A SYSTEM PROTOTYPE FOR INTEGRATING ESTIMATING DATA AND PLANNING INFORMATION IN THE CONSTRUCTION INDUSTRY

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SUMMARY

This paper illustrates a system prototype development for integrating estimating data and planning information, based on the Standard Method of Measurement of Building Works (SMM) and bills of quantities. Information is generated from the resources allowed in the priced bill items. This results in the integration of estimating data and planning information for management. Sensitivity of the system prototype to changing conditions during the production process is also discussed, together with its general application in practice.

Keywords: Bills of quantities, estimating data, planning information, work packages, operations, sub-operations, work targets, resources, durations.

1. Introduction

The integration of processes between design and the construction phase, has in the past, proved problematic mainly because of the incompatibility of project documentation and the requirements of production orientated information. Bills of quantities currently used in the UK are in a different format from the production information requirements of site management. To utilise this information, therefore, calls for manipulation and re-interpretation of the initial data from the estimating process.

The major processes such estimating, planning and control have, to date, been dealt with on a piecemeal basis. Several computerised systems have been developed in order to provide assistance in the management of projects, but the development has been for a specific purpose without the necessary requirements of integration with other processes.

Integration of individual processes is now becoming desirable for the management of projects (Sharad, 1978). Systems have been developed in the USA based on contractors' own mode of operational working (Ryan and McCarthy Jr.,1980; Sharad, 1978). In the UK, developments have been based on the extension of estimating systems to produce management information (McCaffer and Sher, 1981; McCaffer and Baldwin, 1983; Bowman, 1981).

For building work a system is required which can generate information from documentation based on SMM to suit the various detailed requirements of site management. Such information would also need to be timely and responsive to the every changing conditions on site to be of practical value.

2. Planning and Control of Construction

The planning and scheduling techniques used in the industry today often use information from a variety of sources. This can result in difficulties when trying to relate such information with allowances made in the bill of quantities based on SMM. Data from the estimating process should therefore form the basis of information generation and be integrated with planning and control procedures.

The integrated approach has the advantage of avoiding the disparities that exist between the various processes, so that information generated is based on common data rather than on a piecemeal basis (Ryan and McCarthy Jr., 1980).

3. System Prototype Development

The system prototype developed has been based on utilising production data from the estimate to produce information for the various stages of planning. In order to establish the links, a coding system was established to integrate the various levels of planning to the items in the bill of quantities.

3.1 Coding of Bill of Quantities Items

Coding systems have been developed previously for the use with computer systems (DOE, 1969), particularly for bill of quantities production (PSA, 1980). For the system prototype, the requirement was to integrate the bill of quantities, with production data from the estimate and production orientated information for site management. A coding structure was therefore required to represent work packages at various levels of detail.

3.2 Classification and Category Codes

The classification for primary work packages for overall planning needs to relate to specific operations e.g. concrete, brickwork and blockwork. A simple acronym code was therefore used.

For example, concrete work could be represented by:

C_____ Concrete Work

to relate to a concrete work package.

An additional category code was also required to relate to a more detailed level representing a specific secondary work package or sub-operation.

For example, concrete category codes could be represented by:

F_____ Foundations
SS____ Suspended Slabs

Expansion of the codes to six digits would allow for extended detail as required.

Further sub-division of work categories would relate to tertiary work packages or work targets. For this level of detail it is unnecessary to have further coding. Work targets are representative of parts of sub-operations determined by the quantity of work to be included in the target.

The main requirement of coding work packages was one of flexibility. Codes were therefore not fixed for bill items, but left to suit particular requirements.

3.3 Coding of Production Data from the Estimate

In addition to the coding of bill items and work packages, codes were also used for production data from the estimate. Coding of this data could be made to be consistent with previously used estimating data or similar to independent estimating systems (Holes and Thomas, 1982). Three figure codes were used to reference separate resources combined with a five digit acronym code for the resource description. Production data could therefore be input against resources as appropriate (e.g. 661 GLAB General Labourer).

4. Operating the system

The system has been designed on a modular basis to allow the generation of data at various levels of detail. Data can be generated at whatever level required to suit particular circumstances and the requirements of a project. All information generated is based on the same production data, which provides for integration from single work targets to overall operations representing an entire project. Figure 1 shows an overview of the planning model, and the flow of data and information generation at various levels of detail.

4.1 Data Input

Data for the system needs to be input from the bill of quantities in the form of bill reference and abbreviated description, together with the classification and category

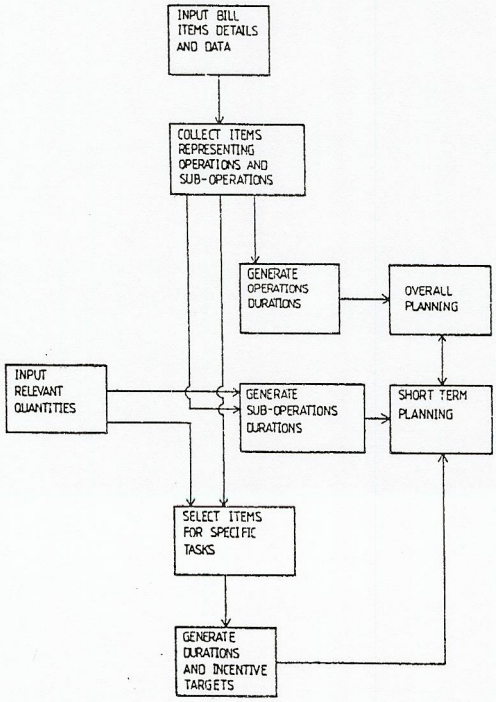

Figure 1. Overview of the Planning Model

codes. Additionally, production data needs to be input to relate to bill items in the form of resources used and output data in the form of multiplication and division fields. An established data base of production performances relating to specific bill items can also be utilised if required (Stephenson, 1988). An example of data entry is shown in Figure 2.

BILL ITEMS AND ESTIMATE DETAILS

PAGE	REF	CLASS	CAT.	ITEM DETAILS	QUANT	UNIT
6	d	C	WL	Walls ne 1.5 ht 150-300th	79.00	m3

REF	RES	MULT	DIVI
661	GLAB	0.77	1.00
0		1.00	1.00
0		1.00	1.00
0		1.00	1.00

Figure 2. Data Entry

4.2 Generation of overall Planning Information

Within the overall planning module of the system, various sub-modules exist for:

1. the creation of overall operations,

2. the assigning of bill items to overall operations,
3. the generation of resource durations for the overall operations based on output data.

The first sub-module allows overall operations to be entered to suit the project along with the appropriate classification codes. Figure 3 illustrates the entry of an overall operation.

LIST OF OVERALL OPERATIONS

OP.NO.	CLASS	OPERATION DESCRIPTION
1	C	CONCRETE WORK

Figure 3. Entry of an Overall Operation

The assigning sub-module assigns bill items previously entered to the overall operations by means of code matching. This allows screen listings and reports to be generated of operations and assigned items as shown in Figure 4.

OVERALL OPERATIONS AND ASSIGNED ITEMS

OPERATION NO. 1 CONCRETE WORK

PAGE	REF	CLASS	CAT.	ITEM DETAILS	QUANT	UNIT
5	a	C	B	Beds ne 100th	32.00	m3
5	b	C	F	Foundations over 300th	139.00	m3
5	c	C	F	Foundations 150-300th	53.00	m3
5	d	C	IFB	Isolated foundation bases	261.00	m3
5	e	C	MB	Machine bases	1.00	m3
5	f	C	ICTB	Iso casing to beams 0.03-0.1m2	1.00	m3
5	g	C	ICTCOL	Iso casings to cols > 0.25m2	1.00	m3

Figure 4. Overall Operation and Assigned Items

Generating resource durations for overall planning information is based on the assigned items and output data. During processing all operations are analysed, and a summary of resources is provided. This itemises the resources and references, together with the corresponding hours.

At the end of processing, a factor can be entered to provide adjustments to the production data. A number of operatives can be entered to represent gang sizes. The results obtained provide information in the form of resource requirements and total durations for operations in hours and weeks. Adjusted durations are also provided based on factoring and gang sizes chosen. Figure 5 shows an example of overall operations details.

OVERALL OPERATIONS DETAILS

OPERATION NO. 1 CONCRETE WORK

RESOURCE DETAILS			RESOURCE REQUIREMENTS					
REF	RES	HOURS	FACTOR	NO.	HOURS	WEEKS	ADJ.HOURS	ADJ.WEEKS
661	GLAB	1803.32	0.80	4	450.83	11.2	360.66	9.0

OPERATION NO. 2 BRICKWORK AND BLOCKWORK

RESOURCE DETAILS			RESOURCE REQUIREMENTS					
REF	RES	HOURS	FACTOR	NO.	HOURS	WEEKS	ADJ.HOURS	ADJ.WEEKS
602	BL	9300.93	0.96	8	1162.61	29.0	1116.11	27.9
663	BLLAB	4694.87	0.96	4	1173.71	29.3	1126.76	28.1

Figure 5. Overall Operations Details

4.3 Generation of Short Term Planning Information

The short term sub-module generation procedure is similar to that of overall planning. The additional feature is that code matching is based on category codes as well as classification codes. This is required to produce information at a lower level of detail to relate to secondary work packages or sub-operations.

Additional variations in the short term planning module relate to the assigning process. In this case, assigning is designed to concentrate on cost significant items only for particular work sections. Items which are cost insignificant are segregated by entering a sundry category code. Sundry items often represent only a small part of an operation in terms of hours and also value (PSA, 1983). Instead of ignoring these completely cost insignificant items are equally proportioned over the total measure of cost significant items.

In the case of concrete work, cost significant items are those which represent items measured in cubic metres. In the case of brickwork and blockwork, significant items relate to those measured in square metres.

An adjustment for an item based on cubic metres would be:

$$\text{Hours} = (A \times A1 \text{ hrs}) + \left(A \times \frac{Y}{X}\right) \qquad (1)$$

where: A = number of cubic metres of concrete in the operation

A1 = production data hours per cubic metre for the significant item

Y = total hours for sundry items in the concrete work section

X = total number of cubic metres in the concrete work section

Such an adjustment does produce inaccuracies since some operations contain more insignificant items than others, but this was considered to be negligible for planning purposes.

The short term planning module also requires quantities to be input to represent the extent of work relating to specific categories. Information is then generated in a similar format to that of the overall planning module. Figure 6 illustrates the information generated.

SUB-OPERATIONS DETAILS

SUB-OPERATION NO. 1 FOUNDATIONS

RESOURCE DETAILS				RESOURCE REQUIREMENTS				
REF	RES	HOURS	FACTOR	NO.	HOURS	WEEKS	ADJ.HOURS	ADJ.WEEKS
661	GLAB	471.15	1.00	4	117.78	2.9	117.78	2.9

SUB-OPERATION NO. 2 ISOLATED FOUNDATION BASES

RESOURCE DETAILS				RESOURCE REQUIREMENTS				
REF	RES	HOURS	FACTOR	NO.	HOURS	WEEKS	ADJ.HOURS	ADJ.WEEKS
661	GLAB	65.16	1.00	4	16.29	0.4	16.29	0.4

Figure 6. Sub-operations Details

4.4 Generation of Work Target Information

The generation of work targets is based on the secondary work packages or sub-operations. Targets to be generated must therefore be selected in terms of relevant bill items and quantities representing the target. A factoring facility exists with this sub-module to make adjustments to production data, with an additional percentage addition representing a bonus increment, if required, to arrive at the target hours. Information generated shows details of the resources representing the target, with provision for the recording of feedback information. An example of the work target information is shown in Figure 7.

5. Sensitivity of the System Prototype to Changing Conditions

Changing condition during the production process is an inevitable occurrence on all construction projects. This may result in changes being made to bill items and quantities, in addition to variations in production. To cater for such changes the facility exists to create, delete, and amend item details, so re-assigning can take

WORK TARGET ITEM

SUB-OPERATION NO. 1 FOUNDATIONS

PAGE REF	CLASS	CAT.	ITEM DETAILS	QUANT	UNIT
5 c	CSUB	FT	Foundations 150-300th	45.00	m3

REF	RES	PROD.HRS	ACT.HRS	GANG	HRS.SAVED	REMARKS	ADJ.O/P
661	GLAB	34.34					
		34.34					
	FACTOR	1.00					
	ADJ.HRS	34.34					
	BONUS %	30					
	TARGET HRS	44.64					

Figure 7. Work Target Information

place to produce up-dated information. The system prototype allows this to be done speedily and timely, and avoid what would otherwise be an arduous task by manual means.

6. Conclusions

The system prototype development brings together design documentation and the generation of management information based on the concept of work packages. The planning information produced can be used to prepare programmes in various levels of detail, including the automatic generation of targets for operatives. The integration of estimating data and the planning process provides a direct link between the estimate and planned production. This enables data to be used consistently and allows feedback information to be recorded for future tenders and projects.

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