could help all actors to identify the connections between the information, resources and components that are needed, both on and off the site, in a way that is not possible with project planning tools and bar-charts alone. Having a model that clearly shows the linkages between the activities, resources, information required and inter-relationships would improve understanding as to what a change in the programme would have as a consequence on the project as a whole. Whilst not intended to replace the project programme, a model of the kind discussed could be used to improve project programming practice.

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