CHAPTER SEVEN

CONCLUSIONS AND FUTURE RESEARCH

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7.1 DISCUSSION

This research is aimed at formulating a frame work for computer aided cost model linked to SMM (SLS 573 revised 1999). To establish a suitable model framework research investigated topics such as design process (Chapter Two), cost control mechanism in design stages (Chapter Three) and practice of approximate estimating in local organizations (Chapter Four).

With innovation of computers new opportunities came into being which have given high potential to investigate, evaluate and synthesise any complex situation. The estimating practice is no exception to this revolution. Cost planning software are commercially available in other countries, specially UK. The use of computer aided models is, presently, low in the industry. The justification can be that practitioners do not opt to accelerated changes in certain disciplines (eg: estimating, electronic bidding) since which carry elements of risks not demonstrated or tested. However, application of information technology is a major determinant in strategic planning of departments of organizations.

7.2 CONCLUSIONS

7.2.1 Status of the current practice in local organizations

The survey executed to collect information on various approximate estimating related issues revealed that local approximate estimating practice has not changed the pattern and methods of approximate estimating other than introduction of general purpose computer software such as Microsoft Excel, Lotus 123 etc.. Changing the mind set to shift to new wave of cost models is not easy. In the context of approximate estimating, practitioners find solutions within commonly practiced approximate estimating techniques. Accuracy is not a critical issue as revealed in Chapter Five. Less attention to degree of accuracy can cause very abortive decisions. Cost advisor with an unrealistic cost estimate and cost limit misguides both selection of most competitive tenderer and Client. Therefore, study of approximate estimating approximate estimating techniques, their limits and latest developments with computer applications are considered contributory to find a promising solution.

In his presidential address Clive Lewis highlighted the need for surveyors (Quantity Surveyors) to become more expert at forecasting (cited by Martin, 1994). A recent research revealed that Simple model building, Non linear modeling, Econometrics, Linear programming, Delphic method, Scenarios, Modern portfolios theory and Duration are the techniques/methods taught at postgraduate levels in universities (Martin, 1994). The research stresses the importance of forecasting skills. Suitable forecasting techniques are required to exercise forecasting skills. The research cost model is an attempt to comply with this requirement thinking globally but acting locally.

7.2.2 Cost advisors emerging role during the Briefing stage

All too often the cost advisor's involvement in the early stage of the design stage is minimal (Smith, 1982). Very few clients seek cost advisor's assistance at feasibility stage. But important design decisions are taken at this stage. Traditionally, the architect (Mostly private sector) is sole information channel between client and design team. Other members of the design team such as quantity surveyor, structural engineer and services engineer are appointed following the critical stages (Briefing and Sketch plan) at which major parameters like structural, aesthetic, quality, quantity and financial are fixed. This practice can result in design decisions which commit the project to many intractable cost consequences. Good approximate estimating techniques create confidence so that client and architect are compelled to check the cost consequences of design alternatives. A good forecasting tool is thus an essential requirement. The research cost model accomplishes this requirement since it can perform over Briefing stage, Sketch plan stage and Working drawing stage, and facilitates to check cost elementally.

7.2.3 Benefits of the proposed cost model

The proposed cost model addresses specific requirements of a cost planner. These can be unfolded as follows:

- Proposed cost model performs its tasks with the design process. Model is sensitive to design decisions. Model allows adjusting quantities, cost and other design specifications of the elected case to match new facility with latest information. Old information is overridden by reliable information. The model only compliments the decisions of the cost advisor. Cost advisor has no reason to fear with black box decisions.

- Model establishes first realistic cost estimate comparing historical data. This is the cost limit and is distributed within building elements setting elemental cost targets. More suitable building type is selected for this purpose referring to developed client's brief. Once the cost limit is distributed within building elements, elemental targets are available for cost control and checking. Necessary remedial actions are sought in case cost targets are not met.

- The model stores new cases as new experience to the model. Such new information can widen and deepen the spectrum of forecasting capability of the model.

- The design database of the model provides the cost advisor information which are not readily available with past cost analysis. For example he can calculate no of WC units and wash basins for selected level of occupancy. Design information is stored in the design database of the model.

- The model produces general information summary, element specification notes, building element cost summary, building element group cost plan, project specific element cost summary, project specific element group cost plan, project cost plan, sub element BOQ and bill of approximate quantities. The priced BOQ forms the basis of Engineers' estimate in local practice.

- Client's brief plays a major role in the research cost model. Whole concept of the design is anchored to Client's Brief. Quantity factors for elements and sub elements are generated based on Client' brief.

7.2.4 Database management perspective of the model

The proposed research cost model use the power of relational database management system (RDBMS). The forms and reports are developed for data input and output. The present trend is to develop integrated construction management systems using power of relational data base techniques. The RIPAC system developed by Rider Hunts in Adelaide is an example of very extensive construction management system which uses the power of relational database management techniques. The relational data base technique used in the research model provides robust methods of describing relationships without ambiguity. The advantage is that organizations can develop their own models based on the concept of the research model (relational) with the hope that such models can be linked to external systems in future. Therefore, the data base concept of the research model addresses the current trend in data base management in the quantity surveying and engineering professions.

7.2.5 Errors and biases in the proposed cost model

There are at least two groups of reasons which explain how errors and biases are crept into estimates and forecasts in building economics. First group stems from common rules of thumb and biases in cognitive processes of human beings making judgments and forecasts in any situations. The second group stems from the tendency, in building economics, to make unrealistic simplifying assumptions. The proposed research cost model uses professional judgment extensively in assessing design and construction contingencies and predicting future price levels. Therefore, two groups of reasons of errors and biases are likely to be present. The solution to this problem is abstractly obvious although difficult to implement. The solution is that forecasters should adopt methods which explicitly deal with both risk and exposure and risk attitude.

There is a general agreement on three common rules of thumb (heuristics) used by forecasters in making judgments (Mak and Raftery, 1992).

1. Representativeness
2. Availability
3. Anchoring and adjustment

Reprentativeness heuristics is the process of evaluating the probability of an event or a sample by the degree to which it (1) is similar in essential properties to its parent population; and (11) reflects the salient features of the process by which it is generated. It is in essence an assessment of the degree of correspondence between model and its outcome.

Availability is a heuristics which makes use of retrievability of instances. For example an estimator, who experienced an inadequate allowance for construction stage contingencies for past three projects, is likely to overestimate construction contingencies in future projects.

Adjustment refers to the cases when the estimators make estimates by starting from a initial value(for example cost of the upper floors are available from the appropriate case in the research model as initial reference) and adjusting it to derive the required value. **Anchoring** refers to the phenomenon where final results are usually biased toward the initial values.

The above explained three heuristics are likely to occur in the process of decision making with the research cost model. The subject of risk attitude and systematic bias in estimating is beyond the scope of the research cost model.

7.2.6 Limitations of the proposed model

The proposed cost model doesn't provide design solutions. It provides cost solutions to match design solutions. Model works iteratively with the design development offering respective cost solutions. Cost advisor is given facility to select most appropriate historical design as qualified case from which to start. What actually designer does in developing the design is the same thing.

Very rarely a designer designs a completely innovative building. Majority of the building design follows features in previous building designs. Accordingly, having historical design and cost databases and referring them in new situations is a logical and practical approach. Model accomplishes this objective.

7.2.7 Experiential learning in cost estimating

Research in pre-tender estimating practice indicates that 'experience' is a major factor in determining the expertise of the estimator and, hence, the accuracy of resulting estimates. In a major study involving 60 estimators in practice, Skitmore et al. (1990) have found that project specific experience was the main factor associated with the accuracy of early stage estimates(cited by Lowe and Skitmore, 1994).

Estimators should learn ways of improving their experiential learning. Improved experiential learning leads to increased feedback and consequent estimating accuracy. Lowe and Skitmore (1994) suggest several tasks to accomplish experiential learning as follows:

1. portfolios-a record of significant learning experiences;
2. journals-a record of self reflection
3. discussion with others;
4. debriefing-an opportunity for structured reflection and peer appraisal;
5. collaboration-to facilitate the examination and analysis of uncertainties and dissatisfaction with others;
6. behaviour records-to enable the analysis of the learning situation;
7. reflective analysis-the use of check lists and self assessment;
8. convergent thinking- the reflection on divergent aspects and perspectives.

The research cost model allows the cost advisor to exercise his judgment on costs, quantities and other design specifications of elements, sub elements and SMM items of the selected case to match the new facility. Structured experience is very helpful in this exercise. Experiential learning is thus emphasized in cost planning with the research cost model.

7.2.8 Implementation of research cost model

The research formulates a frame work for a computer aided cost model. The interfaces, forms and reports required for the operation of the model have comprehensively been described in the report. Formulation of the framework for a physical model is stage 1 of the research project. Development of a physical model to demonstrate the model is stage II of the research project. It was stated that VB6 and Microsoft Access software are suitable for development of a physical model.

The model doesn't assume complete change of existing way of working. Model works through elements, sub elements and SMM items. These are familiar to average quantity surveyor. However, introduction of computer manipulation may accompany resistance from traditional practitioners. Following factors are worthy to note in implementation:

a) People are naturally resistance to change. Involvement of the potential users from the beginning of a new system should be encouraged.

b) Realistic goals should be set during the initial bedding in of a new system.

c) A new system should not force to change (drastically) the way of working.

d) A common user interface throughout a system will assist learning and consistent operation.

The proposed computer aided research cost model meets above requirements. System management is one of the primary factors influencing the expected performance of any selected software.

7.3 FUTURE RESEARCH

The research cost model uses three parameters (keys) to select appropriate building type: building type, quality level and number of storeys. Cost of a building correlates with many design features such as plan shape, wall to floor ratio, spans etc. Research into these areas to establish the relationship between design parameters and consequent costs is important. This allows the cost advisor to equip with a technique to select appropriate building from a sample. The proposed cost model generates quantities and relevant costs referring to a historical case in the database. Improving the selection of appropriate case with more keys ensure that most appropriate case in the case base is selected as initial reference.

The recent developments in the field of expert systems can offer more opportunities. For example Artificial Neural Net Work (ANN) provides models to be trained with test data. Developing ANN bases techniques can help the cost advisor in many respects. For example cost advisor can instruct the model to select most appropriate case from the database against 50 parameters within a short time. This can reduce time which is spent on selection of the appropriate case.

Numerous researchers (Barnes and Thomsoan, 1971; Ashworth, 1981; Seely,1981; Ashworth and Skitmore, 1983; Harmer, 1983) have commented upon the fact that 20% of the measured bill items contribute 80% of the total measured bill value(cited by Munns and Haimus,1999). These findings conform to the 80/20 rule established by Vilfred Pareto and 20% of the items which have the highest value are generally referred to as the cost significant items (Munns and Haimus, 1999). Quantifying and pricing cost significant items of a particular type of building can increase the efficiency of the predicting without compromising accuracy.

The plan shape index calculated and included in the design database of the proposed cost model is wall to floor ratio. Other plan shape indices are plan compactness ratio (POP), length/breath ratio (LBI) etc. These plan shape indices have no reference to U (unit construction cost) and are unlikely to be good predictors of U (Wing, 1998). Plan shape index based on reciprocal model has been suggested to predict amount of floor area that can be constructed with a fixed sum of money (Wing, 1998). It is proposed to include necessary data in the design database of the proposed research cost model to calculate this plan shape index to cross check the cost of the superstructure against the gross floor area. Knowledge of plan shape and consequent cost effect is essential for cost advisors to advise design team.

Capability of the model to derive information based on client's brief can be improved with Client's Requirements Processing Model (CRPM). The CRPM developed by Kamara et al. (2000) provides a suitable frame work to accomplish this requirement. The said CRPM model is based on quality function deployment (QFD). In QFD, multi-functional teams are used to identify, incorporate and deploy the voice of the customer during the product development process.

Research cost model intends to use ICTAD price indices to project present costs to future costs. Based on the behaviour of the past cost indices future indices have to be judged. Akintoye and Skitmore's reduced form model of construction price is a causal quantitative forecasting model involving the identification of variables that related to construction price (Akintoye and Skitmore, 1994). Similar model is proposed to forecast future price levels.

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APPENDIX A

DESIGN DATABASE EXAMPLE 01

DES-code	DES-Speciality	DES-Data
ARCH01	space	office space per person(A)=5.00m2 person , within department circulation(B)=10% of A, inter department circulation(C) =15% of(A+B) , support facilities to office areas(E)=2.2m2 per person, special facilities(F)=.75m2 per person , services core and columns(G)=20% of net usable area(NUA)
ARCH02	provision of fire stairs	at least one fire stair is required in buildings with floors over 18.3m above ground level.
ARCH03	provision of staircases	refer design table ARCH03

APPENDIX A

DESIGN DATABASE EXAMPLE 02

DES-Code	DES-Speciality	DES-Data	
SEV01	water closets for men	Number of men	Number of water closets
		01 to 15	01
		16 to 20	01
		21 to 30	02
		31 to 45	02
		46 to 60	03
		61 to 75	04
		76 to 90	04
		91 to 100	04

DESIGN DATABASE EXAMPLE 03

DES-Code	DES-Speciality	DES-Data		
SEV02	Rain water disposal	roof area in m2	gutter dia (mm)	outlet dia (mm)
		18	75	50
		37	100	63
		53	115	63
		65	125	75
		103	150	89

APPENDIX B

SPECIFICATION TABLE 01 FROM CASE A

E-AC	E-element	E-spec
SB	Sub structure	Excavation of pits and trenches in ordinary soil, Grade 25concrete foundations, Rubble wall foundations
CL	Columns	Grade 25 concrete and high yield steel reinforcements
UF	Upper floors	Insitu concrete slab, Grade 25 concrte, 100-150mm thick
SC	Staircases	Insitu concrete slab, Grade 25 concrte,
RF	Roof	calicut tile roof on steel trusses and timber roof structure
EW	External walls	200mm thick block walls in cement sand mortar
WW	Windows	Powder coated aluminium wndows
ED	External doors	Timber doors and frames , painted with enamel paints
NW	Internal walls	100mm thick block walls in cement sand mortar
ND	Internal doors	Ply wood doors paintd with emulsion
WF	Wall finishes	20mm thick plaster and 100x100mm wall tiles, 200mm tiles
FF	Floor finishes	300x300mm ceremic tiles on 40mm thick (average) cement sand bed
CF	Ceiling finishes	Mineral fibre ceiling with aluminum suspended frame work
SF	Sanitory fixtures	Ceremic corporation fittings, Italy fittings
PD	Sanitory plumbing	National PVC pipes, Type 400, 600
WS	Water supply	National PVC pipes, type 1000
AC	Air conditioning	Nil
FP	Fire protection	Co2 and Water fire extiguishers
LP	Electric light and power	
CM	Communications	PABX system with 80 extensions

APPENDIX C

SUB ELEMENT COST SUMMARY FOR SUBSTRUCTURE

SE-AC	SE-ELEMENT	SE-QTY	SE-UNIT	SE-RATE	SE-AMOUNT(Rs)
SBXF	Foundation excavation	100.00	m2	300.14	30,014.00
SBCP	Column pads and pedestal	521.00	m2	273.82	142,661.60
SBSF	Strip footings	0.00	m2	0.00	0.00
SBFB	Foundation beams	521.00	m2	550.85	286,993.20
SBWG	Walling	203.00	m2	820.74	166,610.00
SBFN	External finishes	150.00	m2	342.00	51,300.00
SBGS	Ground slab		m2		126,072.00
SBES	Open entrance step and ramps	0.00	m2	0.00	0.00
SBNE	Not elsewhere included in SB		pc		0.00
	Total SB				803,650.80

APPENDIX C

SUB ELEMENT COST SUMMARY FOR COLUMNS

SE-AC	SE-ELEMENT	SE-QTY	SE-UNIT	SE-RATE	SE-AMOUNT(Rs)
CLSR	Columns, Single storey buildings,RCC	0.00	m2	0.00	0.00
CLSM	Columns, Single storey buildings, Miscellaneous	0.00	m2	0.00	0.00
CLBR	Columns, Two storey buildings,RCC		m2		341,941.20
CLBM	Columns, Two storey buildings, Miscellaneous	0.00	m2	0.00	0.00
CLNE	Not Elsewhere included in CL	0.00	pc	0.00	0.00
	Total CL				341,941.20

APPENDIX C

SUB ELEMENT COST SUMMARY FOR UPPER FLOORS

SE-AC	SE-ELEMENT	SE-QTY	SE-UNIT	SE-RATE	SE-AMOUNT(Rs)
UFSB	Insitu Slab and Beam Construction		m2		1,357,154.80
UFNE	Not Elsewhere included in UF		pc		0.00
	Total UF				1,357,154.80

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBCP

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBCP10		75mm thick blinding, Grade 15 concrete, concrete footings	m2	47	274.00	12,878.00
SBCP11		Grade 20 concrete, column bases	m3	11	4,422.00	48,642.00
SBCP13		Grade 20 concrete, columns shaft , cross section less than or equal to 0.50m2	m3	3	4,422.00	13,266.00
SBCP20		Formwork to sides of columns bases, height n.e 300mm	m	195	108.00	21,060.00
SBCP21		Formwork to sides of column shafts	m2	50	360.00	18,000.00
SBCP30		High yield steel, column bases, dia n.e 10mm	t	0.34	48,840.00	16,605.60
SBCP31		High yield steel, column bases, dia 10-16mm	t	0.11	48,840.00	5,372.40
SBCP32		High yield steel, column bases, dia exceeding 16mm	t	0.03	48,840.00	1,465.20
SBCP33		Mild steel, column shafts,dia n.e 10mm	t	0.11	48,840.00	5,372.40
		Total SBCP				142,661.60

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBXF

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBXF10		Excavate pits, depth n.e 1.00m deep in ordinary soil	m3	42	130.00	5,460.00
SBXF20		Excavate trench, depth n.e 1.00m deep, in ordinary soil	m3	52	130.00	6,760.00
SBXF30		Earth work support, total depth n.e 1.00m, distance opposing face less than 2.00m	m2	168	8.00	1,344.00
SBXF40		Back filling to excavations	m3	30	15.00	450.00
SBXF50		Termite treratment to excvated surfaces	m2	1000	16.00	16,000.00
		Total SBXF				30,014.00

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBFB

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBFB10		Grade 25 concrete, sectional area less than 0.10m2	m3	18	4,422.00	79,596.00
SBFB20		Formwork to sides, isolated beams,rectangular	m2	208	450.00	93,600.00
SBFB30		Mild steel, column shafts,dia n.e 10mm	t	0.7	48,840.00	34,188.00
SBFB31		High yield steel, column bases, dia 10-16mm	t	1.63	48,840.00	79,609.20
		Total SBFB				286,993.20

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBWG

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBWG10		Grade 15 concrete, 100mm thick, wall foundation	m2	88	548.00	48,224.00
SBWG20		Random rubble work,in cement sand 1:5, wall foundation	m3	62	1,584.00	98,208.00
SBWG30		DPC, 20mm thick, cement sand 1:2, two coats of bitument paint, blinding with sand, n.e 300mm wide	m	342	59.00	20,178.00
		Total SBWG				166,610.00

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBFN

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBFN10		20mm thick plinth plaster finished semi rough.	m2	150	198.00	29,700.00
SBFN20		One coat of primer and two coats of weather proof paints on plastered surfaces.	m2	150	144.00	21,600.00
		Total SBFN				51,300.00

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT SBGS

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
SBGS10		Approved hardcore earth filling in 150mm layers and well rammed and consolidated below ground floor slab	m3	45	216.00	9,720.00
SBGS20		Grade 25, mass concrete bed, thickness less than 150mm	m3	32	3,636.00	116,352.00
		Total SBGS				126,072.00

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT CLSR

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
CLBR10		Grade 20 concrete, isolated clumns , cross section not exceeding .10m2	m3	17	4,842.00	82,314.00
CLBR20		Formwork to sides of isolated columns	m2	290	390.00	113,100.00
CLBR30		High yield steel, in columns,dia 10-16mm	t	2.51	48,840.00	122,588.40
CLBR31		High yield steel, in colums,dia greater than 16mm	t	0.07	48,840.00	3,418.80
CLBR32		Mild steel, in columns,dia n.e 10mm	t	0.45	45,600.00	20,520.00
		Total CLSR				341,941.20

APENDIX D

BILL OF APPROXIMATE QUANTITIES FOR SUB ELEMENT UFSB

SE-ID	SMM-ANC	SMM-Description	SMM-Unit	SMM-Qty	SMM Rate	SMM Amount(Rs)
UFSB10		Grade 20 concrete, suspended slabs, not exceeding 150mm thick	m3	27.00	4,842.00	130,734.00
UFSB11		Grade 20 concrete, attached beams, section not exceeding 0.10m2	m3	19.00	4,840.00	91,960.00
UFSB20		Formwork to soffit of slabs	m2	246.00	450.00	110,700.00
UFSB21		Form work to edges of slabs, height not exceeding 300mm	m	120.00	136.00	16,320.00
UFSB22		Form work to sides and soffits of beams	m2	245.00	450.00	110,250.00
UFSB30		High yield steel, in beams, dia 10-16mm	t	2.23	48,840.00	108,913.20
UFSB31		High yield steel, in beams,dia greater than 16mm	t	1.15	48,840.00	56,166.00
UFSB32		High steel, in beams,dia n.e 10mm	t	1.20	48,840.00	58,608.00
UFSB33		Mild steel, in beams,dia n.e 10mm	t	0.76	48,840.00	37,118.40
UFSB34		High yield steel, in upper floor slabs,dia n.e 10mm	t	2.43	48,840.00	118,681.20
UFSB35		Mild steel, in beams,dia n.e 10mm	t	10.60	48,840.00	517,704.00
		Total UFSB				1,357,154.80