ESTIMATING TOOLS FOR INFRASTRUCTURE PROJECTS

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ABSTRACT

Minimum cost has become a critical performance criteria for most engineers in infrastructure projects where developers need to maximise the number of the property units. Today it is widely acknowledged that the complexity of infrastructure planning and realisation is growing, and on many levels: technical, legal, political, socially and financially. At present the control exercised over forecasting is limited. There is a growing need to manage actively the cost efficiency and forecasting for the wider interest of society.

Government needs to effectively monitor the design process from beginning to end instead of just allocating money and that a different approach is needed to infrastructure projects. While there are numerous political, social and economical aspects of the infrastructure problem, there is a great need for appropriate technical solutions. This research contributes to the underdeveloped area of cost planning and forecasting on infrastructure projects. There has to be a greater effort at improving cost-benefit analysis and integrating infrastructure design options and costs consequences. There is a need for generating ideas for new projects and alternative solutions. In general, the increased efficiency of existing and new infrastructure has to be promoted.

The purpose of the paper is to present the standard outputs of the cost planning model that was discussed in its subsequent paper. The output generated by the model will compare the cost of various design options and is expected to reduce the cost of projects

The cost planning model and its outputs is a disciplined effort to produce fundamental decisions in shaping the project cost. The process must be seen as an integrated whole in order to maximise the opportunities for improving quality and reducing project costs. This will place a heavy burden on the consultants to use client's money in the most efficient way possible. The economic analysis involves undertaking a cost-analysis of the various project options to assess their economic viability. The economic analysis guides the decision-makers by altering key design factors and assessing how and what costs should be increased.

1. INTRODUCTION

Early design decisions are made when too much data are unavailable. The cost model makes cost effective options just one of the criteria relevant to the project approval, which must be balanced against other criteria such as price and quality and ensures that social benefits are obtained with the minimum possible costs to the government.

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The essence of the cost model is to enable the engineer to control the cost of a project (within the target) while he is still designing. The earlier this process is introduced the greater the measure of control that can be exercised over ultimate cost, quality and design.

This paper shows how different levels of cost estimate can be prepared in parallel with design development. The system allows for the various components of the costs to be estimated at their own discrete level, depending on the level of design information available.

2. OBJECTIVES OF THE COST FORMS

The underlying purpose of this paper is to present the standard output forms of the cost planning model as shown in annexure 1. The standardised cost forms were developed to:

- Ensure that the work is carried out in a professional, competent and cost effective manner.
- Set out the methods by which deliverables may be obtained and verified.
- Determine the means by which goals can be quantified at early design stages.
- Measure, quantify and verify cost at any stage of design.
- Provide a basis for planning and budgeting.
- Develop a system of comparing a range of possible design alternatives at any stage in the design evolution and the forecasting of the economic effects upon the change of different variables or elements.
- Achieve the required balance of expenditure between the various elements of the project.
- Keep the expenditure within the amount allowed by the client

3. THE COST PLANNING MODEL METHODOLOGY

Annexure 1 illustrates the conceptual model for cost forecasting at the different stages of design as well as standard forms for the analysis of the various options. (Saroop and Allopi, 2005a)

The model was developed to provide clients and consultants with more control over the economic decisions taken in each design stage. It enables a rapid comparison of the options under consideration and assesses the cost of various engineering solutions as well as cost implications of certain parameters.

This paper shows how different levels of cost estimate can be prepared in parallel with design development. The system allows for the various components of the costs to be estimated at their own discrete level, depending on the level of design information available.

4. COST REPORTS

A cost report is a document that defines in a comprehensive, precise and verifiable manner, the essential characteristics of a deliverable.

The standard forms shown in table 1 are not only concerned with what is specified, but also forms the foundation for an effective cost evaluation, which is laid down in these precise reports. It is used to measure, quantify, verify and audit the different design options on infrastructure projects. (Saroop and Allopi, 2005b)

A critical role identified for designers is that of optimal interaction with clients, particularly at the design brief stage. This is the most crucial phase for the successful completion of any project. .

Design cost planning is particularly crucial as decisions made during the early stages of the development process carry more far reaching economic consequences than the relatively limited decisions which can be made later in the process. (Flanagan and Tate, 1997)

Table 1. Standard forms for each stage.

Stage	Form No.	Form Name
FEASIBILITY STAGE	FORM 1	FEASIBILITY COST REPORT
	FORM 2	LIFE CYCLE COST ANALYSIS FORM
	FORM 3	COMPARATIVE DEVELOPMENT SCENARIO OPTIONS
	FORM 4	COMPARATIVE COST PLAN
SCHEME DESIGN STAGE	FORM 5	ELEMENTAL COST ANALYSIS
	FORM 6	COST TARGET FORM
	FORM 7	DESIGN REVIEW FORM
	FORM 8	COST CHECK FORM
DETAILED STAGE	FORM 9	DETAILED COST ANALYSIS
	FORM 10	DETAILED COST PLAN
	FORM 8	COST CHECK FORM
BILL OF QUANTITIES STAGE	FORM 11	SPECIFICATION AND DESIGN NOTES FORM
	FORM 12	SCHEDULE OF QUANTITIES
	FORM 13	PROJECT BUDGET TRACKING FORM
	FORM 8	COST CHECK FORM (FINAL PRODUCTION)

Form 1- Feasibility cost report

During the first stage, as the brief is considered and developed, some idea of cost has to be established quickly. There may already be a budget limit but if not the client will need to know what order of cost is likely to be involved. The client may have a very firmly fixed budget and want to know what kind of level of services can be expected for the money

Although there is bound to be much rethinking in the early stages, it is critically important to get as much as possible settled before it becomes increasingly expensive and unrealistic to make changes in design.

The estimate is to be prepared on an elemental basis or unit method by comparisons of cost data available from previous similar projects.

The cost of the desired alternative is computed and may be tabulated along with other cost combinations in a standard form called the ‘feasibility cost report form’.

Form 2 – Life cycle cost analysis form

Most Civil Works projects represent major infrastructure investments for the nation, and are likely to remain in use indefinitely. Therefore, in addition to cost considerations, planning and design decisions need to be based on a consideration of the long-term performance of the project.

Benefits and cost should be quantified and monetized to the maximum extent practicable. Benefits and costs should be measured and appropriately discounted over the full life cycle

of the project. Such analysis will enable informed tradeoffs among capital outlays, operating and maintenance costs, and non monetary costs borne by the public. These benefits are translated into measurable items in the life cycle cost form.

Form 3 - Comparative development scenario options

The basic method for identifying the costs of a project is to compare the costs and benefits that are likely to arise if a specific alternative is implemented, to the situation that would prevail if alternative design decisions were implemented.

The alternative designs that were considered, are compared in this standard form.

This method estimates the net savings on costs that are likely to be generated by the project alternatives and quantities.

This form allows a comparative analysis of the different scenarios available to the client and their cost implications.

Functions carried out at this stage include the following:

- Generation of options - For a comparison of reasonableness with other design alternatives, e.g. if stormwater pipes are costing far more than stormwater open channels, it is important in investigating the results of the different design options.
- A comparative evaluation of preferred options and major alternatives in the early stages of design should be done.
- Devising alternatives in response to the projects goals, objectives & constraints
- Evaluating options and impacts relative to its goals and objective

Form 4 – Comparative cost plan

The Comparative cost plan involves presenting the refined cost-analysis of the various project options. The economic analysis guides the decision-makers by altering key design factors and assessing how and what costs should be increased.

The comparative cost plan does not seek to enforce rigid cost limits for the design of particular elements, but rather to maintain flexibility of choice of a combination of possible design solutions, that will serve the purpose to be achieved. (Seeley, 1996)

The comparative cost plan serves two important purposes:

- To confirm the budget already set;
- To allow the distribution of costs within the various functional elements to be made and to ensure that the distribution is appropriate for the needs of the project.

Form 5 – Elemental cost analysis form

This form enables the user to evaluate different scenarios and change the value of a number of key variables, such as length of elements and number of elements, and go through the costing again.

“By setting out the budget based on these elements, budgetary control procedures can be adopted that will allow monitoring and correction of the design should it go outside the cost constrain (Cited by Ferry *et al*, 1999).

The functions of the elemental cost analysis form are:

- To compare the reasonableness of other design options, if stormwater pipes (for instance) are costing far more per metre than stormwater open channels or proportioning it over the project cost, it is worthwhile investigating the results of the different design options
- To determine the probable cost of each element of the project
- To show the distribution of cost of a project amongst its elements

Form 6 - Cost target/limit form

Once the sketch design has been completed and approved by the client, the task of allocating sums to the various elements can take place.

The cost target is a statement of how the design team proposes to distribute the available money among the major elements of the project.

A sum will eventually be agreed that will form the cost target for the whole scheme. Alternatively, a cost limit, once in operation, will become the cost target. This is largely the extent of the consultant's work at this stage, other than to advise on the cost of alternative methods of construction or matters, which have a contractual implication. There is no real point at this stage in formulating elemental targets, since design decisions still have to be made and the whole process could be a rather pointless exercise. If however, the proposed scheme is of a similar type to one already constructed, and a previous analysis is available and going to be followed in principle by the engineer, then these cost targets can be utilized, and they must be updated for inflation or regional factors

Cost limits

Definition-the sum of money, which the client considers, is the maximum that he is able and/or willing to pay for the building based on the amount that can be raised by grants, loans or other sources.

The system of cost limits gives value for money in the public sector:

Cost limits have been used for a large number of public construction projects. Their object is to establish a system limiting the expenditure on initial construction costs, but at the same time requiring a minimum standard of accommodation and specification. Housing cost yardsticks were first introduced in 1963 to keep down the costs of infrastructure services.

In the absence of cost limits, housing standards and expenditure could reach high and unacceptable proportions.

Form 7 - Design review form

The design review is a coherent and systematic study of the design documents with the purpose of identifying problems and assessing the project's ability to fulfill specified and stipulated requirements.

It is necessary to fix the time in the design stage when the design review is to be held. Usually, reviews are affected upon completion of the different steps of the design stage.

Project details are gathered together under this form with considerable specification detail. It will also include a non-conformity section with reasons.

Ashford describes design approval as a formal documented, comprehensive and systematic examination of a design to evaluate the design requirements and the capability

of the design to meet the requirements as well as to identify problems and proposed solution (Ashford, 1992).

Having asked the necessary questions and recorded the responses, it is useful to assemble the design basis on a standard format.

This enforces control in design stage. Design professionals should carry out one or more design reviews during the design stage.

Form 8 - Cost check form.
A process of checking the estimated cost of each section or element of the project as the detailed designs are developed, against the cost target set against it in the cost plan.

The model makes provision for checking on a comprehensive basis whether costs are accurate by cost check forms.

The check makes an adjustment of the design details, followed by a further feasibility.

An analysis is then carried out to determine whether the performance requirements are satisfied. If not, a trial adjustment has to be made to the design details and a new analysis carried out in the search for a feasible solution. Analysis plays a comparable role in a planning problem.

During the process of the consultants' design, it is necessary that the total cost is not to be exceeded. Since the consultants' will design in elements, it is convenient for the cost checks to be carried out on this basis and compared with the cost targets in the agreed cost plan.

Form 9 - Detailed cost analysis
The detailed cost analysis is the process of breaking down a complex product into its component parts before identifying different and hopefully more effective methods of achieving the desired result.

It enables the designer to determine how much has been spent on each element and to show where reductions could be most beneficially made, should the estimate prove to be too high leading to more effective cost control.

It is a systematic breakdown of cost data, to assist in the estimating of cost and in the cost planning of projects.

It is essential for the planning team to take into consideration a range of possible variations in the values of project variables and test how such variations will affect the cost of the project.

Apart from the quantitative variables there are also qualitative variables that affect the viability of the project.

The reason for this is that a detailed cost analysis attempts to achieve a balanced design; so increasing the quality of the specification of the element is more likely to give the client good value for money than returning the savings to the client or distributing them among the other elements.

This financial analysis translates the financial costs and benefits into economic costs and benefits by adjusting the project inputs and outputs for price distortions.

Form 10 – Detailed cost plan

The detailed cost plan involves presenting the refined detailed cost-analysis of the various items options of each element. The economic analysis guides the decision-makers by altering key design factors and assessing how and what costs should be increased.

Definition**-** it is a statement of the proposed expenditure of each section or element to definite standard of quantity. Each item can be regarded as a 'cost target' and is prepared in parallel with the detailed working drawings, and giving an itemized breakdown and outline specification of the cost allocation to design elements.

It is more concerned with the comparison of each element's cost within a total sum, rather than attempting to control the design in relation to targets for sections of the work. Its objective is not necessarily to show how cheaply a project can be produced but to show the spread of costs over various parts of the project and what economies are feasible.

This enables the engineer, within his cost terms of reference, to use the money to the best advantage in interpreting his design. This should lead to economy in design.

This strategy will attempt to spend money in accordance with the client's requirements, by allocating sums of money to the various major components of the project.

Form 11– Specification and design notes form

The technical specifications form is required to ensure that the projects proposed are appropriate and feasible with respect to technical considerations and specifications.

Technical specifications are used to define the product and to set out the acceptance criteria and resource specifications are used to define quality.

These specifications not only define the deliverables which are to be realized in the process of delivery, but also set out the manner in which they can be achieved, measured and monitored.

The function of this form is to check that the project elements will meet with the specified project requirements. The verification of compliance with specifications commences when materials are chosen for the design. This Procedure ensures that non-conforming materials are quarantined or otherwise prevented from being used.

The cost analysis and estimate is supplemented with specification notes.

5. CONCLUSION

The cost planning model and its outputs is a disciplined effort to produce fundamental decisions in shaping the project cost. The process must be seen as an integrated whole in order to maximise the opportunities for improving quality and reducing project costs. This will place a heavy burden on the consultants to use client's money in the most efficient way possible.

Cost planning should be a continuous process, with progressive checks being made from time to time in relatively more detail on perhaps smaller sections of the project as the design is finalized. Another merit of cost planning is that it introduces a positive checking procedure into the design stage where previously nothing systematic had existed.

This paper shows how different levels of cost estimate can be prepared in parallel with design development. The system allows for the various components of the costs to be

estimated at their own discrete level, depending on the level of design information available.

Each of the standard forms has a measurable component, which enables the cost of each design component to be quantified.

The cost model not only promotes cost effective options but extends into accelerated service provision sustainable infrastructure.

The output reports referred to, in the cost-planning model serve to support decision-making and management functions. They are distinguished from textbook definitions in that they are more practical in application.

By the complementary role of preliminary cost reporting in overall project performance, it is sure to enhance cost, productivity, quality and time

The goal for continuous improvement in the infrastructure sector can be achieved through the proposed framework. This, together with basic principles of cost planning and construction economics can contribute to the concept of “affordable township infrastructure” and will result in a delivery system that becomes more efficient and effective.

6. REFERENCES

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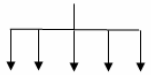
ANNEXURE 1 : THE COST PLANNING MODEL

PROJECT REQUIREMENTS

PROCESS INVOLVED AT EACH STAGE	STANDARD FORM AT STAGE	ROADS	SEWERS	STORM WATER	TOP STRUCTURES	WATER		DESCRIPTION OF EACH STAGE
* APP 1 * APP 2 * APP 7 * FORM 13	* FORM 1 * FORM 2 * FORM 3 * FORM 4	unpaved treated unpaved gravel single seal double seal asphalt block paving concrete	pit lactrine communal toilet vacuum truck cartage low cost septic tank bucket cartage aquaprivy Japanese vacuum truck cartage septic tank water borne sewerage	natural watercourse soakaways storage piped network open channel	roofs ceilings floors ext. walls int. walls foundation plumbing and drainage frame	communal well/ borehole water tanker communal storage with adjacent stand pipes public stand pipes individual water butt individual well/borehole on plot individual piped supply- single tap individual piped supply- multi tap	**STAGE 1** ***FEASIBILITY STAGE***	**OUTLINE PROPOSAL** : ASSESEMENT OF OPTIONS : LEVELS OF SERVICE : APPROXIMATE ESTIMATE OF ALTERNATIVES : SCREENING OUT OF OPTIONS.
	* FORM 5 * FORM 6 * FORM 7 * FORM 8						**STAGE 2** ***SCHEME DESIGN STAGE***	**PRELIMINARY DESIGN** : EVALUATING DIFF. SCENARIOS : 'THE COST BRACKET' : COST LIMIT : QUANTITATIVE VARIABLES
* APP 2 * APP 3	* FORM 9 * FORM 10 * FORM 8						**STAGE 3** ***DETAILED DESIGN STAGE***	**DETAIL DESIGN** : DETAILED DESIGN : QUALITATIVE VARIABLES : ELEMENTS
* APP 4 * APP 5 * APP 6	* FORM 11 * FORM 12 * FORM 8						**STAGE 4** ***BILL OF QUANTITIES STAGE***	**FULL DESIGN** : DETAIL ELEMENT DESIGN : SPECIFICATION OF ELEMENTS : QUALITY OF SPECIFICATION

STANDARD FORMS

* FORM 1	: FEASIBILITY COST REPORT
* FORM 2	: LIFE-CYCLE COST ANALYSIS REPORT
* FORM 3	: COMPARATIVE COST ANALYSIS OF DEVELOPMENT OPTIONS
* FORM 4	: COMPARATIVE COST PLAN
* FORM 5	: ELEMENTAL COST ANALYSIS FORM
* FORM 6	: OUTLINE COST PLAN/COST TARGET FORM
* FORM 7	: DESIGN APPROVAL FORM
* FORM 8	: COST CHECK FORM
* FORM 9	: DETAILED COST ANALYSIS
* FORM 10	: DETAILED COST PLAN
* FORM 11	: SPECIFICATION AND DESIGN NOTES FORM
* FORM 12	: SCHEDULE OF QUANTITIES
* FORM 13	: PROJECT BUDGET TRACKING FORM

STANDARD PROCESSES

* APP 1	: OUTLINE OF COST PLANNING PROCESS
* APP 2	: OUTLINE OF COST CHECKING PROCESS
* APP 3	: OUTLINE OF DETAILED DESIGN PROCESS
* APP 4	: OUTLINE OF ELEMENTAL COST ANALYSIS PROCESS
* APP 5	: OUTLINE OF MATERIALS SELECTION AND EVALUATION PROCESS
* APP 6	: OUTLINE OF COST DATA VERIFICATION PROCESS
* APP 7	: OUTLINE OF VALUE ANALYSIS PROCESS