ESTIMATING DESIGN COSTS - THE DATA DILEMMA.

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ABSTRACT

This paper is concerned with the implications to design professionals in the Construction Industry of the increased use by clients of fee competition in the procurement of professional services. In particular, the need to accurately estimate the cost of these services is identified; and a methodology which has been developed to provide data for developing cost estimates, and improving estimating skills amongst design managers is described.

1. INTRODUCTION.

In recent years, the long established relationship between clients of the construction industry and the project designers has been fundamentally altered by changes in the method of procurement of construction projects and the professional services of the designers of these projects. This has, led in turn, to a need for design organisations to more accurately predict and control the cost of their work. In particular, factors such as the spread of Compulsory Competitive Tendering (CCT) in the public sector, the increase in the use of the Design and Construct procurement system, and the increasing application of fee competition amongst designers by clients using the traditional system has increased pressure on design organisations to review their management approaches. The authors have suggested in a previous paper (Blackwood et al, 1992) that the combination of such pressures will necessitate a move by design organisations, from their previous reliance on management systems which were predominantly cost control based, to systems which involve a more accurate estimate of the necessary staff resources for effective project design. In order to adopt such an approach it is implicit that design organisations would have to draw on a database of information on previous projects to accurately assess the cost of design for new commissions. This paper considers the practicality of the creation of such a database, particularly in the context of civil engineering design within the United Kingdom water industry.

2. THE NATURE OF THE DESIGN PROCESS

The application of planning and estimating techniques to construction operations has been thoroughly researched and documented (Ogunlana, 1989), but little published literature exists on the application of these techniques to design work. There are a number of factors which will influence the applicability of contractors' planning and estimating approaches to design work, including differences in the nature of the organisations that are involved in design, their traditional management systems, and the nature of their employees. The most significant difference however, is the nature of the design process. The design activity has been described as "a sub-set of the general class of action known as decision making" (Markus, 1972). This decision making process is essentially iterative with the ultimate solution being developed by a series of refinements to the most suitable conceptual solution selected from a range of possible original solutions. Many models models have been developed to represent this process including descriptive models (Cross 1989, Jones 1990) and prescriptive models, which are concerned with developing the most appropriate sequence of operations for effective design (Wallace, 1984). These models vary in complexity but the common theme of the models is summarised in Figure 1.

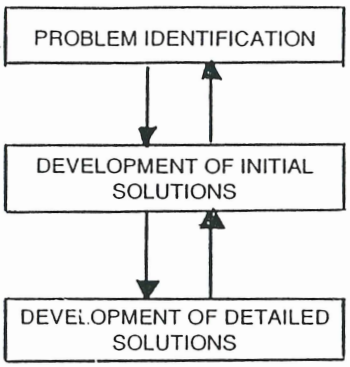

Figure 1 - General Model of the Design Process.

The most significant feature of the model, with respect to estimating design costs, is that the links between the stages are not one directional and the solution is developed in an iterative manner, as shown by the feedback loop between the stages. Consequently, the boundaries of design stages and constituent work packages are extremely difficult to define, and serious doubts must be raised about the practicality of recording meaningful cost data against a sufficiently large number of work packages to enable estimates of design costs to be built up from historic data.

3. THE DATA COLLECTION DILEMMA

The dilemma facing design managers in an increasingly competitive environment is how to develop systems of data collection which will provide sufficiently detailed and accurate cost information to permit realistic fee estimates to be made, whilst maintaining the practicability of the data collection system. The problems associated with the definition of work package boundaries makes the recording of design times through timesheets an onerous and time consuming activity for staff, with a high possibility of erroneous recording due to the lack of definition of the work packages. It is probably significant that a recent survey of design managers demonstrated that design organisations do not currently possess detailed cost information which can be readily used for fee estimation (Blackwood et al, 1992). The survey showed that design managers use intuitive approaches to estimate design costs, because their design office cost control systems are based on a very small number of work packages which do not provide sufficient data for detailed estimates of future fee bids.

The authors are currently engaged on a programme of research work to develop a micro-computer based system which will help Architects and Engineers prepare estimates of the costs of their professional services and, in order to address the data collection dilemma, part of this programme constitutes the development and testing of a data collection methodology.

4. DATA COLLECTION CASE STUDIES.

The case studies are based in one sector of the construction industry, civil engineering design within two Scottish Local Authority Water Services Departments. However, the survey of design managers demonstrated that the problems of fee estimation were common to all design sectors of the industry. Research in the United States Of America (Deikman, 1987) demonstrated that design management systems could only be successful if they were used directly by those actively involved in the design process. A data collection methodology, based on a design project management system, was therefore developed which could be used directly by designers and would provide instant feedback on the income, expenditure and progress on the current projects, thereby encouraging the use of the system, and promoting greater accuracy in the recording of data.

The system operates on a spreadsheet so that it could be installed directly on the project engineer's computer. Three projects of varying durations and magnitudes were chosen, one with one local authority and two with the other. The shortest trial, eight weeks of the latter stages of the design of a sewerage project is described in detail here, but similar approaches were adopted in the other two projects: a water main; and a sewage treatment works; of six and fifteen months of design work respectively.

4.1 Planning and Estimating Stage

The first task was to identify the appropriate work packages. These must be selected to ensure that a common set of work packages can be used across the organisation to maximise the production of data for each work package. They should also be clearly defined to minimise the problems of identifying boundaries between work packages, as discussed earlier in this paper. The project management system was therefore designed to be compatible with the Department's Quality Assurance system, with the project plan based on the quality plan for the project, and the work packages on the appropriate quality assurance procedures. In this case, six relevant procedures were identified and one was subdivided to give seven work packages as follows:

QP408.1 Structural Design/Calculations
QP408.2 Drawings
QP410 Tender Documents
QP409 Bill of Quantities
QP411 Consultation with interested parties
QP413 Drawings (Final preparation)
QP415 Drawing Approval

4.2 Project Design Programme and Resources

Having identified the work packages, the engineers then prepared a resourced programme for the project. This consisted of a bar chart as shown in Figure 2 together with a list of the necessary resource inputs, classified by salary grade.

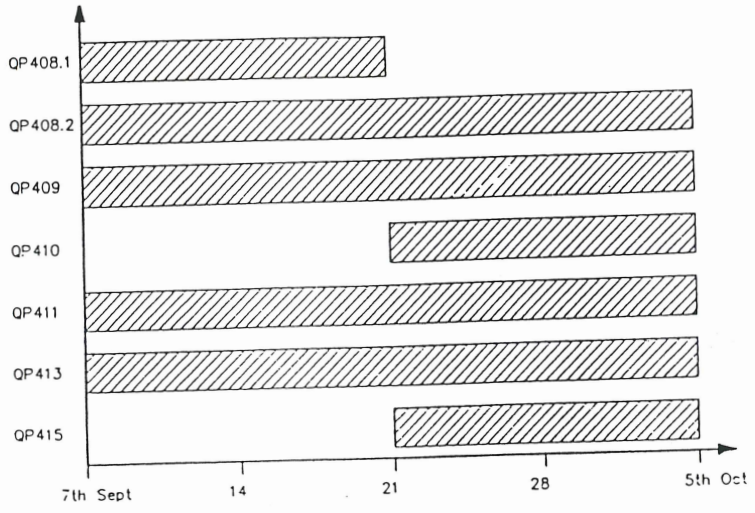

Figure 2 - Project Design Programme

It must be appreciated that the key objective in managing design work in the department has traditionally been to ensure that an annual programme of capital expenditure is adhered to, and the engineers have used the available staff to ensure that tender documents are issued on time. However, the project management system is designed to enable the project engineers to consider not only time but design costs in managing the projects. This is a significant change in emphasis and an immediate consequence of this change was that no data exists to support the engineers in the estimate of the resource requirements for the design work. (The project management system is intended ultimately to produce such data). The resources for the various work packages had to be estimated intuitively.

4.3 Data input and analysis

The spreadsheet contained a section whereby the resource data could be directly input in hours for each grade of engineer for each work package, and charge rates were included for the different grades. Another section of the spreadsheet allowed the programme to be input in terms of percentage complete per week of each work package (PERPLAN). The spreadsheet now calculated:

(i) the total costs of the design work;
(ii) the percentage that each work package contributes to the total cost (PERCONT), and
(iii) the weekly overall planned progress on the project which is given by:

$$\sum_{i=1}^{n} (\text{PERPLAN} \times \text{PERCONT})$$ where n = number of work packages

This is shown cumulatively as the proposed progress line on the graphical output from the system. (see Appendix A)

4.4 Project Monitoring and Control Stage

Data for project monitoring were collected from timesheets which were completed by all staff involved in the project. A specimen timesheet is included in Appendix A. The work package codes correspond with the quality assurance procedures and this, if this system were used across the department, would eventually produce consistent data for predicting the costs of future work on these work packages. In addition to recording hours spent, the project engineer was required to prepare a weekly estimate of physical progress in terms of the degree of completion as a percentage of each work package (PERCOMP).

The data were input using linked spreadsheets which replicate the timesheet shown in Appendix A with each linked spreadsheet covering a four week period. For the purpose of the trial, the data were input and processed by Dundee Institute of Technology but the system should be used directly by the project engineers in future. The project management spreadsheet now calculated:

(i) the actual cumulative cost of the work: i.e the sum of the hours recorded multiplied by the charge rates, with suitable adjustment for overtime periods. This was then expressed as a percentage of the original budget which is shown as the actual cost line on the graphical output (Appendix A);
(ii) the actual weekly progress which was given by:

$$\sum_{i=1}^{n} (\text{PERCOMP} \times \text{PERCONT})$$, where n =number of work packages

This is shown cumulatively as the actual progress line on the graphical output (Appendix A).

4.5 Users Comments on The Project Management System.

Some minor comments were made on the layout of the timesheet and it was suggested that staff should be given more information relating to the completion of the timesheets. The main problem identified was the difficulty in keeping up to date records of hours worked, because the department's central office management clocking in system returned data the following Tuesday at the earliest, and the information required for the central system was much less detailed than the data required for the project management system. To overcome this, separate records had to be kept on a day to day basis by each person involved in the project. Serious doubts were raised about the practicability of this, and the accuracy of the data which would be produced. This was considered to be a particular problem for more senior staff who could be involved in a number of work packages over a number of projects in any week. The data were input and processed by Dundee Institute of Technology and this led to unavoidable delays in the production of output. Consequently, the potentially useful quick feedback of data was not achieved but this should be rectified in future by the direct input and processing of data by the design department's staff, preferably the project engineer.

5. CONCLUSIONS AND OUTLINE OF FUTURE WORK

The trial of the data collection methodology on the two projects in the other local authority experienced similar difficulties. However from the positive feedback obtained from all the design engineers involved in the trial it can be concluded that the design project management system is a potentially useful tool for project engineers, and that it can produce cost data for future estimating purposes.

It is doubtful if the level of detail of data used in the trial can be collected on a long term basis in design organisations. Both organisations requested that modifications should be made to the operation of that part of the system which deals with the calculation of actual cost. Initially, the engineers were required to input timesheet data directly into part of the spreadsheet, as it was thought that this would remove the time lag between engineers completing their timesheets and the production of cost information from the department's central office management system. Furthermore, this direct entry of data was intended to permit a greater sub-division of work packages which would generate more specific data for use in the estimation of cost of future projects. This proved not to be satisfactory for two reasons.

Firstly, the physical size of the linked spreadsheet became a problem for projects involving a number of engineers and spread over a long period of time, both in term of the hardware memory requirements and the processing time. Secondly, where engineers were involved in a number of projects, the efforts of keeping detailed records of time spent on a large number of work packages proved to be prohibitive. Consequently, in future data on actual costs should be produced by the departments central office management system provided that action could be taken to speed up the return of cost information to the project engineers. The only drawback of this strategy is that the central systems can only utilise a limited number of work packages and therefore data for future cost estimation will be limited in detail. The trail run has suggested that this is unavoidable and that any estimating system will have to operate on data which are project specific, but not detailed with respect to the component work packages of the project.

The final stage of the research work will involve the development of the cost estimating element of the project management system so that it may use the limited data collected by the office management system to predict the cost of future projects. The revised project management system has been installed in one of the departments and is currently being linked electronically to the office management system. This will continue to provide data for the development of the predictive cost model.

6. REFERENCES

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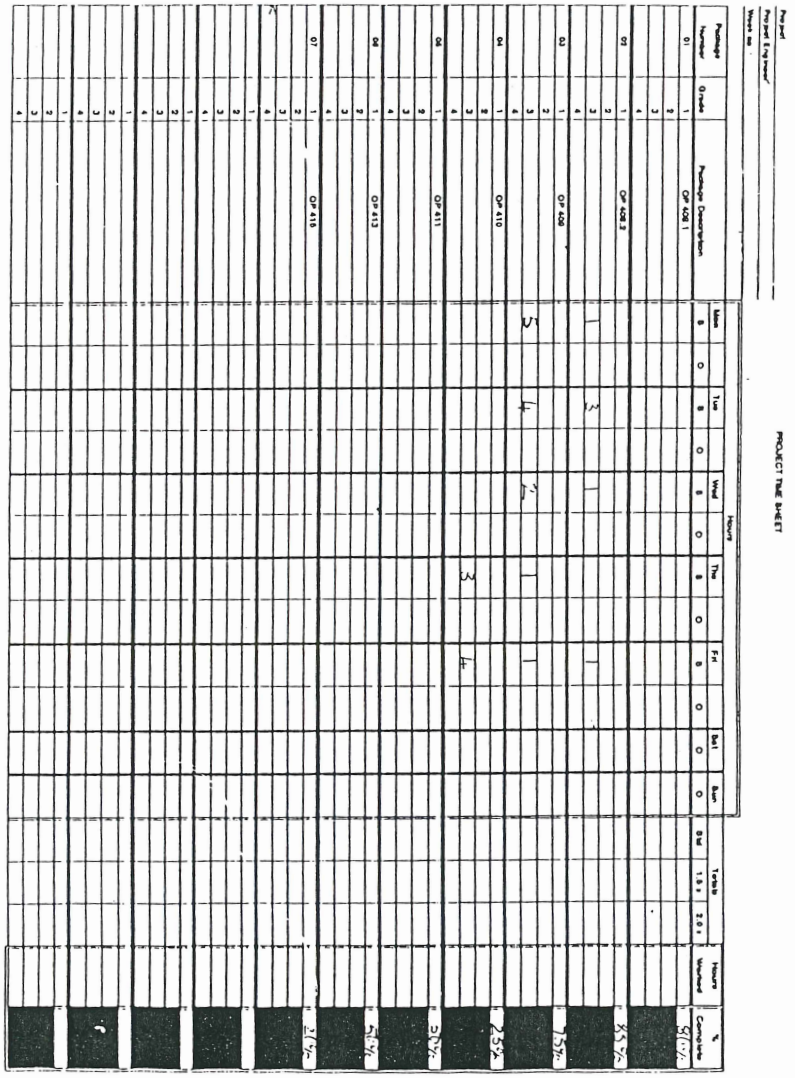
APPENDIX A - Specimen Timesheet



PROJECT TIME SHEET

Project
Project Engineer
Week no