COBRA2009

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The construction and building research conference of the Royal Institution of Chartered Surveyors held at the University of Cape Town, 10-11 September 2009

The RICS COBRA Conference is held annually. The aim of COBRA is to provide a platform for the dissemination of original research and new developments within the specific disciplines, sub-disciplines or field of study of:

Management of the construction process

- Cost and value management
- Building technology
- Legal aspects of construction and procurement
- Public private partnerships
- Health and safety
- Procurement
- Risk management
- Project management

The built asset

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- Urban development
- Planning and property markets
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The property industry

- Information technology
- Innovation in education and training
- Human and organisational aspects of the industry
- Alternative dispute resolution and conflict management
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Kathy Michell	University of Cape Town
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The CIB W113 Law and dispute resolution session was aranged and conducted by Paul Chynoweth of the Univeristy of Salford, UK

Peer review process

All papers submitted to COBRA were subjected to a double-blind (peer review) refereeing process. Referees were drawn from an expert panel, representing respected academics from the construction and building research community. The conference organisers wish to extend their appreciation to the following members of the panel for their work, which is invaluable to the success of COBRA.

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An evaluation of the budgetary reliability of bills of quantities in building procurement

Henry Odeyinka[1] and Shane Kelly

[1] School of Built Environment,
University of Ulster, Shore Road, BT370QB, United Kingdom
E-Mail: H.Odeyinka@ulster.ac.uk

and

Srinath Perera[2]

[2]School of Built Environment,
Northumbria University, Newcastle, NE18ST, United Kingdom

Abstract:
Bills of quantities have been documented to exist in some form or another as far back as when the Egyptian pyramids were being constructed. In spite of that age long history, the bills of quantities (BOQ) seems to be the most misinterpreted aspects of building documentation today. The pros and cons of the bills of quantities have been deliberated on for many years and have generated strongly held and differing views. Whilst this is recognised, the essence of this study is to evaluate the reliability of bills of quantities in building project procurement. The study was carried out using secondary data from some recently completed building projects within the Northern Ireland construction industry. Using secondary data from completed projects, the budgetary reliability of the bills of quantities in building project procurement was investigated. Data analysis was carried out using percentage deviation of final account figures from the bills of quantities. Further analyses were carried out using root mean square deviation and relative mean absolute deviation methods of analyses. Results showed that the budgetary reliability of the bills of quantities seems to vary depending on project types. Whilst a deviation of -3 to 4% was obtained on housing projects analysed, the deviation on educational projects was between -4 and 17% whist on commercial project, it came out to be between -20 and 20% and in the case of refurbishment projects, a deviation of between -11 and 37% was obtained. This seems to suggest that the more complex a project is, the less reliable it is to use the BOQ to guarantee cost certainty.

Keywords: Bills of quantities, budget, building projects, reliability, traditional procurement

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[1] Author for Correspondence, E-Mail: H.Odeyinka@ulster.ac.uk

1. Introduction

Bill of quantities (BOQ) in traditional contracting according to Seeley (1997) is a document itemising all potential works in a construction project and their estimated quantities. According to Davis et.al. (2009), the bill of quantities is usually produced by the quantity surveyor based on drawings and specifications prepared by the Architect. According to them, the contractor tenders against the BOQ, stating his price for executing each item of work. The total of the contractor's prices, added to his prices for the various items in the Preliminaries, forms the contract sum. According to Ramus et. al. (2006) the contract sum cannot be varied just because the actual quantities differ from those in the bills of quantities, so the contractor must satisfy himself that the quantities shown are at least approximately correct.

Bills of quantities have been documented to exist in some form or another as far back as when the Egyptian pyramids were being constructed (Pheng and Ming, 1997). In spite of that age long history, the bills of quantities seems to be the most misinterpreted aspects of building documentation today. The pros and cons of the bills of quantities have been deliberated on for many years and have generated strongly held and differing views. According to Davis et.al. (2009), one of the strong arguments against the use of the BOQ is that it can only accurately price the materials and labour of a project at a given time. According to them, outside the scope of materials and labour, there are additional costs of preliminaries which consist of insurances, site set up, items of plant and so on. These costs according to Davis et.al. (2009), are in some cases priced on the basis of a percentage of the total material and labour costs. Pheng and Ming (1997) view the uncertainty of being able to price items such as preliminaries accurately as a downfall of the bill of quantities. Brewer (1998) among others felt that nothing divides the construction industry quite so much as the argument over the use of Bills of Quantities. According to him, the rules on which a bill of quantities is based does not allow items to be measured accurately enough, thus creating uncertainty in the bill. Brewer (1998) further contended that the interpretation given to some terminologies used in the BOQ is different from the one held by the court, thus leading to uncertainties in case of dispute.

According to Cartlidge (2009) during the recent past, the bill of quantities has been much maligned as outdated and unnecessary in the modern procurement environment. According to him, it is undeniable that on the face of it the number of contracts based on a bill of quantities has declined sharply in the UK over the past 20 years or so. In their survey of the Australian construction industry, Davis et. al. (2009) also observed a general decline in the use of BOQ prepared according to the Standard Method of Measurement as a pre contract tool. Despite all the criticisms against its use, Cartlidge, (2009) maintained that the bill of quantities remains unsurpassed as a model on which to obtain bids. Davis et. al. (2009) also concluded that the BOQ is a very useful tool for post contract cost control.

Whilst the usefulness of the BOQ in obtaining bids and as a post contract cost control tool have been documented, to the best of the knowledge of these researchers, there is no recent documentary evidence of an investigation into the budgetary reliability of the BOQ in building project procurement. This then is the focus of this study.

2. Literature Review

2.1. Previous Works on Bills of Quantities Format and Usage

According to Brook (2008) the BoQ has two primary uses. One is at the pre-contact stage where it assists the contractors in the formulation of their tenders. The other is at the post-contract stage where the BOQ assists contractors and quantity surveyors in the valuing of progress payment and variations among others. For more than 40 years, a lot of work had been done to examine the suitability of the BOQ in these two key phases of construction.

According to Banwell (1964) BOQs were primarily devised for tendering and allied purposes. He however contended that it should not be their only function. According to him, BOQ could be used for other purposes including costing, bonusing, ordering, programming and control. The conventional format of the BOQ was considered by Banwell to be inadequate for such purposes. He however did not propose an alternative. Nelson (1970) also criticized the BOQ as being inadequate to provide the site management team with the information it needs. According to him, site management team spend a lot of their time seeking information from numerous sources and re-calculating dimensions and quantities into units which are required on site. He further criticized the BOQ for lack of coordinated information, aggregation of quantities on a ‘similar material’ rather than on an operational basis; and the measurement of quantities in units which need conversion before they can be used. He therefore recommended the operational format proposed by Skoyle (1968) for the BOQ. Kodikera et. al. (1993) however contended that the operational format was not successful in implementation.

Skinner (1979) investigated contractor’s use of the BOQ and the utility derived from the information contained in a BOQ during the construction phase. A detailed investigation was conducted into the usefulness of the BOQ using three parameters of bill format, adequacy of information presented and independence in terms of any need to seek additional information to supplement that presented in the bill. Skinner’s (1979) study concluded that BOQs make a substantial contribution to the planning, buying and manufacturing areas of production. He also concluded that it was not evident that existing bills were suited either in format or content to the needs of tendering or production. Whilst he did not propose any new method, he pointed out that preparation of a tender document which provides the contractor with the cost significant factors and authoritative information which may be manipulated to satisfy a variety of needs was an urgent requirement.

Kodikera et. al. (1993) investigated the extent of usage of the BOQ for post contract work in building contractors' organizations. Using eight case studies, they concluded that the average extent of use of the BOQ for post-contract work was found to be 50%. According to them, this 50% of the BOQ requires some form of re-working which needs to be reduced if improved post-contract use of estimating data is to be achieved. They further concluded that information stored in the BOQ should be arranged in a directly usable way and that 'quantities', 'quantity units' and 'unit rates' are the key elements of the BOQ information that need to be presented in a more meaningful format if the amount of re-work is to be reduced.

In the UK, the Latham report (1994) and Egan report (1998) questioned the rationale behind using the traditional procurement as the main method of construction procurement despite its draw backs. Since their reports, there had been a significant shift from traditional procurement to the use of other modern methods of procurement. Since traditional bills of quantities are most popular in traditional procurement, that meant a resultant decline in the use of traditional BOQ as well. According to Gruenberg and Hughes (2004), there is a steady decline between 1990 and 2004 in the use of traditional procurement and by implication, the use of traditional BOQ. Davis *et. al.* (2009) argued that over the last 5 years in the Australian construction industry, the use of the traditional BOQ based on the Standard Method of Measurement has greatly declined. They however submitted that there has been an increasing demand for abridged forms and builder's quantities, particularly from contractors.

According to Love *et. al.* (2006), the use of traditional procurement is heavily reliant on the design documentation being complete and a detailed BOQ being produced so that cost certainty can be provided to a client prior to construction commencing. The concept of cost certainty, however, according to Rowlinson (1999) is a fallacy in the context of traditional approaches that are based on full drawings and BOQ. Whilst in principle, traditional lump sum contract can provide a public client with a firm, fixed price for construction, in practice, very few projects are actually completed within the tendered price (Love et. al. 2006). This they contended is because complete drawings are generally not available when a project goes to tender. Thus, by implication, it is unlikely for the BOQ to be complete in such a way as to guarantee cost certainty. Pheng and Ming (1997) were also critical of the risk of pricing the preliminaries as well as the mechanical and electrical services accurately in the absence of adequate information. Besides, according to Odeyinka *et. al.* (2006), there are several other risk factors such as problems with foundations, variations, economic factors and so on which may impact the goal of cost certainty.

According to Seeley and Winfield, (1999) a BOQ prepared by a professional quantity surveyor (PQS) is most useful when pricing projects of medium to large complexity. According to them, a contractor pricing a project like this may feel compelled to increase rates to cover the increased risk which is taken by not using a quantity surveyor to price the job. According to Davis *et. al.* (2009), the Australian Institute of Quantity Surveyors (AIQS) recommends the use of BOQ for the following projects: where the anticipated reduction in tender price is calculated to be greater than the fee for producing the BOQ;

for all projects of a complex nature or alteration work and for less complex projects with an estimated cost of greater than A$2 million.

From the foregoing review of previous works on BOQ format and usage, it is evident despite the decline in the use of the traditional BOQ, there is still a demand for BOQ in one form or another. It is also evident that a primary goal of using the traditional BOQ is to guarantee cost certainty. The question this research seeks to answer is whether or not the BOQ is reliable as a budgetary tool to guarantee cost certainty.

2.2. Risk and Variability in Construction Cost

According to Flanagan and Norman (1993), the environment within which decision-making takes place can be divided into three parts: certainty, risk and uncertainty. According to them, certainty exists only when one can specify exactly what will happen during the period of time covered by the decision. This, they concluded, of course does not happen very often in the construction industry. Bennett and Ormerod (1984) also concluded that an important source of bad decisions is illusions of certainty. They submitted that uncertainty is endemic in construction and needs to be explicitly recognised by construction managers.

According to Flanagan and Norman (1993), uncertainty, in contrast to risk, might be defined as a situation in which there are no historic data or previous history relating to the situation being considered by the decision-maker. In other words according to them, it is 'one of a kind'. Smith (1999) also distinguished between risk and uncertainties in decision making. According to him, risk is a decision having a range of possible outcomes to which a probability can be attached, whereas, uncertainty exists if the probability of possible outcomes is not known. According to Flanagan and Norman (1993), a company has to operate in an environment where there are many uncertainties. The aim is to identify, analyse, evaluate and operate on risks. Accordingly, the company is converting uncertainty to risk. The more one thinks about risk and uncertainty, the more one is inclined to the view that risk is the more relevant term in the building industry (Flanagan and Norman, 1993). Perry and Hayes (1985) submitted that while the distinction between risk and uncertainty is recognised, the distinction is unhelpful when it comes to construction projects.

According to Flanagan and Tate (1997), the budgeted cost in the BOQ determined at the pre-contract stage of any construction project forms the basis of the contract sum and it is the amount established for the project, which is not expected to be exceeded. According to Flanagan and Tate (1997), the budgeted cost should incorporate both foreseen and unforeseen costs needed for the achievement of project's objectives. Ashworth and Hogg (2002) submitted that all the planning and decision-making by both the client and the contractor for the success of the project centre on the budgeted cost. Therefore the budgeted cost is expected to be accurate to avoid cost overruns. Mak and Picken (1999) asserted that contingency sums are often allowed in cost estimates to ensure that the estimated project cost is realistic and sufficient to accommodate any surprises. Perry and Hayes (1985) and Flanagan and Tate (1997) were of the opinion that construction projects are expected to be completed at budgeted costs. This is because of the expected inclusion of contingency sums to cover all the foreseen and unforeseen occurrences.

On the contrary, evidences abound in construction management literature that it is very difficult to find a project in which the final account figure is the same as the contract sum (Winch, 2002; Walker, 2002). This according to Perry and Hayes (1985) and Odeyinka (2000) could be traceable to risk factors inherent in construction. According to Winch (2002), risk is inherent in construction from the inception to the completion stages of a project's life. According to him, less information is available at the inception of a construction project, as such the less the amount of information available, the higher the level of risks and uncertainties. According to Ramus *et. al.* (2006), such uncertainties would come from lack of site investigation information, leading to problems with the foundation, incomplete drawings leading to variations during the construction phase, little or no information about mechanical and electrical engineering services, leading to inclusion of prime cost sums and provisional sums in the BOQ among others.

3. Research Methodology

This study was carried out primarily through the use of secondary data. Data were obtained from past bills of quantities of building projects recently completed in Northern Ireland. Data were collected from 4 different types of building projects, namely, housing, educational, commercial and maintenance projects. The data relate to the tender price and final account figures for the different project types investigated. Detailed element-by-element data were also collected for each project type. The aim of the research was to evaluate the budgetary reliability of the BOQ in each of the 4 project types. As such data analysis was carried using percentage difference between initial contract sum and final account figure. Two further analyses were carried out using root mean square (RMS) deviation and relative mean absolute (Rel MAD) methods of analyses. The *RMS* is expressed mathematically as follows:

$$RMS = \sqrt{\{\frac{1}{n}\sum_{i=1}^{n}(t_i - o_i)^2\}} \qquad \text{(Equation 1)}$$

Where *RMS* is the root mean square deviation measure; *n* is the number of projects investigated, t_i is the tender sum for individual project and o_i is the final account figure for the individual project.

The *Rel. MAD* is expressed mathematically as follows:

$$\mathrm{Re}\,l.MAD = \frac{1}{n}\sum_{i=1}^{n}\frac{|t_i - o_i|}{t_i} \qquad \text{(Equation 2)}$$

Where *Rel. MAD* is the relative mean absolute deviation measure; *n* is the number of projects investigated, t_i is the tender sum for the individual project and o_i is the final account figure for the individual project.

4. Findings and Discussion

Table 1 presents the BOQ data as well as final account figures for 5 housing projects studied. An analysis of the percentage difference between the tender sum and the final account figure gives an indication of the budgetary reliability of the BOQ. From the Table, it is evident that the percentage difference between the budgeted cost and final account ranges between -3.42% and +3.85%. This falls between the ±5% range recommended by Morrison (1984) as the acceptable accuracy range between the Quantity Surveyor's estimate and the accepted tender.

Table 1: Budgetary Reliability Measures for Housing Projects

Tender Sum £	Final Account £	Cost Difference £	Percentage Difference
887,781.35	857,408.29	-30,373.06	-3.42
397,228.49	405,628.84	8,400.35	2.11
452,750.00	460,340.00	7,590.00	1.68
765,539.36	751,366.86	-14,172.50	-1.85
517,180.00	537,105.00	19,925.00	3.85

A detailed examination of the elemental breakdown for each of the 5 projects studied showed a minimal difference between the tender figure and the final account figure. Within the limitation of the data set, this then suggests that in traditional procurement, where traditional BOQ produced according to the Standard Method of Measurement (SMM) are used, the BOQ tends to be a reliable budgetary tool. This is not a surprise because housing projects are usually well defined in terms of design and specification at the pre-construction stage. As a result, the risk of variation and change in scope is usually very low during the construction phase. In the same way, the mechanical and electrical services requirements in housing projects are usually very straightforward, thus removing the risk of cost overrun in complicated building services where complex building is involved.

Table 2 presents the BOQ data as well as final account figures for 5 educational projects. An analysis of the percentage difference between the tender sum and the final account figure gives an indication of the budgetary reliability of the BOQ. From the Table, it is evident that the percentage difference between the budgeted cost and final account ranges between -3.69% and +17.05%. This is a range of more than 20% which is on the high side. A detailed examination of the elemental breakdown for each of the 5 projects studied showed wide variability between the tender figure and final account figures in some elements such as floor and wall finishes, electrical and mechanical engineering services and external works. The observed high variability suggests that the BOQ is not so much a reliable budgetary tool in educational projects. This is a bit of a surprise as one would expect that educational projects like housing projects should be straightforward enough. However, as evident from the elemental breakdown, high variability was

Table 2: Budgetary Reliability Measures for Educational Projects

Tender Sum £	Final Account £	Cost Difference £	Percentage Difference
247,159.97	289,290.08	42,130.11	17.05
352,780.00	363,850.00	11,070.00	3.14
402,730.00	450,340.00	47,610.00	11.82
129,000.00	140,624.95	11,624.95	9.01
298,500.00	287,479.42	-11,020.58	-3.69

observed in some cases which suggest the occurrences of risk factors such as variation and change in specification among others. According to Cooke and Williams (2009), one of the risks with the most serious effects for the client is the failure to keep within the cost estimate.

Table 3 presents the BOQ data as well as final account figures for 5 small to large commercial projects. An analysis of the percentage difference between the budgeted cost and final account shows a range of between -19.94% and +19.92%. This is a range of more than 39% which is on the very high side. A cursory look at the percentage differences of each of the 5 projects showed that the bigger the scope of the commercial project, the higher the level of variability on the positive side between the budgeted cost and the final account. A detailed examination of the elemental breakdown for each of the 5 projects showed wide variability between the tender figure and final account figures in some elements such as roof element, internal wall, floor and wall finishes, electrical and mechanical engineering services and external works. The observed high variability suggests that the BOQ is not so much a reliable budgetary tool in commercial projects, especially where the project is large in scope and of a complex nature. This is not a surprise because where large and complex projects are involved, there is uncertainty in a

Table 3: Budgetary Reliability Measures for Commercial Projects

Tender Sum £	Final Account £	Cost Difference £	Percentage Difference
270,149.83	261,760.76	-8,389.07	-3.11
306,050.00	245,033.74	-61,016.26	-19.94
2,350,740.00	2,591,830.00	241,090.00	10.26
5,086,741.64	6,100,000.00	1,013,258.36	19.92
230,379.04	238,610.04	8,231.00	3.57

lot of project information available. The more uncertain the project information is at the pre-construction stage when the BOQ is prepared and priced, the more risky it is for cost and time certainty to be guaranteed to the client at project completion.

Table 4 presents the BOQ data as well as final account figures for 5 refurbishment projects. An analysis of the percentage difference between the budgeted cost and final account shows a range of between -10.72% and +36.90%. This is a range of more than 47% which is on the very high side. A cursory look at the Table does not show a clear cut pattern of percentage variability. For instance, the highest positive variability came from what would be expected to be a small refurbishment project. A detailed examination of the elemental breakdown for each of the 5 projects showed wide variability between the tender figure and final account figures in some elements such as demolitions and alterations, external wall, finishes and mechanical and electrical services installations. The observed high variability suggests that the BOQ is not so much a reliable budgetary tool in refurbishment projects. This is not a surprise as refurbishment projects are known for their unpredictability in terms of cost and time certainty due to many unknowns in terms of scope and complexity at project commencement.

Table 4: Budgetary Reliability Measures for Refurbishment Projects

Tender Sum £	Final Account £	Cost Difference £	Percentage Difference
283,250.00	313,965.67	30,715.67	10.84
337,248.49	375,628.84	38,380.35	11.38
83,250.00	113,965.67	30,715.67	36.90
206,283.65	184,171.89	-22,111.76	-10.72
63,723.52	57,007.54	-6,715.98	-10.54

Further analyses were carried out in order to ascertain the budgetary reliability of the BOQ for procuring buildings of different types previously analysed. One of the analyses is the *RMS* measure which was detailed in Equation 1. A normalization adjustment was made to the *RMS* measure to convert it to percentage measure so as to make it comparable to other measures. This is referred to in Table 5 as the *adjusted RMS* measure. The normalization precaution was taken because the RMS values obtained are more of the function of the tender and final account figures. However, the adjusted values are relative values which are more comparable. The second analysis is the *Rel. MAD* measure which was detailed in Equation 2. The results of these further analyses are presented in Table 5.

From the Table, it is evident that the adjusted RMS measure and the Rel. MAD measure are relatively close and they follow the same trend, indicating that the measures are reliable for measuring the phenomenon under study. From the Table, the reliability ranking based on the *adjusted RMS* and *Rel. MAD* measures shows that the BOQ is most reliable as a budgetary tool in procuring housing projects. This is followed by educational

Table 5: BOQ Budgetary Reliability Measures of Different Building Types

Building Type	RMS Measure (£)	Adjusted RMS Measure (%)	Rel. MAD Measure (%)	Reliability Ranking
Housing	18,157.99	2.73	2.58	1
Educational	29,734.81	10.34	8.94	2
Commercial	466,621.47	13.58	11.36	3
Refurbishment	27,906.95	19.15	16.08	4

projects and commercial projects in that order. The reliability ranking showed that the BOQ is least reliable as a budgetary tool in procuring refurbishment projects. Whilst this finding is not a surprise, it reveals a great deal about the danger of relying too much on the BOQ as a budgetary tool. Apart from housing project with a budgetary reliability of ±2.58% which is quite acceptable, the deviation margins for other project types are quite high. This suggests that where clients are interested in cost certainty, Quantity Surveyors and Project Managers need to qualify the price they give to clients with an indication of confidence limits. This is very essential because the deviations observed are as a result of risk factors which are inherent in construction.

5. Conclusion and Further Research

This study has investigated the budgetary reliability of the BOQ in procuring building projects using secondary data from completed building projects. Employing three different methods of analyses the study concludes within the limitations of the data set confined to Northern Ireland, that in traditional procurement where traditional bills of quantities are used, there are deviations between the budgeted cost in the BOQ and final account figures. In the case of housing projects, the percentage deviation ranges between -3.42% and +3.85%. In the case of educational buildings, it ranges between -3.69% and +17.05%. In the case of commercial projects, it ranges between -19.94% and +19.92%. In the case of refurbishment projects, the percentage deviation ranges between -10.72% and +36.90%. This suggests that apart from housing project with small and acceptable deviation, the deviations observed in other project types are quite high.

The study further concludes that in aggregate terms, BOQ was found to be most reliable (relative MAD of 2.58%) as a budgetary tool in procuring housing projects. This was followed by educational projects (relative MAD of 8.94%) and commercial projects (relative MAD of 11.36%) in that order. The BOQ was found to be least reliable as a budgetary tool in procuring refurbishment projects (relative MAD of 16.08%).

Whilst there is a general awareness of the limitation of the BOQ as a budgetary tool, an awareness of the possibility of deviations in different project types in quantitative terms offered by this study makes it a useful tool for risk management to avoid cost overrun. According to Smith (1999), risk can be categorized into three: known risks – risks that are an everyday feature of construction; known unknowns – risks which can be predicted or foreseen and unknown unknowns – risks due to events whose cause and effect cannot be predicted. Thompson and Perry observed that all too often, risk is either ignored or dealt with in an arbitrary way on construction projects and that the practice of adding a 10% contingency is typical industry practice. Raftery (1994) maintained that risk in construction has to be recognised, assessed and managed. In projects procured using the BOQ, most of the risks involved would be known risks and known unknowns. These lend themselves to quantitative assessment and management. Thus, the deviation measures yield very useful information as a first step in applying risk management techniques to manage construction cost so as to avoid cost overrun.

6. References

Banwell, H. (1964) The Placing and Management of Contracts for Building and Civil Engineering Work, Report of the Committee of Sir Harold Banwell, HMSO, London.

Bennett, J. and Ormedo, R.N. (1984) Simulation applied to construction projects, Construction Management and Economics, 2 (3), 225-63.

Brewer, G. (1998) The Use of Bills of Quantities [Online]. Available at: http://www.brewerconsulting.co.uk/cases/CJ9822CI.htm Accessed on 25 June 2009.

Brook, M. (2008) Estimating and Tendering for Construction Work, Butterworth-Heinemann, Oxford.

Cartlidge, D. (2009) Bills of Quantities [Online]. Available at: http://www.isurv.com/site/scripts/documents.aspx?categoryID=303 Accessed on 20 June 2009

Davis, P.R., Love, P.E.D and Baccarini, D. (2009) Bills of Quantities: nemesis or nirvana? Structural Survey, 27 (2), 99-108.

Egan, J. (1998) Rethinking Construction. London, Department of the Environment Transport and Regions.

Flanagan, R. and Norman, G. (1993) Risk Management and Construction. Blackwell Science, London. P. 22.

Flanagan, R. and Tate, B. (1997): Cost Control in Building Design. Oxford, Blackwell Science Ltd.

Kodikera, G.W., Thorpe, A and McCaffer, R (1993) The use of Bills of Quantities in building contractor organizations, Construction Management and Economics, 11 (4), 261-269.

Latham, M. (1994) Constructing the Team, Final Report of the joint Government/Industry Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry, HMSO, London.

Love, P.E.D., Edwards, D. and Smith, J. (2006), "Contract documentation quality and rework in Australian projects", Journal of Architectural Engineering and Design Management, Vol. 1, pp. 247-59.

Morrison, N. (1984) The accuracy of quantity surveyors' cost estimating.

Construction Management and Economics, 2, 57-75.

Nelson, J.I'A (1970) Construction information, Building Technology and Management, 8, 3-5.

Odeyinka, H.A. (2000) An evaluation of the use of insurance in managing construction risks. Construction Management and Economics. 18, 519-524.

Odeyinka H.A, Oladapo A.A. and Akindele O. (2006) Assessing risk impacts on construction cost. In: Sivyer, E. (ed.) Proceedings of the RICS Foundation Construction and Building Research Conference (COBRA), University College, London, September 7-8, Pp 490-499.

Perry J.G. and Hayes, R.W. (1985) Risk and its management in construction projects. Proceedings of Institution of Civil Engineers, Part 1, June, 78, 499-521.

Raftery, J. (1994) Risk Analysis in Project Management. E.& F.N. Spon.

Ramus, J., Birchall, S. and Griffiths P. (2005) Contract Practice for Surveyors, 4th Edition. Amsterdam, Elsevier.

Seeley, I.H. (1997) Quantity Surveying Practice, Macmillan Education Limited, London.

Seeley, I.H and Winfield, R. (1999) Building Quantities Explained, Macmillan Education Limited, London.

Skinner, D.W.H (1979) An analysis of the utility of BOQ in the process of Building Contracting. PhD Thesis, Department of Construction and Environmental Health, University of Aston in Birmingham, UK.

Skoyles, E.R. (1968) Introducing Bill of Quantities (Operational Format). BRS current paper, CP62/68. Building Research Station, UK.

Smith, N.J. (1999) Managing Risk in Construction Projects, Blackwell Science.

Walker, A. (2002) Project Management in Construction, 4th edition Blackwell Science.

Winch G.M. (2002) Managing Construction Projects, Oxford, Blackwell Publishing.