Managing the soft aspects of BIM through process modelling and observation

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Abstract:

The Observational Method of design used in ground engineering, is presented as an exemplar of BIM construction. A synergy between BIM and OM is demonstrated through the open sharing of information and performance data in a team environment. Distinction is made between 'hard' product design and 'soft' process design. An example is given of a failure caused by poor design of the soft processes. A methodology is proposed to ensure robustness in such design and construction processes based on business process modelling. The critical impact that human behaviour uncertainty can have on a project is emphasised and Observational Engineering is suggested as an all-inclusive technique for managing construction project uncertainties.

Introduction

BIM can be defined as a way of working; it is information modelling and information management in a team environment, all team members working to the same standards as one another. BIM creates value from the combined efforts of people, process and technology. There are historic precedents in the construction industry of such collaborative working epitomised in the initiatives spawned by the Egan report (Egan 1998) and procurement practices such as partnering and alliancing (Le Masurier, 2014). The Observational Method (OM) is a relatively unknown tried and tested, practical example of information modelling and information management in a team environment, with a long history in geotechnical engineering. OM requires collaborating designers and constructors to generate and use real-time data from monitoring performance of the ground and associated structures during construction, to allow designs to be progressively modified to suit the actual conditions encountered. Using feedback from observations and monitoring of performance, OM maximises value by reducing waste of materials and effort in comparison to the more common predefined design approach.

OM relies on full integration of design and construction information, processes and teams and in this respect here is synergy between BIM and OM . However a danger with such integration and collaborative working is that risks and responsibilities are shared more broadly and are not as clearly defined or understood as they are under familiar, traditional relationships, leading to confusion of responsibilities and the potential for organisational failure, such as the organisational failure which lead to the collapse of the tunnels under construction using OM at Heathrow Airport in

1994. A programme of research following this failure was carried out based on numerous case studies, interviews with practitioners and the development of a process modelling methodology which was then trialled on a live construction project. This research demonstrated that the principles of the OM are generic and can be applied broadly, encompassing the management of soft human behaviour uncertainties in conjunction with the traditional management of hard physical uncertainties (Le Masurier, 2001). The process modelling methodology developed through this programme of research, referred to as Observational Engineering, supports collaborative working by facilitating the proactive design and management of the soft processes, which can be carried out in conjunction with developing the hard BIM models.

The geotechnical design paradigm

Geotechnical engineering provides an exemplar of two alternative modes of working in construction: either collaborative with open sharing of information and feedback from performance or traditional silo working where retaining information is seen as a way of retaining control.

Predefined design is a silo mentality where an attempt is made to eliminate uncertainty by predicting ground conditions with (assumed) certainty before construction. This often leads to conservatism, over design and waste of resources. Despite this inefficiency, predefined design has been the most common in practice, due to the traditional procurement approach of separation of the design stage from construction (Le Masurier, 2015). If during construction conditions are found to be not as predicted, hasty redesign might be required, based on ad hoc feedback, leading to further waste of resources.

The Observational Method (OM) (Peck 1969) provides an alternative whereby designs can be modified during construction, based on planned feedback from observation and monitoring of ground performance. The OM has been practiced for many years by innovative engineers and is far more efficient than predefined design, minimizing waste of materials, time, and effort. It can be applied from the start of a proct (ab-initio) or after a predefined design has failed (best way out).

A model of the OM process is shown in Figure 1. Designs are developed for the full range of conditions likely to be encountered, based on current knowledge of the ground, including design for the most probable conditions and design of contingencies for the most unfavourable conditions. During construction a thorough monitoring and observation strategy is essential in order to check and confirm the actual conditions, with performance indicators selected to represent the areas of greatest uncertainty, for example settlement. Trigger values on the performance indicators (represented by traffic lights) will determine the response to the observed values during construction. The response could be to use contingencies if conditions are unfavourable or to improve the efficiency of construction if more favourable ground conditions are encountered. As construction progresses knowledge of the ground improves providing greater confidence and opening new opportunities.

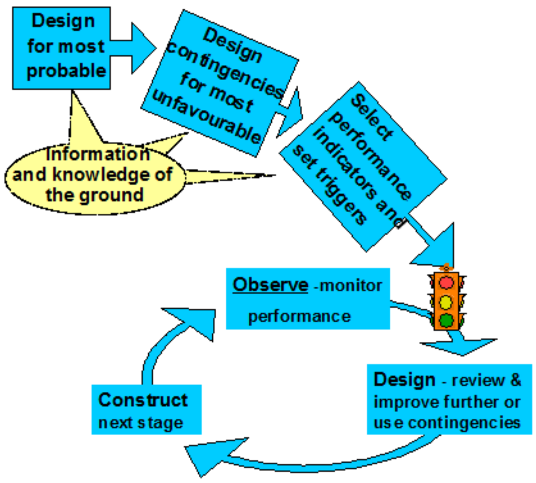

Figure 1 The Observational Method design process

Facilitating collaborative working through OM. BIM and process design

OM requires integration of design and construction and this mode of working has been facilitated over the past 20 years through new collaborative approaches to procurement such as design and build, partnering and BIM (Le Masurier 2015). Apart from the promotion of collaborative working, BIM offers further assistance to applications of OM, through the sharing and updating of all ground related data throughout the life of a project, the importance of which is illustrated in figure 1,

A danger with collaborative approaches to project delivery, as encouraged by BIM and OM, is that responsibilities are not as clearly defined or understood as they are under familiar, traditional relationships. Under such circumstances uncertainty in a process can lead to confusion of responsibilities and unsafe operational practices. The danger is clearly illustrated by the Heathrow Express (HEX) project which suffered a tunnel collapse during construction in 1994. The tunnel construction was attempting to use the 'New Austrian Tunnelling Method' (NATM) (Muir Wood, 2002) which is a variant of the OM and is a very efficient tunnel construction technique when applied successfully. NATM is however a complex process to manage and relies on complete integration of the design and construction processes. The failure of HEX was not due to poor understanding of the hard physical system, since subsequent analysis of the monitoring data available to the project team during construction indicated that a developing collapse could have been detected several weeks before it occurred. In an enquiry, failure of the managerial process was highlighted as follows:

'*There were undoubtedly human errors; but these were merely a consequence of foreseeable cultural, organisational and management failures. The causes of the incident were rooted in failures in 'defensive' systems (i.e. preventative management systems) that did not adequately deal with hazard identification, risk avoidance and* *reduction and the control of the remaining residual risks. There was organisational blindness to the possibility of collapse. As a consequence, human failures were not readily identified and corrected; and mistakes in decision-making were more likely.*' (HSE, 2000).

It is worth noting that procurement of HEX used the NEC contract and contractor self-certification, which were new and unfamiliar ways of working to the project participants. Similarly, during the transition to BIM becoming standard practice throughout industry, there may be occasions when some participants are unfamiliar with this way of working. More specifically the failure at HEX illustrates the need for clarity over roles and responsibilities when using novel, integrated design methods such as NATM and OM in ground engineering and BIM design in general. Such clarity can be enabled by the project team collaboratively designing their processes, to ensure that each party understands their own and other's roles and responsibilities. This can be carried out in conjunction with the BIM modelling of the physical product i.e. designing the project processes, in conjunction with designing the 'product which is the traditional focus of design. This approach concurs with 'Management by design' proposed by Muir Wood (2002) whereby design emphasises: '*the essential interaction between product design (the design of the finished product and its operation) and process design (the design of construction and its means).*'

BIM is focussed mainly on the product and it is somewhat surprising that process design does not explicitly receive the same level of detailed analysis as the product design, particularly given the risks of complacency in BIM processes. For example: '*when all players see themselves as being on the same team, they may cease to look for and find mistakes in each other's work*'. (Azhar 2011)

Clarification and understanding of the responsibilities of different actors in a typical project organisation has been highlighted as a challenge to BIM implementation (Navendren et al, 2014); Eastman et al., 2011; Arayici et al., 2011; 2012a).

Examples such as HEX demonstrate that success of a construction system relies on the integration of the 'hard' product design and the 'soft' process design. Blockley and Godfrey (2000) assert that: '*all hard systems are understood and managed through soft systems… all hard systems are embedded in soft systems'*.

Commensurate attention to both product and process design will ensure robustness of the system. The process design can be represented in process models such as business process models (BPM). There are a number of collaborative BPM software products available to support process design, for example Signavio and Cameo. Such software provides the ideal environment to get all players involved in process design and improvement. Publishing accessible process models creates mutual understanding of roles and responsibilities among all players involved in different parts of the project organization. This shared understanding helps people talk to each other about how they work and, ultimately, to collaborate on process improvement, using tools that enable this communication. The key point is that the process should be proactively designed and not left to chance (or reactive management if the process fails) ie 'ab-initio' rather than 'best way out'. The process models so produced by the team should be dynamic i.e. continuously reviewed and updated, in the same way that the traditional OM model of the physical works is updated and improved, based on the knowledge gained from feedback from the enacted processes as shown in figure 1.

A further development of the modelling methodology proposed here is to incorporate measurement of behaviour of the team. Based on the systemic nature of the OM (Le Masurier et al 2006), the principles can be applied to the management of the full range of uncertainties (of the type that contributed to the collapse of the HEX tunnels) not only to manage uncertainties in the ground but also to manage human behaviour uncertainties. The broader application of OM to the management of all uncertainties together with the process design methodology may be called Observational Engineering, as illustrated in figure 2 and described as follows:

Starting at the bottom of this picture, Observational Engineering is founded on a collaborative project team, for example as described in BS11000 (BSI, 2010). The project team members collectively agree on a set of common project objectives in a workshop environment similar to the process used in Value Management (Wiki, 2016). They then decide on the systems and processes required to reach the objectives, represented by a process flow diagram. The collaborating team, while jointly developing (BIM) models, use BPM software to develop models which represent the construction processes.

Key performance indicators (KPIs) related to the project uncertainties, are linked to the project processes as shown in the table at the top of the picture. The KPIs are shown to include both 'hard' indicators related to time, cost and quality and 'soft' indicators related to people. The actual values of these performance indicators are monitored in real time as the project progresses and reviewed against a set of trigger value criteria. The data are fed back to the project team to inform their actions within the continuing project progression. The team will carry out regular reviews that may result in modifications to the project processes (possibly using pre-planned contingencies) to ensure the project remains on track to achieving the objectives.

Whilst objective measurement of the soft human behaviour KPIs is challenging, requiring the input of social scientists, (Le Masurier, 2016) this is an area where there is increasing interest in construction and some progress is being made, see for example (Kavanagh, 2015); (Ibrahim, et al (2015) and (London 2006).

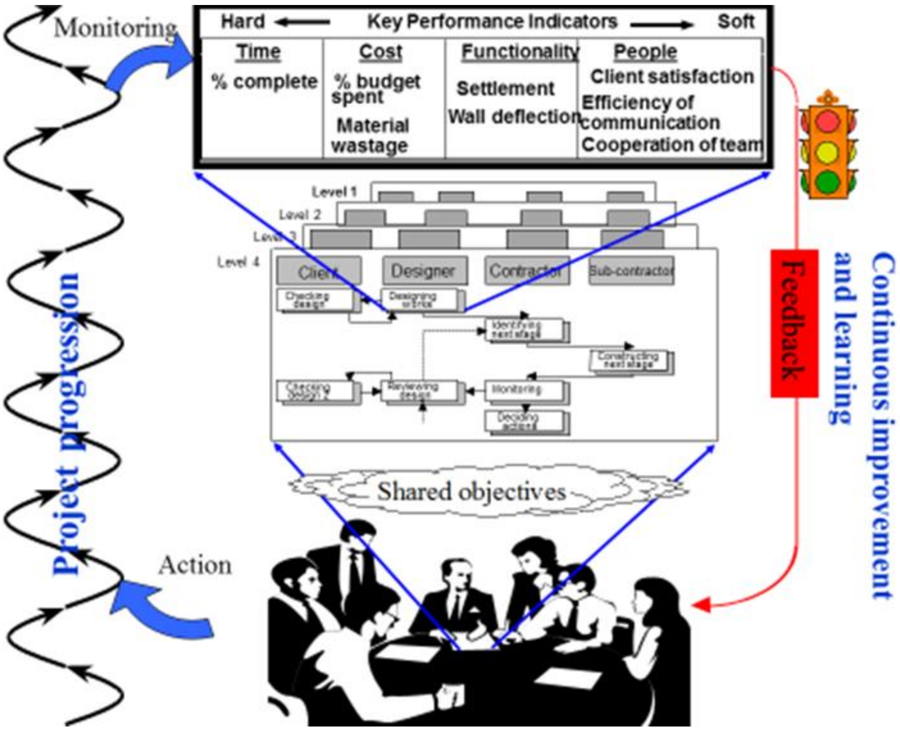

Figure 2 Observational Engineering

Conclusions

The OM is an established exemplar in the construction industry of the BIM way of working and illustrates the benefits of successful collaborative working and open sharing of information. The potential hazards from inattention to process design and the human behaviour aspects of collaborative construction processes have been highlighted. A methodology has been presented that can counter these hazards. The synergy between OM and BIM means conditions for OM design are becoming more conducive, and applications of OM in ground engineering would be expected to increase.

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