CONSTRUCTION PROJECT CHANGE: INVESTIGATING COST AND BENEFITS

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Cost overrun of projects is common in the construction industry. Changes to the original design and to the scope of works during the design development and construction phases contribute significantly to overall cost overrun of construction projects. However, scholars argue that change is inevitable, and some changes add value to the project. Therefore, it can be argued that the overrun of the initial construction cost through the changes made to the project may be insignificant compared to the reductions in life-cycle cost and whole life value of resultant built environments. Early research is presented here of a wider project seeking to evaluate the costs and value of proactive changes made during the construction phase with the intention to add value to the whole life of the project. Change control accounts and other related documentary evidence of two construction projects were investigated to identify changes made to the projects during the construction phase, and cost of those changes. Semi-structured interviews with quantity surveyors and project managers involved in those projects were conducted to enrich this documentary data. Analysis explored the contribution of proactive changes made with the intention to increase whole-life value to the overall cost overrun of construction projects, and clients' understanding and willingness to pay for such changes. The next phase of this research will investigate the whole life value gained by the clients from these changes. Ultimately, this research aims to increase both clients and project managers understanding of cost and value of changes during the construction phase, with due consideration of the whole life cycle of construction projects.

Keywords: project change, cost, cost overrun, value, whole-life-value.

INTRODUCTION

Change in construction projects is often considered inevitable (Cox *et al*. 1999; Sun and Meng 2009) and construction projects simply prone to a high degree of change (Sun and Meng 2009). This can involve alterations to design, construction method, project program or other project aspects caused by modifications to pre-existing conditions, assumptions or requirements (Sun and Meng 2009; Motawa *et al*. 2007). Change can occur from different sources (Motawa *et al*. 2007) and by various causes related to external, organisational and project environments (Sun and Meng 2009). Previous scholars have acknowledged that construction project change can cause serious disruptions (Stasis *et al*., 2013) and in particular can impact on capital cost of construction (zou and Lee 2008; Sun and Meng 2009), construction project duration (Sun *et al*., 2006; Arain and Pheng 2005; Hanna *et al*., 2004) and other aspects such as labour productivity (Ibbs *et al*. 2007; Hanna *et al*. 1999), health and safety (Williams, 2000), and working relationships (Sun and Meng, 2009). Investigating construction

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project change, and its impacts, therefore remains a continuing concern within construction management literature.

In contrast, relatively few scholars have suggested that changes can be beneficial (for instance, Motawa *et al*. 2006; Sun and Meng 2009; Chang 2002) or explored the importance of encouraging beneficial changes (Ibbs *et al*. 2001). Instead, research tends to focus on the negative impacts of construction project change; for example based on a systematic review of previous completed researches into effects of construction project changes, Sun and Meng (2009) identified that construction rework due to project changes can increase construction cost 10- 15% and can also cause reactive impacts including extra work, time loss, design revision, and indirect impacts such as impact on labour productivity, loss of rhythm, impact on resource planning and cash flow etc. When considered from such perspectives, it is therefore unsurprising that the focus of much management research is on the prediction of change, the minimisation of any reactive impact of project changes, and ideally the avoidance of unnecessary change. However, it is argued here that change can actually be a good thing, and this paper seeks to contribute to this thinking by exploring and quantifying beneficial change within construction projects.

LITERATURE REVIEW

Beneficial construction project changes

As previously noted, few scholars have suggested that changes can be beneficial. Motawa *et al*. (2006) categorised construction project changes into beneficial, neutral or disruptive changes. Sun and Meng (2009) stated that some projects may benefits from proactive changes. Ibbs *et al*. (2001) categorised changes into beneficial changes and detrimental changes, and stated the importance of encouraging beneficial changes and discouraging detrimental changes. Exploring beneficial changes further, Ibbs *et al*. (2001) claimed that beneficial changes resulting from value engineering exercises and can help to reduce cost, schedule, or degree of difficulty, are welcomed by the management team, since these changes benefit the project. These beneficial changes not only give an immediate and proactive impact, but they also can provide the platform and environment for managers to seek further beneficial change. Sun *et al*. (2006) categorised changes as ‘necessary’ and ‘unnecessary’ changes and acknowledged that improved project quality as a change effect. Chang (2002) has categorised changes as ‘compensable causes’, ‘non-excusable causes’ and ‘excusable causes’.

However, none of these studies reveals further details of their beneficial changes, or their long term impact to the building or the businesses operated within those buildings. Furthermore, to date there has been no agreement on the definition of what embodies a beneficial project change. It could be argued that any project change is beneficial in some way, since they intend to improve the performance of the project.

In some cases, change could be introduced to the project with the intention of improving the performance of the project beyond initially expected performance levels; in this situation, such changes can be termed 'proactive changes' and are made to improve performance of the project beyond initially expected performance targets, their causes consequentially categorised as 'proactive change causes'. In contrast 'reactive changes' are those made as a result of reaction to 'reactive change causes', such as change the design to rectify the flaws in the development process. However, it must also be acknowledged that proactive changes still have reactive impact on initial capital cost, project duration and other parameters identified above. Yet, they have a long term positive impact on the life cycle of the project, through reductions in life-cycle cost and improvements in whole-life value.

Proactive change causes and their impact

Several scholars have acknowledged the existence of client related changes (c.f. Chan and Kumaraswamy 1997; Wu *et al*. 2004; Chang 2002). It can be argued that clients could introduce proactive changes with the intention of improving the performance of the finished building. Yet, most studies in the area have only focused on reactive and necessary changes initiated for client related causes. For example, Chan and Kumaraswamy (1997) identified that inadequate contract durations imposed by clients can be categorised as a client related cause for variation. Citing from previous studies Sun and Meng (2007) reported variations in clients' expectations, budget reduction, demand for accelerated completion, inexperience of client and inappropriate interferences as key client related causes for change. As a result of this focus, there is much less information about effects of the proactive changes initiated by clients. Chang (2002) has categorised client changes as compensable causes, non-excusable causes and excusable causes, and stated that compensable causes are related to requirement changes by clients and other defaults by clients. Undertaking case studies of four engineering design projects enabled Chang to quantify reactive effects (increase in cost and time) of client requested changes. Clearly, it could also be beneficial if this study had extended to the analysis of proactive changes, based on the client requests.

Design changes have also been identified as a root cause for variation by several researches (c.f. Hsieh *et al*. 2004; Sun and Meng 2007), and this could be a cause for proactive change. Yet, similar to research of client change, reasons for design change has not been explored in sufficient detail to enable distinction between reactive and proactive design changes to be made, which could allow identification of beneficial variations. Much more attention has been paid to reactive and necessary design changes. In Sun and Meng (2007)'s systematic review, they identified design errors and omission as the main causes for design changes, and poor briefing practices and changes in client requirement as indirect reasons for design change.

Change due to site safety considerations and security considerations (Hsieh *et al*., 2004), requirement changes (Wu *et al*. 2004), technology factors such as new materials and new construction methods (Chan and Kumaraswamy 1997; Sun and Meng 2007; Wu *et al*. 2004) have also been identified as causes for change. Even though it is obvious that some of these causes could be related to proactive changes, further details cannot be found within the literature.

As discussed above, the literature reveals existence of proactive changes and proactive change causes. However, research then fails to explore the impacts of such proactive change, which remain unidentified. Based on 101 previous published researches Sun and Meng (2006) summarised change effects into five categories: time related, cost related, productivity related, risk related and other effects. Surprisingly, all the change effects identified by Sun and Meng (2006) are reactive.

The aim of this research is to explore and quantify proactive and reactive changes within construction projects. This resulted in the need to establish the existence of proactive changes and examine how they are introduced to the construction projects, alongside a comparison of the frequency of occurring proactive and reactive changes. Furthermore, comparison of the contribution of proactive and reactive changes to overall construction cost overruns will enable an enhanced understanding of construction project change within this specific context.

RESEARCH METHODS

Research of construction cost overruns often uses surveys and case studies to explore causes of cost overrun and their frequency, however this can lead to a level of superficiality within the data collected and therefore the potential from its analysis. Furthermore, research has often focused on the negative impacts of change, and the benefits change can deliver is often neglected. . In contrast, this study utilised in-depth case studies as the main research method, in order to collect rich data including the details behind causes of construction project change, alongside any proactive and reactive change causes' contribution to the overall cost overrun of the construction project. Two small scale refurbishment projects were selected as case studies based on the availability of access to relevant information.

Case study A: Case study A was an office refurbishment project located in London. The initial contract sum of the project was £489,654 in the third quarter of 2013 and the project was finally completed at a sum of £ £604,654 in the first quarter of 2014. The scope of work comprised refurbishment to the interior and exterior of an outer London office, including refurbishment of the basement, ground and first floors as well as the repair of existing render and renovation works to window frames.

Case study B: Case study B was the refurbishment of an existing gymnasium in central London, bringing it to DDA compliance. The initial contract sum of the project was £426,718 in the third quarter of 2013 and the project was finally completed at a sum of £622,333 in the second quarter of 2014. Scope of works included refurbishment to the space include new finishes, a new sauna, reconfiguration of showers, WC's. The scope of the mechanical works includes the reconfiguration of existing services and installation of new services to suit the new layouts.

Change control accounts and other related documentary evidence of two construction projects were analysed to identify changes made to the projects during the construction phase, cost and further detail of those changes. Semi-structured interviews with quantity surveyors and project managers involved in the projects were conducted to supplement the documentary data, related to the reasons for changes. Data from these interviews were primarily used to categorise change causes into proactive and reactive. Due to lack of previous research related to proactive and reactive construction project changes, categorisation of proactive and reactive change causes was challenging and involved subjective judgement of the researchers and interviewees. Simple statistical methods were used to compare the frequency of occurring proactive and reactive change cases. Agreed monetary values of the proactive and reactive changes were extracted from variation accounts of the project. As both case study projects are refurbishment works, the generalisability of these results is limited, however the findings of this study does provide insights around project change and cost, as well as confirm the application of this approach to a wider sample in future.

FINDINGS

Case Study A had a total cost overrun of £94,500 and Case Study B had a total cost overrun of £195,616, caused by variations to the projects. The first ten and nine (for Case Study A and B respectively) cost significant items (contributing to 80% of total cost overrun) were selected for analysis. Further details were collected through interviews and document observations to identify further details of these cost overrun items to establish the precise value of the cost overrun, details of change causes in order to categorise them into proactive and reactive change causes. Table 1 and 2 below summarise the details of cost significant changes in Case Study A and B.

Table 1: Details of cost significant changes in Case Study A

No	Description of the change	value in £	Reason for change	Additional comments (data from semi-structured interviews)	Type of change
1	Boiler changed to a more efficient variety	3,000	Additional works		Proactive
2	Additional kitchen worktop	1,000	Additional works, design error, poor project management, poor cost management	It is being mistakenly assumed that some of existing kitchen worktop was to be retained, as stated on architect's drawing. Later it was recognised that all the worktops to be replaced.	Reactive
3	Carpet tiles specification change	2,000	Additional works, design change		Reactive
4	New window and improved glazing to the fabric of the building.	27,000	Additional works, design change	Initially it was decided that the original glazing was adequate and had no requirement to be changed. Yet these were later changed to improve performance. Cost also includes renovation works to exterior of existing window to be removed	Proactive
5	Painting of exterior masonry and woodwork	-	Adverse weather condition	Delays due to bad weather	Reactive
6	Replace Lighting and sockets to clients requirements	12,000	Client spec not met, design error, poor project management,	Lighting and sockets needed to be improved to client's requirements at an additional cost. Client requirements were not clearly captured and stated in the specifications and the contractor had installed these to a standard appropriate to the work, which client did not liked. Changing these came at an additional cost to the client	Reactive
7	Render to block work	2,500	weather conditions, mistakes on site	in hot weather caused cracks due to drying out too quickly, had to strip off and re apply	Reactive
8	Repair timber floor	-	Mistakes on site	Water damaged caused by the contractor to the parkey timber flooring which required sanding down and polishing out	Reactive
9	Additional rain water harvesting tank	25,000	Additional works	A requirement identified and added later to improve the project	Proactive
10	Water proofing basement	22,000	inadequate site investigation, technical challenges, additional works	It was later identified that the basement need water proofing measures.	Reactive

Table 2: Details of cost significant changes in Case Study B

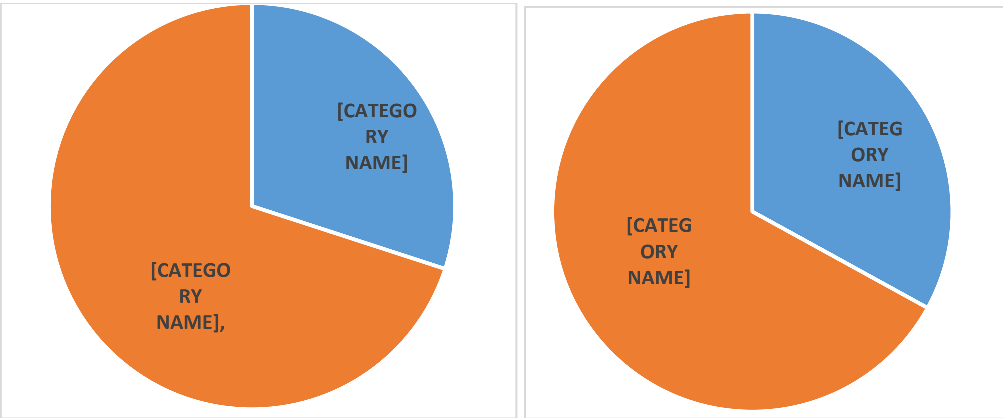
No	Description	value	Reasons for change	Additional comments (data from semi-structured interviews)	Type of change
1	Revised M&E details	60,000	Additional works Design change Design error	Proposed routes in design were not achievable once opening up work had been completed	Reactive
2	Installation of sprinkler system	77,896	Additional works Technical challenge	Future proof area for integration of proposed fire safety works (expected 2016) to limit requirement for opening up once works complete, sprinkler system is now ready for its connection to new system.	Proactive
3	Additional FCU's	17,160	Design change Additional works	Post contract - Client changes to layout required adjustments to ventilation levels and eventually additional FCE's (Fan Coil Units) were required	Reactive
4	Adjustment to New Ramp	5,500	Design error, statutory requirements, additional works	Original design did not meet statutory requirement. Ramp installed as per design was not approved by building control. Adjustments required to make the design compliance with regulations.	Reactive
5	Provide temporary A/C units	7,500	Poor project management, Additional works	Works were phased whilst parts of the gym remain open. It became apparent later that temporary cooling would be required to the gym area in use and this was funded by the project	Reactive
6	Revision to ventilation system	3,500	Design change	Had to be extended	Reactive
7	Remedial works to improving damping in female changing room	4,500	Additional works	Adjustments to fall in shower area to reduce the risk of water pooling and causing damp	Proactive
8	Repair damage to existing partition by sub-contractor	-	Mistakes on site	limited to contractors cost	Reactive
9	New fire alarm loop - Cabling and containment for future void detection and future allowance for install CBS	19,560	Additional works	Future proofing of the space	Proactive

ANALYSIS AND DISCUSSION

Changes due to proactive and reactive causes

Simple statistical analysis was used to analyse the case study data to identify percentage values for the frequency of occurring changes due to proactive and reactive causes (Figure 1). In both Case studies changes were more frequently resulted from reactive change causes (67-70% of times) than from proactive change causes (30-33% of times).

Figure1: Frequency of changes due to reactive and proactive causes



Case study A Case study B

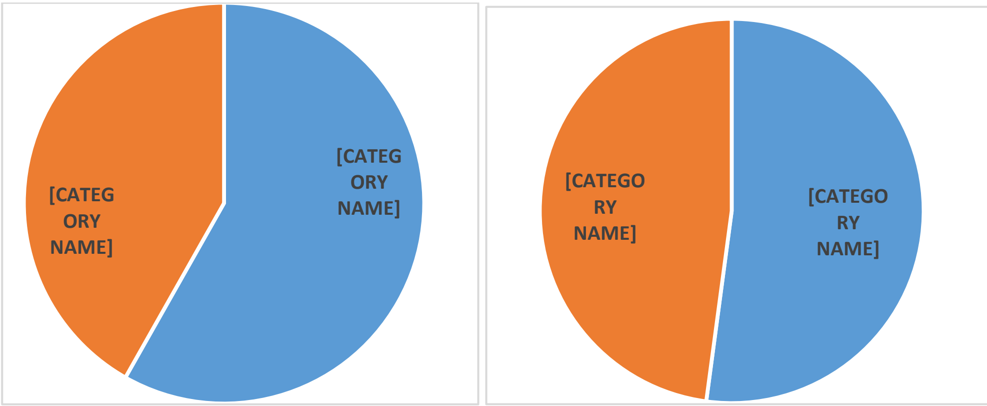
In the analysis of causes for change, it was clear that the changes due to reactive causes were often the result by flaws in the briefing, design development and construction phases (see Table 1 and 2). These include additional works and design changes to ensure the compliance to client requirements and other standards, and re-work to rectify errors. Changes in this category were inevitable to complete the projects to the expected standard of quality. Similar to the findings of (Ibbs *et al*. 2007) some of the changes had ripple effects into construction cost causing additional works in other related elements and thus escalating the cost overrun. For instance, in Case study B, change to the building layout has resulted adjustments to ventilation levels and installation of additional fan coil units.

Proactive change causes were always associated with additional works and design changes to improve the standard of quality of the completed building for operational efficiency (Case Study A), sustainability (Case Study A) and improved user satisfaction (Case Study B) and future proofing (Case Study B) purposes.

Monetary value of changes due to reactive and proactive causes:

Results were further analysed to compare the monetary value of proactive and reactive changes (Figure 2). Agreed monetary values for each changes were extracted from the projects' variation accounts. Surprisingly, total monetary value of proactive changes was higher than the value of the changes, due to reactive change causes in both case studies. These results (including the intentions of proactive change causes discussed above) partly support the idea of beneficial change, suggesting that the overrun of the initial construction cost due to the changes made to the project could result reductions in life-cycle cost and whole life value of resultant built environments. Changes made to Case Study A aimed at operational savings would reduce the life cycle cost of the Case Study A, while some of the changes aimed at improving user satisfaction and sustainability could also improve whole life value. Furthermore, it could be argued that proactive changes aimed at future proofing of the building (as seen in Case Study B) in relation to emerging concerns will eventually contribute to the improvement in whole life value. Surprisingly, the contribution of these type of changes was found to be significant in both cases studied within this research. A clear consequence of these changes is the considerable reduction in life-cycle cost and improvements in whole life value, yet further research is required to estimate or quantify the actual benefits.

Figure2: Value of changes due to reactive and proactive causes



Case study A Case study B

It is interesting to note that for both cases, proactive changes were often initiated by the client, except for the changes aimed at future proofing in Case study B. Involvement of other stakeholders in initiating changes was hardly evident within the data. According to literature, designers remain the primary contributor to the design, although many other sources may also contribute (Emmitt 2007). Evidence of new construction related products and processes emergent to the industry and accessed through the key supply chain organisations involved in the design process is a key source of evidence to the design process, next to the knowledge and experience of the people involved in the design process (Wanigarathna 2014). Furthermore, material and component producers carry out the majority of construction-related research with the aim of improving the performance of buildings (Gann *et al*. 1998). This suggests the existence of un-used opportunities that could have been brought in to the project by other project participants. In general, therefore, it could be argued that construction projects could benefit from changes to adopt new evidence brought in by all key supply chain partners involved in the project. Lack of changes initiated by participants other than the client during the construction phase may be explained by the fact that incorporating changes to a construction project during the construction phase is expensive. Contract mechanisms and conditions of contracts used for the construction projects do not favour late changes into the projects (Bower 2000) and these are often seen as opportunities for the contractors to increase their profit margin (Bijari *et al*. 2006). Further work is required to explore the impact of collaborative working on introducing changes later into the construction projects.

It must also be noted that beneficial changes can have negative impacts on projects with relation to capital construction cost and construction duration, and therefore this should be controlled and managed. Existing change control literature can be employed to supplement the findings of this research, in managing proactive beneficial changes to minimise negative impacts. Yet, attention must be paid to the identification and evaluation of the benefits of proactive change, processes which should be integrated into the existing construction change management procedures.

Results of this research should be interpreted with caution; this analysis is based on the data from just two case studies into small scale construction projects. Both projects are refurbishment projects and therefore, the generalisability of this analysis is limited.

CONCLUSIONS

This paper has made a new contribution to understandings of change, through the identification and exploration of both proactive and reactive change causes, as well as the potential for positive outcomes from proactive changes made during the construction phase of a project. This research extends our knowledge on characteristics of beneficial changes by analysing reactive and proactive changes and change causes. Reactive changes place construction projects at initially expected performance levels, whilst proactive changes intend to improve the performance of projects above the initially set targets. Based on the results from case studies into two construction refurbishment projects, this research found that a significant contribution to the construction cost overrun is related to proactive changes, yet these also have the potential to bring reductions in life-cycle cost and improvements in whole life value of resultant built environments. Further research is required to assess and quantify the extent to which clients realise benefits of these changes over the life cycle of the building. Change is often inevitable in construction projects, and the monetary value of both reactive and proactive changes contribute considerably to the capital cost. This research supports previous research, emphasising the importance of controlling and managing construction project changes (both reactive and proactive) to reduce impacts on construction cost, time and quality. In addition, this study has provided some insights to improve the way of scholars engage in research related to construction cost overrun. There is a lack of literature related to proactive changes within construction projects. Based on the results of this research it could be argued that construction projects could benefit from promoting and facilitating proactive change during the construction phase, and it is recommended that further studies be carried out to validate these findings to different types of construction projects.

REFERENCES

Akinsola, A, Potts, K and Ndekugri, I (1994). Variations on construction projects: A review of empirical studies *"Building research and information"*, **22**(5), pp. 269-271.

Anees, M M, Mohamed, H E and Razek, M E A (2013). Evaluation of change management efficiency of construction contractors. *"HBRC Journal"*, **9**(1), pp. 77-85.

Bajari, P, Houghton, S and Tadelis, S (2006). "*Bidding for incomplete contracts: An empirical analysis"*. National Bureau of Economic Research.

Bower, D (2000). A systematic approach to the evaluation of indirect costs of contract variations. "*Construction Management and Economics*", **18**(3), pp. 263-268.

Bröchner, J and Badenfelt, U (2011). Changes and change management in construction and IT projects. *"Automation in Construction"*, **20**(7), pp. 767-775.

Chan, D W and Kumaraswamy, M M (1997). A comparative study of causes of time overruns in Hong Kong construction projects. *"International Journal of Project Management"*, **15**(1), pp. 55-63.

Creedy, G D, Skitmore, M and Wong, J K (2010). Evaluation of risk factors leading to cost overrun in delivery of highway construction projects. *"Journal of Construction Engineering and Management"*, **136**(5), pp. 528-537.

Emmitt, S (2007). "*Design management for architects*". London: Wiley-Blackwell.

Gann, D M, Wang, Y and Hawkins, R (1998). Do regulations encourage innovation?-the case of energy efficiency in housing. *"Building Research and Information"*, **26**(5), pp. 280-296.

Hao, Q, Shen, W, Neelamkavil, J and Thomas, R (2008). "*Change management in construction projects*". NRC Institute for Research in Construction, NRCC-50325.

Hsieh, T, LU, S and Wu, C (2004). Statistical analysis of causes for change orders in metropolitan public works. *"International Journal of Project Management"*, **22**(8), pp. 679-686.

Hwang, B and Low, L K (2012). Construction project change management in Singapore: status, importance and impact. *"International Journal of Project Management"*, **30**(7), pp. 817-826.

Ibbs, C W (1997). Quantitative impacts of project change: size issues. *"Journal of Construction Engineering and Management"*, **123**(3), pp. 308-311.

Ibbs, W (2012). Construction Change: Likelihood, Severity, and Impact on Productivity. "*Transportation*", **4**(3).

Ibbs, W, Nguyen, L D and Lee, S (2007). Quantified impacts of project change. *"Journal of Professional Issues in Engineering Education and Practice"*, **133**(1), pp. 45-52.

Isaac, S and Navon, R (2013). A graph-based model for the identification of the impact of design changes. *"Automation in Construction"*, **31**, pp. 31-40.

Love, P E (2002) Influence of project type and procurement method on rework costs in building construction projects. *"Journal of Construction Engineering and Management"*, **128**(1), pp. 18-29.

Love, P E, Mandal, P and Li, H (1999). Determining the causal structure of rework influences in construction. *"Construction Management and Economics"*, **17**(4), pp. 505-517.

Arain, F and Pheng, L (2005). The potential effects of variation orders on institutional building projects. *"Facilities"*, **23**(11/12), pp. 496-510.

Motawa, I, Anumba, C, Lee, S and Peña-Mora, F (2007). An integrated system for change management in construction. *"Automation in Construction"*, **16**(3), pp. 368-377.

Raineri, A B (2011). Change management practices: Impact on perceived change results. *"Journal of business research"*, 64(3), pp. 266-272.

Serag, E, Oloufa, A, Malone, L and Radwan, E (2010). Model for quantifying the impact of change orders on project cost for US roadwork construction. *"Journal of Construction Engineering and Management"*, **136**(9), pp. 1015-1027.

Shipton, C and Hughes, W (2013). Making changes in practice: an ethnographic study of a hospital project, "*29th Annual ARCOM conference*", 2-4 September 2013 2013.

Stasis, A, Whyte, J and Dentten, R (2013). A critical examination of change control processes. Procedia CIRP, **11**, pp. 177-182.

Sun, M and Meng, X (2009). Taxonomy for change causes and effects in construction projects. *"International Journal of Project Management"*, 27(6), pp. 560-572.

Voropajev, V (1998). Change management—A key integrative function of PM in transition economies. *"International Journal of Project Management"*, **16**(1), pp. 15-19.

Wanigarathna, N (2014) "*Evidence-based design for healthcare buildings in England and Wales*". PhD thesis: Loughborough University.

Zink, K J, Steimle, U and Schröder, D (2008). Comprehensive change management concepts: Development of a participatory approach. *"Applied Ergonomics"*, **39**(4), pp. 527-538.

Zou, Y and Lee, S (2008). The impacts of change management practices on project change cost performance. *"Construction Management and Economics"*, **26**(4), pp. 387-393.