AN ASSESSMENT OF RISK FACTORS INVOLVED IN MODELLING CASH FLOW FORECASTING

Henry A. Odeyinka[1] **and John G. Lowe**[2]

Department of Building and Surveying, Glasgow Caledonian University, Glasgow G4 OBA, UK.

Many models have been developed to assist contractors and clients in their cash flow forecasting. The majority of these have been based on standard cash flow S-curves, developed using the traditional manual approach, mathematical and statistical models. Many of these models failed to consider and analyse the factors responsible for the considerable variations in the modelled cash flow profiles. This study as a first step in a knowledge-based expert system (KBES) modelling of construction cash flow to incorporate risk and uncertainties, identified and assessed the risk factors responsible for the variation in construction cash flow profiles. The study was conducted through a questionnaire survey administered on contracting organisations. Analyses were carried out using mean response and univariate analysis of variance (ANOVA). Results showed that the major risk factors involved in cash flow forecasting relate to changes in the design or specifications, contract conditions pertaining to cash in flow, interim valuations and certificates and construction programming issues such as inclement weather. Results also indicated that cash flow forecasting modelling that incorporates risk would need to consider categorisation along the groupings of firm size, procurement methods and construction duration.

Keywords: cash flow, construction project, expert system, statistical analysis, modelling, risk factor.

INTRODUCTION

Financial Management has long been recognised as an important tool in construction (Peer, 1982; Hendrickson *et. al.*, 1987; Teicholz, 1987 and Carr, 1993). However, the construction industry suffers the largest rate of insolvency of any sector of the economy. Companies fail because of poor financial management, especially inadequate attention to cash flow forecasting (Boussabaine and Kaka, 1998; Calvert, 1986; Harris and McCaffer, 1995). The major problem that construction managers encounter in making financial decisions involves both the uncertainty and ambiguity surrounding expected cash flows (Eldin, 1989). In the case of complex projects, the problem of uncertainty and ambiguity assumed even greater proportion because of the difficulty in predicting the impact of unexpected changes on construction progress and consequently, on cash flows (Boussabaine and Elhag, 1999). The uncertainty and ambiguity are caused not only by project-related problems but also by the economical and technological factors (Laufer and Coheca, 1990).

Lowe (1987) argued that the factors responsible for variation in project cash flow could be grouped under five main headings of contractual, programming, pricing, valuation and economic factors. Harris and McCaffer (1995) identified the factors that

[1] E-mail: H.Odeyinka@gcal.ac.uk
[2] E-mail: jlo2@gcal.ac.uk

Odeyinka, H A and Lowe, J G (2000) An assessment of risk factors involved in modelling cash flow forecasting. *In:* Akintoye, A (Ed.), *16th Annual ARCOM Conference*, 6-8 September 2000, Glasgow Caledonian University. Association of Researchers in Construction Management, Vol. 2, 557-65.

affect capital lock-up which ultimately affect project cash flow profile to include the margin (profit margin or contribution), retention, claims, tender unbalancing, delay in receiving payments from clients and delay in paying labours, plant hirers, materials suppliers and subcontractors. Calvert (1986) identified other factors to include seasonal effects on construction works, variability in preliminary expenses, contract extensions of time for inclement weather and valuation of variations. Kaka and Price (1993) in developing a model for cash flow forecasting identified other risk factors affecting cash flow profiles to include estimating error, tendering strategies, cost and duration variances. The identified risk factors have been reported to affect cash flow profiles as well as significantly impacting on the modelling of cash flow. However the perception of the contractors to the likelihood of the risk factors occurring in different project types and of varying scope and duration is yet to be investigated. This then is the focus of this study and it is a first step in a programme of research that intends to develop a cash flow forecasting model that incorporates risk and uncertainty using the knowledge-based expert system.

A REVIEW OF EXISTING CASH FLOW MODELS

The traditional approach to cash flow prediction usually involves the break down of the bill of quantities in line with the contract programme to produce an estimated expenditure profile. This could be expected to be reasonably precise provided that the bill of quantities is accurate and the contract program is complied with (Lowe, 1987). This however is likely to be slow and costly to produce; as such, several attempts have been made to devise a ‘short cut’ method of estimation, which will be both quicker and cheaper to utilise. Attempts have been made at the mathematical formulae and statistical based modelling of construction cash flow in both the contractor and client’s organisations. This was demonstrated by the development of a series of typical S-curves by many researchers (Kaka and Price, 1993). The models obtained by these researchers rest on the assumption that reasonably accurate prediction is possible by means of a single formula utilising two or more parameters which may vary according to the type, nature, location, value and duration of the contract.

Several attempts have also been made at computer modelling of cash flow forecast (Kaka and Boussabaine, 1999 and Lowe and Lowe, 1986). Some of the models were based on computer simulations while others were based on value curves. Berny and Howes (1982) and Kenly and Wilson (1986) took the ideographic approach to cash flow forecasting by maintaining that value curves are generally unique and should be modelled separately.

They insisted that a curve should be fitted for each project as opposed to the nomothetic models, which aggregate groups of projects in order to develop a single standard curve to produce typical value curves. Kaka and Boussabaine (1999) however maintained that ideographic models are only useful for analytical purposes. As such, they argued that forecasting requires the use of standard curves developed out of a group of projects similar to the one to be executed (nomothetic models). They therefore have developed cash flow models based on standard cost / value flow curves using logit transformation to fit the data.

Boussabaine and Kaka (1998) have also attempted to model cash flow forecast using artificial neural networks, which simulates neuronal systems of the brain. Boussabaine and Elhag (1999) also applied fuzzy set theory to model movement of cash flow at valuation periods. Attempts have also been made in modelling cash flow forecast using expert system. Efforts in this regard include that of Brandon, 1988; Saleh, 1991; Moussa, 1992; Lowe *et. al.,* 1993 and Lowe and Lowe, 1997. While some of these expert system models focused on the construction contractors, others focused on the clients. The models however have not taken risk and uncertainty into consideration and it is expected that this research effort will focus on this in the next few years.

DATA AND METHODOLOGY

In order to asses the perception of contractors to the risk factors involved in modelling cash flow forecast, a structured questionnaire was designed. This was based on an in-depth literature review of risk factors responsible for variation in cash flow profile and the authors' general knowledge of the factors. The questionnaire was administered through a postal survey to 101 Chartered building companies with annual turnover of £ 5 million and over. All the construction companies in this category listed in the directory and handbook of Chartered Building companies, Published by the Chartered Institute of Building were included in the survey. The sample selection was based on the assumption that construction firms within the sampling frame place a very high premium on cash flow forecasting and also do employ qualified personnel to perform the duty. A total of 34 construction firms returned their questionnaires duly completed. This represents a 33.7% response rate which is typical of the norm of 20-30% response rate in most postal questionnaire survey of the construction industry (Akintoye and Fitzgerald, 2000).

The questionnaire elicited information regarding the firms' annual turnover, which enabled their groupings into small, medium and large firms as shown in Table1.

Table 1: Surveyed firms' turnover in the last financial year

Size	Turnover (£ million)	Number	Percent	Cumulative percent
Small	5 - 25	15	44.1	44.1
Medium	25 – 100	12	35.3	79.4
Large	Over 100	7	20.6	100.0
Total		34	100.0	

Table 2: Project procurement options employed

Option	Number	Percentage	Cumulative percent
Traditional	17	50.0	50.0
Design & build	14	41.2	91.2
Management	3	8.8	100.0
Total	34	100.0	

About 68% of the respondents are in senior management position, 61% have higher education and about 94% are professionally qualified. The mean experience of the respondents is 26.94 years with a standard deviation of 8.19 years. This background information regarding the respondents indicated that responses provided by them could be relied upon for this study.

The questionnaire listed 21 risk factors derived from literature as potentially affecting cash flow forecasting. Contractors were then asked to provide opinion regarding the likelihood of each factor occurring. The scoring was done on a 0 to 5 Likert scale (Holt, 1997) so as to accommodate the instances where the risk factors identified are not applicable by assigning a score of zero. The highest likelihood of a risk factor occurring was assigned a score of 5. In order to obtain a more focussed and targeted scoring, contractors were requested to base their scoring on one recently completed or an on-going project. With reference to the chosen project, respondents were requested to supply further details. This included project type, construction duration, project value, procurement option and nature of project client. Some of these project details which have been used for the analysis are shown in Tables 2 to 4

Table 3: Project construction duration grouping

Construction duration range (months)	Number	Percent	Cumulative percent
0 - 6	6	17.6	17.6
7 – 12	16	47.1	64.7
13 – 24	11	32.4	97.1
25 – 36	1	2.9	100.0
Total	34	100.0	

Table 4: Type of construction projects

Type	Number	Percent	Cumulative percent
Commercial / industrial building	17	50.0	50.0
Public & community building	11	32.4	82.4
Hospital / laboratory building	2	5.9	88.3
Contract housebuilding	3	8.8	97.1
Civil engineering	1	2.9	100.0
Total	34	100.0	

DATA ANALYSIS AND RESULTS

Data analyses were carried out using the Statistical Package for Social Sciences (SPSS). The analysis deals mainly with the ranking of the variables based on their mean values (Holt, 1997). This was followed by the Analysis of Variance (ANOVA) to test the null hypothesis that the mean values of the dependent variables are equal for all the groups considered (Akintoye, 2000; Edwards and Bowen, 1998).

Analysis of risk factors influencing cash flow forecasting

Analyses of risk factors were carried out based on some grouping categories. These included size of construction firms, building types, procurement options, client types, project duration and project value. The main risk factors influencing variations in cash flow forecasting as shown in Table 5 include: architect’s instructions, provision for interim certificate, receiving interim certificates, agreeing interim valuations on site, retention, delay in agreeing variations/ day works, delay in settling claims, inclement weather, etc. and problem with the foundations. Three of these key factors, namely: architect’s instructions, delay in agreeing variations/ dayworks and delay in settling claims could be grouped under ‘changes in the design or specification’. Since changes in design or specification is usually unforeseen until there is an architect’s instruction and their effects could be remarkable on the cash flow profile, it is therefore not surprising that contractors scored them high overall. Two of these major risk factors, namely: provision for interim certificate and retention could be grouped under ‘contract condition’ as far as cash flow consideration is concerned. The fact that contractors scored these factors high overall indicated that they were sensitive to the provision of the contract conditions as they affect cash in flow and capital lock-up. Furthermore another two of the identified major risk factors namely: receiving interim certificates and agreeing interim valuation on site could be grouped under ‘interim valuation and certificates’. Since this is the means whereby contractors receive cash inflows, it is not surprising therefore that contractors scored the factors high overall as well. ‘Inclement weather, etc.’ relates to the issue of construction programming while ‘problems with foundations’ relates to site conditions. These two factors could have substantial impacts on the cash flow profile. It is therefore not surprising that they ranked fairly high by the contractors overall scoring.

In spite of the major risk factors identified by overall ranking, analysis based on grouping categories showed that significant difference of opinion are observable. These have been presented in the following sections.

Risk factors in cash flow forecasting and size of construction firms

Analysis of risk factors based on the size of construction firms is shown in Table 5. From the table, opinions pertaining to four risk factors were shown to have statistical significant difference (P = 0.050). These included: receiving interim certificate, agreeing interim valuations on site, tender unbalancing and level of inflation. 'Receiving interim certificates' ranked 3rd overall; it however ranked 1st under medium firm while it ranked 5th and 7th under small and large firms respectively. 'Agreeing interim valuation on site' ranked 4th overall; it however ranked 3rd under medium firm while it ranked 9th and 4th under small and large firms respectively. These two factors have earlier been categorised under 'interim valuations and certificates' which is the contractors' means of cash in flow. The fact that there was a statistical significant difference in their scoring of these important and high ranking factors showed that they perceived the factors differently and perhaps have different strategies of dealing with them. 'Tender unbalancing' had an overall rank of 12; it however ranked 1st under large firms while it ranked 14 and 15 under the small and medium firms respectively. This is an indication that while tender unbalancing is a major tool utilised by large firms to manipulate cash flow, it appears not so used for that purpose by small and medium firms. Moreover, while 'level of inflation' was considered a major risk factors by large firms (ranked 4), it ranked 15th overall and 15th and 12th by small and medium firms respectively. This is an indication that due to huge cash outlay for projects undertaken by large firms, the level of inflation is for them a major risk factor, which is not the case for small and medium firms.

Table 5: Ranking of risk factors influencing variations in cash flow forecasting utilising construction firms size grouping

Factors	Overall mean score	Rank	Small firms' mean	Rank	Medium firms' mean	Rank	Large firms' mean	Rank	*F* Stat.	Level of significance (p values)
Architect's instructions	3.58	1	3.47	1	3.90	2	3.33	2	0.462	0.635
Provision for interim certificate	3.26	2	3.47	1	3.50	4	2.33	12	0.896	0.420
Receiving interim certificates	3.19	3	2.75	5	4.00	1	3.00	7	3.388	0.048 *
Agreeing interim valuations on site	3.03	4	2.47	9	3.80	3	3.17	4	3.962	0.031 *
Retention	2.94	5	3.33	3	2.70	8	2.33	12	0.724	0.494
Delay in agreeing variation/ daywork	2.94	5	2.93	4	3.00	5	2.83	8	0.029	0.971
Delay in settling claims	2.90	7	2.67	7	3.00	5	3.33	2	0.405	0.671
Inclement weather, strikes, etc.	2.68	8	2.73	5	2.30	10	3.17	4	0.850	0.438
Problems with the foundations	2.61	9	2.47	9	2.80	7	2.67	10	0.154	0.858
Delays in payments from client	2.52	10	2.40	12	2.70	8	2.50	11	0.124	0.884
Extent of float in contract schedule	2.48	11	2.47	9	2.30	10	2.83	8	0.610	0.550
Tender unbalancing	2.26	12	2.00	14	1.90	15	3.50	1	3.481	0.045 *
Estimating error	2.26	12	2.53	8	2.10	12	1.83	16	0.975	0.390
Provisions for phased handover	2.06	14	2.13	13	1.90	15	2.17	14	0.081	0.922
Level of inflation	2.00	15	1.47	15	2.10	12	3.17	4	4.232	0.025 *
Listed buildings	1.55	16	1.27	16	1.80	17	1.83	16	0.429	0.655
Archaeological remains	1.39	17	1.00	17	2.00	14	1.33	21	2.040	0.149
Changes in interest rates	1.35	18	0.87	18	1.60	18	2.17	14	2.423	0.107
Provision for fluctuation payments	1.03	19	0.80	19	1.00	19	1.67	18	0.758	0.478
Tree preservation orders	0.94	20	0.80	19	0.80	20	1.50	20	1.412	0.260
Changes in currency exchange rates	0.68	21	0.40	21	0.50	21	1.67	18	3.074	0.062

* Significant at 5 % level

It is obvious from the foregoing that perception of risk factors between varying sizes of construction firms is different. While there is similarity of opinions between the small and medium firms in few cases, there are significant differences of opinions between them and large firms on major factors. As such, categorisation according to firm size grouping may need to be considered in modelling cash flow forecasting that incorporates risk and uncertainty.

Risk factors in cash flow forecasting and procurement methods

An analysis using the same data set but based on procurement options grouping is presented in Table 6. The questionnaire survey targeted various procurement options, however, responses were received regarding three procurement routes only (Table 2). Due to scanty data available on management procurement option, this analysis was based on traditional and design and build options only.

As evident from Table 6, opinion regarding three risk factors were significantly different (P = 0.050) among procurement grouping sub-categories. These are: architect's instructions delay in settling claims and delay in agreeing variations/dayworks. These three factors had earlier been classified under 'changes in design or specification'. While changes in design or specification occasioned by the architect's instructions are paramount in traditional procurement route, they are less likely under design and build option where design is fused into the construction outfit.

It is therefore not surprising that while these three factors ranked 1st, 2nd and 3rd respectively under the traditional procurement route, they ranked 4th, 11th and 10th respectively under the design and build procurement option. In view of this, it is revealing that any successful modelling of cash flow forecasting that incorporates

Table 6: Ranking of risk factors utilising procurement methods' grouping

Factors	Overall mean score	Rank	Traditional mean	Rank	Design and build mean	Rank	*F* Stat.	Level of significance (p values)
Architect's instructions	3.52	1	4.071	1	2.93	4	6.689	0.015 *
Delay in settling claims	2.86	6	3.53	2	2.14	11	7.073	0.013 *
Delay in agreeing variations/ daywork	2.86	6	3.40	3	2.29	10	6.659	0.016 *

* Significant at 5 % level

risk factors may need to consider categorisation along procurement routes. This aligns with Kaka and Dawood's (2000) finding that the type of procurement route had effect on the shape of the cash flow S-curves.

Risk factors in cash flow forecasting and construction duration

Using the same data set, an analysis was carried out based on construction duration categorisation (Table 7). The construction duration range of 25-36 months (Table 3) was not included in the analysis because only one project fell into that category.

Table 7: Ranking of risk factors utilising construction duration categorisation

Factors	Overall mean score	Rank	0-6 months duration mean	Rank	7-12 months duration mean	Rank	13-24 months duration mean	Rank	*F* Stat.	Level of significance (p values)
Inclement weather, strike, etc.	2.70	8	1.50	15	3.00	4	3.00	4	3.691	0.038 *
Level of inflation	2.03	15	1.33	16	1.73	15	3.00	4	4.258	0.025 *

* Significant at 5 % level

Table 7 indicates that opinions regarding two risk factors were significantly different among construction duration grouping sub-categories. These are inclement weather, etc and level of inflation. The first relates to the issue of construction programming.

While it ranked fairly high overall (rank of 8), it ranked 15th under projects of 0-6 months duration while it ranked 4th under both projects of 7-12 months and 13-24 months duration. This is not unexpected because the longer it takes to complete a construction project, the more it is exposed to the vagaries of weather conditions, labour actions, etc. It is therefore not surprising that while the factor ranked very low under the project of shorter duration, it ranked higher under a project of longer duration. The 2nd risk factor is economic-related. While it ranked very low overall (rank of 15), it however ranked very high under projects of more than one-year duration (rank of 4). This is not surprising because the longer the construction duration of a project, the more susceptible it is to inflation. Therefore these are pointers to the fact that any successful modelling of cash flow forecasting that incorporates risk may need to consider categorisation along construction duration route.

Risk factors in cash flow forecasting and construction project types

Analysis based on categorisation of construction project types is shown in Table 8. The questionnaire survey targeted 5 types of construction projects normally carried out by the chartered builders (Table 4). However, due to scanty data available on other types, this analysis was based on commercial / industrial and public / community buildings only.

It is observable from Table 8 that under this categorisation, 'problem with the foundation' ranked higher, raking 5th overall while it ranked 5th and 12th under commercial/industrial buildings and public/community buildings sub-categories respectively. There is however no statistical significant difference of opinions regarding contractors' scoring under the different sub-categories. It is also evident from Table 8 that contractors' opinions regarding the scoring of 'archaeological remains' risk factor were significantly different between the grouping sub-categories. While the risk factor ranked 17th overall, it ranked 16th and 18th under commercial/industrial buildings and public/community building sub-categories respectively. This significant difference of opinion could be explained by the fact that most commercial/ industrial buildings are built in prime locations, which could have been historic sites, or sites of demolished buildings. It is therefore a probable reason why this risk factor ranked higher under them than under public/community buildings sub-category. Opinions regarding the scoring of 'changes in currency exchange rate' risk factor were also significantly different. However, because these risk factors under reference ranked low overall and under the grouping sub-categories, it cannot be concluded that this categorisation be taken into consideration in cash flow forecasting modelling. Moreover, more data would need to be collected on other construction project type sub-categories not represented in this analysis in reaching a conclusion.

Table 8: Ranking of risk factors utilising construction project type grouping

Factors	Overall mean	Rank	Commercial / industrial Mean	Rank	Public and community mean	Rank	*F* Statistic	Level of significance (p values)
Problems with the foundations	2.79	5	3.00	5	2.45	12	1.106	0.303
Archaeological remains	1.32	17	1.71	16	0.73	18	4.410	0.046 *
Changes in currency exchange rates	0.50	21	0.76	21	0.09	21	4.388	0.046 *

* Significant at 5 % level

Risk factors in cash flow forecasting and other categorisations
Results of analyses based on categorisations of client types and project values did not suggest that modelling of cash flow forecasting be grouped along these categories. As such, the analyses have not been presented in this paper.

CONCLUSION

The emphasis of this paper has been the identification and analysis of the risk factors affecting construction cash flow forecasting. The identified risk factors have been analysed by ranking the mean score and analysis of variance to examine the significant differences of the mean scores between the subcategories of the various groupings identified.

Within the limitations of the data, results showed that the major risk factors affecting cash flow forecasting are: architects instructions, provision for interim certificate, receiving interim certificates, agreeing interim valuation on site, retention, delay in agreeing variations/dayworks, delay in settling claims, inclement weather, etc, and problems with the foundation. Results from the analyses based on various groupings indicated that a successful modelling of cash flow that incorporates risks and uncertainties may need to consider the modelling along the categorisation of firm size, procurement options and construction duration. A definite conclusion could not be reached however regarding construction project type grouping. The research however is an on-going one and it is expected that as more data are sourced, a definite conclusion on that would be reached.

REFERENCES

Akintoye, A. (2000) Analysis of factors influencing project cost estimating practice. *Construction Management and Economics,* **18**(1): 77-89.

Akintoye, A. and Fitzgerald, E. (2000) A survey of current estimating practices in the UK. *Construction Management and Economics,* **18**(2): 161-172.

Berny, J. and Howes, R. (1982) Project management control using real time budgeting and forecasting models. Construction Papers 2, 19-40.

Boussabaine, A.H. and Kaka A.P. (1998) A neural networks approach for cost flow forecasting. *Construction Management and Economics,* **16**: 471-479.

Boussabaine, A.H. and Elhag, T. (1999) Applying fuzzy techniques to cash flow analysis. *Construction Management and Economics,* **17**: 745-755.

Brandon, P.S. (1988) Expert systems for financial planning. *Transactions of the Tenth International Cost Engineering Congress,* New York, **D4**: 1-9.

Calvert, R.E. (1986) *Introduction to Building Management*. Butterworths, London.

Carr, R.I. (1993) Cost, schedule and time variances and integration. *Journal of Construction Engineering and Management – ASCE*, **119**(2): 245-265.

Edwards, P. and Bowen, P. (1998) Note: Risk and risk management in construction: towards more appropriate research techniques. *Journal of Construction Procurement*. University of Glamorgan. **4**(2), November: 103-115.

Eldin, N. (1989) Cost control systems for PMT use. *Transactions of the AACE*, F3.1 - F3.5.

Harris, F. and McCaffer, R. (1995) *Modern Construction Management.* Blackwell Science, Oxford.

Hendrickson, C., Au, T. and Martinelli, D. (1987) Spreadsheet aids for financial planning for construction projects. *Transportation Research Record*, **1126**, 100-109.

Holt, G.D (1997) Note: Construction research questionnaires and attitude measurement – relative index or mean? *Journal of Construction Procurement*. University of Glamorgan. **3**(2), August: 88-96.

Hudson, K.W. (1978) DHSS expenditure forecasting method. *Chartered Surveyor – Building and Quantity Surveying Quarterly*, **5**: 42-45.

Kaka, A.P. and Price, A.D.F. (1993) Modelling standard cost commitment curves for contractors' cash flow forecasting. *Construction Management and Economics*, **11**: 271-283.

Kaka, A.P. and Boussabaine, A.H. (1999) Updating techniques for cumulative cost forecasting on construction projects. *Journal of Construction Procurement*. University of Glamorgan. **5**(2): 141-158.

Kaka, A.P. and Dawood, N. (2000) Assessing the need to consider cash flow as a factor in deciding what type of procurement system the client should implement. In *Proceedings of the CIB W92 Procurement System Symposium on Information and Communication in Construction Procurement.* Santiago, Chile, 24-27 April, 657-665.

Kenly, R. and Wilson, O. (1986) A construction project cash flow model – an ideographic approach. *Construction Management and Economics*, **4**: 213-232.

Laufer, A. and Coheca, D. (1990) Factors affecting construction planning outcomes. *Journal of Construction Engineering and Management*, **116**(6): 135-156.

Lowe, J.G. and Lowe, H.C (1986) Cash flow forecasting and the building client, a simulation approach. In Brandon, P.S. (ed.) *Building Cost Modelling and Computers*, E & FN Spon, London, 503-511.

Lowe, J.G. (1987) Cash flow and the construction client – a theoretical approach. In Lansley, P.R. and Harlow, P.A. (Eds.) *Managing Construction Worldwide*, E & FN Spon, London, **1**: 327-336.

Lowe, J.G, Moussa, N. and Lowe, H.C (1993) Cash flow management: an expert system for the construction client. *Journal of Applied Expert Systems*, **1**(2): 134-152.

Lowe, J.G. and Lowe, H.C (1997*) An expert system to manage cash flow for the construction client.* BSU Research Paper No 3, Dept. of Building and Surveying, Glasgow Caledonian University, Glasgow.

Moussa, N. (1992) *Cash flow forecasting and the client: an integrated database – expert system model*. Unpublished M. Sc. dissertation, Dept. of Building Engineering and Surveying, Heriot-Watt University, Edinburgh.

Saleh, S.O. (1991) *Developing an expert system model for cash flow forecasting in the construction industry*. Unpublished M. Sc. dissertation, Dept of Building Engineering and Surveying, Heriot-Watt University, Edinburgh.

Singh, S. (1987) A computer model for financial resource planning of high rise building projects. In Lansley, P.R. and Harlow, P.A. (eds.) *Managing Construction Worldwide*, E & FN Spon, London, **1**: 337-348.

Teicholtz, P.M. (1987) Current needs for cost control systems. In Ibbs, C.W. and Ashrey, D.B. (eds.), *Project Controls: Needs and Solutions*, New York, ASCE,47-57.