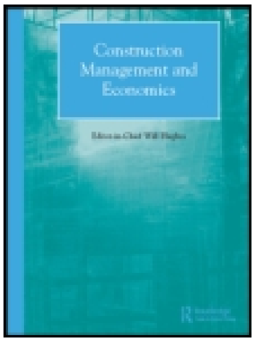

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Cost and time control of construction projects: inhibiting factors and mitigating measures in practice

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Despite the availability of various control techniques and project control software many construction projects still do not achieve their cost and time objectives. Research in this area so far has mainly been devoted to identifying causes of cost and time overruns. There is limited research geared towards studying factors inhibiting the ability of practitioners to effectively control their projects. To fill this gap, a survey was conducted on 250 construction project organizations in the UK, which was followed by face-to-face interviews with experienced practitioners from 15 of these organizations. The common factors that inhibit both time and cost control during construction projects were first identified. Subsequently 90 mitigating measures have been developed for the top five leading inhibiting factors—design changes, risks/uncertainties, inaccurate evaluation of project time/duration, complexities and non-performance of subcontractors were recommended. These mitigating measures were classified as: preventive, predictive, corrective and organizational measures. They can be used as a checklist of good practice and help project managers to improve the effectiveness of control of their projects.

Keywords: Cost control, interview, practice, project control, project management.

Introduction

In the construction industry, the aim of project control is to ensure that projects finish on time, within budget and achieve other project objectives. It is a complex task undertaken by project managers in practice, which involves constantly measuring progress, evaluating plans and taking corrective actions when required (Kerzner, 2003). During the last few decades, numerous project control methods, such as Gantt Bar Chart, Program Evaluation and Review Technique (PERT) and Critical Path Method (CPM) have been developed (Lester, 2000; Nicholas, 2001). A variety of software packages have become available to support the application of these project control methods, for example Microsoft Project, Asta Power Project, Primavera, etc. Despite the wide use of these methods and software packages in practice, many construction projects still suffer time and cost overruns.

In recent years, there have been numerous studies on the identification of influencing factors of project time and cost overruns worldwide. Mansfield *et al.* (1994) carried out a questionnaire survey among 50 contractor, consultant and client organizations in Nigeria and found out that the most important variables causing construction delays and cost overruns are poor contract management, financing and payment of completed works, changes in site conditions, shortage of materials, imported materials and plant items, design changes, subcontractors and nominated suppliers. The top variables causing only cost overruns were revealed as price fluctuation, inaccurate estimates, delays and additional work. Kaming *et al.* (1997) identified factors influencing construction time and cost overruns on high-rise building projects in Indonesia through a questionnaire survey administered on 31 project managers. A total of 11 variables (design changes, poor labour productivity, inadequate planning, material shortages, inaccuracy of material estimate, skilled labour shortage, etc.) were identified for time overrun and seven (materials cost increased by inflation, inaccurate quantity take-off, lack of experience of project location, lack of experience of project type, etc.) for cost overrun. Kumaraswamy and Chan (1998) conducted a more extensive study in

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Hong Kong using 400 questionnaires after which follow-up interviews were held. The study revealed the top 10 causes of construction delays from the contractors' point of view as delays in design information, long waiting time for approval of drawings, poor site management and supervision, mistakes and discrepancies in design documents, etc. Similar survey studies were reported by Frimpong *et al*. (2003) in Ghana and by Assaf and Al-Hejji (2006) in Saudi Arabia. In addition to questionnaire surveys, other researchers adopted a case study approach. Al-Momani (2000) examined 130 public projects in Jordan and concluded that the main causes of delays include changes initiated by designers, client requirements, weather, site conditions, late deliveries, economic conditions, etc. Hsieh *et al*. (2004) conducted a statistical analysis in 90 metropolitan public work projects in Taiwan and identified problems in planning and design as main causes of change orders. Yogeswaran *et al*. (1998) scrutinized 67 civil engineering projects in Hong Kong and suggested that at least a 15–20% time overrun was due to inclement weather. Based on analysis of 46 completed building projects in the UK, Akinsola *et al*. (1997) identified and quantitatively examined factors influencing the magnitude and frequency of variations in building projects. These factors include: client characteristics, especially lack of prior experience and knowledge of construction project organization and the production processes; project characteristics, such as type, size, complexity and duration of the project; and project organization factors, such as: design duration, percentage of design completed before tender, procurement and contract type, adequacy of information provided and number of subcontractors.

While all the above studies, to various extents, helped with the better understanding of the problems associated with cost and time overruns in construction projects, there are some limitations:

(1) Some of these studies are over 10 years old. There is a need for a more up-to-date investigation to reflect any development in recent years.
(2) Most of the studies were carried out outside the UK. Although construction projects worldwide share some common characteristics, there are also some country-specific conditions. For example, it is highly unlikely that 'shortage of materials' and 'import of materials' are major factors in the UK. Therefore, a UK-based study will help to identify issues most relevant to the contemporary practice in this country.
(3) Some of the reviewed surveys had relatively small sample sizes, which may affect the reliability of their results.
(4) All the studies focused on identifying factors that have the biggest influence on project costs and time. They did not discuss the degrees of difficulty in controlling these factors in practice. There seems to be an implicit assumption that the most important factors are also those most difficult to control. This needs to be explicitly validated.
(5) Finally, most existing studies stopped at the identification of the influencing factors, but did not progress on to finding ways of mitigating the identified problems.

These observations underlie the rationale for this study. Its aim is to identify the main inhibiting factors of project control in practice in the UK and then to develop some mitigating measures to help project managers better control their projects.

Research methods

This research adopts a combination of quantitative and qualitative methods. It was conducted in two stages. The first stage was conducted using a quantitative method through a questionnaire survey in a bid to generate information from a large sample population. The second stage of the study was conducted using the qualitative method using semi-structured interviews. The reasons for using the interview in addition to the questionnaire survey were: to triangulate data obtained from the questionnaire survey; to enhance, expand and create depth to the results of the questionnaire survey by investigating and elaborating on some of the issues highlighted; and to explore the experiences of the sample population in relation to the topical issues revealed after analysis of the data obtained from the questionnaire survey.

Questionnaire survey

The aim of the survey is to establish the current common practice of time and cost control in the UK construction industry, including control methods and software applications being used by practitioners as well as inhibiting factors. We started with a thorough review of existing studies that revealed a lot of issues on construction project time and cost overruns, project control tools and techniques and latest thinking and new developments in the field of construction project control. This led to the development of a questionnaire made up of 22 multiple choice questions. The questionnaire was divided into three sections:

- Section one was background information which was targeted at obtaining information on the general particulars of the respondents and their organization, such as the experience of the respondents, their position within the organization, the type of project embarked on by the organization, etc.

- The second section was about time overrun, project planning and time control practice such the frequency of time overrun experienced, the techniques used for planning and time control, the factors that hamper respondents from effectively controlling their projects, etc.
- The third section contained similar questions but specific to cost control practices.

A total of 250 questionnaires were administered: 150 to the top construction companies in the UK by company turnover and the remaining 100 to the top construction project consultancies in the country by the number of professional staff employed and company fee earnings. This list was obtained from the *Building* magazine annual league tables. The league tables did not contain the addresses of the companies so an online web search was conducted to find their addresses and contact details. Telephone calls were subsequently made to these companies to confirm the addresses and to find out the type of hierarchy and structure that exists within the organization. This enabled the questionnaires to be sent to the appropriate department. To supplement this, the name of a construction director, manager or the appropriate personnel responsible for the management of construction projects in the organization was obtained to ensure that the questionnaires were correctly addressed to the appropriate personnel. This ensured a very good response as 110 questionnaires (44% response rate) were returned. Tables 1 and 2 show the profiles of the practitioners that responded to questionnaires on behalf of their companies. Nearly 72% of the respondents that completed the questionnaires were directors, senior managers or commercial managers. As would be expected from their roles, these respondents also had significant years of experience in the construction industry. Nearly half (48%) of respondents had more than 25 years of experience. This showed that there was great depth in the experience possessed by the respondents.

Table 1 Roles of respondents

Roles	Number	Percentage
Director/senior management	79	71.82%
Commercial manager	3	2.73%
Contracts manager	2	1.82%
Construction manager	2	1.82%
Project manager	13	11.80%
Quantity surveyor	2	1.82%
Others	9	8.18%

Table 2 Years of experience of respondents

Years	Number	Percentage
0–5	5	4.54%
6–10	3	2.73%
11–15	9	8.18%
16–20	20	18.18%
21–25	20	18.18%
> 25	53	48.18%

Interviews

The second stage was conducted using a qualitative method—semi-structured interviews. The aim is to explore the topical issues revealed after analysis of the questionnaire survey and experiences of practitioners in greater depth. The same population used for the quantitative stage of the research was used. The offices of the companies that the questionnaires were sent to during the quantitative study were contacted, explaining the objective of the research and requesting a relevant contact (construction directors, project directors, commercial directors, senior project managers, etc.) that could be interviewed. A total of 15 companies presented relevant practitioners for interviews. The interviews conducted were recorded using a digital dictation machine for ease of transferring and storing electronically. The recordings were also transcribed.

Table 3 provides more information on each of the interviewees. As can be seen from the table the interviewees were a mix of contractors and consultants with varying but quite often similar kinds of projects. They were highly experienced practitioners. The total professional experience of the 15 interviewees is 402 years (average experience of 26.8 years). The majority of the interviewees are senior employees of their company and many of these companies are large organizations with national or regional presence in the UK; some also have international coverage.

Survey findings of project controls in practice

The importance of cost and time control is widely recognized by construction professionals in practice. The questionnaire survey of this study revealed that 58% of respondents always apply time controls to their project and a further 29% indicated that they frequently apply time control techniques. Only 11% of respondents indicated that they rarely or do not apply

Table 3 Information of interviewees

	Roles	Years*	Company type	Project types	Interview duration
1	Senior general project manager	30	Main contractor	Construction, civil engineering, nuclear, etc.	50 min
2	Commercial director	25	Main contractor	Building construction, telecommunication, infrastructure, civil engineering	40 min
3	Director	25	Contractor	Building and engineering services	30 min
4	Associate director	28	Consultant	Construction	30 min
5	Senior contracts manager	24	Main contractor	Social housing/regeneration	40 min
6	Planning director	28	Main contractor	Building, transport infrastructure, civil engineering	50 min
7	Director	45	Consultant	Construction	35 min
8	Head of planning	20	Main contractor	Building construction	15 min
9	Regional manager	34	Main contractor	Building construction and civil engineering	20 min
10	Director	25	Main contractor	Building construction	30 min
11	Senior programme manager	11	Consortium	Infrastructure, construction	45 min
12	Director	40	Main contractor	Building construction and civil engineering	35 min
13	Head of project planning	20	Main contractor	Building and construction	30 min
14	Director	22	Consultants and contractor	Construction, infrastructure and engineering	30 min
15	Director	25	Main contractor	Construction	30 min

Note: * Number of years of experience in the construction industry.

time control during their projects. The application of cost control is more overwhelming with 84% of respondents indicating that they always apply their cost control method and 16% indicating that they frequently applied cost control methods to their projects. None of the respondents indicated that they rarely or do not use cost control techniques buttressing the importance placed on cost control by construction project practitioners in the UK. This confirms the suggestion of Sohail *et al.* (2002) that construction professionals seem to pay more attention to cost performance of projects than time performance.

The most popular time planning and control technique is Gantt Bar Chart, which is used by 35% of contractors and 33% of consultants (Table 4). This is closely followed by Critical Path Method (CPM) used by 28% of contractors and 34% of consultants. The popularity of these techniques might be due to the fact that they are the most established techniques in the industry, though ease of use and applicability to the construction process can also be argued as being responsible for their popularity. Other used techniques include the Milestone Date Programming Technique, Program Evaluation Review Technique (PERT), Precedence Network Diagram (PND), Elemental Trend Analysis/Line of Balance (LOB), and Simulation. The use of software support is widespread. Three clear leading applications are Microsoft Project, Asta Power Project and Primavera (Table 5). Microsoft Project is used by 35% contractors and 57% consultants; Asta Power Project by 44% of contractors and 19% of consultants; and Primavera by 15% of contractors and 19% of consultants.

Table 4 Techniques used for project planning and time control

Techniques	Contractors	Consultants
Gantt Bar Chart	35%	33%
Critical Path Networks/ Method (CPM)	28%	34%
Milestone Date Programming Technique	17%	17%
Program Evaluation and Review Technique (PERT)	10%	9%
Elemental Trend Analysis/ Line of Balance (LOB)	5%	2%
Precedence Network Diagram (PND)	2%	2%
Simulation	1%	3%

Table 5 Software packages used for project planning and time control

Software	Contractors	Consultants
Microsoft Project	35%	57%
Asta Power Project	44%	19%
Primavera	15%	19%
Project Commander	4%	5%
Deltek Open Plan	2%	–

The survey results in relation to cost control techniques used in practice are presented in Table 6. Unlike time control techniques where two methods were found to be dominant, cost control techniques are more diverse. Several techniques, such as project cost–value reconciliation, overall profit and loss, profit and loss at valuation dates, unit costing and earned value analysis, have some degrees of usage. However, none can be regarded as the overwhelming choice. Similarly, the use of support software is also more varied (Table 7). Some of the same time control packages are on the list, such as Microsoft Project and Asta Power Project. Others are specialist cost control software, including Project Costing System (PCS), Construction Industry Software (COINS) and WinQS. The general purpose Microsoft Excel spreadsheet is also used by some professionals. In fact, the largest option is bespoke/in-house systems, used by 29% of contractors and 38% of consultants.

Despite the wide application of cost and time control techniques and software, cost and time overruns are still quite common in construction projects. Table 8 shows the proportion of projects that suffer from this problem as reported by the leading contractors and consultants during this survey.

The proportion of respondents that experience overrun on just less than 10% of their projects is 38% for time overrun and 41% for cost overrun. This means that about 62% of respondents experience time overrun on 10% or more of their projects and 59% of respondents experience cost overrun on a similar magnitude of their projects.

In addition to finding out the current status of cost and time control practice and ascertaining existing overrun problems still besetting construction projects, the questionnaire survey seeks to identify the most important factors that inhibit the project control efforts of construction projects practitioners.

Table 6 Techniques used for project cost control

	Contractors	Consultants
Project cost–value reconciliation	22%	20%
Overall profit or loss	15%	16%
Profit or loss on each contract at valuation dates	17%	10%
Labour/plant/material (actual versus forecast reconciliation)	18%	11%
Unit costing	8%	13%
Standard costing	6%	14%
Earned value analysis	7%	11%
Program Evaluation and Review Technique (PERT/COST)	7%	4%
Leading parameter method	–	1%

Table 7 Software packages used for project cost control

	Contractors	Consultants
Bespoke/in-house systems	29%	38%
Microsoft Project	20%	32%
Project Costing System (PCS)	15%	11%
Asta Power Project	15%	5%
Primavera Sure Trak	8%	5%
Microsoft Excel	7%	3%
COINS	5%	3%
WinQS	–	3%

Table 8 Proportion of projects that encounter cost and time overruns

Proportion of projects	Time overrun	Cost overrun
> 90%	2.9%	4.4%
60–90%	1.5%	7.4%
40–60%	8.8%	11.8%
10–40%	48.5%	35.3%
< 10%	38.2%	41.2%

Identify top inhibiting factors

Prior to the survey, a literature review helped to identify most of the common factors that often lead to project cost and time overruns. In total more than 60 factors were initially identified from different studies. Some of these factors are related or overlap each other. After an analysis, 20 factors were shortlisted for the survey. These factors and their sources are outlined in Table 9.

These identified factors were presented to respondents in the questionnaire using this question: 'Please rate the level of importance for each of the following factors in affecting your ability to effectively control the time of your construction projects'. In the same way, a question was also asked separately about cost control. Respondents were asked to rank the factors, using a Likert scale, as 'extremely important', 'important', 'unimportant' or 'extremely unimportant'. Respondents were also asked to include and rate other factors they think should be among the factors put forward to them. It should be mentioned that only a few additions were made to the list, and these additions were always related to one or more of the 20 factors originally presented to the respondents. Responses were simplified to facilitate analysis by assigning numerical values of 1 to 4 to the ratings as follows: 'extremely important' = 4, 'important' = 3, 'unimportant' = 2, 'extremely unimportant'

Table 9 Identified project cost and time control inhibiting factors and classification

Factors	Sources
Inflation of prices	Arditi *et al.* (1985), Kaming *et al.* (1997), Aibinu and Jagboro (2002), Kuruooglu and Ergen (2000), Ogunlana *et al.* (1996), Frimpong *et al.* (2003)
Fluctuation of currency/exchange rate	Dlakwa and Cuplin (1990), Sonuga *et al.* (2002), Aibinu and Jagboro (2002), Mansfield *et al.* (1994), Arditi *et al.* (1985), Baloi and Price (2003)
Unstable government policies	Sonuga *et al.* (2002), Faniran (1999), Iyer and Jha (2005), Kuruooglu and Ergen (2000), Baloi and Price (2003)
Weak regulation and control	Koushki *et al.* (2005), Arditi *et al.* (1985), Kartam *et al.* (2000)
Unpredictable weather conditions	Kaming *et al.* (1997), Koushki *et al.* (2005), Iyer and Jha (2005), Al-Momani (2000), Frimpong *et al.* (2003), Yogeswaran *et al.* (1998)
Dependency on imported materials	Mansfield *et al.* (1994), Sonuga *et al.* (2002), Arditi *et al.* (1985), Frimpong *et al.* (2003)
Low skilled manpower	Dlakwa and Cuplin (1990), Kaming *et al.* (1997), Kuruooglu and Ergen (2000), Assaf *et al.* (1995), Koushki *et al.* (2005), Kumaraswamy and Chan (1998), Arditi *et al.* (1985), Kartam *et al.* (2000)
Risk and uncertainty associated with projects	Egbu *et al.* (1998), Flyvbjerg *et al.* (2003), Baloi and Price (2003), Chan *et al.* (2001)
Unstable interest rate	Mansfield *et al.* (1994), Dlakwa and Cuplin (1990)
Lack of proper training and experience of PM	Iyer and Jha (2005), Kuruooglu and Ergen (2000), Assaf *et al.* (1995), Arditi *et al.* (1985), Kartam *et al.* (2000), Frimpong *et al.* (2003), Ling (2004)
Lack of appropriate software	Lee *et al.* (2005), Iyer and Jha (2005)
Inaccurate evaluation of projects time/duration	Dlakwa and Cuplin (1990), Kaming *et al.* (1997), Assaf *et al.* (1995), Chang (2002), Mansfield *et al.* (1994), Kumaraswamy and Chan (1998), Ogunlana *et al.* (1996), Frimpong *et al.* (2003)
Non-performance of subcontractors and nominated suppliers	Mansfield *et al.* (1994), Kumaraswamy and Chan (1998), Yogeswaran *et al.* (1998), Ling (2004)
Project fraud and corruption	Sonuga *et al.* (2002), Baloi and Price (2003)
Design changes	Mansfield *et al.* (1994), Dlakwa and Cuplin (1990), Kaming *et al.* (1997), Assaf *et al.* (1995), Chang (2002), Lee *et al.* (2005), Ogunlana *et al.* (1996), Kartam *et al.* (2000), Al-Momani (2000)
Financing and payment for completed works	Mansfield *et al.* (1994), Faniran (1999), Assaf *et al.* (1995), Ogunlana *et al.* (1996), Arditi *et al.* (1985), Frimpong *et al.* (2003)
Complexity of works	Egbu *et al.* (1998), Kaming *et al.* (1997), Baloi and Price (2003)
Discrepancies in contract documentation	Dlakwa and Cuplin (1990), Kumaraswamy and Chan (1998)
Contract and specification interpretation disagreement	Dlakwa and Cuplin (1990), Assaf *et al.* (1995), Al-Momani (2000)
Conflict between project parties	Iyer and Jha (2005), Kumaraswamy and Chan (1998), Kartam *et al.* (2000), Al-Momani (2000)

= 1. This four-point scale was converted to a relative importance index (RII) for each individual factor, using the following formula, as adopted by Chan and Kumaraswamy (1997) and Kumaraswamy and Chan (1998), Assaf *et al.* (1995) and Iyer and Jha (2005):

$$\text{Relative importance index (RII)} = \Sigma\, \mathrm{w} \div (\mathrm{H} \times \mathrm{N}) \quad (1)$$

where w is the total weight given to each factor by the respondents, which ranges from 1 to 4 and is calculated by an addition of the various weightings given to a factor by all the respondents; H is the highest ranking available (i.e. 4 in this case); and N is the total number of respondents that have answered the question.

Table 10 gives the RII of the factors that are considered by practitioners as affecting their ability to control time of construction projects. The factors have been assigned ranks in relation to their RII. The table indicates that 'design changes' is considered as the most important factor that inhibits the ability of practitioners to control the time duration of their projects with an RII of 0.94. This was followed by 'inaccurate evaluation of project's time/duration' with an RII of 0.86. The other factors making up the leading top 10 factors in order of the ranking are: complexity of works (RII of 0.86), project risks and uncertainties (RII of 0.85) and non-performance of subcontractor and suppliers (also RII of 0.85), lack of proper training and experience of

Table 10 Ranking of factors inhibiting effective project time control

Time control inhibiting factors	Rank	RII
Design changes	1	0.94
Inaccurate evaluation of project's time/duration	2	0.86
Complexity of works	3	0.86
Risk and uncertainty associated with projects	4	0.85
Non-performance of subcontractors and nominated suppliers	5	0.85
Lack of proper training and experience of PM	6	0.78
Discrepancies in contract documentation	7	0.77
Low skilled manpower	8	0.74
Conflict between project parties	9	0.74
Unpredictable weather conditions	10	0.74
Financing and payment for completed works	11	0.73
Contract and specification interpretation disagreement	12	0.71
Dependency on imported materials	13	0.66
Lack of appropriate software	14	0.61
Inflation of prices	15	0.58
Weak regulation and control	16	0.55
Project fraud and corruption	17	0.50
Unstable government policies	18	0.47
Unstable interest rate	19	0.46
Fluctuation of currency/exchange rate	20	0.45

Table 11 Ranking of factors inhibiting effective project cost control

Cost control inhibiting factors	Rank	RII
Design changes	1	0.94
Risk and uncertainty associated with projects	2	0.89
Inaccurate evaluation of project's time/duration	3	0.86
Non-performance of subcontractors and nominated suppliers	4	0.82
Complexity of works	5	0.81
Conflict between project parties	6	0.81
Discrepancies in contract documentation	7	0.80
Contract and specification interpretation disagreement	8	0.80
Inflation of prices	9	0.79
Financing and payment for completed works	10	0.78
Lack of proper training and experience of PM	11	0.77
Low skilled manpower	12	0.69
Unpredictable weather conditions	13	0.68
Dependency on imported materials	14	0.65
Lack of appropriate software	15	0.62
Unstable interest rate	16	0.59
Fluctuation of currency/exchange rate	17	0.58
Weak regulation and control	18	0.58
Project fraud and corruption	19	0.55
Unstable government policies	20	0.48

the PM (RII of 0.78), discrepancies in contract documentation (RII of 0.77), low skilled manpower (RII of 0.74), conflict between project parties (also RII of 0.74) and unpredictable weather conditions (also RII of 0.74). It will be noticed that some factors have the same RII; in a bid to determine the factor with the higher rank, the factor with the greatest number of 'very important' ranking was ranked higher, hence for example inaccurate evaluation of project time duration was ranked higher than complexity of works even though both have an RII of 0.86.

Table 11 shows the result for cost control. It is interesting that 'design changes' also came top as the most important factor that affects the ability to control cost of construction projects with a RII of 0.94, 'risk and uncertainty associated with projects' was ranked second with and RII of 0.89, while 'inaccurate evaluation of project's time/duration' (RII of 0.86) was closely ranked next. Other leading factors making up the top 10 ranking in order of their importance are non-performance of subcontractors (RII of 0.82), complexity of works (RII of 0.81), conflict between project parties (RII of 0.81), discrepancies in contract documentation (RII of 0.80), contract and specification interpretation disagreement (RII of 0.08), inflation of prices (RII of 0.79) and financing and payment for completed works (RII of 0.78).

When the rankings of the top factors inhibiting the ability to control time of construction projects are compared to the top factors inhibiting cost control, there appears to be a great similarity. Top of the list on both Table 1 and Table 2 is 'design changes'. Design change is undoubtedly considered the most important factor that inhibits the ability to control cost and time of construction projects. This is no surprise because design changes will normally have a cost and time implication and if the process of design change is not well managed it will undoubtedly affect the schedule negatively as well as the cost of the project. Frequent and haphazard design change requests during a project can often be a major bottleneck to effective control. A more critical analysis of Tables 1 and 2 reveals that six of the top seven factors ranked as inhibiting time control and cost control are the same. Even more interesting is the fact that the top five project time control inhibitors and the top five cost control inhibitors are basically made up of the same factors.

The factors that were ranked lowest as inhibiting time control are: weak regulation and control; project fraud and corruption; unstable government policies; unstable interest rate; and fluctuation of currency/exchange rate. Interesting, these factors also make up the five lowest ranked factors inhibiting cost control. This shows that there seems to be an obvious similarity between the time control rankings and the cost control rankings. To statistically ascertain this observation, an inferential statistical test was conducted on both sets of rankings using the Spearman rank correlation coefficient to test the agreement or disagreement between the two rankings. The Spearman rank correlation is a non-parametric test. The correlation coefficient varies between +1 and −1, where +1 signifies perfect positive correlation and −1 shows a perfect negative correlation or disagreement. The formula for the Spearman rank correlation is given by the equation below:

$$r_s = 1 - (6\Sigma d_i^2 / (N^3 - N)) \tag{2}$$

where r_s is the Spearman rank correlation coefficient, d_i represents the difference between ranks for each case and N is the number of subjects or pairs of ranks (Weinberg and Abromowitz, 2008). The result of this test is 0.88, showing a strong positive correlation and indicating a strong agreement between the ranking of time control inhibiting factors and cost control inhibiting factors. This is similar to the finding of Chang (2002) who argued that it is difficult to separate the reasons causing overrun between cost and schedule, concluding that the reasons for cost increases are normally also the reasons for time extensions. Hence it can also be rightly argued that the factors that inhibit effective time control of projects are also likely to inhibit effective cost control.

Develop mitigating measures

Following the analysis of the survey results, the identified top project control inhibiting factors were investigated in greater depth by interviewing experienced practitioners in a bid to find out the reasons why they make project control more difficult. This subsequently led to the development of a list of measures that can be used to mitigate these factors. This stage of the study was achieved through a series of in-depth interviews, which is already described in the research methods section. It was necessary to limit the scope of this part of the study in order to achieve sufficient depth. The top five inhibiting factors were selected as the main focus because of their importance and the fact that they are common for both cost and time control.

The use of semi-structured interviews provided a rich source of information on the experiences of practitioners in relation to these factors and the various reasons why they make project control difficult. In order to maximize the usefulness of the interview sessions they were structured in a way that allowed for flow of questions. The same questions were asked in all interviews for objectivity and ease of analysis. The questions were open ended in order to allow practitioners to fully express themselves albeit in a structured way. The interview sessions started with questions about practitioners' understanding of the concept of project control, leading to a discussion of how cost and time are controlled in their organizations and the bottleneck to this process before finally leading to a discussion on each of the top five identified project control inhibiting factors. No distinction was made between the findings obtained from practitioners from contracting organizations and those from construction consultancies because the questionnaire survey showed no statistical difference between most of their project control practices; the contractors' and consultants' ranking of the inhibiting factors is also statistically in agreement (Yakubu and Sun, 2009). The study is also not aimed at finding out if there is any difference in their experiences; rather, as previously mentioned, the interviews are geared towards exploring in greater depth issues surrounding the leading inhibiting factors in practice with a view to establishing measures that can be used to specifically tackle the problems they pose in relation to project control. The interviews were all transcribed and after which mitigating measures were synthesized from a detailed analysis of the interview transcripts.

It is worth noting that, although the measures have been called 'identified' practices, it is important to bear in mind that the measures were not cherry picked from the interviews; rather, a process was embarked upon that enabled the measures to be established. This process involved analysis of the interview transcripts and through varying quotes from the interviews some emerging problems or needs of the interviewees were revealed. These problems were critically evaluated taking into consideration the literature that has been reviewed in the subject area, the result of the questionnaire survey, etc., after which measures that can be used to mitigate the identified problems were developed. These measures were then assessed to determine where they can best be categorized according to the five leading inhibiting factors and nature of the measures. Figure 1 depicts the process of developing the measures.

A total of 90 measures that can be used to mitigate the effect of the top five leading project cost and time control inhibitors were identified. These measures were critically examined in a bid to find out if a classification system could be developed for them. A critical investigation of the measures revealed that they can be categorized according to the broad function they

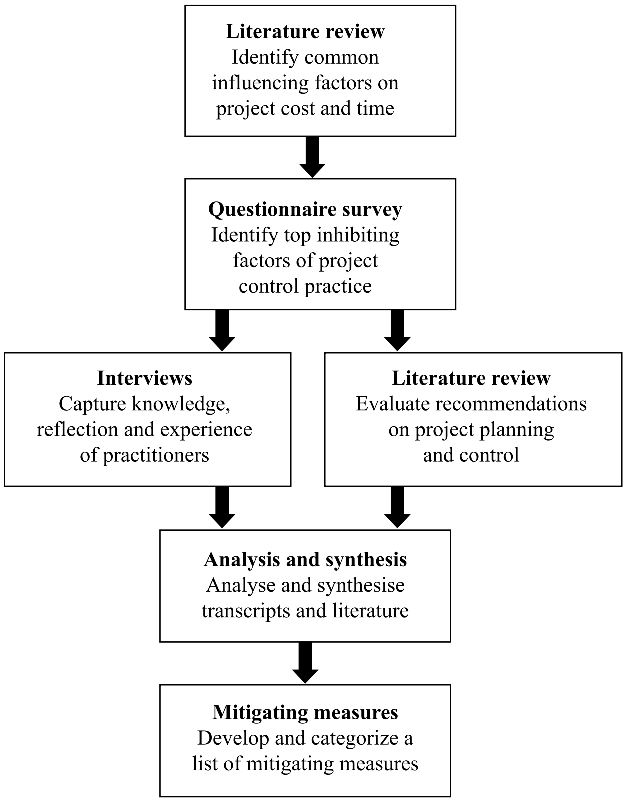

Figure 1 Process of developing the mitigating measures

perform leading to the development of the following classification:

- *Preventive measures*: These are precautionary measures that are put in place as a defence to the inhibiting factors. Most of these measures are active measures that would be put in place during the planning stage of a project. For example a preventive measure against the problem of design changes relating to cost and time of projects is to ensure that the project is designed in great detail at the outset while a preventive measure for risk and uncertainty is to properly identify the project risks before the project starts and devise a strategy for managing them should they come to fruition.
- *Predictive measures*: These may seem similar to preventive measures but they are not the same. Predictive measures are put in place in order to spot potential problems in the control process in the future so that they can be stopped from happening or they can be prepared for should they happen. Most of these measures actually utilize some tools or techniques to look into the current situation in a bid to spot potential future problems. For example using 4D modelling (3D plus time dimension) to test how the plan (programme) will work out is a predictive measure that could be used for the mitigation of complexity of works.
- *Corrective measures*: These are measures that are utilized to mitigate the effect of the project control inhibiting factors by acting as a remedy. These measures are reactive measures that only effected after the event. They may not be as efficient as preventive or predictive measures but they aim to bring the situation back on track or at least 'stop the rot'. These measures have also been further classified as: corrective-preventive measures which are meant to correct and in the process prevent future problems and corrective-predictive measures which remedy the current situation but then go on to predict what the situation is going to be in the future using current information.
- *Organizational measures*: These measures generally encompass practices that go wider than the actual control process but have an effect on project control; they are normally in place because of the company's belief, orientation, management style or philosophy; they have a tendency of not being specific to one project but would normally affect all projects being undertaken by the company as they reflect how the wider organization works. A good example is the philosophy of the company in relation to partnering and collaborative working.

Some measures are fluid and can sometimes look as though they can be classified into more than one category depending on their actual usage during the project. Consequently this classification is not set in stone and should be seen as a first attempt at categorizing the various good practices that can be used for mitigation of these leading project (cost and time) control inhibiting factors.

Design changes

Design change is overwhelmingly the top project cost and time control inhibiting factor from the questionnaire survey results analysis. This was also the case during the interviews as it was acknowledged by practitioners during the interviews as being a major obstacle to effective project cost and time control.

The main issues revealed during the interviews include the following:

- The impact of a design change on project cost and programme is often underestimated.
- The design group is often not able to provide the information in time, which results in difficulty of design management.
- There is a general decline in the production of detailed design, which is perceived as one of the

the greatest causes of design changes especially with the increased usage of the design and build procurement route.

- Lack of detailed design specification leads to the contractor pricing the risk but also looking for every loophole in the specification document to increase cost, reduce specification, etc.
- There is a lack of clear distinction between design change and design development. As a result, project partners often argue whether a design change is actually a change or a development where there would not be the need for additional cost and time compensation.

A lot of good practices that can be employed by practitioners to mitigate the effect of design changes on project cost and time control also emerged during this stage and are presented in Table 12. Some of these include simple practices like ensuring that the time and cost implication of any design change are fully evaluated before sanctioning a design change; ensuring the domino effect of a design change is efficiently analysed as one change can lead to other changes; and ensuring that design changes are requested or made only by authorized persons.

Risks and uncertainties

Risks arise from uncertainty and are generally interpreted as factors that have an adverse effect on the achievement of the project objectives (Smith, 2002). Cooke and Williams (2004) noted that construction is undeniably a risky business for many reasons, including poor records of cost and time certainty. Little wonder this was ranked as a leading factor inhibiting effective project cost and time control. The problem of risks in a project is well documented and has been covered by numerous studies; it is therefore not covered in this section. What this section does is to bring to light the

Table 12 Mitigating measures for 'design changes'

	Practice	Type of measure
1	Clear distinction between a design change and a design development at the outset of a project	Preventive
2	Ensuring the cause of a design change is always determined	Corrective-predictive
3	Determination of the provision of the design change within the building contract	Corrective
4	Identification of potential design changes as a risk and devising a strategy for managing the risk especially in design and build projects	Predictive
5	Ensuring the time and cost implication of a design change is always determined and agreed before going ahead with the change whenever possible	Corrective-preventive
6	Notification of all the relevant project parties of how they will be impacted and the schedule and cost implication of a design change before going ahead with the change	Preventive
7	Freezing design at the appropriate stage of a project or implementing intermediate design freezes at various project stages depending on the type of contract	Preventive
8	Designing the project in great detail at the outset whenever possible	Preventive
9	Provision/allocation of enough resources (labour, equipment, etc.) to cope with a design change	Corrective
10	Design changes should be adequately highlighted and updated on all relevant project documentations (e.g. drawings, specifications, reports, etc.)	Preventive
11	Agreeing and putting in place change management procedure before the commencement of projects (incorporating this into the contract if possible)	Organizational
12	Ensuring prompt resolution to design change queries, issues and authorization requests	Preventive
13	Capturing all design change on a register with corresponding cost and schedule implications for discussion during project team meetings	Corrective-predictive
14	Having a design manager where possible with responsibility for the management of the design change process and reviewing related information as it comes in	Preventive
15	Ensuring no one makes a design change without the knowledge or authorization of the relevant project party, e.g. project manager	Preventive
16	Open discussion by the relevant project party before the project starts about how design changes will be managed and incorporating this into the contract if possible	Organizational
17	Efficient analysis of the direct and indirect consequence (domino effect) of a design change on other activities or areas of the project as one change can precipitate other changes	Corrective-predictive
18	Ensuring design changes are reasonably timed when possible, e.g. late design changes may greatly impact the ability to control the project cost and schedule	Preventive

Table 13 Mitigating measures for 'risks and uncertainties'

	Practice	Type of measure
19	Having a risk register in place for the project as early as possible (e.g. from tender stage)	Preventive
20	Proper identification, allocation and management of risks	Preventive
21	Assigning cost and/or time implication to all identified risks on the risk register whenever possible	Predictive
22	Ensuring the risk register is open to all relevant members of the project team	Preventive
23	Having a strategy already developed for solving each of the identified risks in case they come to fruition	Corrective
24	Conducting a risk workshop involving all relevant project parties at the outset of the project in order to identify potential risks	Predictive
25	Encouraging, emphasizing and striving for a risk sharing regime when possible (it may aid in buttressing partnership and openness among the project parties)	Organizational
26	Risks not being used to mask project problems or deficiency in planning	Organizational
27	Ensuring risk management is a sincere and open exercise	Organizational
28	Looking out for opportunities to improve cost and time performance during risk analysis	Corrective
29	The risk register not being solely kept in the corporate office but communicated to the construction management and site team as well	Organizational
30	Reviewing the risk register at all relevant progress meetings including meetings with the site based team	Organizational
31	Making sure the risk register is a live document that is updated regularly	Predictive
32	Running a risk analysis on the schedule using a schedule-quantities-risk-analysis (SQRA) on the project at an early stage when possible	Predictive
33	Risks that are closed out on the risk register not taken off but used to inform as the project progresses and on other projects	Predictive

emergent themes in relation to the perception of practitioners on how risks and uncertainties inhibit their ability to effectively control the cost and time of their projects and the best practices used to mitigate this problem. The emergent themes from the interviews are as follows:

- Early identification of risk at the outset of a project is considered absolutely essential for project cost and time control to be effective.
- Risks and uncertainties are not often managed using sophisticated quantitative risk management systems; rather, risks are identified through brainstorming sessions, risk workshops and analysed qualitatively.
- The risk register is the most commonly used tool for risk management but most times this is not kept a live document through regular review. Quite frequently it is left as an idle document and this does not bode well for effective project control.
- Risks are mostly not allocated a cost and time implication during risk management and this can often make it difficult to assess their impact on the cost and time objectives of construction projects during control.

The common good practices that were established from the interviews for the mitigation of the problem of risk and uncertainties during project control are shown in Table 13.

Inaccurate evaluation of project time duration

The whole essence of controlling a project is to ensure delivery within a predetermined time and evaluating how long it will take to complete a project is the starting point of project control because it serves as a baseline to measure against. The interviews conducted showed that:

- The main reason why inaccurate evaluation of project time/duration emerged as one of the leading factors inhibiting effective project cost and time control is that project time is often evaluated without any scientific basis; quite often programmes are drawn up on gut feeling.
- Practitioners are usually under pressure from clients to deliver projects, especially commercial speculative projects within unachievable timescales, which are often accepted by the professional team without a clear idea of how this will be actualized leading to project overruns and ultimately client dissatisfaction.
- Programmes of works are often developed by inexperienced planners or by those that have only become planners because of their expertise in the

Table 14 Mitigating measures for 'inaccurate evaluation of project time duration'

	Practice	Type of measure
34	Ensuring the project planner is well trained in the construction process	Organizational
35	Preparation of the project programme with input from the construction site management/ production team	Preventive
36	Developing the programme (schedule) using science based methods augmented by experience and not relying on gut feeling alone	Preventive
37	Educating and advising client on alternative if an unachievable/unrealistic project timescale is stipulated	Preventive
38	Having the courage to refuse unrealistic project timescale by clients unwilling to yield to professional advice	Organizational
39	Developing the project programme of works using experienced planners that have appreciation of the various construction disciplines	Preventive
40	Conducting a process mapping exercise to validate the time allocated to a project	Predictive
41	Ensuring enough time is allocated during tender planning for the proper development of the project programme	Preventive
42	Making sure when possible that the programme is developed by or in conjunction with someone that is experienced in the relevant type of project	Preventive
43	Swiftly informing the relevant project parties if unforeseen circumstances affect the programme/lead-in times	Corrective
44	Making sure the programme is built up from the first principle using metrics of how long typical activities take rather than using assessment only (ensuring that the time allocated to activities is quantifiable)	Preventive

use of scheduling software packages—they do not have a good appreciation of the construction process and this leaves much to be desired in the programmes produced.

Table 14 shows the good practices that emanated from the interviews for mitigation of this inhibiting factor. The most important mitigating measure as agreed by all practitioners is obviously ensuring that the project time forecast and cost budget are realistic in the first place because if they are not, then controlling the project is already a lost cause.

Complexity of works

Project complexity can be defined as a single factor or combination of factors that affect the standard response/actions taken to achieve the project outcomes (Wood and Ashton, 2009). Construction projects may sometimes involve some form of complexity and may not be straightforward; this can sometimes presents a challenge for effective cost and time control. According to the CIOB (2008), complex construction projects in the UK are likely to be finished more than six months late, due to poor time control. It is therefore no surprise to see it rank as one of the top factors inhibiting effective construction project cost and time control. The prevalent issues that emanated from the interviews include:

- Interface issues in projects, for example the interface of different project stages, phases or different trades, are often the main cause of complexity during the implementation of construction projects.
- Complex projects are often not adequately understood before embarking on them and this only increases the negative effect of complexity during project cost and time control.
- Not understanding how the complexities involved in a project are interrelated, which is vital for the management of the whole construction process, is another reason why complexity is so detrimental to effective project control.
- Breaking down projects into manageable chunks would naturally aid effective cost and time control of complex projects.
- Adequate planning is absolutely essential in mitigating the effect of complexity of works but enough time is often not made available for planning due to the haste of going to site after tender.

Table 15 shows the full list of the mitigating measures for complexity of works.

Non-performance of subcontractors

The importance of subcontractors cannot be overemphasized in construction projects. According to Walker and Wilkie (2006) subcontract services in general can form the greater part of any construction project, with many contractors opting to subcontract the whole of

Table 15 Mitigating measures for 'complexity of works'

	Practice	Type of measure
45	Breaking the project down into manageable chunks	Preventive
46	Making sure the project is properly understood before embarking on it	Preventive
47	Detailed review of the information relating to the work before embarking on it	Preventive
48	Developing a project execution plan for the work before starting on it	Preventive
49	Having enough resources to deal with the complexity	Corrective
50	Allocating to the project experienced personnel that have handled similar type of complexity in the past	Preventive
51	Incorporating longer lead-in time/sufficient time for complex works or phases of the project	Preventive
52	Ensuring as much design as possible is done for the complex work or project before commencing	Preventive
53	Ensuring adequate coordination of design and activities preceding and following the complex work	Preventive
54	Calling in specialists to advise and contribute to the planning and management of complex works/projects	Preventive
55	Utilizing in-house expertise for the management of complex projects	Preventive
56	Conducting workshops and brainstorming session to generate ideas and for problem-solving before and during the complex work/project	Predictive
57	Overlaying a risk analysis process specifically for a complex phase or activity in a project	Predictive
58	Ensuring where possible and practical that one team runs with the complex work/project from beginning to the end	Organizational
59	Thinking holistically when planning a complex project by considering logistics, interfaces, etc. e.g. having a preconstruction services department that will not only plan the project but take a holistic look at the project rather than just having planning department as customary	Preventive
60	Ensuring that when subcontractors are needed, the subcontractor with the capability to deal with the complexity is procured for the project	Preventive
61	Constantly monitoring the progress and being open minded to improving the programme and cost plan as things become clearer and to other options available	Predictive
62	Getting as much information on the complex part of the project and sequence all activities	Predictive
63	Ensuring every element of the design has an aspect on the programme and using 4D modelling to show how the work will be built (i.e. have a plan and test it to see how it works)	Predictive
64	Ensuring that when a complex project is broken down into manageable chunks how the complexities interact with each other is understood	Preventive
65	Building in the risk of delay and higher cost allowances for complex projects	Preventive

the works apart from the general or project management services. This is also widely acknowledged by a majority of the practitioners interviewed. Other focal issues that emanated from the interviews are detailed below:

- Non-performance of subcontractors was reiterated as a major obstacle to effective project control but attention was drawn to the fact that quite often, this is not necessarily the fault of the subcontractor but may be due to lack of effective management by the main contractor. For example not properly communicating the objective of the project to a subcontractor or not being able to identify non-performance early enough.
- The importance of a good working relationship between the contractor and subcontractors is considered essential in project control; the intensity of this relationship varies considerably in practice ranging from the most formal kind such as partnering contracts or framework agreements, to very loose forms such as just allowing subcontractors to use the same welfare facilities as the contractor's staff.
- Supply chain management is a widespread practice with many contractors having an ongoing relationship with subcontractors and suppliers in the hope of getting a slightly better level of service than normal including better performance.
- Contractors seem to be more vigilant about the financial buoyancy of potential subcontractors to ensure they are financially secure and will not go bankrupt by reason of the current credit crunch or underperform because of lack of capital.

- The contractual route of determining/terminating the appointment of a subcontractor is only taken as a last resort when a subcontractor is underperforming; other measures are often initially explored in a bid to remedy the situation.

The full list of synthesized measures for the mitigation of the problem of non-performance of subcontractors during project control is presented in Table 16.

Discussion

This study approached the influencing factors of project control from a new perspective. As previously mentioned a lot of previous studies in the area of project control have mainly focused on cost and time overruns, most especially their causes. Their findings are often influenced by the specific context of each

Table 16 Mitigating measures for 'non-performance of subcontractors'

	Practice	Type of practice
66	Properly directing the subcontractor to ensure they know what is expected of them in relation to the project	Preventive
67	Developing a good working relationship with subcontractors	Organizational
68	Putting a system in place for early identification of non-performance in subcontract works/packages in order to nip it in the bud as soon as possible	Predictive
69	Utilizing performance measurements, e.g. S-curve, KPI to monitor the output/performance of subcontractors on their work package	Predictive
70	Ensuring there is a committed supply chain that can be used	Organizational
71	Having a process in place that mutually allows non-performing subcontractors to be removed from the supply chain	Corrective
72	Ensuring there is a partnering/collaborative relationship with the subcontractor (this may ensure the subcontractor gives a better than normal service)	Organizational
73	Integration of subcontractors into the site management team (where possible, practicable and feasible) all through the course of the work	Organizational
74	Incorporating a progress-performance-payment rule in the subcontract where possible, e.g. that stipulates a certain amount can only be earned/paid when certain requirements have been met/a stage has been achieved in the project	Preventive
75	Having a stringent process in place for selecting subcontractors into the supply chain	Organizational
76	Involving where possible, subcontractors doing major/critical part of the project with the internal planning process, i.e. early involvement of relevant subcontractors, e.g. at pre-tender stage in order to advise on design before having cost and time implications (early engagement)	Preventive
77	Ensure there is a prompt system of payment to subcontractors for jobs that have been done (this boosts morale and may prevent financial difficulty by subcontractor)	Organizational
78	Build relationship and communicating at management/board level of the subcontractors' companies	Organizational
79	Holding significant retention on serial non-performing subcontractors as it may serve as a deterrent/be used to remedy any non-performance issue that may occur	Corrective
80	Reduction of the retention for trusted and the best performing subcontractors	Organizational
81	Finding and understanding the root cause of any non-performance and working with the subcontractor to see how to be of help	Corrective
82	Going through the different layers of the subcontractor's management to ensure that a non-performance situation is improved	Corrective
83	Avoiding the selection of the cheapest subcontractor if there is doubt on performance track record	Preventive
84	Taking time to understand the implementation strategy a subcontractor intends to adopt for a subcontract package and ensuring it fits well with the cost and time performance requirements of the project	Predictive
85	Making sure subcontractors are allocated adequate time to complete subcontract work packages	Preventive
86	Seeing the benefits in having a small but quality closely knit supply chain that is well known rather than having a large supply chain where subcontractors are hardly known	Organizational
87	Sharing with individual subcontractors their KPI results and reviewing their weaknesses with them so that they can improve on it going forward	Corrective-preventive

Table 16 *(Continued)*

	Practice	Type of practice
88	Having knowledge of the best projects the company's subcontractors are best able to undertake and allocate these to them and avoid giving subcontractors projects they are not good at	Preventive
89	Having a training system/regime in place for subcontractors in order to indoctrinate them in the ways of the company, e.g. control processes, tools and techniques, etc. (and they will have no excuses to say they don't know what you want)	Organizational
90	Having more than one subcontractor for a particular trade/package to encourage healthy competition	Organizational

study. Many researchers came up with quite different lists of top factors that have major impacts on cost and time. The survey results of this study reflect the current views of the leading practitioners in the UK. Another aspect that distinguishes this study from previous ones is that the survey during the first stage of the study seeks to identify the main factors that hamper project managers' ability to control cost and time, not just those that might have the biggest impact. It is interesting to find that the top five inhibiting factors are all project internal elements. This is in contrast to previous studies where many external aspects are often cited as the most important factors, such as inflation, material shortage, unforeseen ground conditions, inclement climate, etc. (Arditi *et al.*, 1985; Mansfield *et al.*, 1994; Kaming *et al.*, 1997; Kumaraswamy and Chan, 1998). The possible explanation for this is that although external factors are usually difficult to control or even beyond the control of project managers, the frequency of their occurrence is generally low. On the other hand, internal factors are persistent and require constant control.

The mitigating measures are distilled from in-depth interviews with very experienced project management practitioners. They are not simply selected from current best practice. They reflect what should be done to improve the current project control practice. For example in-depth interviews found that there has been a general decline in the production of detailed design for construction projects; and this is perceived as one of the greatest cause of design changes, the foremost bottleneck during the project control process. It was also revealed that there is often a lack of distinction between a design change and a design development leading to argument among project partners. In-depth interviews also brought to light the fact that clients contribute to the problem of project cost and time control by imposing unachievable and unrealistic timescales. These revelations led to the development of a number of mitigating measures, some of the measures developed on the back of these problems include: measure 8 (designing the project in great detail at the outset whenever possible), measure 1 (clear distinction between a design change and a design development at the outset of a project), measure 37 (educating and advising client on alternative if an unachievable/unrealistic project timescale is stipulated), measure 38 (having the courage to refuse unrealistic project timescale by clients unwilling to yield to professional advice). It was also revealed that quite often, the non-performance of subcontractors is not necessarily the fault of subcontractors but due to lack of effective management by the main contractor. The mitigating measures that stemmed from this include: measure 66 (properly directing the subcontractor to ensure they know what is expected of them in relation to the project), measure 68 (putting a system in place for early identification of non-performance in subcontract works/packages in order to nip it in the bud as soon as possible) and measure 69 (utilizing performance measurements e.g. S-curve, KPI to monitor the output/performance of subcontractors on their work package).

The development of the mitigating measures also built on the existing studies on good but often generic project management practices. For example several previous studies revealed that the woolly area of design change and design development is one of the key reasons why design change is considered a barrier to effective cost and time control. To combat this, Kartam *et al.* (2000) recommended that end user requirement should be closely coordinated in the early phase of the project and more attention should be given to managing this requirement during the construction phase. This is similar to some of the mitigating measures identified in this study but this study has gone further by making them more specific to the project control process. For example measures 8, 15 and 18 in Table 12 have been made specific for mitigation of design changes during the project control process. Another mitigating measure for design change is measure 11 (agreeing and putting in place change management procedure before the commencement of projects, incorporating this into the contract if possible). This measure was also buttressed by a number of studies in different ways. For example Lee *et al.* (2005) identified project change management as a critical practice that has important impacts on both cost and schedule performance of projects. Ling *et al.* (2009) in the study of key project management practices affecting project performance found that the most important practices that are significantly correlated with project performance relate to scope management and recommended that emphasis must be given to scope management in order to achieve superior project performance. Similarly Zou and Lee (2008) used multiple one-way ANOVA and linear regression to investigate the effectiveness of change management practice elements in controlling project change cost and found among other things that using change management practices is truly helpful in lowering the proportion of change cost in project actual cost. On the other hand, Kog *et al.* (1999) identified key determinants for construction schedule performance and discovered among other things, that having a constructability programme is a key determinant to construction schedule performance. A constructability programme was described in the study as the application of a disciplined and systematic optimization of construction-related knowledge during the planning, design procurement and construction stages by knowledgeable experienced construction personnel who are part of the team. Measures 34, 35, 36 and 42 in Table 14 developed for the mitigation of inaccurate evaluation of project time duration are specific practices that will go a long way towards ensuring the development of a constructability programme.

The mitigating measures are the result of a three-stage research process. It will be wrong to assume that these measures are identified from only a small number of interviews. In fact, the interview is just the last stage of the development of these measures in a three-stage process involving literature review, questionnaire survey, intellectual thinking and finally the interviews which acted as a way of putting some *practicality* into the mitigating measures by drawing from the real-life experiences of interviewees. It should also be pointed out that the interviews did not ask practitioners about their experience of a single project or a single company but drew on their experiences of many projects they have worked on. This approach has been adopted by related studies such as Kartam *et al.* (2000), Gao *et al.* (2002) and Sohail *et al.* (2002). For example Sohail *et al.* (2002), in a study aimed at developing monitoring indicators for urban micro contracts, began by examining archival records of projects, then used a questionnaire survey to generate more data, conducted interviews to gain more in-depth understanding of the situation, after which the monitoring indicators were eventually developed by inferences made from analysis of interviews, archival records and questionnaires. While these mitigating measures can contribute to the improvement of project control in practice, there are also some limitations. There is a need to integrate the implementation of these measures into project control models. Some of these measures outline what needs to be done, but do not address how it can be achieved. Issues like these need to be investigated in future research.

Conclusions

A combination of questionnaire survey and in-depth interviews has been used to provide useful information on issues surrounding project control in practice in the UK. Issues such as the degree of application of project controls, the most commonly used time and cost control techniques, supporting software packages, frequency of time and cost overrun, the leading inhibiting factors to effective cost and time control, the reasons for these and measures that can be used for their mitigation were brought to light.

The top five factors inhibiting time and cost control in construction practice in the UK were revealed as design changes; risks and uncertainties; inaccurate evaluation of project time/duration; complexity of works; and non-performance of subcontractors. Design change is the single most important factor considered by practitioners as hindering the ability to control not only time of construction projects but also cost. In fact, it is found that there is a high level of correlation between the inhibiting factors for cost control and time control. Following the identification of the inhibiting factors, 90 mitigating measures are established to address potential problems caused by the top five inhibiting factors. The measures can be broadly classified as preventive, predictive, corrective and organizational measures. These measures are by no means exhaustive as there will obviously be numerous practices out there that have not made the list. It is also worth noting that the measures may seem obvious to the experienced practitioner but will be useful to the less experienced and people new to the project management profession. The study should be viewed as the first effort of developing solutions for mitigating leading cost and time control inhibiting factors. Clearly, further development is needed to cover more inhibiting factors beyond the top five. In addition, the effectiveness of these mitigating measures during the project control process needs to be investigated in future research.

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