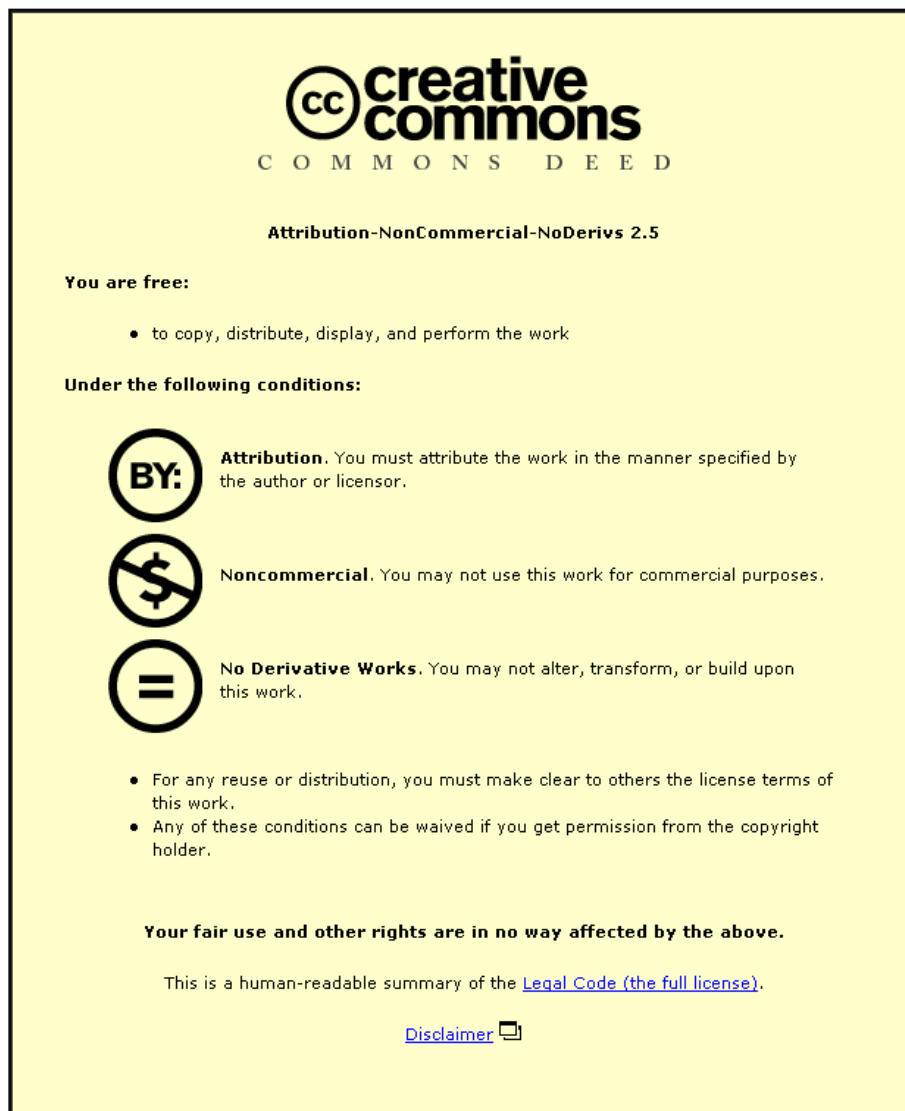


This item is held in Loughborough University's Institutional Repository (<https://dspace.lboro.ac.uk/>) and was harvested from the British Library's EThOS service (<http://www.ethos.bl.uk/>). It is made available under the following Creative Commons Licence conditions.



For the full text of this licence, please go to:  
<http://creativecommons.org/licenses/by-nc-nd/2.5/>

CONSTRUCTION CONTRACT INFORMATION  
MANAGEMENT: AN INTEGRATED SYSTEMS APPROACH

A Thesis submitted in partial fulfilment  
of the requirements for the award of  
the Degree of  
DOCTOR OF PHILOSOPHY

by

ISSAKA, E. NDEKUGRI B.Sc. (University  
of Science and Technology, Ghana), M.Sc.  
(Loughborough University of Technology)

SUPERVISOR: PROFESSOR RONALD McCAFFER  
B.Sc., Ph.D., C.Eng., MICE, MCIOB.

Department of Civil Engineering  
Loughborough University of Technology  
Loughborough

APRIL, 1986

© by ISSAKA E. NDEKUGRI

## DEDICATION

This Thesis is dedicated to the memory of  
James Marshall Ramsey, great teacher and greater friend.

.

(iii)

ORIGINALITY

All the work presented in this thesis has been carried out by the author except where acknowledged, and has not previously been presented for a degree at any institution.



## ACKNOWLEDGEMENTS

This research was inspired by Professor McCaffer's long-standing keen interest in total integration of construction contract management information. Not only did he help with arranging contacts with the construction industry and obtaining funds, but he also offered invaluable advice throughout the research and in the writing up of this thesis.

CAMIC Ltd provided funding for part of the research and contributed immensely to the research by bringing contractors to evaluate the software developed through the research. Through CAMIC many contractors made their experience, expertise and methods of operating available to me. John Walkerdine & Son and the Gilbert Ash Group were particularly helpful.

Professor Pickford, Head of Department, was very kind in making departmental funds available when it was needed.

Mrs. Ayebo has been most encouraging and supportive throughout the entire research. She not only provided 'tuon zafi' (a Ghanaian dish) to keep the spirits high on a regular basis but also supported me financially on countless occasions.

Some of my colleagues as well as some members of the academic staff kindly shared their experiences and expertise with me whilst all the administrative staff were eager to help my research in whatever way they could. I must mention Mrs. June Robson, my supervisor's secretary.

Mrs. Movva Brooks: she typed (re-typed) the thesis with great patience, enthusiasm and cordiality.

To all, thanks.

## ABSTRACT

Even by 1980 it was observed that software for construction management comprised many independent packages with different programming languages and hardware. By and large, not only were these packages stand alone systems but they were also not suitable for their individual functions. Not only do construction projects increase in complexity but competition and volatile markets also generate pressures for better management and that requires integrated and effective systems.

The hypothesis of this research has been that computer technology and systems concepts can be used to develop the necessary tools that will make integration possible and effective. To that end, the following research has been undertaken:

- \* an investigation of the causes of the lack of integration,
- \* a survey of the operations of the management functions,
- \* the specification, development and testing of a computer-based system called PLUS VAL to demonstrate the viability of integration,
- \* an assessment of PLUS VAL.

Causes of lack of integration revealed include:

- \* segregated education, training and working of functional groups, . . .
- \* development of software by people without the relevant expertise,

- \* inadequate research and failure to apply research findings due to the structure of the construction industry.

A survey of the operations showed:

- \* the various methods of carrying them out,
- \* the flow of data among them,
- \* their interdependencies.

The major features of PLUS VAL are:

- \* it assists valuations, purchasing management and cost control,
- \* it can be linked to estimating, planning and accounting,
- \* it allows quick access to contract information.

Its assessment which involved demonstrating it to and interviewing potential users, and comparisons with similar packages commercially available showed that:

- \* It provides all the facilities that the users wanted .
- \* It covers all the methods of operations of companies contacted .
- \* It is more comprehensive than those surveyed .
- \* Integration is possible and provides such benefits as:
  - . reduced costs of data capture,
  - . better use of computer storage,
  - . reduced turn around times of data processing,
  - . increased data consistency.

The results of the research show that the application of computer technology and systems concepts can produce effective integrated systems which not only assists contractors in carrying out their obligations but also provide reliable information for decision-making.



|  | <u>Page</u> |
|--|-------------|
| 1. INTRODUCTION  | 1           |
| 1.1 The Nature of Contractors' Operations                    | 1           |
| 1.2 The Use of Computers in Construction Contract Management | 2           |
| 1.3 Shortcomings of the Software                             | 3           |
| 1.3.1 Lack of Suitability For Functions                      | 3           |
| 1.3.2 Lack of Integration                                    | 4           |
| 1.3.3 New Demands  | 5           |
| 1.4 Hypothesis and Justification For the Research            | 6           |
| 1.5 The Research Undertaken                                  | 6           |
| 1.6 Main Findings  | 9           |
| 1.6.1 Lack of Integration                                    | 9           |
| 1.6.2 The Operations of The Management Functions             | 10          |
| 1.6.3 The Requirements For Effective Integration             | 11          |
| 1.6.4 Systems Specification                                  | 12          |
| 1.6.5 System's Description                                   | 13          |
| 1.6.6 Testing of the System                                  | 14          |
| 1.6.7 Assessment of the System                               | 14          |
| 1.6.8 Integration of Contract Information                    | 15          |
| 1.6.9 The Significance of The Research                       | 16          |
| 1.7 A Guide to the Thesis                                    | 17          |
| 2 SYSTEMS METHODOLOGY  | 19          |
| 2.1 Outline of Methodology                                   | 19          |
| 2.2 Systems Investigation and Analysis                       | 21          |
| 2.2.1 Terms of Reference                                     | 21          |

|           | <u>Page</u>                                   |
|-----------|---|
| 2.2.2     | Information Sources 22                        |
| 2.2.3     | Information Gathering Techniques 23           |
| 2.2.3.1   | Interviewing 23                               |
| 2.2.3.2   | Questionnaire 24                              |
| 2.2.3.3.  | Literature Survey 24                          |
| 2.2.3.3.1 | The Operations of the Management Functions 24 |
| 2.2.3.3.2 | Organizational Theory 26                      |
| 2.2.3.4   | Author's Experience 29                        |
| 2.2.4     | Systems Analysis 29                           |
| 2.2.5     | Results of the Investigation and Analysis 31  |
| 2.3       | System Design 31                              |
| 2.3.1     | Output Design 33                              |
| 2.3.1.1   | Methods of Outputting Information 33          |
| 2.3.1.2   | The Role of The User 35                       |
| 2.3.1.3   | General Guidelines 36                         |
| 2.3.2     | Input Design 36                               |
| 2.3.2.1   | Importance of Input Design 36                 |
| 2.3.2.2   | Guidelines of Input Design 37                 |
| 2.3.2.3   | The Input Process 38                          |
| 2.3.2.4   | Source Document Design 39                     |
| 2.3.3     | File Design 40                                |
| 2.3.3.1   | File Organisations 40                         |
| 2.3.3.2   | Sequential Organisation 42                    |
| 2.3.3.3   | Random Access Organisation 43                 |
| 2.3.3.4   | Direct Access 43                              |
| 2.3.3.5   | Indexing Methods 45                           |

|           | <u>Page</u>  |
|-----------|--|
| 2.3.4     | Procedure Design 47  |
| 2.3.4.1   | Outline of Procedure Design 48   |
| 2.3.4.2   | General Guidelines 49  |
| 2.4       | Software Development 51  |
| 2.4.1     | Selection of Programming Language 52                                     |
| 2.4.1.1   | Language Design 52   |
| 2.4.1.2   | Implementation 53  |
| 3         | CONSTRAINTS TO THE INTEGRATION OF SOFTWARE IN CONSTRUCTION MANAGEMENT 55 |
| 3.1       | Technical Limitations of Computer Hardware 55                            |
| 3.2       | Inadequate Expertise of Software Developers 58                           |
| 3.3       | Limitation of Software Tools 58  |
| 3.4       | Organizational Factors 60  |
| 3.4.1     | General Outlook of the Construction Industry 60                          |
| 3.4.2     | Organisational Theory 65   |
| 3.4.2.1   | Organisation Structure 66  |
| 3.4.2.2   | Types of Organizational Structures 67                                    |
| 3.4.2.3   | The Traditional Organization 67  |
| 3.4.2.3.1 | Advantages of The Classical/ Traditional Organization 68                 |
| 3.4.2.3.2 | Disadvantages of the Classical/ Traditional Organization 70              |
| 3.4.2.4   | Project Organisation 71  |
| 3.4.2.4.1 | Rules, Standards and Procedures 75                                       |
| 3.4.2.4.2 | Hierarchical Referral 76   |
| 3.4.2.4.3 | Planning Procedures 76   |

|           | <u>Page</u>  |
|-----------|--|
| 3.4.2.4.4 | Liaison Positions 76                                     |
| 3.4.2.4.5 | Co-ordinator Position 76                                 |
| 3.4.2.4.6 | Task Forces 77   |
| 3.4.2.4.7 | Special Teams 77   |
| 3.4.2.4.8 | Full Project Management 78                               |
| 3.4.2.4.9 | Matrix Organization 78                                   |
| 3.4.3     | Construction Company Organization 79                     |
| 3.4.3.1   | Construction Project Organizations 83                    |
| 3.4.3.2   | Construction Organisation in<br>Transition 86            |
| 3.4.4     | Professional Divisions 89                                |
| 3.4.5     | Assimilation of Technology 93                            |
| 3.4.6     | Implications For Software Development/<br>Acquisition 96 |
| 4         | THE DETERMINATION OF USER INTERFACE<br>REQUIREMENTS 99   |
| 4.1       | Human Performance 100                                    |
| 4.2       | Computer Performance 100                                 |
| 4.3       | The Hardware Interface 102                               |
| 4.4       | The Software Interface 104                               |
| 4.4.1     | Function 104   |
| 4.4.2     | Dialogue Structure 106                                   |
| 4.4.2.1   | Types of Dialogue 107                                    |
| 4.4.2.2   | Screen Design 109  |
| 4.4.2.3   | Feedback and Assistance 110                              |
| 4.4.2.4   | Error Control 111  |
| 4.4.2.5   | Response Time 111  |



|           | <u>Page</u>  |
|-----------|--|
| 4.5       | The Specific Application of The System 113             |
| 4.5.1     | Classification of Users 113                            |
| 4.5.1.1   | The Clark 113  |
| 4.5.1.2   | The Specialist 114                                     |
| 4.5.1.3   | The Manager 115  |
| 4.5.2     | Types of Users in Construction 115                     |
| 4.6       | The Environment 116                                    |
| 4.7       | Special Problems 116                                   |
| 4.7.1     | Human and Organizational Aspects of Implementation 116 |
| 4.7.1.1   | Training 120   |
| 4.7.1.2   | Systems Support 120                                    |
| 4.7.1.2.1 | Documentary Support 121                                |
| 4.7.1.2.2 | Human Support 124                                      |
| 4.7.1.3   | Job Redesign 124                                       |
| 4.7.1.4   | Persuasion/Policies 126                                |
| 4.7.1.5   | User Participation 127                                 |
| 4.7.1.6   | Management Commitment 128                              |
| 4.7.2     | Appropriate Testing Strategy 128                       |
| 4.7.2.1   | Program Testing 129                                    |
| 4.7.2.1.1 | Testing Strategy 129                                   |
| 4.7.2.1.2 | Source of Data 130                                     |
| 4.7.2.1.3 | Levels of Testing 131                                  |
| 4.7.2.2   | User Acceptance Testing 134                            |
| 4.7.2.3   | Debugging 134  |
| 4.7.3     | Strategy For The Assessment of the System 136          |
| 4.7.4     | Financial Justification of The System 136              |

|         | <u>Page</u>   |
|---------|---|
| 4.7.5   | Strategy For Change Over 140                            |
| 4.7.5.1 | Running Parallel Systems 140                            |
| 4.7.5.2 | Operating a Pilot System 141                            |
| 4.7.5.3 | Phase-in/Phase-out Method 141                           |
| 4.7.5.4 | Cut-off Method 141                                      |
| 5       | VALUATIONS AND PROJECT CONTROL 143                      |
| 5.1     | Parties and Responsibilities in External Valuations 145 |
| 5.2     | The Frequency of Valuations 146                         |
| 5.3     | Valuation Procedures 147                                |
| 5.4     | The Accuracy of Valuations 147                          |
| 5.5     | Retention 151   |
| 5.5.1   | Important Contract Dates: ICE Contracts 151             |
| 5.5.2   | Important Contract Dates: JCT Contracts 152             |
| 5.5.3   | Retention Under The ICE Contract 154                    |
| 5.5.4   | Retention Under The JCT Contract 154                    |
| 5.5.5   | Release of Retention: The ICE Contract 156              |
| 5.5.6   | Release of Retention: The JCT Contract 157              |
| 5.6     | Dealing with Errors in Valuations 158                   |
| 5.7     | Payment 160   |
| 5.8     | Checking Valuations 160                                 |
| 5.9     | Valuations and Cashflow 163                             |
| 5.10    | Valuations and Financial Accounting 164                 |
| 5.10.1  | The Balance Sheet 165                                   |
| 5.10.2  | The Profit and Loss Account 167                         |
| 5.10.3  | The Directors' Report 172                               |

|            | <u>Page</u>  |
|------------|--|
| 5.11       | Valuations and Management Accounting 172             |
| 5.11.1     | Control at the Corporate Level 172                   |
| 5.11.1.1   | Budgetary Control at The Corporate Level 174         |
| 5.11.1.2   | Maintenance of Corporate Estimating Data 176         |
| 5.11.2     | Project Control 177                                  |
| 5.11.2.1   | Time Control: Progress Reporting and Forecasting 177 |
| 5.11.2.2   | Project Cost Control 180                             |
| 5.11.2.2.1 | Setting Objective 181                                |
| 5.11.2.2.2 | Reporting 182  |
| 5.11.2.2.3 | Evaluation 188                                       |
| 5.11.2.2.4 | Corrective Action 189                                |
| 5.11.2.2.5 | Types of Cost Control Systems 191                    |
| 5.11.2.2.6 | The Contribution of Valuation to Project Control 193 |
| 5.11.2.2.7 | Retrospective/Forward Looking Control Systems 196    |
| 5.12       | The Cost Value Reconciliation 197                    |
| 5.12.1     | Sources of Inaccuracy in External Valuations 198     |
| 5.12.1.1   | Inaccurate Measurement of Works 198                  |
| 5.12.1.2   | Inaccurate Assessment of Materials on Site 199       |
| 5.12.1.3   | Variations Not Yet Settled 199                       |
| 5.12.1.4   | Claims in Dispute 200                                |
| 5.12.1.5   | Unbalanced Bids 200                                  |
| 5.12.1.6   | Pricing of Preliminaries 201                         |
| 5.12.1.7   | Dayworks Not Yet Agreed 201                          |

|   | <u>Page</u> |
|---|-------------|
| 5.12.1.8 Remedial Works                           | 202         |
| 5.12.1.9 Foreseable Risks                         | 202         |
| 5.12.1.10 Late Invoices From Sub-contractors      | 202         |
| 5.12.2 The Mechanics of Cost Value Reconciliation | 203         |
| 6 THE VALUATION OF MEASURED WORK                  | 205         |
| 6.1 Sources of Data For Valuations                | 206         |
| 6.1.1 Cost Records                                | 206         |
| 6.1.2 Invoices/Receipts                           | 207         |
| 6.1.3 Sub-contractors' Payment Applications       | 207         |
| 6.1.4 Program/Progress Schedules                  | 207         |
| 6.1.5 Dayworks Sheets/Dayworks Schedules          | 208         |
| 6.1.6 Analysis of Stages of Construction          | 208         |
| 6.1.7 Site Measurement                            | 208         |
| 6.1.8 Contract Documents                          | 210         |
| 6.2 Site Measurement Procedures                   | 211         |
| 6.2.1 Measurement of Work Contained in Bill Items | 211         |
| 6.2.1.1 Dimensions                                | 212         |
| 6.2.1.2 Quantities                                | 213         |
| 6.2.1.3 Values Earned                             | 213         |
| 6.2.1.4 Anticipated Future Expenditure            | 217         |
| 6.2.1.5 Percentages Completed                     | 217         |
| 6.2.2 Measurement of Activities                   | 217         |
| 6.2.3 Determination of Stages of Completion       | 219         |
| 6.3 Valuation Procedures                          | 220         |



|           | <u>PAGE</u>                                   |
|-----------|---|
| 7         | THE VALUATION OF VARIATIONS                   |
|           | 220   |
| 7.1       | Introduction                                  |
|           | 222   |
| 7.2       | The Scope of Variations Allowed               |
|           | 223   |
| 7.2.1     | The JCT Forms                                 |
|           | 224   |
| 7.2.2     | The ICE Condition                             |
|           | 227   |
| 7.3       | Administrative Procedures                     |
|           | 229   |
| 7.3.1     | The JCT Form                                  |
|           | 230   |
| 7.3.2     | The ICE Conditions                            |
|           | 232   |
| 7.4       | The Format of Variation Orders                |
|           | 232   |
| 7.5       | Measurement of Variations                     |
|           | 233   |
| 7.6       | Principles of Valuing Variations              |
|           | 235   |
| 7.7       | Factors Affecting The Valuation of Variations |
|           | 236   |
| 7.7.1     | Consistency of Prices in Contract Bills       |
|           | 236   |
| 7.7.2     | Availability of Tender Analysis               |
|           | 240   |
| 7.7.3     | Pricing                                       |
|           | 240   |
| 7.7.4     | Errors in The Contract Bills                  |
|           | 244   |
| 7.7.4.1   | Errors in Pre-tender Bills                    |
|           | 246   |
| 7.7.4.2   | Contractor's Errors                           |
|           | 246   |
| 7.8       | The Valuing of Variations                     |
|           | 250   |
| 7.8.1     | The Pro-rata Approach                         |
|           | 251   |
| 7.8.2     | The Bill Analysis Approach                    |
|           | 252   |
| 7.8.3     | Dayworks                                      |
|           | 254   |
| 7.8.3.1   | Pre-Tender Procedures                         |
|           | 254   |
| 7.8.3.1.1 | The JCT Forms                                 |
|           | 255   |
| 7.8.3.1.2 | The ICE Contract                              |
|           | 255   |

|           | <u>Page</u>  |
|-----------|--|
| 7.8.3.2   | Procedures For Determining Payments 257            |
| 7.8.3.2.1 | The JCT Form 257                                   |
| 7.8.3.2.2 | The ICE Form 257                                   |
| 7.8.3.3   | Preparation of Dayworks Sheets 258                 |
| 7.8.3.4   | Dayworks Accounts 260                              |
| 7.8.3.5   | Payment For Dayworks 261                           |
| 7.9       | Billing of Variation 261                           |
| 7.10      | Summaries of Variations 262                        |
| 8         | THE VALUATION OF CLAIMS 264                        |
| 8.1       | Definition 265                                     |
| 8.2       | Causes of Claims                                   |
| 8.3       | Types of Claims 266                                |
| 8.3.1     | Contractual Claims 266                             |
| 8.3.2     | Common Law Claims 266                              |
| 8.3.3     | Quantum Meruit Claims 267                          |
| 8.3.4     | Ex Gratia Claims 268                               |
| 8.4       | Authority of the Architect/Engineer on Claims 268  |
| 8.5       | Contractual Provisions For Additional Payments 268 |
| 8.5.1     | Potential Claims Under the JCT Forms 269           |
| 8.5.2     | Potential Claims Under the ICE Conditions 271      |
| 8.6       | Common Heads of Claims 271                         |
| 8.6.1     | On-site Establishment Costs 277                    |
| 8.6.2     | Head Office Overheads 278                          |

|           |   | <u>Page</u> |
|-----------|---|-------------|
| 8.6.2.1   | Categorization of Head Office Overheads               | 280         |
| 8.6.2.2   | Justification of Head Office Overheads                | 281         |
| 8.6.2.3   | Quantification of Head Office Overheads               | 284         |
| 8.6.2.3.1 | Maintenance of Records                                | 284         |
| 8.6.2.3.2 | The Hudson Formula Method                             | 285         |
| 8.6.2.3.3 | The Emden Formula Method                              | 288         |
| 8.6.2.3.4 | Assessment of 'Variable' Notional Preliminaries       | 288         |
| 8.6.3     | Loss of Profit  | 289         |
| 8.6.4     | Inflation Costs                                       | 292         |
| 8.6.5     | Interest/Financing Charges                            | 293         |
| 8.6.5.1   | Calculation of Finance Charges                        | 295         |
| 8.6.6     | Cost of Disruption                                    | 299         |
| 8.6.6.1   | Evaluation of Plant and Labour Records                | 300         |
| 8.6.6.2   | Review of Labour/Plant Activity                       | 301         |
| 8.6.6.3   | Analysis of Extensions of Time                        | 301         |
| 8.6.6.4   | Application of a General Productivity Formula         | 302         |
| 8.6.6.5   | Application of a General Percentage                   | 303         |
| 8.6.6.6   | Quantification of Losses Due to Delays and Disruption | 304         |
| 8.6.6.6.1 | Labour Losses   | 304         |
| 8.6.6.6.2 | Plant Losses  | 304         |
| 8.6.7     | Cost of Preparing a Claim                             | 307         |
| 8.7       | Notices of Claims Under the ICE Conditions            | 307         |
| 8.7.1     | Variations Under Clause 51                            | 308         |

|         | <u>Page</u>                               |
|---------|---|
| 8.7.2   | Claims Due to Changed Quantities 308      |
| 8.7.3   | Other Claims Under the Contract 309       |
| 8.8     | Notices of Claims Under the JCT Forms 309 |
| 8.9     | Evidence to Support Claims 309            |
| 8.9.1   | Analysis of Tender 312                    |
| 8.9.2   | Analysis of Preliminaries 313             |
| 8.9.3   | Program/Progress Schedules 314            |
| 8.9.4   | Method Statements 314                     |
| 8.9.5   | Cost Records 315                          |
| 8.9.6   | Correspondence 315                        |
| 8.9.7   | Records of Meetings 316                   |
| 8.9.8   | Site Diaries 316                          |
| 8.9.9   | Analysis of Extensions of Time 318        |
| 8.9.10  | Variation Orders 318                      |
| 8.9.11  | Revised Drawings 319                      |
| 8.10    | The Presentation of Claims 319            |
| 8.11    | Negotiation of Claims 322                 |
| 8.12    | Beyond Claims 322                         |
| 9       | THE VALUATION OF UNFIXED MATERIALS 324    |
| 9.1     | The Importance of Materials Control 324   |
| 9.2     | Control of Materials' Costs 326           |
| 9.2.1   | The Influence of Quantity 327             |
| 9.2.1.1 | Scheduling of Orders 327                  |
| 9.2.1.2 | Centralization/Decentralization 329       |
| 9.2.2   | Source of Materials 331                   |



|            |   | <u>Page</u> |
|------------|---|-------------|
| 9.2.3      | Records of Suppliers  | 331         |
| 9.2.4      | Prices in Orders  | 332         |
| 9.2.5      | Losses and Wastage  | 332         |
| 9.3        | Steps of Procurement  | 337         |
| 9.3.1      | Sources of Supply   | 337         |
| 9.3.2      | Purchase Orders   | 338         |
| 9.3.3      | Expediting  | 340         |
| 9.3.4      | Deliveries  | 340         |
| 9.3.5      | Invoices and Disbursement Control   | 342         |
| 9.4        | Unfixed Materials and Interim Valuations                                    | 343         |
| 9.4.1      | Contractual Provisions  | 344         |
| 9.4.1.1    | The ICE Conditions  | 344         |
| 9.4.1.2    | The JCT Standard Form   | 345         |
| 9.4.2      | Measurement of Unfixed Materials  | 346         |
| 9.4.3      | Payment Checks  | 348         |
| 10         | THE VALUATION OF PRELIMINARIES SUB-<br>CONTRACTED WORK AND PROVISIONAL SUMS | 351         |
| 10.1       | Preliminaries   | 352         |
| 10.1.1     | Building Contract Preliminaries   | 352         |
| 10.1.2     | Civil Engineering Preliminaries   | 354         |
| 10.2       | The Valuation of Preliminaries  | 355         |
| 10.2.1     | The Valuation of Building Contract<br>Preliminaries                         | 356         |
| 10.2.1.1   | Valuations Using a Totally Isolated<br>Preliminaries Bill                   | 356         |
| 10.2.1.1.1 | Individual Items of Preliminaries   | 357         |

|            |   | <u>Page</u> |
|------------|---|-------------|
| 10.2.1.1.2 | Grouping of Items of Preliminaries                        | 362         |
| 10.2.1.1.3 | Use of Preliminaries Budgets                              | 363         |
| 10.2.1.1.4 | Payment Against Actual Costs Incurred                     | 363         |
| 10.2.1.2   | Preliminaries Partially or Wholly Included in Main Work   | 365         |
| 10.2.2     | The Valuation of Civil Engineering Contract Preliminaries | 366         |
| 10.2.2.1   | The Adjustment Item                                       | 368         |
| 10.3       | The Practice of Sub-contracting                           | 369         |
| 10.3.1     | Domestic Sub-contracting                                  | 370         |
| 10.3.1.1   | Disadvantages of Sub-contracting                          | 371         |
| 10.3.2     | Nominated Sub-contracting                                 | 373         |
| 10.3.2.1   | Procedure For Nomination                                  | 375         |
| 10.4       | The Valuation of Sub-contracted Work                      | 376         |
| 10.4.1     | The JCT Recommendations                                   | 376         |
| 10.4.2     | The ICE Condition   | 378         |
| 10.4.3     | Administrative Procedures For Valuing Sub-contract Work   | 379         |
| 10.4.4     | Valuation Procedure                                       | 380         |
| 10.4.5     | Discounts   | 381         |
| 10.5       | The Control of Sub-contracted Work                        | 382         |
| 10.5.1     | Qualitative Control Procedure                             | 383         |
| 10.5.1.1   | Selection of Sub-contractors                              | 383         |
| 10.5.1.2   | Contract Conditions                                       | 384         |
| 10.5.1.3   | Co-ordination of Sub-contracted Work                      | 385         |
| 10.5.1.4   | Fair Payment  | 385         |
| 10.5.2     | Quantitative Control of Sub-contractors                   | 386         |

|   | <u>Page</u> |
|---|-------------|
| 10.5.2.1 Letting Margins  | 386         |
| 10.5.2.2 Attendance   | 387         |
| 10.6 Provisional Sums   | 389         |
| 11 PRICE ADJUSTMENTS DURING VALUATIONS                              | 391         |
| 11.1 The Traditional Approach                                       | 391         |
| 11.1.1 Building Contracts   | 392         |
| 11.1.1.1 Pre-contract Preparations                                  | 392         |
| 11.1.1.2 Price Adjustment Procedures                                | 393         |
| 11.1.1.3 Recovery of Fluctuations Beyond<br>The Date of Completion  | 394         |
| 11.1.2 Civil Engineering Contracts                                  | 395         |
| 11.2 The Formula Approach   | 395         |
| 11.2.1 Building Contracts   | 396         |
| 11.2.1.1 Pre-Contract Procedures                                    | 397         |
| 11.2.1.2 Incorporation of the Method                                | 397         |
| 11.2.1.3 Completion of Schedule of<br>Fluctuations                  | 398         |
| 11.2.1.4 Formation of Work Groups                                   | 401         |
| 11.2.1.5 Structural Steel Provisions                                | 402         |
| 11.2.1.6 Price Adjustment at Valuations                             | 402         |
| 11.2.1.6.1 Work Categories  | 402         |
| 11.2.1.6.2 Work Groups  | 404         |
| 11.2.1.6.3 Balance of Adjustable Work                               | 404         |
| 11.2.1.6.4 Specialist Work  | 404         |
| 11.2.1.6.5 'Fix only' Work  | 405         |
| 11.2.1.7 Consideration in Determining Building<br>Price Adjustments | 406         |

|            |   | <u>Page</u> |
|------------|---|-------------|
| 11.2.1.7.1 | Provisional Indices   | 406         |
| 11.2.1.7.2 | Valuation Period  | 406         |
| 11.2.1.7.3 | Retention   | 407         |
| 11.2.1.7.4 | Work Executed After The Date of<br>Completion               | 407         |
| 11.2.1.7.5 | Valuations After Practical<br>Completion                    | 408         |
| 11.2.1.7.6 | Dealing With Errors   | 408         |
| 11.2.2     | Civil Engineering Price Adjustment By<br>The Formula Method | 409         |
| 11.2.2.1   | Pre-contract Preparations                                   | 411         |
| 11.2.2.1.1 | Definition of The Scope of The<br>Contract                  | 411         |
| 11.2.2.1.2 | Proportions For The Main Civil<br>Engineering Formula       | 412         |
| 11.2.2.1.3 | Incorporation of the Method of Price<br>Adjustment          | 414         |
| 11.2.2.2   | Pre-contract Procedures: Fabricated<br>Structural Steelwork | 414         |
| 11.2.2.3   | Price Adjustment Procedures                                 | 415         |
| 11.2.2.4   | Considerations in Determining Price<br>Adjustments          | 417         |
| 11.2.2.4.1 | Variations  | 417         |
| 11.2.2.4.2 | Unfixed Materials and Goods                                 | 417         |
| 11.2.2.4.3 | Claims  | 418         |
| 11.2.2.4.4 | Provisional Indices   | 418         |
| 11.2.2.4.5 | Sub-Contractors and Suppliers                               | 418         |
| 11.2.2.4.6 | Work Executed After the Date of<br>Completion               | 419         |

|          |   |     |
|----------|---|-----|
| 12       | THE CONTRACTOR'S MANAGEMENT FUNCTIONS<br>AND THE FLOW OF INFORMATION AMONG THEM | 421 |
| 12.1     | Planning  | 422 |
| 12.2     | Estimating  | 424 |
| 12.2.1   | Programming the Estimating Task   | 426 |
| 12.2.2   | Preliminary Project Study   | 426 |
| 12.2.3   | Materials and Sub-contract Enquiries  | 427 |
| 12.2.4   | Detailed Project Study  | 427 |
| 12.2.5   | Calculating Labour and Plant Costs  | 428 |
| 12.2.6   | Estimating Direct Costs   | 428 |
| 12.2.7   | Calculating On-costs  | 429 |
| 12.2.8   | Tendering   | 430 |
| 12.3     | Cashflow Forecasting  | 432 |
| 12.4     | Valuations  | 437 |
| 12.5     | Cost Control  | 437 |
| 12.6     | The Accounting Function   | 439 |
| 12.6.1   | Gathering and Recording Data  | 441 |
| 12.6.1.1 | Payroll Transactions  | 443 |
| 12.6.1.2 | Disbursements   | 445 |
| 12.6.1.3 | Sales   | 447 |
| 12.6.1.4 | Accounts Adjustments  | 448 |
| 12.6.2   | The Provision of Business Information   | 448 |
| 12.7     | Information Flow Analysis   | 449 |
| 12.7.1   | Data Capture  | 455 |
| 12.7.2   | Turn Around Time  | 455 |
| 12.7.3   | For Management of Computer Resources  | 456 |
| 12.7.4   | Inconsistency   | 456 |
| 12.7.5   | Inflexibility   | 456 |
| 12.8     | The Use of a Suitable Work Breakdown<br>Structure                               | 457 |
| 12.8.1   | The Concept of a Work Breakdown<br>Structure                                    | 457 |
| 12.8.2   | The Relevance of the WBS to Integration   | 458 |
| 12.9     | The Influence of the Analysis in the<br>Design of PLUS VAL                      | 462 |
| 12.9.1   | Data Modelling  | 462 |
| 12.9.2   | File Structures   | 464 |
| 12.9.3   | Procedures Supported  | 465 |
| 12.9.4   | Output Produced   |     |



|         | <u>Page</u>                                      |
|---------|--|
| 13      | SYSTEMS SPECIFICATION 467                        |
| 13.1    | General System's Objective 467                   |
| 13.2    | Specification of Features of User Interfaces 468 |
| 13.3    | Specification of Principal Output 474            |
| 13.4    | General Specification For Input 475              |
| 13.5    | Specification of Storage 476                     |
| 13.5.1  | Contract General Information 477                 |
| 13.5.2  | Sub-contractors' Information 479                 |
| 13.5.3  | Data From The Contract Bills of Quantities 480   |
| 13.5.4  | Build-ups Data For Bill Items 483                |
| 13.5.5  | Resource Data 485                                |
| 13.5.6  | Data on Claims 486                               |
| 13.5.7  | Data on Dayworks 488                             |
| 13.5.8  | Dayworks Schedule 489                            |
| 13.5.9  | Data on Unfixed Materials 490                    |
| 13.5.10 | Data on Sections 490                             |
| 13.5.11 | Data on Activities 491                           |
| 13.5.12 | Data on Work Packages 491                        |
| 13.5.13 | Data on Purchase Orders 492                      |
| 13.5.14 | Data on Suppliers 492                            |
| 13.5.15 | Data on Delivery of Materials 493                |
| 13.5.16 | The NEDO Indices For Fluctuation Adjustments 493 |
| 13.5.17 | Data on Variations 494                           |
| 13.6    | Specification of Procedures 495                  |
| 13.6.1  | File Maintenance 495                             |
| 13.6.2  | Measurement of Permanent Work 496                |

|  | <u>Page</u> |
|--|-------------|
| 13.6.3 Data Entry                                      | 497         |
| 13.6.4 Access to Bill of Quantities Data               | 497         |
| 13.6.5 Bill Aggregation                                | 499         |
| 13.6.6 Manipulation of Valuation of Main Work          | 499         |
| 13.6.7 Control of Materials                            | 500         |
| 13.6.8 Claims Management                               | 501         |
| 13.6.9 External Valuation                              | 503         |
| 13.6.10 Internal Valuations                            | 503         |
| 13.6.11 Management of Retention Fund                   | 504         |
| 13.6.12 Management of Variations                       | 505         |
| 13.6.13 Calculations For Reports                       | 505         |
| 13.7 Systems Flowchart                                 | 505         |
| 14 A DESCRIPTION OF PLUS VAL                           | 506         |
| 14.1 System's General Description                      | 507         |
| 14.2 Price Adjustments For Inflation                   | 507         |
| 14.3 Starting a New Contract on The System             | 508         |
| 14.4 Working on an Existing Contract                   | 512         |
| 14.4.1 Bill Aggregation                                | 512         |
| 14.4.2 Measurement                                     | 514         |
| 14.4.2.1 Data on Measured Works Accomplished           | 514         |
| 14.4.2.1.1 Measurement of Work Contained in Bill Items | 518         |
| 14.4.2.1.2 Access To Valuations of Bill Items          | 523         |
| 14.4.2.1.3 Measurement of Work Contained in Activities | 527         |
| 14.4.2.1.4 Cost-related Work Items                     | 527         |
| 14.4.2.2 Dayworks                                      | 530         |

|   | <u>Page</u> |
|---|-------------|
| 14.4.2.2.1 Maintenance of the Dayworks Schedule | 530         |
| 14.4.2.2.2 Data Entry From Dayworks Sheets      | 532         |
| 14.4.2.3 Claims                                 | 532         |
| 14.4.2.4 Unfixed Materials                      | 534         |
| 14.4.3 Materials Control                        | 534         |
| 14.4.3.1 Suppliers of Materials                 | 536         |
| 14.4.3.2 Purchase Orders                        | 536         |
| 14.4.3.3 Deliveries                             | 536         |
| 14.4.3.4 Buying Margins                         | 540         |
| 14.4.3.5 The Measurement of Unfixed Materials   | 540         |
| 14.4.3.6 Materials Usage Report                 | 542         |
| 14.4.3.7 Materials Extraction                   | 544         |
| 14.4.4 Variation Orders                         | 546         |
| 14.4.4.1 Deleting a Bill Item                   | 548         |
| 14.4.4.2 Modifying a Bill Item                  | 548         |
| 14.4.4.3 Adding a Rogue Item                    | 548         |
| 14.4.5 Unscrambling of Valuations of Activities | 553         |
| 14.4.6 Aggregation of Valuations                | 553         |
| 14.4.7 Control of Retention Funds               | 556         |
| 14.4.8 Editing of Data                          | 556         |
| 14.4.9 External Valuation                       | 559         |
| 14.4.10 Internal Valuation                      | 560         |
| 14.4.11 Preparation of Reports                  | 560         |



|         |   | <u>Page</u> |
|---------|---|-------------|
| 15      | THE TESTING AND ASSESSMENT OF THE SYSTEM                            | 562         |
| 15.1    | Comparison of the System with it's Specification                    | 563         |
| 15.2    | Demonstrations of the System  | 563         |
| 15.2.1  | Feedback From Demonstrations  | 564         |
| 15.3    | Comparison of PLUS VAL with Similar Systems Commercially Available. | 573         |
| 16      | SUMMARY, CONCLUSIONS AND RECOMMENDATIONS                            | 581         |
| 16.1    | Summary of Findings   | 581         |
| 16.1.1  | Lack of Integration   | 581         |
| 16.1.2  | Systems Development Methodology                                     | 581         |
| 16.1.3  | The Operations of The Management                                    | 582         |
| 16.1.4  | The Requirements of Integration                                     | 583         |
| 16.1.5  | Systems Specification   | 583         |
| 16.1.6  | System's Description  | 584         |
| 16.1.7  | Testing of The System   | 584         |
| 16.1.8  | Assessment of The System  | 584         |
| 16.1.9  | Integration of Contract Information                                 | 585         |
| 16.1.10 | Further Integration   | 585         |
| 16.1.11 | Financial Justification of The System                               | 586         |
| 16.1.12 | User Support Requirements   | 587         |
| 16.1.13 | The Significance of The Research                                    | 587         |
| 16.2    | Desirable Enhancements to The System                                | 588         |
| 16.3    | Future Research   | 589         |
|         | REFERENCES  | 592         |
|         | APPENDICES  | 609         |

|  | Page |
|--|------|
| APPENDIX 1: RICS Standard Valuation Form   | 609  |
| APPENDIX 2: Method A of Recording Variations   | 610  |
| APPENDIX 3: Method B of Recording Variations   | 611  |
| APPENDIX 4: Sample Dayworks Sheet  | 612  |
| APPENDIX 5: Sample Statement of Retention and of Nominated Sub-contractors' Values   | 613  |
| APPENDIX 6: Example of the Quantification of General Overheads by "The Assessment of 'Variable' Notional Preliminaries" Method | 614  |
| APPENDIX 7: A Sample Materials Fluctuation Payment Request   | 616  |
| APPENDIX 8: List of Work Categories For the NEDO Series 2 Indices  | 617  |
| APPENDIX 9: Standard Form for the Completion of the Schedule of Fluctuations   | 619  |
| APPENDIX 10: Listing of the NEDO Index Groupings For Civil Engineering Work  | 622  |
| APPENDIX 11: Sample Calculation of Fluctuations  | 623  |
| APPENDIX 12: Sample Payment Certificate  | 624  |
| APPENDIX 13: Sample of Statement of Retention and of Nominated Sub-contractors' Values   | 625  |
| APPENDIX 14: Sample Resource Analysis  | 626  |
| APPENDIX 15: Sample Page of the Bill Listings  | 628  |
| APPENDIX 16: Sample Page of Listing of Valuations of BOQ Items   | 629  |
| APPENDIX 17: Samples of Listings of Contract Resource  | 630  |
| APPENDIX 18: A sample Priced Dayworks Sheet  | 633  |
| APPENDIX 19: A Sample Summary of Dayworks  | 634  |
| APPENDIX 20: A Sample Valuations of Unfixed Materials  | 635  |
| APPENDIX 21: Squaring Dimensions by PLUS VAL   | 636  |
| APPENDIX 22: A Sample of a Bill of Variations  | 637  |
| APPENDIX 23: A Sample of a Summary of Claims   | 638  |
| APPENDIX 24: Pricing of Resources Employed on a Claim on a given Day   | 639  |
| APPENDIX 25: A Sample of a Sub-contractors' Letting Margins  | 640  |
| APPENDIX 26 Implementation Considerations  | 641  |

## LOCATION OF FIGURES

|   | <u>PAGE</u>   |
|---|---------------|
| Figure 1.1: A Guide to the Thesis   | Between 18-19 |
| Figure 2.1 Systems Methodology Used in<br>the Development of PLUS VAL                       | 20            |
| Figure 2.2: Requirements Gathering Technique  | 25            |
| Figure 2.3: The Leavitt Model of Organisation<br>Sub-systems Modified to Include<br>Culture | 28            |
| Figure 2.4: Outline Flowchart of PLUS VAL   | 32            |
| Figure 2.5: Direct Access File Organisation   | 44            |
| Figure 2.6: Index File Organisation   | 46            |
| Figure 3.7: The Traditional/Classical Organisation<br>Structure                             | 69            |
| Figure 3.2: The Structure of the Matrix<br>Organisation                                     | 80            |
| Figure 3.3: The Basic Construction Company<br>Organisation                                  | 82            |
| Figure 3.4: An Example of a Project-oriented<br>Organisation                                | 85            |
| Figure 3.5: Organisational Assimilation of<br>New Technology                                | 93            |
| Figure 3.6: Nolan's Four-Stage Model of<br>Information Systems Development                  | 97            |
| Figure 3.7: Nolan's Six-Stage Model of<br>Information Systems Development                   | 97            |
| Figure 3.8: Nolan's Repeating Stages of Shifts<br>of Technology                             | 97            |
| Figure 5.1: Important Contract Dates  | 153           |
| Figure 5.2: The Essence of Control  | 173           |
| Figure 5.3: A Typical Contractor's Annual<br>Financial Budget                               | 175           |
| Figure 5.4: Forecast and Actual Revenue Curves  | 197           |
| Figure 5.5: Format of a Cost Control Statement  | 187           |
| Figure 5.6: The Effect of Unbalanced Tender Rates<br>on Cost Control                        | 200           |
| Figure 5.7: Standard CVR Form   | 204           |



|   | <u>PAGE</u> |
|---|-------------|
| Figure 6.1: Booking dimensions  | 214         |
| Figure 6.2: Squaring of dimensions  | 215         |
| Figure 6.3: Billing of Measurement  | 216         |
| Figure 7.1: Cost-Quantity Relationships   | 242         |
| Figure 7.2: Recommended Cost-Price-Quantity Relationship                        | 243         |
| Figure 7.3: Pricing Calculations  | 245         |
| Figure 7.4: Traditional Billing   | 247         |
| Figure 7.5: Recommended Billing   | 247         |
| Figure 7.6: A Variation of a slab   | 252         |
| Figure 7.7: Rate-fixing by Analysis of the Contract Bills                       | 253         |
| Figure 7.8: A Example of a Summary of Variation                                 | 263         |
| Figure 8.1: The Effect of Inflation on Claims                                   | 292         |
| Figure 8.2: Calculation of the Weighted Time Lag Between Expenditure and Income | 296         |
| Figure 9.1: A Typical Materials Buying Margins Report                           | 333         |
| Figure 9.2: A Typical Format of a Materials Usage Report                        | 335         |
| Figure 10.1: Contractor's Own Work Less Than Tendered Value                     | 361         |
| Figure 10.2: Contractor's Own Work More Than Tendered Value                     | 361         |
| Figure 10.3: A Sample of a Preliminaries Budget                                 | 364         |
| Figure 10.4: An Example of a Letting Margins Report                             | 388         |
| Figure 12.1: Information Flow Diagram For The Planning Function                 | 425         |
| Figure 12.2: Information Flow Diagram For The Estimating Function               | 431         |
| Figure 12.3: Information Flow Diagram For The Cashflow Forecasting Function     | 436         |

|  | <u>PAGE</u> |
|--|-------------|
| Figure 12.4: Information Flow Diagram For<br>The Valuations Function   | 438         |
| Figure 12.5: Information Flow Diagram For<br>The Cost Control Function   | 440         |
| Figure 12.6: Information Flow Diagram For<br>The Accounting Function   | 459         |
| Figure 14.1: Data Entry and Maintenance - NEDO<br>Indices For Use in Connection With<br>the Civil Engineering Contract Price<br>Fluctuation Clause | 509         |
| Figure 14.2: Data Entry and Maintenance - NEDO<br>Series 2 Indices   | 511         |
| Figure 14.3: Starting a New Contract on PLUS VAL   | 513         |
| Figure 14.4: Sample of the Build-up of an Activity   | 515         |
| Figure 14.5: A Sample Bill of Activities   | 516         |
| Figure 14.6: Price Breakdown of Activities   | 517         |
| Figure 14.7: Data Entry - Dimensions of<br>Accomplishments of BOQ Items  | 520         |
| Figure 14.8: Data Entry - Quantities of BOQ<br>Items Accomplished  | 522         |
| Figure 14.9: Data Entry - Percentage of BOQ<br>Items Accomplished  | 524         |
| Figure 14.10: Confirmation of Bill Items Against<br>Which Measurements are Entered   | 525         |
| Figure 14.11: Inspection of Valuations of Pages<br>of the BOQ  | 526         |
| Figure 14.12: Data Entry - Accomplishments of<br>Activities  | 528         |
| Figure 14.13: The Flagging of Cost-related BOQ<br>Items and Activities   | 529         |
| Figure 14.14: Changing the Percentage Adjustment<br>For a Dayworks Resource Group  | 531         |
| Figure 14.15: Data Entry - Dayworks Sheets   | 533         |
| Figure 14.16: Data Entry - Claims  | 535         |
| Figure 14.17: Data Entry - Information on Suppliers  | 537         |
| Figure 14.18: Data Entry - Information on<br>Purchase Orders   | 538         |

|  | <u>PAGE</u> |
|--|-------------|
| Figure 14.19: Data Entry - Deliveries of Materials   | 539         |
| Figure 14.20: A Sample Buying Margins Report   | 541         |
| Figure 14.21: Data Entry - Unfixed Materials   | 543         |
| Figure 14.22: A Sample Materials Usage Report  | 545         |
| Figure 14.23: The Operation of the Materials<br>Extraction Facility  | 547         |
| Figure 14.24: Data Entry - Variation Orders  | 549         |
| Figure 14.25: Deleting a Bill Item   | 550         |
| Figure 14.26: Amending a Bill Item   | 551         |
| Figure 14.27: Adding a 'Rogue' Item  | 552         |
| Figure 14.28: The Operation of the Facility<br>For Breaking Down Valuations of<br>Activities into Valuations of<br>BOQ Items | 554         |
| Figure 14.29: The Operation of the Facility For<br>Aggregating Valuations of BOQ<br>Items into Valuations of Activities      | 555         |
| Figure 14.30: The Operation of the Facilities For<br>Releasing Retention Funds   | 557         |
| Figure 14.31: The Operation of the Facility For<br>Reversing Wrong Release of<br>Retention of Funds                          | 558         |

LOCATION OF TABLES

|  | <u>PAGE</u> |
|--|-------------|
| TABLE 3.1: Improvements in Hardware Performance                                    | 57          |
| TABLE 7.1: Rules/Principles For Valuing Variations                                 | 237         |
| TABLE 8.1: Summary of Claims Under the ICE Conditions                              | 272         |
| TABLE 9.1: Cost Profile of the Construction Industry                               | 325         |
| TABLE 9.2: Effects on Profits of Cutting Costs                                     | 325         |
| TABLE 9.3: Cost Reduction required to increase return on Capital Employed by 18.3% | 325         |
| TABLE 10.1: Typical Preliminaries  | 353         |
| TABLE 12.1: Analysis of the Flow of Information Among the Functions                | 451         |
| TABLE 15.1: Comparison of PLUS VAL With Similar Packages Commercially Available    | 575         |

## CHAPTER ONE

### INTRODUCTION

This Chapter contains:

- \* a description of the background to the research,
- \* the justification of the need for the research,
- \* a summary of the research undertaken and its main conclusions,
- \* a guide to this thesis

#### 1.1 THE NATURE OF CONTRACTORS' OPERATIONS

The following functions are identifiable in the management of contracting organisations:

- \* Estimating,
- \* Planning,
- \* Cashflow Forecasting
- \* Valuations,
- \* Cost Control,
- \* Plant Management,
- \* Accounting (general and payroll).

An examination of the operations of these management functions reveals the following common tasks:

- \* the storage and retrieval of large volumes of data and information,
- \* a high degree of repetition of many types of calculations,



- \* the preparation and printing of numerous reports.

These common tasks make the operations of contractors prime candidates for computerisation for, according to McCaffer (3), they are the tasks for which computers are best suited.

## 1.2 THE USE OF COMPUTERS IN CONSTRUCTION CONTRACT MANAGEMENT

Surveys (4) reported in 1980 showed that most of the computer programs available covered the following areas:

- \* Estimating
- \* Planning/Network Analysis,
- \* Cashflow Forecasting,
- \* Valuations,
- \* Accounting,
- \* Payroll,
- \* Plant control,
- \* Costing.

Most of these packages were implemented on main-frame computers and/or minicomputers with their use being limited to the larger construction companies which could afford their prices of the costs of developing them.

New additional areas of application include

( 6 ) :

- \* Cost Control,

- \* Taking off Quantities,
- \* Management Accounting.

and a lot more software packages are available on microcomputers. Even though some of the smaller firms now also use computers, only 17% of the 88,000 construction establishments in Europe use computers to any degree (6).

### 1.3 SHORTCOMINGS OF THE SOFTWARE

The main shortcomings of the software are:

- \* they are not suitable for their individual functions;
- \* they are not integrated.

#### 1.3.1 LACK OF SUITABILITY FOR FUNCTIONS

One of the reasons why Baldwin (46) designed a computer-based system for estimating between 1979 and 1982 was that none of the systems then available for estimating adequately reflected the manner in which estimators worked. Harrison (26) writes that some of the systems produce piles and piles of data printout and very little information for management.

According to McCaffer and Sher (2) most of the estimating systems available in 1979 had been developed by the larger construction companies. Even now the most cursory examination of any directory

of construction management software will show that many of them are owned by the larger companies. As systems developed by individual companies are likely to be tied to their own operational methods, they may not be of universal applicability. This is supported by Gobourne (160) who writes that the operations of the management functions vary from company to company and that even within the same company they could vary from year to year and from project to project.

### 1.3.2 LACK OF INTEGRATION

By and large, the software in existence are independent systems in the sense that they do not share common data files or pass data amongst themselves (4). In computer jargon they are said to stand along (39). This lack of integration is as surprising as it is undesirable, considering the inter-related nature of the individual functions they support. For instance, the construction program of a project has a great influence on the estimate of costs as well as its cashflow forecast whilst the basis of any effective cost control must be the figures which are prepared by the estimator before submitting the tender (177). Unintegrated systems are undesirable for they suffer from the following disadvantages which are discussed in detail in Chapter 12:

- \* costly data capture,
- \* long turn around times,
- \* poor management of computer resources,
- \* inconsistency,
- \* inflexibility.

Geary (1) and McCaffer (3) advise that this 'piece meal' approach be abandoned for total systems.

### 1.3.3 NEW DEMANDS

Apart from the disadvantages of stand alone systems changes in the nature of projects have created a demand for integrated software.

According to Morris (22), increasing size and complexity of projects also accompanied by increasing competition and volatility of markets and other environmental factors have generated demands for more efficient management of construction projects in the 1980's. This implies a demand for effective and integrated contract management information systems for Harrison (26) writes that a key prerequisite for effective management of projects is the availability and use of such systems.

The 1980's have also been characterized by improvements in hardware and systems development techniques. These improvements are discussed in some detail in Chapter 2.

## 1.4 HYPOTHESIS AND JUSTIFICATION FOR THE RESEARCH

Arising from the background described the hypothesis that computer technology and systems concepts can be used to develop the necessary tools that will produce the effective and integrated systems needed was formulated. The justification for this stem from the following:

- \* there is an established need for more effective integrated systems and a lack of software to meet this established need;
- \* computer technology has improved a great deal in recent years;
- \* falling prices of hardware may make the proposition viable.

## 1.5 THE RESEARCH UNDERTAKEN

With a view to verifying the hypothesis the following investigative research, software development and testing were undertaken:

- \* an investigation of the possible causes of the lack of integration and their significance for success in integration,
- \* a survey of the operations of the management functions of construction companies,
- \* the specification, design, development and testing of a computer-based system called PLUS VAL,
- \* an assessment of PLUS VAL.



A research team under the leadership of Professor Ronald McCaffer in the Civil Engineering Department of the Loughborough University of Technology had produced a computer-aided estimating system called INTEREST which, not only meets the requirements of most estimators, but also makes provisions for total integration of contract information (46). Ndekugri and McCaffer (5) write that a computer-aided valuations system is a logical follow-on to such systems. For that reason and also because the valuations function can provide data to other functions such as cost control and accounting it was decided that the system should address itself mainly to the valuations function and hence the name for PLUS VAL (INTEREST plus valuations).

Sub-systems for cashflow forecasting (named CAFLARR but now called PLUS CASH (to indicate INTEREST plus cashflow) (24) and, time analysis and resource balancing (TIANAREBA) (25) have also been developed to link to INTEREST.

The research involved the undertaking of the following tasks:

- (i) The structure and nature of the construction industry were studied.
- (ii) General organisational theory was studied.
- (iii) A literature survey of typical organisation structures existing in construction firms was undertaken.

- (iv) A review of how organisations in general assimilate Electronic Data Processing (EDP) was carried out.
- (v) Based on the findings of the work already mentioned a suitable methodology was designed to govern the development of PLUS VAL.
- (vi) The procedures and processes involved in carrying out the operations of the various functions were studied. Particular emphasis was placed on valuations, purchasing management and cost control.
- (vii) The interrelationships, interdependencies and the flow of data among the functions were analysed.
- (viii) From the results and findings of the work mentioned so far the specification for PLUS VAL was drawn up.
- (ix) PLUS VAL was designed and developed.
- (x) The System was tested by checking that
  - \* the arithmetical calculations were correct
  - \* the tasks were being carried out according to the specification and the design
  - \* the System as a whole is acceptable to its intended users.
- (xi) The system was assessed by:
  - \* comparing it against its specification (testing the system as a black box),
  - \* inviting feedback from individuals and firms to which demonstrations of the

System had been given,

- \* comparing it against the findings of a survey of similar software currently available commercially.

(xii) Possible enhancements to the System and of desirable additional work were examined.

## 1.6 MAIN FINDINGS

The main findings of the research carried out are summarized below.

### 1.6.1 LACK OF INTEGRATION

The causes of the lack of integration are:

- \* technical limitations such as:
  - . inadequate memory and speed of micro hardware,
  - . cost and lack of transportability of mainframe computers;
- \* segregated education, training and experiential exposure of the functional groups involved in construction work leading to professional divisions and rivalries;
- \* development of software by people who do not possess the relevant expertise;
- \* inadequate research and/or failure to apply research findings due to the following attributes of the construction industry:
  - . competitive bidding,
  - . size and number of firms,

- . fragmentation,
- . conservatism,
- . preponderance in management of people from trades' backgrounds.

The significance of these causes is that developers of software for construction management should:

- \* select systems analysts who have adequate understanding of construction management;
- \* adopt systems development methodologies which reflect the ill-defined nature of the problems as well as the diversity of operational methods employed in the industry.

### 1.6.2 THE OPERATIONS OF THE MANAGEMENT FUNCTIONS

The main findings are as follows:

- (i) The methods of carrying out the various functions vary from firm to firm and from project to project.
- (ii) In many cases the operations of the management functions share common sources of data and provide data to each other.
- (iii) In practice the effort required to carry out the manipulations and transfers of data necessary for integration is great.
- (iv) The valuations function is important for the following reasons:

- \* it controls the firm's cashflow,
  - \* it provides data for financial accounting information,.
  - \* it provide data for management accounting.
- (v) Valuations can be grouped into six major headings:
- \* valuations by direct reference to the Bill of Quantities (BOQ),
  - \* valuations of dayworks,
  - \* valuations of claims,
  - \* valuations of unfixed materials,
  - \* calculation of price fluctuation adjustment,
  - \* calculation of retention.
- (vi) Valuation of work in the BOQ, involves the determination of:
- \* dimensions covering Bill items
  - \* quantities, values, percentages of:
    - . Bill items,
    - . portions of the BOQ,
    - . pages of the BOQ,
    - . sections of the BOQ completed.
  - \* quantities, values, percentages of activities completed.

### 1.6.3 THE REQUIREMENTS FOR EFFECTIVE INTEGRATION

The requirements are:

- \* the establishment of a suitable Work Break-down Structure (WBS)



- \* the WBS is simple, and is understood and accepted by all participants
- \* a reasonable number of work packages (about 15 is the recommended range)
- \* all project functions use the same WBS
- \* consistent data for all functions.

#### 1.6.4 SYSTEM'S SPECIFICATION

The main features of the Systems Specification are:

- (i) The System should provide facilities which assist the carrying out of the following functions:
  - \* external valuations,
  - \* internal valuations,
  - \* the provision of information for the control of materials, purchasing and sub-contractors,
  - \* the provision of yardsticks of earnings against which corresponding costs incurred or accruing may be compared,
  - \* integration of project information.
- (ii) The interface between the user and the computer should be acceptable.
- (iii) 19 reports were identified as being necessary for carrying out the functions listed under (i) above. The system should be able to prepare and print them.

- (iv) Desirable features of input include:
- \* data entry by QWERTY Keyboard,
  - \* free format entry of data,
  - \* minimum data entry,
  - \* simplicity of data entry procedures,
  - \* all variable data to be verified and confirmed.
- (v) The System should store 15 types of contract information identified as being necessary to produce the required reports.

#### 1.6.5 SYSTEM'S DESCRIPTION

The main practical achievement of the research is the specification, design and development of PLUS VAL which is essentially a computer-based system for assisting valuations (internal and external), purchasing management and cost control. PLUS VAL is capable of being implemented as a stand alone system or as a link to software for the other management functions.

PLUS VAL is written in ANSI FORTRAN 77 and is implemented on a PRIME 750 computer of the Loughborough University of Technology. It comprises 17,000 of FORTRAN statements and its compiled version takes 245 K of storage.

### 1.6.6 TESTING OF THE SYSTEM

The System was tested by the author during its development and by an M.Sc (construction) student for four months. The testing showed that :

- \* all calculations were carried out correctly,
- \* the system complied with its specification.

### 1.6.7 ASSESSMENT OF THE SYSTEM

The following types of assessments were carried out:

- \* a comparison of the System with its specification,
- \* monitoring of feedback from demonstrations of the system to potential users,
- \* a comparison of the System with similar systems commercially available.

The assessments showed that PLUS VAL:

- \* provides all the facilities for valuations, materials control and the control of sub-contractors that the potential users wanted;
- \* covers all the methods of operations of companies contacted;
- \* is more comprehensive than any of the packages surveyed;
- \* achieves integration of estimating, valuations, purchasing management and cost control.

## 1.6.8 INTEGRATION OF CONTRACT INFORMATION

The following features of PLUS VAL demonstrates that integration of contract information is possible:

- \* the System has one each of the following which are used by the estimating, valuations, purchasing and cost control functions:

- . the BOQ,
- . the Bill items' build-ups file,
- . the resources' file,
- . the activities file,
- . the work packages file.

The use of common work packages means the functions use the same WBS.

- \* The valuations function builds up activities which are needed by the planning and cashflow functions

- \* The valuations function provides the stages of completion of the various activities which are required by the planning and cashflow functions to update programs and cashflow forecasts

- \* The valuations function uses data provided by estimating to produce earnings of work packages against which actual costs collected along work packages may be compared by the cost control function.

- \* The materials control part of PLUS VAL provides all the data required by the accounts division to settle the payments of materials' suppliers,

- \* the valuations and estimating functions provide the information on wastage of materials needed by the cost control function.

### 1.6.9 THE SIGNIFICANCE OF THE RESEARCH

The research undertaken has produced a System which:

- \* integrates estimating, valuations, purchasing management and cost control;
- \* provides a framework for integration with the operations of the other management functions;
- \* satisfies the requirements of its intended users contacted;
- \* is more comprehensive than any of the similar packages surveyed;
- \* has tremendous potential for commercial viability.

The System amply demonstrates that computer technology and systems concepts can be used to produce the effective integrated management information systems which are required to meet the increasing challenges of the management of construction contracts.

Improvements in hardware and the increasing availability of telecommunication capabilities have reduced the scope of technical limitation of hardware as an inhibiting factor to integration. The



accomplishment of integration implies that other inhibiting factors can be overcome.

## 1.7 A GUIDE TO THE THESIS

Figure 1.1 provides a diagrammatic guide to the thesis.

Chapter 1 contains a description of the background to the research, its justification, work undertaken and a summary of its findings and results.

Chapter 2 describes the methodology adopted to develop the System. Possible causes of lack of integration were investigated during the early stages of the research. The work carried out and findings made in that regard are described in Chapter 3.

Chapter 4 addresses the question of desirable features of the interaction between the potential users of the System and its other components.

Chapter 5 describes the role of valuations in the management of construction contracts. The relationships of valuations with the other management functions are identified. Various heads of valuations are described in Chapters 6 to 11.

Based on the findings contained in Chapters 5 - 11, Chapter 12 describes the interdependencies of the various management functions as well as the flow of data amongst them.

A specification of the System to be produced was drawn up from the findings contained in Chapters 2 to 12. The specification is contained in Chapter 13.

Chapter 14 describes the PLUS VAL whilst Chapter 15 describes its assessment.

Chapter 16 contains the summary, conclusions, and recommendations of the research.

## CHAPTER TWO

### SYSTEMS METHODOLOGY

A methodology in systems analysis terminology is a method of developing computer-based systems with defined phases and sub-phases, recommended techniques to apply in each phase and sub-phase, and recommendations about planning, management, control and evaluation of the project (47). This Chapter describes the methodology used in the design and development of PLUS VAL.

#### 2.1 OUTLINE OF METHODOLOGY

A survey (40, 200) of methodologies used by systems analysts was made and it was found that there are many in use with most of them applying the same general approach that a systems development passes through a so-called system's life cycle consisting of iterations of the following activities:

- (i) Systems Investigation and Analysis,
- (ii) Systems Design,
- (iii) Development of Software,
- (iv) Testing and Implementation,
- (v) Maintenance and Evaluation.

The methodology used in the development of PLUS VAL is illustrated in Figure 2.1.

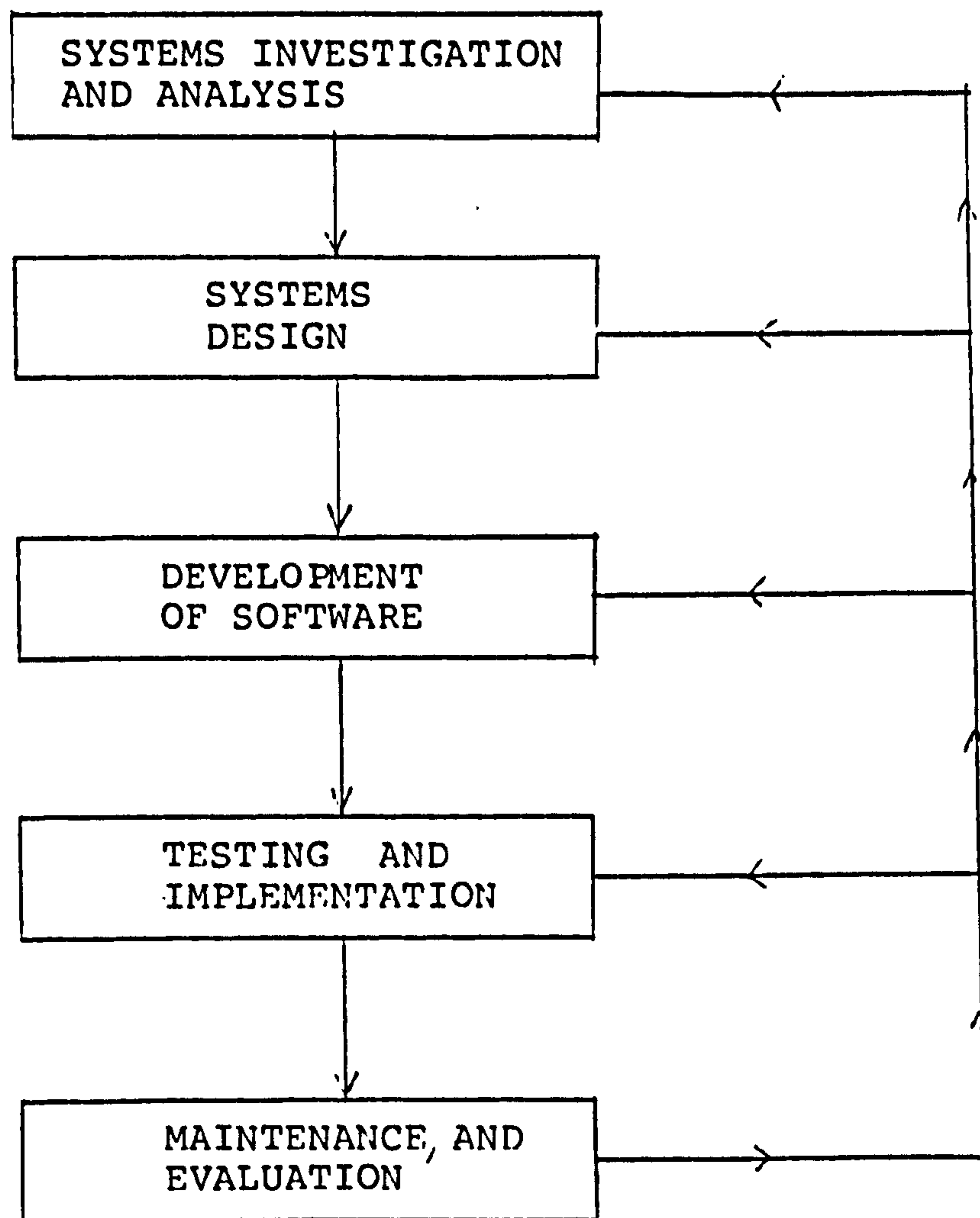


Figure 2.1: Systems Methodology Used in The Development of PLUS VAL.

## 2.2 SYSTEMS INVESTIGATION AND ANALYSIS

This was the stage of fact-finding, fact-recording and analysis so as to be able to describe the essential operational requirements of the existing systems for measurement, valuation and cost control. The purpose was to determine if a problem exists and, if one does, to ascertain its nature and scope as well as possible solutions. Out of this stage came a definition of the output required from the System, the input data needed to generate the output information, the processing requirements and the operational objectives.

According to Tuman (41) it cannot be overstated that the most important step in the successful development of an effective information and control system is success at this stage. A lot of time was therefore spent on this phase during the research.

### 2.2.1 TERMS OF REFERENCE

The scope of systems investigation has to be governed by some terms of reference. In this case they included:

- \* examination and preparation of a comprehensive and accurate description of the existing system of measurement, valuation and cost control;
- \* appraise, review and evaluate the information requirements of contractor's organisations for



effective measurement, valuation and cost control with a view to defining the System's objectives;

- \* a broad definition of the structure and scope of a computer-based solution to meet overall system's objectives;
- \* identification of viable sub-systems (projects) and determination and assignment of development priorities to each, taking interface requirements fully into account;
- \* identification of organisational and human constraints to the System and vice versa.

## 2.2.2 INFORMATION SOURCES

The potential sources of information identified include:

- \* long term plans of INTEREST (46),
- \* potential users,
- \* various reports and forms of construction
- \* companies,
- \* visits to appropriate departments and people,
- \* visits to installations having similar applications,
- \* author's experience,
- \* published literature.

### 2.2.3 INFORMATION GATHERING TECHNIQUES

The techniques considered were:

- \* interviewing,
- \* the use of questionnaires,
- \* literature surveys,
- \* the use of author's experience.

#### 2.2.3.1 INTERVIEWING

Daniels and Yates (40) maintain that interviewing is probably the most productive fact-finding technique for not only do interviews provide the facts but they also enable them to be verified. It goes without saying that to be most productive both the interviewer and the interviewee have to be committed and adequately prepared for it. For reasons of confidentiality of corporate operations and value of time required, interviewing potential users at the very beginning of development was not thought a feasible option.

It was however thought that where some sort of system is operational and potential users are invited to make comments on shortcomings and suggestions as to desirable enhancements there might be enough incentive for them to contribute meaningfully, particularly where they happen to be looking around for suitable systems. It was therefore decided to carry a preliminary investigation by other techniques and to develop a prototype system for demonstrating to potential users.

When the prototype system was operational

21 demonstrations were given to various parties which included individuals, companies and two seminars in Loughborough University of Technology organised by the Chartered Institute of Building (CIOB). Reactions to the prototype system were monitored and the amendments and enhancements found desirable were carried out. This approach to the gathering of information is illustrated in figure 2.2.

#### 2.2.3.2 QUESTIONNAIRE

This technique was considered as an option but, on examining its intrinsic shortcomings, the confidentiality of the information required and the considerable amount of efforts required to fill in suitable and unambiguous answers it was not used.

#### 2.2.3.3 LITERATURE SURVEY

Most of the preliminary investigation involved a survey of literature on:

- \* the operations of the management functions,
- \* organisation theory .

##### 2.2.3.3.1 THE OPERATIONS OF THE MANAGEMENT FUNCTIONS

The procedure and processes involved in the following management functions were studied:

- \* Estimating,
- \* Planning,
- \* Cashflow Forecasting.

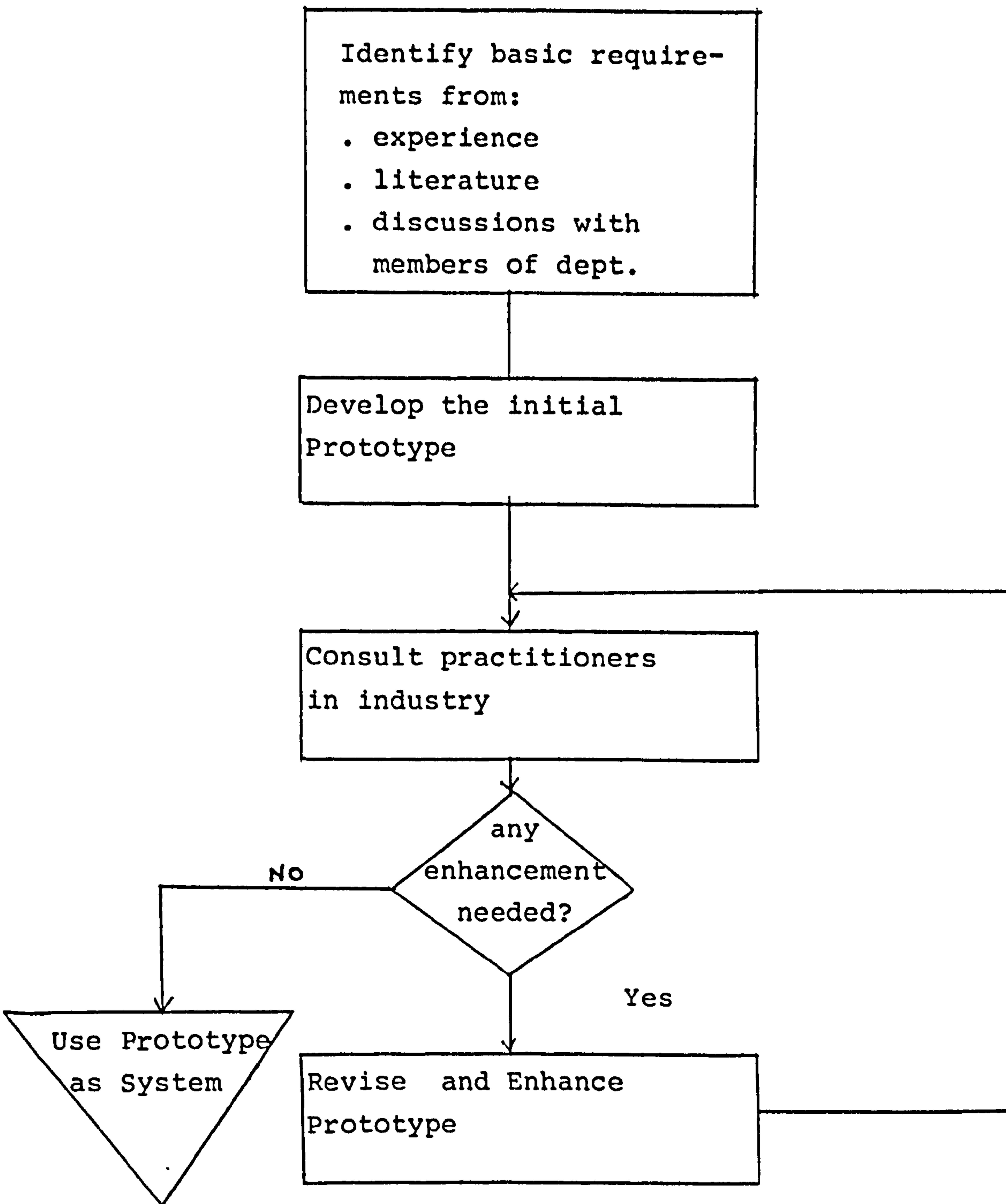


Figure 2.2: Requirements Gathering Technique

- \* Valuations,
- \* Cost Control,
- \* Accounting.

The rationale behind this study was to be able to draw up an effective specification for the System.

The findings of this study are described in Chapters 5 to 12.

#### 2.2.3.3.2 ORGANIZATIONAL THEORY

There is a growing consensus among authors of literature on information systems that the common practice of most systems designers is to focus on the task and technology sub-systems and completely ignore their effects on people and the organisation structure (40, 200). They generally criticise this approach on the grounds that a computer-based system cannot exist in a vacuum: the influence of information systems and organisational structures is reciprocal. Information systems can affect future organisational structure whilst the existing organisational structure can influence how information systems are designed, whether they are implemented successfully, and how they are used. When individual needs and organisational goals are not congruent, poor performance, resistance and other dysfunctional



consequences can result. Davis and Olson (200) recommend a better view of organisations from both the individual and overall organisational perspective. This is usually called the sociotechnical approach (200).

One such view is provided by the Leavitt model which describes the organisation as consisting of four interrelated components:

- (i) Tasks,
- (ii) Technology,
- (iii) Structure,
- (iv) People.

Many management theorists add organisational culture as a fifth element. Figure 2.3 shows a model of the interrelated components including culture. The significance of Leavitt's model for understanding organisational change is that, because of the strong interdependence, a change in one component inevitably has effects, planned or unplanned, on the others.

During the development a review of general organisation theory as well as of typical structures in the construction industry were carried out (Chapter 3).

The human aspects of the development of information systems and their considerations in the design of systems is described in Chapter 4.

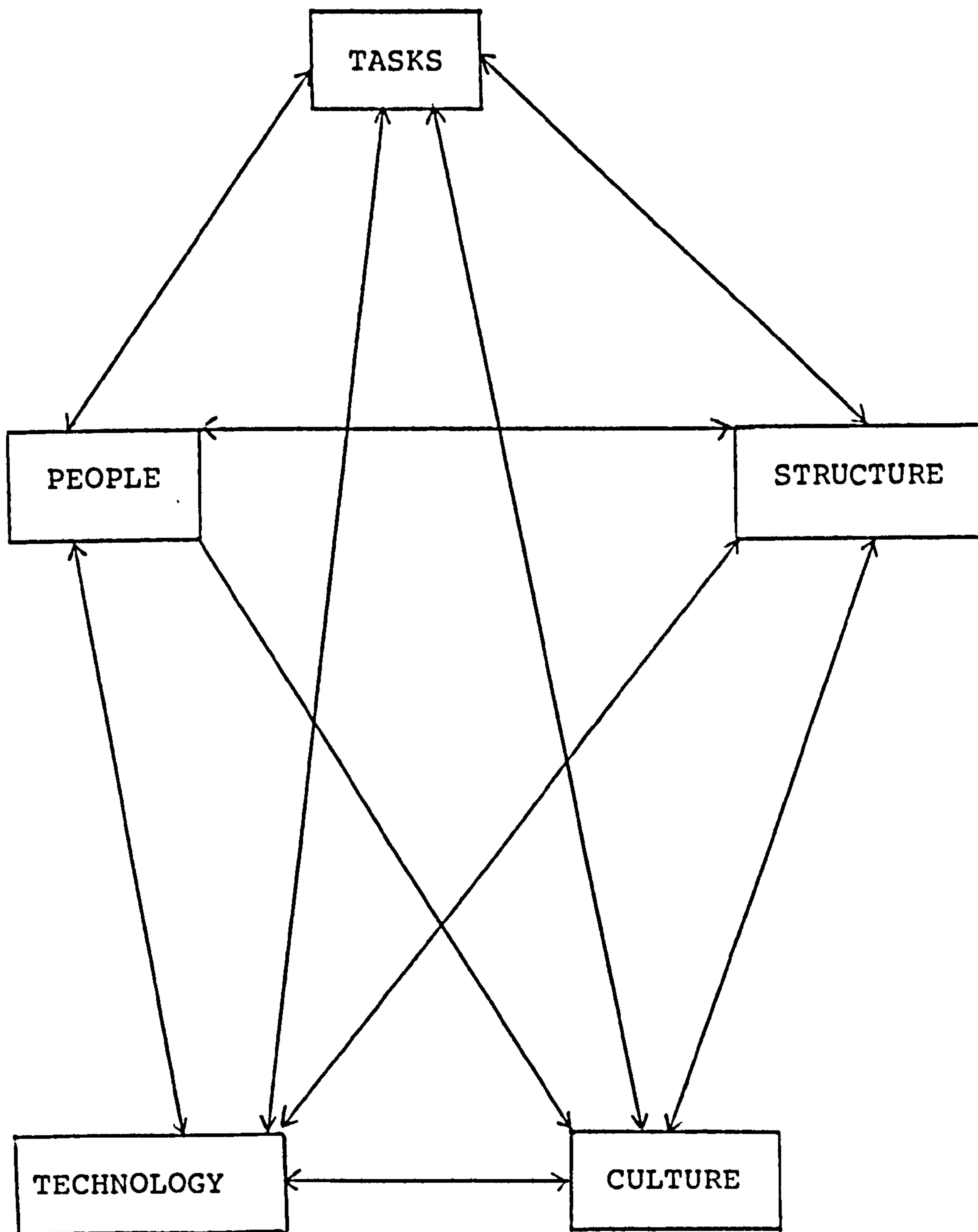


Figure 2.3: The Leavitt Model of Organization  
Sub-systems Modified to Include Culture  
(after Davies and Olson (200)).

#### 2.2.3.4 AUTHOR'S EXPERIENCE

The author has been involved in resident engineering duties and the planning and control of civil engineering works on a direct labour basis. This gave him the opportunity to acquire some first hand experience of the measurement, valuations, purchasing management, scheduling and the planning functions of construction work.

#### 2.2.4 SYSTEMS ANALYSIS

The main activity here is the determination of the objectives and requirements of each sub-system. This stage may be compared to a mathematician writing down the equation linking variables associated with a problem before attempting to solve it. This is a very important stage because recent reports of studies (41,47,49) have shown that omissions and errors in the analysis, which may then go undetected until implementation and live operational use, are responsible for the very high cost of systems' maintenance and enhancements.

There are two main approaches to analysis - data analysis and process analysis (47). A methodology may include data or process analysis, and may be oriented more to one or to the other. The idea behind the data analysis approach is that

each item of data should be uniquely identified and defined and, in the latter stages of systems work, be cross-referenced to the records in which it appears and the procedures which use it. This complete identification may be thought of as a data 'dictionary'. The extent of process analysis varies between methodologies. Some analyse how the end-user and reporting structure relate to the end-user processes. Here processes mean activities, operations or events. Process analysis may include analysing information flows between end-users as well as input, output, and the stored data for each process.

The strategy adopted was a combination of the two approaches. For the overall System and each sub-system the following questions were answered:

- \* what processes make up the System/sub-system?
- \* what data is used in each process?
- \* what data is stored?
- \* what data enter and leave the system/sub-system?

The answers to the questions were structured into logical data flowcharts for the overall systems, sub-systems and finally processes within sub-systems. This process of moving down from an analysis of the general to analysis of sub-systems and processes in increasing levels of details is referred to as the 'Top-down' approach to analysis (44).

## 2.2.5 RESULTS OF THE INVESTIGATION AND ANALYSIS

The results of the investigation provided the basis for a fairly detailed blueprint of the proposed system in the form of a User System Specification in terms of:-

- \* general objectives,
- \* functions,
- \* design criteria,
- \* future extensions,
- \* management implications,
- \* potential benefits,
- \* evaluation criteria.

The outline flowchart of the proposed system is shown in Figure 2.4, whilst the Systems Specification is shown in Chapter 13.

## 2.3 SYSTEMS DESIGN

Design here refers to the entire system and may be viewed as a conscious process of translating the requirements of the user into a specification of the required facilities and interfaces (47).

Two main headings of systems design may be recognized :-

- \* interface design which determines the requirements relating to all aspects of Man-computer interaction,



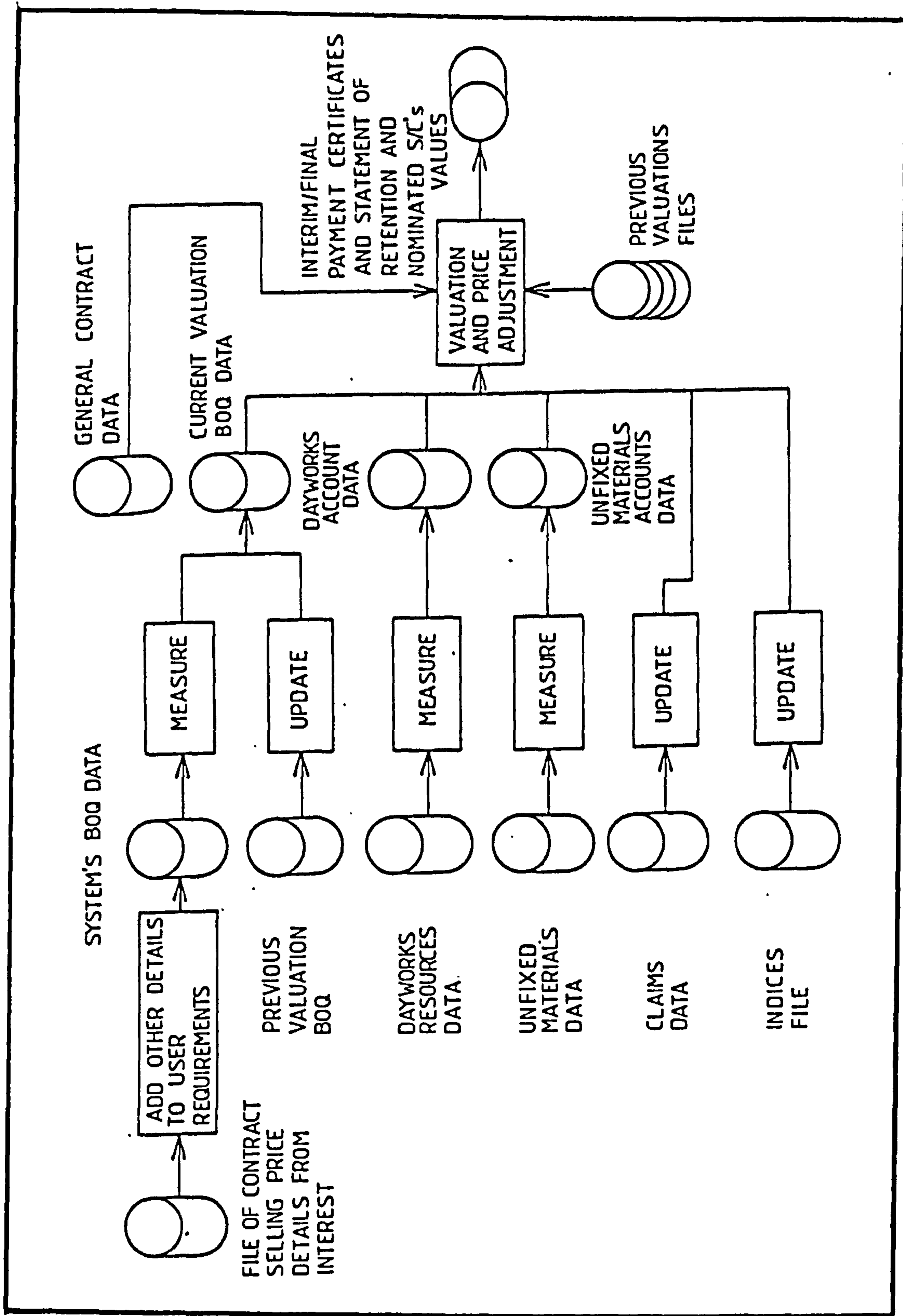


Figure 2.4: Systems Outline Flowchart For PLUS VAL

- \* design of the application software which determines the computer programming necessary to produce the desired facilities.

Interface design is discussed in Chapter 4 whilst this section deals with the design of the application software.

Design of application software can be divided into four phases (49):-

- \* output design,
- \* input design,
- \* file design,
- \* procedure design.

### 2.3.1 OUTPUT DESIGN

Output is a somewhat confusing term. It is used by computer personnel when referring to the transfer of data from a central processor to magnetic media such as tapes, discs and drums. It is also used to describe what emerges from a computer-based system for users to act upon. The latter meaning is implied under this heading.

#### 2.3.1.1 METHODS OF OUTPUTTING INFORMATION

The principal methods of outputting information for people to act upon were identified (49):

- \* printing by impact printer (hammer striking ribbon or paper) or non-impact printer

(ink-jet, or electrostatic),

- \* screen display,
- \* microfilm,
- \* synthetic speech.

With the first three methods it is required to define the layout of information according to formal standards, partly in order to facilitate the programming of the requirements. Synthetic speech has not yet developed to the stage where it can be of immediate use in the context of construction. Due to the geographical spread of potential users and additional requirements of peripherals it was not considered practicable to use microfilm in this case.

Output may be categorized as follows (40):

\* External Output :-

These go outside the organisation (e.g. payment certificates, purchase orders) and therefore call for special attention as they may directly affect the organisation's business relations with its customers.

\* Internal Output :-

These remain within the organisation but still require careful consideration because they may affect the operational efficiency of the total system.

\* Computer Operations Output :-

These are required within the computer

services department.

### 2.3.1.2 THE ROLE OF THE USER

Output design is an area of work <sup>in</sup> which the user should play a significant role. Working jointly the designer and user will have to define the following (40):

- \* type of output,
- \* content,
- \* format,
- \* frequency,
- \* response time required,
- \* sequence.

The variety of ways by which different contractors carry out their operations implies that it is not likely that there will be any set of output formats which will satisfy all potential users. However, some professional institutions have recommended standard formats for some reports. An example is the form for interim payments used by the Royal Institute of Chartered Surveyors (RICS) (146). Where such standard forms exist they were used as the basis for designing their corresponding output forms. Where no such standard forms exists the basis of design was typical report formats encountered by the author.

### 2.3.1.3 GENERAL GUIDELINES

The following general guidelines were used in output design (44):

- \* reports, documents, screen output should be designed to read from left to right and top to bottom;
- \* the most important items should be easiest to find;
- \* all pages should have a title and page number and should be dated;
- \* all columns should be labelled to identify their contents;
- \* abbreviations are to be avoided;
- \* well designed screen output (Section 4.4.2.2).

### 2.3.2 INPUT DESIGN

Like output, input is a confusing term because to computer personnel it often refers to anything being transferred into the central processor, e.g. from magnetic discs. However in our context data originating from outside a System is referred to.

#### 2.3.2.1 IMPORTANCE OF INPUT DESIGN

Input design specifies the manner in which data enters the system for processing. Input design can ensure the reliability of the system



and produce results from accurate data, or it may result in the output of erroneous information.

The input design also determines whether or not the user interacts with the system efficiently. There is no doubt that data capture in its totality (from origination to recording on computer storage medium) is costly. For business systems it may well account for 25 per cent of the total cost of a system over its entire life (23). In many cases data input is labour intensive and therefore time used in designing forms which are speedily and accurately completed and capable of being efficiently recorded into computer storage media is time well spent.

#### 2.3.2.2 GUIDELINES OF INPUT DESIGN

The following guidelines were applied during the design (49):

- \* the amount of input should be the minimum necessary to carry out the system's functions;
- \* delays in processing should be the minimum possible;
- \* errors in data should be avoided;
- \* the data input process should be simple.

It is discussed in Chapters 4 and 12 that these features contribute to the cost of data capture and the quality of the information system.

### 2.3.2.3 THE INPUT PROCESS

Four ways in which source data can be input into a computer have been identified and examined:-

(i) It can be converted into a computer readable medium by a person using a keyboard.

The commonest media are cards, paper tape, and magnetic tape.

(ii) It can be read directly by a computer-readable device.

The commonest examples are as follows:

Optical Mark Reader (OMR), Optical Character Reader (OCR), Magnetic Ink Character Reader (MICR), magnetizable plastic card readers and punched card readers..

(iii) It can be keyed directly into a computer from a remote terminal.

(iv) It can be produced as a by-product (e.g., of an accounting machine) and read directly into a computer (magnetic tape cassette).

Data input may also be classified as in batch mode or interactive mode. Batch processing is the practice of holding records of data collected about transactions until records making up a group, or batch, are accumulated for processing at a later time. With interactive processing the entry of the data is carried out directly

into the computer, usually from some terminal attached by communication lines to the central processing unit.

Batch processing entails the maintenance of special data processing staff to carry out work passed to them by various users. Competition for such shared resources and the very nature of batch processing itself implies that the turn around times may not always be satisfactory. On the other hand with interactive systems, or on-line systems as they are sometimes called, the user can input the data himself as and when he finds it desirable.

Based on the above considerations and the nature of construction operations on-line interactive data entry via a keyboard was selected.

#### 2.3.2.4 SOURCE DOCUMENT DESIGN

A source document is the form on which data is initially captured, e.g. daywork sheets, time sheets, to mention a few. A Source document contains not only places for data, but also captions and information telling the user how to complete the form and what information to provide.

Source document design is an area in which the user should play a significant role. Daniels and Yates (40) caution that the user should only

be guided to design his own documents and that to impose something on him could be counter-productive. Again the lack of standardisation of operations in the construction industry did not allow rigid design of forms for input data. The input requirements are specified with the intention that the particular user would contribute to the form design during implementation.

### 2.3.3 FILE DESIGN

The activities of a contractor require data. Estimating, costing and payroll are examples of activities that use data. Data items have value to the extent that they are useful in the performance of the contractor's activities. However, data items are of value only if they can be retrieved, processed and presented to those who need them within the time allowed for the decision or action to which they apply. Data that cannot be located or processed in time has no value. Storage and retrieval of data are therefore important issues in the design of computer-based systems.

#### 2.3.3.1 FILE ORGANISATIONS

The organisation of data in a file is influenced by a number of factors. The most significant factor is the very large difference between the time required to access a record and

transfer the data to primary storage or to write a record compared with the time to do the processing once the record is in primary storage. The magnitude of this relative difference for disk drives may be from 1000:1 up to 100 000:1 (200).

Given the significant differences in these times, an important factor in information system's file design is a physical organization that will support the kind of record access needed to be efficient in terms of access times.

The following types of operations are required for processing records in file:

- \* file creation,
- \* locating a record,
- \* adding a record,
- \* deleting a record,
- \* modifying a record.

The purpose of a file organization is to allow these operations to be carried out as easily as possible. There are two main types of file organisations: (i) sequential organisation, and (ii) random access organisation. The latter type was used because its features described below are better suited to the contractor's informational transactions.



### 2.3.3.2 SEQUENTIAL ORGANISATION

This is the simplest way to store and retrieve records in a file. In a sequential file, records are stored one after the other without concern for the actual value of the data in the records. The first record stored is placed at the beginning of the file. The second record is stored after the first (there are no unused positions), the third after the second, and so on. This fact never changes in a sequential file. .

To read a sequential file, the system always starts at the beginning of the file. If the record sought is somewhere in the file, the system reads its way down to it, one at a time.

Where it is necessary to do something with every record in the file for a particular system sequential file organisation is very advantageous. On the other hand, in a very large file where it is required to find a particular record, sequential file organisation is a disadvantage. The program must start at the beginning of the file and read past every record in the file until the record wanted is found. This could very time-consuming unless the record turned out to be one of the first records.

### 2.3.3.3 RANDOM ACCESS ORGANISATION

With random access file the user can get to a desired record without having to institute a search through a file; as is the case with sequentially organised files. Such organisations are associated with on-line systems, or rapid response systems.

There are several different categories of random access organisation based on the method of determining the position in the file of the record wanted. The main types of methods are:

(i) direct access (ii) indexing.

### 2.3.3.4 DIRECT ACCESS

With this method the position (called address) for storing or retrieving a record is computed arithmetically and logically from its key (43). The type of address determination by algebraic computation is referred to as 'Key-to-Address Transformation' (KAT). The choice of the transformation is made so that no two keys are mapped into the same record position. Generally this is feasible only where the key values are highly non-random or the choice of key is within the control of the designer (43).

An example of such a situation is where employees are numbered consecutively from some number. The address of the record of an employee

| Employee |  | Last | First | Date of    | SS. | Wage/ | Division |
|----------|--|------|-------|------------|-----|-------|----------|
| No.      |  | Name | Name  | Employment | No. | Hour  |          |
| Address  |  | (Key |       |            |     |       |          |

Transformation:

Record address =

Employee no. - 3599

|    |      |           |         |          |       |        |            |
|----|------|-----------|---------|----------|-------|--------|------------|
| 1  | 3600 | JONES     | STEVE   | 20/1/75  | 97809 | 5.00   | ACCOUNTS   |
| 2  | 3601 | LEWIS     | KEN     | 23/4/78  | 99071 | 7.00   | ACCOUNTS   |
| 3  | 3602 | CLARKE    | JOHN    | 2/6/80   | 91542 | 10.00  | PERSONNEL  |
| 4  | 3603 | BARNES    | CECIL   | 1/9/75   | 9888  | 5.00   | ESTATES    |
| 5  | 3604 | WRIGHT    | TONY    | 11/10/82 | 9871  | 17.00  | ADMIN      |
| 6  | 3605 | BURKE     | ERNEST  | 13/1/80  | 90891 | 11.00  | PLANNING   |
| 7  | 3606 | SCHOFIELD | PAUL    | 7/12/82  | 9345  | 15.00  | MECHANICAL |
| 8  | 3607 | TAGG      | MALCOLM | 29/10/83 | 9001  | 100.00 | TRANSPORT  |
| 9  | 3608 | SPELMAN   | HOWARD  | 21/7/84  | 9557  | 90.00  | ESTIMATING |
| 10 | 3609 | YELDNAM   | MARK    | 1/12/83  | 9789  | 80.00  | CONTRACTS  |

Figure 2.5: Direct Access File Organisation

may then be related to the key (employee number in this case) as shown in Figure 2.5. This method can still be used even when the keys are non-consecutive provided we are prepared to accept some 'gaps' or wasted space in the file storage area. In most practical situations the space which would be wasted by this method is too great to be acceptable, because key values are drawn sparsely from a wide domain of potential key values.

#### 2.3.3.5 INDEXING METHODS

An index for a file consists of the keys of its records, together with pointers or addresses which indicate where the complete record can be found. Figure 2.6 illustrates an indexed file of employee details.

There are variety of ways of constructing indexes for files. Common methods include the following which are described in detail in various publications (103, 108):

- \* Key-to-Address Transformation (or hashing methods),
- \* B-tree indexing.

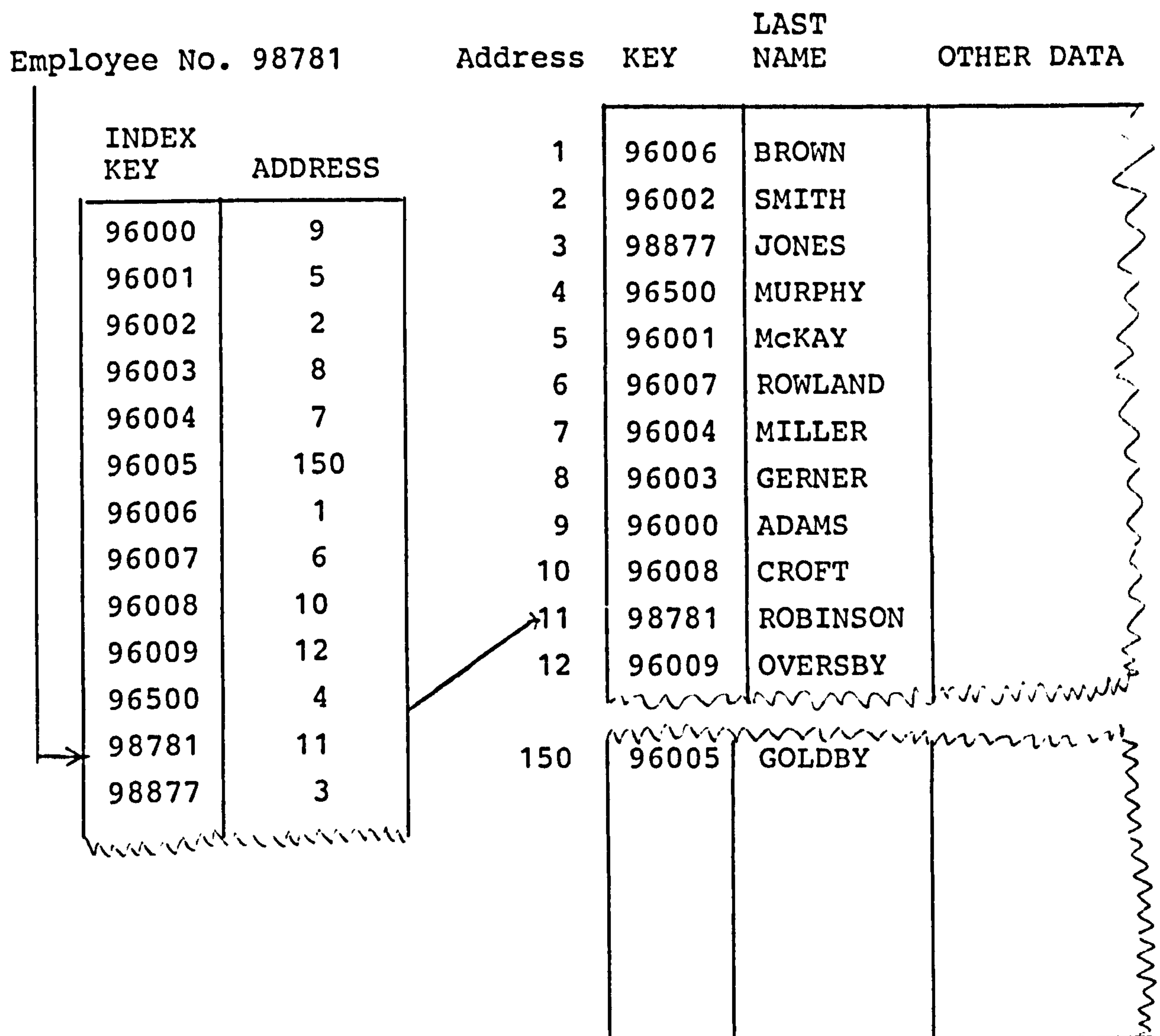


Figure 2.6: Index File Organisation



## 2.3.4 PROCEDURE DESIGN

The aim of this phase of the design is to determine the processing and computational requirements necessary to link input, output and the data files. The main approach adopted in procedure design was to separate individual functions within the overall system into relatively independent modules. This approach is usually referred to as structured design or modular design (109).

The approach is not much different from the strategy in dividing a problem into pieces and then solving each piece. The approach avoids the difficulty of having to consider all aspects of the general problem simultaneously.

Stevens (109) lists the advantages of structured design as:

- \* the program is simpler: it can be understood, checked, programmed, debugged, fixed and changed piece by piece;
- \* modules can be programmed relatively independently; errors are less likely because less code has to be dealt with at a time;
- \* side effects of changes are drastically reduced;
- \* the program can be understood piece by piece;
- \* testing is easier because the program can be tested piece by piece;
- \* change of programmers is less critical;
- \* optimization efforts can be applied to critical areas;

- \* single-function modules are uniquely qualified to be used in function programs.

#### 2.3.4.1 OUTLINE OF PROCEDURE DESIGN

Procedure design involved two main activities:-

- (i) identifications of functions, tasks, operations, transactions and the links among them,
- (ii) determination of programming modules.

As functions, tasks, operations and transactions had been identified during the systems investigation and analysis stage no further work was necessary during the procedures design stage.

A module is a set of program statements that can be invoked by a name (109). The objective of modularity is to enable the piece of the program to be examined with relative independence.

Two measures are of interest relative to achieving independence between modules. The primary measure is coupling. Coupling measures the strength of relationships between modules. The objective is to maximise independence by minimising coupling. The second and complementary measure is binding. Binding measures the strength of the relationship between elements of

code within a module. Hence coupling and binding measure opposite aspects of the same thing.

Measures of coupling and binding are usually determined from charts but generally designing the same relationships as exist among the functions in the real world would usually arrive at the same result (109).

## 2.3.4.2 GENERAL GUIDELINES

According to Stevens (109) the key guidelines of structured design are independence, simplicity and observability. The goal is to have the best of all three. Independence allows the parts of the program to be debugged, understood, fixed, and changed relatively independent of the rest of program. Simplicity is achieved primarily through independence of the modules. Observability measures how easy it is to see why the program does what it does.

The following guidelines recommended by Stevens (109) were followed:

### \* *Elements of a Functional Module*

A function must be represented by a module. Any module must certainly do its assigned job. If there is any circumstance in which the module is going to be unable to do its assigned job it must be able to indicate this to its caller. A module should issue error messages that are dependent upon the particular status of errors encountered.

\* *Duplication of Functions*

Duplication of functions is to be avoided. One of the major benefits of structured design is that functions do not need to be implemented within the same program more than once. Monolithic programs tend to duplicate functions wherever there are different data areas to which a function is to be applied. The problem of having the same function implemented more than once within the same program include:

- . waste of time writing and debugging the function multiple times instead of once.
- . the function will typically be implemented slightly differently for each occurrence.

\* *Specification within a module*

Implementing each part of the specification in only one module, or in as few modules as possible, is similar to implementing each function in only one module. This way, if the specification changes, only one module needs to be changed.

\* *The Simplest Solution*

The simplest solution to the immediate problem is to be sought. Attempts at generality with a view to future applications should be avoided because the result is



often wrong or the effort necessary to produce a more general routine is charged to the wrong project.

\* *Flexibility and Versatility*

Allowance should be made for flexibility and versatility. Flexibility is the ability to adopt to new requirements not currently specified for in the program. Versatility is the range of functions a program can perform.

\* *Naming Modules*

As far as possible every module should be given the name or phrase of its function. If a name is longer than allowed for module names, an abbreviation or acronym can be used. An alphabetic name that describes the module's function makes it easier to understand and remember what each module does. This can help substantially to make the program easier to understand, check, debug, and change.

## 2.4 SOFTWARE DEVELOPMENT

The development of software followed the following steps:

- \* selection of programming language
- \* determination of general guidelines
- \* coding, compiling, debugging, and testing of modules.



## 2.4.1 SELECTION OF PROGRAMMING LANGUAGE

The options identified are:

- \* machine language/assembly language
- \* high-level language

Every computer has its own machine language which practically consists of binary code (1's and 0's). A machine language is designed along with the computer itself and is as much a part of the computer as its central processing unit or its input/output devices. An assembly language is closely related to machine language but will usually need a special program to translate it into pure machine code (102).

High-level languages are far removed from machine code and are usually made of English and mathematical expressions (102). They are therefore easier to understand and more convenient to use.

In selecting the appropriate programming language both its design and implementation aspects were considered.

### 2.4.1.1 LANGUAGE DESIGN

Ledgard and Marcotty (111) recommend that a language must aid programmers in the following areas:

- \* Program design: a structured design is

enhanced by a structured language.

- \* Understanding: A well-designed language will encourage the programmer to write so clearly that the program will be self-documenting.
- \* Verification: the language notation should be designed to expose careless mistakes.

#### 2.4.1.2 IMPLEMENTATION

The following general questions of implementation were considered:

- \* Are there compilers available for the language on a wide range of machines?
- \* Is the compiler easy to use and does it produce clear diagnostics?
- \* Is the compiler efficient both in the compilation process and in the object code that it produces?
- \* Is the language and its compiler well documented?
- \* Are the supporting documents written clearly and unambiguously?

Based upon the above considerations machine language was very quickly eliminated. High-level languages considered include:

- \* BASIC,
- \* FORTRAN,
- \* PASCAL,
- \* ALGOL,
- \* ADA,
- \* COBOL

FORTRAN 77 was selected based on the considerations above and also on the fact that INTEREST is written in FORTRAN. The version of FORTRAN is ANSI FORTRAN 77 (112).

Testing, maintenance and evaluation are dealt with in Chapters 14 and 15.

## CHAPTER THREE

### CONSTRAINTS TO THE INTEGRATION OF SOFTWARE FOR CONSTRUCTION MANAGEMENT

In order to find the solution to a problem it is often advisable to acquire some understanding of its causes. This Chapter contains the results of a literature review of the organisational aspects of the construction industry, construction firms, construction projects and EDP technology. The review was carried out with a view to finding out if some of the causes of the production of predominantly stand alone systems for construction management are traceable to organisational factors..

The following causes of lack of integration have been identified:

- \* technical limitations of computer hardware,
- \* development of software by people who do not possess the necessary expertise,
- \* limitation of software tools,
- \* organisational factors.

They are discussed in detail below.

#### 3.1 TECHNICAL LIMITATIONS OF COMPUTER HARDWARE

Until only recently the hardware available

were mainly stand alone micros with 128K memory sizes, minis and mainframes (18). Micros which are transportable and therefore more suited to work on site had the drawback of inadequate memory and speed for integrated systems. Minis and mainframes had the memory and not the transportability.

Of late the following improvements in hardware are being made (18):

- \* reductions in the cost of hardware,
- \* increases in memory sizes and speed of available micros,
- \* the increasing availability of communications capability whereby one computer can exchange information with another through the telephone network.

According to Race (12), processor and even memory prices had been falling steadily by roughly a factor of two per year during the period 1975 - 1980, power to power and capacity for capacity. Falling prices have been accompanied by improvements in the size and speed available to micro hardware. Keen and Woodman (18) claim that these have improved to the point where the distinctions among micros, minis and mainframes have become blurred. They cite the case of IBM's 370/XT personal computer which is equivalent to one of its smaller mainframes.

The improvements are summarized in Table 3.1.



However, Keen and Woodman (18) write that the development of communications capability in the micro field is even more important than the improvements in size. They maintain that the addition of such capability removes the main limitation of stand alone micros: small memory leading to lack of access to data resources and their separation from the company's mainframe computer resources. This new communication capability implies that:

- \* the micro is in effect an intelligent terminal that can operate as a self-contained computer or as a terminal linked to a remote computer or other source of information;
- \* the micro has both of two worlds:
  - . access to mainframe speed, power and data,
  - . economics of a stand alone system (no timesharing costs).

TABLE 3.1: Improvements in Hardware Performance -  
(After Warren and McFarlan (17)).

| YEAR                   | 1958                | 1965               | 1972                 | 1980                           |
|------------------------|---------------------|--------------------|----------------------|--------------------------------|
| TECHNOLOGY             | VACUUM TUBE         | TRANSISTOR         | INTEGRATED CIRCUIT   | LARGE-SCALE INTEGRATED CIRCUIT |
| COST PER UNIT          | \$8                 | \$0.25             | \$0.02               | \$0.001                        |
| COST PER LOGIC         | \$160               | \$12               | \$2.00               | \$0.05                         |
| OPERATION TIME SECONDS | $16 \times 10^{-3}$ | $4 \times 10^{-6}$ | $4.0 \times 10^{-6}$ | $200 \times 10^{-12}$          |

### 3.2 INADEQUATE EXPERTISE OF SOFTWARE DEVELOPERS

According to Keen and Woodman (18) successful deployment of computing rests on 'hybrids' - people who are either technically fluent in computer science yet literate in the area of application, or the reverse. Bensasson (19) attributes the lack of appropriate software for the construction industry partly to the scarcity of people combining the skills of computing with those of the industry's disciplines. Some educational institutions are waking up to the problem and are putting the necessary emphasis on computing.

The problem of lack of appropriate skills is compounded by the segregated training of the various professionals involved in construction. This means that even with the addition of computing to school curricula knowledge of the total operations of construction companies still has to be catered for to produce the 'hybrids' required.

### 3.3 LIMITATION OF SOFTWARE TOOLS

Until recently the software tools required to develop the integrated systems were lacking. For organisational reasons explained in Section 3.4.5 and also because of the long times that software development takes integrated systems can only be built up by gradually adding to the functions supported. This requires that it should be possible

to examine a function without losing sight of the total system and that functions can be added without extensive revisions. However, it is only recently that the use of systems approach and the availability of structured programming languages have made this much easier than ever before.

The concept of a system has a long history. According to Evered (69) the word may have entered the English language in the early 1600's to mean 'an organized whole, as with a body of men'.

An accepted definition of a system today states: it is 'a concept that refers both to a complex arrangement of interdependencies between parts, components and processes that involves discernible regularities of relationships, and to a similar type of interdependency between such a complex body and its surrounding environment' (63).

The systems approach is a strategy for problem-solving by examining systems which demands that any system should first of all be understood as a whole entity (64, 65, 66). This is done by first defining the objectives of the system and then identifying the parts bearing on the objective. These parts may then be considered as sub-systems. The main aim is to so define the sub-systems' boundaries that the overall system can easily be viewed as a simple arrangement of sub-systems. Once the boundaries of the sub-systems have been defined, management may then be in a position to concentrate attention on

any of them.

The application of systems approach to software design supported by structural languages such as FORTRAN 77 made it easier to achieve integration in stages.

### 3.4 ORGANIZATIONAL FACTORS

This section examines the organisational aspects of EDP technology. The examination serves two purposes. The first aims at finding out any factors which inhibit integration of software. In Chapter 2 it was explained that as information systems function in an organisational context there is a need to carry out an examination of the organisational aspects as part of the systems development cycle. Satisfying this need is the second purpose of this section.

This section begins with a review of organizational theory with the intention of providing the general concepts and principles with which the rest of the section can be understood.

#### 3.4.1 GENERAL OUTLOOK OF THE CONSTRUCTION INDUSTRY

The construction industry is characterised by the following features:

- \* demand for its services is subject to a great degree of fluctuation ,
- \* it is highly fragmented,



- \* the rate of insolvencies is very high,
- \* it has failed not only to carry out enough research but also to apply the findings of most research carried out,
- \* it is custom-oriented.

In terms of Gross National Product (GNP) construction is the largest industry in both the United Kingdom (19, 20) and the United States (11,20). This probably also applies to many countries of the Western World (21). Yet, by and large, the demand for its services is not controlled by the industry itself but is rather governed by the general level of economic activity and by Government policies in relation to social services and capital investment (54). This feature of the industry makes it vulnerable, not only to unavoidable fluctuations in global and national economic activity but also, to use by Governments to regulate the national economy. It has been observed that since 1954 the construction industry has been characterised by fluctuations in demand (52, 55, 56, 57).

The construction industry is highly fragmented into various sectors each with different methods of operating (19). Typical sectors include housing, highways and industrial buildings. In addition to the sectoral fragmentation there is also a great deal of fragmentation in the organisation for undertaking construction work. This latter type of



fragmentation accounts for there being more firms in construction than in any other industry with the majority of them being small business (19,53,58). The differences in methods of operating may have tended to fragment the market for software to a degree where their developers may have found it economically inadvisable to shoulder the huge expense of developing the desired systems.

Hillebrandt (52, 53) writes that on the whole the rate of insolvencies within the construction industry is much higher than in other industries. She attributes this to the following factors:

- \* the high risks involved (including that of having to price the product before it is produced),
- \* tendering as a method of procuring work,
- \* the low fixed capital requirements,
- \* a tendency for construction firms to operate with too little working capital.

The fourth feature is related to the three features already discussed, in that the industry's poor performance in research compared to that of other industries may be partly attributable to those features. A report (21) commissioned by the Science and Engineering Research Council and the Departments of the Environment and Transport and prepared by the Civil Engineering Task Force has it that in 1981 expenditure on construction research and Development (R & D) was equivalent to about 0.5% of the total expenditure on construction in the UK or

about 0.3% of the combined value of work on which British firms were engaged in the U.K. and overseas. These figures are in great contrast to the expenditure of 2% of GNP in all fields for the same year contained in the report.

The report attributes the disproportionately less expenditure on construction research to the following:

- \* the low capital structure of the majority of firms and the keen competition leading to low profit margins means that most of them cannot afford the overhead of research expenditure;
- \* the fluctuation in demand makes the rational prediction necessary in research baseless;
- \* rigid contractual practices (e.g. by placing undue risks on contractors, by absence of allowances of adequate time) have inhibited the willingness of contractors to experiment with new ideas;
- \* the fluctuation in demand inhibits innovation because potential innovators have no guarantee that there will be adequate work to enable the research to be followed through.

Another possible inhibiting factor which does not appear to have engaged the attention of researchers is the relatively public nature of construction work. There should obviously be a

disinclination to shoulder the R & D costs only for the benefits to be copied, or passed on to competitors, by his sub-contractors, migrant labour and other participants in the contract.

However, the report (50) of research sponsored by SERC and carried out by Reading University maintains that the conventional claim that research is not adequately funded is without foundation. The report claims that research findings are being made and that the industry is failing to apply them due to the following factors:

- \* Familiarity - the case with the research findings are understood by firms.
- \* Focus - the entrepreneurial level at which research is pitch (applying to individuals or groups) .
- \* Completeness - the extent to which the research can be applied directly.
- \* Standing - the extent to which research is likely to be associated with influential individuals and/or institutions.

Apart from these research failings the majority of construction companies appear to rely too much on past experience and to despise everything academic or scientific. As Parker and Oglesby (59) writes of the United States' construction industry which has substantially the same failings in respect to research as that of

the U.K. (11, 20), construction management is too busy putting out the fires of yesterday's mistakes to pause and think of today, much less tomorrow. Lemarie (60) and the Site Management Committee of the CIOB maintain, without detracting from the importance of experience, that many site managers have risen from trades background and the majority of them may need some academic training.

In a nutshell research, particularly management and organisational research, has had a poor track record in the construction industry (50). Whilst Basil and Cook (62) maintain that successful assimilation of technology requires management technique and organisational innovation this custom-oriented stance of the construction industry is failing to provide the intellectual and scientific environment conducive to the inception of new ideas, their development for experimentation and their implementation for productive returns. More specifically, the industry seems to have ignored the research finding as regards the need to co-ordinate data (50) and that may have contributed to the development of a mishmash of stand alone software/hardware systems.

### 3.4.2 ORGANISATIONAL THEORY

Organisational theory is an approach to studying the behaviour of organisations in terms of the social structure of the situation irrespective



of the particular personalities involved (67). For convenience organisations may be examined at two levels: (i) the effect of an organisation's environment on its structure and (ii) the effects of its environment on individual behaviour (68). The former is the 'structural' approach, the latter the 'behavioural' one.

Woodward (70,71) has done some pioneering work on the influence of technology on the structure of organisations whilst Davis (72) and Hackman (73) have written about the behavioural effects of technological change.

### 3.4.2.1 ORGANISATION! STRUCTURE

According to Beer (74) organisations are formed to achieve purposes which individuals alone cannot achieve whilst individuals join organisations to achieve personal goals they cannot attain on their own or which are better met through membership in their organisations. Organisation structures refer to the formal mechanisms and systems of the organisation that are designed to channel behaviour towards the organisational goals and fulfil members' needs.

An organisation's structure may therefore be thought of as channels which describe the authority, responsibility and accountability in respect of each individual for work flow. The following definitions due to Kertznor (13) are used:



- \* *Authority* is the power granted an individual (possibly by his position) so that he can make final decisions for others to follow.
- \* *Responsibility* is the obligation that one incurs in his role in the formal organisation in order to effectively perform his assignments.
- \* *Accountability* is the state of being totally answerable for satisfactory completion of a specific assignment.

Authority and responsibility can be delegated to lower levels in the organisation but accountability usually rests with the individual.

### 3.4.2.2 TYPES OF ORGANIZATIONAL STRUCTURES

The origin of all organisational structures is the traditional (also called functional, or classical) organisation. There is wide variety of organisational forms to which the traditional form can be structured. The exact method depends upon the people in the organisation, the organisation's market and services, and management's philosophy (13).

### 3.4.2.3 THE TRADITIONAL ORGANISATION

This type of organisation is based on departmentalization along distinct functions. This functional organisation provides for both a horizontal dimension, into which the organisation is divided

by the departments, and a vertical dimension which contains several levels which represent varying degrees of authority. This hierarchical structure is the basic framework of the traditional organisation and the superior-subordinate relationships are the lines along which authority flows from top management to the lowest levels. The structure of the traditional organisation is illustrated in Figure 3.1.

There is a large degree of agreement amongst authors as to the advantages and disadvantages of the traditional organizations. Those listed by Kertzner (13) are typical and are shown below.

#### 3.4.2.3.1 ADVANTAGES OF THE CLASSICAL/TRADITIONAL ORGANIZATION

The main advantages are (13, 26):

- (i) Budgeting and cost control are easier.
- (ii) It provides better technical control:
  - \* Specialists can be grouped to share knowledge and responsibility.
  - \* Personnel can be used on different projects.
  - \* All projects will benefit from the most advanced technology.
  - \* Technical supervisors provide better control and supervision.
- (iii) It provides flexibility in the use of manpower.
- (iv) It provides continuity in the functional disciplines.

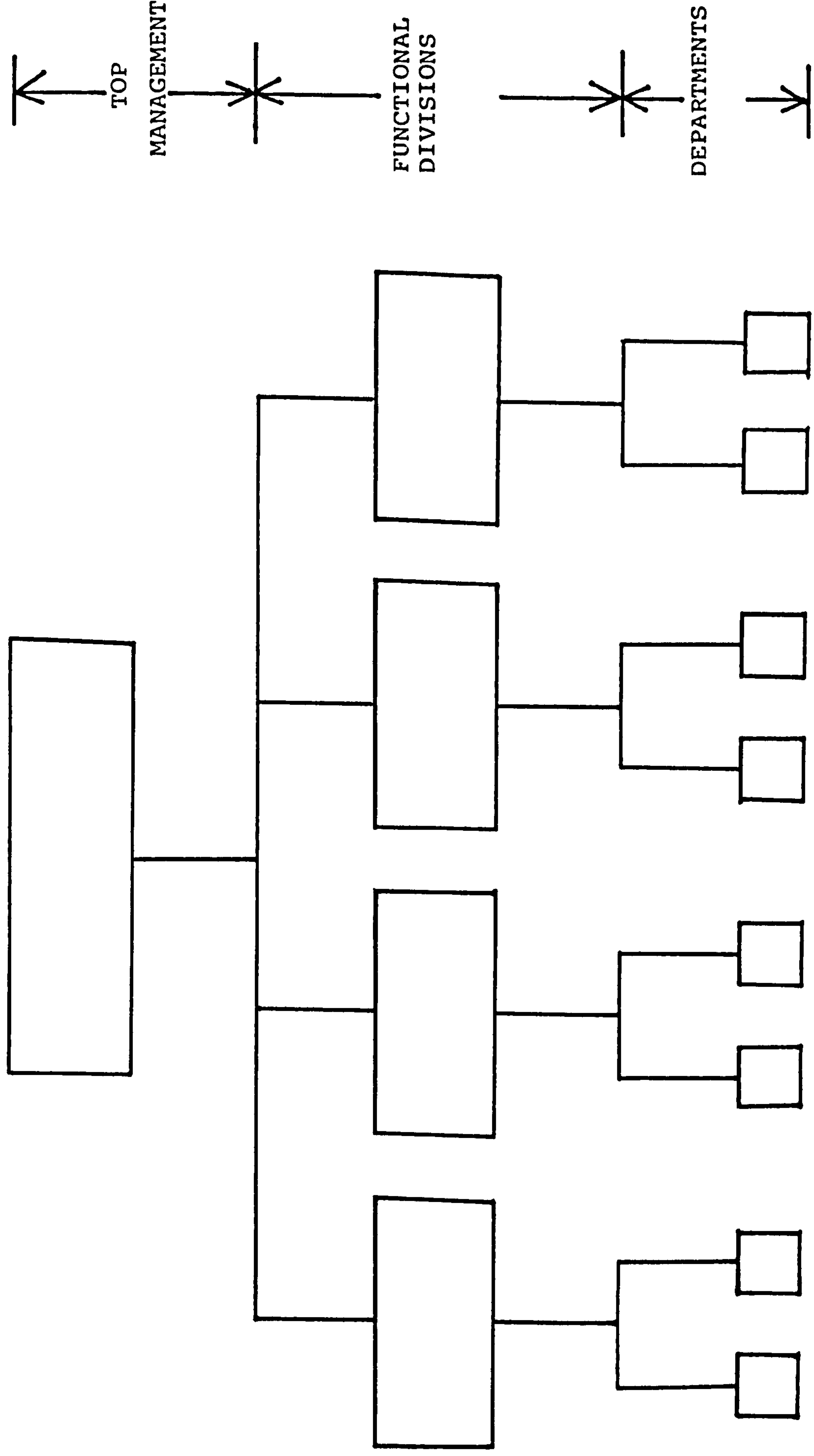


Figure 3.1: The Traditional/Classical Organisation Structure

- (v) Policies, procedures and lines of responsibility are more easily defined and understandable.
- (vi) It provides good control over personnel since each employee has one and only one person to report to.
- (vii) Communication channels are vertical and well established.
- (viii) Quick reaction capability excels, but it may be dependent upon the priorities of the functional managers.

#### 3.4.2.3.2 DISADVANTAGES OF THE CLASSICAL/TRADITIONAL ORGANIZATION

- (i) No one individual is directly responsible for the total project.
- (ii) It does not provide the project-oriented emphasis necessary to accomplish the project tasks.
- (iii) Co-ordination becomes complex and additional lead time is required for approval of decisions.
- (iv) Decisions normally favour the strongest functional groups.
- (v) There is no customer focal point.
- (vi) Response to customer needs is slow.
- (vii) There is difficulty in pinpointing responsibility.
- (viii) Motivation and innovation are decreased.
- (ix) Ideas tend to be functionally oriented with little regard for on-going projects.

- (x) New projects tend to be excessively oriented on the originating function.

#### 3.4.2.4 PROJECT ORGANISATION

In the context of a project the problem is how best to combine the various functional contributions to achieve the objectives of the project. From the point of view of the contractor this objective should be to deliver to his client what he asked for, when he asked for it, at the price he agreed to pay and also make an adequate return on his capital and management resources employed.

It is generally contended that there is no best structure and that the 'best' structure must be one which optimises performance by obtaining a balance between conflicts generated by the social and technical constraints within which the organisation must function. Sadler (75) proposes the use of the following checklist as an aid to a decision on the appropriate structure to use:

- \* To what extent does the task of organisation call for close control if it is to be performed efficiently?
- \* What are the needs and attitudes of the people performing the task? What are the likely effects of control mechanism on motivation and performance?
- \* What aspects of the organisation's activities need to be closely integrated if the overall



task is to be achieved?

- \* What are the natural social groupings with which people identify themselves? To what extent are satisfying social relationships important in relation to motivation and performance?
- \* What organisational measures can be developed which will provide an appropriate measure of control and integration of work activities while at the same time meeting the needs of people and providing adequate motivation.
- \* What environmental changes are likely to affect future trend of operations? What organisational measures can be taken so as to ensure that the enterprise responds to these effectively?

Koontz and O'Donnell (189) and most writers on organisations agree that to achieve group objectives there must be co-ordination and control of inputs from the individual functional groups. It is the mechanisms for doing so which are controversial.

The Tavistock Institute's (76) approach to co-ordination and control is to:

- (i) identify the forces which create the pattern of structural differentiation within the organisation;
- (ii) identify the means of effecting integration.

Differentiation measures the relative differences between the sub-systems whereas integration is the measure of unity of effort.

There has been a lot of research on various aspects of differentiation/integration within organisations (77, 78, 79). Lawrence and Lorsch (79) have shown that for an organisation to perform effectively it must have both the right degree of differentiation appropriate to its sub-systems, and at the same time the right degree of integration appropriate to its needs as a whole. Thus even when the differing parts of an organisation have to work together their essential differences should not be smoothed over; rather their boundaries should be made clear. And if additional integration is required to compensate for any imbalances between the sub-systems, this should be provided.

To be able to manage differentiation/integration, management has to know the degree of differentiation to allow for and when and to what extent to integrate. Lawrence and Lorsch (79) write that the measure of differentiation may be decided by considering differences in:

- \* organisation structures,
- \* interpersonal orientation,
- \* time horizons,
- \* goals and objectives.

According to Morris (80) research has shown that tighter organisational integration is necessary when:

- \* the goals and objectives of an enterprise bring a need for different groups to work together;
- \* the environment is complex and changes rapidly;
- \* the technology is complex and uncertain;
- \* the enterprise is changing quickly;
- \* the enterprise is organisationally complex.

Having determined the amount of differentiation and integration to allow for, the next problem is how to achieve them. Galbraith (81) proposes the following integrating mechanisms, each depending on the interdependence of the sub-systems:

- \* rules, standards and procedures,
- \* hierarchical referral,
- \* planning procedures,
- \* liaison positions,
- \* co-ordinator positions,
- \* task forces,
- \* special teams,
- \* full project management,
- \* matrix organisation.

Thompson (82) has observed that there are three types of interdependence each requiring its own strategy for integration:

- \* *POOLED INTERDEPENDENCE* where participants each pool a discrete contribution to the whole. The participants do not have to be operationally dependent upon or even interact with each other but the failure of any one participant can be

detrimental to the whole as well as the individual participant. Examples include clubs and the decentralized divisions of a company.

\* *SEQUENTIAL INTERDEPENDENCE* where the participants follow each other serially, the output of the one serving as the input of the other. An example is valuations following estimating.

\* *RECIPROCAL INTERDEPENDENCE* where participants are in continuous interaction. An example is the relationship between planning and control.

Thompson (82) writes that integration of pooled interdependence is best achieved through standardisation and formal rules, sequential interdependence through planning, and reciprocal interdependence through mutual adjustment and feedback between the participants.

#### 3.4.2.4.1 RULES, STANDARDS AND PROCEDURES

With this method management attempts to eliminate potential conflict by specifying and documenting detailed rules, procedures and standards to be complied with by the various participants. This implies that management would have to provide for every eventuality. Whereas this may be possible with repetitive work such as production in factories, it is of very little use in one-off situations such as construction.



#### 3.4.2.4.2 HIERARCHICAL REFERRAL

This method implies that nothing is done until a conflict arises when it is then progressively reported upstairs until a level of authority is reached where it can be resolved.

#### 3.4.2.4.3 PLANNING PROCEDURES

Tasks to be undertaken are anticipated and the sequence planned, usually at meetings so that the interdependence is acknowledged and commitment to future action by the various participants established.

#### 3.4.2.4.4 LIAISON POSITIONS

The primary function of liaison positions is to facilitate communication between functional departments. Other than this, the liaison position carries no real authority and little responsibility.

#### 3.4.2.4.5 CO-ORDINATOR POSITIONS

Management appoints someone, whose prime responsibility is the project, to co-ordinate the work on the project of the functional departments. The co-ordinator usually acts essentially in a staff position supporting the divisional manager above all the functional departments engaged on the project. A co-ordinator provides a similar



service as a liaison position but has some formal authority. He exercises his authority over the decision making processes, however, not over actual decision-makers themselves. He usually has to 'harass' or attempt to 'influence' functional managers into completing the contribution required of them on time. Eventually most conflicts outstanding are resolved by hierarchical referral.

#### 3.4.2.4.6 TASK FORCES

Task forces provide mission-oriented integration: a group is formed specifically for a particular task and upon completion of the task the group disbands. The rationale of the task force concept is that integration can be achieved if each functional unit places a representative on the task force. Theoretically decisions can be made at the lowest possible levels, thus expediting information reducing, or even eliminating time delays. Kertzner (13) criticises this method that functional managers tend to place their inadequately qualified and undesirable members on task forces.

#### 3.4.2.4.7 SPECIAL TEAMS

These are like task forces but attend regularly recurring types of problems rather than specific issues.

### 3.4.2.4.3 FULL PROJECT MANAGEMENT

A full project manager role upgrades the authority and responsibility of the integration function to allow cross-functional co-ordination. The project manager has authority to directly order groups to take certain actions and decisions. This is in effect, setting up a separate goal-oriented division of the company with its own functional departments.

Its main drawback is that it tends to use scarce manpower resource less efficiently because it is necessary in this form to duplicate the specialists in each project and allocate them in total to each project, more or less for the life of the project.

### 3.4.2.4.9 MATRIX ORGANISATION

The rationale behind the concept of a matrix organisation is to achieve integration by having staff account simultaneously to both the project manager and the functional managers whose work is being integrated. Both project managers and functional managers have authority and responsibility over the work. However the project manager has total responsibility for time and costs whilst the functional managers have responsibility for allocating and assigning resources.

Morris (80) cautions that the matrix organisation has its disadvantages. He mentions the following:

- \* the intolerable position of the poor souls actually doing the work if the project and functional managers are in conflict;
- \* matrix organisations have a tendency to generate conflict;
- \* matrix organisations suffer from constantly changing boundaries and interfaces.

The structure of a matrix organisation is illustrated in Figure 3.2.

### 3.4.3 CONSTRUCTION COMPANY ORGANIZATION

It is generally accepted that the organisation of construction companies is predominantly based on the classical organisation structure (83, 84, 85). Various authors have sought to explain this by comparing the origins of construction to those organisations which first started the use of the classical model. Whilst Walker (85) writes that the classical organisation originated from the Church and the Military, Gill (11) writes that it started in industry, particularly manufacturing. However there is general agreement on the essential point that the classical model evolved to govern stable and repetitive situations.

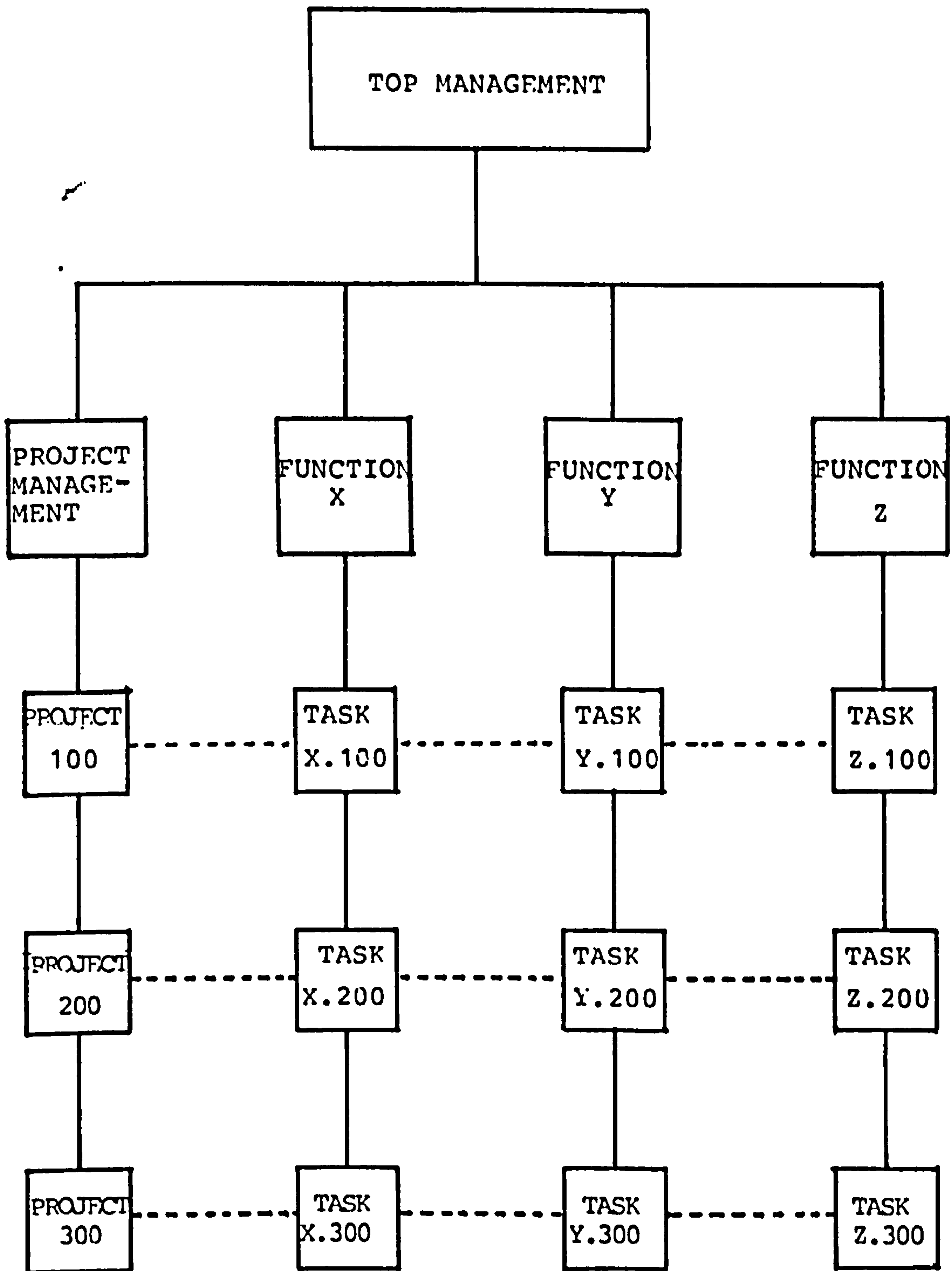


Figure 3.2: The Structure of the Matrix Organisation

Construction work started as a passive standardized craft activity (11, 85, 89). There should therefore be little wonder that many construction companies in the past, and even today, are based on the traditional model. Harris and McCaffer (83) identify the main functions which form the basis of departments as:

- \* Plant Management,
- \* Tendering,
- \* Contract Management,
- \* Purchasing,
- \* Accounts,
- \* Administration.

This type of structure is shown in Figure 3.3 whilst the details of the functions are contained in Chapter 12.

Depending on several factors such as size and type of work, company size and the catchment area for work the various functions may be subdivided into elements.

Another aspect of the organisation in construction companies is that a different plane of division based on professions is often superimposed on the traditional structure. By and large, the professional divisions tend to match departmental boundaries.



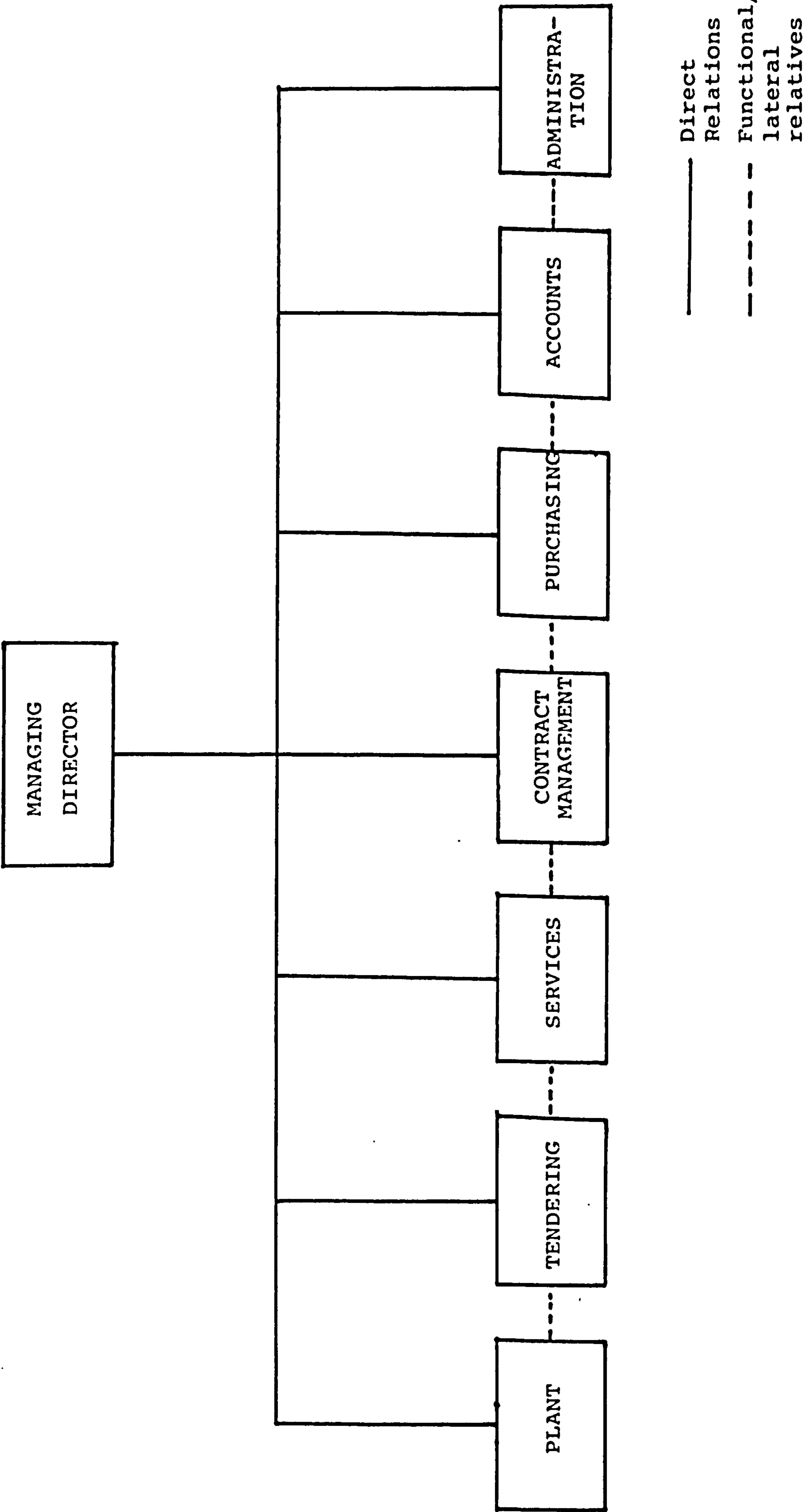


Figure 3.3: Basic Construction Company Organisation

### 3.4.3.1 CONSTRUCTION PROJECT ORGANIZATIONS

From the discussion on general project organizations there are a variety of possible organizations ranging from the purely functional type to a complete matrix structure. For simplicity two classifications are adopted in this work: functional-oriented and project-oriented organizations. Where the outlook of participants is more towards their head office departments than to the project it is said to be functional-oriented. Where the vice versa is the case it is said to be project-oriented. Scott (87) writes that the project-oriented organization is the type more often used in construction.

Research by Lemarie (86) showed that the type of site organisational adopted by builders depend on the following factors:

- \* company size,
- \* size of project,
- \* nature of work,
- \* company's catchment area of work.

No matter the type of organisation most Contractors have <sup>a</sup> person on site who acts as a focal point for the project. With the Joint Contracts Tribunal (JCT) and Institution of Civil Engineers (ICE) Standard Forms (27,187) the presence of such a person is a contractual term and he goes under many titles which include:

- \* Site Agent,

- \* Site Manager,
- \* Project Manager,
- \* Project Engineer.

The 'Site Manager' title is assumed in this work.

Lemarie (86) found out that the authority and responsibility of the Site Manager were not standardized and that they may depend on functional interests and backgrounds of the personnel involved. The Site Manager is of the least influence under the functional organization. In that situation each department has responsibility for its own function, the function of the Site Manager being the co-ordination of all departmental activities on the project.

With the project-oriented organization the Site Manager controls substantially all aspects of the project: engineering, programming, legal, purchasing, and financial. The level of control may vary from function to function depending on whether or not the particular function is centralized in the head office or branch office, or is site-based. Even where a function is site-based the level of control would depend on the level of seniority of the site functional manager. An illustration of a project-oriented organization taken from ICE publication (88) is shown in Figure 3.4.

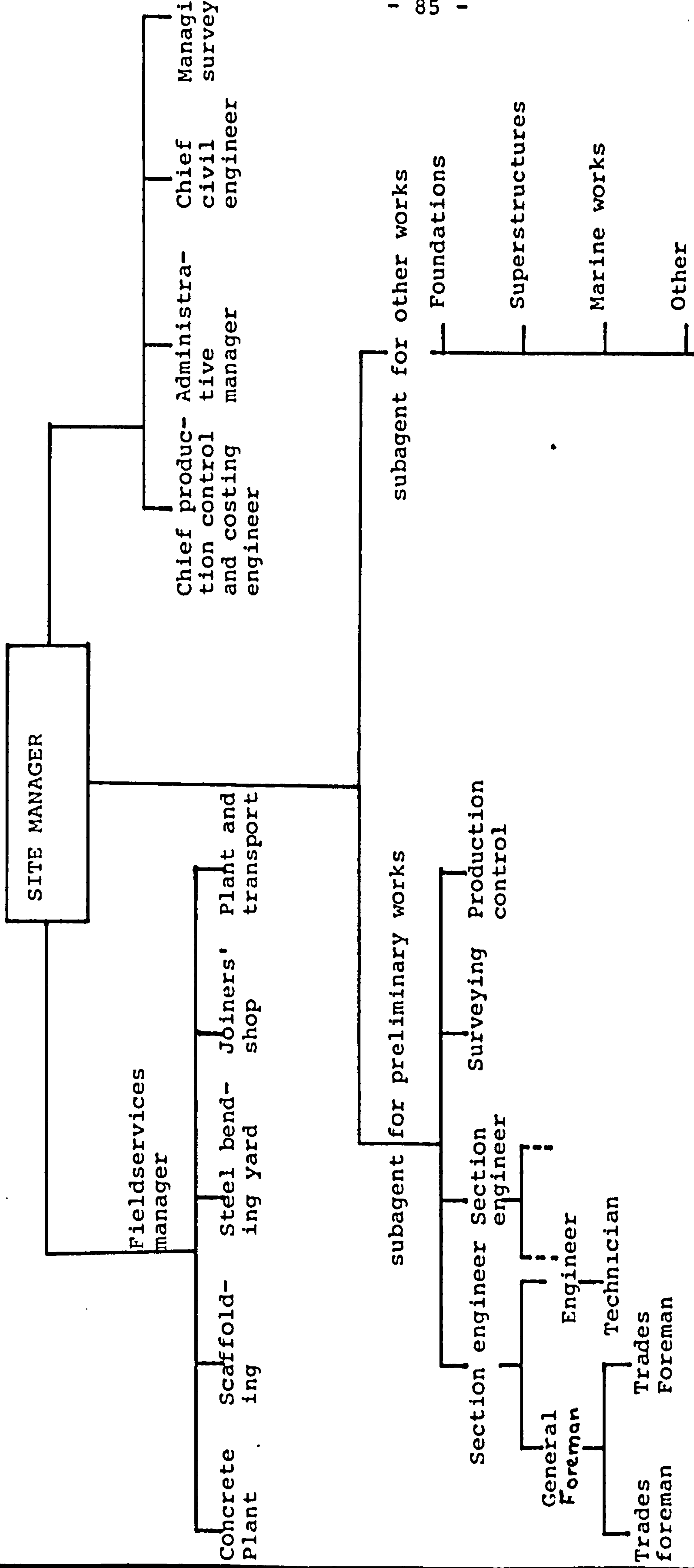


Figure 3.4: Example of a Project-oriented Organisation

### 3.4.3.2 CONSTRUCTION ORGANIZATIONS IN TRANSITION

There is general agreement that the task of managing projects today is considerably more difficult than it was 10 to 20 years ago. Morris (80) and Wearne (84) attribute the increased difficulty to increased complexity of projects. According to Walker (85) projects have been made more complex by factors such as project size, new engineering and management techniques, increased specialization among project participants, new materials and new client demands. Complexity tends to cause time and cost overruns leading to demands for better economy and value for money on the one hand. On the other hand complexity generates pressures towards greater specialization. Specialization entails a multiplicity of objectives not necessarily directly related to cost and time considerations. The challenge then is how to have specialization and unity of objectives, i.e. integration.

Research by Skinner (89) reveals that there had been increasing concern on the lack of adequate integration since the early part of this century. Since the Second World War there have been 40 reports all dealing with the need to integrate information in the construction industry (90). Higgins and Jessop (8) came to the following conclusions of the construction industry:



- (i) the building industry is remarkable among industrial activities for lack of detailed information about how it proceeds;
- (ii) if building is thought of without the people involved it can be seen as a chain of interdependent operations;
- (iii) there is a lack of match between the technical interdependence of the resources used in construction and the organisational independence of those who control them;
- (iv) the industry had been struggling to reconcile technical interdependence and organisational independence for over three centuries.

A study by Bishop and Alsop (92) showed that though the need for data co-ordination was being widely acknowledged, day-to-day practice fell short of this ideal. This view was confirmed by a subsequent survey (93) of systems of structuring project information which found that the various originating parties of information had tended to put their own interests first and had not sufficiently considered the requirements of the receiving parties.

The problem of lack of data co-ordination was further highlighted in the 'Estimating in Building and Civil Engineering' Conference held

in Loughborough University of Technology on September 20th 1973, and on March 22/23, 1974 after which the consensus of opinion was that the systems for data collection, recording, budgeting, planning, estimating, measurement of bonuses, cost reporting and contract settlement were not sufficiently integrated in many organisations.

According to McCaffer and Sher (2) the use of data assembled for estimating in subsequent job control activities is limited. They write that though such data are of value for job control, they are difficult to access or interpret and that this situation may be responsible for the clear and unnecessary division of the management functions.

Even today there is no evidence to show that the contract management information is being integrated. This view is supported by Evans (161) who writes that estimating, planning, cost control, cashflow forecasting and accounting are still being carried out in isolation.

Though the problem has been recognised there is little indication that it has been solved. Perhaps the most radical indictment of the organisation through construction is undertaken is the production of the British Property Federation's (BPF) system (90) which

seeks to abolish the Bill of Quantities as we know it today and to replace it with a schedule of activities. One of the main reasons for its production was the belief that the Bill of Quantities which is the main output of the estimating function does not usually meet the requirements of other functions such as planning, payment, costing and purchasing.

Without adequate integrating mechanisms then the functional managers, in attempts to optimise their particular specialities, may have most likely created a demand for stand alone software and thus influenced software developers to meet the demand pattern created. During this research the author came across many people who expressed a desire to acquire a valuations system. They were usually quite keen when being shown the valuations part of PLUS VAL but showed signs of boredom when shown other aspects such as materials control with comments like 'that is for accounts people'. One or two asked questions such as 'can we link PLUS VAL to our payroll?' and their attitude is explainable under 'Assimilation of New Technology' in Section 3.3.5.

#### 3.4.4 PROFESSIONAL DIVISIONS

It has been suggested that the professional divisions existing in the construction industry may be preventing the maximum exploitation of

computer technology (91) whilst Walker (85) writes that they may be inhibiting innovation in general. An examination of the potential influence of computer technology on the professions shows that they may not be without some understandable motives to resist integration, or even any computerisation.

In the typical contractor's organisation the following professionals may be found:

- \* accountants,
- \* quantity surveyors,
- \* engineers,
- \* plant specialists,
- \* personnel managers.

Even within these specialist occupations there are often further subdivisions of types of expertise. For instance, there may be design engineers, measurement engineers, planning engineers, estimators, cost engineers, to name a few. According to Walker (85) the differences in the cognitive and emotional orientation of these specialists within the construction process are readily apparent and that they tend to view each other with a certain amount of scorn.

The Tavistock Group (78) have developed a concept called sentience which is closely related to the difference in cognitive and emotional orientation of the specialists. A



sentient group is one to which individuals are prepared to commit themselves and on which they depend for emotional support. It has been found that sentience is likely to be strongest where boundaries of a sentient group and a task coincide (85). And this is generally the case in the construction industry. The various contributors have a tendency to focus upon, and be concerned only with their own specialism and are unable to perceive and respond adequately to the problems of others.

Computer technology, by its facilities and the very nature of most of these specialisms, has a remarkable tendency to increase sentience and make integration that much more difficult to achieve. Perhaps nobody has put the dilemma of the professionals much more succinctly than Evans (14). He argues that in many cases what is considered as professional expertise boils down to special accumulated data and a couple of rules of thumb. If this is true, and it most likely is, and as computers are particularly good at storing masses of data and carrying out routine calculations, this very strength of the professions may indeed turn out to be their Achilles heel. Brandon (15) writes of various indications that attempts at territorial expansion by some professions may be in the offing. That sort of attitude would increase group sentience.



There is also the political dimension of integration. Integration could lead to a redistribution of the sizes of functional departments and that is fraught with political implications (13). The mere introduction of computers often creates the need to establish a separate department to control the computing aspects of the company's operations (18). As Kertzner (13) writes, the addition of even a position in the organisation structure may produce political reverberations. The political significance of numbers may also be deduced from Bertrand Russell's (16) concern that in our modern times it is becoming increasingly necessary for the individual to dominate a vast organisation in order to achieve important goals. Though he had the larger society in mind the implication seems to be that the power wielded by a department within an organisation depends to some extent on its size.

As a result of departmentalization substantially around professional services and the education of the professions in relative isolation to each other, the possession of a reasonable all-round competence in all the processes of construction is the exception rather than the rule. On the other hand people of such competence are needed to develop specifications for effective integrated systems.

### 3.4.5 ASSIMILATION OF TECHNOLOGY

It has been observed that organizations change much more slowly than technology (94, 95). According to Long (94) the relationship between the development of new technology and the ability of organizations to cope with it is illustrated by Figure 3.5.

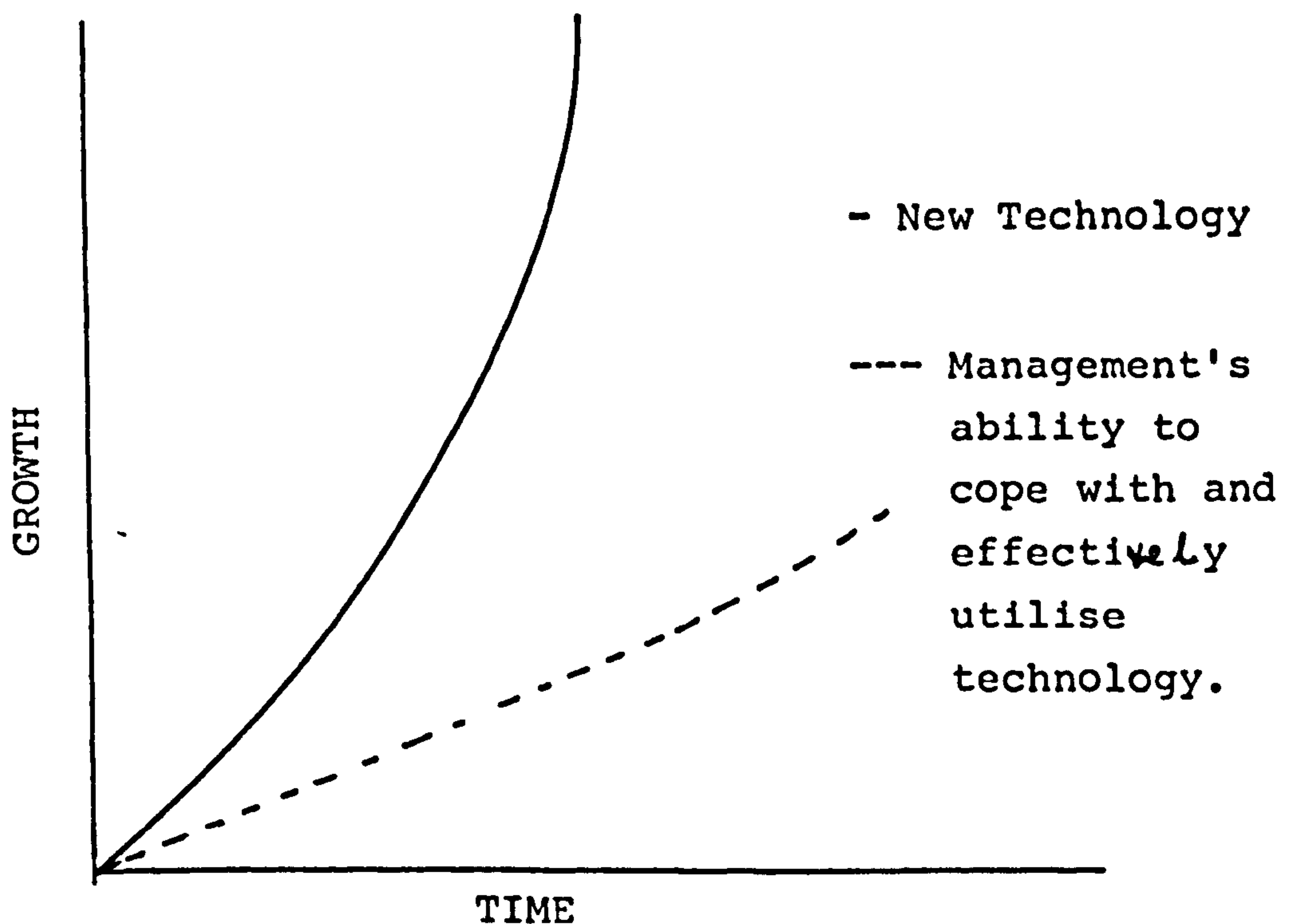


Figure 3.5: Organizational Assimilation of Technological Change - After Long (94).

The construction industry is not an exception. However, the peculiar characteristics of the industry such as the more marked professional divisions, the structure of the industry and its lower research and innovation performance may have contributed to widening the gap between the technology and management's ability to cope with it. Walker (85) writes that though generally the ability to organize and take advantage of the growth in techniques and computing power has fallen behind the rate of development of technology the comparatively lower performance of construction is predominantly due to organisational structures and the traditional professional roles.

Nolan and Gibson (7) have identified four phases through which the typical organisation passes in assimilating computer technology. The growth of applications and management techniques applied to each stage are shown in Figure 3.6.

#### *STAGE 1: INITIATION*

Features of this stage are:

- \* acquisition of first computer;
- \* computer acquisition justified in terms of cost savings;
- \* senior management fails to assess long-term effect of the computer on personnel;
- \* management may ignore some crucial issues;
- \* computer located in the department where it is

- first applied - very frequently accounting;
- \* job-displacement anxiety among some employees;

#### STAGE 2: EXPANSION

The features of this phase include:

- \* a period of more applications and rapid expansion;
- \* budget may be exceeded;
- \* many employees use computers for a variety of reasons;
- \* economic justification may take a back seat;
- \* chores of program maintenance may be neglected;
- \* acquisition of more middle level EDP managers;

#### STAGE 3: FORMALIZATION

The main features of the phase are:

- \* management becomes aware of the run-away budget and it begins a crash effort to find out what is going on;
- \* over control may result;
- \* reorganisation of the systems analysis function takes place.

#### STAGE 4: MATURITY

The features of this phase are:

- \* broad-based communication and spread of the technology within the organization.
- \* strengthening of bridges between users and computer personnel.

In a subsequent article (214) Nolan expanded the model to six states as illustrated in Figure 3.7. Another of his models is based on the four-stage model. The main difference is that with the third model rapid changes in hardware, software and systems designs prevent the reaching of the stage of maturity so that the growth causes repetitions of three staging following shifts of technology. This is illustrated in Figure 3.8.

#### 3.4.6 IMPLICATIONS FOR SOFTWARE DEVELOPMENT/ACQUISITION

The main implication is that acquiring computer-based systems for an organisation is not like acquiring, say, an advanced copier. Computerisation tends to induce structural and behavioural stresses in the organisation. It is therefore the duty of management to find ways and means of reconciling the new technology with the capacity of the organization to assimilate it.

The rapid change of technology and the tendency for organizations to pass through the phases described suggest that it may be bad business strategy to adopt a strategy of wait and see. Management today may have to gaze periodically into the crystal ball and make intelligent forecasts and subsequently make plans for expected changes. Nolan's stage model, though it puts forward no mechanism of the changes is a useful conceptual model to understand the general directions of change.



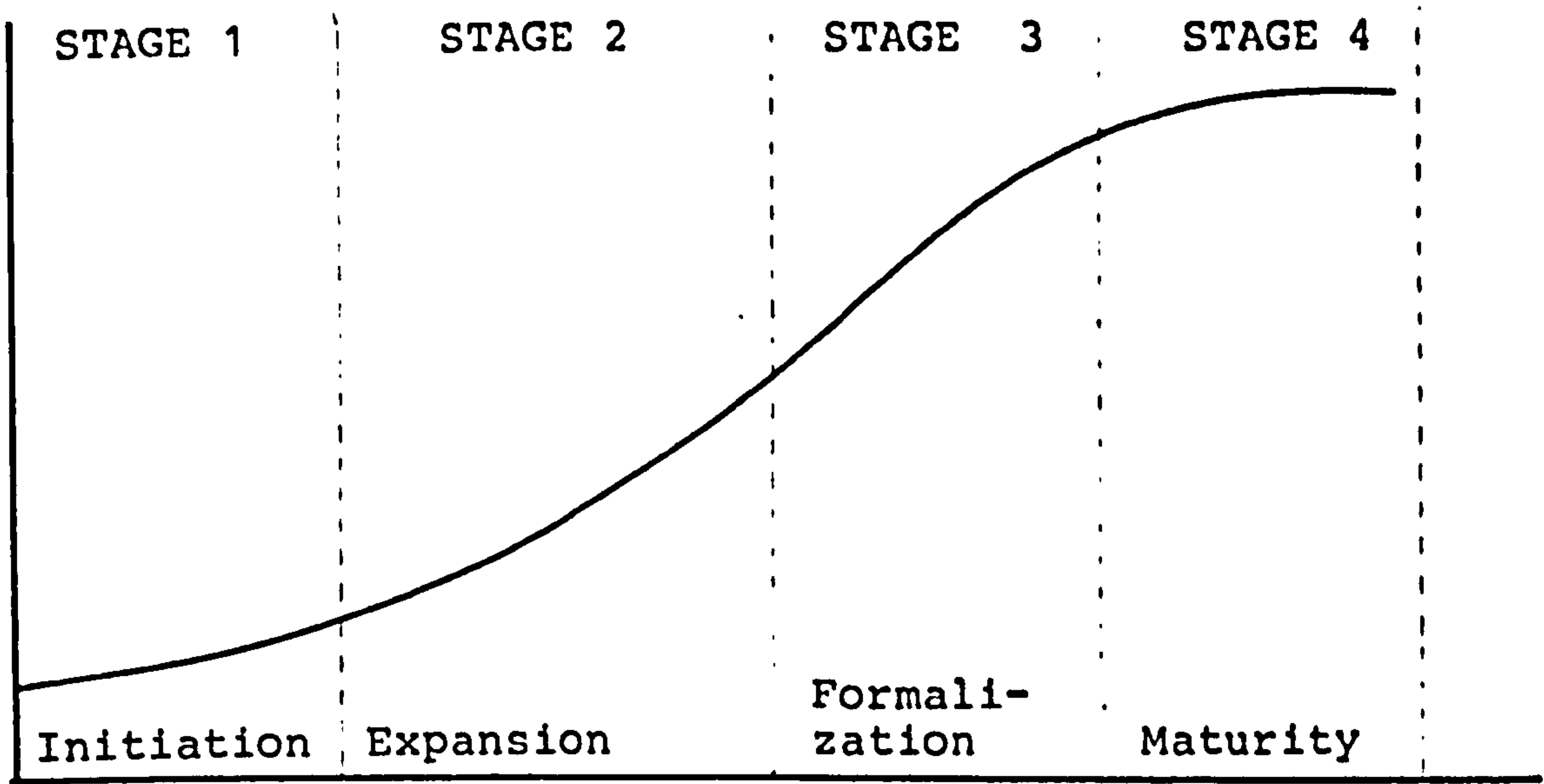


Figure 3.6: Nolan 4-stage Model

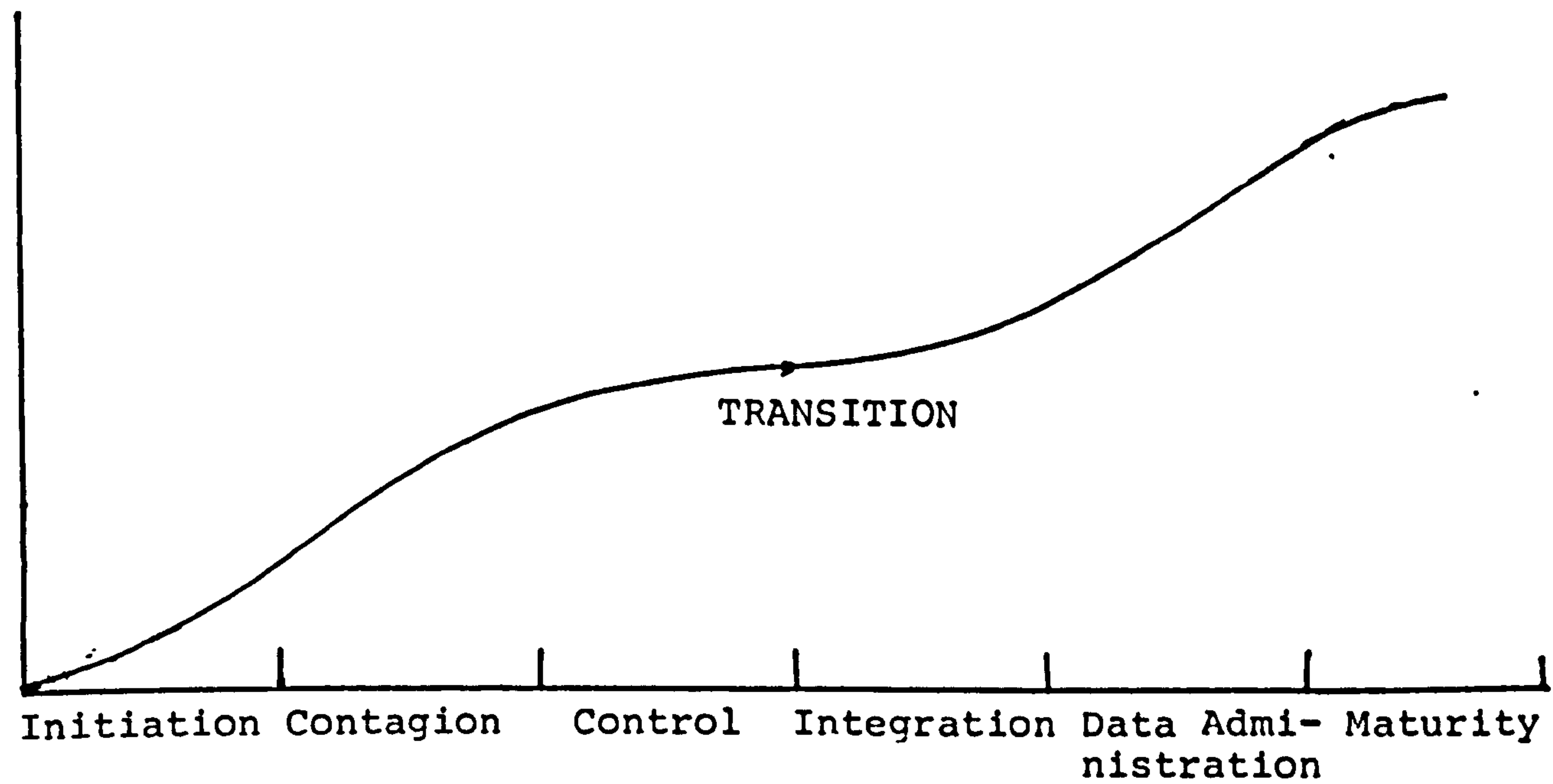


Figure 3.7: Nolan 6-stage Model

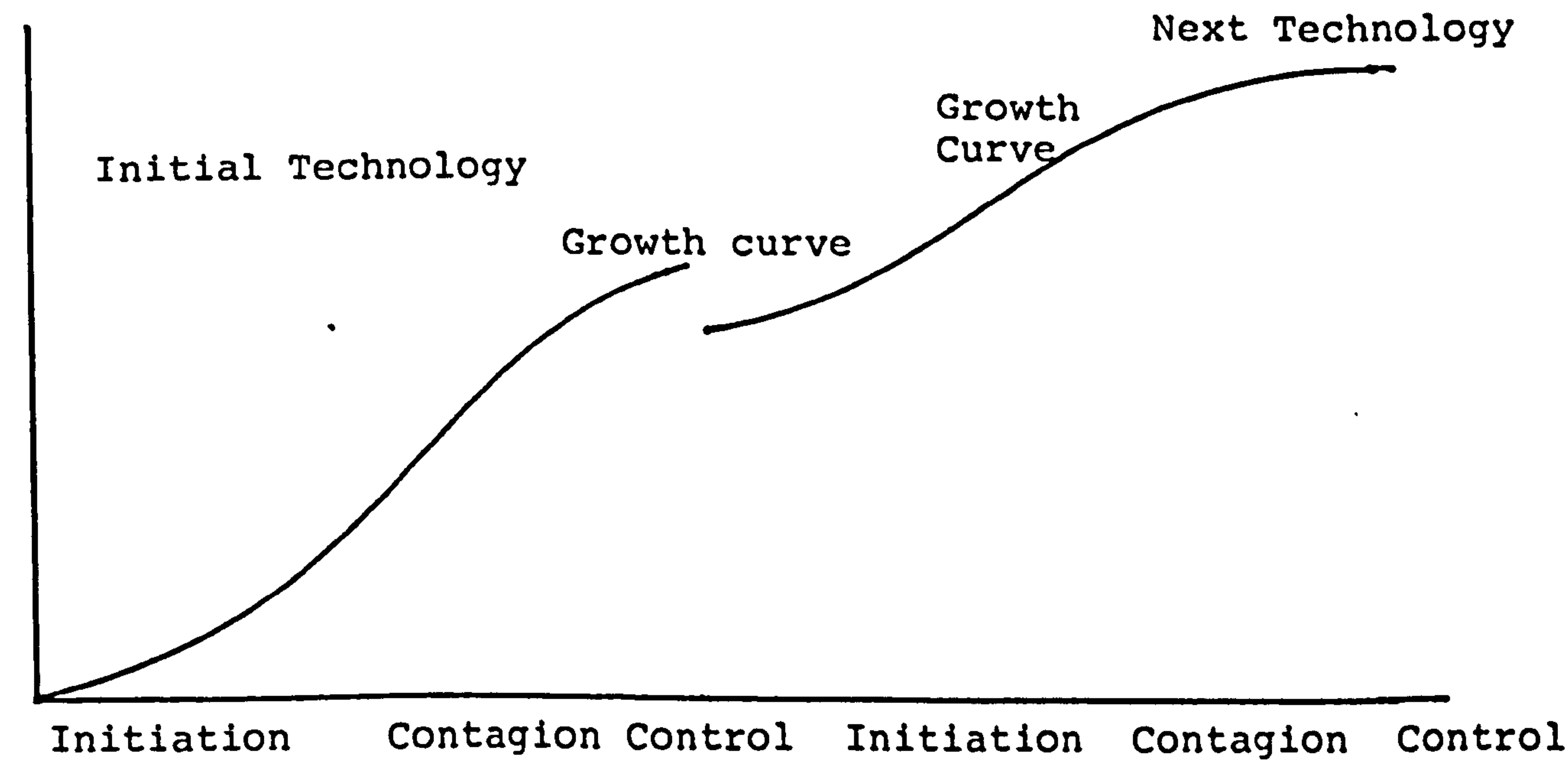


Figure 3.8: Life Cycle of Stages

With particular reference to the case of software for construction management, the main points of significance include:

- (i) It may be commercially unwise for any construction firm to develop an all-purpose software for the industry. This implies the central research institutions and universities have a contribution to make by way of drawing up adequate specifications.
- (ii) Any software which is intended for a wide cross-section of construction firms should be flexible and versatile.
- (iii) Prototyping may be the most appropriate methodology to use.
- (iv) Stand alone systems are not intrinsically undesirable for they may be useful for organizational learning.

## CHAPTER FOUR

### THE DETERMINATION OF USER INTERFACE REQUIREMENTS

The use of computer-based systems often involves some interaction between the human user and the computer. The areas of such interaction are referred to collectively as the user interface (200).

The user interface consists of video display screens, keyboards, other hardware devices, languages, and many other means by which the human user and the computer system exchange inputs and outputs. It is therefore apparent that the nature of this interface influences the following:

- \* user understanding of the system,
- \* resistance to the use of the system by its intended users,
- \* the incidence of errors,
- \* systems support required.

This Chapter provides an overview of the important features of user interfaces and of how such features should be selected during design. Features which were considered desirable for PLUS VAL were incorporated in its Systems Specification contained in Chapter 13.

Shackel (194) identifies the main factors influencing Man-machine interaction as:

- \* human performance,
- \* computer system performance,
- \* the hardware interface,
- \* the software interface,

- \* the specific application of the system,
- \* the environment,
- \* special problems relating to the system.

## 4.1 HUMAN PERFORMANCE

It is generally accepted that one of the main sources of resistance to the introduction of computer-based systems is fear by the intended users of being unable to use the system for want of the necessary skills and know-how. It was therefore decided that the intended users should not be required to possess prior knowledge of computers or of computing. They should also not be expected to possess any special skills over and above those already recognized in their existing jobs.

## 4.2 COMPUTER SYSTEM PERFORMANCE

The performance of a computer-based system depends on its quality. Quality refers to its fitness for its purpose. It is not an absolute concept; it is defined within a context. Perfect quality is very costly and virtually impossible.

Davis and Olson (200) write that quality in information systems has a number of characteristics with the importance of each depending on the application and its context. Some of the characteristics they enumerate which may be desirable in this application are:

---

| Information system<br>quality<br>characteristic | Implementation of quality<br>concepts   |
|---|---|
| Complete data                                   | All data items are captured and stored for use. Data items are properly identified with time periods.   |
| Accurate data                                   | The correct data values are recorded.   |
| Precise data                                    | Measurement of variables meets user needs for precision.  |
| Understandable output                           | The output of the system is understandable to the users.  |
| Timely output                                   | The output of the application is available in time for actions and decisions.   |
| Relevant output                                 | The outputs are relevant to the actions and decisions to be taken.  |
| Meaningful output                               | The format, labeling, data provided, and context in which data is presented makes the output meaningful for actions and decision making.            |
| User friendly operation                         | The system provides user interfaces that are understandable and designed to conform to human capabilities.  |
| Error resistant<br>operations                   | Suitable error prevention and detection procedures in place. There are procedures for reporting and correcting errors. Various audit procedures are |

---



---

Information system  
quality  
characteristic

---

Implementation of  
quality concepts

Authorized use

Only authorized personnel have access to facilities, applications, and data.

Protected system and  
operations

The system and its operations are protected from various environmental and operational risks. There are provisions for recovery in the event of failure or destruction of part or all of the system.

---

### 4.3 HARDWARE INTERFACE

Though extensive research has been carried out on this subject, particularly on keyboard design and problems of displaying information on Visual Display Terminals (VDT's) not all hardware interface problems have been solved. However, some of the researchers have come up with guidelines on ergonomic considerations in the selection of VDT's.

Raftering and Keener (196) recommend the following considerations in the selection of VDT's:

- \* The screen should usually be fixed at an angle of 10 to 15 degrees from the vertical, away from the user.. Preferably, the tilt should be adjustable, horizontally as well as vertically.

- \* Characters should not flicker or move on the screen.
- \* Glare and reflections on the display surface should be minimised.
- \* Resolution must provide a sharp image.
- \* Character-to-background brightness contrast should be greater than 50 per cent.

Preferably, the brightness should be adjustable.

Keyboard considerations focus on the physical feel and placement of the keyboard as a whole, as well as the placement of the individual keys. Keyboard design preferences are often highly individualistic; for this reason an ideal keyboard has as many adjustable features as possible.

According to Galitz (197) some of the ergonomic considerations in the physical design of keyboards are:

- \* Key force: A range of 15 to 125 grams pressure;
- \* Key space: 18 to 20 millimetres between keys;
- \* Key displacement and activation: suggested displacement is 3 to 5 millimetres, with key activation point requiring an increasing force until contact is made 65 to 75 per cent of downward travel, then decrease in force so that the point of contact can be felt;
- \* Key shape: Concave shape, with matte finish to prevent reflection;
- \* Keyboard: 10 to 15 degrees angle of inclination, preferably adjustable.

The layout of the keyboard should fit the convenience of the operator and the task. The keyboard should have all essential keys, and they should be grouped for convenience. Most keyboards have a standard QWERTY keyboard layout.

In addition to the ergonomic factors the following have to be considered:

- \* corporate strategy on hardware acquisition (18),
- \* value for money,
- \* the likelihood of the manufacturers staying in business long enough,
- \* availability of other software supported by hardware.

#### 4.4 THE SOFTWARE INTERFACE

Software interface refers to the link between the user and the application software. Stewart (198) identifies two requirements of the software interface:

- \* that the application software carries out its functions,
- \* that the structure of the dialogue promotes the carrying out of the functions.

##### 4.4.1 FUNCTION

The function of the System to be produced is to provide facilities to assist the valuations, purchasing and cost control functions in contractors' organizations. Important decisions to be made here

concerned the division of the function between the user and the computer. The overall guideline in the making of such decisions was to take maximum advantage of the characteristics of each.

According to Eason (199) whereas the computer is better than Man in:

- \* speed of processing,
- \* accuracy of processing,
- \* large scale memory,
- \* rapid translation,

Man is better than the computer at:

- \* pattern recognition,
- \* resolving conflict,
- \* goal formation,
- \* resolving ambiguity,
- \* recognising novelty,
- \* creating.

Tasks related to data processing, storage and report generation were allocated to the computer while the rest, such as data collection, and keying in and confirming data were allocated to the user.

Details of the design of the software to carry out the tasks of the computer are described in Chapter 2, whilst the tasks of the user are described in Chapter 13.

#### 4.4.2 DIALOGUE STRUCTURE

According to Shackel (194) dialogue structure refers to the set of procedures, commands, responses and prompts for the exchange of information between the system and the user. The importance of the dialogue structure cannot be overemphasized as the user's understanding of the system is directly related to the dialogue structure (212). Not only does this influence users resistance to the new system but it will also determine the amount of training required.

A lot of research has been carried out on the subject but no consistent theory appears to have emerged yet. However there are guidelines on good practice. For instance, Hebditch (201) states the attributes of good dialogue as:

- \* easy to learn,
- \* easy to use,
- \* easy to extend and modify,
- \* error avoiding,
- \* error detecting,
- \* unobstrusive,
- \* economical.

The need to give the user some discretion in terms of tasks or pace of work is highlighted by Davis and Olson (200) whilst Gaines and Facey (202) recommend that the user should be given adequate control over the system so that he knows:



- \* where he has been,
- \* where he is going,
- \* where he can go from the current position.

This implies that the dialogue should not contain any jargon such as computer science terminology of which the user is ignorant.

Considerations in the design of the dialogue aspects of the user-software interface include (200):

- \* type of dialogue,
- \* screen design,
- \* feedback and assistance,
- \* error control,
- \* response time.

#### 4.4.2.1 TYPES OF DIALOGUE

The dialogue between the user and the system can follow many different structures: commands, menus, forms, graphics, and natural languages (200).

With commands there is a command for every identified transaction which the software recognises. Whenever a user wishes to carry out a particular transaction he is required to type in the appropriate command either from memory or from a document. Thereafter the software takes over and responds according to its design.

When a system is menu-driven a list of options on what to do in order to carry out various transactions supported by the system is displayed on the Visual Display Unit (VDU) and the user is required to select his option.

After the user makes this selection the software takes over and responds accordingly.

'Menu-driven' is often equated with 'user friendly'. However Walker (113) claims that this is not always true. He puts forward the following stages of user reaction to menu-driven systems:

\* First stage:

They are wonderful at first. They are simple to follow: just press a key or type in a response. The menu is highly efficient at allowing a novice to converse with the computer.

\* Second stage:

After a while menus are irritating. The user is often compelled to go through a series of menus to arrive at the appropriate menu. Also when the right key is hit at the wrong time the user is sent to modules he does not wish to work on.

The form-driven concept is a hybrid of the menu and command-driven idea. A form detailing what input is necessary to do what is presented on the screen.

Graphics are of very limited applicability to data management whilst the use of natural languages is still under research and development.

Based on the considerations above the type of interactive dialogue to be selected is the menu-driven type. However provision should be made for future incorporation of command- and form-driven facilities.

#### 4.4.2.2 SCREEN DESIGN

A good screen design is clear, uncluttered, and free of irrelevant information. Two useful guidelines for deciding what information should be put on a single screen are the following (197):

- \* Provide only the information that is essential to making a decision or performing an action;
- \* Provide all data related to one task on a single screen. The user should not have to remember data from one screen to the next.

Davis and Olson (200) recommend the following guidelines which are based on human information processing limitations plus culture-based habits for processing:

- \* place items together that logically belong together (e.g. name and address);
- \* place items in customary processing order (e.g. bill item code, description, unit, quantity, unit rate, amount);
- \* position most important items (preferably) at the left side and arrange in importance from top to bottom;
- \* leave sufficient spaces so that items do not get confused;
- \* position items across close enough that the eye does not change rows in moving across.  
Use as guide strips, lines, dots or dashes if necessary;



#### 4.4.2.3 FEEDBACK AND ASSISTANCE

Two types of feedback should be part of a user-system dialogue (200):

- \* the system should acknowledge every user request in some way;
- \* additional assistance should be available on request.

In the first case, the most common form of acknowledgement is the result from the request. However if the request requires a long time to process, receipt of the request should still be acknowledged. For example, the message 'your request is being processed ...' may be displayed. Failure to provide such feedback may give rise to psychological fears of system being broken down, or of wrong use, or even taking potentially disastrous actions such as pressing keys at random.

Another type of feedback provided in user-system dialogue is system prompting which guides a user step by step through a task. Prompting is very useful to new users but it may be frustrating to experienced users. Ideally, an experienced user should be able to 'turn off' such prompting.

#### 4.4.2.4 ERROR CONTROL

A basic objective of user interface design is to minimise the errors of the human in the information dialogue. This objective is often inherent in the meaning of such jargon as 'user friendly' or 'ease of use'.

According to Galitz (197) a well designed user-system interface should have four distinct dimensions of error control:

- (i) Error prevention: As much as possible, the system should provide specific instructions so that the user knows exactly what to do and avoid making errors.
- (ii) Error detection: When an error is made, the system should identify it clearly and explicitly using 'polite' error messages.
- (iii) Error correction: Correction should be straightforward and should require rekeying of only the portion of the data in error.
- (iv) Error recovery: An important feature of a well designed system is the ability to 'undo' incorrect action.

#### 4.4.2.5 RESPONSE TIME

Response time in an interactive system is the time that elapses between the user keying in a command and the system beginning to display a



response (200). Response times are affected by:

- \* the system's capacity;
- \* the number of other users (if it is a time-sharing system);
- \* the complexity of the user's request.

Instantaneous or zero response delays may appear ideal but very often the keying efficiency of the user may not warrant it. Besides, fast response requires costly hardware. The user may also be under a psychological pressure to keep pace with the response of the system.

Shneiderman (203) proposes the following guidelines in defining desired response times:

- \* frequent, simple commands should take less than a second;
- \* for a given command type, response time should be as consistent as possible. A maximum response time deviation of no more than 20% from the mean has been suggested;
- \* short response times to relatively complex requests may actually increase error rates;
- \* if a response will take a long time (say greater than 10 seconds) a message should be issued within 1 to 2 seconds to give the user feedback.

## 4.5 THE SPECIFIC APPLICATION OF THE SYSTEM

There is a need to identify the types, characteristics and the basic needs of the intended users of a computer-based system to be designed. This is important not only for making decisions on some of the other aspects of interface design, but also for determining training needs.

### 4.5.1 CLASSIFICATION OF USERS

According to Davis and Olson (200) users can be classified in a variety of ways such as novices versus experts, occasional users versus frequent users, or primary users versus secondary users. However the classification of Eason et al (204) is used in this research because they match categories of people involved in construction projects. The classes are:

- \* the clerk,
- \* the specialist,
- \* the manager.

The basic needs attributed to each class are summarized below:

#### 4.5.1.1 THE CLERK

The clerical user is concerned primarily with the input of data relating to the processing of documents (e.g. orders, and invoices). Additional

tasks may involve the checking of data for accuracy and updating of existing data. The job of the clerk has minimal discretionary content and is fundamentally dependent on the computer system. Consequently, the level of job satisfaction and performance is mainly dependent on the organisation of the function.

#### 4.5.1.2 THE SPECIALIST

The specialist user is usually a professional person (For example, engineer, quantity surveyor, or purchasing manager) who is required to use the system to solve a problem. The specialist user will usually have much to learn about the computer system.

#### 4.5.1.3 THE MANAGER

The manager uses the computer to provide him with the information required for decision making. As a user he is characterized by the random, intermittent use made of the computer. The type of decision making may change from occasion to occasion whilst a high work load allows him little time for tasks peripheral to the decision making. Where the operation of the system presents problems the manager may stop using the system directly and interpose a 'human interface'.

#### 4.5.2 TYPES OF USERS IN CONSTRUCTION

In the case of a system for valuations, purchasing management, and cost control the personnel in the categories already discussed are as follows:

- \* CLERK: Foremen, quantity surveyor's clerks, storekeepers, timekeepers, .
- \* SPECIALIST: quantity surveyors, measurement engineers, cost engineers, bonus surveyors, accountants,
- \* MANAGER: site management and head office contracts management.

From the literature (60) as well as contacts made with contractors during the demonstrations it was observed that in some firms some personnel who would be classed as specialists infact carry out duties that would be carried out by clerks in other organisations, and vice versa. However it was decided that tasks requiring only clerical skills should be designed for as if they are to be done by clerks and those requiring specialist skills as if they would be carried out by specialists.



## 4.6 THE ENVIRONMENT

There has been a lot of research related to physical aspects, such as furniture design, office layout, noise, and lighting of computer systems. Some of this research is discussed under Section 4.3.

## 4.7 SPECIAL PROBLEMS RELATING TO THE SYSTEM

Strategies have to be developed to overcome the following special problems as part of the overall systems design:

- \* human and organisational problems,
- \* appropriate testing strategy,
- \* strategy for assessing the system,
- \* financial justification of the system,
- \* strategy for change over.

### 4.7.1 HUMAN AND ORGANIZATIONAL ASPECTS OF IMPLEMENTATION

The introduction of an information system can be viewed as an organisational change process. A significant problem with organisational change is resistance to the change by those affected. User resistance to new information can be a serious problem. Davis and Olson (200) write that if the use of the new system is voluntary resistance will be manifested by avoiding the system whilst if use is compulsory user resistance can cause



significant problems in the way of disruption, increased error rates, or even deliberate sabotage. The implication of this is that ways of overcoming this resistance have to be determined as part of the systems design process.

An understanding of the resistance is a '*sine qua non*' for determining ways of overcoming it. The following theories attributable to Markus (205) may be used to explain resistance.

- \* *People-oriented theory*: resistance occurs because of factors internal to the users as individuals or as a group.
- \* *System-oriented theory*: resistance occurs because of factors inherent in the designs of the system to be implemented.
- \* *Interaction theory*: people or groups resist systems because of an interaction between characteristics related to both people and systems.

In this particular case factors relating to the people-oriented theory may include:

- \* fears of not possessing the necessary skills,
- \* fears of redundancy,
- \* fears of loss of control (e.g. his absence is not felt),

- \* fears of loss of personal power,
- \* fears of exposure of inadequate performances  
(e.g. due to increased availability of control  
information such as buying margins, and cost  
control statements),
- \* security of professional data.

Factors relating to the system-oriented theory  
include the following:

- \* loss of discretion (e.g. when system provides  
only a few of many alternative facilities),
- \* mechanistic work, e.g. keying in operations,
- \* loss of job satisfaction.

Factors relating to the interaction theory  
are discussed in detail in Chapter 3. They  
include:

- \* redistribution of departmental power,
- \* control of the information (which division  
will house the system, for instance),
- \* changes of departmental duties (e.g. estimators  
may have to key in work packages and base  
indices even though they are not needed in  
estimating).

The following strategies for implementation depending on the nature of the problem of resistance have been identified (200):

| Theory          | Implementation strategy  |
|-----------------|--|
| People-oriented | Educate users (training)<br>Coerce users (edicts, policies)<br>Persuade users<br>User participation (to obtain commitment)   |
| System-oriented | Educate users (better technology)<br>Improve human factors<br>Modify packages to conform to organizational procedures<br>User participation (to obtain better design)                            |
| Interaction     | Fix organizational problem before introducing system<br>Restructure incentives for users<br>Restructure relationships between users and designers<br>User participation (not always appropriate) |

The strategies to adopt in the particular situation will depend on the characteristics of the users, the system and of the organization. Typical implementation strategies which may be applicable here include:

- \* training,
- \* systems support,
- \* job redesign,
- \* persuasion/policies,
- \* management commitment.



No matter the strategy adopted, designing the system to follow traditional practices may reduce resistance, particularly where it is attributable to fears of being unable to cope with the new technology.

#### 4.7.1.1 TRAINING

Tuman (41) identifies the following four stages of training:

- \* *1st Stage Training - System Philosophy:* This stage involves a series of seminars to management on the facilities and benefits offered by the system.
- \* *2nd Stage Training - System Capabilities:* This focuses on middle management and operational specialists. Training deals with specifics of what the system can do.
- \* *3rd Stage Training - System Operations:* This stage involves providing training to those who will operate the system.
- \* *4th Stage Training - System Utilization:* This involves seminar-type sessions to give site, middle and top management the chance to see first hand how the system can be used to enhance their functions and capabilities.

#### 4.7.1.2 SYSTEMS SUPPORT

In providing a computer-based system to be operated by people within an organisation there is always gap between what the user knows and what is necessary for him to know to derive maximum benefit from the system. Systems support addresses the

question of how to bridge the gap. Truman (41) advises systems support must be taken very seriously, otherwise the system's effectiveness will diminish and reams of unread computer reports will begin to pile up.

Damodran, Simpson and Wilson (206) identify the following broad classes of support:

- \* instruction manuals,
- \* systems-centred aids,
- \* circulars,
- \* internal training,
- \* computer advisory personnel,
- \* dedicated programmers,
- \* local experts,
- \* organisational representatives.

It can be seen that they are either documentary or human.

#### 4.7.1.2.1 DOCUMENTARY SUPPORT

There are 3 main types of documentary support:

- \* Users' Documentation,
- \* Programmers' Documentation,
- \* Circulars.

##### (A) USERS' DOCUMENTATION

This type of support involves the provision of user manuals prepared by people who have a detailed understanding of the system. These usually suffer from the drawback that as a result of the need to cover all aspects of the system they become bulky documents and this makes the finding of information in them difficult.



The information that the Users' Documentation should contain are (19):

- \* *Theory:* The theory of valuations, purchasing management and cost control should be fully explained.
- \* *Assumptions:* Any assumptions that the System makes should be made clear.
- \* *Decision Making Mechanism:* When the program makes decisions related to the problem being solved, wholly or partly without the user's knowledge or participation, the logic involved should be fully explained.
- \* *Operational Guidance:* Instructions for starting the System up, preparing data, running the program and interpreting the output should be clear and unambiguous.
- \* *Examples:* Examples of input and output are essential to clarify data preparation and explain the presentation of the results.
- \* *Error Messages:* The documentation should explain the messages issued by the System in terms that the user can understand, and suggest remedial action. Where relevant, the documentation should explain any procedures the program employs to check the validity of the data.

(B) PROGRAMMERS' DOCUMENTATION

A second type of documentary support is the Programmers' Documentation which is usually provided to enable programmers other than those who developed the System at first to alter the program, improve upon it, or remove errors from it. This type of documentation should contain the following (19):

- \* The description of the flow of logic through the System. This functional description should consist of flow-charts which essentially show the transformations the input undergoes in order to produce the desired output.
- \* The description of the 'layout' of the program, the relationship between program modules, input and output files.
- \* The description of the data, the format and structure of data files, file labels, and the mode of access to them.
- \* The program listing.
- \* A description of tests carried out as well as further tests that are needed.
- \* All information necessary to implement it on any particular hardware/systems software configuration.

### (C) CIRCULARS

Circulars are normally distributed by suppliers of the system or maintenance staff within the organisation to give notice of latest revisions of the software. There is a tendency for circulars to be mislaid or ignored by users.

### 4.7.1.2.2 HUMAN SUPPORT

It is becoming increasingly realized that documentary support is a poor support substitute for support by direct contact with people who have enough understanding of the system and of the needs of the users. Human support may consist of Programmers or of other personnel who have developed a specialist understanding of the system.

### 4.7.1.3 JOB REDESIGN

Hackman and Oldham (207) have identified the following dimensions that affect the motivation of employees:

- \* *Skill variety*: the degree to which a job requires employees to perform activities that challenge their skills and abilities.
- \* *Task identity*: the degree to which the job requires completion of a 'whole' and identifiable piece of work;



- \* *Task significance*: the degree to which the job has substantial and perceivable impact on the lives of other people, either within or outside of the organization;
- \* *Autonomy*: the degree to which the job gives the worker freedom, independence, and discretion in scheduling work and determining how it will be done;
- \* *Feedback from the job*: the degree to which an employee gets direct information about the effectiveness of his or her efforts.

It is most likely that the integration envisaged in the proposed system will influence these factors a great deal. Not only does the substitution of faceless computer files for human contact profoundly reduce the scope for feedback but it also reduces the scope for perceiving significance. For instance the site manager may get access to the cost data of the estimator without personal contact. On the other hand some workers will lose some amount of autonomy due to the need to use uniform coding. For some employees such as clerks their roles may become more 'mechanical'.

It was considered inappropriate to design standardized jobs to which all intended users would comply. Rather it was considered desirable that this aspect should be left for further action between the user organisation and the user support team

#### 4.7.1.4 PERSUASION/POLICIES

The use of policies and/or persuasion depends on management's perception of how to motivate employees towards the attainment of goals. There are numerous theories about leadership and much empirical data regarding conditions under which different styles are appropriate.

McGregor (208) defines two extremes of leadership styles:

- \* **AUTOCRATIC:** The leader determines policy and directs the activities required to carry it out. He seldom gives reasons for orders. The leader's commands are enforced by the power to reward or punish.
- \* **SUPPORTIVE:** This type is called participative, consultative, or democratic leadership. The leader solicits suggestions and consults his employees.

The use of policies/persuasion appears to depend on leadership style existing in the prospective user organisation. Therefore, it is inappropriate to decide whether or not to use policies at this stage.



#### 4.7.1.5 USER PARTICIPATION

The use of sociotechnical approach (explained in Chapter 2) to deal with the effects of new information systems involves viewing organisations from both the individual and overall organisational perspective. According to Davis and Olson (200) one of the key principles of the sociotechnical approach is that user participation in the design process is necessary to gaining user commitment to any changes necessitated by the new system and to assuring accuracy of requirements specifications. However a review of research by Ives and Olson (209) failed to establish any relationship between user involvement and propensity to use a system.

One of the objectives of the development of the System was that it should be applicable to a wide cross-section of contracting organisations. User participation should take the form of giving demonstrations of the System to prospective users and inviting feedback from them. Such feedback must then be used to modify the system when necessary.

It was envisaged that for any particular organisation the system would require some fine-tuning to its own methods of operations. User

participation at this level would be desirable as well as during full conversion which is discussed in Section 4.7.7.

#### 4.7.1.6 MANAGEMENT COMMITMENT

Ginzberg's study (213) of implementation successes and failures across many systems revealed that one of the key requirements for success was the commitment of management.

A committed management will not only procure a suitable system but will also make the necessary efforts to reduce resistance to a minimum.

#### 4.7.2 APPROPRIATE TESTING STRATEGY

Collins, Blay, Yearsley (188) write that two main types of tests are usually carried out during system development. The purpose of the first type is to check that the system is working to the specification and that every path executes as designed. This type of testing is called Program Testing. The purpose of the second type is to prove that the system works as intended and is acceptable to the users and is called User Acceptance Testing.

#### 4.7.2.1 PROGRAM TESTING

The philosophy behind this type of testing is to find errors (44). Ideally every path of the program must be executed at least once and every major combination of conditions must be tested, including error conditions. However, for almost all programs, even the simplest, there is an infinity of possible combinations (190). This large size of combinations implies a less rigorous testing will usually have to be done. Choosing the amount of testing calls for making decisions on the following:

- \* testing strategy,
- \* source of test data,
- \* level of testing,

##### 4.7.2.1.1 TESTING STRATEGY

Senn (44) identifies two main strategies which may be applied to all levels of testing:

- \* code-testing,
- \* specification testing.

###### (A) CODE-TESTING

This involves examining the logic of the program. To do this, cases which result in the execution of as many instructions as possible in the program or module must be developed.



(B) SPECIFICATION TESTING

This strategy treats the program or module as a black box. Test cases are developed, and the results examined to determine whether or not the program works to the specification. An example is provided by the testing of the dayworks modules. This would involve testing to ensure that the module accepts and stores dayworks information correctly and that it produces a correct dayworks account.

4.7.2.1.2 SOURCE OF DATA

As far as possible data used for testing should be taken from documents of past, on-going, or future construction projects. Such sources of data include bills of quantities, dayworks schedules, materials data, and plant data. Sources of recurrent data such as NEDO indices, current measured rates, and prices of resources include construction periodicals and price books.

Live data such as quantities of bill items completed, hours of plant time may be taken from author's experience as well as the experience of the people to whom demonstration of the system will be given.

Conscious efforts should be made to wreck the system by feeding wrong data. Data may be

wrong because of differences in types or because they are out of range. The idea behind this is to ensure that the system recognizes wrong data and takes appropriate action. The importance of this aspect of testing is emphasized by Collins et al (188) who write that, as there is a psychological tendency for programmer/designer to prove that the system works, it is more advisable for a second party to undertake the testing.

#### 4.7.2.1.3 LEVELS OF TESTING

Tests may be carried out at the following levels (44):

- \* as modules
- \* as an entire system.

##### (A) TESTING OF MODULES

In Chapter 2, one of the reasons given for adopting a modular design was related to the ease of testing. During the development each module should be tested to locate errors of coding or logic.

The following basic types of tests should be carried out on each module:

- \* Where the module was designed to receive input or generate output, test cases are to be drawn up to test the range of values expected, including both valid and invalid



data. An example of invalid data is the entry of a negative quantity or of a quantity far in excess of the bill quantity as the quantity of a bill item completed.

- \* If a module is designed to perform iterations, each boundary condition should be executed: 0 iterations, 1 iteration through the loop, and the maximum number of iterations through the loop.

- \* Where a module is designed to file data, the data should be read back into main memory and printed to verify that they are being stored correctly.

Senn (44) writes of two main approaches to modular testing:

- \* bottom-up approach
- \* top-down approach.

With the bottom-up approach testing starts at the lowest-level modules and proceeds up one at a time, whereas the top-down approach involves and proceeds downwards.

Collins et al (188) write of a third approach called Isolation and Linkage Testing. It is intended to be used where the structure of a program may not be fully defined, or where there is one critical module which must be tested before it can be decided if the program is viable. Isolation and Linkage Testing consists of two stages (188):

- (i) The development of each module on its own by simulating the calling module
- (ii) The linking of coded and tested module to test the module linkages.

The nature of the problem is such that a combination of these three would have to be used. A top-down approach is required to identify the sub-systems. For example, the whole valuations unit would have to be broken down into the following subsystems using a top-down approach:

- \* permanent work,
- \* claims,
- \* unfixed materials,
- \* variations,

A bottom-up approach would then be used to develop the sub-systems. For instance, programming to store, retrieve, and amend dayworks sheets may be carried out and tested before programming required to determine the amount payable on account of dayworks. Such separate development and testing of low-level modules also constitutes the first stage of Isolation and Linkage Testing. Each separately developed module should be built into the next higher module and the linkages tested, thus completing the second stage of Isolation and Linkage Testing.

## (B) ENTIRE SYSTEMS TESTING

As the heading indicates, this is a test of the integration of each module within the system. The following guidelines attributable to Glasson (182) should be followed during the Entire Systems Testing:

- \* testing of the validity of files for the various programs within the system,
- \* examination of the format and content of displays and reports,
- \* checking of the interfaces between the user and the system,
- \* checking of the interfaces between programs within the system.

### 4.7.2.2 USER ACCEPTANCE TESTING

This type of testing is similar to Entire System Testing. The key difference between Entire System Testing and User Acceptance Testing is that the users are testing the system as a black box and are only interested in inputs and outputs (188).

### 4.7.2.3 DEBUGGING

Testing is intended to expose errors which have to be corrected. The desirable tool for correcting errors is a computer which has the

following debugging facilities (190):

- \* Pinpoints of the location in the program and causes of errors: Errors located by this facility are generally those which cause program failures.
- \* A retrospective trace of any program under test: This facility is particularly useful for locating errors which do not cause failure but which cause discrepancies between the expected results and those that are actually produced.
- \* A statement by statement flow through the program: This facility is used mainly where only the general vicinity of the error is known.
- \* 'snapshot' of values of selected variables at key points in the program: Where the actual results produced by the system are different from what were expected this facility is often required.

Errors encountered should be corrected and checks made to ensure that the corrections do - not produce their own problems.



### 4.7.3 STRATEGY FOR THE ASSESSMENT OF THE SYSTEM

The aims of the assessment of a system include:

- \* to determine the extent to which it satisfies its requirements;
- \* to determine the extent to which the system is acceptable to its intended users;
- \* to determine desirable improvements.

Possible ways of carrying out assessments include:

- \* a comparison of the system with its specification;
- \* a comparison of the system with similar systems available;
- \* giving demonstrations of the system to its intended users and obtaining feedback from them.

### 4.7.4 FINANCIAL JUSTIFICATION OF THE SYSTEM

According to the description of the systems life cycle in Chapter 2, the final phase involves an evaluation of the system. Evaluation implies some comparison of the performance of the system against the objectives of the organisation involved. This is often a retrospective analysis with a view to being used for improved costs justification and management of



future software development projects.

However, in this report, evaluation concerns an examination of if and how a case can be made for the adoption of the System by contracting organisations. Unfortunately there is very little literature on consistent methods of carrying out this type of evaluation. This shortcoming may be due to the fact that differences in organisations and applications make the use of general formulae inappropriate. The method proposed for the system to be designed is based on the approach of Bensasson (19) which assesses the costs and benefits against alternatives.

The main problem with this approach is that while some costs and benefits are quantifiable many are not, and the unquantifiable ones may be more important. Another problem is that some of the benefits and costs lie far into the future.

Costs may be incurred on account of:

- \* purchase of hardware and systems software
- \* development costs or purchase of application software
- \* maintenance and administrative overheads.

Benefits may be:

- \* improved quality of management decision making,
- \* cost savings,
- \* increased income,

- \* early completion of projects,
- \* improved quality of projects,
- \* improved understanding of computer, technology (as described by Nolan Stage theory in Chapter 3),
- \* increased employee job satisfaction.
- \* spin-off benefits.

One of the benefits which can be quantified is cost of professional time saved. By comparing the time spent by personnel in carrying out the functions supported by the system with and without the use of the system the time saving can be determined for typical projects. Such determination may be complicated by the following factors:

- \* the unique nature of every contract
- \* the time saving may vary with the level of familiarity with the system (learning curve effect).

Costs, however, are less difficult to quantify. Even with the difficulty of quantification some attempt at evaluation using simplifying assumptions is to be preferred to no evaluation at all.

The main assumption in the approach is that the only benefit of the system would be the value of the time saved by using it. By calculating the minimum time which must be saved to break even and determining the actual time saved on typical projects some quantitative measure of the system's viability may be obtained. Even if such a measure cannot by itself provide complete justification for adopting the

system or not doing so it may nonetheless be taken into account in reaching a decision.

The calculations involved are illustrated by the example below.

#### ASSUMPTIONS

Cost of hardware: £10,000

Write-off period: 5 years

Residual value: nil

Cost of application software (including training) = £10,000

Maintenance: 10% of combined cost of software and hardware

Cost one man day: £100

Cost of borrowing: 15%

#### CASHFLOW

The cashflow is as follows:

| YEAR | COST   | MAINTENANCE<br>10% | DISCOUNT<br>FACTOR | DISCOUNTED<br>EXPENDITURE |
|------|--------|--------------------|--------------------|---------------------------|
| 0    | 20,000 |                    | 1.000              | 20 000                    |
| 1    |        | 2000               | 0.869              | 1 738                     |
| 2    |        | 2000               | 0.756              | 1 512                     |
| 3    |        | 2000               | 0.657              | 1 314                     |
| 4    |        | 2000               | 0.572              | 1 144                     |
| 5    |        | 2000               | 0.497              | 994                       |
|      |        |                    |                    | <u>26 702</u>             |

Total discounted expenditure = £26 702

= £(26 702/3.3521) per year

= £7966 per year



Net savings to break even = £7966/12 per month  
= £663.8 per month  
= 6.6 man-days per month  
= 46.2 man-hour per month

If the System is used on 10 contracts, say, each contract should save 4.6 man-hours per month to break even.

#### 4.7.5 STRATEGY FOR CHANGE OVER

When a new system is fully tested, changeover from the old to the new system is necessary. Management information textbooks offer a variety of schemes for putting a new system into operation. These include (41):

- \* running parallel systems
- \* operating a pilot system
- \* using the phase-in/phase-out technique
- \* cut-off method (burning the bridges)

##### 4.7.5.1 RUNNING PARALLEL SYSTEMS

This method involves using both old and new systems simultaneous in order to cross-check the results. The advantages of this method are:

- \* it provides further testing of the system
- \* the old system acts as a standby in case the new system breaks down.

Its main disadvantage is that it is costly because of the need to duplicate efforts.



#### 4.7.5.2 OPERATING A PILOT SYSTEM

This involve testing the system under simulated conditions until all refinements are made. The new system then becomes the real system.

#### 4.7.5.3 PHASE-IN/PHASE-OUT METHOD

With this method the system is introduced in a piecemeal manner by phasing in different areas of work gradually.

#### 4.7.5.4 CUT-OFF METHOD

This method involves the introduction of a completely new system without any reference to any previous system. According to Daniels and Yeates ( 40) this method is normally adopted only when there is insufficient similarity between the old and the new systems to make parallel or pilot runs meaningful or when the extra staff required to supervise parallel runs are not available.

In the case of valuations, purchasing and cost control the cut-off method may be too dangerous because valuable data may be lost or corrupted. The least dangerous is to run parallel systems. However implementing some facilities at a time may reduce the expense of running parallel systems. Running a pilot scheme has the drawback that all the intended users may not have access to it.

The appropriate strategy to adopt would depend on the particular organisation but running parallel systems or implementation by phases may be the most advisable method.

## CHAPTER FIVE

### VALUATIONS AND PROJECT CONTROL

The term 'Valuations' is used in the construction industry in two slightly different contexts. It is used in one context to refer to the determination of the amount the payment of which the Contractor may apply to the Employer under the appropriate conditions of contract. This use of the term is referred to as External Valuation (157, 166).

For a variety of reasons specified in Section 5.12.1 the External Valuation usually produces only an approximation of the 'real' value of work done and services supplied by the Contractor. The other context in which the term is used refers to the determination of this 'real' value. Valuation in the latter context is called Internal Valuation whilst the 'real' value is often referred to as the amount earned, revenue, or simply earnings.

Perceval (166) identifies three uses of valuations:

- \* they control the contractor's cashflow;
- \* they provide data for financial accounting information;
- \* they provide data for management accounting information.

This Chapter contains a summary of the findings of literature reviews and of consultations with the construction industry on the procedures involved in valuations as well as their role in project and corporate controls. The following topics are covered:

- \* parties and responsibilities in valuations,
- \* the frequency of valuations,
- \* valuation procedures,
- \* the accuracy of valuations,
- \* retention,
- \* errors in valuations,
- \* payment,
- \* the checking of external valuations,
- \* valuations and cashflow,
- \* valuations and financial accounting,
- \* valuations and management accounting,
- \* cost value reconciliation.



## 5.1 PARTIES AND RESPONSIBILITIES IN EXTERNAL VALUATIONS

Under Clause 56 of the Institution of Civil Engineers (ICE) Conditions (27) the Engineer has the duty to measure the work during valuations. However it is the duty of the Contractor under Clause 60 to prepare valuations. As some valuations will usually involve site measurement it appears that two sets of site measurements are needed during valuations. Indeed, where there is little or no co-operation between the staff of the Contractor and the Engineer's team this is precisely what might happen. However in the vast majority of cases there is a joint site measurement which the Contractor uses as a basis of his valuations (145). When the Engineer comes to checking the valuation, as he is required by the contract to do, there is therefore much less scope for disagreements on the amount of payment.

The situation with the Joint Contract Tribunal (JCT) Contract (42,187) is different. The respective roles are spelt out in Clause 30.1 as follows: Here the Quantity Surveyor on the Employer's side is given the responsibility for preparing valuations. However there is a limitation to this responsibility. This limitation stems from the fact that the Quantity Surveyor needs the authorization of the Architect before he can carry out any such valuation. Valuations are however mandatory where fluctuations are to be paid for by the use of the Price Adjustment Formula (Clause 40.1.3).

It is discussed in Section 5.12 that the Contractor's Surveyor may be required to carry out internal valuations for the purpose of Cost Value Reconciliations. It has been suggested that on some building contracts such valuations may then be presented to Employer's Quantity Surveyor for his use. As the Employer's Surveyor is supposed to prepare an independent valuation he can refuse to go along with such a procedure.

Nisbet (167) writes that in practice, on building contracts valuations are often prepared jointly between both Surveyors as a matter of courtesy and convenience.

Where there are sub-contractors and nominated suppliers they are usually expected to submit payment applications to the Contractor in good time to be included in the main valuation. Many contractors may find it prudent to inspect and assess sub-contracted work as a cross-check of such sub-contract payment applications. In building contracts where the Employer insists on independent valuations there may be no need for sub-contract pay applications.

## 5.2 THE FREQUENCY OF VALUATIONS

Under Clause 60(1) of the ICE conditions the Contractor is required to submit an interim external valuation at the end of each month to the Engineer and a final external valuation within 3

months of the date of the Maintenance Certificate. The Maintenance Certificate is issued by the Engineer when the Contractor has completed his obligations under the Contract.

With the JCT Form interim external valuations, by Clause 30(1), are to be made whenever the Architect considers them necessary for the purpose of ascertaining amounts payable in certificates. Wainright and Wood (142) argue that the Contractor is therefore entitled to demand a payment certificate whether or not the Architect decides on a valuation.

In practice the timing of external valuations for JCT contracts are very much the same as in the case of the ICE Contracts (142).

Internal valuations can be made as often as suits the Contractor's control policy. However the usual frequencies are weekly and monthly (155).

### 5.3 VALUATION PROCEDURES

Clause 60 of the ICE contract defines what should be included in external valuations whereas the equivalent clause for the JCT form is Clause 30.

External valuations are usually done in parts. According to Ramus (146) these parts may include any of the following:

- (i) Preliminaries,
- (ii) Insurances,
- (iii) Measured Works,



- (iv) Dayworks,
- (v) Variations,
- (vi) Unfixed Materials,
- (vii) Statutory Fees,
- (viii) Nominated sub-contractors,
- (ix) Fluctuation of Price Adjustments,
- (x) Claims,
- (xi) Retention.

Each of the items on the list above is considered in detail as follows:

- \* Preliminaries: Chapter 10
- \* Variations and Dayworks: Chapter 7
- \* Unfixed Materials: Chapter 9
- \* Claims: Chapter 8
- \* Fluctuation of Price Adjustments: Chapter 11
- \* Measured Works, insurances, statutory fees  
: Chapter 6
- \* Nominated sub-contractors: Chapter 10
- \* Retention: below.

Two possible ways of determining the amount of interim payment to be applied for have been identified:

- (i) measure and value all work done, and goods and services supplied since the previous valuation,
- (ii) measure and value the work done, and goods and services supplied since the beginning of the contract. From the total value so obtained,



the total previous payment on account, if any, is deducted leaving a balance due for payment.

Ramus (146) recommends the use of the latter approach on the grounds that if it is followed strictly any under-valuation or over-valuation of either work completed or of unfixed materials would be automatically corrected in subsequent valuations.

Barrett (157) writes that internal valuations are usually carried out by adjusting external valuations to take account of various sources of inaccuracies. Details of the sources of inaccuracies in external valuation and the adjustments necessary are discussed in Section 5.12.1.

## 5.4 THE ACCURACY OF VALUATIONS

There are opposing views as to the level of accuracy required in interim valuations. Willis and Willis (150) and Nisbet (167) maintain that external valuations should be made as accurately as possible. Their reason is that under-valuation on the one hand increases the capital requirements of the Contractor whilst over-valuation on the other hand reduces the security of the Employer. This view is in keeping with the general legal view. This view was upheld in the case of *SUTCLIFFE v. THACKRAH* (185) in which an architect who had over-valued a payment certificate was held liable for the over-valuation

when the contractor went into bankruptcy after having received the payment.

That valuation need not be accurate, also has some support. A committee (141) set up in 1964 to investigate the placing and management of building and civil engineering contracts was of the view that detailed valuations were being made too frequently resulting in delayed interim payments to contractors and sub-contractors. One of the committee's recommendations was that interim valuations should be made on approximate assessment with exact assessments made only quarterly. In a more recent publication Nisbet (168) writes that the Quantity Surveyor is not contractually obliged to carry out detailed valuations because their fee scales do not provide for valuations based on detailed measurement and valuation. He also argues that as the purpose of valuation is to provide an advance payment it is only necessary to prepare a realistic assessment and not detailed valuations.

As far as external valuations are concerned it appears that the level of accuracy adopted on any particular contract would depend on the attitude and mutual confidence of the Contractor, the Employer and his professional team (150).

As discussed earlier in this chapter there is a need to carry out internal valuations more accurately than external valuations. However Wilson (175) advises against spurious accuracy such as stating values to many places of decimals.

## 5.5 RETENTION

It is common provision in most construction contracts for a percentage of the total amount payable to the Contractor to be deducted and the remainder paid to him <sup>later</sup> (146). The sum deducted is said to be 'retained' by the Employer and is called 'the Retention'. The percentage used to calculate the amount of retention is called 'the Retention Percentage'.

The purposes for holding retention monies include (146):

- \* to provide an incentive for the contractor to complete the work promptly;
- \* to provide the Employer with some security against the effects of the Contractor's default.

Towards the end of the Contract or of defined sections of it, the amounts retained are paid back to the Contractor at times and in instalments specified in the Conditions of Contract. The times of releases of retention are determined from some important dates in the progress of the Contract. These dates and the details of retentions held or released are discussed below.

### 5.5.1 IMPORTANT CONTRACT DATES: ICE CONTRACTS

Under the ICE Contract when the Contractor has substantially completed the works he is required to apply to the Engineer for a certificate which



acknowledges that in the opinion of the Engineer the work is indeed substantially complete. This certificate is called the Certificate of Completion and the procedure for obtaining it is spelt out in Clause 48(1). Similarly separate certificates of completion may be issued for different sections of the works subject to certain conditions in Clause 48(2).

The Contractor is still responsible for the execution of any work outstanding at the issue of the Certificate of Completion as well as for the maintenance of all the works. This responsibility is binding for a period stated in the Appendix to the Form of Tender and which is called the Period of Maintenance. There may be separate periods for separate sections (Clause 49).

The dates are illustrated in Figure 5.1.

## 5.5.2 IMPORTANT CONTRACT DATES: JCT CONTRACTS

Provisions similar to the above are made in Clause 17 of the JCT Form. In this case the certificate signifying substantial completion is called the Certificate of Practical Completion whilst the period of maintenance is called the Defects Liability Period.



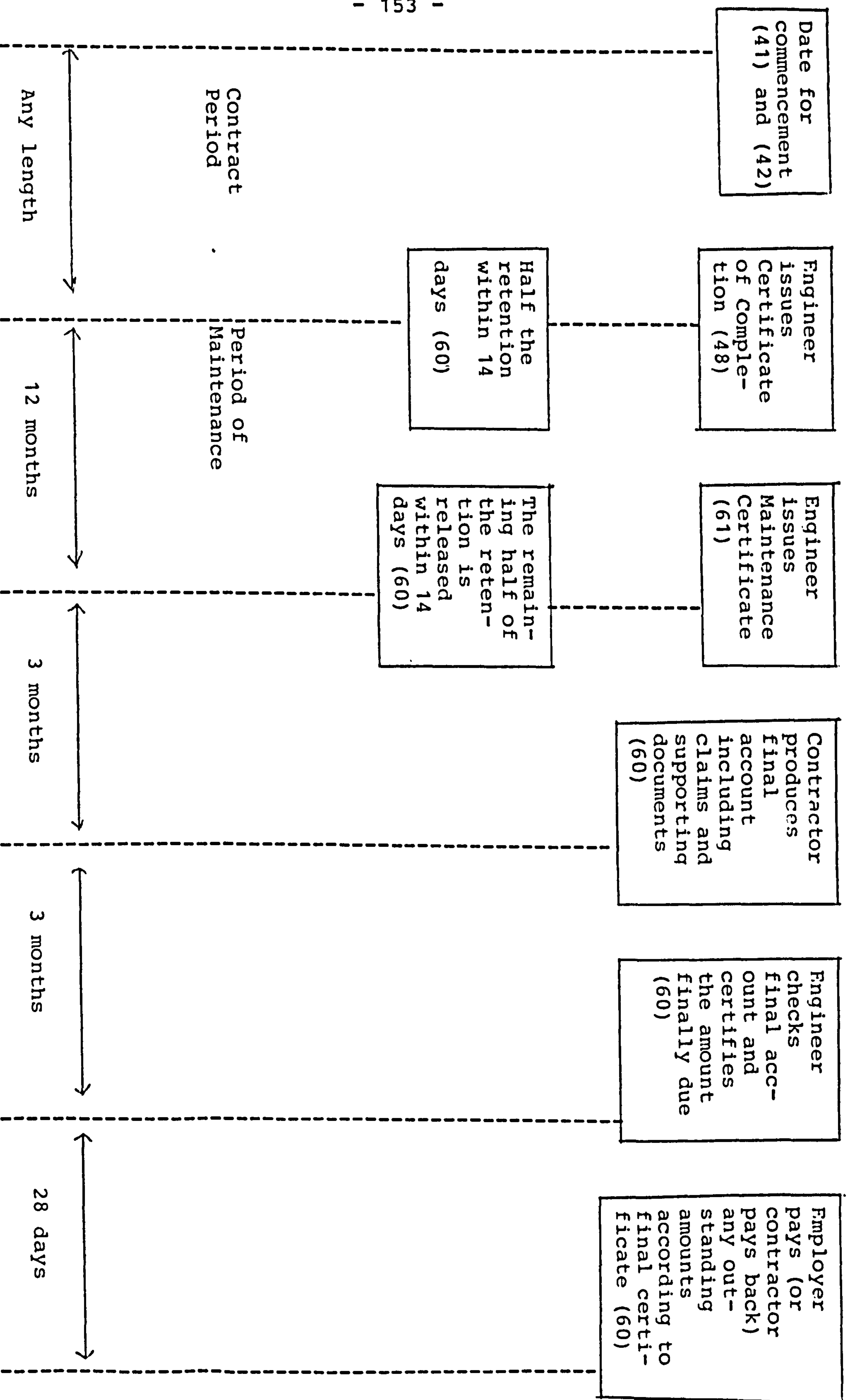


Figure 5.1: Important Dates for Retention and Payment Provisions.  
N.B. Figures in parenthesis are ICF clauses.

### 5.5.3 RETENTION UNDER THE ICE CONTRACT

The details contained in Clause 60 are as follows:

The assessment of the amount of retention to be held at any interim valuation is detailed in Clause 60. The amount to be held is 5% of the amount due under the contract accumulating to a limit beyond which no additional retention is allowed. The limit of retention is a percentage of the Tender Total. Where the Tender Total does not exceed £50,000 the percentage is 5% (up to a maximum of £1,500) but it is 3% if it does.

Payments for unfixed materials are not subject to retention and is therefore not part of the amount due on which the Retention Percentage is applied. All other heads of valuations are subject to retention.

### 5.5.4 RETENTION UNDER THE JCT FORMS

Clause 30.4.1.1 and the Appendix to the JCT Form provide for a Retention Percentage of 5% unless a lower rate is specified. A footnote to Clause 30.4.1.1 requires the Retention Percentage not to exceed 3% where the Contract Sum is up to £500,000 or more.

Whereas payments for unfixed materials are not subject to retention under the ICE Conditions, they

are in this case. Other exclusions from the application of the retention percentage under the JCT form include:

- (i) statutory fees and charges (Clause 6.2);
- (ii) the cost of correcting any errors in setting out the works, for which the Contractor is not responsible (Clause 7);
- (iii) the cost of opening up work which has been covered up and/or the cost of testing materials, goods or executed work (Clause 8.3);
- (iv) costs relating to patents (Clause 9.2);
- (v) cost of making good faulty work for which the Contractor is not responsible (Clauses 17.2 and 17.3);
- (vi) insurance premiums payable by the Contractor in order to maintain insurance cover against damage to property other than the works (Clause 21.2);
- (vii) insurance premiums which should have been paid by the Employer but in regards to which he has defaulted (Clause 22B and 22C);
- (viii) loss or expense due to the regular progress of the works having been affected by specified matters (Clauses 26.1 and 34.3);
- (ix) final payments to nominated sub-contractors (Clause 35.17);
- (x) fluctuations in the cost of labour and materials calculated other than by the 'Formula Rules' method (Clauses 38 and 39).



#### 5.5.5 RELEASE OF RETENTION: THE ICE CONTRACT

Whenever a Certificate of Completion is issued in respect of any section, half the retention held on its account becomes payable within 14 days to the Contractor.

The other half of a sectional retention fund is released within 14 days of the expiration of the Period of Maintenance or, where there are separate Maintenance Periods for different sections, the latest of such periods (Clause 60(5)(c)).

After the issue of a Certificate of Completion of the whole works half of the total retention fund less sums already released in respect of sections is payable within 14 days.

The other half of the total retention fund is released within 14 days of the expiration of the Period of Maintenance, or where there are separate Maintenance Periods for different sections, the latest of such periods. The Employer is entitled to hold back payment of so much of the second half of the total retention fund which, in the opinion of the Engineer, represents the cost of work still outstanding at the issue of the Maintenance Certificate.



#### 5.5.6 RELEASE OF RETENTION: THE JCT CONTRACT

Where the Employer takes possession of any part of the works before the Date for completion stated in the Appendix to the JCT Form the amount of retention to be released in the next certificate is one-half of the proportion of the total retention which the estimated value of the part bears to the total value of the works. The second-half of the retention in favour of the relevant part is released in the next payment after the expiry of the Defects Liability Period in respect of the relevant part.

By Clause 30.4 one-half of the total retention is payable to the Contractor in the next interim certificate after the Architect has issued a Certificate of Practical Completion subject to any releases of retention already made.

The remaining retention is released when the Defects Liability Period has expired and the Contractor has made good such defects as have appeared during that time.

The Architect may, if he wishes, subject to certain conditions below, release the whole of that part of the retention monies which relates to any nominated sub-contractor's work at any time before Practical Completion of the works as a whole. The Architect is obliged in any case to release this retention upon the expiry of twelve

months from the certified date of Practical completion of the sub-contract work.

## 5.6 DEALING WITH ERRORS IN VALUATIONS

There are two categories of potential errors in valuations (146):

- \* errors which arise in the use of the fluctuation formulae which are dealt with in Chapter 11;
- \* errors in preparing other aspects of valuations, e.g. valuations of provisional items of work at quantities given in the bills which, upon remeasurement, are found to be different.

The ICE conditions make very definite provisions on errors in valuations. Under Clause 60(7) the Engineer has power to delete, correct, or modify by any certificate sums previously certified. The only restraints to this power are:

- (i) He cannot delete or reduce sums certified in respect of work executed by nominated sub-contractors and suppliers which the Contractor has paid, or is obliged to pay, accordingly.
- (ii) If in the final certificate the Engineer reduces sums payable to nominated sub-contractors or suppliers which sums the Contractor has already paid out accordingly and despite all reasonable efforts he cannot recover the over-payment from the sub-contractors or suppliers, the Contractor is

entitled to reimbursement from the Employer of the over-payment together with interest according to Clause 60(6).

With the JCT Form there are no similar provisions. However the Quantity Surveyors (Practice and Management) Committee of the RICS have stated the view that, if errors have occurred in the preparation of a valuation, they should be corrected but that where the fluctuation formula is being used the facility for such correction will no longer exist after the firm index numbers have been used (146). As this is simply a recommendation as to good practice, it is not contractually binding and the question seems to be still moot. Perhaps the question has not yet been put to the courts because the various parties have adopted mutually satisfactory procedures to deal with such errors.

However a case throws some light on the probable legal position. In the case of *Gilbert-Ash (Northern) Ltd. v. Modern Engineering* (186) it was said that the Contractor is entitled to be paid for only work properly executed. This judicial decision is relevant where the mistake is at the expense of the Employer. Where there is under-valuation in previous certificates the position is not so clear.



## 5.7 PAYMENT

Apart from satisfying the condition that the payment requested must be properly earned according to the conditions of contract there may be a further condition. Under the ICE Conditions the amount payable must be more than the Minimum Amount of Interim Certificate stated in the Appendix to the Form of Tender (Clause 60). However the Engineer has a discretion to certify payment even where this condition is not satisfied.

The JCT Form does not make similar provisions.

None of the standard forms lays down a format for the application of payment. However the standard RICS valuation certificate form shown in Appendix 1, is used in many organisations (150).

## 5.8 CHECKING OF VALUATIONS

Nisbet <sup>(167)</sup><sub>(160)</sub> recommends the following detailed checks:

- (i) The computation has been prepared by the Surveyor, where he is responsible for reporting valuations.
- (ii) The gross valuation is within the approved funds and/or financial report figures and Architect/Client should be advised if there is a probable need for extra funds.
- (iii) The preliminaries and insurances have been calculated in accordance with the firm's



policy, such as 'pro rata' to the value of work done.

- (iv) The work done has not been under- or over-valued by reference to the Architect/Supervising Officer's progress report.
- (v) The value of materials on site does not exceed the value of materials required to be incorporated in the works for the forthcoming two to four months, depending on size of Contract and stage of completion.
- (vi) The value of materials off site has been inspected and properly identified as the Client's property.
- (vii) Defective work (if applicable) has been notified by the Architect/Supervising Officer and the value deducted from the valuation.
- (viii) The value of Mechanical and Electrical services has been confirmed in writing by the consulting engineers (where applicable).
- (ix) The value of nominated sub-contractors and suppliers should be cross-checked by the Surveyor (using random sample test).
- (x) The value of fluctuations represents a reasonable proportion of the work done in relation to the rate of inflation.
- (xi) The contract completion date or extended date has not been reached or Architect/

Supervising Officer should be notified of Contractor's potential liability for liquidated and ascertained damages.

- (xii) The release of retention is authorised by the issue of the appropriate certificate (that is of practical completion and of making good defects).
- (xiii) The value of previous payments has been calculated from previous certificates as issued by the Architect/Supervising Officer.
- (xiv) The arithmetic has been checked.
- (xv) The time spent is in accordance with the manpower budget.

Though these checks are meant for JCT Standard Form contracts and their amendments some of them may well apply to civil engineering contracts.

It appears from the checklist above that the documents required for the checks include the following:

- (i) the Contract Bill of Quantities,
- (ii) the Bill of Activities built from the BOQ,
- (iii) extensions of quantities of Bill items completed,
- (iv) invoices from statutory authorities, suppliers, nominated sub-contractors,
- (v) Architect's/Engineer's instructions,

- (vi) the appropriate NEDO indices,
- (vii) dayworks sheets,
- (viii) Practical Completion Certificate(s),
- (ix) variation orders,
- (x) bills of variations,
- (xi) receipts covering payments of insurance premiums,
- (xii) previous payment certificates,
- (xiii) dayworks schedules,
- (xiv) specified details of valuations calculations,
- (xv) drawings,
- (xvi) site measurement notes (e.g. percentages, dimensions, quantities),
- (xvii) time sheets

## 5.9 VALUATIONS AND CASHFLOW

The valuations function of a project forms the only source of income for that project.

In the construction industry the Contractor usually has to meet the following types of liabilities (31):

- \* wages of labour 1 week in arrears,
- \* costs of materials 1 week after receiving payment,
- \* plant hire charges 1 week after receiving payment,
- \* sub-contractors' payments upon receipt of payment

from the Employer,

\* overheads 3 weeks in arrears.

If the conditions of contract did not make allowance for interim payment the Contractor would have had to include the charges for financing the liabilities above in his tender (142). It is also conceivable that the prudent contractor would price the risk of the Employer being unable to pay at the time of completion. Interim payments therefore finance the Contractor's operations and may also be of benefit to the Employer in the form of reduced tender prices.

## 5.10 VALUATIONS AND FINANCIAL ACCOUNTING

Financial accounting is concerned with the provision of information to parties outside the organisation (176). The provision of financial accounting information is a statutory requirement. By the Companies Acts 1948 and 1967 (184), every company is required, at least once a year, to provide the following in its published accounts:

- \* the Balance Sheet,
- \* a Profit and Loss Account,
- \* a Directors' report

The contribution of the valuations function to their preparation is discussed below.



### 5.10.1 THE BALANCE SHEET

According to Pizzey (173), the Balance Sheet is a statement of the affairs of a business showing the items owned by the business against a list of claims on those assets by those who have provided the funds with which the items have been purchased. The items owned are called assets whereas the claims on them are called liabilities. Harris and McCaffer (83) write that the assets of a contractor usually comprise:

- \* fixed assets such as buildings, plant, machinery, and vehicles,
- \* current assets such as stocks of materials intended for the works, work in progress, debtors, and cash in the bank.

By the Conditions of Contract monies certified by the Architect/Engineer are 'bona fide' debt owed to the Contractor by the Employer (Clause 60(2) of the ICF Conditions and Clause 30.1 of the JCT Form). The total of such monies not yet paid for all on-going contracts therefore constitutes the Debtors component of Current Assets in the Balance Sheet, i.e.

$$D = \sum_{i=1}^N (E_i + R_i)$$

where

D = Debtors

$E_i$  = amount certified in respect of the  $i$ th contract but not yet paid by the Client,

$R_i$  = total retention held on the  $i$ th contract,

$N$  = number of on-going contracts.

Nedved (101) writes that the value of work not yet certified represents Work in Progress in the Balance Sheet. The value of work not yet certified can be determined by carrying out an internal valuation and deducting the amount last certified from the result of the internal valuation. The Works in Progress component of the Current Assets is therefore given by

$$W = \sum_{i=1}^N (IV_i - E_i)$$

where

$W$  = Works in Progress element of the Current Assets

$IV_i$  = internal valuation of  $i$ th contract

$E_i$  = total amount certified for  $i$ th contract

$N$  = number of on-going contracts.

The cost of stocks of materials for a contract can be obtained from a valuation of unfixed material which is described in Chapter 9. The Stocks component of Current Assets is therefore given by the equation

$$S = \sum_{i=1}^N M_i$$

where

$S$  = Stocks in Balance Sheet,

$M_i$  = Unfixed materials component of the valuation of the  $i$ th contract,

$N$  = number of on-going contracts.

The valuations function can therefore provide the following data towards the Company's Balance Sheet:

- \* Debtors,
- \* Works in Progress,
- \* Stocks.

#### 5.10.2 THE PROFIT AND LOSS ACCOUNT

The Profit and Loss Account is a summary of the transactions carried out during the period covered by the account (173). It sets the costs of the period against the revenue from that period, thus showing profit or loss made during that period. Revenue is determined by the internal valuations (166). According to Perceval (166) the importance of valuations as far as the Profit and Loss Account is concerned stems from the fact that over-valuation may lead to an over-statement of profits, and vice versa.

That valuation for the purpose of drawing up the Profit and Loss Account of construction companies is a problem which is admitted by many authors. Pizzey (173) and Barrett (157) attribute the difficulty to the fact that many construction projects last more than a year. One of the main concepts used in accounting is that of prudence, or conservatism. This states that revenue and profit should never be anticipated and that they

should only be included in financial statements when they are realized, but that provision should be made for all anticipated expenses or losses (174).

In accountancy terms revenue is only realized where a sale has been made. In the case of construction a sale can be said to have been made only when the work is completed. If the prudence principle is adopted strictly it would imply that profit is recognized only at the end of the contract. The effect would be distortions of the Profit and Loss Account with only years during which contracts have been completed showing profit. These distortions would not only give an inaccurate reflection of the performance of site management but may also displease shareholders who may want uniform dividends from profits.

Valuations may provide the revenue component of the Profit and Loss Account either directly or they may need various prior adjustments depending on the accounting method by which profit is recognized.

Four methods for accounting for profit have been identified:

\* *Cash Method* (153)

Revenue is cash received and costs are those that have been paid during the accounting period.

\* *Accrual Method* (153, 166)

Revenue is what the Contractor is entitled to bill under the Contract (whether or not it has been billed or collected in cash) and costs are costs incurred (whether paid for or been billed or collected in cash) and costs



are incurred (whether paid for or not) during the period being accounted for.

\* *Percentage-of-Completion Method* (153)

Progress of the job is measured in terms of percentage completion. This derived percentage is applied to the total estimated gross profit which is added to the actual costs to date to determine earned revenue. Costs are those incurred (whether paid for or not) during the period being accounted for.

\* *Completed Contract Method* (153, 166)

Billings and costs are accumulated on the Balance Sheet. Revenue, costs and profit/loss are recognized when the job has been completed.

According to Coombs and Palmer (153) hybrid refinements are sometimes also used. Quite clearly the use of the different methods leads to different conclusions on profits. Barrett (157) cautions that in a takeover situation the buyer on applying his own method may discover that the profits in the published accounts are overstated.

The method recommended by the Accounting Standards Committee is the Accrual Method (180). However, whatever the method adopted valuations

can still provide some of the data necessary.

In the case of the Cash Method copies of payment applications honoured and sent to the accounts division are sources of the cash component. The cash component can be determined from the equation:

$$C = \sum_{i=1}^N P_i$$

where

C = cash component,

$P_i$  = total value of certificates in respect of the  $i$ th contract honoured by the Employer for work earned out during the accounting period,

N = number of on-going contracts.

As valuations are the only source of revenue for companies engaging exclusively in construction work the total of the valuations of work executed during the accounting period for all on-going contracts constitutes revenue for the Accrual Method. The revenue can therefore be obtained by applying the equation

$$R = \sum_{i=1}^N V_i$$

where

R = revenue for the Accrual Method

$V_i$  = internal valuations of  $i$ th contract for work carried during the accounting period,

Figure 5.3 it is necessary to make forecasts of revenue from on-going as well as from contracts expected to be won during the course of the year. Data from valuations of past similar projects may be used for the forecasting. Such use of data from past valuations is limited because conditions for construction work tend to vary widely from project to project (177). An alternative is to use a generalized s-curve approach (83, 155, 178). Even with the use of s-curves, Nisbet (167) writes that data from actual valuations may be used to update the forecasts as the projects proceed.

Budgetary control involves the comparison of what is actually achieved (i.e. earned in this case) with the budget. Earnings are obtained by adding up the valuations of all on-going contracts as discussed in Section 5.10.2. Cooke and Jepson (155) and Pilcher (150) describe in some detail the calculations involved and possible remedial action.

#### 5.11.1.2 MAINTENANCE OF CORPORATE ESTIMATING DATA

McCaffer and Baldwin (123) write that many construction companies maintain corporate estimating data which are adjusted to suit the particular circumstances of various contracts tendered for. The comparison of data from valuations against

| ANNUAL FINANCIAL BUDGET - 1986 (£000s) |     |     |     |     |     |      |      |     |      |     |     |     |       |
|--|-----|-----|-----|-----|-----|------|------|-----|------|-----|-----|-----|-------|
| CONTRACT                               | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEPT | OCT | NOV | DEC | TOTAL |
| CONTRACT 1                             | 60  | 70  | 80  | 100 | 110 | 90   | 60   | -   | -    | -   | -   | -   | 570   |
| CONTRACT 2                             | 130 | 110 | 80  | 50  | 65  | 60   | 65   | 50  | -    | -   | -   | -   | 610   |
| CONTRACT 3                             | 15  | 20  | 15  | 20  | 50  | 60   | 75   | 80  | 55   | 30  | 15  | 15  | 450   |
| CONTRACT 4                             | -   | 50  | 50  | 80  | 90  | 110  | 115  | 115 | 130  | 145 | 120 | 100 | 1105  |
| CONTRACT 5                             | -   | -   | -   | -   | 50  | 50   | 75   | 115 | 120  | 120 | 150 | 150 | 830   |
| TOTAL                                  | 205 | 250 | 225 | 250 | 365 | 370  | 390  | 360 | 305  | 295 | 285 | 265 | 3565  |

Figure 5.3: A Typical Contractor's Annual Financial Budget - After Pilcher (156).



Construction companies carry out two main types of controls (156):

- \* control at the corporate level,
- \* control of individual projects.

### 5.11.1 CONTROL AT THE CORPORATE LEVEL

The valuations functions can provide data for:

- \* budgetary control,
- \* maintenance of corporate estimating data.

#### 5.11.1.1 BUDGETARY CONTROL AT THE CORPORATE LEVEL

The making of desired profits is one of the most important objectives of a construction firm (155, 156). Even where there are other objectives they will all usually be expressed collectively in quantified financial terms (156). The main vehicle of expression of the objectives is a corporate financial plan called a budget. An annual budget based on one described by Pilcher (156) is shown in Figure 5.3. According to that budget the Contractor has three on-going contracts:

CONTRACT 1, CONTRACT 2, and CONTRACT 3. CONTRACT 4 and CONTRACT 5 are in the pipeline and are expected to commence in February and May, respectively.

To draw up the type of budget shown in

objectives, managerial control is necessary.

There appears to be some misconceptions as to the essence of control. The commonest is the use of the word to mean only the recording of transactions (177). The meaning of the work in this thesis is as used by Cooke and Jepson (155) who define control as the process of regulation seeking to maintain conformity to some plan. They identify the following three elements of control:

- \* a detector,
- \* a system of communication,
- \* a reactor.

The role of the detector is to acknowledge the plan, monitor performance and to compare them. The system of communication tells the controller of the material elements of the situation being controlled. Corrective action to match performance closer to the plan is taken through the reactor. This view of the control function in the context of construction is illustrated in Figure 5.2.

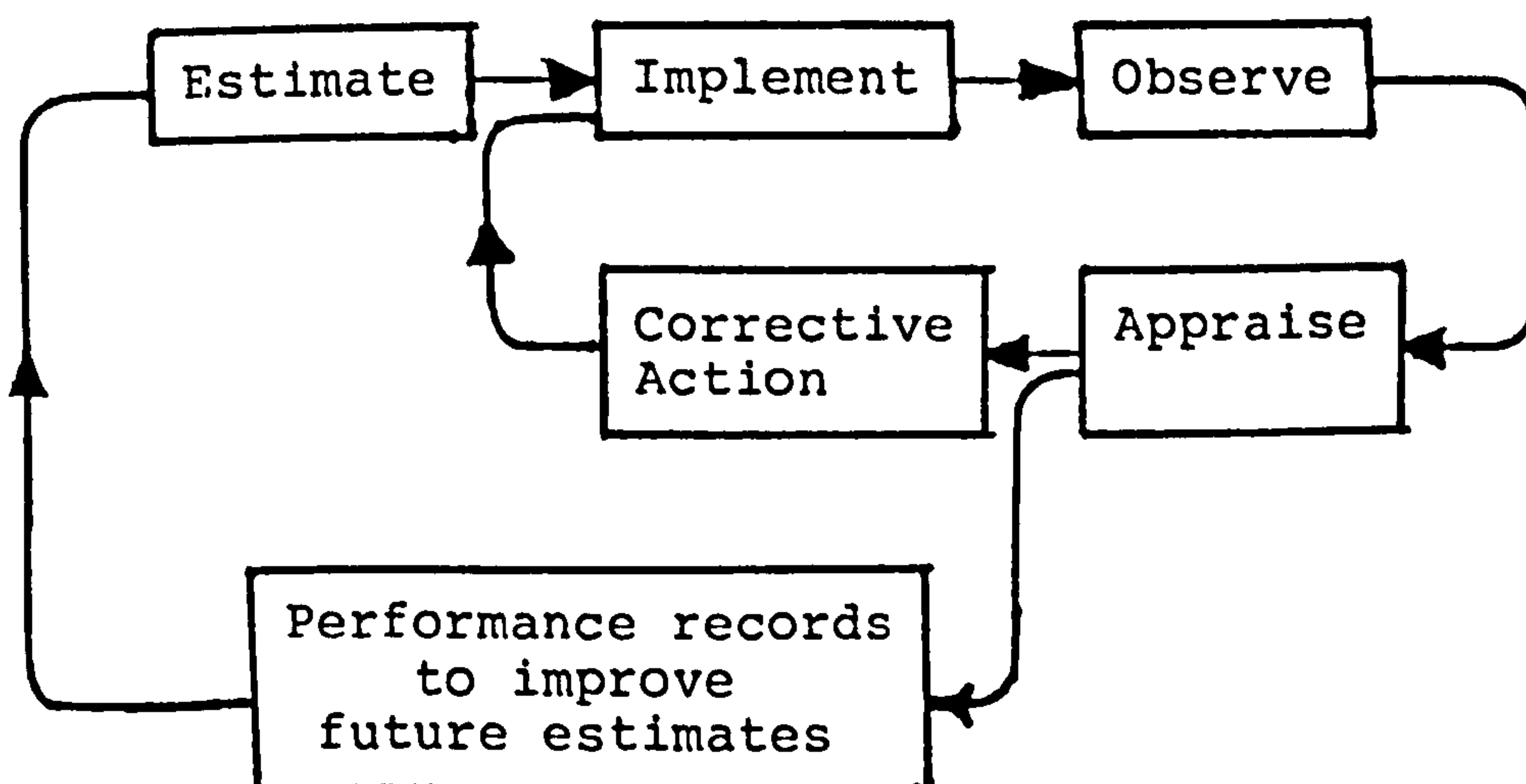


Figure 5.2: The Essence of Control - (After Trimble (10))

### 5.10.3 THE DIRECTORS' REPORT

The Directors' report contains, inter alia, a breakdown of turnover and profit by different corporate activities (172). Turnover refers to the total sales of a company's services and products and for a construction company it can therefore be obtained from the equation:

$$T = \sum_{i=1}^N V_i$$

where

T = turnover,

$V_i$  = total value of payment certificates in respect of work done during the current accounting year for the  $i$ th contract.

N = Number of on-going contract.

Where valuations data are suitably structured a breakdown of the turnover can be obtained.

## 5.11 VALUATIONS AND MANAGEMENT ACCOUNTING

Management accounting is concerned with the provision of information to managers to aid them in decision making during planning and control (176).

Pilcher (156) writes that in the construction industry there is a need for projects to be completed on time, within budget and to the required quality and that to achieve these

N = number of on-going contracts for the accounting period.

The contribution of valuations to the drawing up of a Profit and Loss Account by the Completed Contract Method is substantially the same as by the Accrual Method. The only difference is that only contracts completed during the accounting period are considered when using the Completed Contract Method.

The contribution of valuations in the case of the Percentage of Completion Method is less direct. The proportion of the Contract Sum represented by the last valuation of work carried out may be used as the percentage of the contract completed. Profit for the current accounting period can be determined from the equation:

$$P = \sum_{i=1}^N (PN_i - PL_i)$$

P = profit to be recognized for the current accounting period,

PN<sub>i</sub> = profit for i<sup>th</sup> contract, recognized for all work done to date,

PL<sub>i</sub> = profit for i<sup>th</sup> contract recognized for the last accounting period,

N = number of on-going contracts.



actual costs on projects may reveal incorrect estimating data. Pilcher (177) stresses on the need to correct such estimating data where reliable feedback from projects is available. However care should be taken to distinguish the effects of rate loading from those of incorrect estimating data.

## 5.11.2 PROJECT CONTROL

Project management needs to exercise the following three basic controls (179):

- \* *Quality Control*: This is required to ensure that the quality of materials and the standard of workmanship are in accordance with the specifications.
- \* *Time Control*: This is to ensure that the contract is completed on schedule.
- \* *Cost Control*: This is to allow the Contractor to achieve the anticipated margin.

Valuations provide data for decision-making relating to the control of time and cost as described below.

### 5.11.2.1 TIME CONTROL: PROGRESS REPORTING AND FORECASTING

According to Nisbet (167) valuations provide data from which the progress of a contract can be measured. He writes that this is done by drawing

the following two curves:

- \* a solid curve depicting the rate of expenditure which should be achieved to complete the contract on schedule;
- \* a dotted line showing the actual rate of expenditure.

An illustration of the curves is shown in Figure 5.4.

Though the planned rate of expenditure can be derived from the Contractor's program Nisbet (167) claims that a solid line drawn from a formula is accurate enough. Drake (51) has produced one such formula for hospital construction at the Department of Health and Social Security whilst Peer (181) produced similar models for housing construction. Not only can these formulae be used to forecast expenditure but they can also be used to predict the likely duration as the project progresses (156).

The advantages offered by the graphs described above are (167):

- \* they provide a basis for checking and reporting progress;
- \* they provide a basis for forecasting a likely completion date;
- \* they can be used to forecast the Employer's cashflow requirements;
- \* they can be used to assess the risk to the

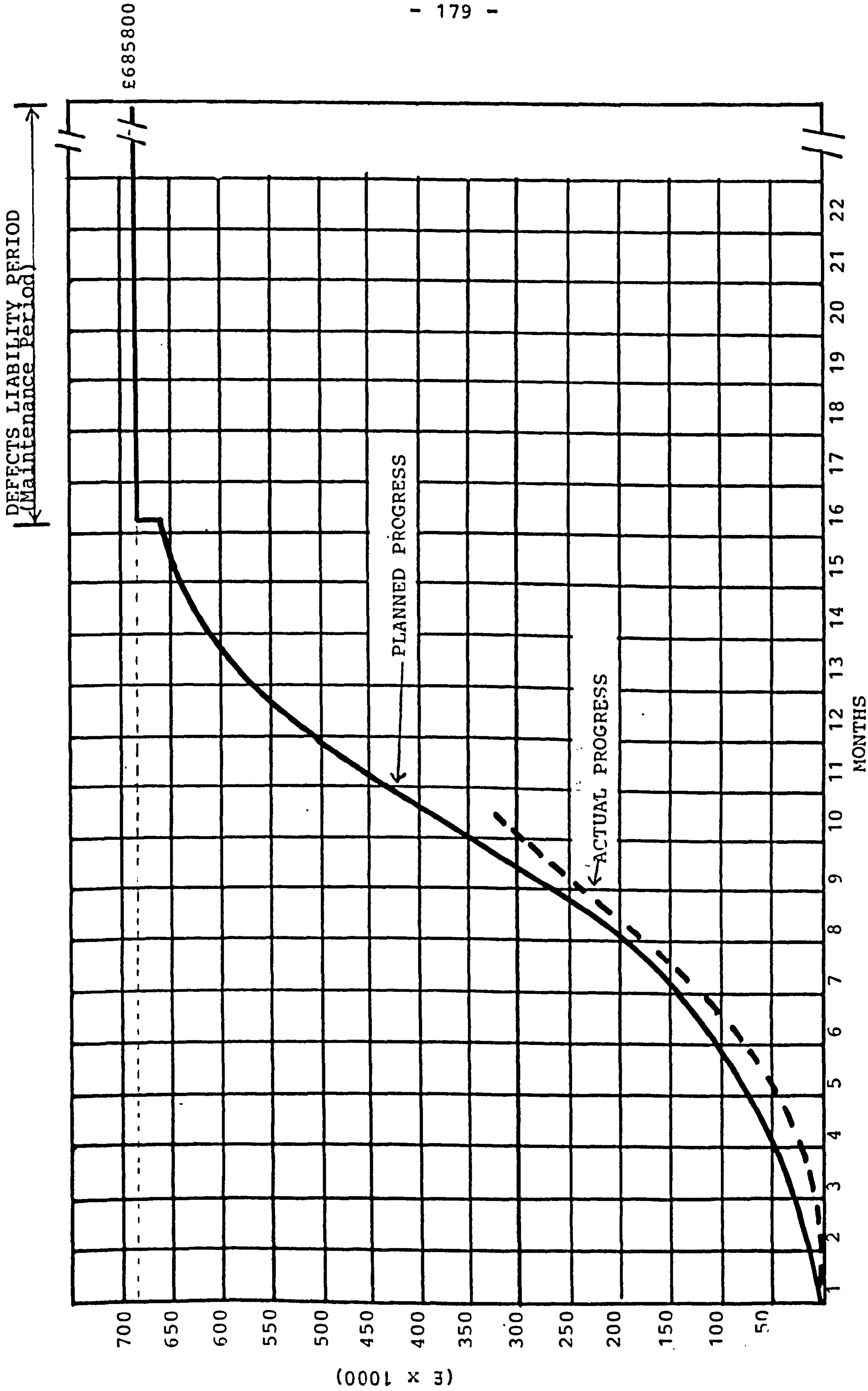


Figure 5.4: Forecast and Actual Revenue Curves.



Employer of the Contractor's insolvency.

It can be observed that this aspect of management control may be made easier by linking the following functions:

- \* Planning,
- \* Cashflow Forecasting,
- \* Valuations.

Very few contracts reach completion as planned from the beginning. Interactive computing has the capability to amend programs as and when necessary. Where there is a link to a cashflow forecasting package which is based on the Contractor's program, revised cashflow forecasts can be carried out interactively. A link to a valuations package will allow the graphs described to be produced whenever necessary.

#### 5.11.2.2 PROJECT COST CONTROL

Cooke and Jepson (155) and Pilcher write that cost control systems used by construction companies vary from company to company and from project to project. Details of the most common types of cost control systems are provided in Section 5.11.2.2.5.

From the model of control described at the beginning of Section 5.11 a control system must involve the following essential tasks:



- \* setting objectives,
- \* reporting,
- \* evaluating,
- \* taking corrective action.

#### 5.11.2.2.1 SETTING OBJECTIVES

Pilcher (156) identifies the following feasible objectives for which contractors undertake projects:

- \* maximising profit at any cost,
- \* maximising profit while still enhancing their reputation for high performance,
- \* utilization of idle resources with profitability as a secondary consideration,
- \* gaining experience of work of a different nature,
- \* gaining a project with high publicity value.

Clark and Lorenzoni (179) identify the following objectives which may be sub-objectives of Pilcher's objectives above:

- \* To focus management attention on potential cost trouble spots in time for corrective or cost-minimising action to be taken.
- \* To keep each project supervisor informed of the budget for his area of responsibility and how his expenditure performance compares to the budget.
- \* To create a cost-conscious atmosphere so that

all persons working on a project will be cost-conscious and aware of how their activities impact on the project cost.

- \* To minimise project costs by looking at all activities from a cost-reduction point of view.

Whatever the objectives are Pilcher (156) writes that it is often necessary to state them in quantifiable financial terms, e.g. yardsticks of costs or output rates to be achieved. Such yardsticks are referred to by various terms which include:

- \* budgets,
- \* standard costs,
- \* standard outputs,

Gobourne (160) writes that such yardsticks are likely to be derived from one or more of the following:

- \* library of historical outputs,
- \* works study standards,
- \* estimator's pricing,
- \* textbook pricing.

#### 5.11.2.2.2 REPORTING

A system of reporting is vital to any cost control endeavour as a means of bringing information to each level of management. Reports should contain the results of monitoring

performance and their comparison to objectives. Information for control purposes should be compiled upon the basis of the following characteristics and requirements (175):

- \* relevance,
- \* selectivity,
- \* accuracy
- \* timeliness,
- \* accountability,
- \* simplicity,
- \* yardsticks of comparison,
- \* facilitation of follow-up.

#### (A) RELEVANCE

The most obvious requirement is that it must help in interpreting the level of achievement. In addition, no manager should be presented with information relating to matters over which he has no control. The reports submitted to the Site Manager, Contracts Manager and Directors will usually contain information of different levels of detail. Morris ( 22) writes that whereas the use of a small number of back-of-the envelope 'key variables' would be adequate for control at the tactical level more sophisticated reporting will usually be necessary for strategic control.

(B) SELECTIVITY

Wilson (175) cautions control will collapse if management endeavours to control too much, with the result that the really important issues become submerged in a mass of irrelevancies. This view is supported by Parreto's Law which states that in any series of elements to be controlled, only a small fraction in terms of elements will usually account for a large fraction in terms of results (175).

(C) ACCURACY

Obviously if inaccurate information is presented for decision-making purposes, unknown to the decision-maker, wrong decisions may be the result.

(D) TIMELINESS

Cooke and Jepson (155), Pilcher (156), Harrison (26) and many other writers on project control maintain that reports should be up-to-date in order that any necessary control action may be taken before the events that form the subject of the reports are purely of historical interest.



(E) ACCOUNTABILITY

This requirement is related to relevance. Wilson (175) writes that it is essential to the success of any financial control system that an individual is only held responsible for results when the following conditions prevail:

- \* that he knows what he is expected to achieve,
- \* that he knows what he is actually achieving,
- \* it is within his power to regulate what is happening.

(F) SIMPLICITY

The report needs to be simple to be easily understood by those who must act upon it.

(G) YARDSTICK OF COMPARISON

A reported figure in isolation of a benchmark has little meaning. Comparison is necessary for appraising performance.

(H) FACILITATION OF FOLLOW-UP

There are four requirements in this regard (175):

- (i) to spot things that are going wrong,

(ii) to spotlight what has already gone wrong,

(iii) to determine exactly how and why failure has occurred,

(iv) to find out who is responsible.

Various ways in which these requirements can be met have been identified in the literature, They include:

- \* the establishment of a WBS, e.g. dividing work into Work Packages which have identified sources of responsibility ( 83,171,177 );
- \* breakdown of yardsticks and accomplishments into their elements for labour, plant, sub-contractors, materials and overheads/profit (156). This may be done for the total Contract, Work Packages, Activities, or Bill items. This procedure allows the Contractor to pinpoint the cause of variations as to whether it relates labour productivity, plant utilization and performance, materials costs and wastages, sub-contract performance, or overheads.

The format of a report structured along the considerations above and which is based on reports in "Site Cost Control in the Construction Industry" (160) is shown in Figure 5.5.



With this sort of format the controller can very easily see the part of the works which is suffering deviations from plan, the source of such deviation (labour, plant, or overheads) and who is responsible (e.g. Section Engineer in charge of the affected part).

Another way of providing for ease of follow-up involves carrying out monthly and weekly control systems in parallel (155).

Gobourne (160) writes that further breakdown of work item may be required to locate sources of deviation. Such further breakdown includes:

- \* the provision of control statements on a trades basis (called trade costing)
- \* the calculation of the cost per unit of measurement for various work items within each trade (called unit costing).

#### 5.11.2.2.3 EVALUATION

Evaluation involves pinpointing the cause of variations from the planned performance and as this will be the basis of any corrective action it is extremely important. The ease with which that exercise can be carried out depends on the extent to which the reporting system allows for follow-up.

Cooke and Jepson (155) write that the following may need investigation in order to



locate causes of inadequate performance:

- \* analysis of percentage margin release,
- \* accuracy of cost and value data,
- \* production information available,
- \* analysis of labour, plant, preliminaries costs,
- \* effectiveness of site management.

#### 5.11.2.2.4 CORRECTIVE ACTION

According to Pilcher (156) variants from budgets will normally be the result of one or more of the following four principal causes:

- (i) construction performance,
- (ii) poor technical and administrative performance,
- (iii) errors in preparation of the estimate or budget,
- (iv) special circumstances which will have affected the site in particular, such as strikes, poor foundations conditions, and poor weather.

Only the first cause has any direct bearing on valuations and is therefore the only one discussed further.

##### (A) POOR CONSTRUCTION PERFORMANCE

The appropriate remedial action depends on the cause of deviations as

discussed below.

(i) LABOUR:

This may involve changing the labour element and/or changing the level of supervision (156).

(ii) PLANT

Corrective action may involve (156):

- \* better plant section,
- \* better planning,
- \* higher plant utilization.

(iii) MATERIALS

The control of materials is discussed in Chapter 9.

(iv) SITE OVERHEADS

These are controlled by reviewing the level and type of supervision (156).

(v) SUB-CONTRACTORS

The control of sub-contractors is discussed in Chapter 10.

#### 5.11.2.2.5 TYPES OF COST CONTROL SYSTEMS

Barnes (29) and Pilcher (177) write that some construction companies do not apply any cost control at all but rather often depend on the submission of claims to make good losses incurred and to make the desired level of profit. Even where cost control is applied the type of system varies from company to company and from project to project (155, 156). The type used on any project depends on its size and the nature of work involved.

The most rudimentary system entails the comparison of revenue and costs at the end of the contract. Pilcher (177) writes that apart from the benefit of feedback of data for use on future contracts such a system is of very limited value. A variation of this type of system is called Cost Value Reconciliation (CVR) and is described in detail in Section 5.12.

Cooke and Jepson (156) write of two main types of cost control systems: monthly and weekly systems. They report the findings of a survey which indicated that most medium-sized (60 - 299 staff and operatives) applied only monthly control whilst mostly the larger firms supplemented monthly controls with weekly controls.

Cost control systems may also be

classified under one of the following types which provide varying degrees of detail (160):

- \* prime cost systems,
- \* standard costing,
- \* trade costing
- \* unit costing.

Whatever the type of system used the valuations function can provide measures of actual performance against which yardsticks may be compared. Details of this contribution of the valuations function is provided in Section 5.11.2.2.6.

#### (A) PRIME COST SYSTEMS

With this type a comparison is made between the payment and the expenditure incurred to the same date.

#### (B) STANDARD COSTING

By comparing the costs of each item of work with a known standard value, a picture emerges of the actual and potential savings or losses enabling any remedial action necessary to be taken.

#### (C) TRADE COSTING

This system is often applied on a weekly



basis. Costs are separated into labour , plant and overheads against which the value of corresponding work is compared.

#### (D) UNIT COSTING

These systems entail the calculation of the cost per unit of measurement for each item of work within each trade. This system is particularly useful for providing cost and output data for future projects.

#### 5.11.2.2.6 THE CONTRIBUTION OF VALUATIONS TO PROJECT CONTROL

It has been discussed in Section 5.11.2.2.1 that the yardsticks against which actual performance data may be compared may be in the form of:

- \* budgets,
- \* standard costs,
- \* standard outputs.

It is also discussed in Chapter 6 that valuations can provide values of Bill items completed for each valuation period. Where Bill prices are broken down into their cost elements for labour, plant, materials, and sub-contractors, valuations can also provide anticipated costs of labour, plant, materials and sub-contractors for Bill items. Such

values or costs constitute budgets against which actual costs collected along the same division of work may be compared for the purpose of assessing performance.

Various writers have commented on the limited usefulness of the traditional BOQ for cost control purposes. Staffurth (171), Barnes (29), Pilcher (156), to name just a few of them, maintain that the BOQ is rarely in a form to be used for either physical measurement of the work or for the purpose of cost control. For example, excavation is required by the CESMM to be covered by various Bill items depending on the depth of the excavation. Not only will measurement along the divisions of work created by Bill items be impracticable but the realistic allocation of labour and plant time along those lines may be virtually impossible.

Where the BOQ has been prepared along the traditional format it is invariably necessary for the estimate to be considerably rearranged for the purposes of measurement, valuation, and cost control. Gobourne (160) writes that such rearrangements entail the storage and retrieval of vast amounts of information, and extensive manipulation of data.

The main elements of work for control

purposes are activities, trade elements and Work Packages (156, 160, 171). One way of obtaining valuations along these elements of work is to build up a schedule of such elements similar to the BOQ and to determine their stage of completion during measurement. Another method is to carry out valuations of individual Bill items and to total the values of Bill items contained in the elements.

In the case of standard costing and standard outputs, data for valuations may be used in calculating the parameters of performance against which the standards may be compared. For example, the volume of concrete placed determined for valuation can be divided by the amounts of resources used on the activity to obtain the achieved output rate which may then be compared with the standard output. With standard costing, division of the cost of resources used on the activity by the volume will produce the cost/unit for comparison with the standard cost.

It is abundantly clear from the discussion above that no matter the type of control system the valuations function can provide it with data. It is also apparent that the main problem with the contribution of data by the valuations function is that a lot



of storage, retrieval and manipulation of data is necessary to get the data into the format required by the control function.

#### 5.11.2.2.7 RETROSPECTIVE/FORWARD-LOOKING CONTROL SYSTEMS

The description of the control procedures already discussed indicates that basically costs already incurred or output rates already achieved are compared with the appropriate yardstick. This approach has been criticised on the grounds that looking back at past performance is an excuse in futility as there is no way the past can be changed.

This approach is analogous to that of a driver who blackens his front windscreen and depends on' occasional backward glimpses to guide his progress. For repetitive work such an approach would be useful as work in the next period will be similar to work already completed.

An alternative approach advocated involves comparing forecast value and forecast cost and changing plans whenever the variance is unacceptable (170). The ability to forecast outcomes for more than a week ahead may require clairvoyance of a high degree. A weekly forward-looking system, Short Term Planning and Control (STPC) has been developed by the Civil Engineering Department of the Loughborough



University of Technology (170). Pilot studies indicate that with suitable software back-up STPC may be an effective tool in the control of projects.

## 5.12

### THE COST VALUE RECONCILIATION

A Cost Value Reconciliation (CVR) is a report comparing the total value of the contract works with the total costs incurred in bringing the contract to that level (157, 166). Whilst determining the total costs incurred may be easy (e.g. taking them from accounting data) the determination of the 'real' value of the work at any stage may not be that straightforward. The External Valuation may not always reflect that value. Indeed, Cooke and Jepson (155) write that there is a tendency for contractors to undervalue work in progress. The main reason for this tendency is that the valuation processes involve various inaccuracies. Barrett (157) writes that adjustments to allow for the inaccuracies will usually be made to the External Valuation to arrive at the Internal Valuation. The sources of these inaccuracies in external valuations as well as the mechanics of preparing CVR's are discussed below.

## 5.12.1 SOURCES OF INACCURACY IN EXTERNAL VALUATIONS

Sources of inaccuracy in External Valuations include:

- \* inaccurate measurement of valued work (153, 157),
- \* inaccurate assessment of materials on site (155, 157),
- \* variations not yet agreed (155, 157),
- \* claims not yet settled (157),
- \* unbalancing of bids at tender (157, 166),
- \* pricing of preliminaries (155, 157),
- \* dayworks not yet agreed (157),
- \* remedial works (157),
- \* foreseeable risks (157),
- \* late invoices from sub-contractors (155, 157).

### 5.12.1.1 INACCURATE MEASUREMENT OF WORKS

Research by Barnes and Thompson (189) has shown that for most civil engineering contracts about 80% of the value of work is contained in 20% of the items. This probably also applies to building contracts. The significance of this is that it may be unwise for the Contractor to attempt applying uniform effort to the measurement of all the items involved. Any attempt to strike a balance between the contribution of a work item to revenue and the effort required to measure it

accurately is bound to introduce some inaccuracy.

It is an open secret contractors do not always carry out physical measurement of all parts of the work (146, 155). The details of the valuation of measured works are contained in Chapter 6.

#### 5.12.1.2 INACCURATE ASSESSMENT OF MATERIALS ON SITE

Cooke and Jepson (155) write that this appears to be one of the main sources of inaccuracy. For substantially the same reasons as for the measured works contractors do not usually assess the exact value of materials on site.

Details of the measurement of materials on site are contained in Chapter 9.

#### 5.12.1.3 VARIATIONS NOT YET SETTLED

As discussed in Chapter 7, a contractor may sometimes carry out work involving a variation even though the variation has not been properly authorized under the contract.

Even where variations have been properly ordered, according to Barrett (157), their valuations can be in dispute.

#### 5.12.1.4 CLAIMS IN DISPUTE

The full effect of an event giving rise to a claim may not be fully known when first encountered (133). Any valuation in such circumstances may be inaccurate as a result.

As explained in Chapter 8 even where the details of a claim are known the amount to include in valuations may be in dispute.

#### 5.12.1.5 UNBALANCED BIDS

Tactical estimating is discussed in Chapter 7. The effect of unbalanced tender rates on valuations on cost control is illustrated in Figure 5.6.

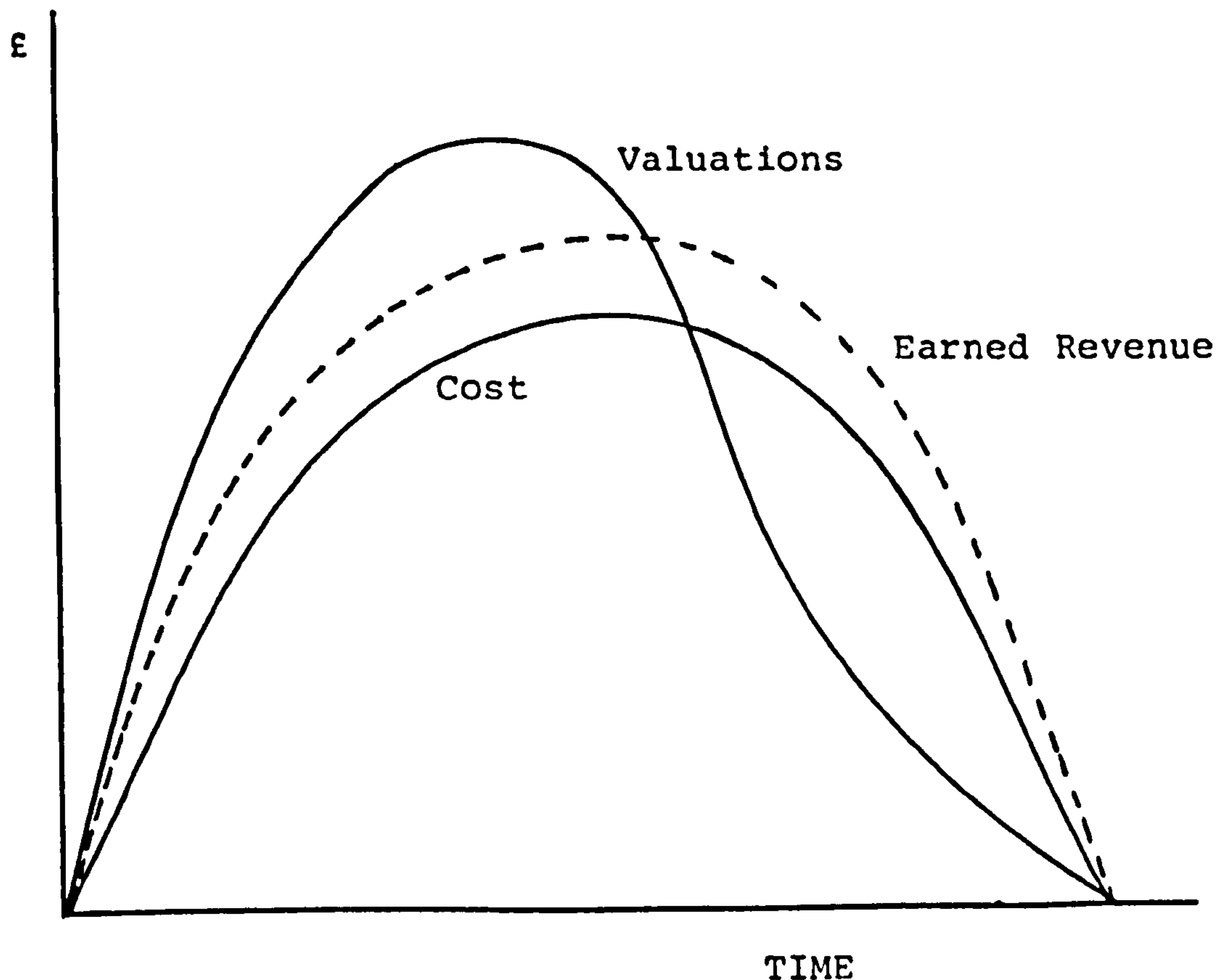


Figure 5.6: The Effect of Unbalanced Tender Rates on Cost Control - After Coombs and Palmer (153).



As can be seen in Figure 5.6, though there may be no over-valuation or under-valuation so far as the Employer is concerned the values placed on work from the Bill rates is considerably higher or lower than the costs expected to be incurred in carrying out the work.

#### 5.12.1.6 PRICING OF PRELIMINARIES

This subject is discussed in detail in Chapter 10. The main cause of inaccuracy occurs where the costs of the preliminaries is spread on some, or all, of the rates of the associated permanent work. In such a case even where all the 'work' in connection with providing the item of the preliminary has been done its value cannot be included in valuations until the associated permanent work has been done and included in valuations.

#### 5.12.1.7 DAYWORKS NOT YET AGREED

This is an aspect of the disagreements over variations already discussed. Disagreement could arise from failure to comply strictly with contractual requirements of dayworks discussed in Chapter 7. Sometimes the Contractor does work which he thinks should have been covered by a dayworks instruction but which has not been issued.

#### 5.12.1.8 REMEDIAL WORKS

When items are included in the external valuation it is on the basis of being 100% complete with no further work necessary. In construction, completed works will not always remain in a state of perfection until handover and the Contractor will have to make good the defects.

#### 5.12.1.9 FORESEABLE RISKS

The need to make deductions for foreseeable risks stems from the accounting principle of conservatism which requires that all foreseeable losses should be allowed for in the current accounting period. Losses from foreseeable risks may be due to (157):

- \* increased winter working,
- \* consequential costs associated with delays,
- \* liquidated damages,
- \* increases in labour costs not covered in contract provisions,
- \* claims from sub-contractors.

#### 5.12.1.10 LATE INVOICES FROM SUB-CONTRACTORS

According to Barrett (157) it is unlikely that all sub-contractors' valuations and the main contractor's valuations can all be brought together at the same time.

## 5.12.2 THE MECHANICS OF COST VALUE RECONCILIATION

The type, and format of the calculations involved in cost value reconciliations is shown on a standard reporting form contained in a publication (157) of the CIOB. Figure 5.7 shows the form.

Perceval (166) writes that if the CVR is to be of any worth it is essential that there is a degree of consistency in filling in the form, from contract to contract, and from month to month. SAAP9 (180) gives guidelines, some of which have already been discussed, on what to include and exclude, and what adjustments should, and should not, be made.

| COST VALUE RECONCILIATION                                    |                |                   |            |                            |  |  |  |  |  |
|--|----------------|-------------------|------------|----------------------------|--|--|--|--|--|
| Contract number  |                | Contract type     |            | Accounting period ending   |  |  |  |  |  |
| COST AND VALUE FORECAST                                      |                |                   |            |                            |  |  |  |  |  |
| Estimated cost   | Tender stage % | Provision %       | Variance % | Estimated final estimate % |  |  |  |  |  |
| Estimated value  |                |                   |            |                            |  |  |  |  |  |
| Estimated profit   |                |                   |            |                            |  |  |  |  |  |
| Cost to employees  |                |                   |            |                            |  |  |  |  |  |
| VALUATION  |                |                   |            |                            |  |  |  |  |  |
| 1. APPLICATION AND CERTIFICATE                               |                |                   |            |                            |  |  |  |  |  |
| Add (1a) Total payment application limit of document & VAT   |                |                   |            |                            |  |  |  |  |  |
| Deduct (1b) Disputed items, claims not agreed to application |                |                   |            |                            |  |  |  |  |  |
| Add (1c) Associated gross variations                         |                |                   |            |                            |  |  |  |  |  |
| Deduct (1d) Associated agreed contract amounts               |                |                   |            |                            |  |  |  |  |  |
| 2. ADJUSTMENTS   |                |                   |            |                            |  |  |  |  |  |
| Add (2a) Sub-construction adjustments                        |                |                   |            |                            |  |  |  |  |  |
| Deduct (2b) Variations before date of accounting period      |                |                   |            |                            |  |  |  |  |  |
| Add (2c) Variations on site                                  |                |                   |            |                            |  |  |  |  |  |
| Deduct (2d) Variations not agreed                            |                |                   |            |                            |  |  |  |  |  |
| 3. OVERVALUATION   |                |                   |            |                            |  |  |  |  |  |
| Deduct (3a) Variation after end of month                     |                |                   |            |                            |  |  |  |  |  |
| Add (3b) Unagreed items                                      |                |                   |            |                            |  |  |  |  |  |
| Deduct (3c) Shortfalls on site                               |                |                   |            |                            |  |  |  |  |  |
| 4. PROVISIONS  |                |                   |            |                            |  |  |  |  |  |
| Deduct (4a) Remedial works                                   |                |                   |            |                            |  |  |  |  |  |
| Add (4b) Unagreed items                                      |                |                   |            |                            |  |  |  |  |  |
| Deduct (4c) Unagreed items                                   |                |                   |            |                            |  |  |  |  |  |
| Add (4d) Unagreed items                                      |                |                   |            |                            |  |  |  |  |  |
| Deduct (4e) Shortfalls in increased costs recovery           |                |                   |            |                            |  |  |  |  |  |
| 5. INTERNAL VALUATION  |                |                   |            |                            |  |  |  |  |  |
| SITE MANAGER   |                | QUANTITY SURVEYOR |            |                            |  |  |  |  |  |

| COST VALUE RECONCILIATION                       |                        |                         |                         |                         |                         |                         |                         |                         |                         |
|---|------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| TIME ANALYSIS (in weeks)                        |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Original contract period                        | Present work           | Time to date            | Time to date            | Time to date            | Time to date            | Time to date            | Time to date            | Time to date            | Time to date            |
| Estimated of time awarded                       | Value to complete      | Estimated value to date | Estimated value to date | Estimated value to date | Estimated value to date | Estimated value to date | Estimated value to date | Estimated value to date | Estimated value to date |
| Period contract period                          | Period contract period | Period contract period  | Period contract period  | Period contract period  | Period contract period  | Period contract period  | Period contract period  | Period contract period  | Period contract period  |
| 6. COST ELEMENTS                                |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (6a) Material                               |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (6b) Site staff and overheads            |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (6c) Labour                                 |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (6d) Sub-contractors                     |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (6e) Remedial works                      |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (6f) Costs transfer to month revenue        |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| 7. TOTAL COSTS TO DATE                          |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| 8. RECONCILIATION                               |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Internal valuation                              |                        |                         |                         |                         | Up to previous period   |                         |                         |                         |                         |
| Cost Profit (100%)                              |                        |                         |                         |                         | Current period          |                         |                         |                         |                         |
| Total   |                        |                         |                         |                         | Total                   |                         |                         |                         |                         |
| 9. PROVISIONS                                   |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Internal valuation                              |                        |                         |                         |                         | Up to previous period   |                         |                         |                         |                         |
| Cost Profit (100%)                              |                        |                         |                         |                         | Current period          |                         |                         |                         |                         |
| Total   |                        |                         |                         |                         | Total                   |                         |                         |                         |                         |
| 10. CASH POSITION                               |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Total payment application (1a)                  |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (1b) Gross variations value              |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (1c) Retention                              |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (1d) Certified sum outstanding (from 1a) |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (1e) Claims income expected (from 1a)       |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Deduct (1f) Total cash outstanding              |                        |                         |                         |                         |                         |                         |                         |                         |                         |
| Add (1g) Total cash received to date            |                        |                         |                         |                         |                         |                         |                         |                         |                         |

Figure 5.7: Standard CVR Form



## CHAPTER SIX

### THE VALUATION OF MEASURED WORK

The Bill of Quantities contains a total quantity, a unit price, and a total value for most Bill items. The only exceptions are lump sum items but even with them, if £1.00 is taken as the unit price and the lump sums as the total quantities they can be treated in a similar manner to the more common type of item.

If the Contractor can determine the value of the work contained in each Bill item completed, the total value of the work represented in the Bill of Quantities completed can be assessed. By the very nature of the Bill the values may be determined directly or indirectly. An example of a direct determination is the totalling of insurance premiums paid and using the result as the value of the item in the Bill for that service. Indirect determination may involve assessing the quantity of the appropriate work completed and then multiplying it by the unit rate to arrive at the value.

In practice the basic approach described above is used in a variety of different procedures. This Chapter describes such procedures.

## 6.1 SOURCES OF DATA FOR VALUATIONS

To carry out valuations of work contained in the Bill of Quantities site management have to collect data pertaining to each valuation period. The following sources of such recurrent data have been identified:

- \* cost records,
- \* invoices/receipts,
- \* sub-contractors' payment applications,
- \* program/progress schedules,
- \* dayworks sheets/dayworks accounts,
- \* analysis of stages of construction,
- \* site measurement,
- \* the contract documents.

### 6.1.1 COST RECORDS

In some cases the Contractor may seek to recover his expenses incurred on the work, goods or service in question. The recovery of expenses may be a contractual right or it could be a convenient way of determining interim payment. Examples of the latter case include valuations of items of preliminaries such as costs of supervision and and maintenance of site offices. Where the Contractor is not contractually entitled to recover his costs and the costs relating to Bill item are in excess of the contractual value of the work involved, over-payment will occur if the costs incurred are used as

values. It follows therefore that this approach should be used only guardedly.

#### 6.1.2 INVOICE/RECEIPTS

In certain situations the Contractor is entitled to reimbursements for payments made by him to third parties such as statutory authorities. He will usually be expected to produce invoices/receipts covering such payment.

#### 6.1.3 SUB-CONTRACTORS' PAYMENT APPLICATIONS

It is discussed in Chapter 10 that applications for payment from sub-contractors are often used to determine:

- \* instalments of P.C. sums to include in interim payments,
- \* amounts earned by the Main Contractor on account of attendances on nominated sub-contractors,
- \* amounts in respect of charges for profit on the work of nominated sub-contractors,
- \* amount to include for his own sub-contracted work.

#### 6.1.4 PROGRAM/PROGRESS SCHEDULES

Program/progress schedules form the main basis for the valuation of time-related preliminaries as is described in Chapter 10.



### 6.1.5 DAYWORKS SHEETS/DAYWORKS ACCOUNTS

Payment for dayworks may be treated in any of the following two ways:

- \* valuation against provisional sums in the Bill of Quantities,
- \* maintenance of a separate dayworks account which is brought forward only in a summary of valuations.

### 6.1.6 ANALYSIS OF STAGES OF CONSTRUCTION

Certain types of repetitive work are suitable for grouping into stages of construction. An example for housing project is shown in Table 6.1. Such a breakdown can provide data for valuation as described in Section 6.2.3.

### 6.1.7 SITE MEASUREMENT

Site measurement provides most of the recurrent data for valuation. Site measurement in this context includes the following tasks:

- \* approximate assessments of the percentages or stages of completion of work items by visual inspection,
- \* physical determination of lengths, weights, or numbers of work or materials,
- \* assessments of future expenditures necessary to complete work items.



Table 6.1: Analysis of Stage Payments

| STAGES                             | AMOUNT (£)           |
|------------------------------------|----------------------|
| 1. Excavation of footings          | 1,000                |
| 2. Concreting of footings          | 2,100                |
| 3. Brickwork up to DPC             | 3,000                |
| 4. Hardcore fill                   | 2,250                |
| 5. Concreting of ground floor slab | 2,000                |
| 6. First lift brickwork            | 2,500                |
| 7. Second lift brickwork           | 2,500                |
| 8. First floor joists              | 2,500                |
| 9. Third lift brickwork            | 2,500                |
| 10. Fourth lift brickwork          | 2,500                |
| 11. Topping out of brickwork       | 2,000                |
| 12. Roof joists                    | 4,050                |
| 13. Floor boarding                 | 2,200                |
| 14. Internal partitions            | 3,000                |
| 15. Joinery                        | <u>20,500</u>        |
| Total                              | <u><u>54,600</u></u> |

### 6.1.8 CONTRACT DOCUMENTS

In the majority of cases the contract documents of a civil engineering contract comprises the following (88):

- \* Bill of Quantities,
- \* Invitation to Tender,
- \* Form of Tender,
- \* Form of Agreement,
- \* Drawings,
- \* Conditions of Contract,
- \* Specifications.

There are equivalent documents for building contracts.

The Bill of Quantities provides the following data on items of work directly:

- \* unit of measurement,
- \* total quantity expected,
- \* unit price,
- \* total value.

Manipulation of the build-ups of the Bill of Quantities can also provide the following:

- \* analysis of the tender (Section 8.9.1):
  - . Contract Sum/Tender Total,
  - . total value of Preliminaries,
  - . total value of nominated sub-contractor's work,
  - . total amount for provisional sums,
  - . total amount for attendances,
  - . budgeted profit;

- \* data on activities (Section 6.2.2):
  - . unit of measurement,
  - . total quantity,
  - . unit price,
  - . total values for labour, plant, materials, overheads/profit.

## 6.2 SITE MEASUREMENT PROCEDURES

Most of the procedures involved in the valuation of measured work identified concern the measurement of work completed and how such measurements are converted to monies for inclusion in payment applications.

Three main types of site measurement have been identified:

- \* measurement of work contained in Bill items completed,
- \* measurement of activities,
- \* determination of stages of construction.

### 6.2.1 MEASUREMENT OF WORK CONTAINED IN BILL ITEMS

The following ways of assessing the amount of items completed have been identified:

- \* determining dimensions of the physical work involved,
- \* determining quantities completed,
- \* assessing values earned,
- \* assessing anticipated future expenditure to completion,

- \* assessing percentages completed.

Bill items may be measured for in these ways as individual items, groups of items, sections, or pages of the Bill of Quantities.

#### 6.2.1.1 DIMENSIONS

There are three types of dimensional items (150):

- \* linear items which are quantified by the lengths of the appropriate physical work, e.g. meters of kerbing;
- \* superficial items which are quantified by areas of the appropriate physical work, e.g. hectares of site cleared;
- \* cubic items which are quantified by volumes of the appropriate physical work, e.g. m<sup>3</sup> of concrete placed.

The main procedures involved in this type of measurement are:

- (i) the scaling of the dimensions of the work,
- (ii) the working out of quantities: volumes, areas, or lengths (squaring),
- (iii) the collection and classification of the quantities in a recognized order (abstracting),
- (iv) transfer of quantities from the abstract to a bill.



The procedures entailed in (ii), (iii) and (iv) are referred to collectively as 'working up' (150). Willis and Willis (150) advise that working up calculations should usually be checked by a third party to ensure that no arithmetical or copying errors occur. The need for such check can be eliminated by computerisation for which these procedures appear to be tailor-made.

The procedures are illustrated in Figures 6.1, 6.2 and 6.3.

#### 6.2.1.2 QUANTITIES

The following classes of quantities have been identified:

- \* volumes, areas, or lengths of physical work,
- \* weights, e.g. tonnes of reinforcement,
- \* numbers of itemised packets of work, goods or services, e.g. number of boreholes;
- \* time, e.g. weeks of supervision;
- \* a sum of money, e.g. insurance premiums paid.

Quantities may be measured or assessed directly, or obtained by the working up of dimensions.

#### 6.2.1.3 VALUES EARNED

Sometimes the value of an item earned may be known. Most of the items which fall into this category are lump sum items. The determination of the value may require calculations of varying

|      |      |      |  |  |  |  |  |  |  |  |  |  |
|------|------|------|--|--|--|--|--|--|--|--|--|--|
| F113 | 2/   | 8.00 |  | Provide in-situ<br>concrete Grade 10<br>cement to BS12,20mm<br>aggregate; minimum<br>cement content<br>250 kg/m3 |  |  |  |  |  |  |  |  |
|      |      | 8.50 |  |  |  |  |  |  |  |  |  |  |
|      |      | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 4.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 0.50 |  |  |  |  |  |  |  |  |  |  |
|      |      | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      | 1/2/ | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 0.50 |  |  |  |  |  |  |  |  |  |  |
|      |      | 1.00 |  |  |  |  |  |  |  |  |  |  |
|      |      | 2.00 |  |  |  |  |  |  |  |  |  |  |
|      |      |      |  | (1st projection  |  |  |  |  |  |  |  |  |
|      |      |      |  | (2nd projection  |  |  |  |  |  |  |  |  |
|      |      |      |  | <u>Deduct</u> for  |  |  |  |  |  |  |  |  |
|      |      |      |  | opening  |  |  |  |  |  |  |  |  |

Figure 6.1: Booking dimensions

F113

|     |                      |        |   |  |  |
|-----|----------------------|--------|---|--|--|
| 2/  | 8.00<br>8.50<br>2.00 | 272.00 | Provide in-situ<br>concrete Grade 10<br>Cement to BS12,<br>20mm aggregate;<br>minimum cement<br>content 250kg/m3<br><br>(1st projection<br><br><br>(2nd projection<br><br><br>Deduct for<br>opening |  |  |
|     | 4.00<br>0.50<br>2.00 | 4.00   |   |  |  |
|     | 2.00<br>2.00<br>2.00 | 4.00   |   |  |  |
|     | 0.50<br>1.00<br>2.00 | 1.00   |   |  |  |
| 1/2 |                      |        |   |  |  |

Figure 6.2: Squarring of dimensions

| NUMBER | DESCRIPTION  | UNIT | QUANTITY | RATE  | AMOUNT<br>£ | LAST PERIOD |             | THIS PERIOD |             | TO DATE  |             |
|--------|--|------|----------|-------|-------------|-------------|-------------|-------------|-------------|----------|-------------|
|        |  |      |          |       |             | QUANTITY    | AMOUNT<br>£ | QUANTITY    | AMOUNT<br>£ | QUANTITY | AMOUNT<br>£ |
| F113   | Concrete Grade 10, cement to BS12, 20mm, aggregate, minimum cement 250 kg/m3 | m3   | 300.00   | 12.00 | 3600.00     | 250.00      | 3000.00     | 29.00       | 348.00      | 279.00   | 3348.00     |

Figure 6.3: Billing of Measurement



degrees of complexity being carried out. Such calculations could be as easy as totalling amounts of payments made to third parties under the Contract or as complex as valuing items along the same principles as for cost-related preliminaries described in Chapter 10.

#### 6.2.1.4 ANTICIPATED FUTURE EXPENDITURE

It is sometimes easier to assess further expenditure expected to complete a work item than to assess the amount earned. In such cases the difference between the Bill amount and such expected expenditure may be considered as the amount earned for the purpose of interim payment.

#### 6.2.1.5 PERCENTAGES COMPLETED

Through a visual inspection the measurement team may be able to assess the percentages of Bill items or activities completed. Some of the contractors contacted during this research indicated that very often percentages to be applied to all items on identified pages of the Bill of Quantities may be assessed.

#### 6.2.2 MEASUREMENT OF ACTIVITIES

The limitations of the traditional Bill of Quantities in project control are discussed in Sections 3.4.3.2 and 5.11.2.2.6. Forbes and Skoyles

(48,95) at the Building Research Station have developed an approach which entails the use of a different type of bill, the operational bill. In an operational bill the work involved in construction is analysed into stages of work or into operations which become the units for estimating and pricing labour. With the great diversity existing in construction work, 'operations' or 'stages of work' are subject to wide differences in definition. Forbes and Skoyles (48) write that the main source of differences is the level of detail in defining work. A convenient level of detail would be where an operation represents an activity capable of being used in a network.

Though Lansley (50) reports that, by and large, the construction industry has ignored the use of the operational bill as a tender document, site visits undertaken and consultations made as part of this research indicated that some companies prepare a post-contract bill out of the Contract Bill of Quantities for controlling construction. This post-contract bill is referred to by different names as is to be expected. The name preferred in this research is a 'Bill of Activities'.

The basic approach to producing the Bill of Activities is to aggregate all the items in the Contract Bill contained in a site activity into a sort of 'macro-item' with a description, unit of measurement, unit rate, total quantity and

total amount. Where the unit rates in the Contract Bills are broken into their elements for labour, plant, materials, sub-contract costs, overheads/ profit a similar breakdown may be provided for each activity.

The following procedures for measuring the accomplishment of an activity have been identified:

- \* determining the dimensions of the physical work contained in the activity,
- \* determining the quantity of the activity completed,
- \* assessing values earned,
- \* assessing anticipated future expenditure to completion,
- \* assessing the percentage of an activity completed.

The details of these procedures are similar to those described under Section 6.2.1.

### 6.2.3 DETERMINATION OF STAGES OF CONSTRUCTION

The breakdown of a project into defined stages is described in Section 6.1.6. During site measurement the measurement team inspect the work and decide on the nearest defined stage to which it conforms. The most advanced use of this approach is normally made in housing projects. Figure 6.4 shows a tick sheet used during site measurement of 10 similar estimates of the same



| CONTRACT: LOUGHBOROUGH XYZ ESTATES |                                 |               |   |   |   |   |   |   |   |   |    |       |  |   | STAGE PAYMENT CHART |  |  |  |  |  |  |  |  |  |
|------------------------------------|---------------------------------|---------------|---|---|---|---|---|---|---|---|----|-------|--|---|---------------------|--|--|--|--|--|--|--|--|--|
| NO                                 | STAGE                           | BLOCK NUMBERS |   |   |   |   |   |   |   |   |    | TOTAL |  |   |                     |  |  |  |  |  |  |  |  |  |
|                                    |                                 | 1             | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |       |  |   |                     |  |  |  |  |  |  |  |  |  |
| 1                                  | Excavation of Footings          | ✓             | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |   |    | ✓     |  | 9 |                     |  |  |  |  |  |  |  |  |  |
| 2                                  | Concreting of Footing           | ✓             | ✓ | ✓ | ✓ |   | ✓ | ✓ | ✓ |   |    |       |  | 7 |                     |  |  |  |  |  |  |  |  |  |
| 3                                  | Brickwork up to DPC             | ✓             | ✓ | ✓ |   |   | ✓ | ✓ | ✓ |   |    |       |  | 6 |                     |  |  |  |  |  |  |  |  |  |
| 4                                  | Hardcore fill                   | ✓             | ✓ | ✓ | ✓ |   | ✓ | ✓ | ✓ |   |    |       |  | 7 |                     |  |  |  |  |  |  |  |  |  |
| 5                                  | Concreting of ground floor slab | ✓             | ✓ | ✓ | ✓ |   | ✓ | ✓ |   |   |    |       |  | 6 |                     |  |  |  |  |  |  |  |  |  |
| 6                                  | First lift brickwork            | ✓             | ✓ | ✓ | ✓ |   | ✓ | ✓ | ✓ |   |    |       |  | 7 |                     |  |  |  |  |  |  |  |  |  |
| 7                                  | Second lift brickwork           | ✓             | ✓ | ✓ |   |   | ✓ | ✓ | ✓ |   |    |       |  | 7 |                     |  |  |  |  |  |  |  |  |  |
| 8                                  | First floor joist               | ✓             | ✓ | ✓ |   |   | ✓ |   |   |   |    |       |  | 4 |                     |  |  |  |  |  |  |  |  |  |
| 9                                  | Third lift brickwork            | ✓             | ✓ | ✓ |   |   | ✓ |   |   |   |    |       |  | 4 |                     |  |  |  |  |  |  |  |  |  |
| 10                                 | Fourth lift brickwork           |               | ✓ | ✓ | ✓ |   |   |   |   |   |    |       |  | 3 |                     |  |  |  |  |  |  |  |  |  |
| 11                                 | Topping out of brickwork        | ✓             | ✓ | ✓ |   |   |   |   |   |   |    |       |  | 3 |                     |  |  |  |  |  |  |  |  |  |
| 12                                 | Roofing joists                  | ✓             | ✓ |   |   |   |   |   |   |   |    |       |  | 2 |                     |  |  |  |  |  |  |  |  |  |
| 13                                 | Floor boarding                  | ✓             | ✓ |   |   |   |   |   |   |   |    |       |  | 2 |                     |  |  |  |  |  |  |  |  |  |
| 14                                 | Internal partition              | ✓             |   |   |   |   |   |   |   |   |    |       |  | 1 |                     |  |  |  |  |  |  |  |  |  |
| 15                                 | Joinery                         | ✓             |   |   |   |   |   |   |   |   |    |       |  | 1 |                     |  |  |  |  |  |  |  |  |  |

Figure 6.4: Ticksheet for recording stages for payment



type. Such a tick sheet can even be modified to cover different types of dwellings.

### 6.3 VALUATION PROCEDURES

The aim of the procedures involved in the valuation of measured work is to determine the total amount in respect of such work to include in the overall valuation. To achieve this aim site management have to carry out many calculations using the data assembled.

The main types of calculations identified are:

- \* multiplying quantities of Bill items or activities by their unit rates,
- \* taking percentages of total amounts for Bill items or activities as their values to include in the valuation,
- \* subtracting assessed future expenditure to completion from the total amount for Bill items or activities to obtain their values to include in the valuation,
- \* multiplying the numbers of units of sub-projects at the same stage of completion by the amount earned in bringing one unit to that stage (e.g. if £P is earned by bringing one dwelling to first floor level, £(P x N) is earned by bringing N similar dwellings to the same level),
- \* taking a fraction of cost-related Bill items or activities represented by the proportion of the entire project completed (Section 10.2.1.1),

\* totalling monies earned for all Bill items, activities and stages, ensuring that no duplication of recovery of earnings occurs.

The total amount earned on measured work is then transferred to a summary of valuations which totals the values earned on the various heads of valuations described in Chapter 5.

## CHAPTER SEVEN

### THE VALUATION OF VARIATIONS

#### 7.1 INTRODUCTION

In construction contracts what is finally constructed is not always identical in every detail to the original contract tendered for. Modifications, generally referred to as variations, are often made to the original contract. Powell-Smith and Sims (30) attribute the most usual causes of such variations to the following:

- \* it is impossible to foresee every eventuality at the design stage;
- \* the client is unable to make up his mind at the design stage about precisely what he does want;
- \* there is too much haste to get the project underway;
- \* lack of adequate planning;
- \* lack of foresight by the design team.

This Chapter reviews the circumstances under which variations arise and how they are usually included in valuations. The review is discussed under the following headings:

- \* the scope of variations allowed,
- \* administrative procedures concerning variations,

- \* the format of variation orders,
- \* the measurement of variations,
- \* the principles of valuing variations,
- \* the factors affecting the valuation of variations,
- \* the valuing of variations,
- \* the billing of variations,
- \* the summary of variations.

## 7.2 THE SCOPE OF VARIATIONS ALLOWED

Unless there is a clause in the conditions of contract allowing variations to be made, the Contractor cannot be ordered to do work outside what he had originally agreed to do, nor can the Employer omit any of the original work. The various standard forms incorporate clauses allowing variations to the works within well-defined limits. As long as a variation falls within these limits the Contractor is obliged to carry it out and the Employer is bound to make payments determined according to the contractual provisions. If a variation is outside the conditions of contract the Contractor is not bound to accept it and if he still does accept it, the Employer is not bound to pay him on account of such a variation.

The scope of variations allowed by the JCT and ICE Contracts are defined below.



## 7.2.1 THE JCT FORMS

A variation under the terms of the Contract is defined in Clause 13.1 as follows:

### 13 Variations and provisional sums

13.1 The Term "Variation" as used in the Conditions means:

- 13.1.1 the alteration or modification of the design, quality or quantity of the Works as shown upon the Contract Drawings and described by or referred to in the Contract Bills, including
  - .1.1 the addition, omission or substitution of any work,
  - .1.2 the alteration of the kind or standard of any of the materials or goods to be used in the Works,
  - .1.3 the removal from the site of any work executed or materials or goods brought thereon by the Contractor for the purposes of the Works other than work materials or goods which are not in accordance with this Contract;
- 13.1.2 the addition, alteration or omission of any obligations or restrictions imposed by the Employer in the Contract Bills

*in regard to:*

- .2.1 access to the site or use of any  
specific parts of the site;*
- .2.2 limitations of working space;*
- .2.3 limitations of working hours;*
- .2.4 the execution or completion of the  
work in any specific order;*

*but exclude*

- 13.1.3 nomination of a Sub-Contractor to supply  
and fix materials or goods or to execute  
work of which the measured quantities  
have been set out and priced by the  
Contractor in the Contract Bills for  
Supply and fixing or execution by the  
Contractor.*

For the purposes of valuations the following are also to be treated as variations:

- (1) Correction of departures from  
the method of measurement laid  
down, and correction of errors  
in description or in quantity or  
omissions of items from the  
Contract Bills* *Clause 2.2.2.2*
- (2) Variation to the works  
instructed by the Architect  
in relation to a divergence  
from Statutory requirements* *Clause 6.1.3*
- (3) Work executed and materials*

supplied in emergency

compliance with Statutory

Requirements

Clause 6.1.4.3

- (4) Work where the conditions  
under which it is executed  
are changed by executing  
a Variation or changed by  
work executed pursuant to  
the expenditure of a provi-  
sional Sum

Clause 13.5.5

- (5) The restoration of damaged  
work, the replacement and  
repair of materials or the  
removal and disposal of debris  
following loss or damage due to  
Clause 22 Perils where such  
perils are at the risk of the  
Employer

Clause 22B.2.2

- (6) Work uncompleted upon the  
determination by the  
Contractor of his employment

Clause 28.2.2.2

- (7) The execution of protective  
work or the execution of  
work up to a point of  
stoppage all in accordance  
with Architect's instructions  
following an out break of  
hostilities

Clause 32.3

(8) The removal of debris or  
damage work the execution  
of protective works and the  
reinstatement and making  
good of war damage

Clause 33.1.4

## 7.2.2 THE ICE CONDITIONS

The definition of variations allowed is  
stated in Clause 51 as follows:

### ALTERATIONS AND ADDITIONS AND OMISSIONS

51. (1) The Engineer shall order any variation  
to any part of the Works that may in  
his opinion be necessary for the  
completion of the Works and shall have  
power to order any variation that for  
any other reason shall in his opinion  
be desirable for the satisfactory  
completion and functioning of the Works.  
Such variations may include additions  
omissions substitutions alterations  
charges in quality form character kind  
position dimension level or line and  
charges in the specified sequence  
method or timing of construction  
(if any).

(2) No such variation shall be made by the  
Contractor without an order by the Engineer.



All such orders shall be given in writing provided that if for any reason the Engineer shall find it necessary to give any such order orally in the first instance the Contractor shall comply with such oral order. Such oral order shall be confirmed in writing by the Engineer as soon as is possible in the circumstances. If the Contractor shall confirm in writing to the Engineer any oral order by the Engineer and such confirmation shall not be contradicted in writing by the Engineer forthwith it shall be deemed to be an order in writing by the Engineer. No variation ordered or deemed to be ordered in writing in accordance with sub-clauses (1) and (2) of this Clause shall in any way vitiate or invalidate the Contract but the value (if any) of all such variations shall be taken into account in ascertaining the amount of the Contract Price.

- (3) No order in writing shall be required for increase or decrease in the quantity of any work where such increase or decrease is not the result of an order given under this Clause but is the result of the quantities exceeding or being less than those stated in the Bill of Quantities.

The key requirements are that:

- \* the variations are to be in writing or confirmed in writing;
- \* the change should, in the opinion of the Engineer, be necessary for the satisfactory completion and functioning of the works;
- \* they must be ordered by the Engineer (a change requested by the Employer directly is therefore not a valid variation under the contract);
- \* the variation should be made before practical completion.

### 7.3 ADMINISTRATIVE PROCEDURES CONCERNING VARIATIONS

The first task in relation to a variation order is to ensure that it is valid. What constitutes a valid variation order is determined from the conditions of contract.

It is all too easy for casual remarks to be construed as variations or for the scope of oral orders to be misunderstood. Such problems of communication lead to disputes and claims with all their attendant effects on all parties. Abrahamson (133) estimates that most of the employment given the legal profession by Engineering work is to do with disputes about variations. Both the ICE and the JCT forms have sought to regularize the issue and acceptance of variations

by requiring them to be given or confirmed in writing.

One of the first tasks which need to be undertaken soon after possession of site is the establishment of clear channels of communication in general between the establishments of the Employer's supervisory team and the Contractor's organisation on the one hand and within the Contractor's organisation on the other (133, 134). In particular there is an absolute need to agree to procedures to be adopted with regards to variations. Questions which need answering include:

- \* Who can issue variations?
- \* How should variations be communicated?
- \* What records should be kept and by whom?
- \* How should the Contractor apply for variations which are considered necessary and who in the Contractor's organisation should be responsible for doing so?
- \* When should measurement be carried out?

### 7.3.1 THE JCT FORM

The procedures for giving effect to variations are as follows:

- (i) Where the Architect issues a written variation order in the first place it takes immediate effect subject to



the Contractor's right to object under Clause 4.1.

- (ii) If the instruction in which the variation is conveyed is not in writing, the Contractor is obliged to confirm it within 7 days of its being given. If within 7 days and before the Contractor actually confirms the instruction, the Architect confirms his instruction it takes effect from the date of such confirmation.
- (iii) If (a) the Architect gives an oral instruction and (b) the Contractor confirms it in writing within 7 days of its being given and (c) the Architect does not respond within 7 days of receipt of the Contractor's letter of confirmation, the variation order is deemed to take effect at the end of the latter 7 days.
- (iv) The Architect may later confirm an oral instruction complied with by the Contractor without due confirmation and the variation order will be deemed to have taken effect on the day the oral instruction was given.
- (v) The Contractor carries out a variation without any instructions at all and the Architect sanctions it.
- (vi) Where the Contractor raises reasonable objections to an instruction that instruction does not take effect.



### 7.3.2 THE ICE CONDITIONS

Basically the same requirements on valid instructions are demanded by the ICE Contract under Clause 51. The main difference is that no time limits are expressly laid down.

There is a need to check that the nature of the variation is within the scope of the variation clause. For instance, the contract does not permit work intended to be done by the Contractor to be taken away from him so as to be done by a different Contractor unless such work was initially covered by a provisional sum.

### 7.4 THE FORMAT OF VARIATION ORDERS

None of the standard forms lays down any specified format for variation orders. According to Wainright and Wood (142) any of the following could be a valid variation order:

- \* a variation in the form of a letter signed by the Architect,
- \* a drawing showing variations and signed by the Architect,
- \* an unsigned drawing showing variations dispatched with a covering letter signed by the Architect.

However Architects and Engineers have special printed forms on which variations are often issued

in triplicate, one copy being sent to the Contractor, the second to the Quantity Surveyor/Measurement Engineer and the third copy is retained by the Architect/Engineer. The forms have the advantage of maintaining a uniform, complete, orderly and distinctive approach.

## 7.5 MEASUREMENT OF VARIATIONS

Most variations have effects on the Contract Sum and the value of work executed to date. In order to adjust the Contract Sum and valuations accordingly, measurement of the affected work is often necessary. Such measurement may be done from drawings or, if drawings are not available, by physically measuring the substituted work on site after it has been carried out.

Seeley (140) advises that it is good practice for the Quantity Surveyor to arrange to meet the Contractor's representative<sup>e</sup> at the beginning of the Contract to discuss the procedures to be adopted with regard to variations. Where varied work is likely to be covered up before the next measurement the responsibility to keep clear and accurate records on it should be established and seen to be discharged properly.

Varied work should be measured as soon as it is convenient. According to Seeley (140) early measurement of variations not only allows them to be included in interim valuations but also improves

the chances of completing the final account on time. However, Willis and Willis (150) caution that it is not always advisable to start too soon on measurement of variations when future developments are likely to affect the measured work.

Willis and Willis (150) propose the use of the following guidelines when measuring variations:

- (i) The Quantity Surveyor should have with him during measurement the Architect's instructions or lists of items of variations compiled for which variation orders will be required.
- (ii) As a general principle adjustment will be made by measuring the item as built and omitting the corresponding measurement from the original dimensions before the variation.
- (iii) It is important to keep omissions and additions separate.
- (iv) Each item of variation should be headed with a brief description and instruction number if known.
- (v) It is not essential that omissions and additions shall be set down in the dimensions book at the same time as the additions are measured. It is more usual whilst on the site to measure the 'additions', leaving the 'omissions' to be looked up and put down in the office.



- (vi) Where the variation involves specialist work a copy of the specialist's estimate accepted should be submitted to the Quantity Surveyor to be used as a reference during measurement of the work involved.
- (vii) Where an item of variation has not yet been accepted it may be necessary to measure for it pending any settlement particularly if the work is to be subsequently covered up. However, the value of such work should not be included in valuations until a valid variation order covering it has been issued.

Though these guidelines are proposed in the context of building work, they may be applicable to civil engineering construction.

There are two main methods of recording the details of variations during measurement (142). A sample produced by the first method is shown in Appendix 2 whilst that of the second method is shown in Appendix 3. The second has the advantage that it involves less subsequent procedures in drawing up Bills of Variations which are discussed in Section 7.8

## 7.6 PRINCIPLES OF VALUING OF VARIATIONS

The principles of valuing variations summarized from the Conditions of Contract are shown



in Table 7.1

## 7.7 FACTORS AFFECTING THE VALUATION OF VARIATIONS

The ease with which variations are valued are influenced by the following factors (31):

- \* the consistency of the Contract Bills,
- \* the availability of the analysis of the tender,
- \* the pricing method adopted on the contract,
- \* errors in the Contract Bills.

### 7.7.1 CONSISTENCY OF PRICES IN CONTRACT BILLS

The valuation of variations can be very difficult and contentious if the prices in the bills are inconsistent. An example of possible inconsistency is where the price of an item in one part of the Bill is three times the price of the same item in another part. Trickey (31) writes that it is in the interest of both the Contractor and the Employer to resolve any such inconsistencies before signing the contract.

An item of work can have different prices under different locations in the Bill but the difference should be capable of explanation. McCaffer and Baldwin (123) write of tactical approaches to estimating whereby contractors carry out rate loading with the aim of improving upon their cashflow. Loading of rates implies raising the rates in some parts of the bill and

Table 7.1: RULES/PRINCIPLES FOR VALUING VARIATIONS

| TYPE OF VARIATION  | VALUATION RULE/<br>PRINCIPLE  | JCT<br>CLAUSE | ICE<br>CLAUSE |
|--|---|---------------|---------------|
| (1) Omitted Work   | Contract Bill rates<br>and prices   | 13.5.2        | 52(1)         |
| (2) Additional and<br>substituted works<br>that can be properly<br>valued by measure-<br>ment:<br>(i) work of<br>similar character<br>to, and with<br>quantities not<br>changed signifi-<br>cantly from those<br>in the Contract | Contract Bill rates<br>and prices   | 13.5.1.1      | 52(1)         |
| (ii) As above but<br>quantities signifi-<br>cantly changed and/<br>or work not<br>executed under<br>similar conditions   | Contract Bill rates<br>and prices to be<br>used if applicable<br>with fair allowance<br>for changed<br>conditions | 13.5.1.2      | -             |
| (iii) Work not of<br>a similar character<br>to that in the<br>Contract Bills   | fair rates and<br>prices  | 13.5.1.3      | -             |
| (iv) Work not of<br>similar character<br>or not executed<br>under similar<br>conditions to those<br>in the Contract<br>Bills   | Contract Bills to<br>be used as a basis<br>of valuation if it<br>is reasonable to<br>do so                        | -             | 52(1)         |
| (3) Additional or<br>substituted work<br>which cannot be<br>properly valued by<br>measurement  | daywork   | 13.5.4        | 52(3)         |
| (4) Variations other<br>than omissions,<br>additions or sub-<br>stituted work  | fair valuation  | 13.5.6        | 52(2)         |

Table 7.1: Continued

| TYPES OF VARIATION   | VALUATION RULE/<br>PRINCIPLE                          | JCT<br>CLAUSE | ICE<br>CLAUSE |
|--|---|---------------|---------------|
| (5) Work for which it is unreasonable to apply Contract Bill rates and prices or to use them as a basis of valuation | Fair valuation  | 13.5.6        | 52(2)         |
| (6) Work for which the conditions of execution have been changed by a variation                                      | Treat as if that work were the subject of a variation | 13.5.5        | -             |
|  | Fair valuation  |               | 52(2)         |



decreasing the prices in others correspondingly. For instance, to reduce his capital lock up a contractor may increase the rates of work to be executed early in the contract period by a percentage. To keep his tender at the same level of pricing he can remove the total addition made as a result of the percentage increase by decreasing the prices of some of the work to be done later by an appropriate percentage. Where the prices of work to be done early are increased in this manner the exercise is referred to a front end rate loading (123).

Back end rate loading is the opposite of front end rate loading. Here the prices of work to be done towards the end of the contract period are increased at the expense of work to be done at the beginning. The result would be to increase his capital lock up. A situation where a contractor may wish to gamble in this fashion is where the cost of borrowing is low and the rate of inflation is so high that the contractor stands to gain by improved additional payments due to inflation.

When the contractor had loaded his rates inconsistencies may result. It is the duty of the Promoter's professional advisers to undertake a detailed inspection of the prices to identify possible inconsistencies which should then be taken up with the Contractor before signing the contract.



Seeley (140) advises that work sectional price differences of the order of 25% should be investigated. The reasons for this advice is that where the prices of work affected by a variation are subject to this type and order of differences its valuation may present problems.

### 7.7.2 AVAILABILITY OF TENDER ANALYSIS

The importance and uses of the analysis of the Contractor's tender are discussed in Chapter 8.

### 7.7.3 PRICING

The main problem with variations is that changes to the work from what was originally planned may produce changes of total cost which are unrelated to changed quantities. According to Barnes (29) the extent of this problem depends on how closely the Contract Bills model the parameters of the cost of the work. Where the Bill is not properly compiled and completed by tenderers variations can lead to claims which bring with them a climate of contention. Barnes (29) writes that variations arising in those circumstances invalidate the Contractor's financial control procedures and lead to delays in final accounts settlements.

On the whole the solution prescribed (29) for the problem is based on a recognition of 3 types of costs in the Bill of Quantities:-

- \* costs that vary proportionally to the length of time over which the associated permanent works are being executed, e.g. equipment rentals, and running and operating costs;
- \* costs which are fixed where the quantities of the associated permanent work may vary within defined limits, e.g. costs of setting up and of removal;
- \* costs which vary proportionally to the quantities of the permanent works, e.g. costs of providing some materials.

The rationale behind this approach may be demonstrated by the following analysis of an operation: There is a fixed cost in any operation which is the cost of setting it up, of finishing it off and of working up to, and down from the steady output of the plant and labour involved. The total cost of the operation may then be approximated by the equation:

$$CT = K + Cq \quad (29)$$

where

CT = cost of the operation,

K = a constant for the fixed cost,

q = quantity of the permanent work in the operation, and

C = cost/unit quantity.

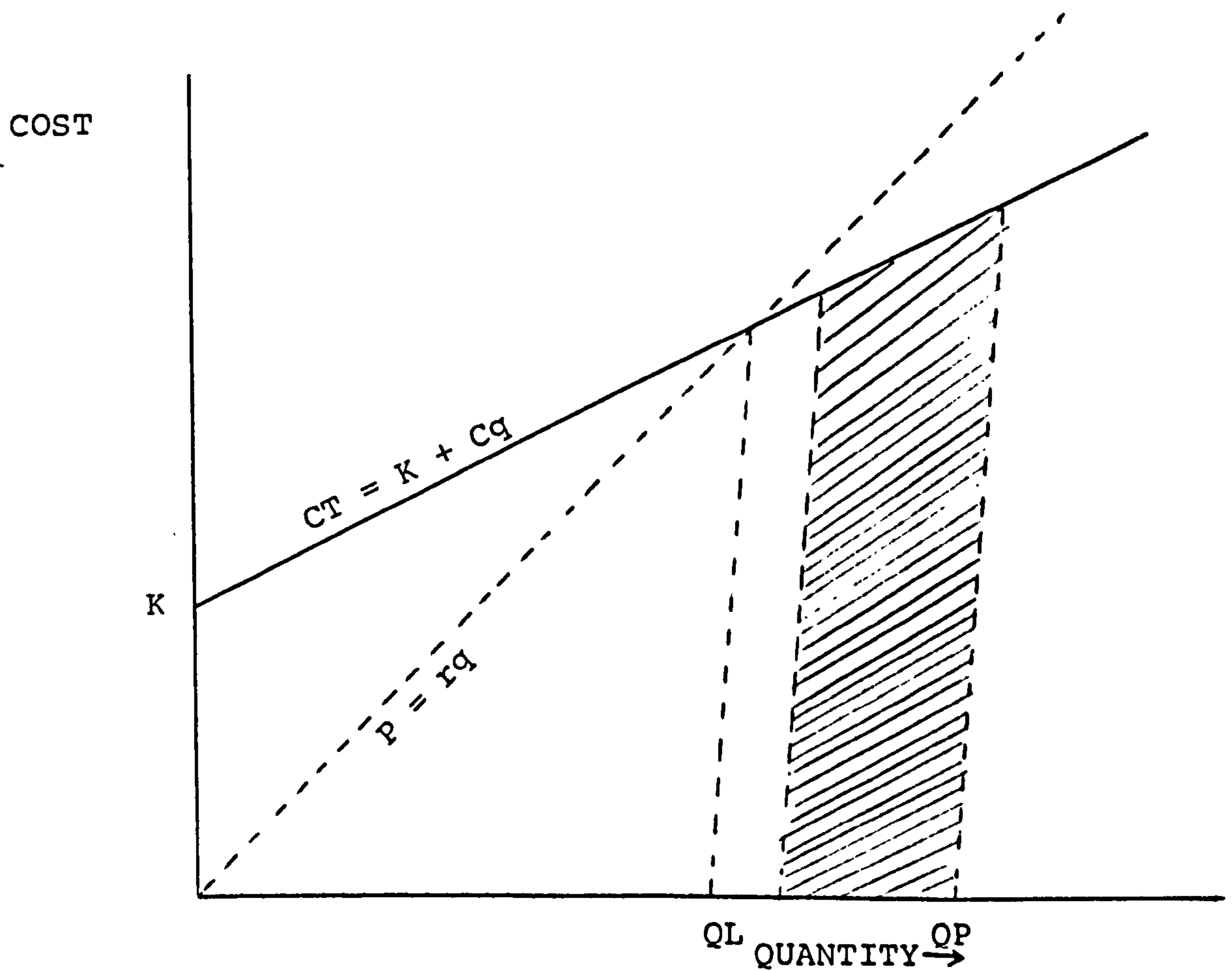


Figure 7.1: Cost-Quantity Relationships

The traditional bill of quantities has sought to represent the value of the operation as proportional to the quantity of the associated permanent work, i.e.

$$P = rq \quad (29)$$

where

$P$  = value of the operation,

$r$  = unit rate in the bill of quantities, and

$q$  = quantity of the associated permanent work.

It can be seen from Figure 7.1 that should the quantity turn up to be less than  $Q_L$  the Contractor will be under-recovering his fixed cost. On the other hand if the quantity of work is more than  $Q_P$  the Employer will have to make excessive payments to the Contractor.

The approach advocated is to represent the value as:

$$P = f + rq$$

where

$P$  = value of the operation,

$f$  = fixed charge for the fixed cost,

$r$  = unit rate, and

$q$  = quantity.

The relationship of price and quantity is then as shown in Figure 7.2.

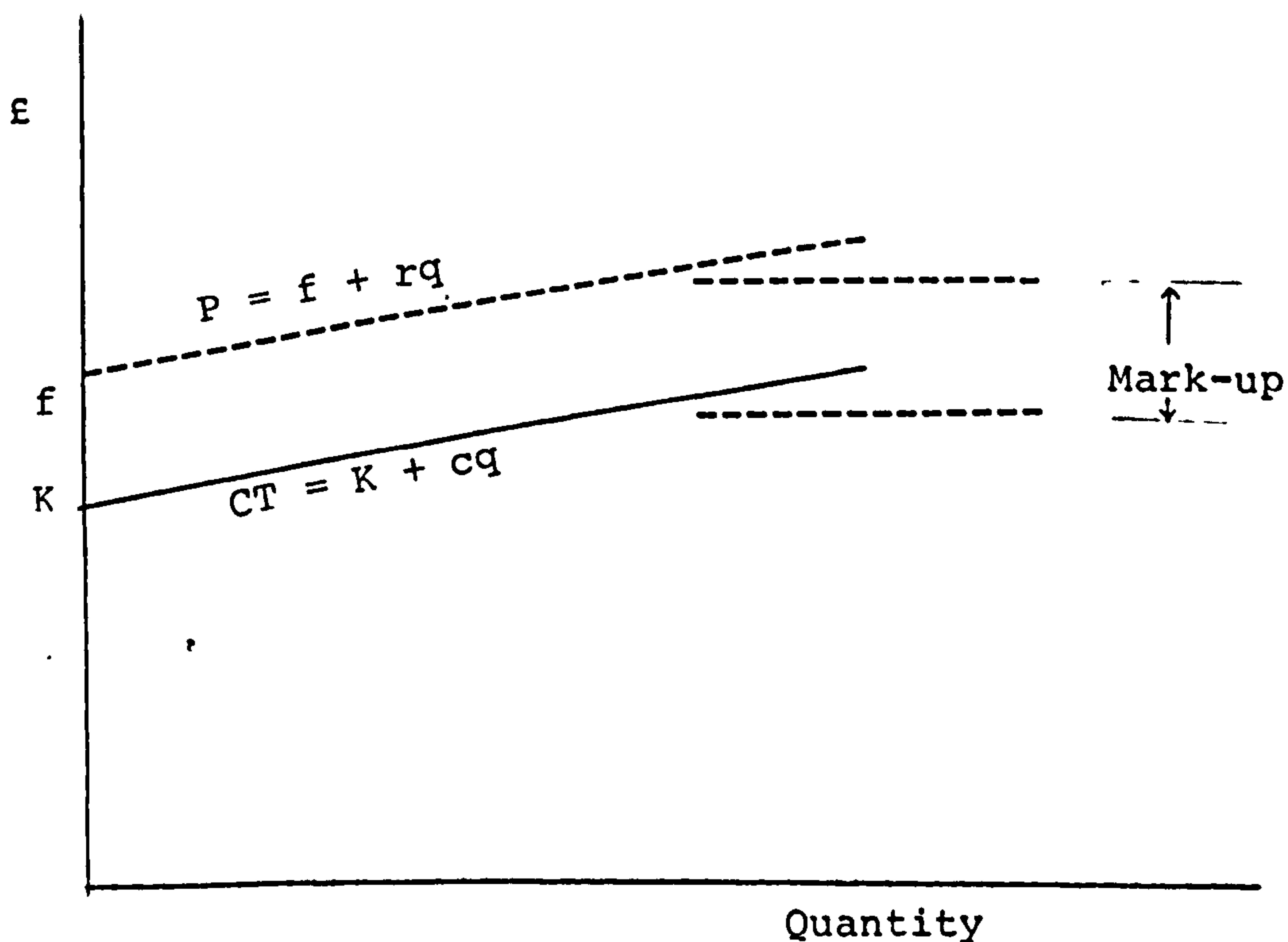


Figure 7.2: Recommended Cost-Price-Quantity Relationship.



It can be seen that this relationship of price and quantity is valid for a wider band of quantities and therefore variations may not always result in adjustment of bill rates.

An example to demonstrate the importance of the method of pricing to the valuing of variations is shown by the two alternative pricings of 2000 m<sup>3</sup> of a given grade of concrete given below.

Drawing on the same calculations shown in Figure 7.3, the traditional bill of quantities would provide for the concrete as shown in Figure 7.4, whilst Figure 7.5 shows the recommended approach. Suppose a variation is made which changes the quantity of concrete so much that a change of plant is made necessary. With the traditional method the whole build-up would be necessary to establish a new rate. With the recommended method the last two items may not be affected. The effect on the Contractor's method of working is thus more observable and thus makes the rate fixing that much easier to carry out and agree with.

#### 7.7.4 ERRORS IN THE CONTRACT BILLS

There are two categories of errors recognized by the JCT and the ICE Standard Forms:

- \* errors in descriptions of quantities or omissions of items from the Contract Bills sent to the tenderers (Errors in Pre-tender Bills),
- \* computational errors made by the Contractor

|   |  |                 |                          |
|---|--|-----------------|--------------------------|
| <i>(i) Fixed Charges</i>  |  | £               | £                        |
| Cost of setting up and removal of concrete mixing plant             |  | 10,000.00       |                          |
| plus 15% overheads/profit   |  | <u>1,500.00</u> | 11 500.00                |
|   |  | 11,500.00       |                          |
| <i>(ii) Time-Related Charges</i>                                    |  |                 |                          |
| Hiring, running and operating costs for 40 weeks @ £500.00 per week |  | 20,000.00       |                          |
| plus 15% overheads/profit   |  | <u>3,000.00</u> | 23 000.00                |
|   |  | 23,000.00       |                          |
| <i>(iii) Materials</i>  |  |                 |                          |
| Coarse Aggregate @ £18/m3   |  |                 |                          |
| 0.84 m3 x 18  |  | 15.12           |                          |
| Sand @ £18/m3   |  |                 |                          |
| £18 x 0.53m3  |  | 9.54            |                          |
| Cement @ £49/tonne  |  |                 |                          |
| 0.304 tonne x 49  |  | <u>14.90</u>    |                          |
|   |  | 39.56           |                          |
| 15% overheads/profit  |  | <u>5.93</u>     |                          |
|   |  | 45.49           |                          |
| 2000 m3 @ £45.49/m3   |  | 90,980.00       | 90,980.00                |
| <i>(iv) Labour mixing, transporting and placing</i>                 |  |                 |                          |
| For 1 m3 of concrete  |  |                 |                          |
| 4.50 namhours @ £4.60/hour  |  | 20.70           |                          |
| Plus 15% overheads/profit   |  | <u>3.11</u>     |                          |
|   |  | 23.81           |                          |
| Labour for 2000 m3  |  | 47,620.00       | <u>47,620.00</u>         |
| Total Value   |  |                 | <u><u>173,100.00</u></u> |
| Total Cost:   |  |                 |                          |
| = £(10.000 + 20,000 + 39.56 x 2000 + 20.70 x 20000)                 |  |                 |                          |
| = £(10,000 + 20,000 + 79,120 + 41,400)                              |  |                 |                          |
| = £150,520  |  |                 |                          |
| Value/m3 = £87.55   |  |                 |                          |

Figure 7.3: Pricing Calculations

in his tender (Contractor's errors).

#### 7.7.4.1 ERRORS IN PRE-TENDER BILLS

Where both the Employer's supervising team and the Contractor's team agree that there has been such errors the forms make categorical provisions. Under Clause 55(2) of the ICE Conditions and Clause 2.2.2.2 of the JCT Form such errors are to be corrected and the affected work valued in the same manner as variations.

Whether or not there has been an omission from the Contract Bills may sometimes be subject to disagreement. The supervising team can always claim that an item alleged missing is included in other Bill items. This brings up the knotty question of exactly what operations are covered by a particular Bill item. Abrahamson's (133) answer to the question is that the work included in an item must be decided by reference to the ordinary meaning of the words used in the item, with the help of the method of measurement and standard legal rules of interpretation.

#### 7.7.4.2 CONTRACTOR'S ERRORS

Both forms bind the Contractor and the Employer to this type of error (Clause 55(2) of the ICE Conditions and Clause 14.2 of the JCT Form. On this point the conditions are simply



| ITEM | DESCRIPTION                                  | UNIT | QUANTITY | RATE  | AMOUNT     |
|------|--|------|----------|-------|------------|
|      | Concrete<br>(1:2:4) and<br>19mm<br>Aggregate | M3   | 2,000.00 | 87.55 | 173,100.00 |

Figure 7.4: Traditional Billing

| ITEM | DESCRIPTION   | UNIT | QUANTITY | RATE  | AMOUNT    |
|------|---|------|----------|-------|-----------|
| 1    | Setting up<br>and removal<br>of concrete<br>mixing plant      | Sum  |          |       | 11,500.00 |
| 2    | Hiring,<br>running and<br>operating<br>concrete<br>plant      | Sum  |          |       | 23,000.00 |
| 3    | Provision of<br>concrete<br>(1:2:4) and<br>19 mm<br>Aggregate | M3   | 2,000.00 | 45.49 | 90,980.00 |
| 4    | Placing of<br>concrete<br>(1:2:4) and<br>19 mm<br>Aggregate   | M3   | 2,000.00 | 23.81 | 47,620.00 |

Figure 7.5: Recommended Billing



restating the common law position, anyway.

However, under the common law where the Employer or his professional advisers had discovered what was palpably an error in the contractor's prices before accepting the tender, the rates may not be binding (35, 133). This follows from the general legal principle that where one party (offeror) makes an offer containing a material mistake as to his intentions, and the other party (offeree) knows, or is deemed to know, there may be no contract if the offeree purports to accept the offer.

Whether a particular 'mistake' is indeed a genuine error or the result of motives or assumptions underlying the tender is not easy to decide. Two factors tend to make it difficult to decide when there is a genuine error. The first is tactical estimating discussed in Section 7.7.1. The second relates to Contractors' mark-up considerations. Marks, Marks, Grant and Helson (145) suggest that a contractor may deliberately underprice his tender just to be in employment at times of fierce market competition for work. The difficulty of the Employer or his professional advisers is deciding what exactly an unusual occurrence in the Bill of Quantities implies is therefore great. Where they do not admit knowledge of a genuine mistake it is unlikely that any court would imply such knowledge on their part

simply on a basis of the level of pricing.

However, there is persuasive precedent from Canada that where the Employer snaps up a low offer the contract may not be binding (143). The Employer's professional advisers may be well advised to follow the procedures recommended in the *Code of Procedure for Single Stage Selective Tendering* (144). That document contains two alternative procedures. One involves contacting the tenderer and asking him to either stand by his tender or withdraw it. The second procedure involves the Employer allowing the Contractor to confirm his tender or correct any error and running the risk of having to accept a higher tender.

Even where an error is binding, some contractors may argue thus: 'I am prepared to stick to my prices in pricing the work in the original Contract Bills but it is unreasonable to expect me to allow them to be used for any extra work' (133). Trickey (31) argues that this position is untenable because the prices in the Contract Bills form part of the contract solely for the purpose of valuing variations and that the Contractor offers to complete the work shown in the Contract Bills for the Contract Sum and also undertakes to carry out variations at the same price levels.

Taking full advantage of all contractual rights may not always be in the best interest of the Employer. Where a Contractor had made a mistake in his tender and is held to it he may resort to claims and sub-standard work to minimise the effect of such errors. Marks et al (145) write that when contracts are undertaken at patently uneconomic prices, the outcome is generally highly unsatisfactory for both parties. For these reasons it may be advisable to let the contractor off the hook to some extent depending on the circumstances.

## 7.8 THE VALUING OF VARIATIONS

Be it a fair valuation or a valuation on the basis of the Contract Bills, Trickey (31) advises that one should ask the question: 'At what rate would the tenderer have priced this item had he known at the stage of tender that the work (now the subject of a variation) was required?' This would entail an examination of the following basic components of the Contract Bills (32):

- \* the labour costs,
- \* the labour output,
- \* costs of materials,
- \* waste factors on materials,
- \* the use of plant,
- \* the level of supervision and preliminary items,



- \* the provision of temporary works,
- \* profit level,

It does seem that one is not entitled to take account of changed market conditions, such as extra costs due to materials becoming scarcer since the tender.

Three principal methods of fixing rates have been identified:

- \* the pro-rata approach,
- \* the Bill Analysis approach,
- \* dayworks.

#### 7.8.1 THE PRO-RATA APPROACH

With this approach new rates are obtained by taking the arithmetic average of two or more Bill rates. The example below based on a procedure by Wainright and Wood (142) illustrates the approach.

| ITEM | DESCRIPTION   | UNIT | QUANTITY | RATE  | AMOUNT |
|------|---|------|----------|-------|--------|
|      | <u>BILL ITEMS</u>   |      |          |       |        |
|      | Concrete (21N/mm <sup>2</sup> )<br>in walls 150 mm<br>thick | m2   | 100      | 8.00  |        |
|      | Concrete (21N/mm <sup>2</sup> )<br>in walls 300 mm<br>thick | m2   | 200      | 15.00 |        |
|      | <u>VARIATION ORDER</u><br><u>ITEM</u>                       |      |          |       |        |
|      | Concrete (21N/mm <sup>2</sup> )<br>in walls 200 mm<br>thick | m2   | 150      |       |        |



CALCULATIONS

1 m3 in wall, 150 mm thick:    £ 8.00 x  $\frac{1000}{150}$  = 53.33    £

1 m3 in wall, 300 mm thick:    £15.00 x  $\frac{1000}{300}$  = 50.00

Extra cost of placing in wall 150 mm thick    3.33

Therefore,

200 mm thick wall:     $\frac{2}{3}$  x £15    10.00

Assuming the cost of placing increases in ratio to the reduction of wall thickness, extra cost of placing:    £3.33 x  $\frac{2}{3}/m^3$

= £3.33 x  $\frac{2}{3}$  x 2/10/m<sup>2</sup>    0.44

Rate for new item    10.44

7.3.2 THE BILL ANALYSIS APPROACH

This approach is illustrated in Figures 7.6 and 7.7. Figure 7.6 shows that a variation has changed the thickness of a slab from 125mm to 175mm. The fixing of a new rate for the new item based on the analysis of a Bill item is shown in Figure 7.7.

| ITEM | DESCRIPTION  | UNIT           | QUANTITY | RATE  | AMOUNT    |
|------|--|----------------|----------|-------|-----------|
|      | <u>BILL ITEM</u>                                       |                |          |       |           |
|      | Concrete (30N/MM <sup>2</sup> )<br>in slab 125mm thick | m3             | 200      | 48.00 | 9.6000.00 |
|      | <u>VARIATION ITEM</u>                                  |                |          |       |           |
|      | Concrete (30N/mm <sup>2</sup> )<br>in slab 175mm thick | m <sup>3</sup> | 150      |       | 7,027.50  |

Figure 7.6: A Variation of Slab

Information from Bill build-ups:

(i) allowance for overheads and profit: 15%  
addition on direct costs

(ii) All-in labour rate: £2.00/hour

(A) Analysis of Bill Item

|   | £           |
|---|-------------|
| Bill rate   | 48.00       |
| 15% overheads/profit $\frac{15}{115} \times £48.00$ | <u>6.26</u> |
|   | 41.74       |

Labour placing: 9 man/hour

@ £2.00/man hour 18.00

Cost 1m<sup>3</sup> of Concrete at mixer 23.74

(B) Build-up of New Rate

Cost of 1m<sup>3</sup> of Concrete at mixer 23.74

Labour placing, say 8.5 man hours

@ £2.00/hour 17.00  
40.74

15% overheads/profit 6.11

Rate for variation item 46.85

Figure 7.7: Rate-fixing by Analysis of Contract Bills

### 7.8.3 DAYWORKS

Daywork is a method of paying for work based on the prime costs of all labour, materials and plant used in carrying out the work, normally with a percentage addition to the total cost of each of these three resource groups for overheads and profit. From time to time, particularly when carrying out work in connection with adjacent buildings, it is necessary to undertake certain activities which by their nature cannot be measured and valued at bill rates. Typical examples include removals of obstructions and works of modification.

The ICE conditions (Clause 52 (3) and the JCT (Clause 13.5.4) Forms prescribe rules/principles for the valuation of variations that cannot be properly valued by measurement. The pre-tender procedures necessary to define the framework within which these rules/principles are applied are discussed below.

#### 7.8.3.1 PRE-TENDER PROCEDURES

The pre-tender procedures concern the definition of the method of calculating payments to be made on account of dayworks and how to allow for expected dayworks in the Contract Bills.

#### 7.8.3.1.1 THE JCT FORMS

By Clause 13.5.4.1 payment for dayworks is to be calculated in accordance with the *Definition of Prime Costs of Daywork Carried out Under a Building Contract (147)* issued by the RICS and the National Federation of Building Trades Employers (NFBTE) which was current at tender. Where the work is of a specialist nature, by Clause 13.5.4.2, payment is to be calculated in accordance with a definition of prime cost of daywork issued by the RICS and the appropriate body representing workers in the specialist trade current at the Date of Tender.

If the Contractor would desire to be paid more or less than the amounts obtained by applying the definitions above he is expected to insert his percentage additions or deductions on labour, materials and plant in the Bill of Quantities.

#### 7.8.3.1.2 THE ICE CONTRACT

The Contractor is to be paid for dayworks under the conditions and at rates and prices contained in a Dayworks Schedule which should be specified at the pre-contract stage. There are three procedures for producing the



Schedule (29):-

- (i) procedure (a) in paragraph 5.6 of the CESMM is the use of an *ad hoc* schedule of resources and conditions of payment compiled specifically for the particular contract;
- (ii) procedure (b) of paragraph 5.6 of the CESMM is the use of the Federation of Civil Engineering Contractors' (FCEC'S) schedule (148) with provisions for adjustment of rates by percentages inserted by the tenderer;
- (iii) The third method, not directly mentioned in the CESMM, is where a Dayworks Schedule is not in the Bill of Quantities at all. The effect of this situation is that the FCEC'S Schedule is used without adjustment (Clause 52(3)).

Under paragraph 5.7 of the CESMM provisional sums for work executed on a dayworks basis may be given comprising separate items for labour, materials and plant. Where the FCEC'S Schedule is to be used and provisional sums have been provided for labour, materials and plant, then each of the provisional sums should be followed by a separate item to cover the additional payment due to adjustments of the prime costs by the percentages inserted

by the tenderer. The amount for adjustment items are to be determined by multiplying the corresponding provisional sums by their percentage adjustment inserted by the tenderer.

#### 7.8.3.2 PROCEDURES FOR DETERMINING PAYMENTS

The procedures for the JCT and ICE Contracts are described below.

##### 7.8.3.2.1 THE JCT FORM

The Contractor is expected to deliver to the Architect, not later than the end of the week following that in which the work was done, vouchers on dayworks (Clause 13.5.4.2). Such vouchers should specify all resources and other supervisory personnel employed, and are usually called time sheets or dayworks sheets.

##### 7.8.3.2.2 THE ICE FORM

Before he orders any materials expected to be used on dayworks the Contractor is required to submit quotations covering them to the Engineer for his approval.

As dayworks are carried out the Contractor is also expected to submit to the Employer each day a list in duplicate of resources employed on daywork that day. Plant covered

by the percentage adjustment to prime costs are not to be included in the list. The Engineer is required to check these lists and, if they are properly compiled, to sign one copy of each list and return it to the Contractor.

At the end of each month the Contractor draws up a priced statement covering all the lists for the month for inclusion in his valuations.

Though the Engineer still has power to include in payments for dayworks in respect of which the Contractor has failed to comply with the requirements there is a need to make detailed arrangements for proper rendering of dayworks sheets.

### 7.8.3.3 THE PREPARATION OF DAYWORKS SHEETS

Gerrity (149) lays down certain guidelines for the preparation of dayworks sheets. Though they refer to the JCT Contract in particular they are also applicable to dayworks under the ICE Conditions. The very important guidelines include:

- (i) Each dayworks sheet must relate to a specific instruction of the Architect and its reference number must be stated.
- (ii) Dayworks sheets should be submitted to



the Architect or his representative for signature. Nominated Sub-contractors should first submit their vouchers to the Main Contractor who will then include his own attendance and submit new vouchers to the Architect.

- (iii) Dayworks sheets should be submitted within the time limits set down in the Conditions of Contract. This means dayworks records must be prepared weekly. Sub-contractors must be informed of the procedure and of the day on which their own vouchers must be submitted.
- (iv) Dayworks sheets should properly describe the work done.
- (v) Dayworks sheets should cover plant, materials and labour and should describe them.
- (vi) The names of operatives as well as hours spent on dayworks will usually be required on dayworks sheets. Sub-contractors should be asked to provide similar details.
- (vii) The status of operatives should be stated.
- (viii) Dayworks sheets must be produced in triplicate.

In general Gerrity (149) emphasizes that



it is very easy to forget obvious information when preparing dayworks sheets. Examples of things easily forgotten include scaffolding, storing, special formwork with one possible use, and time spent in sharpening tools. To prevent this, supervisory staff need to pay careful attention to activities involved in dayworks.

A sample dayworks sheet is shown in Appendix 4.

#### 7.8.3.4 DAYWORKS ACCOUNTS

Dayworks accounts are built from dayworks sheets and included in valuations. The accounts will usually be checked by the Employer's team to ensure that every detail is in accordance with the conditions before including them in valuations (140). Matters checked include:

- \* that the dayworks have properly sanctioned;
- \* the rates for resources are according to the Schedule of Dayworks;
- \* the sheets have been properly signed;
- \* the valuation of work covered by daywork is not duplicated in the Bill of Quantities or claims;
- \* inconsistencies and arithmetical errors.

Any matters arising from such checks are

usually taken up with the Contractor's representative.

#### 7.8.3.5 PAYMENT FOR DAYWORKS

Under the JCT Form dayworks payments are to be included in interim certificates and final accounts but whether or not any particular daywork is subject to retention depends on the work covered. If the activity is normally subject to retention then amounts in respect of such work done on a dayworks basis would be subject to retention and vice versa. For instance, if the Contractor makes good, on a dayworks basis, faulty work for which he is not responsible the amount in respect of such work is not subject to retention. This is so because under Clause 30.2 that type of work is not subject to retention.

Under the ICE conditions all dayworks payments are also included in interim and final certificates and are always subject to retention (Clause 60(2)(a)).

#### 7.9 BILLING OF VARIATIONS

A bill, called a Bill of Variations, is usually drawn up from details of variations recorded during measurement. A sample bill of variations is shown in Appendix 22.

Wainright and Wood (142) advise that no attempt should be made to square out the dimensions as the variations are recorded. One of the reasons is that a more suitable sub-division of the work into items which may later have to be devised in order to easily explain the variation account to interested parties (e.g. Employers, auditors) may not correspond with the measurement as recorded. For instance, there may be one order for increasing the size of storage tanks, another for omission of a drinking water point and a third for the addition of lavatory basin. Each of these will be measured as separate items, but they may be conveniently grouped as 'Variations on plumbing works'.

Where a variation is small it can be billed directly from the dimensions but where the variation is complex it may be necessary to draw up an abstract.

## 7.10 SUMMARIES OF VARIATIONS

An example of the summary of variations is shown in Figure 7.8. The summaries may be contained in payment certificates or they may be drawn up in separate documents.

| VARIATION<br>ORDER<br>NUMBER | DATE OF<br>ISSUE | ADDITION<br>£ | OMISSION<br>£ |
|------------------------------|------------------|---------------|---------------|
| 1                            | 1/1/85           | 3500          | -             |
| 2                            | 25/2/85          | -             | 2000          |
| 3                            | 9/11/85          | 5000          | 150           |
|                              |                  | 8500<br>3500  | 3500          |
|                              |                  | 5000          |               |
|                              |                  |               |               |

Figure 7.8: An Example of a Summary of Variations.

Summaries of variations are most often used as supporting evidence for payment applications. Where for any reason any interested party needs more detailed information than is contained in the summary additional documents such as the variation order, rate-fixing calculations, site measurements of variations and Bills of Variations may be called for.



## CHAPTER EIGHT

### THE VALUATION OF CLAIMS

This chapter contains a review of the situations when the Contractor may submit claims for additional payments, the procedures to be complied with and methods of quantifying his claims.

This is organised under the following headings:

- \* Definition of a Claim,
- \* Causes of Claims,
- \* Types of Claims,
- \* Authority of the Architect/Engineer on Claims,
- \* Contractual Provisions for Additional Payments,
- \* Common Heads of Claims,
- \* Notices of Claims Under the ICE Conditions,
- \* Notices of Claims Under the JCT Forms,
- \* Evidence of Support Claims,
- \* The Presentation of Claims
- \* Negotiation of Claims,
- \* Beyond Claims.

## 8.1 DEFINITION

The term 'claim' has assumed widespread usage within the construction industry even though it does not appear in any of the standard forms.

There is a welter of definitions for it. A dictionary (32) definition is that it is 'a demand for something supposed due' whilst the *Civil Engineering Procedure* (88) defines it as a dispute where the Contractor has objected to a decision of the Engineer. The last two definitions would include a miscellany of rights and obligations, not necessarily monetary, allowed for under the particular contract.

In this dissertation the term refers to all those occurrences during a construction contract which potentially give rise to differences of opinion as the Contractor's and, to a lesser extent, the Employer's monetary entitlement.

## 8.2 CAUSES OF CLAIMS

According to Green (45) claims occur for the following reasons:

- \* projects are not always fully designed prior to tender leading to variations;
- \* errors occur in the quantities and descriptions of items in the Bill of Quantities;
- \* actions of the Architect or the Employer may delay the project;

- \* the Employer may stop or abandon the project;
- \* the Employer may breach one of the contract conditions.

### 8.3 TYPES OF CLAIMS

Powell-Smith and Sims (30) identify four main classes of claims:

- \* Contractual claims;
- \* Common law claims;
- \* *Quantum Meruit* claims;
- \* *Ex gratia* claims.

#### 8.3.1 CONTRACTUAL CLAIMS

These are claims that arise from express or implied provisions of the particular contract, e.g., for 'direct loss and/or expense' under certain clauses of the JCT Standard Forms and costs incurred due to late drawings under Clause 7(3) of the ICE Contract.

#### 8.3.2 COMMON LAW CLAIMS

These are claims for damages for breach of contract at common law and/or legally enforceable claims for breach of some other aspect of the law, e.g. in tort. Entitlement to some of such claims are expressly provided for in some of the standard forms, e.g. JCT 80 Clause 26. As a

general rule, the parties who have entered into a contract will not lose their common law rights on any issue unless either:

- (i) the terms of the contract make clear rules on the issue in which case the common law rights are superseded; or
- (ii) a term in a standard form which would have covered such rights has been deleted by agreement between the parties: *Mottram Consultants Ltd. v. Bernard Sunley & Sons Ltd.* (34).

Even where a specific contractual term makes clear provisions on an issue it may be invalidated by the *Unfair Contracts Terms Act, 1977* (33).

The common law claim is often resorted to where the conditions to be complied with in making a claim under the provisions of the contract are too onerous.

### 8.3.3 'QUANTUM MERUIT' CLAIMS

*Quantum meruit* is latin for 'as much as he has earned'. A plea for *quantum meruit* provides a remedy for a party who has carried out work for which no price has been agreed or the original contract has been replaced by a new one and payment is claimed for the value of work done under the substituted contract.



### 8.3.4 'EX GRATIA' CLAIMS

An *ex gratia* (out of kindness) claim is one in which the Employer is not legally obliged to meet. For example, an employer might find it cheaper to make *ex gratia* payment to save a contractor from insolvency where the cost of completing the work in the event of the liquidation/bankruptcy would be more than the amount of the *ex gratia* payment.

## 8.4 AUTHORITY OF THE ARCHITECT/ENGINEER ON CLAIMS

Under the JCT and ICE Standard Forms the powers of the Architect/Engineer are limited as regards dealing with claims in general. They can certify for payment only sums which express terms of the contracts authorize them to do so.

## 8.5 CONTRACTUAL PROVISIONS FOR ADDITIONAL PAYMENTS

The standard forms make provisions for the payment to the Contractor of monies additional to those provided for in the Contract Bills in defined situations. Where there is agreement between the two teams at site such monies are included in valuations as provided for in the particular contract. It is only when there is disagreement, actual or potential, as to the amount that claims arise.

### 8.5.1 POTENTIAL CLAIMS UNDER THE JCT FORMS

The provisions are:

- Clause 6.2: Statutory fees and charges not allowed for in the Contract Bills and which do not cover work executed or materials or goods supplied by a local authority, statutory undertakers or Nominated Sub-contractors/Suppliers.
- Clause 8.3: The cost of opening up for inspection any work covered up or the testing of materials or goods and the cost of making good, unless the test or inspection shows that the work materials or goods are not in accordance with the Contract.
- Clause 9.2: Liability in respect of any infringement of patent rights.
- Clause 13.5.6: Any direct loss or expense that is not reimbursable by virtue of the valuation of variations.
- Clause 17.2 and 17.3: The cost of making good defects that appear within the Defects Liability Period, such defects not being the responsibility of the Contractor.

Clause 22.C.1.1 and 2: The cost of insurance premiums in respect of existing structures.

Clause 26.1: Any direct loss and/or expense resulting from disturbance of the regular progress of the works, caused by any of the following matters:

- \* late instructions, drawings, details or levels;
- \* any discrepancy in or divergence between the Contract Drawings and/or the Contract Bills;
- \* work not forming part of the Contract;
- \* supply or failure to supply materials and goods by the Employer.
- \* postponement of work;
- \* failure to give ingress to or egress from the site;
- \* variations and work against provisional sums.

Clause 28.2: Direct loss or damage arising out of the determination of the Contract by the Contractor upon the default of the Employer.

Clause 34.3      Loss or expense in dealing with  
                         antiquities found on the site.

Clause 37: fluctuations.

### 8.5.2 POTENTIAL CLAIMS UNDER THE ICE CONDITIONS

The provisions are summarized in Table 8.1 where cost has the meaning defined under Clause 1(5). It should be noted that only clauses 12 and 65(6)(b) categorically state the Contractor's entitlement to profit. Other situations in which the Contractor is considered entitled to profit are based on the interpretations of the clauses by Abrahamson (133).

## 8.6 COMMON HEADS OF CLAIMS

The following are the common heads of claims  
(30, 31, 38):

- \* on-site establishment costs (on-site overheads),
- \* Head Office overheads (off-site establishment costs),
- \* Loss of profit,
- \* Inflation costs,
- \* Interest/Financing charges,
- \* Cost of disruption,
- \* Cost of preparing claim.



TABLE 3.1: SUMMARY OF CLAIMS UNDER THE ICE CONDITIONS

| CLAUSE | CAUSE OF CLAIM   | MONETARY ENTITLEMENT   |
|--------|--|--|
| 7(3)   | Delay in issuing drawings and instructions   | costs  |
| 12(3)  | Adverse physical conditions and artificial obstructions which are unforeseeable by an experienced contractor.                | (i) costs of additional work and additional constructional plant plus reasonable profit<br><br>(ii) reasonable costs incurred by reason of unavoidable delay or disruption |
| 13(3)  | Delay due to instructions (including instructions in regard to ambiguities and discrepancies under Clause 5)                 | reasonable costs beyond that reasonably to have been foreseen  |
| 14(6)  | Delay in giving consent to Contractor's method of working or in supply of design criteria                                    | costs  |
| 17     | Rectification of setting out errors resulting from incorrect data supplied by the Engineer                                   | (i) costs<br><br>(ii) reasonable profit (debatable).   |
| 20     | Repair and making good damage, loss or injury arising from the Excepted Risks  | (i) costs to the Contractor<br><br>(ii) reasonable profit (debatable)  |
| 26     | Payment of statutory fees, rates and taxes by the Contractor   | amount paid by the Contractor  |
| 27(6)  | Delay due to variations which involve execution of work in a street, Controlled land or a prospectively maintainable highway | costs reasonably attributable to such delay  |

TABLE 8.1 (Continued)

| CLAUSE | CAUSE OF CLAIM  | MONETARY ENTITLEMENT  |
|--------|---|---|
| 30(3)  | Damage to bridges or highways arising from the transport of materials for which the Contractor is not responsible under the Contract  | costs, charges or expenses attributable to such damage            |
| 31(2)  | Delay arising from Contractor's duty to provide facilities to other contractors of the Employer, authorities and statutory bodies   | cost of such delay which could not reasonably have been foreseen. |
| 32     | Orders of Engineer as the disposal of fossils, coins and articles of geological or archaeological interest found on the site  | expense incurred as a result of such orders                       |
| 36(2)  | Supply by the Contractor of samples not provided for in the Contract  | (i) costs to the Contractor<br>(ii) reasonable profit (debatable) |
| 38(2)  | Uncovering, making openings in or through any part of the works where such work had been executed in accordance with the Contract   | (i) costs to the Contractor<br>(ii) reasonable profit (debatable) |
| 40     | Suspension of the works   | costs to the Contractor   |
| 42(1)  | Failure to give possession of site  | the amount of Contractor's actual cost as may be reasonable       |
| 49(3)  | Execution during the Maintenance Period of works of repair, amendment, reconstruction or rectification where the need for such work arises from a cause for which the Contractor is not responsible | the value of work as if it were additional work.                  |

TABLE 8.1 (Continued)

| CLAUSE | CAUSE OF CLAIM   | MONETARY ENTITLEMENT  |
|--------|--|---|
| 49(5)  | Contractor's liability due to damage, injury arising out of permanent reinstatement of roads and highways undertaken by the appropriate authority after the appropriate Maintenance Period | Indemnities   |
| 50     | Contractor's search for faults ordered by the Engineer where the fault is not the responsibility of the Contractor   | (i) costs to the Contractor<br><br>(ii) reasonable profit (debatable)                       |
| 51(2)  | Variations   | value of such variations determined according to principles contained in Clause 52(1)       |
| 52(2)  | Change attributable to variations of the circumstances or conditions under which any part of the work is to be done  | value, determined by rates fixed by the Engineer  |
| 52(3)  | Work done by day-works   | value determined from dayworks schedule   |
| 55(2)  | Correction of errors in descriptions in the Bill of Quantities   | work actually done to be valued as a variation  |
| 56(2)  | Quantities actually required to be executed being so different from their corresponding quantities in the Contract Bills that the price in the Bills are inapplicable                      | value calculated from new prices determined by the Engineer after consulting the Contractor |



TABLE 8.1 (Continued)

| CLAUSE | CAUSES OF CLAIM  | MONETARY ENTITLEMENT  |
|--------|--|---|
| 58     | Directions of the Engineer as to the use of provisional sums.  | <p>(i) where the use implies some work or service being done or provided by the Contractor then the work or service is to be valued as a variation</p> <p>(ii) where the use implies work or service being done or provided by a Nominated Sub-contractor or Supplier it is valued as such (See Chapter 10)</p> |
| 59A    | Break in the chain of liability due to improper sub-contract with a Nominated Sub-contractor being entered into at the instigation of the Engineer   | loss or damage (i.e. costs plus reasonable profit)  |
| 59B    | <p>FORFEITURE OF NOMINATED SUB-CONTRACT</p> <p>(i) forfeiture of sub-contract with or without the consent of the Employer in circumstances where the Contractor is entitled to enforce forfeiture</p> <p>(ii) Delay due to forfeiture</p> <p>(iii) work done, goods or materials provided by the Contractor subsequent to forfeiture</p> | <p>the amount of reasonable cost and expenses of the Contractor in trying to recover the Employer's losses from the sub-contractor which have not been recovered.</p> <p>costs</p> <p>value according to principles of valuing variations.</p>  |



TABLE 8.1 (Continued)

| CLAUSE | CAUSE OF CLAIM   | MONETARY ENTITLEMENT   |
|--------|--|--|
| 65(5)  | Outbreak of war  | <p>(i) value of preliminaries to the extent that the work or service entailed has been carried out.</p> <p>(ii) increases in costs of labour, materials, or power attributable to the war.</p> <p>(iii) other increases in costs of carrying out the work attributable to war.</p> <p>(iv) value of work destroyed or damaged by the war.</p> <p>(v) costs of making good damage arising from war.</p> <p>(vi) expenditure reasonably incurred in expectation of completing the work.</p> <p>(vii) costs of materials or goods of which the Contractor is legally obliged to accept delivery after determination of the Contract.</p> <p>(viii) reasonable costs of removing plant on determination.</p> |
| 69     | Tax fluctuations   | Total amount of change in labour tax   |
| 70     | Value Added Tax(VAT)   | All the Contractor's liability for Value Added Tax on the Contract   |
| 71     | Delay due to unavailability of materials in units (metric or imperial) specified | cost   |

### 3.6.1 ON-SITE ESTABLISHMENT COSTS

These are commonly called on-site overheads and relate to, inter alia, supervisory and administrative staff engaged upon the site, site huts, telephones, electricity, rates, welfare and sanitary facilities, lighting and heating.

These are often priced in the preliminaries section in building Contract Bills of Quantities (120). With civil engineering work measured according to the CESMM they may be method-related charges in Class A of the Bill of Quantities.

Where the Contractor keeps proper records the additional costs due to on-site overheads are readily ascertainable and claimable as 'direct loss and/or expense' under the JCT Forms and as costs incurred under the appropriate clause of the ICE Contract. According to Powell-Smith and Sims (30) in cases of claims for reimbursement of additional on-site overheads arising from delayed completion, the fact that ordinarily the Contractor would be running down his site establishment towards the end of the Contract should be recognized in the assessment of the amount of reimbursement. In such cases, they argue, taking the costs from the date when the work would have been completed to the date of actual completion as the reimbursable amount would be unfair to the Contractor.

It is generally important that the Quantity Surveyor/Measurement Engineer knows how the

Contractor has made up his site overheads in the tender calculations. It is therefore not unreasonable for them to ask the Contractor for this information, though it should be pointed out that the Contractor is under no contractual obligation to provide it. Where the Contractor fails to provide the information the adoption of 'average' attitude by the Quantity Surveyor/Measurement Engineer may be justified (38). This involves using breakdowns of site overheads from relevant past experience or records of similar jobs.

It is also necessary to analyse the Contractor's program to establish just when those various overheads were being incurred, for it is not always the case that they are expended equally and evenly over the period of the contract.

## 8.6.2 HEAD OFFICE OVERHEADS

Head office overheads refer to costs incurred in maintaining and running a head office, with its attendant costs in the way of staff salaries, rents, rates and other costs of that kind. According to Spence Geddes (122) these include:-

- (i) salaries paid to the head office staff, directors' fees, attendants and cleaners:
- (ii) the rentals of the offices, including rates and taxes and depreciation of the office furniture and effects;



incidental insurances, fire and insurance;  
heat, light, power and fuel;  
stationery, books, postage and telephone  
charges;  
auditors' fees;  
staff cars;  
interest on working capital, loans, bank  
charges and retention moneys.

Head office overheads are included in the  
Contract Bill of Quantities in any of the follow-  
ing ways:

- \* as a percentage addition to the direct cost  
(or prime cost) of Bill items at tender to  
allow for head office overheads separately  
(122, 123).
- \* as a percentage addition to the direct cost  
of Bill items to cover both head office  
overheads and profit (122, 123)
- \* as Method-Related Charges (29).

McCaffer and Baldwin (123) write that a  
single mark-up on the direct costs may also be  
made out to cover head office overheads, profits,  
charges of risk, and sometimes discounts on  
materials purchases and sub-contracts.

Methods of calculating the percentage  
addition to allow for head office overheads can be  
found in textbooks such as those by McCaffer and  
Baldwin (123), and Spence Geddes (122).



### 8.6.2.1 CATEGORIZATION OF HEAD OFFICE OVERHEADS

Head office overheads are sometimes split into direct head office overheads and general head office overheads. Direct head office overheads are those which relate to a particular contract, such as managerial time used in buying materials, hiring plant, and updating programs. General head office overheads are those which do not relate to any particular contract and include rates, lighting, heating, telephone, tendering and stationery. Powell-Smith and Sims (30) advise that these two elements of overhead costs should be kept separately and that contractors should require their staff to keep time records of work on particular contracts.

In recent court cases discussed below there are indications that the courts might expect contractors to keep such separation of overhead costs.

The entitlement of the Contractor to claims for payment of head office overheads has been the subject of much debate (31). Two separate questions are at issue in this regard:

- \* whether the particular contract allows this type of claim;
- \* how should the claim be quantified.

### 8.6.2.2 JUSTIFICATION OF HEAD OFFICE OVERHEADS

The ICE Contract clearly entitles the Contractor to recover extra head office overheads, because Clause 1(5) defines 'cost' to include overheads both on and off the site.

The JCT Standard Forms are not so categorical on the subject. The main problem has been whether extra head office overheads are part of the 'direct loss and/or expense' to which the Contractor is entitled for the causes listed in Clause 26. Most of the commentators (30, 124, 125) have taken issue to the meaning of the word 'direct'.

However there is now general agreement that head office overheads is covered by the 'direct loss and/or expense' entitlement. The commentators have come to this view by examining relevant case law. In the case of *Wraight Ltd v. P. H. & T. (Holdings) Ltd* (96) it was held that under the JCT 63 (42) the phrase 'direct loss and/or expense' means that the sums recoverable are equivalent to damages at common law. The principles for establishing liability for damages as formulated in the leading case of *Hadley v. Baxendale* (97) are:

- (i) Losses arising naturally from the breach itself are recoverable.
- (ii) Any other special losses which should have been in the reasonable contemplation of the parties (or at least,

**PAGE  
NUMBERING  
AS ORIGINAL**

the contract breaker's) at the time of the making of the contract as the probable result of its breach are also recoverable.

According to McCaffer and Baldwin (123) the construction of a project must contribute towards the cost of running the company's head office. If a project is prolonged by disruption its monthly turnover will be reduced. This implies a reduction in its contribution to the head office overheads. Thus loss of head office overhead recovery can be held to arise naturally from such disruption. This argument would make loss of head office overhead recovery claimable under the first principle in *Hadley v. Baxendale* (97).

The fact that there have not been cases in the courts which directly dispute the inclusion of head office overheads in 'direct loss and/or expense' provisions of the JCT forms may be an indication that both contractors and employers accept it. Powell-Smith and Sims (30) have written that some 'loss' due to underrecovery of head office overheads would normally be assumed by the courts as reasonably foreseeable in prolongation claims.



### 8.6.2.3 QUANTIFICATION OF HEAD OFFICE OVERHEADS

Four methods for calculating the amount recoverable for head office overheads have been identified:-

- \* Maintenance of records,
- \* the Hudson Formula Method,
- \* the Emden Formula Method,
- \* assessment of 'variable' notional preliminaries method.

#### 8.6.2.3.1 MAINTENANCE OF RECORDS

This is often used to determine the amount recoverable for direct head office overheads.

Powell-Smith and Sims (30) have written that efficient contractors will usually require their staff to keep time records.

It is not uncommon for contractors to use percentages and formulae discussed below to calculate total head office overheads and profits recoverable without differentiating direct costs to the contract from general overheads applicable to all contracts (125). In view of a recent court decision this practice may not be able to stand up in court in the future. In the case of *Tate and Lyle Food & Distribution Ltd v Greater London Council* (98) the Plaintiff incurred costs for dredging sedimentation around their jetties caused by the construction of piers

up the River Thames by the Defendants. The Plaintiffs sought to recover the cost of actual dredging and a percentage addition for managerial and supervisory time spent on the whole exercise. While the Court of Appeal accepted that the Plaintiff were entitled to recover the cost of the managerial and supervisory time spent it refused to accept the use of percentages plucked from the air, on the grounds that the Court should never advance into an area of speculation.

#### 8.6.2.3.2 THE HUDSON FORMULA METHOD

This formula is contained in *Hudson's Building and Engineering Contract, 10th edition* (35). It states:

$$AP = PC \times \frac{C}{CP} \times PD$$

where,

AP = Amount recoverable for head office  
overheads and profit,

PC = Percentage allowed in tender for head  
office overheads and profit.

C = Contract Sum.

CP = Contract Period (Usually in weeks).

PD = Period of delay (also usually in weeks).

The use of the Hudson's formula is subject to the following drawbacks (30, 31):

- (i) The method assumes that the overhead/profit percentage budgeted for by the Contractor in his prices was in fact capable of being earned by him elsewhere had he been free to leave the delayed contract at the proper time. In reality it could happen that the contractor had underestimated his direct costs and thus rendered the percentage for overheads/profit unachievable. Also there could be a change of market conditions for work necessitating a change of mark-ups.
- (ii) The linking of profit and overhead together in this way clouds issues because recoverability of head office overhead and of profit may not always coincide. Usually recoverability of overheads is accepted with only the quantum to be substantiated. As discussed in Section 8.6.3 the Contractor first has to prove that he had lost on profit before setting out to quantify any such loss.
- (iii) The formula ignores the effects of variations and fluctuations on the Contract Sum. The pricing of variations would normally include an allowance for overheads and profit by the application of the rates in the Contract Bills or



under the 'fair valuation' rule under Section 7.3. The valuation of this excess due to variations in this way leads to some double recovery of overheads and profits. Fluctuations which are not included in the Contract Sum have the effect of reducing the percentage of overheads/profit recovery on actual total costs.

- (iv) Using the formula as it stands would, it appears, result in profit being added to the profit already in the Contract Sum. For the Formula to work effectively in this respect the term C should equal Contract Sum less overheads/profits.
- (v) The formula ignores the Contractor's opportunity, and therefore general duty, to redeploy his resources elsewhere during a period of delay, to the extent reasonably possible in the circumstances. This might mean a management decision to put some of his head office staff on other work.
- (vi) The decision in *Tate & Lyle Food & Distribution Ltd v. Greater London Council* ( 98) may well apply here.

Powell-Smith (125) cautions that though many claims have been made and settled on the basis of the Hudson's Formula, any contract



supervisor who does so without prior consultation with the Employer may be acting at his peril.

#### 8.6.2.3.3 THE EMDEN FORMULA

The formula which is published in Emden's *Building Contracts and Practice* (119) states:

$$\text{Overheads Recoverable} = \frac{P}{100} \times \frac{C}{CP} \times PD$$

where

$$P = \text{head office percentage} = \frac{\text{total overhead and profit}}{\text{total turnover}}$$

CP = Contract Period

PD = period of delay

C = Contract Sum

It can be seen that though this formula is also open to the same criticisms as the Hudson's Formula, it has the merit of having some relation to the Contractor's actual operations.

#### 8.6.2.3.4 ASSESSMENT OF 'VARIABLE' NOTIONAL PRELIMINARIES

With this method head office overheads form part of general overheads which are assessed from the Contract's total preliminaries element in the following steps (36):

- (i) determine total preliminaries element for the Contract Bills;
- (ii) deduct overheads/profit, allowances for

- inflation and 'non-variable' items such as  
'access to site',  
(ii) divide total by the Contract Period to  
give an average cost/week  
(iii) general overheads are then taken as a  
percentage of the result in (iii). An  
example is given in Appendix 6.

Wood (36) advises that where this method is used the Contractor should be prepared to justify all the percentages used, usually from tender calculations. A danger in this calculation is that the notional variable preliminaries in (iv) could exceed the actual costs incurred. As the Quantity Surveyor/Resident Engineer might want to check this out, proper cost records of preliminaries should be kept.

### 8.6.3 LOSS OF PROFIT

Loss of profit is often claimed for delay or disruption. According to Abrahamson (133) the rationale behind this head of claim is that the Contractor's site and management resources are his revenue earning instrument, and that insofar as they are detained on a contract by delay he will lose the earnings he would have made with on some other contract out of which he would have paid his overheads and pocketed his profit.

The ICE Contract specifies situations where loss of profit is allowable head of claim. For instance, the Contractor is entitled by Clause 12(3) to profit on extra work and plant made necessary by unforeseeable ground conditions being encountered. However in some other situations such as cost of delay due to late issue of drawings under Clause 7(3) the Contractor is not entitled to any profit.

It has already been explained that under the 'direct loss and/or expenses' provisions of the JCT Forms the Contractor's entitlements are equivalent to entitlement to damages for the same breach under the general law. It has long been established that the plaintiff in cases of breach of contract can recover damages for loss of profit-earning capacity: *Victoria Laundry (Windsor) Ltd v. Newmann Industries Ltd* (99). The level of profit recoverable is normal profit the Plaintiff makes in his business. If he had indeed been prevented from earning an exceptionally high profit, this special profit would, in general, be irrecoverable unless it was made known to the Defendant at the time the contract was entered into. By the same principles the Contractor is entitled to his normal profit and when he has lost an exceptionally large profit due to delay, that



contingency should have been made known to the Employer to entitle the Contractor to recover such a loss. These conclusions have been confirmed in the construction case of *Peak Construction (Liverpool) Ltd v. McKinney Foundations Ltd* (100).

Powell-Smith and Furmston (126) write that to be able to recover loss of profit as a head of claim under JCT Clause 26 the Contractor should be able to establish profitability elsewhere, i.e. that he could have employed his resources elsewhere had he been free to do so.

The judgement in the last mentioned case suggests that the Contractor would have to provide the following information to support a claim for loss of profit:

- \* details of his site organisation during the delay or disruption;
- \* details of head office involvement;
- \* company turnover over several preceding years.

The common practice has been to determine head office overheads and profit together using the formulae methods (125).



#### 8.6.4 INFLATION COSTS

According to Powell-Smith and Sims (30) additional expenditure on labour, materials or plant due to increases in cost during a period of delay is an allowable head of claim.

Figure 8.1 illustrates the point.

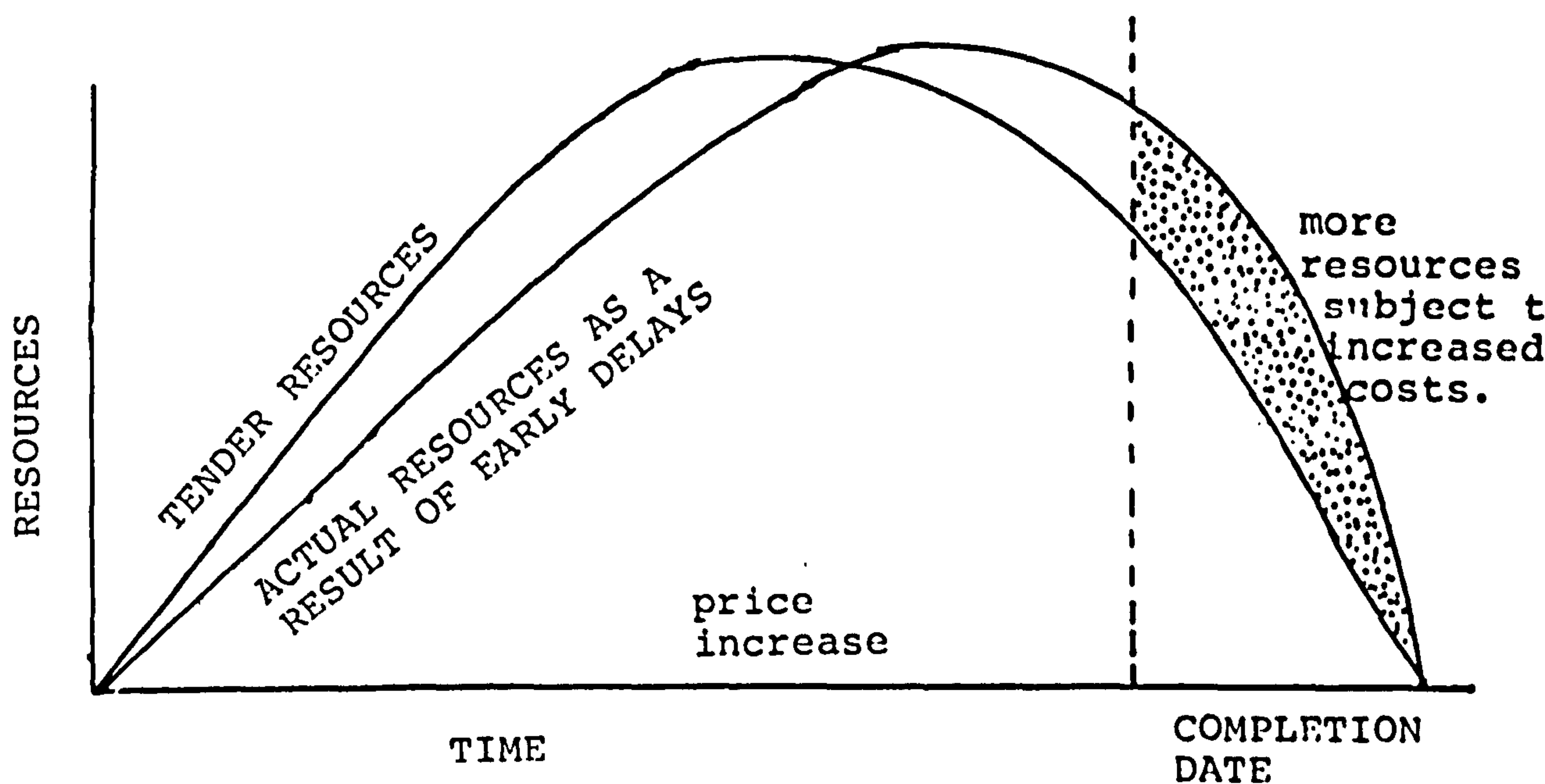


Figure 8.1: The Effect of Inflation on Claims.

The amount claimable would be the difference between what the contractor would have spent on labour, materials and plant and what he has actually had to spend over the whole period of the work as a result of the delay and disruption concerned. Trickey (31)

cautions that care must be taken to ensure that any reimbursement under the fluctuation clauses is not duplicated when determining additional amounts due to increased costs.

Though the amount of inflation that qualifies as loss and expense is never easy to calculate an attempt should be made to do so in whatever manner is most appropriate in the circumstance. Simmonds (38) proposes two approaches:

- (i) comparing actual and tender labour, plant and materials costs;
- (ii) using published indices, such as the ones for use in connection with the appropriate fluctuation formula.

#### 8.6.5 INTEREST/FINANCING CHARGES

The principle at common law on interest is that there is no right to recover interest on a debt or damage: *London, Chatham and Dover Railway Co. v. South-Eastern Railway Co.* (104). However, the High Court and arbitrators have statutory power under Administration of Justice Act 1982 (113) and Law Reform (Miscellaneous Provisions) Act 1934 (114) to award simple interest on debt.

Where a contract is disrupted or delayed through some cause for which the Employer is

responsible part of the Contractor's claim often relates to:

- \* additional interest which the Contractor has paid on capital borrowed as a result of the delay or disruption
- \* interest which he had been prevented from earning on his capital as a result of the disrupt or delay.

Attempts have been made to use the common law position on interest to refute such claims. However, it is now established that under JCT forms interest and finance charges can be recovered as part of the 'direct loss and/or expense' provisions: *F. G. Minter v. Welsh Health Technical Services Organisation* (115).

The position in the ICE contract is not so explicit. These Conditions use a galaxy of phrases to describe additional payment to which the Contractor may be entitled. This can be verified from an examination of some typical clauses such as 7(3), 12(3), and 14(6).

Abrahamson (133) draws attention to anomalies which may occur as a result of possible interpretation of the word 'cost' used in the clauses entitling the Contractor to additional payment. On the one hand a contractor doing work on borrowed money will incur, and presumably be entitled to recover interest charges. On



the other hand where he finances the works from his own resources it is debatable whether his loss of alternative investment of the amounts involved would be classed as 'cost'.

To avoid this uncertainty a prudent civil engineering contractor would have two alternative courses of action. The first involves pricing his finance charges as head office overheads which are explicitly claimable. The second involves financing the effect of disruption on borrowed money.

#### 8.6.5.1 CALCULATION OF FINANCE CHARGES

The following example which follows the approach of Trickey (31) illustrates a method of calculating finance charges:

The following data are required:

- \* the weighted time lag between expenditure and income, assuming monthly valuations,
- \* breakdown of the Contract Sum into:
  - . Contractor's own labour,
  - . materials purchased by contractor,
  - . hired plant,
  - . site staff,
  - . head office overheads,
  - . subcontractors,
- \* payment terms for:
  - . contractor's own labour,
  - . materials



| (COLUMN A)<br>HEAD OF EXPENDITURE<br>OF THE CONTRACTOR | (COLUMN B)<br>TERMS OF PAYMENT   | (COLUMN C)<br>APPROX TIME (WEEKS)<br>LAG BETWEEN<br>EXPENDITURE AND<br>EARNING | (COLUMN D)<br>% OF<br>CONTRACT<br>SUM | (COLUMN C X COLUMN D)<br>WEIGHTED TIME<br>LAG |
|--|--|--|---------------------------------------|---|
| Contractor's Own Labour                                | Paid weekly in arrears<br>(labour paid on average<br>4½ weeks before<br>certificate) | 4½   | 25                                    | 1.125   |
| Contractor's Materials                                 | One week after receiving<br>payment  | -1   | 36                                    | -0.36   |
| Hired Plant  | One week after receiving pay-<br>ment  | -1   | 4                                     | -0.04   |
| Sub-contractors  | Paid upon receipt of payment<br>from Employer  | -  | 25                                    | -   |
| Site Staff   | Paid at the end of the month   | 3  | 5                                     | 0.15  |
| Head Office Overheads                                  | Similar to site staff  | 3  | 5                                     | 0.15  |
|  |  |  | <u>100</u>                            | <u>1.025</u>                                  |

Figure 8.2: Calculation of Weighted Time Lag Between Expenditure and Income

- . site staff,
- . head office overheads,
- . hired plant,
- . sub-contractors

\* Contract Data:

- . Contract Sum/Tender Total
- . retention details
- . Contract Period
- . Defects Liability Period/Maintenance Period
- . period of delay
- . borrowing rate

Assume the following:

Contract Sum: £5,000,000

Main Contractor's work: 70% of total

Retention: 3%

Half retention released at Practical Completion

Contract Period: 2 years (104 weeks)

Period of Delay: 1 year

Defects Liability Period: 6 months

Cost of Borrowing 18% per annum

Further assumptions are made in the calculation of the weighted time lag between expenditure and income as shown in Figure 8.2.

The calculation of financing charges is as follows:

|     |   |                                |
|-----|---|--------------------------------|
| (A) | WITHOUT DELAY   | £                              |
|     | Average amount outstanding between<br>payment and receipt   |                                |
|     | $= \frac{1.025 \times 6 \times 10^6}{104}$  | 59,134.62                      |
|     | Retention Before Practical<br>Completion  |                                |
|     | $= \frac{3}{100} \times \frac{6 \times 10^6}{2} \times \frac{70}{100}$                                | $\frac{63,000.00}{122,134.62}$ |
|     | Finance Charges:  |                                |
|     | (i) £122,134.62 $\times \frac{18}{100} \times \frac{1}{\text{yrs}} \times 2 \text{ yrs}$              | 43,968.46                      |
|     | (ii) Retention during Defects<br>Liability Period   |                                |
|     | $\frac{1.5}{100} \times 6 \times 10^6 \times \frac{70}{100} \times \frac{1}{2} \times \frac{18}{100}$ | $\frac{5,670.00}{49,638.46}$   |
|     | Total Financing Charges   |                                |
| (B) | WITH DELAY  | £                              |
|     | Average amount outstanding between<br>payment and receipt   |                                |
|     | $= \frac{1.025 \times 6 \times 10^6}{156}$  | 39,423.08                      |
|     | Retention before Defects<br>Liability Period  |                                |
|     | $= \frac{3}{100} \times \frac{6 \times 10^6}{2} \times \frac{70}{100}$                                | $\frac{63,000.00}{102,423.08}$ |

|   |                         |
|---|-------------------------|
| Finance Charges:  | £                       |
| (i) £102,423.08 x $\frac{18}{100}$ x $\frac{1}{\text{yrs}}$ x 3 yrs                                   | 55,308.46               |
| (ii) Retention during Defects   |                         |
| Liability Period  |                         |
| $\frac{1.5}{100} \times 6 \times 10^6 \times \frac{70}{100} \times \frac{1}{2} \times \frac{18}{100}$ | 5,670.00                |
| Total Financing Charges   | 60,978.46               |
| Less  | <u>49,638.46</u>        |
| Amount claimable  | <u><u>11,340.00</u></u> |

### 3.6.6 COST OF DISRUPTION

Disruption of the Contractor's planned methods and sequence of working can have two effects:

- (i) the Contractor is compelled to employ more labour and/or plant on the disrupted activities;
- (ii) labour and plant may have to stay idle.

Either way, disruption causes extra costs to be incurred. Five approaches to assessing payment to be recovered have been identified. The choice of the appropriate method to use depends on the data available. The methods are:

- \* evaluation of plant and labour records,
- \* review of labour/plant activity,
- \* analysis of extensions of time,
- \* application of a general productivity formula,
- \* application of general percentages.



### 8.6.6.1 EVALUATION OF PLANT AND LABOUR RECORDS

With this approach records are specifically kept for the purpose of ascertaining the value of the claim. Both the JCT and ICE Standard Forms contain provisions which empower the Architect/Engineer to request the Contractor to keep records pertaining to occurrences on site.

The *Civil Engineering Procedure* (88) recommends that the Engineer's Representative and the Agent should agree and record details of all the facts and circumstances relevant to any matter that may be the subject of a claim. Even if the Contractor is not ordered to keep records it is still to his immense advantage to keep them because where they are kept properly they are the best evidence for calculating rates of output and must be preferable to any assumptions. To be of maximum use in the subsequent adjudication and settlement of claims, records kept should be detailed enough to relate particular items of expenditure to particular events.

The general approach with this method is to extract the labour or particular plant content of the work affected assuming no disturbance, determining the actual costs of these elements and taking the difference as the amount reimbursable, allowance being made for extra costs which are the responsibility of the Contractor.

#### 8.6.6.2 REVIEW OF LABOUR/PLANT ACTIVITY

In the absence of specific records, particularly for isolated disruption, Trickey (31) proposes that the only reasonable alternative is to look back at the Contractor's labour/plant level being maintained on the site at the relevant time. This is not an accurate method because an element of judgement is required in identifying the activities worked on by particular resources.

#### 8.6.6.3 ANALYSIS OF EXTENSIONS OF TIME

As the reasons for extension of time are very often also grounds for claiming cost of disruption, the evidence used in assessing extensions of time in principle and the quantum arrived at can be useful in determining loss of output. Though it may be unsatisfactory to rely solely upon the extensions of time as prime evidence for assessing loss of output they cannot be ignored. Indeed the amount of extension, the reasons for decisions and any element of delay purposely eliminated in the evaluation of the extension can be important guidelines. According to Trickey (31) the main dangers in using the approach are:

- (i) only delays on the project's critical path need be considered in assessing extensions

of time. Delays on non-critical activities for which extra costs are recoverable are ignored;

- (ii) sometimes entitlements to extension of time and to recovery of extra costs for disruption do not coincide.

#### 8.6.6.4 APPLICATION OF A GENERAL PRODUCTIVITY FORMULA

As workmen become more familiar with a task so they become more and more efficient until the maximum rate of output is reached. The progression of increasing output is referred to as the learning curve. Research on house building by the Building Research Establishment (127, 128) construction found that the labour requirements of operations generally improved to a steady state as workmen became more and more familiar with the work. Bishop (127) reports that the improvement ranged from 8 - 33% over the average productivity, depending on whether the construction was conventional, unconventional, or involved new operations altogether.

Trickey (31) writes that the data necessary to apply this method is hard to come by and that even where they exist they may not suit the particular situation in hand. Where they exist in a suitable form they may be used to calculate the amount recoverable on account of disruption. The approach for calculating this



amount is as follows:

Suppose the Contractor can establish from reliable data that without disruption his plumbing operations in 80 flats would have required 70 man hours per flat and due to disruption he used 6000 man hours on all the plumbing. Barring his own inefficiency he may be entitled to recover his cost of  $(6000 - 80 \times 70)$  i.e. 400 man hours as extra due to disruption.

#### 8.6.6.5 APPLICATION OF A GENERAL PERCENTAGE

Wood (135) and Trickey (31) write that the application of an overall percentage on the total labour estimate or actual labour cost of disrupted operations to arrive at the reimbursable element of disruption is sometimes resorted to. The main drawback of this approach is that the following elements of labour costs would be wrongly included in the amount so determined:

- \* extra labour costs due to variations valued according to the appropriate clauses,
- \* labour employed to correct defects,
- \* contractor's own inefficiency,
- \* labour not affected by the disturbance,
- \* unrealistic labour output assumptions at tender stage.



#### 8.6.6.6 QUANTIFICATION OF LOSSES DUE TO DELAY AND DISRUPTION

Costs of delay or disruption are quantified by:

- (i) multiplying the period of delay or idle time by the cost of the resources per unit time;
- (ii) determining fixed charges, e.g. setting-up and removal costs of plant made necessary by the disruption.

##### 8.6.6.6.1 LABOUR LOSSES

There are two possible ways of assessing these losses (30):

- (i) the amount the Contractor would have made by the use of the labour during the period of delay or idle time,
- (ii) the amount based on a calculation of the total cost to the Contractor of employing the labour.

##### 8.6.6.6.2 PLANT LOSSES

It is often necessary to consider plant costs under the following headings:

- (i) *Setting-up Charges*

If the plant is already on site, or is required on the site at some time, the cost of delivery, setting-up is covered

in the Contract Bills and no extra charges for setting up can be admitted, but the inflationary effect of late delivery due to an earlier delay would be admissible. If the use of a piece of plant, not originally required, is made necessary the cost of setting up would be reimbursable.

*(ii) Time-Related Charges*

This is the charge for using the plant from day to day. If an item of plant is already on site but for the disruption it would have been idle and it is used in carrying out additional work only the running cost is reimbursable.

Hired-in plant and those belonging to the Contractor require different treatment. With hired-in plant the amount claimable is the loss actually incurred, i.e. the sums paid or payable to the plant owner under the terms of the contract of hire, subject to the normal legal principles of mitigation of loss. With the Contractor's own plant there are two possibilities:-

- (i)* the amount the Contractor would have earned by the use of the plant during the period it was idle;

(ii) an amount based upon a calculation of the rate of depreciation and maintenance of the machine.

Parris (124), Powell-Smith and Sims (30) are of the opinion that the Contractor will usually be able to claim under (ii) successfully but that to succeed with a claim under (i) the Contractor must prove the following:

- \* his actual loss by detailed calculations based on properly kept records;
- \* that the type of loss was in the reasonable contemplation of the Employer or his site management team.

*(iii) Running Costs*

Where the disturbance causes plant to be used more than when there is no disruption the extra running costs are reimbursable. However, if disruption causes the plant to stand idle running costs are not incurred and therefore they are not claimable.

*(iv) Removal Costs*

Where the removal of plant is delayed any resultant extra removal charges due to inflation could form an element of costs reimbursable.



#### 8.6.7 COST OF REPAIRING THE CLAIM

Trickey (31) and Powell-Smith and Sims (30) maintain that the costs involved in preparing claims as demanded by the JCT contract are not admissible as a head of claim. The main argument is that as the Conditions envisage the occurrence of claims the Contractor should have allowed for the costs of their preparation in this tender. This argument implies that the practice of engaging specialist claims consultants to prepare and produce voluminous documents on claims should be financed by the Contractor.

However, Trickey (31) suggests that when specific research is necessary to prepare and submit a claim the cost of doing so should be claimable.

The same arguments would also be applicable to the ICE Contract.

#### 8.7 NOTICES OF CLAIMS UNDER THE ICE CONDITIONS

Clause 52(4) is the operative sub-clause setting out the requirements of notices and the procedures to be followed. The notice requirements fall under three categories:

- (i) notices relating to claims on variations under Clause 51,



(ii) notices of claims due to changed quantities,  
(iii) notices of other types of claims under the  
Contract.

#### 8.7.1 VARIATIONS UNDER CLAUSE 51

Under sub-clause 52(4)(a) the Contractor must give notice in writing of his intention if he requires any increase in a rate or price which has been fixed by the Engineer for a variation. This notice must be given within 28 days after notification of the rate or price by the Engineer. One general principle to start the time running there must be a clear notification. This clause does not require the notification to be in writing.

#### 8.7.2 CLAIMS DUE TO CHANGED QUANTITIES

In the case of a change of quantities within Clause 56(2), under sub-clause 52(4)(a) notice is required of the Contractor that he requires additional payment, the notice to be given within 28 days after the happening of the events giving rise to the claim. It appears the events have happened when the actual quantities have been executed.

### 8.7.3 OTHER CLAIMS UNDER THE CONTRACT

Sub-clause 52(4)(b) lays down the procedure where the Contractor intends to claim any additional payment pursuant to any clause of the Contract other than those arising under sub-clause 52(1), 52(2) and 56(2). The Contractor is required to give written notice to the Engineer as soon as is reasonably possible after the event giving rise to the claim.

### 8.8 NOTICES OF CLAIMS UNDER THE JCT FORMS

The Contractor is required to make a written application to the Architect/Supervising Officer stating that he has incurred, or likely to incur, direct loss and/or expense. The notice is to be made as soon as it has become, or should reasonably have become, apparent to the Contractor that the events giving rise to loss have arisen, or are likely to arise.

### 8.9 EVIDENCE TO SUPPORT CLAIMS

Powell-Smith and Sims (30) write that many claims submitted by Contractors are deficient in the matter of supporting evidence and that many a potentially valid claim founders because of lack of proper substantiating evidence. When a claim is not accepted the next course of action available to the Contractor is either

litigation or arbitration. Even with such courses of action Davies, Hay and Sneden (130) write that the Contractor is likely to learn one major lesson - the importance of records whilst Simmonds (38) estimates that most arbitrators spend 90% of their time trying to establish the facts of the dispute.

As it has been discussed already a claim arises only when the Contractor and the Employer or his professional advisers disagree on their payment entitlements. It may be that such disagreement stem from inadequate evidence in the first place and that where the appropriate records exist additional payments can be made without the need to submit claims. Adequate documented evidence is therefore important, not only in the substantiation of claims but also in preventing them in the first place.

Fisk (131 , 132) and Davies et al (130) advocate the establishment of well thought out schemes for systematically documenting project information. The extent to which lawyers can find unexpected grounds, often quite real, on which to cast doubt upon evidence not backed up by fool-proof records cannot be over-emphasized. Cooke (134) advises that one of the first duties on site of the Contractor is to establish a systematic procedure for communication within his organisation and more importantly, with the



site management team of the Engineer/Architect. The importance of agreement between the two teams on records relating to matters with a claims' potential has already been discussed in Section 8.6.6.1. Where the two sides fail to agree the *Civil Engineering Procedure* (88) advises that separate records should be kept and the reasons for disagreement carefully noted.

Because of the immense diversity of claims situations the nature of the back-up evidence will vary from claim to claim. However, evidence will usually include one or more of the following identified from published literature and discussions with practising professionals:

- \* analysis of tender,
- \* detailed analysis of the preliminaries,
- \* programme/progress schedule,
- \* method statements,
- \* cost records,
- \* correspondence,
- \* records of site meetings,
- \* site diaries,
- \* analysis of extensions of time granted,
- \* variation orders,
- \* revised drawings.



### 8.9.1 ANALYSIS OF TENDER

The Contractor's tender contains some of his assumptions as to cost of resources he plans to employ on the works, how productive they are going to be, and how they are going to be deployed. Since the purpose of a claim is often to reimburse the Contractor for extra costs incurred due to changes by the Employer, or his agents, of these assumptions they are obviously needed to assess and quantify claims. The following information is usually of some use:

- \* breakdown of work into responsibilities of of the Main Contractor, and various sub-contractors/suppliers,
- \* profit and head office overheads percentages, profit and attendances on sub-contractors,
- \* preliminaries, contingencies and provisional sums.

Though the analysis of the Contractor's tender is very important no provisions in the standard forms require him to divulge this. However it is to the advantage of all parties for the Contractor to make this analysis available. Under the rules of discovery of documents, the Contractor may be bound to produce his tender make-ups if he embarks on arbitration or litigation. Therefore, although there is no contractual obligation for him to

do so, where the Architect/Engineer feels that the tender make-up is essential to the assessment of a claim there is a good practical reason for the Contractor to comply with any demand to disclose the analysis of his tender.

### 8.9.2 ANALYSIS OF PRELIMINARIES

An examination of the typical preliminaries bill will show that it is closely linked to the Contract program. For instance, supervision will usually be a head of expenditure throughout the entire duration of the contract and when there is delay in completion increased costs will be incurred on it. Setting up <sup>and</sup> removal costs are dependent on the program to the extent they are influenced by the time when they are incurred. The same argument applies to insurances, some temporary works such as scaffolding, site transport, and running and maintenance costs of plant.

The discussion in Section 8.9.1 about the availability of the Contractor's general tender build-ups would also hold true for the breakdown of the preliminaries bill.

### 8.9.3 PROGRAM/PROGRESS SCHEDULE

The Contractor's program is important because it is the baseline from which delay and disruption may be assessed (30, 133) Clause 5.3.1.2 and 14(1) of the JCT and ICE forms, respectively, require the Contractor to provide a program at the start of construction and to keep it updated. According to Abrahamson (133) a good program will address itself to dates when information or drawings are required from the Engineer's site organisation, and co-ordination with the work of sub-contractors and suppliers.

Neither the ICE nor the JCT Forms provide feasible ways of enforcing compliance by the Contractor with these requirements apart from the rather extreme step of forfeiture. However it is the Contractor's advantage to provide a realistic program so that his requirements will be known and programmed for by the other parties.

### 8.9.4 METHOD STATEMENTS

A Method Statement is a description of how the work involved in a construction contract will be carried out (123). McCaffer and Baldwin (123) write that the preparation of a method statement is one of the tasks a Contractor's estimating team



undertakes before submitting a tender. Cooke (134) also writes that more detailed method statements are to be prepared before the commencement of actual construction. The method statement referred to here is of the latter category.

The ICE Conditions require the Contractor to provide a written method statement covering his proposed construction arrangements within 21 days after the acceptance of his tender. He is also required to provide further statements and details as and when the Engineer requests him to do so.

The JCT Conditions do not seem to make equivalent provisions.

Where such method statements exist they may be used in substantiating or rebutting claims of delay and disruption.

#### 8.9.5 COST RECORDS

Where records exist they may be used in assessing claims but there is a need for such records to be sufficiently identifiable with the cause of the claim.

#### 8.9.6 CORRESPONDENCE

Types of correspondence which may be useful include letters containing instructions, notices, applications to comply with the terms of contract



which entitle the Contractor to additional payment, and all other letters which touch on the subject of the dispute.

### 3.9.7 RECORDS OF MEETINGS

Abrahamson (133) advises that meetings provide a means of raising and recording facts and disagreements on programs and method statements. It is therefore very important to ensure that minutes reflect accurately all what have been discussed. Powell-Smith and Sims (30) advise that parties should check the minutes carefully and challenge any inaccuracies and ambiguities and ensure that the relevant corrections are recorded both in correspondence and in the record of the next meeting. Obviously the need to do so before memories fade is absolutely important.

### 8.9.8 SITE DIARIES

A well-kept site diary will constitute a useful record and may be invaluable several years after the events. Fisk (132) makes the following requirements of site diaries:

- \* all information should be entered into the diary the same day that it occurred;
- \* all days must be accounted for;
- \* no pages should be torn out.

Site staff should be mindful that the diaries may end up in arbitration or litigation and the discipline with which they enter information should reflect this fact. For the same reason it should be remembered that a diary may be also useful for what is not recorded. For instance the absence of any reference in an otherwise well-kept diary to a variation order may be evidence to support an assertion that it was never given.

Davies et al (130) propose a list of topics that Contractors should require their agents and sub-agents to make either a daily entry against each, or a general note that nothing happened against certain items. They are:

- \* access to any part of the site due from the Employer,
- \* access to any part of the site given by the Employer,
- \* weekly labour strength - normal and actual,
- \* plant in use,
- \* visitors,
- \* delays and instructions required and reasons why required on this date,
- \* weather,
- \* drawings or instructions received,
- \* materials to be supplied by the Employer,
- \* materials to be supplied by Employer received,
- \* default or delay by sub-contractor,
- \* default or delay by direct contractors,

- \* unforeseen physical conditions encountered,
- \* labour disputes,
- \* artificial obstructions encountered, e.g. services,
- \* work suspended or impeded and reasons,
- \* work done out of sequence and reasons,
- \* labour idle or uneconomically deployed and reasons,
- \* work expedited and reasons,
- \* inspections and work approved or rejected,
- \* remedial work and reasons,
- \* accidents,
- \* comments.

### 8.9.9 ANALYSIS OF EXTENSIONS OF TIME

It is discussed under Section 8.6.6.3 that the Contractor may draw on the implications of extensions of time already granted to assess new claims. In such situations the analysis of the extensions of time depended upon should obviously be of use as back-up evidence.

### 8.9.10 VARIATION ORDERS

Both the JCT and the ICF Contracts recognize only written variation orders or oral orders confirmed in writing (Section 7.3). A Contractor who wishes to make a claim relating to



a variation order could therefore be expected to produce the written evidence of the order if requested by the Architect's/Engineer's team to do so.

#### 8.9.11 REVISED DRAWINGS

It is discussed in Section 7.4 that variation orders may be communicated to the Contractor in the form of revised drawings. Where this is the case such drawings are essential evidence.

#### 8.10 THE PRESENTATION OF CLAIMS

None of the standard forms lays down any format to which all claims are required to comply. Where the Employer or his professional advisers have a preferred format this should be suggested to the Contractor at the preliminary site meeting or, where this is not possible, at subsequent site meetings. Though the Contractor is not contractually bound to accept it the greater likelihood of expeditious treatment of claims may be enough incentive for the Contractor to co-operate. In any case Powell-Smith and Sims (30) advise that every claim should be prepared with the possibility of eventual litigation or arbitration in mind. It is therefore advisable that it should be in such a form that it can be



readily used for the purpose of formal pleadings.

The following format based on that of Wood (135) seems to satisfy the requirement of being structured enough to be using for pleadings:

(A) INTRODUCTION

This section contains an outline of the Contract. The following may be included:

- \* brief description of the facility to be built,
- \* Contract Sum/Tender Total,
- \* Commencement date,
- \* Date of Completion,
- \* Form of Contract.

(B) CLAIM NARRATIVE

This section contains the following particulars of the claim:

- \* events giving rise to claim,
- \* contractual terms relied upon,
- \* compliance to date with contract requirements on claim including references to relevant correspondence,
- \* statement of total claim entitlement.

(C) SUMMARY OF CLAIM

This section contain a summary of the claim under some or all of the following

heads:

- \* on-site overheads,
- \* head office overheads,
- \* profit,
- \* Interest/finance charges,
- \* Inflation,
- \* Costs of disruption.

Reference may be made to detailed calculations in other sections.

#### (D) APPENDIX 1

The appendix contains carefully laid out and detailed calculations of the heads of claim under Section C. References may be made here to evidence in Appendix 2.

#### (E) APPENDIX 2

This appendix contains evidence relied upon. They may include:

- \* analysis of tender,
- \* analysis of preliminaries,
- \* analysis of final account if available,
- \* analysis of program/progress charts,
- \* correspondence relating to claim,
- \* diaries where relevant,
- \* cost data,
- \* minutes of meeting,
- \* drawings.

## 8.11 NEGOTIATION OF CLAIMS

Trickey (31) writes that any claim for extra payment will comprise certain areas which are factual black and white areas and others which are grey. He attributes the grey areas to the following reasons:

- \* the wording of the contract is not as precise as it might be;
- \* when evaluating extra payment one has always to contrast the reality with what would have happened had not the delay or disruption occurred. Some element of crystal-ball gazing is called for;
- \* settlements are all too often made months, if not years, after the events to which they relate when memories are blurred and the people involved with the project may have moved on.

The existence of grey areas implies that there is some element<sup>of</sup> negotiation in the settlement of claims and Contractors staff dealing with claims need negotiating skills.

## 8.12 BEYOND CLAIMS

Where the Contractor and the Architect/Engineer fail to come to a settlement on a claim the next course of action is for them to go to arbitration or litigation. The action is

arbitration if the parties submit their differences to a third party, called an arbitrator whereas it is litigation where the action is in the courts.

Article 5 of the JCT forms and Clause 66 of the ICE conditions demand in mandatory terms that disputes should be settled in arbitration. But this does not generally stop any party going for litigation from the outset. Where a party does so resort to litigation the other party may apply to the court for a 'stay of proceedings': *Arbitration Act, 1950* (116). Staying proceedings implies a refusal of the court to hear the case. The courts have a discretion under the Act to refuse to stay proceeding but Abrahamson (133) writes that this discretion is used guardedly.

Generally arbitration cannot be started before the completion of the Contract. However immediate arbitration is available as of a right in some situations. One such situation is relates the withholding of a Certificate of the Architect/Engineer. There is a case which suggests that where a claim is turned down immediate arbitration may be available. In the case of *Farr Ltd v. Ministry of Transport* (117) it was held that refusal to include the value of some items in a valuation is tantamount to withholding a certificate.

Details of arbitration are contained in a book by Parris (136).