MANAGEMENT, QUALITY and ECONOMICS in BUILDING

EDITED BY
Artur Bezelga
and
Peter Brandon

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Management, Quality and Economics in Building

EUROPEAN SYMPOSIUM ON MANAGEMENT, QUALITY AND ECONOMICS IN HOUSING AND OTHER BUILDING SECTORS

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Contents

Preface

This book presents the proceedings of the European Symposium on Management, Quality and Economics in Housing and other Building Sectors held in Lisbon, from 30 September to 4 October, 1991. The Symposium was organized by the Civil Engineering Department of the Technical University of Lisbon (Instituto Superior Técnico), Portugal and the University of Salford, Surveying Department, United Kingdom.

The purpose of this book and the Symposium is to establish the state-of-the-art and new trends in research and practice in four important scientific and technical themes for residential and other buildings. The themes are:

- building policy,
- building quality,
- building economics,
- construction management.

In the structuring of this work two strategic objectives were pursued:

- to establish, in a comprehensive and rigorous way, the situation and trends in the above areas within the European Community and, to establish a more general picture in the rest of the world;
- to cover all types of buildings, but with particular emphasis on housing, which is so important in all countries of the world.

These objectives were broadly achieved. The authors hope that the book contributes to a detailed analysis of the domains of management, quality and economics in building and also looks across the boundaries between the main themes. The development and integration of these three domains addresses a real need felt by numerous experts in the practice of construction, and in research and education.

The book has 189 invited papers, 60 per cent of which are from European Community countries. The remaining 40 per cent were provided by Northern and Eastern Europe, Asia, Africa, North and South America and Australia—with more than 20 countries represented, including USA, Australia, Brazil, Turkey, Canada, Sweden, Singapore, Finland, Japan, Yugoslavia and others.

Knowledge transfer

Over the last decade there has been an acceleration in knowledge transfer in construction, both in EC countries and worldwide. The role of CIB (International Council for Building

Research, Studies and Documentation), has been most valuable, for building in general and for this book in particular.

There are many CIB Commissions that are, in a direct or indirect way, related to the areas of management, quality and economics in building. The ones that are closest are:

W65—Organization and Management of Construction
W88—Quality Assurance
W55—Building Economics
W70—Property Asset Management.
W92—Procurement Systems.

The Commission W87—Post Construction Liability and Insurance, W86—Building Pathology, W91. A—Housing Research Latin America, and several others, are also, to various degrees, related to the management, quality and economics subject areas.

In the quality domain, the valuable work of EOQC (European Organization for Quality, Construction Section) should be recognized. The results of the EOQC Construction Quality Seminars have been very significant in introducing and developing quality in building.

Recently, the work of ENHR (European Network for Housing Research) has played an important part with regard to housing.

Many other bodies are also beginning to work in related areas and it would be difficult to point to them all. The role of the European Community in research and technology transfer in building is now increasing. It is hoped that in the near future it will be of even greater importance.

The EEC SPRINT Programme was the first sponsor of the European Symposium on Management, Quality and Economics in Housing and Other Building Sectors which ultimately gave rise to this book.

Programmes such as SPRINT, ESPRIT, COMETT, TEMPUS, ERASMUS, BRITE, SCIENCE and others, could be very valuable in the future to develop research and technology transfer in building.

It is hoped that this book will contribute effectively to creating an international European community of research and practice in management, quality and economics in housing and building and, at the same time, promote a worldwide exchange of knowledge across different continents.

Objective matrix framework

The objectives of this work, already referred to above can be classified as follows:

- Housing/Building Policies, Management, Quality, Economics, Information Technologies, in general.
- Project Life Phase—Inception, Briefing, Design, Construction, Use, Global Process.

- Type of Works—New Construction, Rehabilitation, Maintenance.
- Project/Firm Focus—Project Focus, Firm Focus, Other Focus.

Under these headings the invited experts could present one of the three types of contributions, a state-of-the art review, a specialized contribution, or a case study. In general terms, contributions in this book fit into this framework, which is presented in the table opposite.

Book structure

It was decided to divide the book into five parts following the concepts defined above.

Part One	Management
Part Two	Quality
Part Three	Economics
Part Four	Information Technology
Part Five	Policy

The most important themes are management, quality and economics, but the other two provide a contextual framework.

Part Four, Information Technology, includes the information technology contributions that could be separated out although these are, of course, related to the other important themes of the book. It should be stressed that nearly all the invited papers in this part belong to the management area.

In Part Five, Policy, the idea is to present a framework embracing general issues including the market, financing, legal, policy and other matters.

The classification made and the designation of contributions in a particular part can certainly be the object of debate. For instance:

- a few invited papers included in Part Five such as legal or other frameworks could also belong to Parts One, Two or Three;
- maintenance or facilities management could be included in Part One, considering that is a management domain: however, it was decided to put all the contributions in this area inside Part Three since the majority of them are of a conceptual nature and can be related to economics and maintenance;
- some of the invited papers dealing with information technology could obviously be included in Part Four, or in Parts One, Two or Three. The editors had to make a personal judgement as to which was most relevant.

European Symposium on Management, Quality and Economics in Housing and other Building Sectors

Basic themes	Project life cycle
	Inception Briefing Design Construction Use Global process
0. Housing Building Policies	
0.1 Market—Supply/Demand	
0.2 Financing	
0.3 Policies	
1. Management	I STATE OF THE ART REVIEW (in all themes) II SPECIALIZED CONTRIBUTIONS (in all themes) III CASE STUDIES (in all themes) A NEW CONSTRUCTION (in all themes) B REHABILITATION (in all themes) C MAINTENANCE (in all themes)
1.1 Management of Projects-Time, Cost, Quality, Risk, Human Resources, Procurement….	
1.2 Management of Housing, Building Firms—Organization, Investment, Production, Financing, Marketing, Subcontracting,…	
2. **Quality**	
2.1 Housing/Building and Product Liability ● Certification ● Assurance ● Control	
2.2 Quality Management of Housing/Building Projects and Firms ● Quality Management ● Quality Assurance ● Quality Control ● Quality Evaluation	
3. Economics	
3.1 Cost Modelling	
3.2 Economic Evaluation-Deterministic, Risk,…	

3.3	Economic Optimization
4.	**Information Technology** (DB, IDB, CAD/CAM, KBS, DSS, RS, VT)
5.	**General** (Management/Quality/ Economics, Building Technology)

It is difficult to summarize the principal subjects treated in the different chapters. In fact, the great number of papers included ensures that the majority of the subjects in management, quality and economics are dealt with, in more or less detail, depending on the contributions.

Part One—Management
The subjects covered include the management of projects and the building firm with particular emphasis on the following:

- Strategic management studies.
- Management information systems.
- Construction site management.
- Integrated management in the building firm.
- Contracting and subcontracting.
- Human resources management.
- Procurement methodologies.
- Safety and health management.
- Bidding systems and contract strategy.
- Management of design.
- Time/cost management of projects.
- Expert systems in management.
- Risk management and building failures.
- Industrial planning and control methods applied to building.
- Work time modelling.
- Cash-flow planning and control.

Part Two—Quality
The majority of contributions in this part belong to the fields of quality management and quality assurance, both for building projects and firms. The European standards EN 29000 are beginning to be the object of great interest.

Building quality evaluation, both in design and in construction, the relationship of quality to other fields (e.g. technology, economics, pathology, insurance, human resources, research, education and others), the certification of products and housing quality profiles are also covered.

The following subjects are addressed:

- Quality evaluation and control in design and construction-methodologies and case studies.
- Quality in rehabilitation works.
- Overall approach to quality.
- Quality assurance for clients.
- Quality management and assurance of building projects.
- Quality management and assurance in the building firms.
- The use of EN 29000 in construction.
- Implementation of quality assurance programmes.
- Inspection and testing plans and procedures.
- Quality and the consumers.
- Quality and education.
- Quality and technology.
- Quality, pathology and insurance.
- Certification of construction products, building projects and firms.

Part Three—Economics

The subjects included in this part cover a wide range; real estate appraisal, cost modelling, design economics, economic evaluation methods, economics of maintenance and facilities management, economics of rehabilitation and many others.

The following subjects are addressed:

- Real estate appraisal methods.
- Cost estimating methods.
- Economic evaluation of building projects.
- Economics of residential areas.
- Economic evaluation of public buildings.
- Asset management.
- Property portfolio management.
- Systematic evaluation on site for rehabilitating buildings.
- Cost estimation in rehabilitation.
- Renewal theory and strategic maintenance management.
- Economics of maintenance and facilities management.
- Case studies in maintenance and rehabilitation.
- Asset management manuals.
- Quality evaluation and control in design and construction-methodologies and case studies.

Part Four—Information Technology

In this part are included contributions belonging principally to the following areas: information technology systems, integrated data bases, knowledge-based systems and CAD systems.

The following areas are covered:

- Project databases.
- Expert systems in design, construction and housing administration.
- Design review and IT.

- CAD in structural design.
- Presentation of CAD systems in building design.
- Expert systems in rehabilitation.
- IT in housebuilding management.

Part Five—Policy
The subjects included in this part cover the present situation of the construction/housing sector in several countries, the presentation and analysis of some alternative building policies and the influence of some policy frameworks, such as regulations, codes and others.

The following subjects are emphasized:

- The market for the building industry in countries or regions (United Kingdom, Germany, Nordic, Turkey and others).
- Housing in Latin America and in the Portuguese speaking countries.
- Regulations, codes, standards and affordable housing.
- Development of a European housebuilding industry.

Conclusion

The areas of building construction management, economics and quality are becoming more and more the object of international research, practice analysis and application. The need to create a consistent body of knowledge for building project management and building firm management which attempts to address rigorously the areas of management, quality and economics seems to be a goal to aim at in the near future, at both a European and an international level.

This aim will only be successful if it puts together the industrial, educational and research systems and creates networks of technology development and transfer, i.e., linking and strengthening theory and practice.

This book and the Symposium on which it was based are a first step on the road to reaching this goal.

A.A.Bezelga
P.S.Brandon

PART ONE
MANAGEMENT

1
The client's brief: a holistic view

P.BARRETT

Abstract
This paper considers the construction briefing process starting with the traditional perspective. Consideration is then extended by viewing briefing, respectively, as communication, leadership and teamwork. The issue of the "worldview" taken of the client is then treated.

A holistic view of the briefing process is then presented and, within this context, a contingency approach suggested with the client's level of knowledge as a major independent variable.

Keywords: Briefing, Construction, Holistic View, Project Management, Facilities Management

1 Introduction

Establishing the client's brief is, of course, a critical step in any construction project. By this means the client's requirements are set down: time, quality and cost parameters are defined around the central issue of the physical artefact desired by the client. Although this sounds straightforward the process is, of course, complex and the result uncertain. This paper reviews the traditional approach to briefing and then moves on to more complex views.

2 Traditional Views

The Banwell Report stated strongly that clients:

> *…seldom spend enough time at the outset on making clear in their minds exactly what they want or the programme of events required in order to achieve their objective… (MPEW, 1964)*

It recommended that greater effort should be made to establish the brief and further criticised professional advisers for not emphasising that this is 'time well spent'. It is clear from this that the ideal brief was seen as a well defined input at the start of the construction project.

The way in which the client's brief links into the construction process is very clearly defined in the RIBA Plan of Work (RIBA, 1967). Here the brief is developed from Stage

A (Inception) through to Stage D (Sketch Design) via feasibility studies and outline proposals. It is then stated that the *"brief should not be modified after this point"*. That is, no change should occur as the scheme is designed in detail, production information prepared, or while the Works are tendered or executed. At the *end* of the process Stage M allows for 'Feedback'.

The Plan of Work was criticised in a study by the Tavistock Institute for the *"sequential finality"* (Tavistock, 1966, p 45) implied by the step-by-step process. The need to adapt to the client's changing needs and to new information as it comes to light are both stressed (p 47).

A further area of concern raised revolves around the oversimplified use of the term "client" which is often, in reality, an organisation with competing factions. Thus Tavistock use the term "client system" and suggest that there is a need:

> *...to be very much more aware and responsible in developing the brief through a more conscious understanding of the whole field of social forces they must work with. (p 40)*

One reaction to this problem is provided in the Wood Report (NEDO, 1975) which focussed on public sector clients and suggested that:

(a) a senior officer of the user department should be appointed as the client's representative for each project to coordinate requirements;
(b) for large or complex developments, a project manager should be appointed to assume overall responsibility;

Thus, a mechanism to orchestrate the requirements within the client organisation is proposed and the integrating role of the project manager is suggested, typically focussed on the construction team. An erosion of the traditional "linking pin" (Likert, 1967) role of the architect is implicit in the above developments and the need for clear communication between the principal parties is thereby made explicit.

The above reports generally put forward a view that the "traditional" approach to construction in the UK requires a full brief at the start and that this should not be changed thereafter. A dissenting view is provided by the work of the Tavistock Institute. From whichever angle it is viewed successful briefing relies critically on good communication.

3 Briefing as Communication

Bejder (1991) insightfully suggests the application of the Johari Window concept (Luft, 1970) to the briefing process. This assists in the analysis of the process of communication involved and highlights possible problem areas. The framework provided by the Johari Window (adapted to the subject analysis) is given in Fig. 1, below:

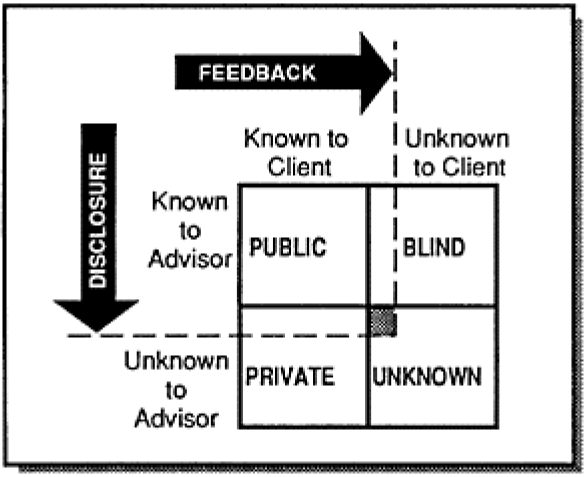


Fig. 1. Johari Window View of Briefing

From the diagram it is clear that there are four main situations to consider. The "public" area represents the client communicating without difficulty his requirements to the professional advisers. The "blind" area can be seen to be the needs of the client that are identified by the adviser through two-way discussion *(feedback)* even though the client cannot initially articulate these needs himself. The "private" area relates to the information that the client does not *disclose,* whether purposefully or not. The "unknown" area is not known to the adviser or the client, but through the twin processes of feedback and disclosure this last area can be revealed, at least in part.

If the brief is to accurately and fully represent the client's requirements then the importance of advisers encouraging clear disclosure and providing feedback information to the client is apparent. This argues for close and freeflowing discussion possibly over a considerable period. This need not of necessity be limited to the early stages of the project.

The communication process is that much more complicated if the "client" is in fact a group of people or an organisation. In this case the communications must be multi-stranded both in terms of disclosure and feedback.

In the above briefing is viewed in global terms. Recent work by Gameson (1991) has analysed, at a detailed level, the process of communication between clients and professionals in the initial stages of brief formation. This was achieved by recording the discussions and breaking down the content into categories. The predominant types of interaction were: "giving orientation" (information) and "giving opinions" with, to a lesser extent, "agreeing". Thus, *disclosure* and *feedback* are key areas as anticipated.

A very interesting finding was that the inputs from the parties varied considerably from one case to another depending on the client's prior experience of construction. For instance, with an experienced client the architect only spoke for 36% of the time, whilst the client made a 64% input. In contrast, taking a case where the client had no previous experience of construction, the comparable percentages were 76% and 24%. A complete reversal.

It is clear from this work that the briefing process will be quite different depending on the experience the client brings with him. This argues strongly for a *contingency approach* to briefing. The objective is to identify the appropriate approach to briefing in particular circumstances. One independent variable is clearly the project relevant knowledge-base of the client. Are there others?

4 Briefing As Leadership

A fuller view of clients can be obtained by viewing the briefing situation in terms of situational leadership theory. In this literature the distinction is made between the task-related needs of the follower and the sociometric dimension (Hersey and Blanchard, 1982).

Clients want their professional advisers to do something they cannot, or do not want to, do themselves. The relationship is founded on the adviser giving the client something he lacks. In all commissions the client will expect the professional to “get the job done”, but the actual contribution made may differ considerably, especially at the early briefing stage as shown in Gameson’s work, described above. This work did not however distinguish the two dimensions drawn from leadership theory. Taking these dimensions together a matrix can be formed as shown in Fig. 2, below.

	SUPPORT NEEDED	
	A LOT	VERY LITTLE
A LOT	*"Help me through it"*	*"Give me the extra space"*
KNOWLEDGE NEEDED		
VERY LITTLE	*"Do it so I can check it"*	*"Get on with it"*

Fig. 2. Typology of Clients Based on Their Needs

The professional is generally leading, providing varying degrees of knowledge and support to the client depending on the client’s particular needs, however, in the case of a very knowledgable, confident client the roles may be reversed with the client taking the lead (influencing). The client types given in the grid can be typified as follows:

Table 1: Suggested Typical Client Types

Description	Explanation
"Help me…	Often the naive private individual involved in construction for the first and possibly only time in relation to a very personal project. A lot of knowledge and support required from the adviser.
"Do it…	This client is often a representative in a large organisation which has a lot of its own procedures and requirements, for example many local authorities. The representative has to "cover his back" and demands support for this despite a high level of relevant knowledge.
"Give me…	Clients in this category have little interest in construction per se. It is a means to an end, for example a factory extension required for increased production. Little support is needed, but a lot of knowledge must be supplied.
"Get on…	This client is knowledgable and confident, say a developer client. He does not need support and can articulate his requirements clearly. That done the onus is on the "adviser".

Although the above model is crude, the message is clear: advisers must diagnose their client's individual needs if the appropriate input is to be provided to the briefing process.

5 Briefing As Teamwork

The briefing process can be viewed as a *team* effort between the various parties. There are many categorisations of the various types of team members to be found in a team, however, to be effective such groupings should ideally have *complementary* abilities, but *compatible* underlying norms (eg Handy, 1985).

Based on his work in this area Powell (1991) argues that clients should:

(a) *"…understand their own needs first and then… secure a design/build team who will reflect their own view of the world."*

(b) choose a design team which displays a full range of *functional* roles and *team* roles by bringing together a group of complementary individuals thus releasing latent synergy. The functional skills has been discussed above in terms of the knowledge requirements of the project. At an individual level psychosocial factors have also been considered in terms of leadership. Powell's perspective extends consideration to include the group dynamics necessary for the team to achieve its objectives.

A central point in Powell's analysis is that:

> *"the skills required to produce truly user responsive buildings can no longer exist in any one designer/builder"*

Thus, the issue of effective groups is inescapable. This is very sweeping and, although undoubtly resonant with a strong trend, it is possible to imagine a private individual with straightforward needs who would be manageable for a single designer.

The principal generator of the overload on the traditional designer is the need to accommodate a wide variety of perspectives within the client system if buildings are to be created that satisfy the wide range of demands. Thus, it can be seen that a fuller appreciation of the client's requirements leads to the need for a more elaborated construction team. And it is inevitable that the issues of communication and leadership discussed above will be of critical importance *within* the design team as well as between the client and the "team".

There is also the question of the contractor's early involvement which seldom occurs in the traditional approach to construction in the UK. This has long been criticised and various newer approaches are allowing the beneficial inputs possible, such as Design and Build. This radically changes the roles of those involved in construction and other forms such as Design Led and Build are emerging where architects are acting as lead consultants *and* contractors (Nicholson, 1991). There is not space here to pursue this area, but the issue is clear—the range of factors and involvement is variable on the building team side in just the same way as within the client system.

The above considerations are inextricably linked to the issue of a project management role drawing together the participants within the *construction system* and focussing them towards the client's objectives (eg Walker, 1984).

A key factor implicit in all steps of the discussion so far is that the starting point for any analysis should be the choice of view taken of the "client" and the level of complexity thus admitted.

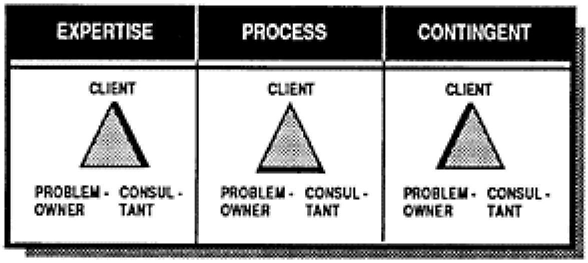
6 Views of the Client

The Lancaster School of Management (eg Wilson, 1984) stresses the importance of the "worldview" ("W" for Weltanschuung) taken of any problem that is being analysed. Solutions found will be inextricably bound up in the orientation of the decision-maker. Ask an architect and you will get a design-biased answer, ask a quantity surveyor and you will get a financially-biased answer, ask an engineer and you will get a technology-biased answer and so on. Over simplified, yes, but broadly true.

Apply this to the question of briefing and it is clear that if an adviser's "W" of his "client" is of someone who has funds and is looking for a quick return then the briefing process will be quite different in substance and style from an adviser whose "W" includes, say, longer-term issues, the user and society at large.

Obviously the "W" adopted will be conditioned by the client to a great extent, but there are many other forces at work such as education and professional conditioning and simply an awareness of the possibilities.

Drawing from his observation of trends in management consultancy (Garrett, 1981) suggests that the consultant will often have to deal with the client and the "problem-owner" (who is often not the client, for example tenants) and that this has led to three different styles of consulting becoming evident. These are shown in Fig. 3, below.



Fig, 3. Garrett's Alternative Consulting Styles

Expertise consulting is the traditional approach. Process consulting is where the consultant works predominantly with the problem-owner, but this can unsettle the client. Garrett favours contingency consulting which is where the consultant draws out a solution from the client system including both client and problem-owner. This assumes that *"...most of the experiences needed to solve a client's problems are already in the organisation."*

Research by Bejder (1991) in Denmark focussed on University buildings confirms the importance of involving in the briefing process all parties whose needs should ultimately be satisfied. In the study cited the views of students, administrative staff, cleaners, maintenance workers, funders, designers and others were included. Comparing two building phases of the same University it was found that the appropriateness of the involvement in each phase did correlate with the differences found in the quality of the buildings against a range of criteria.

This broadening of perspective when viewing the client system is consonant with recent developments in the field of facilities management (eg Becker, 1990, pp 123–151).

7 Summary

The question of the client's brief has been approached from a variety of directions. In mapping out the range of factors, and therefore actors, who should be involved it has become clear that the formal, or traditional, view of the process is greatly over-simplified and excludes many factors that can be crucial. This coarsening of the analysis occurs both in the worldview ("W") taken of the client system and the "W" of the building team. Generally the architect and the particular part of the client system that has the need (the "instigator") are the focus for the analysis. Fig. 4 shows the parallel trends (Bertalanffy, 1971) within the two systems towards a broader view, symbolised by the *project manager* in the construction system and the *facilities manager* within the client system.

Taken together these trends suggest a more holistic view developing which is bound to influence the briefing process, also depicted in Fig. 4., below.

When the project manager talks to the facility manager sparks should fly!

Having said that, in addition to the range of factors involved, the *nature* of the interaction and the outcomes of different scenarios has been considered. A *contingency* *approach* has been suggested depending on the client's knowledge and confidence and also driven by the range of functional and team management skills required which itself will depend on the breadth of view taken of the 'client'. Tentative evidence has been adduced to support the proposition that those whose needs you are trying to satisfy should be involved in the briefing process.

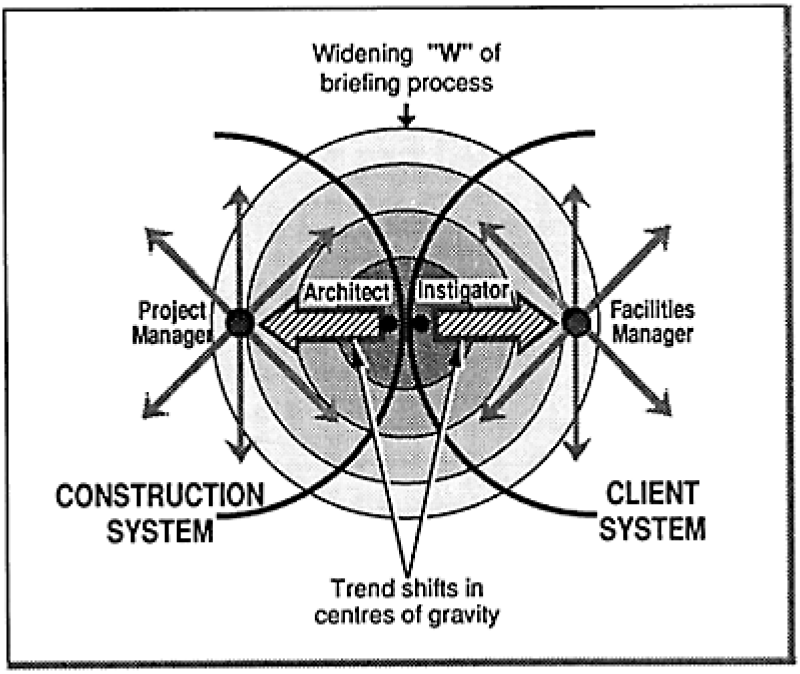


Fig. 4. A Holistic View of the Briefing Process

8 Conclusion

When those in construction approach the briefing process with a client it seems reasonable to suggest that they should initially consider:

(a) how extensive a view to take of the client and construction systems;
(b) the location of pertinent knowledge and experience; be it with the client, the designer, the contractor, etc.;
(c) contingent on the outcomes of (a) and (b), how to satisfy the client's needs through consideration of alternative structural and technological responses (Galbraith, 1973).

In any particular instance it is quite possible that the traditional approach will be appropriate, however, it is also entirely conceivable that a broader view may be required.

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Management information systems: the use of work breakdown structure in the integration of time and cost

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Abstract
A systematic way of defining and identifying the division of production activity is considered. The work package is analysed to classify the varying resource requirements of construction programme activities. Criteria for a work breakdown structure for production control models are reviewed. Problems in integrating time and cost control are considered based on a case study of an integrated reporting system. Finally criteria for a project control model are given.
Keywords: Management Information, Work Breakdown Structure, Integrated Production Control.

1 Introduction

The incompatibilty of estimating with the production process and any relevance to resource control was noted by Blyth and Skoyles (1984). In competitive tendering the completed building should reflect the information provided at tender stage but rarely does so. Any calculation of resources at the start of a contract will therefore remain fluid for much of the duration of the building process. Resource control is seen to involve labour, plant and materials; but information is also a resource. It is in the form of drawings, specifications and instructions and required control. A limited proportion of resources are in the direct control of the site manager when there is a high element of subcontracting.

The direct cost of production (labour, plant and materials) plus the indirect costs (site staff, accommodation and the like) can be readily derived, but the detail is in different forms from that in which resources are developed or consumed. It is impossible to provide any degree of control without the provision of good budgetary information and the problem is one of quantifying needs. Those reflected in the documentation of the contract are often in the wrong terms. The principal skill in production control will lie in procedures that enable site managers to apply their resources flexibly in a changing environment.

2. Activity based schedules

The existing standard methods of measurement were not designed to produce bills of quantities that relate to work items or cost centres. The organisation of construction in the UK reflects traditional practice and there is inherent resistance to change.

McCaffer and Tyler (1986) recognised that, given forms of contract where contractors are required to produce their own data, it is possible to study aspects of contract control unconfined by bills of quantity. The effectiveness of computer based control and information transfer in contracts where the contractor originates basic data on measurement, time and cost can be evaluated. The use of activity schedules as a control and information source is then worthy of research. Such systems should:

> Create a greater awareness of progress. Ease the task of interim measurement and valuation. Assist in assessing the impact of variations on time and cost.
> Facilitate in the valuation of variations.

If data drawn from activity schedules is appropriately coded then the computer can sort by operation sequence, trade, phase or element. Having sorted items they can then be listed. The system can respond to the manner in which a demand for information occurs.

3 Work breakdown structure

A systematic way of defining and identifying the division of production activity is required. The need is for a Project Breakdown Structure or Work Breakdown Structure (WBS). This involves an elemental dominance in definition such as foundations, frame or external cladding. WBS is a hierarchical method of breaking down a large project into the services and work items required to produce the end product (Lavold 1983). The result is a hierarchy of portfolios of smaller projects, each with their responsibility defined and allocated. WBS descriptions which are synonomus with network activities in a master or overall programme (produced at pre-tender or pre-contract stage) create the link between elements and their progress. By allocating resources we can then proceed to cost.

3.1 Work package

The work package classifies the varying resource requirements of network activities. The dominating influence on classification will be work section, trade, construction form or material and location. A clearer statement of construction logic is produced for short-term or stage planning. It should aid measurement for progress reporting. The work package breaks down the WBS for example: a suspended concrete floor slab could appear under formwork, reinforcement and concrete work packages; an electrical installation subcontractors work into location by floors. It is important, of course, that work packages are defined in a standard form for transfer to a data base. Retrieval for future planning or estimating is important for the full economic utilisation of such a system.

In detailed terms there are three dimensions to be recorded in a work package:

Physical characteristics (quality, specification and location).
Resourcing (personnel, plant, materials, work space and time).
Relationship to priced items of work.

A standard system of WBS will be required that has to be constantly applied to a firm's work to reconcile accounts with and between jobs. It will be necessary for the level to lie between summarised general information (too crude for meaningful comparison from job to job) and too detailed a collection of information (requiring too much administration). A problem is that some work packages are critical while others are incidental to contract sucess. A small negative value in one may be considerably more damaging than a large one in another. Warning and danger limits should be identified if control is to be exercised properly.

3.2 Integration

A uniform and consistent system of communication is required where data input or information produced by the various control functions can be sorted and reported on a common basis. Sharing data electronically is not enough for effective integration. For example, the value of work for an item and its cost must be allocated to the same work package if comparison is to produce accurate and meaningful information. The WBS will form the basis of communication between all control functions involved with a contract and therefore the use of a common WBS is required for the effective integration of a management information system. Integration is not the collection of data but the correlation of data so that variences can be calculated in relation to a standard.

The WBS is at a summary level for reporting time and cost in relation to master programme activities. The work package is at a detailed level for allocating labour and plant or labour only subcontract use of resources. An example of a coding application for an insitu reinforced concrete internal wall is shown in Table 1. The coding system relates to that devised by Baxendale (1987). Additional coding digits will be required for location and subcontract identification that are contract specific.

Table 1. Work breakdown structure and work package coding.

ALL superstructure	2	0		
Superstructure internal walls	2	2		
ALL concrete work			E	0
Insitu concrete			E	1
Formwork			E	2
Reinforcement			E	3
WBS code	2	2	E	0
Work package code: Concrete	2	2	E	1
Formwork	2	2	E	2

Reinforcement	2	2	E	3

4 Work breakdown structure criteria

The criteria devised for production control models based on a WBS are as follows:

(a) Each work package is to be identified as a network programme activity (each activity will also have to be a work package).

(b) The definition of each work package for each contract will have to be identified and agreed by all who use the system (estimator, planner, contracts surveyor and site manager).

(c) Data will have to be collected in relation to the work contained in each activity.

(d) Activity data will have to include resources that are to be the subject of control (labour, plant, site overheads and materials in order of priority).

(e) The input of data will be site based and the output of information reported for both contract and company.

(f) Updating of work package content will be necessary for any variations in quantity or value.

(g) The coding of work packages in a standard form that is transferable from contract to contract for comparison.

(h) A statistical data collection facility in relation to an historical input to a data base (mean, range and distribution).

(i) Recognition that different criteria will apply to subcontractors who are controlled on site by performance and quality only.

(j) Easily understood by all those who use the system.

5 Integration of time and cost

The integration of a planning (time control) system and a budgeting (cost control) system gives rise to a number of problems. However cost information cannot be meaningful unless it is related to a time frame (Sancho 1982). The major functions of a planning system are to:

Establish a work programme (or schedule of objectives).
Report progress of the work.
Identify deviations from plan.
Show a projected schedule for the remaining work.
Show the effect of contract changes.

The primary functions of a budgeting system are to:

Establish cost objectives.
Report historical costs to date.
Show estimated costs to date.
Compare estimated with actual costs.
Show the effect of changes.

The functions of control systems are:

To set standards (performance objectives).
To measure output and compare it with standards.
To react to unacceptable deviations by signalling them.
To repond to signals by providing a basis for decision making in respect of any corrective action.
To facilitate that action.
To review standards.

5.1 Alternative methods of integration

An information system that integrates time and cost has two important requirements:

Integrated data collection based on consistent cut-off dates and single data sources.
Reporting that reflects both cost and time effects on project performance trends.

Two alternative approaches considered by Hermes (1982) are now reviewed.

The direct alternative:

Project costs can be broken down to agree with scheduled activities and will directly eliminate the structure mismatch problem. At the planning stage costs must be budgeted by activities and during project execution, budget accounts are opened and closed as activities are started and finished. Thus performance problems are detected early as each activity reports progress or is completed. This approach of work packaging is considered to have serious limitations.

(a) The practical problem of collecting actual cost by activity.

Scheduled activity breakdown often changes during project life and is more volatile than cost codes. Scheduling can require activities to be defined at levels of detail where cost data collection can be cumbersome. The reverse also being possible, for example tracking bulk material costs by activity.

(b) The factors that drive costs and schedules are not all same.

A material may not be purchased for only one activity. Operative and plant resources may be used across more than one activity.

The indirect alternative:

Cost and schedule breakdown remain different but both the structure and processing of data are interfaced where appropriate. There will be a common dependency on resource links for both cost and schedule. Reporting costs in the same format as schedules can be an artificial way of suggesting that integration exists. Progress is reported from the scheduling system which in turn integrates with a resource control system. Finally the resource control system is integrated with cost reporting, financial and accounting systems in which data is summarised into information. The indirect approach can be attractive to contractors who manage construction resources in the field. Implementing this approach requires a careful use of coding structures and information systems interfaces. The emphasis is on achieving cost/schedule integration without compromising the individaul objectives of each control function.

5.2 Level of detail for integration

Cook (1982) states that it is impossible to integrate cost and schedule systems effectively at summary level. Measurement of the criticality of the work being performed is required in order to give proper weighting to reports. To be successful, cost/schedule integration must be performed at the detailed level. The interrelating of the systems needs to:

Develop the cost system and the schedule system at the level of detail each independently requires.

Determine which cost items and which schedule items can be correlated.

Transmit meaningful and required data between the systems.

Realise that it is not possible to determine a direct correspondance for transmitting all information.

Analyse the information being generated by direct contact with the personnel involved.

Cost and schedule systems are compatible but not identical, every item cannot be integrated. Correlating data and analysing the resulting reports will improve the ability to develop, monitor and control both cost and schedule.

6 Case study of an integrated system

The application of an integrated time and cost control system is considered that was in use on a project. An integrated reporting system (IRS) is developed, with the emphasis on cost, to enhance an adequate existing short-term programming system. The reporting system is based on work packages which are broken down in relation to resource usage and location. A variance report is also calculated for each work package as a basis of forecasting for the total project. The problems found with data collection and presentation together with the implications for site mangement found are now reviewed.

The project ran without any major problems as regards progress, however, the failure of the programme to define distinct work package activities created problems. This was highlighted in the case of the edge strip and floor slab, but is of more importance in other areas, where whole sections of work were missing. On this project no builder’s work appeared in the budgets or on the programme and labour was released from the site too soon; this led to daywork bills for 2 men for 2 months. A simple mistake in grouping builder’s work with service sub-contract work could easily have been avoided had the IRS system been used.

With the traditional system the invoicing of materials provides the cost control point, however, this can lead to problems when assessing the cost of individual activities. This becomes more pronounced at the project level. At one stage of the project the profit to date was shown as £20,000 less than it should be. This was due to profits made on materials which did not come to light until after all the invoices had been collected.

To overcome this problem fully is difficult due to the historical nature of invoicing, however considerable improvment is made by the introduction of the IRS system. Each work package has its own budget, including materials and also has its own reporting sheet. Therefore full information on materials for each area can be applied, providing a good guide to the material costs in relation to budgets. In this way the future costs of materials can also be judged leading to a correct statement of profit and clear understanding of the contract status. The IRS reporting system would be weekly. This provides site management with a more up to date view of activity and resource needs at a time before problems occur and the project falls behind schedule.

The decisions that site management make will depend on two major factors, namely previous experience and the information provided by their control system. The IRS system provides a wide range of co-ordinated information on both costs and progress relevant to each clearly defined area for the contract, or work package. This should lead to more accurate and relevant decisions. Variance from the control plan can be accurately assessed and located at the root cause for correction. The availability of historical data adds to the previous experience of the management. The ability to forecast specific events, from data specific to those events, allows genuine control of cost and time, not merely historical confirmation of events.

In terms of data processing the administrative workload is increased. The effect of such a system on resource allocation on site and therefore for the company and industry must, if properly used, be advantageous. With increased accuracy in making decisions, resources will be more fully utilised, leading in turn to greater efficiency for all parties.

The case study has shown that there are many common elements between a cost system and a time system: the programme develops dates which are required for calculating cash flow forecasts; the budget estimate provides data for resource outputs required for determining activity durations and resource levels; the cost reporting generates information on work completed and payments made which relate to schedule progress; the remaining activities can be extrapolated to give cost at completion forecasts. The primary aims of integration are to transmit information between the systems, provide better utilisation of data and provide consistency of information between the systems. The advantages of integration shown agree with those reviewed by Shiring (1982). There is a natural dependency between when the work is scheduled and the spending of the budget and the budget can be phased over the time of the project. The effect of contract changes can be more easily found when both the budget and the schedule are involved, as well as improving the accuracy of estimates on completion.

7 Criteria for project control

Control of time and cost can be integrated through work packages. These can be defined in a standard form for continuity of feedback. The objectives and functions of each contributing resource data system should remain unaffected. A work package will relate to a programme activity and to an estimate of cost for that activity. It is the presentation of processed data in the form of variances in time and cost that should assist managers in controlling projects. The control system should also afford strategic aims against which the satisfying of user needs by the system can be measured.

A model to represent the practice of project planning, monitoring and control will have the following objectives:

(a) Model the projected work in terms of planned progress and cost using a common data base.

(b) Permit a comparison of actual progress and cost against planned.

(c) Identify the sources of variance and quantify them in terms of time and cost.

(d) Provide a means to explore operational decision making by allowing independent access at varying levels of detail.

(e) Record data on resource usage in relation to performance and cost to facilitate future planning and estimating (historical records).

(f) Relate the flow of funds for the project to the policy and performance of the organisation as a whole (accounting records).

(g) Recognise that user requirements are of paramount importance and that information from the system must be capable of influencing the decision maker.

The possibility of integrating time and cost data for site based control, at both the overall and detailed level, has been established. An integrated system has been devised in a case study that overcomes the practical problems of producing control variance and forecasting reports.

There is a need to integrate time and cost control systems, but for such information to be effective it must also be practical. Automated computer project control systems are available, but their success is more a function of how they are used rather than what the software can do.

Indirect integration can be achieved by using a common coding system which allows all existing systems to interface information. Careful use of work breakdown structure for programme activities at project level, particularly in relation to subcontracting, will overcome the problems of direct integration, provided that cost data is prepared in relation to activity format.

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3
Choosing between building procurement approaches-concepts and decision factors

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Abstract
The situation of the choice between various building procurement approaches is considered as' an early decision of the building client. Such decision will be in the context of his opportunity costs among the available procurement processes because each has a different effect on the execution of the various phases of the generic building procurement process as well as on the overall benefits and costs of the client from the building. Each procurement approach will be outlined in relation to phases of the generic process of building procurement. Decision/choice factors drawn from research projects on building procurement will be presented. The effect of each factor will be related to the procurement process with which it is most and least compatible.

Key Words: Buildings, Procurement, Client, Decision, Factors, Approaches, Traditional, Design/Build, Construction Management, Vendor/Provider, Program Manager, Cost/Benefit Analysis, Opportunity Costs.

Introduction

The choice of procurement approach for every future building project should be made as a specific choice to match primarily, the needs of the building's client. That choice should be made objectively, carefully and at its latest, prior to beginning designing of the building.

This paper discusses the concept of building procurement and a feasibility study approach including opportunity costs in each of the array of procurement approaches as a means of choosing the most appropriate procurement process for each future building project.

It goes on to outline each procurement approach and then presents four groups of factors which could lead to a more appropriate choice of procurement approach for a future building project by a more rational choice process than is generally used currently.

The stimulation for writing this paper came after carrying out and re-reading the results of two research projects on building procurement. During these it became very clear that numerous role experts in the building industry saw that the rational choice of one procurement approach came more from (a) the building clients' desire's from the procurement process, (b) the nature and current status of the client, (c) the nature and current status of the local construction industry as well as to a lesser extent, (d) the expected nature of the physical building.

The generic process of procuring most building's comprises the phases of Building Idea or Need, Feasibility Study, Design Process, Construction Contracting, Construction Process and Commissioning. In each phase consideration should be made of the effects of the management processes and decisions which guide this generic process as well as considering the materials of the building and its construction and erection work.

There are five alternative approaches to procuring buildings i.e. Vendor/Provider, Traditional, Design/Build, Construction Management, and Program Management. The choosing of one of them for each building project should be seen as managerial decision which, currently, is often made by default or ignored. This important decision should be made rationally and objectively and no later than before the design process begins. Furthermore, as this choice of one approach from an array of approaches can affect the processes of design, contracting and construction which in turn affects the quality, cost and duration of the building project for the client, it follows that the Feasibility Study for the building project should have variables based on the use of each of the alternative approaches to building procurement. Thus, there is a complementary relationship between the timing of the feasibility study for the building and the choosing of one building procurement approach from those available in the marketplace.

Research Process

All of the above and what follows was derived mostly from the results of two research projects examining building procurement approaches (1), (2). The balance of sources comes from reading, practicing and discussing building procurement over many years.

One of the sets of research results from which this paper was produced was a research report from face to face interviews with many building client/owners on the comparison between and strengths and weaknesses of various of procurement approaches. The other set of more specific research results from which the paper was produced was a series of six round table discussions at each of which there were usually two representatives of building clients, architects, general contractors, construction managers and sub contractors responding to a single questionnaire/discussion guide on construction management. These groups of exponents were chosen to represent top quality practitioners in their role in each urban area in which the meetings were held.

Subsequent to completing both of these studies this topic of why and how to objectively choose the most appropriate procurement approach for a particular project was considered, contemplated, the results reexamined and the paper written.

Building Procurement as a Concept

Building procurement implies the client receiving a physical building but also implies that the client has to pay for the building he receives. It is insufficient to consider that there is only the process of delivering a building from which there are flows of benefits-social and pecuniary- to the building client over its economic life. The form of payment is as a capital investment cost (including the cost of materials put in place plus human and machine construction resources used to do so) and functioning costs (maintenance and operating) of the building over its economic life. Furthermore, from these, the client can use the concept of value of the building, meaning that the maximum value is derived from the maximum difference between the life cycle sums of both the flows of benefits (social and pecuniary) and of the flows of costs (social and pecuniary) from the building.

The abstract opportunity costs derived from making the choice to use one building procurement approach over other available approaches should be built into this benefit/cost Feasibility Study phase of the generic procurement process for buildings. These opportunity costs of each procurement approach should be considered because they relate to the potentials to change both the degree of satisfaction of the needs of the building users and client and hence change the flow of benefits and change the flow of costs by affecting construction costs and its duration of negative cash flow as well as affecting the maintenance and operating costs of the designed building.

Choosing the Most Appropriate Procurement Approach

Making a rational, objective choice of one procurement approach from those available should be a major managerial decision for the building client because it will have widespread long term and short term effects on the client and his future buildings and the fortunes of both. Too often this choice is made by default or only made after the design phase is nearing completion or is made by choosing the current fashionable process which is being lauded in journals and publicity vehicles.

At the very latest this major decision or choice should be made before design begins. It should be made by choosing the one approach which is most compatible with (a) the needs of the client from the procurement process, (b) the nature and current status of the client, (c) the state of the current local building marketplace and (d) the resulting nature of the future building. As a result of careful thinking in making this decision/choice the project can be put in place with better “goodness of fit” to the needs, benefits, and costs of the client and building users than would be the case if the generic procurement process was always carried out by one procurement approach as a given rather than as a choice from alternatives. By objectively making the choice between these procurement alternatives, considerable latent value potential could be harvested by the client in the form of less cost in money and time and greater goodness of fit to the building users and client needs etc. The decisions and choices which create and crystallize most of the benefits and costs of any building occur mainly in the design and contracting phases.

Alternative approaches to building procurement are now sufficiently common that it is possible to see each as a separate alternative management technology for building procurement.

The Alternative Procurement Approaches

The array of alternative building procurement approaches available in the marketplace are Vendor/Provider, Traditional, Design/Build, Construction Management, and Program Management. Each has characteristics to best suit different clients, under different procurement situations and different marketplace characteristics. Each of these alternative procurement approaches has different characteristics and effects on the potential activities in the design, contracting, and construction phases of the generic building process.

Vendor/Provider and Program Management Approaches. In both of these approaches a building procurement expert agent is hired by the client to operate as the knowledgeable surrogate of the real client. This surrogate makes the choice of most appropriate procurement approach for each building project from among the three other basic approaches.

In the Vendor/Provider approach the agent will buy land, design, construct, and rent the building to the client based on how best to procure each building.

In the Program Management approach the agent will be an advisor or executant for the client on how best to procure each building in that program of buildings.

Traditional Approach. The client will hire the architect as his only principal agent advisor. The architect will be in charge of the whole design and all contract documents and contracting for construction. He will advise on the choice of contracting process and be an inspector of the building during construction but will not manage the construction process. The construction process will be carried out by and be the responsibility of a general contractor usually for a fixed sum of money.

The client has the advice of the architect throughout all phases of the procurement process but the architect’s capabilities are mainly in design and constituents of the building rather than in management of complex contracting processes and settlement of contractual matters before, during, and after construction.

Design/Build Approach. The client will seek from a single source, or say from each of three competing sources, a single contractual offer for a proposed building. Each design/build bid is based on either an outline building program or a proposed conceptual design, a set of contract conditions, outline specifications, a building delivery date and the lump sum of money bid for carrying out all the work of remaining design, contracting and construction.

Usually the contract conditions, delivery date and the lump sum for the building are fixed and the remaining design content and specifications are variables to be controlled by the design/builder which is usually dominated by the “build” side of the company or joint venture. Such control is to produce a building within the contracted lump sum by adjusting the design, its constructabi1ity, and specifications etc. by the design/builder who will hire local sub contractors to work under his own “build” staff operating as an internal quasi general contractor.

The client may not have the expertise to evaluate the constituents of the design proposals from each bidding design/build organization and may not even be able to write a feasible design program. The client will have no influence on what is designed, contracted or constructed after he has accepted the design/build bid, based on the above outline design and specification and all such decisions and work are carried out by the design/builder.

Construction Management Approach. The client hires both the architect and the construction manager before design begins. Then, the triumvirate of client, architect, and construction manager carry out and manage each sub phase of the procurement process as a core team with different but appropriate inputs and periods of participative leadership of that team. The architect will have the capabilities of a professional architect, he will be responsible for all design work required for the building and will manage all work of the array of design consultants. The construction manager should bring considerable abilities in providing construction related advice in costing, scheduling, constructability to the building as its design evolves as well as provide advice on appropriate structuring of contracting subtrade packages to match the current local construction marketplace as well as having capabilities to manage the construction process.

Decisions Factors by Which to Choose the Most Appropriate Procurement Approach

The format of use of these decision factors is to pose them as questions regarding the anticipated building project. For example, the first factor in Group A is-Clear or Unclear Objectives. Put as a question it would be "Does the client have clear objectives of what he wants as a result of the procurement process?" That he can state these clearly in writing is one response, if he is unclear of what he wants then such objectives remain to be established in the procurement process by his agents and a procurement approach which accommodates that should be sought.

Alternately, each factor can be seen as an "if" statement. If that state exists points to one procurement approach and if it does not, it points to another procurement approach to be best for the client.

After having evaluated the situation of the proposed building project by these factors there will be sets of votes from zero upwards for each or the alternative procurement approaches for that building project. The approach which gains the most votes is the procurement approach most likely to best satisfy that proposed building project. Furthermore, by spotting the factors which go against that most desirable approach can warn the procurement participants to carefully handle features under these factors as they carry out their work.

A client should be aware that the choice/decision of one procurement alternative may come from the permutation of factors rather than the individual factors. Thus, care should be exercised in moving from the apparent choice based on the sum of votes from individual factors to a final decision of which procurement approach is best for the whole project.

These factors are presented in four groups: Group A, Client's Objectives from the Procurement Approach; Group B, Nature of the Client; Group C, Marketplace Prevailing

Conditions for Procurement; and Group D, Client's Objective from the Physical Building.

Below, each decision factor is outlined within its group. Mostly, these factors were distilled from the results of the two research projects on procurement approaches for buildings. Also, suggested against each factor is its most favorable and unfavorable procurement approach. The examples of procurement approaches chosen for each factor resulted from thinking about the implications of each factor in relation to the nature of each alternative building procurement approach.

Group A: Client's Objective From the Procurement Process

1. Client's Clear or Unclear Objectives. Where the client is clear (with validity) on what he wants from the procurement process etc. he can benefit by inputting his clear objectives to the design/build approach but the more unclear he is about his objectives means he can benefit more from the construction management approach, unless the clear objectives dictate otherwise.
2. Client's Maximum Value. To achieve a building of best fit to his space and aesthetic needs along with minimum cost and minimum procurement duration is most likely to be achieved by the interactive multiple advice of construction management approach and least likely with the design/build approach.
3. Client's Desire for Maximum Control. Desire for maximum client control of details in the procurement process will come from construction management or traditional approaches. Least client control of procurement comes from the design/build approach.
4. Client's Minimum Construction Cost. Minimum construction cost to the client requires easy constructabi1ity from the design and competitive bidding for construction trade which could be achieved by the construction management or traditional approaches.
5. Minimum Calendar Duration of Procurement. Most likely to be achieved by the design/build or by construction management approaches whereas the traditional approach usually will consume most calendar duration.

Group B: Nature of the Client

1. Client's Knowledge of Building Procurement. A client whose knowledge of building procurement is considerable creates greater potential to reap the full benefits of construction management or design/build approaches. A client whose knowledge of building procurement is small could be best served by the traditional or construction management approaches.
2. Client's Willingness to Participate in Procurement. Greater client willingness to participate in procurement phases leads towards construction management and least willingness to participate leads to design/build.
3. Client's Entrepreneurial Risk Carrying Capability. The client who can mentally and emotionally tolerate knowingly being involved in entrepreneurial risks in the procurement process can benefit most from construction management and the opposite type of client would be best served by the design/build approach.

4. Client's Operational Constraints. An organizational client which has bureaucratic rules by which to carry out most of his procurement is most likely to benefit from the traditional approach and has least potential to benefit from using the construction management approach.
5. Size of Client's Organization. A large organization as client tends to have complexity in design programming and information handling which is best handled by the construction management or to a lesser extent, the traditional approach. A very small client would tend to benefit from the traditional or design/build approaches.

Group C: Marketplace Prevailing Conditions for Procurement

1. Status of the Money Markets. When interest rates and/or inflation rate is high then the approximately good design with high speed procurement of the design/build approach provides the best results where as the traditional approach probably provides the most benefit under the opposite circumstances.
2. Local Building Regulations. Very complex, multi agency or stringent building regulations can require special handling by the client's agents during procurement which can best be done under construction management or design/build.
3. Ensuring High Quality Construction Skills. Ensuring high skill quality in construction work can be achieved best by the traditional or construction management approaches.
4. Ensuring Availability of Trade Contractors and Workers. Most achievable under the construction management and design/build approaches. The former is set up to benefit the client and the latter to benefit the design/builder.
5. Matching the Building Needs with the Local Construction Industry. This match can be best achieved by the construction management approach for the benefit of the client. Design/build can do the same but the benefits flow to the design/builder.

Group D: Client's Objectives from the Physical Building

1. Unusual/Unique/Complex Building. The more extreme is the nature of the building the more likely it will be best procured by the construction management approach and least likely under the design/build approach. Simple buildings can be best procured by design/build or the traditional approaches
2. Quality of Functional Use of Building. High functional quality in design is best achieved with the traditional approach or construction management approach.
3. Quality of Materials in Building. Ensuring specified quality of materials in the finished building is best achieved with the traditional approach or construction management approach.
4. Requirements of Building Alteration Work. Complex integration of new to exisiting buildings and to enable the client's organization activities to continue during construction may require uncommon building construction sequencing. Construction management approach can best satisfy this whereas design/build has the least potential to provide this satisfaction.
5. Neighborhood Surrounding the Site. The simplicity of procuring a building on a clear, open site would be best satisfied by the design/build and traditional approaches

whereas a central business district site tends to provide benefits from the construction management approach.

Conclusion

Making the choice of which procurement approach is most appropriate to the project should be by considering factors grouped under the client's objectives from the procurement process, the nature of the client, the nature of the current, local construction marketplace and prevailing conditions as well as features of the physical building. This choice/decision is very important for the client to achieve highest value from the building and should be made as rationally as possible prior to design and perhaps as early as the feasibility study for the project. Currently, this major choice/decision is usually made by subjective habit or default which precludes the client from benefitting from carefully considering the opportunity costs of each alternative procurement approach in the cost/benefit analysis feasibility of the proposed building project.

This paper suggests a research based outline of an improved way of selecting the procurement process for a building project.

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4
Factors and variables to induce effective construction schedules and efficient construction

G.S.BIRRELL

Abstract
The paper will present an array of factors deemed most important and variables stated as appropriate for inclusion in construction schedules. The sources of the underlying data were senior executives of general contractors and the research methodology was by a carefully structured and executed research process. The use of these factors and variables will be in creating effective construction schedules as guides to future efficient building construction work. Also presented will be the effect of these factors in the form of savings and losses on the costs and durations of building work from their inclusion in construction schedules.
Keywords: Building, Construction, Schedules, Factors, Variables, General Contractors, Effectiveness, Efficiency, Expertise, Cost Saving, Duration Savings.

Introduction

Implementation of buildings' designs means different things to different people. However, for the building to stand ready for use requires that it be built and presumably built as presented in the plans, specifications and contract documents.

The building process is complex and in it there can be considerable variances in efficiency of the building process from the different uses and choices of permutation of construction resources over the duration for construction. Also, the nature of the building, its design features, the specifications and contract conditions can cause increases and decreases in efficiency of the construction process from variances in resource consumption and/or durations of construction of parts of the building or of the whole building.

The result of considering all of the above variables for construction of a particular building is the schedule of the future construction process which is prepared as a guide to the execution of its actual construction process.

This paper addresses the topic of the factors and variables which provide the emphases and biases in construction schedules which lead to maximizing efficiency in the actual construction process.

The contents of this paper may seem strange and unusual to people who only design buildings. However, these contents summarize the views of general contractor experts in the construction process regarding effective scheduling and efficient actual construction of buildings. If the contents of this paper are unusual to designers of buildings that indicates a potential to learn about efficient construction of buildings. In turn these can be used to adjust designs, specifications and contract documents to facilitate efficient construction.

Alternatively, the contents of this paper may appear to lack uniqueness to people who are seeking the latest "way out potential solution" to all construction problems in the future. Seeking such a single solution tends to have failings which have yet to be perceived by such an uninitiated person. Rather, the comparatively simple suggestions to maximizing effectiveness in construction schedules and efficiency in the actual construction process presented in this paper comprise the consensus of the thinking of many top quality general contractor construction experts. It will be by appropriately applying them to each and every construction process that tending towards maximum construction efficiency can be achieved.

Source of Research Results in Scheduling of Construction

This paper is derived from the results of a research project which sought the views of senior construction executives on factors and variances in building construction schedules (1). Fifty senior executives were drawn equally from office based and site based executives of top quality general contractors companies which operated in major urban areas in a major growth state in the U.S.A. Each was questioned face to face on the topic of construction scheduling using a carefully prepared questionnaire prepared according to the tenets of social science research.

The Cost and Duration Effect of Including These Factors in Construction Management

It was the consensus of the views of these experts in construction of buildings that using their normally experienced construction schedule as their datum, if the factors mentioned in this research were included in a construction schedule that there would be a 10% saving in cost and 15% saving in duration in the actual construction process, These experts considered that If these scheduling factors were not included in the construction schedule that construction costs would be 17% higher than normal and durations would be increased by 30% from the achieved by a normal construction schedule. Thus, there is a cost range of saving 10% to losing 17% and a duration range of saving 15% to losing 30% from the datum of a normally experienced construction schedule based on the degree of inclusion or exclusion of these factors from the construction schedule. Thus, the client's team of advisors wishing minimum duration and cost of construction i.e. a major part of the implementation of the building, should pay attention to the following factors in creating the schedule which will guide the actual construction process. Also, the contents of the bid package produced by the design team should pay attention to the following factors and variables in the creation of the design and its documentation as input to the construction process.

Most Important Factors in Construction Schedules

From a pilot research project among equivalent construction executives, forty-five factors were produced which affected the efficiency of the actual construction process and which were seen to be valid for expression in the construction schedule by whatever scheduling technique was to be used. In the subsequent main research project each of the fifty experts was asked to state the degree to which he used each of these factors. From the summation of the results, fifteen factors of the forty-five factors were categorized as most important. In order of their importance and only very briefly described these were:

1. Realistic Construction Duration. The overall duration for a construction process should be compatible with and usually derived from a realistic construction process and its duration. Too short or too long a duration leads to inefficiency and to arrive at an overall duration calls for study and creation of a realistic construction process.
2. Lead Time for Materials Delivery. The position of work tasks in the schedule should be set after establishing the realistic require delivery durations for its materials from their source and including shop drawing and contracting for supply as well as the logic of the on site construction process.
3. Required Types of Construction. By having to create a schedule forces an examination of the types of materials and construction processes as the schedule. Such thinking causes facing up to construction issues before they occur on the site so that surprises during the actual construction process are at a minimum.
4. Critical Pieces of Work. Work tasks which are critical to the overall duration or to the logic of construction or because of their geographic location in the building having the potential to cause construction complexities should be highlighted in the schedule as such. The thinking creating the schedule should dissolve as many of these bottlenecks as possible.
5. Work or Materials by Others. The construction schedule should be for all required construction work for the building including that of non contractors such as utility companies, work by the client's workers and staff as well as inspections of work done by local government officials.
6. Previous Experience of the Contractor. The scope of the basic construction knowledge of the general contractor and his scheduling knowledge are both very important in producing or precluding a high quality schedule and construction process.
7. Complexity of the Project. A major function of the schedule is to dissolve the complexity of the construction process arising from the required design and express it in the simplest, best process for efficient construction.
8. Previous Experience of the Scheduler. The person making up the schedule or responsible for its creation must have high quality knowledge of construction

processes as well as scheduling capability and have the ability to blend together these two bodies of knowledge.

9. Subcontractor Input. The construction schedule should receive input from at least major subcontractors before or during its creation to solve their trade work problems and the conflicts from interactions among the work of most trades as efficiently as possible.
10. Contract Documents. The contract package of conditions of contract, specifications and drawings etc. should be carefully examined in order to focus on features which aid or inhibit efficient construction work.
11. Restraining Items. Required work items which restrain, block, or compound the start of other work items should be identified and a construction process should be selected to minimize their restraining influence.
12. Expected Productivity. The duration of work tasks and hence the whole construction process is dependent on the quality and numbers of resources used and the duration of use. The quality and duration of work is dependent on the productivity capacity of local workers. These expected productivity rates should be sought and used as input to scheduling.
13. Size of Project. To create its schedule, a large project can be analyzed to be an array of adjacent small projects. However, the results of such analyses should be to create one schedule meshed together as a whole schedule with the best overall construction strategy as well as containing or representing the required details. Once created it can be cut into sub sets relevant to the configuration of the local construction marketplace.
14. Communication with Others. The schedule once completed, has to be in a form, complex or simple, which can be communicated, understood and used by the people in contractors' offices, on construction sites and in the clients' offices. Thus, it must take into consideration their level of understanding and communication capabilities.
15. Conditions Which Affect Productivity. The local construction marketplace in which construction will take place should be examined and analyzed to establish major existing variables which will affect construction productivity at the time when this building will be under construction for inclusion in the schedule.

Types of Buildings and Their Variables in Construction Processes for their Effective Scheduling

In the main research project the views of the construction experts were sought on the constituents of the variables to be incorporated into the construction of different types of buildings to maximize efficiency of construction. These are presented below individually.

For each future construction process to be efficiently carried out, its input should be drawn not from only one of the following set of variables but from the permutation of variables expressed below appropriate to the type and nature of the future building. For example, an hospital could be high rise, of normal materials, of few repeatable work process etc. or it could be low rise of high quality materials and with many repeatable work processes. Thus, to effectively schedule construction work requires its creation to include these variances as well as the above factors.

The variables and sub variables are in the following groups: A-Quality of Materials, B-Height of Building, C-Degree of Repeatability of Construction Activities, D-Location of the Building, and E-Nature of Major Use of the Building.

A1 Building of High Quality Materials. These will require special scheduling attention to the delivery processes of such materials and the flow of materials and high skilled craftsmen to and across the site (as well scheduling of their construction processes). In the construction work schedule greater attention should be put on the greater volume of preceding support/work usually required to receive the high quality material finishes in the building.

A2 Buildings of Normal Quality Materials. Efficient construction and effective scheduling will require realistic appraisal of the availability and supply of highly productive workers to the site so that the flow of materials to the site will be scheduled and controlled to match the requirements of an efficient construction process.

B1 High Rise Buildings. The construction of high rise buildings requires scheduling of vertical movement of materials for all trades as well as their cross site movement. Construction work in the schedule should be expressed with maximum parallelism of the different required work flows. Establishing the sequence of parallel work flows should be derived from “cycle analysis” of the design of repeatable elements of the buildings. This should be preceded by expediting foundations and structural framework. The early enclosure of the building and bringing elevators into early operation require attention in the schedule.

B2 Low Rise Buildings. To achieve efficient construction, the schedule should focus on maximizing continuous harmonious work flows with minimum of interferences. This calls for high quality strategic common sequencing of all work flows around the building as input to the detail scheduling. Such strategic scheduling should include considering the layout of site support services and their movement on the site to support the changing locus of direct construction work. Enclosure of the building, structural framework, foundations, and installations of major pieces of equipment should be both executed quickly and carefully positioned in the schedule within the strategic sequencing of work around the building.

C1 Buildings with Many Repeatable Work Processes. The schedule should try to harness as fully as possible the learning curve benefits on as many resource flows as possible as they progress through each repeatable work item. This requires maximizing parallelism in the schedule and allocating resources to each flow so that the work on all flows are changes in resource allocations and inspections of work delaying the specific flows of work which then delay other flows of work. The design should be “cycle analyzed” to produce the best start sequence of work flows through the most repeatable location in the building.

C2 Buildings with Few Repeatable Work Processes. Efficient construction requires premium thinking on the logic of the interactions between the diverse array of work items so that down time between them is minimized. Complementary to the above is establishing a realistic duration for each work task. In this type of construction work a greater volume of information has to be handled expeditiously. Also, the use of work people with a broad array of skills is advantageous and all the above has to be expedited by management to achieve the most expeditious flow dynamics.

D1 Buildings in City Center Locations. Here careful scheduling is needed of the deliveries of materials to the site, their movement on site combined with carefully considered storage locations on site. The security interface between the site and the public must be maintained for safety of people as well as for security of materials on site. If materials are lost, considerable construction holdups can occur because their loss is not realized until the work is about to start. Scheduling of work expediting site utilities, subsurface work and providing appropriate lead times to bring subcontractors on to the site can also lead to efficient construction process.

D2 Buildings in Rural Locations, Here efficient construction work calls for focussing on ensuring that materials will be on site when needed and that there is security for the materials already delivered to the site. If the matters are not attended to, there will be holdups in direct construction work. Lack of required skill labor, in total or in calendar time, can impede the construction process as can the usually slow and awkward travel for materials to such sites. Early scheduling of on site utilities work and early availability of temporary power lead to more efficient construction.

D3 Buildings in Suburban Locations. Efficient scheduling of construction work in such locations should reflect compatabi1ity to local government ordinances, controlling working hours, material delivery times of the day and load capacities of streets. Carefully selecting and maintaining accesses to the site for all types of resources traffic and for security of adjacent properties should be built into construction work and its schedule. Also, work should be directed at maintaining separation of the site from the neighborhood for both the safety of children etc. and security of materials and equipment delivered to the site.

E1 Office Buildings. These tend to require sequential waves of work in the construction of (1) the shell and (2) tenant finishes. The shell work tends towards many repetitive work processes and the tenant finishes tends towards few repetitive work processes with high quality materials.

E2 Apartment Buildings. These tend to require waves of work processes which may be constrained by a strategic work flow to achieve completion dates for specific parts of the project and a balancing between maintaining stable sized work crews and minimizing time friction between work crews.

E3 Schools. These have their desired finish date as a major priority and tend to require careful scheduling of work particularly to dates of government inspections. Kitchens and heavy machines appear to be potential restraining work in construction.

E4 Factories. Critical types of work tend to be the foundations and bases and power supplies for machines as an early wave of work to be followed by the installation of the completed machines prior to their encasing by the fabric of the building. Thus, these two major waves of work should bracket the scheduling of installation of the machines.

E5 Hospitals. These tend to be unique buildings which require many stringent inspection clearances and quality considerations along with a critical mass of complex logical interactions among building parts and construction resources. Also, the temporary openings for the building in of special equipment has to be included in the construction process schedule usually after long delivery durations. Hospital construction which includes alterations to existing buildings should be scheduled interactively with new construction. Both should be scheduled around maintaining ongoing hospital services if the construction is adding a building to an existing hospital.

Conclusion

The factors, variables, emphases and biases outlined above can increase the efficiency of construction processes and increase the effectiveness of schedules created to guide construction processes. These elements can reduce cost and durations by 10% and 15% respectively by their inclusion in a construction schedule. Their omission from a schedule can add to cost and duration of construction 17% to 30% respectively.

As these factors and variables could provide such benefits to the participants in the construction of buildings it follows that for the client to also gain from such advantages requires every bid package (conditions of contract, specifications and drawings, etc.) should be examined for compatabi1ity to the above factors and variables to maximize the building features which are in harmony with them to lead to efficient construction of the buildings.

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5

The building procurement roles—their professional personalities and communications issues among them

G.S.BIRRELL and R.G.McGARRY

Abstract

This paper presents the hypotheses and results of a pilot research project into the professional personalities of role representatives in the building procurement core team of roles. This research was set up to seek and initiate the improvement of communication quality among members of the procurement team. While the hypothesis of different personalities for each role was found invalid, there is value in establishing the common professional personality which exists across all team roles. That personality type is the extrovert, sensing, thinking, judging (ESTJ) type. Knowing this, the vital topic of communication among them can begin to be handled more effectively to benefit the output of the whole team and other roles around it.

Keywords: Building, Roles, Communications, Personality, Temperament, Human, Professional, Testing, Management, Theory, Research

Introduction: Background and Common Notions

Organisational Theories and Managerial Communications

The concept is well founded in managerial literature that information is very important to the work of managers. Moreover, the closer the organisational structures reflect the needed lines of communication among managers the more efficient it will be. Some theorise that Information is considered as "the stuff" by which managers do their work (1) (2) and that information is the major input into the managerial major function of decision making (3) as well as being a major component of the managers others functions (4). Other theorists argue that about 80% of a manager's time is spent in communicating with others (5) and that a manager can expect only a maximum of half and hour without interruption from having to communicate others (6). It follows that the flow of information between managers is a fundamental component of the structure of an organisation (7), (8). Most of the above theories about communications in organisations were derived from whole, single entrepreneurial organisations. However, the principles derived therein apply equally to the ad hoc organisation described below for managing the procurement of a building. In fact, that the procurement organisation team is ad hoc and derived from the members of different entrepreneurial companies should increase the need for quality communications and information to promote team efficiency.

Information and Communication in the Bui lding d ing Project Team

For the effective execution of the entire procurement processes many different roles (identified below) are involved. A vast amount of information is necessary for completion of all work. Much of that information has to be processed and coordinated in an interactive and sometimes iterative manner among the participants. Thus, in order to maximise the performance of the whole team as a communication network there is great need for high quality communication.

The Building Project Team and Core Roles

Many roles are involved in the process of procuring a new building. The core set of roles are (a) the client for whom the building is to be designed and constructed, (b) the architect who is an agent of the client and who carries out the design process, and (c) the many specialist subcontractors who carry out most of the actual construction work. The work of the numerous subcontractors is coordinated on each building project by either (d) a general contractor or (e) a construction manager.

Usually, the client will seek the advice of many other disciplines such as real estate advisors, bankers, urban planners, and specialists within the client's organisation whose space needs etc. have to satisfied in the future building. The architect will direct and coordinate the required array of specialist design consultants whose expertise has to be coordinated to produce the design of the building. Each of the subcontractors has a trade speciality which requires the service of specific material suppliers and fabricators and specially skilled labour to perform that trade on the building project.

The two alternate coordinating roles between (i) the client, his agent, the architect and (ii) the subcontractors are the general contractor or the construction manager. The general contractor is an entrepreneurial role usually under contract to the client to coordinate the construction of the whole building as designed and specified by the architect. Alternatively, the construction manager is an agent of the client who provides advice on construction and contracting during design and contracting. This role may also be used to guide the execution of the actual construction process by subcontractors.

Thus, each major role in the core team has a subsidiary set of roles with which it generally interacts. Moreover, it is these core roles which, by communicating with each other, carry the building project through the building procurement process to fruition. Core role participants tend to operate within the context of two team formats and two time phases. For the two types of core teams, (1) general contractor and (2) construction manager, each major communications pattern is shown in Figure 1 below for (a) the design and contracting phases and (b) the construction phase. (9)

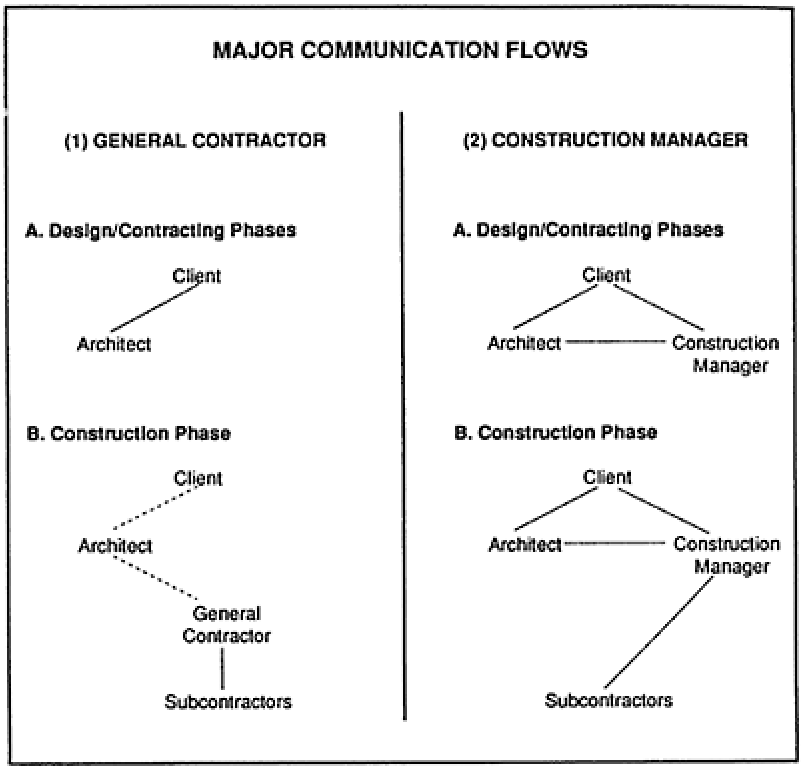

FIGURE 1

Establishing Role Characteristics in the Building Project Team

A major step in improving the quality of communications in the building project team would be to establish the professional personality of each member of the core team. Having done so, guidance could be provided to participants regarding how best to communicate with each professional role. This was the original objective of this pilot research project.

Underlying this assumption is the basic premise that each professional role would have its own individual or unique personality. Each of the core roles of the procurement team, client, architect, general contractor, construction manager, and subcontractor would tend to come from different, professional and perhaps even social positions. Certainly, the educational processes, formal and informal, through which each passes prior to entering their roles would be different. Moreover, it is possible that the perceived characteristics of each role would attract people with certain characteristics or the roles are known about by different types of human beings prior to their entering that role.

From the above, it was hypothesised: that communication quality is a major and probably essential feature in achieving the fullest effectiveness and efficiency of the building procurement core team of roles; that because of the professional interests, responsibilities and background of each core role were different, the professional personality of each core role would be different; that by discovering the professional personality of each different role, that communication to and from that role can be improved for the whole team during the whole procurement process.

Moreover, by so improving communication among the core roles there would be more effective and efficient management of the building procurement process.

People, Roles and Personalities

Characteristics of Individual People

Every individual possesses a predisposition toward certain beliefs and modes of actions (10). These researchers state that,

> people are different in fundamental ways. They want different things; they have different motives, purposes, aims, values, needs, drives, impulses, and urges. Nothing is more fundamental than fact. They believe differently: they think, recognise, conceptualise, perceive, understand, comprehend, and cogitate differently. And, of course, manners of acting and emoting, governed as they are by wants and beliefs, follow suit and differ radically among people. (10)
>
> It is this fundamental notion as it affects communication

between the roles in the alternative patterns of teams managing the design and construction of building that forms the basis for this study.

Noted research psychologists Myers and Briggs present a way in which personality/temperament of individuals can be established and quantified in some measure (11). Historically, this Myers-Briggs Type Indicator Test has served as a valuable tool for measuring factors within individual personalities. This measurement of human personality is carried out by establishing the individual predispositions from among the overall array of tendencies in human personalities. It is possible to measure these tendencies by considering them in dyads and establishing patterns of temperaments. A simpler but close adaptation of the Myers-Briggs Type Inventory test is the Keirsey Temperament Sorter (10). It utilises four major personality dyads, the compilation of which is a measure of an individuals personality or temperament.

A caveat must be offered before presenting these dyads. The personality typologies discussed below are tendencies only. They are not to be taken as strict opposites. For example, a person who is termed a “sensing-thinker” is so labelled because he/she tends to be most comfortable in environments wherein objectivity, facts, and rules are prevalent. This is not to suggest that these individuals have no feelings nor do they, from time to time, creatively envision future possibilities.

The Four Personality Dyads

The first such dyad consists of extroversion vs. introversion. Extroverts tend toward "sociability" while introverts are inclined to "territoriality". In other words, extroverts prefer engaging in human contact/interaction and work well as members of a larger collegial team. Introverts, by contrast, perform best when given a task involving few other people, wherein they have an opportunity to analyse and elucidate a problem with little interference from others.

The second dyad consist of intuition vs. sensation. An intuitive type person is one which suggests descriptors such as "visionary", "speculator", "daydreamer". These persons are most comfortable performing tasks which demand that they look at possibilities for the future. Sensing types of people are those who are seen as "realists", relying mainly on experience and facts and who "notice the actual and want to deal with that. They focus on what actually happened rather than worrying about what might have been or what will be in the future" (10).

The third dyad of human personalities comprise a thinking vs. feeling axis. This opposition is somewhat self-explanatory. Thinking types tend to be most comfortable in environments wherein rules, norms, and overtly expressed objectives are observed, where as feeling types tend toward cooperative environments wherein people take precedence over the task itself. In other words, for the thinker, task resolution is of primary importance whereas, for the feeler, the communal process leading to a solution provides the individuals with satisfaction.

The fourth and final dyad is that of judging vs. perceiving. These terms are somewhat misnamed in that all persons maintain the capacity to both perceive and make judgements about their environments despite their temperament. However, a judging personality is a planner, a decision maker. The judging type does not like to leave unfinished business, but rather opts for reaching closure on a particular item. By contrast, perceivers tend toward fluidity of interactions. That is, they tend to postpone decisions in order to accommodate as much data as possible. Judging types of people tend to be satisfied once a decision has been reached, in stark contract to people who are perceivers who tend to possess disquietude over their decisions.

The application of the Kiersey Temperament Sorter can establish which of four elements are predominant in a subject's personality makeup. There can be sixteen permutations of results or sixteen personality makeups which can be described.

Research Hypotheses

As indicated above, the objective of this pilot research project was to state which of the sixteen personality types was attributable to each major role in the building project core team and then provide insight into how best to communicate with each.

Research Process

The Research Tool

The chosen means of establishing the professional personality of each role was the Kiersey Temperament Sorter (10). The more detailed Myers-Briggs personality type indicator test requires a trained professional to apply and score the test. Neither of the authors of this paper have that skill and as the Keirsey Termperament Sorter is a seventy personal choice questionnaire tool which can be administered by untrained personnel it was used in this pilot study. Furthermore, it assumed that the Kiersey Bates Personality Test could establish the personality of a professional group of people as well as for individuals.

Situation of the Research Work

An ongoing research project was funded to establish the essential features of the building procurement approach known as Construction Management. (12). The chosen research process was to hold six round table discussions in major urban areas of Florida, USA on this subject. The locations of these meetings were Gainesville, Orlando, Tampa, Jacksonville, Tallahassee, and Miami. The participants comprised two representatives of each of the core team roles i.e. building clients, architects, construction managers, general contractors and subcontractors. A crucial feature in selecting all participants was that they were seasoned professionals in their role.

Selection of Role Representatives for Research

The process of selecting the subjects consisted of contacting professional and business representative organisations in each locality such as the American Institute of Architects, the Associated General Contractors of America as well as Local Builders Exchanges. Additional information was obtained from locally knowledgeable acquaintances. During the initial contract, the nature of the construction management research project was explained and a request was made for names of top quality role representatives in the local design and building industry. From these contact sources, the seasoned professionals names were sought and compiled. The choices of participants represented the nature of the building procurement industry in that locality for public and private, commercial and services buildings. (Housing subdivisions participants were not included in the work type universe.) Role representatives were chosen as follows: building clients from public agencies and private real estate developers, architects from both large and small practices dealing with public and private projects, construction managers from national and local firms, general contractors from large and small firms and sub contractors from the electrical and mechanical trades who do a large percentage of the work constructing a building, but a few other sub trades were represented in one or two of the meetings.

The key ingredients sought in all the role representatives were that each had considerable experience in their role, had worked on many projects and would be willing to speak their mind on the subject of the construction management approach.

We did not gather specific information about each discussion participant but we know that all had at least ten years experience, most had twenty to forty years experience and some had experience greater than forty years.

At a couple of the meetings, one or two role representatives did not attend or show up due to sudden business emergencies. Proxies were sent on other occasions by their organisation for the same reason. In total, fifty five subjects, out of a potential complement of sixty subjects, participated (two representatives of each of five roles at six meetings).

Research Findings

Overall Findings

First and most significant finding was that all role representatives in the research universe exhibit approximately the same temperament type. That is, across the different roles in the core building team there were only minor variances in their professional personality. This finding invalidates a part of the original research hypotheses because there was not a separate professional personality for each major role.

Findings on Each Dyad

Considering this common professional vis-a-vis the four dyads it was found that most participants across all roles tend to be extroverted. Of the fifty five respondents surveyed, 80% showed strong indications toward extroversion. A mere 11% of respondents were scored as introverted types. The remaining 9% of participants were borderline, i.e. having an equal number of extroversion and introversion responses. Interestingly, the location of these minor introversion features is indicated on both ends of the building project management team. Among project owners (3 clear introversion scores, 2 borderlines) and architect/design engineers (2 clear introversion scores) on one end of the team and among subcontractors (3 borderline scores) on the other end. Apart from a single general contractor who was scored "introverted", the remainder of the construction managers and general contractors display clear extroversion scores.

Considering the combination of the second and third dyad (intuition vs. sensation and thinking vs. feeling)) as a single temperament unit the majority of role representatives (73%) were "sensing thinkers". This is indicative of a person who is a skilled organiser who prefers orderly processes and rule governed behaviour.

On the individual dyad of intuition vs. sensation, 82% of the participants were sensing types and about 15% were intuitive types with the balance being on the borderline. The feeling vs. thinking dyad results were that 89% of the participants were thinking types and 5 1/2% were feeling types with the balance being on the borderline.

The fourth dyad of judging vs. perceiving shows that the very large percentage of 94.5% of the participants were judging types. Only one project owner registered a positive "perceiving" score and two subcontractors were borderline. With a strong judgement component, it could be assumed that these role representatives are "comfortable judging others in terms of standard operating procedures". (10)

The Common Personality in the Building Core Team

These results suggest that professionals in the building procurement process are sensing-thinking-judging (STJ) types with tendencies towards extroversion (E). This type of personality would likely have planned each stage in the process well in advance of actual negotiations with others. Moreover, this STJ type would likely have predicted and planned for most unforeseen circumstances which can (and normally do) occur in the building procurement process. However, the down side for the STJ personality would be his/her tendency to be more comfortable carrying out the planning process individually rather than as a member of a team. Moreover, because STJs tend to be fact-oriented, problems in communication can occur when the same facts are interpreted differently by different members of the team. Effective resolution of such conflicts is often facilitated by individuals in the team or added to the team who, according to Kiersey & Bates, are "capable of tracking the processes and ideas of others", and are sensitive to harmonious relations among team members (10). A team comprised solely of STJs may have trouble resolving communication conflicts due to the insistence of each member on "keeping on their own track". Thus, to gain more effectiveness from the expertise and professional capabilities of the normal role representatives in the team, their communication network could benefit by adding participants or communication skills of the type mentioned above.

Conclusions

The patterns discussed above and derived from this small pilot study lead to two fundamental conclusions. First, contrary to one of the initial hypotheses, there is a common professional personality among seasoned practitioners in the building process. Second, communications among the role representatives could be enhanced by each knowing that common personality type and by adding to that team participants who have some capability in sensing what other role representatives are saying and meaning in group or individual communications

Subsequently, two interesting hypotheses can be derived from these conclusions, meriting further research in this area. First, the findings may indicate that despite an individuals personality temperament upon entering the field of building procurement, over time, he/she develops an STJ temperament given the actualities of their work in building procurement process. Alternatively, the results may indicate that persons of similar personality temperaments may tend to cluster into the construction field.

In order to offer firm conclusions on these resulting hypotheses, diachronic tests, using the Keirsey Temperament Sorter, should be performed on a larger survey universe.

The second conclusion reached by this study is that communication among team members of this common type in the building procurement process can be enhanced by either the addition of personalities who are aware of and sensitive to the personality temperaments of their colleagues while furthering their own contributions to the team's objectives or each member of the core team could enhance the communications among the group by deliberately being more considerate of the thoughts and ideas of other team members.

The adjustment in communication role behaviour suggested above increases the potential effectiveness of the communication networks shown in Figure 1 of this paper.

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APPENDIX

RAW RESULTS FROM KIERSEY-BATES TEST

	GVLL	ORLD	TAMP	TALL	JVLL	MIAM
BOWN1	XNTJ	ESTJ	XSTJ	ISTJ	ISTJ	ISTJ
BOWN2	ENFP	ESTJ	ESTJ	ESTJ	ESTJ	–
A/E1	ENTJ	ESTJ	ISTJ	ESXJ	ISTJ	ESTJ
A/E2	ESXJ	ESTJ	ESTJ	ENTJ	ENTJ	ENXJ
CM1	ESTJ	EXTJ	ESTJ	ESTJ	ESTJ	ESTJ
CM2	ESTJ	ESTJ	ESXJ	ESTJ	–	ESTJ
GC1	ESFJ	ISTJ	EXTJ	ESTJ	ESTJ	ESXJ
GC2	ESTJ	ESTJ	–	ESFJ	ESTJ	ESTJ
SC1	ESTX	ESTJ	XSTJ	ENFJ	ESTJ	XSTJ
SC2	XXTJ	–	ESTJ	ENTX	–	ESTJ

6
Towards automation of design, construction, maintenance and management for residential buildings

T.BOCK

Abstract
Techniques involved in building activities are related either to industrial processes -e.g. prefabrication-to onsite production or to building maintenance. Problems of robotization differs according to their application in the factory or at the site. Development of robots in factories can be executed in the framework of industrial robotics and factory automation. Some prototypes of on-site robots have been tested different construction works, and the successful types are already marketed. The building site of the future will look very different from now, uti1izing advanced robotic technology to decrease high accident rate and to humanize working place and increase quality and productivity of construction.

Keywords: Construction Automation and Robotics, Design, Construction, Construction and Building Management, Construction Quality, Building Operation and Maintenance.

Introduction

Today the building and construction industry is considered as one of the least efficient and technologically stagnating industries.

This can be attributed to the complexity of the building projects, their geographical dispersion, heterogeneous nature and sensitivity to various economical and environmental factors, lack of skilled workers, aging workers, high accident rate, occupational disease and death This can also be explained by the general decline in the quality of the construction labor, and the reluctance of architects and engineers to experiment with new solutions and technologies already implemented in other branches of engineering and industries.

The main difference between the industrial robots which are applied to the prefabrication of buildings and their subsystems and the construction robots which are mostly needed for on-site construction, is requiring ability of the later movement from one location to another with interaction of environment through sensors and built-in intelligence, and cope with hard work conditions. The specific technology needed for this purpose already largely exists, and can be modified for the particular building tasks. The problem is not with the robot, but rather with an integrated system of robot- oriented construction and building which are essential for an economic implementation of this technology.

Robot Oriented Construction and Building System (ROCBS)

The “ROCBS” includes the building design, the building technology, the organization of building production which should be robot-oriented. The design must conform to the physical, geometrical and computational constrains of the robots and their robotic-subsystem. The building technology—materials and components—must be designed for the robot’s performance and capacity. The organization on the building site must be oriented towards robots working at different locations, transfer them from one location to another, and arrange in an appropriate manner the components and materials supply to robots. The management must be able to organize a robotized building site, and to operate -to program, activate and maintain—the robotic machinery. Due to the high capital costs that are tied up in robotic machinery, the operation of such a system can be economically justified only by a continuity of demand for appropriate building projects, which will allow constant and rational utilization of human and technical resources.

The robots will be initially employed in such as well structured as is the case for prefabrication. As far as onsite construction is concerned the simplest application is the automation of existing construction machinery—cranes, concrete pumps and like—and their preprogramming and teleoperation. A more advanced case involves an autonomous processing—smoothing, cleaning, etc., of large homogeneous surfaces—horizontal or vertical. A more complex application involves operation of a robot for more difficult tasks such as assembly and finishing of three dimensional elements.

The construction industry surely is in need for improved thinking about quality. Because of the multiplicity of materials and components available and the sophistication of client demands, building projects are becoming more and more complex, and the formation of totals quality becomes more obscure. In large design or construction organizations, the significance of one employee’s effort for the final result is usually difficult to grasp. Total quality control may be seen as an application of the systems approach. The purpose of this is to consider the goals and the wider context of the problem situation, instead of looking only at the means available and the immediate problem. Thus by means of TQC, the mission of a company can be broken down to a guideline for the everyday activities of every employee. Similarly, the position of each task in the overall process of project realization can be made more understandable. So, TQC is a way of managing the complexity of the construction project. It is interesting that the reduction of compartmentalisation is mentioned as one result of QC activities. Specification of a common goal and better understanding of one’s own and other departments role may contribute to this. Quality Control in the construction industry is divided into design QC, Construction QC and customer relation QC. In the design stage quality is defined in architectural requirements, engineering considerations and the proper use of materials and fixtures. Each of these areas poses many quality questions which have to be answered to suit the specific site, construction conditions, intended use and more.

Generally design QC should focus on considering customer requirements for the design and reducing construction mistakes. Customer state their requirements and architects find ways to satisfy this. The planner should examine the own design for clarity and completeness and try to avoid ambiguities, inaccuracies and over complexity that might lead to confusion on site. If mistakes occur during the design process they can never be corrected later during construction unless cost increase considerably.

Construction QC deals with quality in the actual production process. Given the personal and institutional differences in experience, training and quality consciousness, the actual construction process is performed differently from worker to worker and company to company, even when same plans are used.

To prevent errors and promptly identify them and correct them require a QC framework to be established which includes guidance on writing work specifications, checking quality, assigning QC responsibility, setting clear technical standards and coordinating work procedures. If errors occur most workers correct them without analyzing the causes thus mistakes show up again and again. Because construction skills and procedures are not well structured it is important to scientifically analyze work procedures and follow statistical methods so that quality data can be identified and QC implemented.

In the case of subcontractors QC becomes more crucial since bad coordination with general contractor results in gray areas where nobody is responsible for. There for standardized QC methods are to be implemented.

Although quality control at on-site can hardly be achieved, it will be automatically implemented as soon as robotic construction is realized in the framework of integrated construction and building system.

In many industries automation is very advanced. Functions of human labor are gradually replaced by machines. But as far as building industry is concerned, automation is not yet commonplace in all stages of manufacturing. The industrial building production is most advanced at the product level of materials and parts production, such as steel sections, cement and glass.

Human labor is only partially substituted by machines at the product level of building parts and groups. The productional functions of power generating and manufacturing are mostly replaced by machines except the controlling function. Automation is least advanced especially at the final stages of production hierarchy, for example the manufacturing of building kits and the final assembly. The human labor at on-site construction is only substituted for its power generating functions such as cranes. The functions of human labor requiring skill such as forming, adjusting and assembling are carried out and controlled by workers. Besides the fact of low productivity, aging workforce, lack of skilled workers and poor quality are also the death/accident rate and occupational disease of building industry is higher than that of other industries. Among the building industry, the prefab makers showed lowest rates except for on-site operation.

In cases were design and production of cars, ships and so on are performed in the same company and factories, the data for the standardized parts, materials, processes and working drawings will be sent from the technical department to the production facilities as CAD/CAM data.

In the case of building planning, design and production, the transmission of information is mainly executed by sending a set of drawings and specifications between the concerned people such as architects, engineers, general contractors and manufacturers of materials, parts and facilities equipment. In order to industrialize the building industry through rationalization, quality control and higher productivity it is necessary to increase the use of computers for sending data, drawings and informations between the participants of a project. Therefore it becomes necessary to standardize the information transmission and to identify the parts, materials, proçesses and drawings with codes and dates for immediate or future reference. Once this computer network is established it will also facilitate introduction of robotic construction machinery.

A prerequisite of these advanced and integrated production technology is a standardized communication and information system. Recent efforts to achieve this are the IRON and the MAP system. The latter was developed by GM of Detroit. MAP is a seven layer, braodband hierarchical system that provides a set of communications-related services from the lower level to the layer above with the top layer providing services to the application program. The upper layers are devoted to the processing of information and the user’s functional requirements, while lower layers are devoted to communications related technologies. A complete message is collected at the top layer and passes down through the layers to the destination node and travels back again after arrival. This functional separation of network communication into layers shows the modular design of networks and facilitates the addition the addition of enhancements to a particular network layer without affecting layers below or above. This map strategy could also be applied in construction and construction robotics.

Industrialization is most advanced in the prefabrication due to clearly defined circumstances at the place of production, similar to applications of industrial robots in other manufacturing industries. In Japan and other industrialized countries the modular house industry reached a high standard of production technology through mass production of limited variety of un-differentiated building elements, components and units.

For example at the production line of Sekisui Chemical Sekisui Heim, for box units where more than 85 percent of the house is prefabricated, quality control became as thorough as for other industrial products. The steel frames of the unit are assembled from the roof-, floor-, and end wall frames which are welded together in a totally automated process using arc- and spot welders. Production process starts with cutting of prescribed length of highly rust resistant fused galvanized steel. Robots then weld connecting fittings to the columns. At the ceiling frame production line, 2″×4″ beams are attached to ceiling frame and electric wiring is installed. In the floorframe production line, insulation is laid on the floorframe and an automatic nailer installs the floor boards. Another automated process assembles columns fitted with connecting lugs to form a column frame. The frames are spot welded together in a fully automated process. The frame supports serve as jigs establishing the frame’s dimensions. After the exterior wall panels that are manufactured on a subline, are fitted to the structure, the interior items and partioning panels are installed.

The utilization of robotics on the building site could eventually increase the work security and productivity while reducing building costs. In the steel industry the design processes are already linked to manufacturing and production planning through the utilization of a computerized system for drawing and specification information listing. This process will lead to CAM and finally to CIM. These proposals for future construction processes share a common basis with CIM and robotics in other industries. The design will be executed and simultaneously purchasing and production information is compiled, which are later sent to the factory where they are further distributed to the production facilities and robots. Up to now in the construction process however the stages of design and production preparation are separated and the design information can not be directly linked to the NC machine or robot. The same is true for the feedback of information and therefore mistakes are sometimes not realized until they are discovered at the site where it is very expensive to correct them. . However if robots are to be introduced into construction industry it becomes necessary to industrialize construction through standardization and modularization of parts and information according to the possibilities of robotic execution. In the longer run the use of sensors to detect movements and positions which are able to feedback information of. design process to robots.

The on-site construction process is of course different from that of a factory and the smooth linking of design information with the fabrication and production information cannot be easily realized, but nevertheless a potential exists for the future due to urging present problems in construction which are discussed in the next chapter.

In the buildings of today advanced technologies are mostly applied to subsystems that service the building. But even this differs considerably from e.g. maintenance cost of a car. This shows that there are too few criteria to check the quality of the product or its maintenance efficiency or the reliability of design. Some reasons this backwardedness are the complexity of functions of buildings, not standardized design methods and insufficient control of design quality, production quality and assembly quality. The recent trend towards information society brought the design of so-called “intelligent buildings” further emphasizing the demand for advanced building systems.

As more advanced technology such as OA, security systems and energy efficient equipment and maintenance robots will be used, a new design method is required to fulfill these extended requirements. All parts of subsystems of building have to be analyzed and tested, before they will be assembled to serve their total function.

To achieve this the partial functions have to be interfaced physically, functionally and geometrically. Another dimension of advanced technology applied to construction is the dimension of time. The various subsystems designed for specified life cycles require a certain degree of exchangeability thus contributing to the extension of total life cycle.

As we can understand from the change of construction component cost through the history architecture is not only expressed by terms of a space enclosed by walls and ceiling, but also more and more in terms of a couples environmental system of interfaced qualities of appropriate technologies.

Another more obvious sign of these changes is the historical change of the location of the production of the building. Whereas in earlier times the building was produced on site, the production location gradually moved to the factories where components of building are prefabricated. In the most advanced cases of prefabrication, quality control on the building group level can be achieved.

The majority of the administrative work normally includes communication, preparation, editing, retrieval, filling and copying of informations. The hours of creative work consumed by reading the information is about 25 percent of the total working hours in administrative sections according to a survey conducted by NTT.

Thus the major motivation for introducing OA is the improvement of productivity in order to strengthen competitiveness. OA should expedite office work and increase its efficiency. The establishment of an information control system is required in order to reduce office work operations. The introduction of OA involves reviewing the overall company structure even though its immediate purpose is only to rationalize office work and reduce costs.

In Japan the operation of buildings is called “Home Automation” referring to housing and “Intelligent Building” related to office buildings mostly.

After Factory Automation (FA) and Office Automation (OA), so-called Home Automation or HA is receiving increasing attention. HA stands for integration of monitoring, operating, communicating and controlling various functions at home.

HA systems are offered by all major electronic companies, such as Hitachi (home control system), Nihon Denki (Jema Hoe Bus), KEC (Kansai home bus system), Matsushita Denki Sangyo (Stavtec, Hals, HA system), Matsushita Denko (Napic Remote Control, Homen Mast, HA Installation System), MITI (MITI Home Bus), Mitsubishi Denki (House Keeping System, Home Automation System), MPT (HBS), NEC (Home Media Bus), NHK (Home Bus System), NTT (HAN), Sanyo Denki (Shains), Sharp (home Terminal System, House Info System, Home Bus System), Sony (Access 3), Toshiba (Newhome Media System, Home Control System).

Major functions of standard installation cover fire alarm, gas leakage alarm (detection and notification), oxygen shortage alarm (detection and notification), electric lock (unlocking function, when a visitor is checked), burglar alarm (sensor notifies when a door or window is opened or broken), emergency alarm (notification to the public emergency center), earthquake alarm (notification of an inherent earthquake while switching appliances to appropriate mode), guest monitor at door, interphone between rooms, doorphone, power control, HVAC control and control of water level and temperature of bathtub. As an example of HA follow as a brief outline of Mitsubishi Melon HA system.

Mitsubishi Electric thinks of HA as information oriented home management. center piece is the “in house total information system.” The next level is formed by “household control systems” and “lifestyle information utilization system.” On the third level we find “house keeping”, “home management”, and “life-culture.”

Last level consists of “fire and crime prevention”, “Energy control”, “environmental and equipment control”, “Data communications”, “health care”, “education and training”, “bossiness and culture” and “hobbies and entertainment.”

This means that home medical care, home banking, home shopping, at home ticket reservation, at home employment, electronic mail, home nursing, home study, tele-control-monitor ing-metering can be done without leaving home.

The major construction companies are all undertaking research into intelligent buildings. The aim is to make buildings easier and cheaper to run and to make them do new things.

The research is based on the idea that buildings should “know” what is happening inside and immediately outside themselves and “decide” the most efficient way of providing a convenient, comfortable and productive environment for the users. Intelligent buildings should also be able to respond quickly to users’ requests.

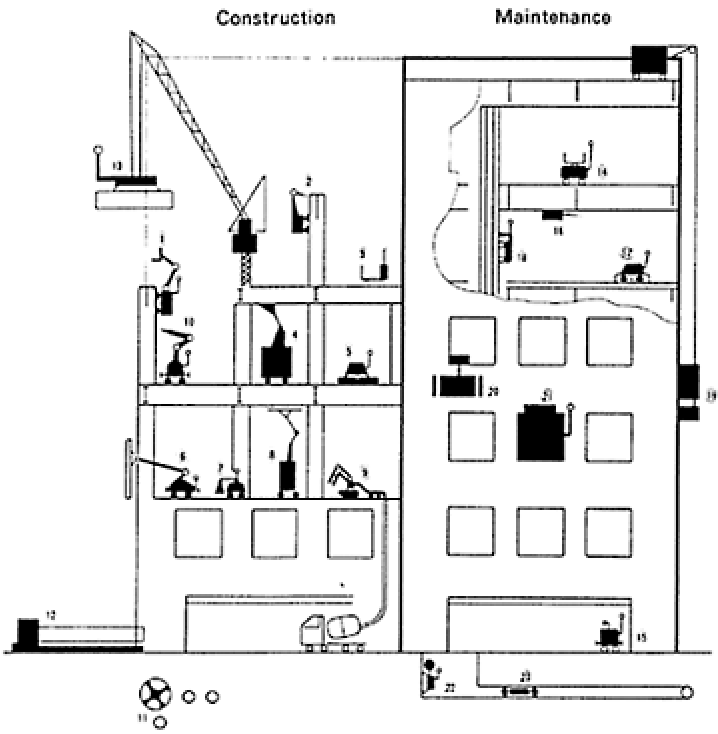
Due to the favorurable development of sensor technology, it became technologically and economically feasible to control various functions with electronic equipment.

Research into intelligent buildings is taking place in laboratories and in experimental buildings in Japan. In laboratories many different combinations of building equipment and fittings, electronic sensors and controls and various mechanical devices have been assembled. For instance hotel which is already existing, the bedroom where the gust could lie in bed and tell the room to run a bath of water of a stated temperature and depth, could ask the room to make a cup of tea, switch on the television to a stated channel, record and type simple spoken messages, draw the curtains and raise or lower the lights. Also the apartment in which telephone, television, video camera, voice control, burglar alarms, fire and gas detectors, lighting, air conditioning, the front door, curtains, cooker, dishwasher, bath, voice synthesizer, computer and control panels were all interconnected. It provided the equivalent of a very competent and compliant servant 24 hours a day.

The depreciation period for reinforced concrete building is 65 years. The overall cost of the Super Energy Conservation Building, assuming a life cycle of 65 years, is shown in the figure.

The initial cost (the construction cost) is a small part of the overall life cycle cost, while the running cost is a large one. Clearly, the Super Energy conservation Building has great advantages over an ordinary building with the same size (assuming building service systems are renewed three times during the 65-years life cycle).

In another example Takenaka, also one of the Big Six, have set up a working office in which ever aspect of the interaction between building and users' performance is monitored. The office is extremely flexible allowing light, sound, colour, temperature and humidity to be changed at will. Workers are provided with furniture, equipment, communications and information systems and spaces which can be altered easily to provide environments matched to the current work requirements. At one time the environment is relaxed and comfortable for creative problem-solving; at another more mechanical and structured and later in the day, there is a burst of sound, light and lasers to stimulate the workers to renewed efforts. The aim is to create offices which help managers make quick and accurate decisions on the basis of excellent information, which can also raise the productivity of general office-workers by providing a very comfortable and happy environment. All this and the results in terms of workers' performance are monitored in order to learn how offices behave as total socio-technical systems. Takenaka rely on manufactures to develop intelligent and controllable devices. Their task as a construction company is to understand the whole building-user system so that they can design and manage the construction of intelligent buildings. The scope of their research is very broad.



1 Steel frame erecting robot
2 Steel frame welding/bolt tightening robot
3 Material transport robot
4 Fireproof spraying robot
5 Floor finishing robot
6 Robot to manipulate exterior wall board
7 Floor cleaning robot
8 Robot to manipulate wall board
9 Concrete placing robot
10 Interior finishing robot (spraying, painting)
11 Pipe embedding robot
12 Reinforcement bar erecting robot
13 Position controlling robot
14 Package transport robot
15 Security patrol robot
16 Duct cleaning robot
17 Floor cleaning robot
18 Piping system diagnosing robot
19 Exterior wall maintenance robot (painting, cleaning)
20 Exterior wall diagnosing robot
21 Window cleaning robot
22 Tank cleaning robot
23 Pipe inspection robot (gas, sewage)

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7

Strategic dialogue—a framework to improve developmental processes in construction companies

J.BORGBRANT

Introduction

Successful researchers and businessmen have at least one thing in common: they are very interested in discovering basic principles that are important for how to manage their workarea in an optimum way.

This paper describes some concepts and models that I use to help me to find these crucial variables.

Section 1 provides a description of a model for analyzing an organization from a holistic perspective.

Section 2 outlines a management philosophy that underlines that management is a process in which managers and co-workers have a mutual responsibility.

Section 3 deals with more characteristics to describe the management behaviour used in "Strategic Dialogue".

Section 4 discusses "Strategic Dialogue" as a change strategy.

Section 5 describes a program for developing the managemet based on "Strategic Dialogue".

Section 6 is a short summary and conclusions.

Naturally, the reader may react in many different ways to this article. For some it may be difficult to find anything new and useful, while others may find the concepts and models interesting. However this article is an attempt to make managers more aware of their own management style. At best the content can be a tool to stimulate the readers to find out more about the management philosphy that exists in their own organization, how the organization operates and what to do to speed up the process for management development.

I A Holistic and Mutual Management Function—a model for a common analys of an organization

To develop the organization and make change processes successful, it is necessary to develop a mutual management function. Management function is a concept based on the systems theory that different parts of a system mutually influence each other. It is important that management not be thought of only as authority by bosses over people at lower levels of the organization. We would make it clear that managers and co-workers are both participants in the management process. They are mutually responsible for outcomes.

Holistic mutual management means that everyone participates in the process of integrating the external strategy to satisfy customers and the internal strategy to develop technology, organization, and people to support this strategy.

If we want to manage this holistic and mutual management process it is necessary to develop a common framework. The framework must be broad enough so that different functions in the organization can recognize their own ideas and tasks.

The following provides a summary of a framework which may be used in order to make analyses of an organization.

Content / Level	Core	Climate	Principles	Resources
Environment	Market Customer Products Competitor	Opinions in society to work, management, business	Laws Agreements Taxes	Economy Technology Human resources Labour market
Organization	Vision and Business Idea Strategy	Organizational Culture Informal system	Organization Administration Principles Policies	Economic Financial Questions
Group	Work tasks Quantities and Qualities	Climate in teams/ groups	Structure in group	The situation of resources in the groups
Individual	Necessary Knowledge to do the job accurately Personal competence	Attitudes and basic assuption to work-content, work environment	Individual regulations	Level of individual competence

Figure 1. A model for analysing an organization.

There are two main variables in the model. One focuses on levels (Environment, organization, Group and Individual). AS a user you must decide where the border between environment and organization is. The decision is made from what you want to focus on. If your primary interest is making an analysis of your own department, the rest of the company belongs to the environment. Inside the organization (company, department or unit) you must find out the existing groups. These can be both formal and informal groups. Examples of groups can be market unit, production, economic, human resources. The individual level focuses on every individual. These can be people at different levels in the organizational structure for example, a production man, a salesman, a supervisor, a top manager.

The other main variable has to do with the content of the levels. This variable is divided into four areas (core, Climate, Principles and Resources)

Core stands for the main thing the organization contributes to the environment. It can be products or services for examples cars, houses, guns or consulting service.

Climate represents culture, climate and attitudes on the varions levels. It can be values in the society, cultures in the company, managers and other employees individual attitudes.

Principles is an area to which laws, agreements, regulations, policies, structures and administration systems belongs.

Resources is the area where the focus is on economic, technical and human resources dimensions. It concerns the economic situation in the country and company, the technical maturity of the country and the branch where the company operate. This field also includes the state and knowledge in the labour market, the profile of the employees in the company etc.

The discussion/analysis can be done from two perspectives, from the outside-in, and from the inside-out.

Outside-in analysis starts with questions about the market, business goals, strategies for change, organizational systems and sub systems (technical, administrative, social, etc.), and ends up in a discussion of how these conditions affect the indiviual's situation and tasks.

Inside-out analysis begins with questions about how each individual experiences his work, feelings about motivation, social environment, the climate in the team and how the team works, how management functions and responds to suggestions and new ideas. It ends with a discussion of how circumstances external to the individual hinder or support work performance.

The idea is that management can find data that describe the focus as accurately as possible in the framework. The data must be in a form which allows communications in work groups and among co-workers at different organizational levels.

As can be seen from Figure 1 the model consists of 16 foci. Some of them focus on very familiar areas of discussion for some participants in the organization while others are unfamiliar. One main idea in a holistic management is to create a process in which both managers and co-workers play a mutual role.

It must be accepted that people have different perspectives, knowledge and interests in describing a particular situation or understanding a focus. The dynamic in the organization is created from the process of discovering what the situation really is. It is important that efforts are directed towards describing the reality for all the 16 foci.

The dynamics will increase when members in their organization examine the links between the foci and impact on each other. The impact can be between levels and areas.

A management style that provides this common framework must be very explicit and clear. The next section outlines a management policy that stresses more factors which are important in a holistic management process.

A Management policy for supporting a holistic management style

One of the most important concerns for the management is to use and develop the resources inside the group or company. The demand on managers to become aware of and to act on factors that exist both inside and outside the company is increasing. A very explicit and clear management policy needs to support a management style that allows co-workers to participate in the work, to stimulate themselves to develop as individuals, and to support changes.

The following represents the management philosophy expressed at the BPA Group.

In the company it is very important that every individual employee

– feels that he can participate and can accept the companys goals and business
– feels that co-operation, and a spirit of community exist in the team and finds the work environment good as a whole
– gets reward for what has been produced both in economic and psychological terms
– gives opportunities to take responsibilty and has opportunites to evaluate performance vis a vis known goals. This is a basis for good work performance.

The mangement style is characterized by

– coaching through goals
– continuosly evaluating results
– continous awareness of development and need for change
– using change strategies that are built on openness (frankness), and participation in longterm thinking
– emphasizing or accentuating learning through monitoring both work and management behaviour
– internal and external communication in the form of a dialogue

As a support for management behaviour there must be

– a form of decentralized directing that stresses the line manager's responsibility for using and developing all existing resources
– a form of decentralized organisational structure with as few levels as possible. The different levels are linked together by managers who are "linking pins". A manager is a co-worker in the group above his own team
– meetings arranged regularly at all levels from top management to shop floor workers
– personal meetings and regular appraisals between managers and co-worker at least once a year to discuss results, the future and individual development

The management policy can be put into action in the daily work through

– a dialogue in the team to evaluate (monitor) the daily management behaviour vis a vis the formed policy
– frankly expressing opinions on what support and hinders good work performance
– respecting every manager's and co-worker's opinion about existing goals, resulting management-style, needs and strategies for change
– managers attending to questions of work motivation, atmosphere in teams and stimulating co-worker's willingness to take responsibility for. their own deve lopment

III Strategic Dialogue—a number of characteristics

This section describes in more detail why strategic Dialogue may be regarded as a successful management model, It will also attempt to answer the following questions

– Who must contribute to get a successful process
– What the content of the dialogue should be
– Which data can be used in a Strategic Dialogue
– Which conditions are important for a successful Strategic Dialogue

Strategic dialogue is intended to create a process whereby work-groups develop a long-term perspective. Here both individuals and groups bring their interests as a basis from which they work, to understand the reasons for change and the interests and needs of other individuals or groups. In the dialogue, problems can be understood from the different perspectives of the top managers, the middle managers, the line workers, and the unions. Everybody's situation, interests and concerns are accepted as having equal value to that of management. The goal is to agree on a mutually beneficied vision.

Dialogue requires a democratic spirit even though decisions are not always by consensus, people must agree on the problem to be explored. They must respect each other's point of view and be willing to gather further information to resolve differences of opinion. There must be active involvment, open disagreement and creative conflict must be encouraged. Furthermore, good dialogue allows for an interplay of ideas, people need not be committed to ideas they suggest for exploration. Finally, dialogue requires leadership that draws conclusions on the basis of the dialogue and makes a deci-sion. At the end of each meeting, each member of the group should have a clear idea as to what is going to be done about the issue discussed, who is responsible for it, when it is to be done, and what the expectations are.

Sometimes there are non-resolvable differences in interests which must be negotiated. But decision and negotiation do not end the strategic dialogue which must be an on-going process in an organization that is adapting to changing conditions.

The function of a strategic dialogue is to develop both the organization and the individual members within the workteams. Such dialogue is designed to make the organization more effective and productive, as all employees have more input into the process. Workers have the opportunity to analyze their work and requirements, the formal roles and structures within the organization, and the administrative system. At the same time they can discuss their feelings and reactions, and observe the process of communication with each other. There is an on-going learning process and an arena in which to develop new knowledge about work and what it requires from people.

As was pointed out above, a Strategic Dialogue needs active contribution from both managers and co-workers. The idea is that the dialogue must be done in the ordinary "lineteam". There the managers are important as a link between two groups on the closest organizational level. Through this uniting all members in the organization will be involved.

A complement to the dialogue in the team are regular meeting between the manager and just one of his co-worker each time. These meetings—or appraisals- must be regular for example once or twice a year.

The content of the strategic dialogue must be about everything that has to do with the work. Results in the production (quality, quantity, costs, productivity) and how it is to work in the team (atmosphere, stress, environment) are in two different types of content. Ideally the content in the dialogue should be about all the 16 foci in the model presented in Fig. 1.

To make the dialogue useful it is important that everyone has an opportunity to take an active part in it. Therefore it is necessery to use different types of basic data. Three examples are

* observations
* investigated or provided data
* individual experiences

Observations stands for what anybody has registered (seen) inside or outside the company. It is important that everyone both manager and co-worker is prepared to communicate the observations. The observations can focus on both worker's and manager's behaviour.

Provided data stands for information that are more measurable and unbiased, for example statistics, production lists and economic tables.

Individual experiences stands for more intuitive information. It can be statements on information based on earlier experiences or just feelings that you have about the subject discussed. It is of course important to give this type of data a chance to be accepted even in a very logical and analytical atmosphere. For some people it is difficult to accept another person's opinions specially if they are only based on feelings.

There are many General Conditions that can support a successful strategic dialogue.

First of all the number of members in the team must be realistic. It is very difficult to manage a group process in a productive way if the group is too big. As a manager you must be very sensitive and aware of group dynamics if you have groups as large as 15–20 persons. The top management group needs to be smaller, for example 5±2 persons.

It is even important that the workgroup is managed by one manager. This statement suggests more groups with less members instead of large groups with a manager and some assistant managers.

A third condition has to do with the organizational structure. It is important that there is a clear structure for how the different work teams are linked together. This structure makes it possible to make the internal information system more efficient.

IV Strategic Dialogue—a basis for successful change

Let us make the assumption that all changes have impact on individuals release energy in themselves. This energy can be both positive and negative. Examples of positive energy are when an employee is involved, supports the change of ideas, and is keen to bring about the change.

When negative energy dominates the person tries to stop or at least hinder the changes. This resistance can manifested both overtly and covertly. Someone can, for example, offically support the idea but avoids behaving as the decision suggests.

In the following I will give a brief overview of three change strategies: expert, project and line dialogue.

We know that some change strategies involve a few employees in the beginning of a change process. Every stage of the change is prepared by experts. From a technical point of view the optimum solution is developed. The problem can, in spite of this, occur when the manager must inform the employees what has to be changed. The whole idea can disintegrate and no changes will be accepted by those it concerns. We can call this "Expert-strategy for change."

Another change strategy is based on assumptions that employees who are the target of the change will support the change activities if they have been represented by one or more persons in a project group. The task for that group is to make the change ideas clear and prepare the practical aspects of the change process. This change strategy involves a high level of administration and organization. Boards, project—groups, subgroups and so on. This strategy may be called "Project Strategy".

The third stragey is the Strategic Dialogue or Line Dialogue, The basic assumption in this strategy is that one large part in the general management behaviour is to make continues changes. Needs and methods for change is an ongoing process in the teams. At all group meetings, weekly or fortnightly, the agenda is built up to ensure change.

In group meetings the focus is put on strategic questions

* How the situation is: "Current Situation"
* How we want it to be: "Desired Situation"
* What to change
* How to change it (methods)

Meetings in work groups that are very important in Strategic Dialogue can also be summed up through the following questions: What can we learn from

– the core area we have worked through today
– the management behaviour that has occurred during this meeting

The following schedule is an attempt to clarify the differences between the three strategies.

	Expert	**Project**	**Line dialogue**
Management-approach	One in the top has the power	Formal procedure	Team managers (leaders) anticipate co-workers knowledge
Co-worker-	Machinery of	Involved through	Co-workers competence

approach	production that needs expert help	representatives	must be used in the change process
Organizational approach	Power is important	Conventionally regulated responsibility for example in a project organization	The team is the basis for change
Involvement	A few Executive Consultants and just a few internal co-workers	Employees are involved through representives	Teams that are impacted by the change ideas
Time aspect	Quick results Action oriented	Schedules in plans for action	Change is seen as a necessary and natural part of the ordinary tasks in the team
Role of consultant	Main role trough his individual competence	One of the representatives in the project organization	Is involved as a resource person in the team where the changes are made
Learning	Not especially important	Knowledge and behavior specifically referring to project administration improves	A central element for achieving a better management behaviour and to learn for future core activities
Conflicts	A question of information and selling	Like a question for negotiation	Creates higher motivation, participation and activity
Structure	Not aware of question about procedure. Stresses rationality and analyzing objective data	A combination of project administrative structure and content structure. Logical organization in subprojects. Looking for structures even in feelings	Close connection between the ordinary management structure, directing the business and structure for change
Process	A process, including co-workers thoughts and feelings isn't important. As few as possible must be involved so feelings and irrational behaviour can be avoided	Changes in plans and procedures are confusing and time wasting. The need for defining everything means that vaque processes are disregarded	Very conscious of processes. Processes in change activities are continuously analyzed. Learning from the process in the here and now is important.

Figure 2. Three different strategies for change.

V Management development—an approach to Strategic Dialogue in practice

In the program for management development there is a combination of on one hand education in traditional subjects: economy, finance, marketing, production planning and on the other individual training in, communication, group dynamics, conflict solving. In the program there should be quite a lot of time for analyzing the situation in the participants own companies and units. The products that everyone produces during the program, for example, tables, diagrams, summaries or visual descriptions must be used, tested and evaluated at home. This work is in itself a very important element in the management program. The effect of the program is of course measured in the ordinary business and work in the unit.

The case of BPA

The aim of the management program at BPA AB. is to provide a powerful tool to increase the profit (earnings) and to make the BPA GROUP stronger in a long term perspective. There will be a lot of occasions to practice both analyzing the environment and the different companies' internal situations. There will also be training in practical leadership and individual development.

The program is structured in seven blocks as shown in figure 3.

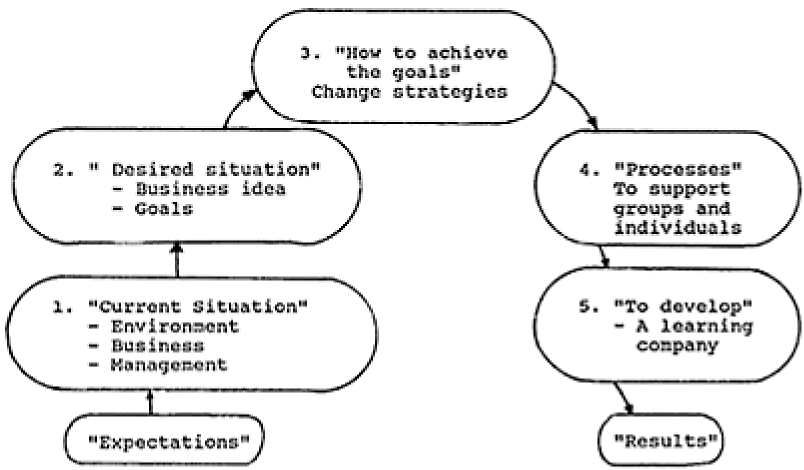

Figure 3. The blocks in BPA AB's program for management development.

Expectations

This block is arranged as an introduction to the whole program. Individual presentations and expectations are made. Philosophy, methodology, content and expected results of the program are discussed. The participants are asked to submit 5 variables that can be used to evaluate the effect of the program. Values of the 5 variables when the program starts are written down and stored in an envenlope. The same variables are measured when the program is completed. The effect of the whole program is analysed by every participant and their manager in relation to these variables.

An example of homework is to prepare an analysis of the "Current Situation" in the participant's unit or company.

Block 1. "Current situation"

One week's intensive work in a conference hotel. The aim of this block is to provide the participants with a broad frame of referance to be used when describing the company (unit) and their environment.

In this block there will be many occasions for discussion of the market, technical development, labour market and economic realities. The teachers or facilitators come from Government, unions, business confederations, universities but also from the BPA-Group, board and top management group.

A lot of time is spent on improving the ability to describe the company with regard to the broad frame of reference (The model shown in Figure 1). Some analyses are also carried out into participant's own leadership. The description of the current situation that has been made during block 1 will be discussed, examined and corrected in the participant's home unit.

Block 2 "Desired situation".

This block starts with a report on the results from the homework. What reactions were there in the home team regarding the description of the "Current State"? The second week goes on with a focus on the "Desired situation". The main task is to make clear goals at different levels in the company, unit group and individual.

There will be exercises to make clear descriptions of goals in business, for example, economic, marketing and human resources. Time is also given for practising formulating goals in the area of culture, climate and values. The participants also discuss the policy for management.

Block 3 "Change Strategies"

This block concerns the question "How to reach the goals". There are discussions about different change strategies and methods based on the table, presented in Figure 2, Expert, Project and Line dialogue strategy.

An important aspect is about the type of data that you need for successful changes and how you use that data. It can be used as a basis for analyses or information given about deci-sions, policies or statements which have already been taken.

In this block the homework about the “Desired situation” is very useful. The idea is to find out how the participants can continue with their own change process at home.

It is important to bridge the gap between current and desired situation with things that need to be changed and how to do this successfully. The need and strategy for change must be worked on in an adequate way at home. If the participant prefers, for example, a Line dialogue he has to test that basic assumption in his own management behaviour.

Block 4 “Process”

When you start development activities in your unit or company it is normal to initiate some reactions or release energy. As stated in section IV, this energy is either positive and supportive of change or negative and resistance oriented. It is therefore very important to be open minded and interested in learning more about this process.

The content in block 4 concerns individual and group processes. The block differs radically in material and learning methods from the others in the program. The participants get a real opportunity to learn about themselves as individuals. How to communicate ideas, feel about stress, project their own values to others in groups, are some areas that are studied.

A lot of time is spent on developing more knowledge about what is happening in small and large groups and between groups in an institution. The learning method is a combination of practical learning and theoretical analysis.

The product of this week is aimed at a personal developmental level. It is intended to stimulate more active awareness and sensitivity to group processes in the participant’s own unit and workgroup.

Block 5 “To grow”

This block is the last one week meeting in the program. The aim of this week is to achieve deeper learning in those areas that have arisen as important during the program. The following examples can be cited:

– Information technology
– Ethics
– Mass Media
– Internationalization
– Personal health and environment at a construction place
– Marketing as a strategic issue

This block is more traditional in the learning methodology. There are clear subjects that are taught by lecturers from universities, expert organizations and other companies.

Results

After half a year break the last block “Results” will be managed. The aim of this block is to evaluate the effect of the program. What has been developed in the business, units, cultures, motivation and individual management behaviour. The aim of this block is also to make an economic analysis of the results. Here we use the five variables that are measured at the begining of the program. The values that exist now are compared to the earlier ones. What can we learn from the differences? What will the economic results be like if we try to put the variables in economic terms? This discussion is made together with the participant’s own supervisor or the executives for the three business areas Construction, Installation and Painting in the BPA GROUP.

VI Summary and conclusions

In this paper I have attempted to outline an approach to developing companies through a continuous change process. The basic idea that needs to be used is named Strategic Dialogue. The main conclusions to be drawn from this article are that:

* A manager needs a holistic strategic perspective to achieve a successful change process. A holistic model for the analysis of a company is outlined.
* A management behaviour that supports a continuous change process must be very distinct and described in a policy document. Acceptance of the philosophy by both the managers and co-workers in a company is vital.
* Strategic Dialogue is based on a management philosophy
    - where everyone must be involved through a “linking pin” system
    - which recognises that the content in the dialogue must concern all areas in the holistic model
    - where the data used in the dialogue is derived from Observations, Provided data and Individual experiences
    - that underlines a decentralized organization with groups managed by <u>one</u> formal leader
* Four central concepts must be made clear and explicit to enable a successful change process
    - Current situation
    - Desired situation
    - What to change
    - How to change
* A systematic program for management development is necessary

8
Information flows in building construction management

D.W.CHEETHAM, D.J.CARTER and R.A.EELE

Abstract
The paper outlines the results of an analysis of the management information system of a large U.K. Contractor. The company's Procedures Manuals were examined and the company management information system modelled on two sites and the regional office using systems analysis techniques. Recommendations for improving the system are made.

Keywords: Systems Analysis, Standard Procedures, Management Information Systems

1 Introduction

Building construction management is concerned with providing buildings of acceptable quality at an agreed price and to programme. The parties engaged in this endeavour; client, architect, quantity surveyor, other design team members, contractors management and head office supporting staff, site management, supervisors, operatives, suppliers and subcontractors all require information to perform the multitude of tasks associated with creating a building.

The communication of information between the parties has traditionally relied on the use of paper to convey drawings and written messages in addition to verbal communication. In recent years the construction industry has started to take advantage of the developments in information technology which allow storage, processing, retrieval and transmission of information by electronic means.

In many organisations systems for conveying information have been developed to satisfy organisational needs based on the real or perceived hierarchy of the members of the management structure and their need to have access to particular items of information. Information flows are thus related to decision making.

Changes in organisational structure of a contractor's business are caused by external factors such as economic conditions, success in tendering, changing workloads, evolving markets for various building types, changing contractual procedures adopted by clients and new prod-uction technology. Adjustments to meet these factors are often made without recognition to their impact on the existing information system. Most information systems have evolved to ensure that the company can organise building works, function as a commercial organisation and satisfy legal requirements for production of accounts and payment of taxes.

A large number of organisations co-operate to produce a building. Although they all come together on a particular project they will each be simultaneously involved with other firms on other projects. Consequently the contractor's s management information system has to cope with a wide range of information from many sources of variable quantity and quality. Despite this many of the procedures to handle this information are common across a wide range of project types.

2 Case Study Company

The company is a typical large U.K. contracting organisation with the capacity to carry out building contracts of all sizes and types throughout each of its regions. The regions are controlled from a national head office which sets targets and controls budgets. In the winning and running of individual contracts the regions are autonomous. Each region administers several projects at any one time from the regional office. Larger sites tend towards greater organisational self sufficiency than smaller sites.

2.1 Procedures manuals

Management systems and procedures are developed at national level. These systems are laid down in a company manual issued to all senior management within each region and are periodically reviewed and updated. Standard procedures developed by regions are described in the regional site procedures manual. The procedures manuals provide written details of how to carry out each procedure and provide examples of standard forms to be used. The manuals are sectionalised to be of relevance to particular departments.

Table 1. Contents of National Procedures Manual

1)	Company quality manual		
2)	Prep and admin. of manual	10)	Work instructions
3)	Prep of quality plans	11)	Drawings and variations
4)	Internal auditing	12)	Inspection and testing
5)	Storage of records	13)	Permanent works design
6)	Suppliers & subcontractors	14)	Planning
7)	Purchasing procedures	15)	Temporary works design
8)	Materials receipt & storage	16)	Concrete control
9)	Training	17)	Masonry control

Table 2. Contents of Site Procedures Manual

1)	Drawings	16)	Wages

2) Information schedules
3) Variations & instructions
4) Mail in/mail out
5) Contract programming
6) Weekly programming
7) Site meetings
8) Site reporting
9) Sub contract assessment
10) Sub contract ordering
11) Post contract procedures
12) Material ordering
13) Deliveries
14) Stores control
15) Weekly costs
17) Labour requests
18) Plant ordering
19) Preliminaries
20) Internal valuation
21) External valuation
22) Site monitoring
23) Sub contract pay
24) Forecasting
25) Final account
26) Quality control
27) Engineers records
28) Quality assurance
29) Security
30) Health and safety

Standard procedures are employed as a means to gain certainty so that everyone knows what to do and when to do it. This is especially important when introducing new individuals to the system, through training or where personnel are relocated between sites. But standard formats for reporting information are also required so that regional office can quickly assess the current situation and will provide a method for comparison between sites. The main system study was undertaken on two contrasting sites together with a systems study of the regional office.

2.2 Case study sites

The two contracts chosen for this study were a £60 million industrial complex and a £3 million hospital extension. The former was a fast track steel frame structure employing over 50 subcontractors and a large direct labour force. The project has been running for 2 years, the first stage is now completed. The hospital contract was a more traditional building with load bearing brick and block walls and precast concrete floors. The larger value, more technically complex contract involved many specialist designers, subcontractors and suppliers. A greater number of contractors management and administration staff were necessary to interpret the design and organise and control the site works. There was greater separation of functions on the larger site, for example administration is separated into departments concerned with costs, stores and security with a coordinating manager. Assistants in quantity surveying were allocated different work packages. Section managers supervised general foremen and there was a separate building services manager. Programming of works, commercial operations such as subcontract buying, quality assurance normally undertaken by regional office were undertaken on site for the industrial contract. The presence of these functions on site allowing better informal coordination. The smaller value contract had fewer management staff on site and depended on regional office for support.

3 Research Method

The techniques of systems analysis were used to create a model of the management information system. The objective being to discover what information is being communicated within the organisation under study.

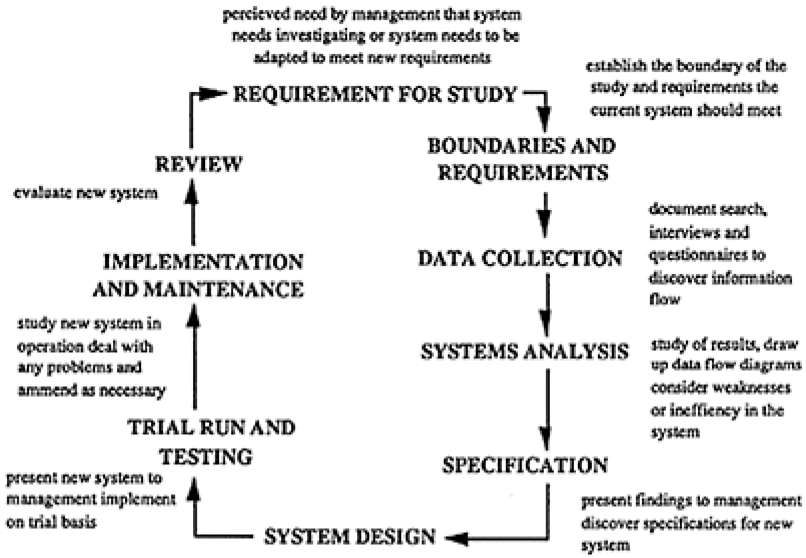

Fig.1. Stages of systems analysis

The analysis commences with an investigation in order to obtain a model of the current system which in turn also forms the basis of problem identification. A model of a future system is then developed which forms the start point for the design of a new system and ultimately a working implementation.

Interviews ascertained the information people required to perform their duties, the routing of this information, and the resulting information output. This process was supplemented by study of the procedures manuals. Various techniques of collection and presentation were attempted, one of the most successful of which proved to be the contact diagram.

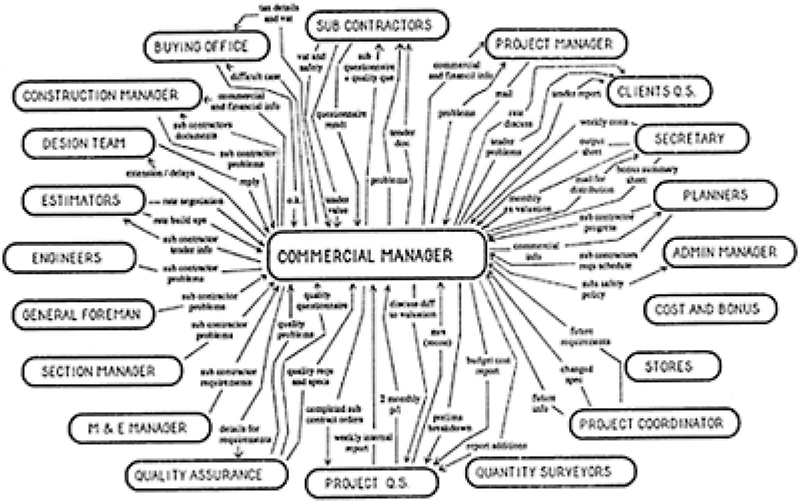

Fig. 2. Contact diagram showing the functional contacts of the commercial manager

Data flow diagrams were then drawn to show documents passing between defined activities in the form of input/ activity/output allowing the system to be analysed. The diagrams were drawn up as a series of interlocking sub systems presented as layered data flow diagrams covering several hundred activities.

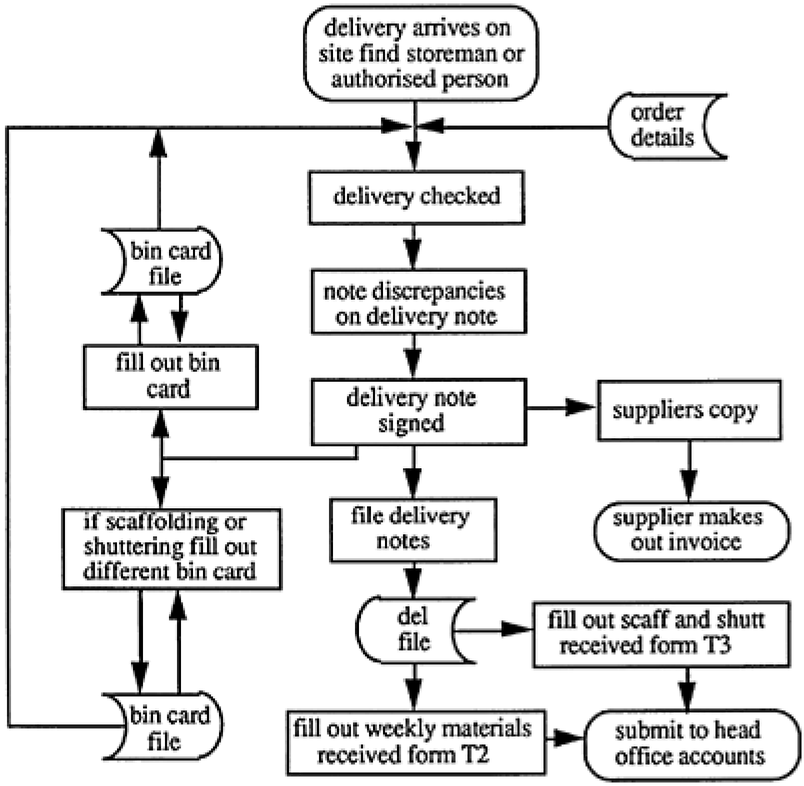

Fig. 3. Example data flow diagram for stores procedures

4 The Results

Examination of the site procedures manual revealed that some procedures were described in more operational detail than others. Detailed instructions referenced to standard forms were provided for procedures such as wages, drawing control, mail in/mail out, subcontract ordering, material ordering, deliveries, stores control, weekly costs, quality control and engineers records. Less detailed instructions were provided for the other procedures. This gave scope for the site to interpret them in different ways and allocate the duties to different job titles and functions depending upon the size of the management team.

As operational detail is clearly a matter for interpretation by each management team a comparison was made between the procedures developed and operated on each of the two sites. For those procedures for which detailed instructions were not provided variation could occur. This variation was seen in information input (data collection), procedures adopted for processing this information and the form of information output.

Table 3. Variation in procedures between the two sites

National Procedures manual	info. input	process	info. output
3) Prep. of quality plans	yes	yes	yes
Site Procedures manual	info. input	process	info. output
2) Information schedules	yes	yes	yes
6) Weekly programming	yes	yes	yes
7) Site meetings	no	no	yes
8) Site reporting	yes	yes	yes
17) Labour requests	no	yes	yes
19) Preliminaries	no	yes	yes
20) Internal valuation	yes	no	no
21) External valuation	yes	yes	no
22) Site monitoring	yes	yes	yes
24) Forecasting	yes	yes	yes
25) Final account	no	yes	no

There was variation between the two sites in the interpretation of national procedure 3—preparation of quality plans. The larger sites quality plan laid down responsibilities for the different team members, control procedures to be used additional to those described in the manual, the parties involved in the construction, the work stages and work instructions to be used. The smaller site used only a list of work instructions. The work instructions included safety instructions, information on special working methods (that differ from normal practice) and in some instances information on tolerances. The difference in control procedures required that a separate quality assurance manager was employed on the larger site to provide a check on the additional requirements.

There was greater variation in interpretation of the procedures described by the site procedures manual. The greatest area of variation lay within the procedures numbers 19–25 concerned with quantity surveying. The differences in quantity surveying procedures occur because the procedures manual focuses on the form of information output in order to ensure that the firm receives payment

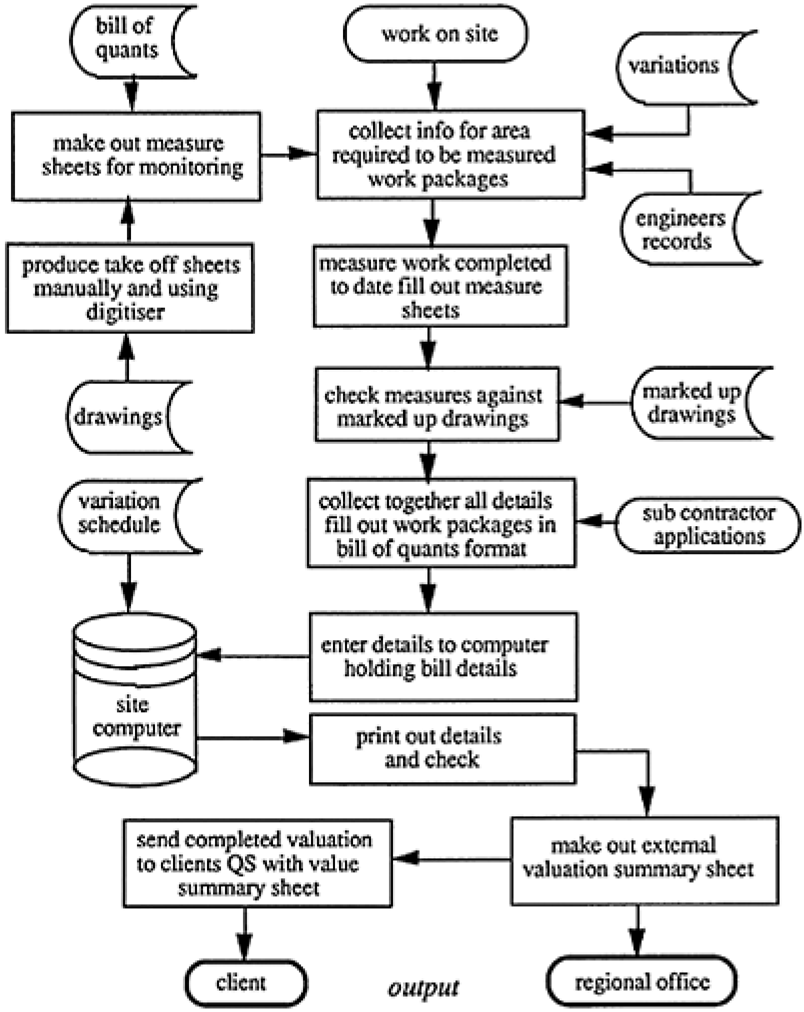

Fig. 4. Data flow diagram for external valuations on the industrial contract

from clients. They are less concerned with the methods used to generate this information. The commercial manager on the larger site was keen to innovate and encourage the introduction of computer systems to the site with the objective of improving efficiency in data handling.

The processes for generating external valuations were compared. The comparison of data flow diagrams showed that on the larger site work is physically measured and marked up on drawings, these measured values were compared carefully against subcontractors applications for payment on specific work packages. The smaller contract bases its control of costs on estimates of overall percentages rather than the precise measurement of individual elements. Despite the differences in preparation the same formats were used for the presentation of both the valuation bill and figures on it's summary sheet. Consequently the quality and accuracy of data used to generate these requests for payment cannot be ascertained by the recipient.

Output was usually in the form of specific standard forms. The systems analysis also showed where duplication of information and procedures existed. This duplication was most evident on the larger site due to its more departmentalised management structure. Examples were seen in the collection of progress information and monitoring of site progress by different departments each of which required the information in a particular format. Duplication was also found in the processing of cost information to determine the weekly costs and the monthly valuations.

5 Conclusions

Procedures manuals were seen to focus more on output (what was required) than the way to achieve it. This is clearly a reasonable policy for it accommodates the variations in size of projects gained by the region and specific contract conditions and types. The difference in scale and the smaller number of people on the hospital site often meant that individual members of the management team on this smaller site were able to see the whole site work progress and a larger part of the total management information system. This had implications for information input and processing within procedures. Where individuals can collect their own information there is a much larger potential for collecting data and checking it informally than where an individual is in receipt of someone else's information. The quality of decision making is influenced by the knowledge of the person making the decision as to the accuracy of the information with which they have been presented. This knowledge can be lacking where persons based at regional office receive data presented on standard forms.

The difference in scale and quantity of information was also seen to have implications regarding adherence to procedures. Where smaller quantities of information are involved and individuals are aware of the working of the whole management information system on site the strict adherence to formal procedures was often felt to be unnecessary. Informal methods were adopted and in some circumstances procedures were bypassed. Both sites were seen to suffer from a problem when interfacing with regional office. The ultimate use of information supplied by site was little known by many of those generating information and information was regarded as "disappearing to unknown destinations". Although in certain instances, such as planning on the larger site, this was not the case as these regional office functions were undertaken on site.

The aim of the procedures manuals to create certainty that all persons within the organisation are operating procedures in the same way. They often failed to achieve this aim for individuals used their initiative to ensure that site works progressed satisfactorily. There was evidence on both sites of some procedural requirements being bypassed due to requirements for faster information and flexibility; material ordering being one example. More informal methods such as not filling out all the required forms or contacting suppliers direct were noted.

6 Recommendations

A computer based system for making payments to subcontractors was developed and tested on a trial basis. This testing using live data in parallel with the existing manual system established that the computer generated output was both accurate and more rapidly produced. The system is compatible with other existing independent computer systems based on the larger site. It is now being considered for implementation by the company.

Proposals were also made to place stores records onto computer and to link them with the quantity surveying computer system so that information concerning materials orders, deliveries and stock control (materials on site) was readily available. This would enable those responsible for programming deliveries and receipt of materials more rapid access to information and also to allow the surveyors to exercise better cost control.

Possible improvements to the financial reporting system from regional office to head office and proposals for linking the planning function with costing were made in the context of the design of a master computer database management information system. This work continues.

9
The potential for automation and robotics in the design and production of buildings

M.M.CUSACK

Abstract
Construction projects contain a high manual input in all aspects of assembly. In the manufacturing industries where the application of robotics is at an advanced stage the importance of design for assembly is clearly demonstrated. This paper argues that attention must be focused on building design if the potential for robotic assembly is to be realised for construction projects. Three areas are addressed. First the assembly operations. Second, the developing environment of the building in which these assembly operations take place. Third, the creation of formal methods for cost effective site layout to facilitate robotic assembly. Methods of rule based generation of building descriptions are examined. The development of such descriptions of building designs offers the potential for effective planning for robotic assembly because the building design descriptions are created in a way which 'parallels' the construction operations required for their realisation.
Keywords: Automation, Robotics, Planning, Control, Building Assembly, Building Design, Rule Systems.

1 Introduction

To meet the demand from clients for continuing programmes of building—housing, schools, hospitals, libraries, offices etc. it is necessary to reconsider the methods used in the design and production of buildings. This is particularly appropriate at a time when a new young industry is emerging and provides increased opportunity for changes in traditional methods of working including the industrialisation of components both on and away from the site. It is essential to reduce the duration of projects and reduce the labour intensive nature of the industry due to the cost and difficulty of finding skilled labour. For this to be effective it is essential that the designer has a much greater understanding of the production needs of buildings and the potential of linking computer aided design to on-site use of robotics is an attractive proposition.

The intention of this paper is to explore the implications of the wide range of on site assembly operations in building construction and to examine ways in which the introduction of automatic and robotic methods of assembly affect the procedures for building design. It is argued that robotic assembly implies the need to examine building assembly operations as central to the design of the building.

The foundation of the relationship between design and automatic assembly have been examined in the field of manufacturing (1). The problems of flexible assembly systems have centred around the appropriateness of the design for robotic assembly. Robots are considered a vital part of such flexible systems because of the variety of manipulation which they can provide.

Assembly operations represent a concentration of manual tasks which have proved difficult to automate. Problems are compounded from basic considerations of the cost, time relationship (2, 3) and technical feasibility. The nature of the assembly operations lie at the heart of these problems. They are not concerned with the operations on a single component as is the case with machining but will bring aggregates of components together in specified spatial relations. These relations may be complex and their successful execution depends on many properties of the assembly design including lead in features on components, partial obstructions, the criteria for recognising when assembly has been completed and fixing methods.

In addition to the complexity of individual assembly operations are the problems of intricate sequences of these operations to complete the assembly. This problem is generally overcome by passing the partial assembly between robotic work stations designed specifically for implementing a particular type of assembly operation. This solution essentially avoids the introduction of flexibility and is often applicable only to large batch sizes and relatively constant products.

Many of the concerns of robotic assembly in manufacturing are similar to those of construction. The need for complex manipulations, sensors to determine the states of an uncertain and changing environment and the intelligence to make plans for action and recover from errors. Assembly in building construction does not offer the means to structure the assembly tasks to minimise these problems. The stationary nature of the building implies that components must be brought to assembly locations rather than subassemblies moved between assembly stations. In effect the assembly stations are moved around the construction site creating the need for autonomous site navigation not generally present in manufacturing applications. Further, the construction site is generally poorly structured with little control or explicit knowledge on the locations of equipment and components until they are finally in position on the building.

The comparison of building and manufacturing assembly implies that the design of assemblies, critical for successful automatic assembly in manufacturing, is even more so in building construction. The design of assembly components in terms of desirable component features for robotic assembly is not the main purpose of this paper which is to present the means by which the overall design of the building may facilitate robotic assembly.

Small changes to design practice in terms of component design and choice are only a minor consideration in this aim which rather seeks to expose the need for building designers to think more formally about designs in terms of assemblies of building components. Consideration of building designs in this way will not only allow attention to be focused on assembly operations to put individual components into place, but also to include the delivery and transfer of the components and the robotic devices used in the assembly to the site of assembly.

The introduction of robotic methods of assembly provides the opportunity to reassess the procedures and methods of design. This lesson has been learnt in a piecemeal fashion in manufacturing assembly. The effective and productive use of automated construction equipment is critically dependent on the nature of the building design at all stages of construction. It is the changing environment of the building design during construction that presents the major problems for robotic automation. The designer should be formally and explicitly aware of the stages in construction of a design. It is only in this way that the designer can make realistic decisions on the suitability of the design for robotic construction.

There are three levels at which the designer should consider the building design for robotic assembly. At the lowest level are the specific operations required to bring the components together. Second the developing nature of the building during construction. Third, the wider issues of site layout concerning the number, location and delivery of materials and components.

2 Assembly Operations

Research on the nature of assembly operations considers the strategies for the successful completion of single tasks (4). This work is largely confined to manufacturing assemblies. However, there is little knowledge on the assembly strategies for construction assembly operations. Specific design features, such as unidirectional assembly, lead in features and snap fixing methods have been identified for manufacturing assembly. Although, the considerations for building design for automatic assembly may be similar the relationship of these operations in assembly sequences is quite different in construction. Manufacturing assembly tends to be concentrated around a single identifiable product but in construction some components comprise the building 'frame' but most are placed on and fixed to this frame. A building assembly system will need to move over the frame between assembly operations. The robot will need to move itself to new locations.

Knowledge of building assembly operations is required by the designer in order to design for robotic assembly. Understanding the capabilities of automated assembly equipment is required at the design stage. This knowledge is often available in the field of component manufacture using machine tools, but is rarely so in the assembly of components which has been predominantly a manual operation. The flexibility inherent in these manual assembly operations has led to little consideration being given to the assembly operations at the design stage.

Building design thus requires an input on the characteristics of assembly operations if the robotic assembly methods are to be used effectively. It cannot now be assumed that all assemblies are equally difficult to make. The investment in, and availability of automatic assembly machines will limit the kinds of assembly which can be incorporated in a design.

It should not be assumed that this will necessarily introduce constraints on the nature of the overall design scheme. In many cases the effect will be to place limits on the component details particularly in the methods of fixing, the geometry of mating surfaces and the types of manipulations needed to bring the components into the final spatial relations. The limits may not affect the overall spatial properties of the components.

The attention to these detailed features of the building component design specifically concerned with the relationships between the components will have the effect of. increasing the designer's awareness of the importance of the spatial relations among the component's of the building. Assembly is the business of realising these spatial relations. The problems of assembly are essentially about the passage through a sequence of spatial relations as one component is moved into its final position relative to another. The strategies for robotic assembly are expressed in terms of these sequences of intermediate spatial relations, which represent sub-goals in the path to the goal of final assembly.

In order to consider the relation of building design and robotic assembly it is not sufficient to examine current component types and their assembly. As in manufacturing the problems of robotic assembly are as much about the design of the robotic systems as the design of the assemblies to make them suitable for robotic methods. The building design process must therefore adopt methods and procedures which produce designs appropriate for robotic construction. The emphasis should be on the ways that components are brought together to form the spatial and functional characteristics of the whole building.

The concentration on automating individual assembly operations has been identified (5) as a shortcoming in the development of robotic automation in construction. The examination of rule based systems arising from assembly operations will enable the planning of robotic methods of construction at the design stage, as well as the integration of these methods in the construction process.

3 Dimensional Coordination

If robotic construction is to be effective then it will be necessary to establish rule based generative systems for building design, based on the spatial relations among components. Rule based systems have the potential to ensure that dimensional coordination among the components in the design is maintained. The rules can be used to encapsulate a system of dimensional coordination for arranging the dimensional framework of a building so that components can be used within the framework in an inter-related pattern of sizes. To do this it is necessary to establish a rectangular three dimensional grid of basic modules to which the component will fit. The first step in producing a rational system capable of robotisation is to agree the basic dimensions of the enclosing fabric of the building at the design stage. The principle of relating components to a planning grid are not new and there are a number of British Standards which give recommendations for controlling limits to the dimensions and sizes for the structure and components. A process of dimensional coordination supposes a complete and careful appraisal of precise requirements at the design stage and decisions cannot be left until the building is being erected.

Dimensional coordination expressed as rules for design will lead to simplification of constructional details which will assist the mechanisation of construction both on site and in the prefabricated manufacture off site.

In order to take full advantage of the use of robots it will be necessary to adopt an agreed system of dimensional coordination, net only on a national but also an international scale. As part of this process an agreed standard of tolerances will also be an essential feature. This in turn presupposes a more comprehensive system of inspection and control to guarantee that manufacturing tolerances are maintained. The nominal dimensions of a component is fixed and indicates the zone in which the component must at all times fit.

The above considerations all lead to the requirements for design systems in construction which allow for the building to be described in terms of the assembly of components. The assembly operations incorporated into the design rules will be based on the examination of the nature of these operations and the strategies for their execution by robotic or other means. It is argued therefore that the need to design for efficient assembly on site using flexible robotic systems where appropriate, brings rule based systems of building design to the fore. This allows a formal description of the building in terms of the spatial relations among components and the spatial and functional characteristics of aggregate assemblies. In turn this allows the designs to be evaluated for robotic assembly and provides the input for planning construction. There are now pressing reasons to begin to formalise the nature of the building design process in terms of rules of design (6).

4 Rule Systems for Building Assembly Design

The examination of the importance of understanding assembly operations in construction has led to the conclusion that rules of design can be based on the assembly of components. The major advantage of such an approach lie in being able to ensure dimensional coordination within the rules used and in selecting those rules which correspond to robotically executable assemblies. However, it is essential to look further and examine how the generation of building designs using rule based systems should be guided and controlled to ensure design functionality as well as constructability. The problems here are considerable, since the application of individual rules can guarantee neither designs which meet functional specification nor sequences of assembly operations which are realisable, even though the individual operations are satisfactory. It is the combinations of rules which will have a semantic interpretation in the areas of function and construction.

Despite these difficulties the use of rule based design systems will bring the processes of design closer to those of construction, particularly the assembly processes on site. Designs will cease to be two dimensional formal compositions and become genuine three dimensional compositions of spatially related components. Design is thus no longer remote from the needs of construction in the same way that design and manufacture cannot be divorced in the progress towards effective manufacturing automation. The changes in building design arising from the introduction of robotic automation are not the central subject of this paper, but rather the framework and methods which are required to bring about these changes.

It is noted that the necessity of transporting the robot to the site of assembly as well as the components will impose more limitations on building design than the individual assembly operations. The rule based systems provide the appropriate tool to enable the examination of developing building geometry. This is the context in which the robot and components must move.

Before considering these issues, the development of rule based design formalism will be traced. In principle the methods provide the means to explore design spaces by rule applications within the rule based system. The control and selection of generated designs may be based on a wide range of criteria ranging from the aesthetic to the functional. In the present context the designs generated will be evaluated against the methods and devices available for robotic assembly.

It has been demonstrated that the formal methods of the shape grammar implementation (7) of rule based design systems can provide the means to describe architectural design spaces as coherent aggregates of spatial relations among building elements. This work has led to a deep understanding of the meaning of architectural style. The focus of this research has been on aesthetic considerations. The main argument of this paper is that the natural derivation of design rules from construction assembly operations allows similar methods to be used in the exploration of design spaces for the evaluation and planning for robotic construction.

The thrust of this shape grammar approach to the description of building design in the creation of a design language whose elements are generated by the rules (8). The language of architectural designs may be thus generated from the spatial relations to be realised by assembly operations. Robotisation requires a design language to express and convey ideas of shape, size and construction of the architectural components of an individual building or group of buildings. To have an optimum value the information conveyed by the language must be clear concise and subject to well defined interpretations.

The translation of a concept from a designer’s mind into something that can be created by a robot is a complex process and involves a series of intricate steps which eventually converge as the designer incorporates many individual and diverse ideas into the complete and final design. The rule based approach will enable the steps in this integration to be formalised. Design and production of complex structures requires the solution of many complex problems. Construction projects may be composed of thousands of individual activities, each with a sequential or parallel relationship. The total design and production budget is often in the many million pound category and an economic method of designing that takes account of production processes must be seen as an essential facet. It is essential that provision is made for testing or simulating the final building at the design stage through the creation of a three dimensional model within a CAD system. It is argued here that the rule based approach allows the building design at all stages of construction to be evaluated and methods of robotic construction assessed.

5 Building Design and Robot Planning

The rule based generation of building designs allows sequences of assembly operations which realise the spatial relations, incorporated in the rules, to be evaluated for robotic execution. The rules of design generation allow potential designs and sequences of assembly operations to be explored in terms of robot and component movements. The critical feature of a building design is that the developing design is the environment in which robot assembly devices are to operate.

To evaluate the design and plan for robotic assembly it is necessary to understand the emerging spatial properties of the design as the rules are applied. The problem here is that the spatial relations to be realised in assembly only represent a fraction of the spatial relations that arise from the rule applications. Spatial properties of the building design emerge as the design is generated. The design generation will be guided and controlled to produce some of these since they will form an integral part of the formal and functional specification of the completed building. However, many others will not be critical in meeting overall specifications but may nevertheless be important in providing information on the potential accessibility for robots and components.

Design generation in terms of available methods of robot assembly will require the addition of attachments for the robotic devices and the means of component delivery to the design. The means of robot support must be included in the design description.

The generative systems for building design will allow the overall development of the building on site to be examined because the design process parallels the development of the design on site. This is not just a means of simulating building development but of exploring the design space defined by the rules for solutions meeting functional and formal specifications as well as constructability criteria.

The design rules based on assembly operations enable sequences of these operations to be explored in terms of the emerging building geometry. Evaluation and choice is possible at the design stage, so that modifications to the overall design can be incorporated using backtracking procedures and the invocation of alternative rules.

The attention to automation of individual assembly operations is not sufficient to integrate robot assembly methods into construction (3). The developing building geometry and the environment in which the robot works must also be considered at the design stage. The robot environment on the construction site is often identified as a major difficulty. The robot moves to the site of assembly and components are delivered in a complex and uncertain spatial environment. The motivation for describing the building design in terms of spatial relation based rules is that knowledge of this environment is included at the design stage and can be used in creating well structured plans for robot actions.

Planning for robot assembly will require the spatial properties of large and complex aggregates of components which emerge from the rule applications, to be inferred from the sequences of rule applications. The process of design will require that the rule applications be controlled to direct the design generation towards those emergent spatial properties appropriate for robotic assembly. The sequence of rule applications corresponding to component assemblies must create at each stage a partial assembly on which the robots can work and to which both robots and components can gain access. The problem is therefore to specify the nature of the spatial environment for robot assembly, to guide design by this specification and to match emergent spatial properties against specification.

6 Planning and Control

The means to evaluate building designs for robot, assembly have been sketched. Precepts and guidelines need to be established for movement within the developing building of robots, components and materials as well as access to building and the general organisation of site layout. This will allow the planning of the priorities and sequencing of construction operations and provide the control structures to implement the plans on site.

Site layout is dynamic and changes physically during each phase of construction. These phases are specified by activities and it is important to determine a series of central focuses in each stage about which other activities revolve. In particular, points of access to site or developing building will determine the focal points of activities. It is likely that in a particular phase one activity, for example, concrete work, may have a coordinating priority. This may occur in a number of phases and therefore, the focus of this activity should be within reach of casting and placing areas, within crane sweep for horizontal and vertical movements and have access to hoists for vertical movement.

Once ground work and substructure have been completed the next phase introduces vertical movement and robots may be used in conjunction with cranes and hoists. As work progresses site layout requires adjustment and becomes increasingly determined by the building geometry. Planning and control of the construction becomes more complex with wider spans of control, a more dynamic approach to communications between activities and a more intensive use of robotic assembly.

Access to the points of activity must be provided as the building geometry develops. Doorways and windows are often used, but temporary access routes for robots, materials and components should be provided at design stage. Careful planning should enable floor and wall sections to be temporarily omitted to allow access without affecting structural integrity.

The movement of materials, components and robots within the building is a major problem in robotic assembly. Guiding frameworks, rails and ramps will need to be incorporated for the duration of a construction phase.

7 Prefabrication

In drawing comparisons between manufacturing and construction in terms of design for robotic assembly the continuing interest in prefabricated components should not be ignored. Prefabrication has resulted from an examination of the difficulties of on-site assembly operations. In this way there has been considerable influence exerted on building design. Prefabricated components may still leave difficult assembly problems on site, particularly with the access and fixing of geometrically complex components. However, they do offer the scope for robotic assembly of those components either off site or in specially prepared workplaces on site.

The prefabrication option can be assessed along with other assembly methods in the planning and evaluation procedures applied to the building design. Prefabrication now represents just one route to guide the generation of building assembly operations. It is based on a decomposition of the building into functional components. As a design philosophy it attempts to reduce the interactions between components and as a construction method it removes many assembly operations from the complex spatial constraints of the developing building geometry.

Rule based design systems allow construction plans to be generated as the design is taking shape. Many different construction methodologies can be explored with their associated impact on possible designs. There is no need to be constrained by a single methodology such as prefabrication.

8 Computer Aided Design

Methods of rule based design description have been advocated as most appropriate for the parallel generation of designs and their planning and evaluation for robotic construction. CAD systems for building design are generally used as a formal modelling framework for entering, recording and displaying the spatial features and characteristics of a design. This process involves the haphazard and informal applications of design rules and is generally structured according to levels of detail and types of service. The main purpose is to describe the design in all its complexity and to submit this for analysis of cost, structure, materials requirements, services and circulation. This distinction between formal design and functional analysis makes it difficult to assess a design for robotic assembly which requires that the stages of construction are available. Partially completed buildings are the environment in which the robot operates. Design evaluation for robot construction should be accommodated within the design process and be able at each stage to guide design generation. The CAD system for building design must therefore be able to accept and apply rules of spatial composition to generate assembly sequences for buildings.

These changes to the processes of design do not just deal with new ways of entering a design, previously formulated, into a CAD system or in structuring that information in a database for subsequent use in planning for automatic assembly. The thrust of the argument is that a rule based approach provides a structured approach to the examination of alternative designs in terms of assembly operations from which the rules are derived.

9 Conclusion

Building assembly operations can be used to provide the basis for rules to generate building designs. These rules are derived from the spatial relations between components and may be incorporated into shape grammars specifying languages of design. The design process can then include the evaluation both of individual assembly operations and the planning of sequences of those operations for robotic construction. The descriptions of building designs in this way allows the developing building geometries to be explored to aid planning and control of robotic assembly on site.

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The impact of multicultural work teams on the management style of construction site managers

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Abstract

A review of literature reveals that there has been little research in the Middle East regarding the relationship between the culturally heterogeneous work forces and the managerial style of site managers. The intention of this paper, therefore is to explore the association between the cultural diversity of work forces who are frequently drawn from more than one culture and the managerial style of construction site managers. Data were obtained from 79 site managers in 6 Middle Eastern countries. The results indicate that the association between the cultural diversity of work forces and the style of site managers was weak and failed to reach statistical significance. In particular, the results show that construction site managers tend not to adapt their style according to the types of culture encountered. The paper recommends that construction companies operating in the Middle East need to recognise and consider the cultural training as an integral part of construction management development if they are to remain competitive and successful.

Managing work teams in the Middle East

The success of a construction project, whether it is carried out in the country of the contractor or beyond its borders, is determined in the main by the quality of its management. Projects which are undertaken beyond national borders may create special problems for managers, such as dealing with multi-ethnic work forces, operating within local laws, regulations, and social customs, and importing materials. This increases the pressure upon managers who require particular qualities and understanding in order to achieve their target in the most economical way.

A work force is one of the main resources available to any construction firm (Rabbat and Harris, 1982). In the Middle East many construction projects have work forces which come from more than one country, and show variations in language, attitudes, religion, and education. Such situations pose great difficulties, not only to managers with western backgrounds but also to local ones. However, the problems met by western managers are usually greater because they have been brought up in a completely different environment, usually with a work experience gained in developed countries.

Rabbat and Harris (1982) reported that labour disputes and conflicts arising from cultural differences (e.g. religion, values, attitudes, and social traditions) have increased in the Middle East which may lead to serious disruption and financial losses to international construction firms. The success of managers in this particular setting is to a large degree dependent on the interpersonal relationship between foreign managers and their subordinates which is influenced by the degree of cultural diversity of both parties (Malony, 1982; Imbert, 1987).

Rabbat and Harris (1982, p. 219) stated that: "management must adapt to the culture if conflict is to be minimised…efficiency, and thus productivity, can be greatly increased if conflicts among individuals and groups can be reduced". Imbert (1987) also emphasised the need of understanding cultural diversity and international labour productivity factors when operating in developing countries.

The Concept of culture

Culture reflects the patterns of life in any society regarding education, beliefs, customs, traditions and social structure. It consists of several elements, which embrace : values and attitudes, language (communication) and religion. These components have extremely strong relationships with each other, in other words each item has a considerable influence on the other one. Consequently, it is impossible to investigate one element in isolation; and at the outset it would be helpful to review other researchers' definitions of culture.

Layman (quoted in Hall and Whyte, 1960, p. 5) has defined culture in three terms, namely: the way people dress, the beliefs they hold and the customs they practice. Taylor (quoted in Phatak, 1974, p. 138) has defined culture as: "That complex whole which includes knowledge, belief, art, law, morals, customs, and any other capabilities and habits acquired by man as member of society".

Kluckhohn (1951, p. 86) defined culture according to several anthropological definitions: "Culture consists in patterned ways of thinking, feeling and reaction, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artefact; the essential core of culture consists of traditional (i.e. historically derived and selected) ideas and especially their attached values".

Hofstede (1984, p. 21) has given a more specific explanation of the cultural image. He says: "Culture is to a human collectivity what personality is to an individual". Hofstede refers to Guilford's (1959), definition about personality, that is "The interactive aggregate of personal characteristics that influence the individual's response to its environment", Hofstede, then, concluded that "Culture determines the identity of the human group in the same way as personality determines the identity of the individual".

Kaplan (1972) reported that four theoretical subsystems were used to explain the cultural differences: ideology, social structure, techno-economics, and personality. Whitchill (1964, p. 69) gave a very broad description for culture: "Culture is not made in any esoteric sense but, rather, the whole complex of distinctive features characteristic of a particular stage of advancement of a given society". This definition is very comprehensive and yet dynamic as well; it is suitable or valid to any time and for any change. Schuapp (1978, p. 9) explained the concept of culture in two parameters to serve the purpose of his study. lie defined culture as "The attitudes and values of a given society at a particular state of advancement".

Fayerweather (1959) interpreted culture in his comparative managerial study of Mexicans and Americans as: the attitudes, beliefs, and values of society. Although this definition is not comprehensive, it does reflect significant elements which are basic to the study of cultural differences across nations.

Other studies (e.g. Megginson and Eugene, 1965) defined the concept of culture according to anthropological analyses. The classical definition includes all sociocultural elements: political, economical, law, social and characteristics of education. Such a broad definition will certainly leave the reader to his imagination to consider which element will be relevant for this study. The cultural integration between one community and another will depend upon various factors, such as: the degree of cultural differences, language, politics, and religious understanding. Hall and Whyte (1960, p. 10) highlighting the importance of communication and its relation to the culture, stated that: "We would be mistaken to regard the communication patterns which we observed around the world as no more than a miscellaneous collection of customs. The communication pattern of a given society is part of its total culture pattern and can only be understood in that context.

Hofstede (1984, p. 23) believed that the norms of society can rarely be changed by the direct adoption of outside values, but rather through the shift in ecological factors, such as those of technology and the economy. He added: "In general, the norms shift will be gradual unless the outside influences are particularly violent (such as in the case of military conquest or deportation)".

This seems to underplay the importance of social norms such as rules, principles and behaviour, because in some countries these are fundamental concepts underlying the whole manners of conduct and thought which must be accepted as they can not be changed easily, even in the long term. For instance, the societies in the Middle East elicit their norms from the Koran and the Prophet's teaching, which is considered essential in their daily lives; therefore it would not be possible to change them without a fundamental modification of religious understanding, though their influence may vary in rigour between religious parties.

In this brief review, several cultural definitions have been examined and discussed. As its aim is to provide an insight into the concept of culture, and to choose the most appropriate definition to serve the purpose of this study, a decision has been made to focus upon Fayerweather's definition for the following reasons.

Firstly, the study aims to investigate the impact of work forces' values and attitudes on the style of construction site managers who manage a mixed-cultural work group.

Secondly, the religious faith in the environment (that is the Middle East) where the study is concentrated is a fundamental element. However, it is necessary to take another element, language, into consideration for the following reasons: firstly, language reflects the nature of culture; secondly, the perception and interpretation of words or expressions vary from culture to culture, which might have an impact on the interpersonal relationship among work group's members who, probably, come from different cultures. Thirdly, in a construction project, communication between manager and work group members or among members themselves has a considerable effect on progress of the project.

Management style and culture

Management style can be defined as the pattern of behaviour that site managers, as leaders of their team, exercise during the process of supervising, planning, and directing resources on site. There is a large body of literature investigating the managerial style in industries other than construction, in which two main categories of managerial style have been identified, namely task orientation (or initiating structure) and employee orientation (or consideration) (Hemphill, 1950; Halpin and Winer, 1975; Stogdill and Coons, 1957; Flishman and Peters, 1962; Kerr et al, 1974; Blake and Mouton, 1964; and Fiedler, 1967, 1984).

For the purpose of this paper, the expressions of "task" and "employee orientation" are used. They can be defined as follows:

Task oriented managers are those who are concerned with the management of external task activities, such as organisation, control, efficiency, and productivity. Managers do not expect the work force to adapt work methods in which the have been trained and as they accepted them. On the other hand, employee oriented managers who give priority to the management of internal relationships among the work team members and themselves. They establish a rapport with their multicultural work forces by understanding the cultural differences and solving their problems.

There is still a debate surrounding the universality of management theories and their applications. On the one hand, several scholars believe that management style varies from one culture to another, and therefore managers should adapt their style according to individual situation. Phatak (1974) reported that, the greater the degree of cultural differences faced by a management team in an international company, the more likely that failures will affect them. Schein (1985) stated that, it is not possible to separate the process of leadership from the culture of a team.

Hofstede (1980, 1984) found distinct differences across cultures towards the perception and preference of the leadership style. Hundal (1971) reported that, although the leadership principles are universal, the methods and procedure in which they are adapted to each culture and work location decide their success and failure. In other words, the culture has an impact on the leadership style. Gonzales and McMillan (1961) stated that, the management practice in a multi-national organisation is culturally bound; the managerial practice must be closely associated to the influx of technology moderated by cultural norms of behaviour (Starbuck, 1976). Child (1981) eported that there are several factors associated with the divergence in management, namely organisation political, and cultural factors.

Whyte and Williams (1963) concluded from their survey that there is a common satisfaction and agreement between the American and the Peruvian workers regarding a supervisor who understands the needs and problems of his workers, and who is interested in improving their skills by training. On the other hand, they found that for the Peruvian workers there was a positive correlation between closeness of supervision and general satisfaction with the supervisor. The Peruvian workers expressed their preference and satisfaction for a supervisor who tells them what to do and observes their progress rather than one who offers general supervision and leaves the operatives on their own most the time. It can be clearly seen from the above discussion, that culture does affect workers' expectations and perceptions of managerial style. This indicate that managers should adjust their style according to the cultures being encountered.

On the other hand, other scholars believe that management theory and practice can be applied in every culture and situation without a need for adaptation to specific cultures. Negandhi (1983) pointed out that several management practices, namely planning and decision making, are not influenced by cultural diversity, but are contingent upon technological and market conditions. Negandhi lent support to the believe that management styles vary among cultures: he tended however, to refer such variation to technological and economic discrepancies rather than cultural differences. Haire, Ghieslli, and Porter (1966) concluded that there were many similarities in managerial attitudes and motivations among managers in all countries. Thiagarajan and Deep (1969) concluded from their survey that all managers preferred democratic supervision irrespective of the cultural differences. This seems to be consistent with Haire et al's result.

Al-Jafary and Hollingsworth (1983) found that managers in the Gulf region operated in a consultative managerial style as did their American counterparts. Massie and Luytjes (1972) said that there is a tendency towards a similar management practice in Western and Eastern Europe, South America, Asia and Africa. They referred to several reasons which contributed to this result, namely the increase of management education across cultures, management functions (e.g., planning and organisation) and participation in decision making. Based on the above, it seems to be very difficult to conclude that management style is universal or culturally bound.

Hypothesis

Based on the above review of previous research findings, the hypothesis which our project was designed to examine was that:

There is no association between the cultural heterogeneity of work forces and the style of construction site managers in the Middle East.

Methodology

Subjects and procedure:

The data were obtained from 79 construction site managers representing 62 international and local construction organisations which were drawn from 6 countries in the Middle East (Figure 1). 47 projects were being carried out by international organisations and 32 projects by local construction firms (Figure 2). Construction site managers were considered as individuals in charge of running and directing construction projects. Their main task was to obtain a high level of productivity from resources and from the work forces who utilise those resources. The criteria for the selection of site managers and contractors was basically contingent upon various factors, these were: construction projects must contain a work force composed of several cultures; site managers should have a direct and daily contact with all members of the team; accessibility, and willingness to co-operate. The names and

Figure 1. The Locations of Construction Projects

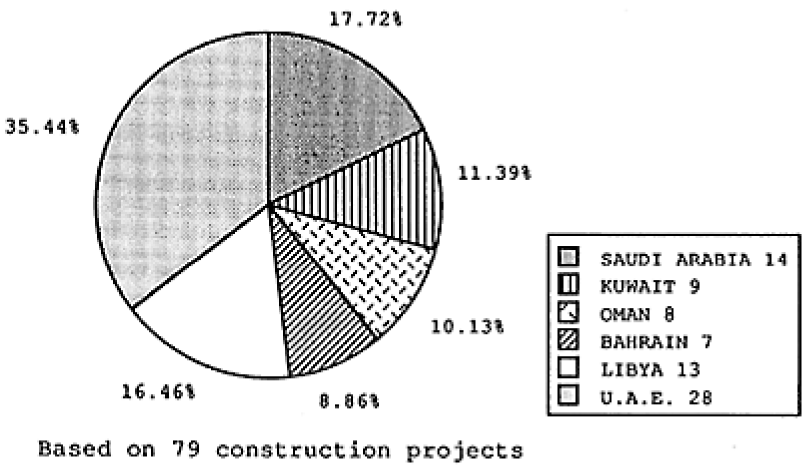
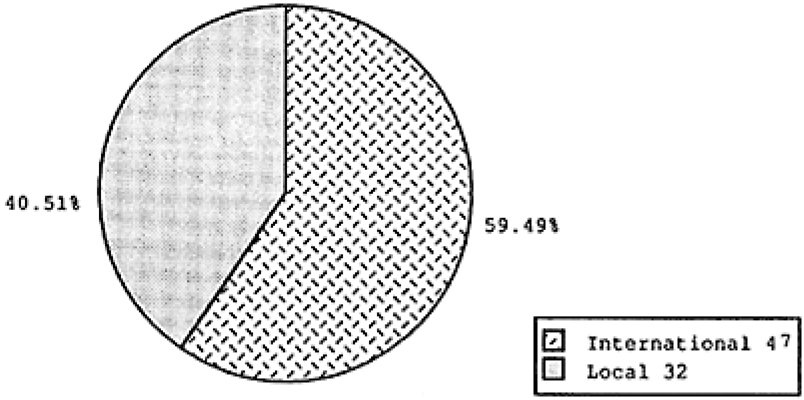


Figure 2: Categories of Construction Projects



addresses of construction companies were obtained from Engineering News Records' annual list of the top 250 international contractors; Department of Trade and Industry; Chartered Institute of Building (CIOB); and Middle East Association.

The focus in this study was on organisations that acted as main contractors and upon medium to large-scale contracts (medium with a contract value of between £0.75M and £2.5M, and large scale with a contract value of over £2.5M) (Figure 3). The reason for such a choice was to reflect the general distribution of project size in the construction industry which meant that small size projects were not included.

Data in this study were obtained by means of questionnaires distributed to site managers currently working in the Middle East. The sample included not only Western but also local site managers and others from third country national (from third world countries), representing both international and local construction firms (Figure 4). This might appear to be an arbitrary selection, but it was unavoidable because of the nature of the Middle East construction industry, which frequently involves more than one culture. Besides, it was felt that the research should reflect the general site managers' style when managing a mixed-cultural work force, whatever the culture of site managers, as they are eventually working in a similar condition, Table 1 shows the nationalities of construction site managers.

A total of 180 questionnaires were distributed, of which 79 were returned completed. Regarding the non-response subjects, some recipients did not reply at all to the letters, other insisted that their completed questionnaires were posted, and a few site managers apologised for not answering the questions, saying that they could not provide such information for reasons of confidentiality. Having said that, the returns were encouraging as 44% returns can be considered excellent for this type of sample, and sufficient to carry out statistical tests. The data were analysed using Cluster Analysis, Cross-Tabular, and Kruskal-Wallis one way analysis of variance (ANOVA) test available is SAS package.

Measurement

The style of construction site managers was measured by asking respondents to answer a question consisting of 14 statements which related to managerial practice on site. The statements were rated on a 5-Step Likert type scale from 1 (strongly agree) to 5 (strongly disagree). A group of statements (a, b, c, f, k, l, n) were related to task oriented managers' style, and another group (c, d, g, h, i, j, m) referred to employee managers' style (see Appendix A). The statements were mixed, but orientated capable of identification into groups at the analysis stage. It was hoped that such a method would avoid any possible bias, and reflect the real orientation of construction site managers.

The cultural diversity of multi-cultural work forces has been measured into three steps: first, site managers were asked whether differences in work forces' values and attitudes, languages, and religion make them modify their managerial style to suit the cultures encountered. The question was constructed in the form of statements and on a 5-Step Likert scale. Secondly, the degree of cultural domination in a construction project was measured based on the assumption of the percentage of individual cultures involved in a project. If one culture represented more than 80% of the work force, then it was assumed that such a project was dominated by one culture. Otherwise, it was assumed that such a project was dominated by more than one culture. The degree of cultural heterogeneity within a project was measured using an approximate index of the cultural diversity of the work force. This index ranged from a score of 1 referring to a homogeneous team of the same ethnic background, to a score of 9 indicating that there were 8 additional cultures in one project.

Limitations of study

Although the study in the main achieved all the aims of this investigation, there are some limitations which should be mentioned. Firstly, the convenience of the sample,

Figure 3: Size of Projects

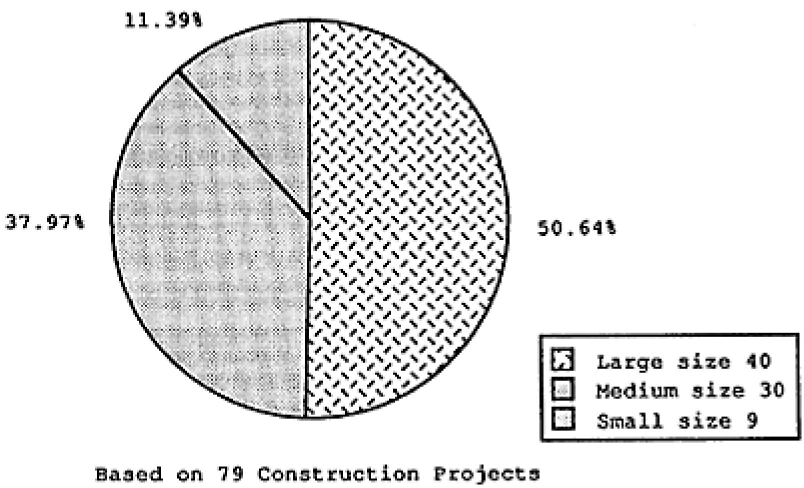
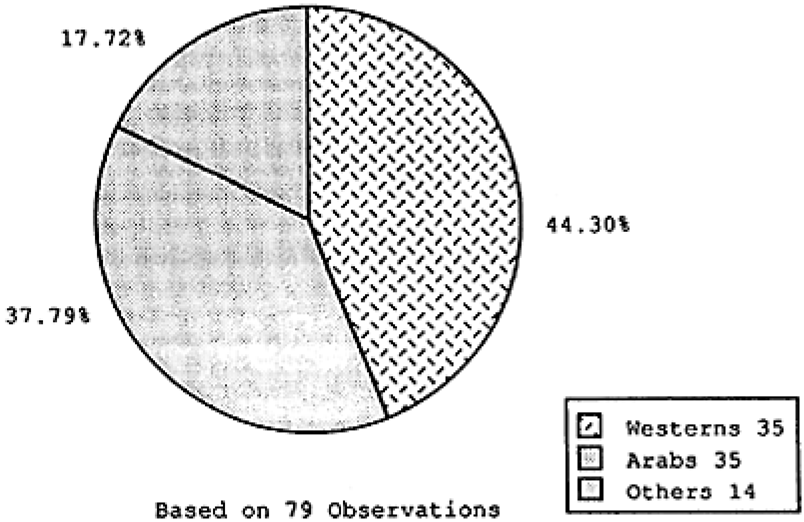


Figure 4: Cultures of Site Managers



although it is statistically viable, may cast some doubt on whether it presents the attitudes of those construction site managers who did not participate in this research and who manage multi-cultural work forces in the Middle East. Secondly, the sample was drawn from United Arab Emirates, Saudi Arabia, Bahrain, Kuwait, Libya and Oman without representation from other Mideastern countries, e.g., Jordan, Qatar, Iraq and Algeria, a fact that may qualify generalisations in the findings. Therefore, there is no claim for representing all Middle East Countries.

Results

Site managers' styles have been categorised into four groups, on the basis of the Cluster analysis result (Table 2). These four groups are: high task/low employee orientation managers' style; low task/low employee orientation managers' style; low task/high employee orientation managers' style; and high task/high employee orientation managers' style.

The average score on perceptions of site managers towards the impact of the cultural factors on their styles, was tested with the four categories of managerial styles, using the Kruskal-Wallis one-way analysis of variance (ANOVA) test. The results indicate that the probabilities associated with the occurrence under the null hypothesis is P>0.25, 0.93 and 0.46. Since these probabilities are larger than the level of significance of 0.05, the null hypothesis cannot be rejected. This means that there is no recognisable relationship between the perception of cultural variables and site managers' style in the Middle East.

Although the association was weak and failed to reach statistical significance, it might be interesting to look at the contingency tables of each variable with the four suggested managers' style (see Tables 3, 4, 5). The following can be noticed: First, Table 3 shows the cross-tabulation between the four style categories and the language factor which is combined in three categories (column 2: agree that language differences affect the style; column 3: neither agree nor disagree; and column 4: disagree that variation in work forces' languages affect the style of site managers). As can be seen in Table 3, the high proportion of respondents are located in column two and almost evenly distributed over styles 2, 3, and 4. The rest of respondents are located in column 4 and only three observations are in column 3.

About 79 per cent of construction site managers believed that the differences in the work forces' languages should make them modify or adjust their managerial style. 18 per cent of managers thought that the variations in language had no impact on their style, and about 4 per cent neither agreed nor disagreed. Secondly, Table 4 illustrates the four style categories which are cross-tabulated with values and attitudes. It can be seen that the results of Table 4 are to some extent similar to the results in Table 3. A near majority of respondents are situated in column 2 and almost evenly spread over styles 2, 3, and 4. The remaining subjects are located in columns 3 and 4. About 67 per cent of managers perceived that differences in a work forces' values and attitudes should make them modify their style. About 22 per cent thought that they should not adjust their style, and 11 per cent did not give a clear opinion.

Finally, Table 5 shows the contingency table between the style of managers and the perception towards religious differences of subordinates. In contrast to Tables 3 and 4 a very high proportion of respondents are placed in column 4, but similarly this high proportion is almost evenly spread in 2, 3, and 4 style categories. About 61 per cent of construction site managers disagreed upon the fact that the variations of work forces' religion or beliefs had a significant impact on their managerial style. About 30 per cent believed that they should adjust their style because of religious differences, and about 9 per cent neither agreed nor disagreed.

To sum up, it can be inferred from Tables 3 and 4 that the majority of construction site managers agree that language differences and the variation of values and attitudes of work forces are very important to their style. This agreement is

Table 1. Nationalities of construction managers who participated in the research survey

Nationality	Number in Sample	Percentage of Sample
British	20	25.3
Jordanian	12	15.2
Indian	11	13.9
Palestinian	6	7.6
Lebanese	3	3.8
Egyptian	3	3.8
Sudanese	3	3.8
Turkish	3	3.8
Japanese	2	2.5

American	2	2.5
German	2	2.5
Dutch	2	2.5
U.A.E	2	2.5
Greece	2	2.5
French	2	1.3
Italian	2	1.3
Pakistani	2	1.3
Irish	2	1.3
Bangaladesh	2	1.3
Srilankan	2	1.3

Sample size=79

Table 2. Classification of Site Managers' Style

Cluster	Managers' Style	Number in Sample	Percentage of Sample
1	High task/low employee	14	17.72
2	Low task/low employee	24	30.38
3	Low task/high employee	19	24.05
4	High task/high employee	22	27.85

similar between the four categories of management style. In other words, site managers said that they should adapt their style to suit the cultural environment in construction projects. Therefore, there is no clear evidence, at this stage, to conclude whether construction site managers really adapt their style or just practice their accustomed style when working with multi-cultural work force.

The two main categories of cultural domination on construction projects (that is when one culture predominates the other cultures, and when more than one culture are dominating) were tested with the four classifications of site managers using the Chi-square test. The results indicate that there is no visible association between the site managers' style and cultural domination (P>0.05).

The degree of cultural heterogeneity in terms of the number of cultures involved in construction projects was tested against the four management style categories using the Kruskal-Wallis one way analysis of variance test. The probability (P) was found to be 0.32. Since this P is more than 0.05, the decision in this case fails to reject the null hypothesis of condition differences. That is, there is no observable association between the degree of cultural heterogeneity of work forces and the site managers' style.

Discussion

In looking at the results described above, it appears that there is strong evidence of a discrepancy between the site managers' style and the multicultural work forces, i.e., there is no visible relationship between both variables. Having said that, it is not to be expected from statistics to find from cross-sectional data in studies of management style the kind of clear-cut relationship of cause and effect; rather than talk about causality one talks about the association between variables (Lawshe and Bryant, 1953; Youngman, 1979; Siegel, 1956; Norusis, 1986). However, the results do indicate several important issues that need to be discussed in more detail.

There is an indication that the association between the managerial style of construction site managers and the cultural diversity of work force were weak and failed to reach statistical significance. This suggests that the two varied largely independently of one another. This might lead one to believe that the cultural differences of a work force have no recognisable impact on the managerial style of construction site managers.

This is congruent with the findings of previous cross-cultural research, which suggested that cultural differences did not change the managers' style and showed that there were considerable similarities in managerial style across countries (Haire, Ghiselli, and Porter, 1966; Thiagarajan and Deep, 1969; Al-jafary and Hollingsworth, 1983). The results also support the finding of Massie and Luytjes (1972), that there is a tendency toward a similar managerial practice in Western and Eastern Europe, South America, Asia, and Africa. This also lends support to the universal school which assumed that no variations exist in managerial behaviour across cultures when the functions are the same.

On the other hand, the results of the statistical test do not lend support to the results reported by other researchers, namely that management style is culturally dependent, and therefore managers should adapt their style to match the work force's culture (Hofstede, 1980; Maloney, 1982; Imbert, 1987). The results are not congruent also with Schein's suggestion (1985), that culture and leadership practice cannot be separated, this suggests that there is an association between both variables. The results do not lend support to Hofstede's finding, that there are distinct differences across countries toward the perception and performance of leadership style.

Most modern management theories and organisational behaviour research showed that management style is a function of the leadership style, the subordinates, and the situation. Besides, while management theories can be transferable across cultures, management practices are not (Maloney, 1982). This suggests that site managers have to modify their style to meet their subordinates' expectations.

Table 3. Cross Tabulation Of Managers'style Categories By Respondents Perception Towards The Impact Of Language Differences Of Employees On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	8 (10)	1 (1.3)	5 (6.3)
2	Low task/low employee	19 (24.1)	2 (2.5)	3 (3.8)

3	Low task/high employee	18 (22.9)	0 (0.0)	1 (1.3)
4	High task/high employee	17 (21.5)	0 (0.0)	5 (6.3)

Sample Size=79
Percentage of sample=(100)

Table 4. Cross Tabulation Of Managers' Style Categories By Respondents Perception Towards The Impact Of Values And Attidudes On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	8 (10)	2 (2.5)	4 (5.1)
2	Low task/low employee	17 (22)	2 (2.5)	5 (6.3)
3	Low task/high employee	12 (15.1)	1 (1.3)	6 (7.6)
4	High task/high employee	16 (20)	4 (5.1)	2 (2.5)

Sample Size=79
Percentage of sample=(100)

Table 5. Cross Tabulation Of Managers' Style Categories By Respondents Perception Towards The Impact Of Religion On The Managerial Style.

	Managers' Style	Agree	Undecided	Disagree
1	High task/low employee	6 (7.6)	2 (2.5)	6 (7.6)
2	Low task/low employee	5 (6.3)	3 (3.8)	16 (20)
3	Low task/high employee	6 (7.6)	0 (0.0)	13 (16.6)
4	High task/high employee	7 (8.9)	2 (2.5)	13 (16.6)

Sample Size=79
Percentage of sample=(100)

Moreover, the nature of the construction industry in the Middle East regarding the composition of its work force, which is probably drawn from several cultures, and obviously shows differences in language, beliefs, values and attitudes leads one to believe that site managers should adapt their style according to the situation. Several scholars advocated this point theoretically and put emphasis on the need of managerial style adaptation or modification in the Middle East (Rabbat and Harris, 1982; Maloney, 1982; and Imbert, 1987).

The results of the contingency Tables 3 and 4 show that the majority of construction site managers, in this sample, believed that the variations in work forces, language and differences in values and attitudes should make site managers modify or adapt their managerial style according to the types of cultures being met. Moreover, most construction site managers who manage multi-cultural work force in the Middle East were unaware of their subordinates' cultural differences. These facts may offer an explanation for the non-response of site managers to adapt their managerial style in multi-cultural construction projects, preferring to continue practising their accustomed style.

In addition, the majority of site managers who had a direct involvement with a mixed-cultural work force did not receive any kind of cultural training regarding cultural differences and similarities of the work groups involved in construction projects. This can also lend support to the argument that managers did not adjust their style to the new environment as they did not receive cross-cultural training. It was also found, that there is no recognisable association between site managers' experience in the construction industry and their adapted style in the Middle East. This also suggests that site managers practice their accustomed managerial style, which has usually evolved as a result of many years of experience in the field.

In addition, the results indicate that site managers' effectiveness decreases when managing multi-cultural work groups and the productivity of such work teams also decreases lend more support to the argument that culture has an impact on the managerial style of site managers.

Indeed, based on the above discussion, it can be concluded that, there is no recognisable evidence that site managers modify their style to suit the new environment. These results are somewhat surprising considering both instinctive logic and psychological researches indicate that cultural differences should make managers modify their style because of the diversity in work-related values and customs and dissimilarity in expectations regarding managerial style. The management of heterogeneous work forces most probably requires a managerial style which is different from the managerial style demanded by culturally homogeneous work forces. Although the results of the statistical test does not give evidence of the association between the cultural diversity of the work forces and the site managers' style, it would be incongruous to ignore the cultural differences of the work forces, and their impact on managerial style.

The authors believe that construction companies operating with multi-ethnic work forces in the Middle East need to recognise and consider the cultural training as an integral part of construction management development if they are to remain competitive and successful.

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1. To what extent would you agree or disagree with each of the following statements:

1 Strongly agree

a.	I try to practice close supervision to reduce unexpected errors.	1	2	3	4	5
b.	I try to put emphasis in getting out a lot of work.	1	2	3	4	5
c.	I try to be as friendly and approachable to my subordinates as possible.	1	2	3	4	5
d.	I try to hold meetings for discussing work-force problems.	1	2	3	4	5
e.	I try to use threats and punishments to encourage good work.	1	2	3	4	5
f.	I try to insist work-force come to work exactly on time.	1	2	3	4	5
g.	I try to make my subordinates as satisfied as possible with their work.	1	2	3	4	5
h.	I try to encourage good work through my friendship with my employees.	1	2	3	4	5
i.	I try to be as fair and equal as I can in my dealings with subordinates	1	2	3	4	5
j.	I encourage subordinates to feel that they can come to me with their personal problems.	1	2	3	4	5
k.	I expect subordinates to follow instructions without a debate.	1	2	3	4	5
l	I try to keep a close eye on my subordinates work, to make sure that they understand the instruction.	1	2	3	4	5
m.	I allow subordinates to adopt work methods as they see fit, to get the job done.	1	2	3	4	5
n.	I have little tolerance of subordinates who question instructions or deviate from instructions.	1	2	3	4	5

11
Developing a knowledge based system for planning low rise house building projects

C.T.FORMOSO and P.S.BRANDON

Abstract
This research work is concerned with the development of a model of the expertise employed by construction planners for planning the production stage of low rise house building projects. A knowledge based system was developed using knowledge elicited from a panel of experts from the construction industry in the UK.

The system can be regarded as a knowledge based framework which supports the decision making process involved in planning house building projects at a tactical level. It was implemented using the knowledge based system shell Leonardo Level 3, which runs on cheap and widely available micro-computers.

This paper focuses on describing the main features of the implemented system.

KEY WORDS: Knowledge based systems, Construction Planning, House Building

1 Introduction

Construction planning is one of the knowledge intensive tasks within the construction process that is closely related to the aim of improving the effectiveness of construction projects in terms of cost, time, and quality.

Since the introduction of the first software tools for construction planning in the Sixties, computers have had relatively little impact in supporting decision making in this field. Most existing commercial CPM (Critical Path Method) based tools are completely knowledge independent, i.e. the expertise employed by construction planners for defining activities, estimating durations, establishing the amount of resources required, etc. cannot be captured and re-used in such tools (Levitt & Kunz, 1987). They are used only as electronic sketchpads where planners have to input all their decisions each time a cycle of planning is performed. Moreover, the reasoning used for making decisions is not made available to other people involved in subsequent stages of the project, for tasks such as interpreting and updating construction plans, evaluating project performance, carrying out real time control, etc. (Levitt & Kunz, 1987).

The recent development of knowledge based systems for supporting decision making in several different fields has demonstrated that knowledge engineering has a great potential for expanding human beings' capability to manipulate and utilize qualitative and experiential information.

Particularly in the field of construction planning, several authors have pointed out that knowledge based systems can have a major impact in the decision making process, by turning it into a less painstaking task, and freeing experts for the work which essentially requires human decisions (Levitt & Kunz, 1987; Hendrickson et al., 1987). In the long term, knowledge engineering has also the potential of providing the means for organizing, structuring, and refining a robust body of knowledge in this field, which has not been formally expressed yet.

2. General approach

The main objective of this research work has been to investigate the feasibility of using a knowledge based system for introducing more automation in the construction planning practice. The study has focused on modelling construction planning expertise concerned with a very specific task, in order to limit the amount of knowledge that had to be captured. The task chosen was the generation of plans for low rise house building projects.

Knowledge based systems have not proved yet to be capable of performing difficult tasks at the level of human experts, except in well structured, very narrow domains, with very clear boundaries (Brandon, 1990). Bearing in mind the current stage of this technology and the fact that construction planning involves a relatively wide domain of knowledge, the decision was made to develop a decision support system for construction planners, rather than a consultancy type of system which stands on its own.

One of the main restrictions for the development of this application was concerned with the hardware and software available. The limited amount of resources available for the research discarded the use of expensive knowledge engineering programming environments and workstations. Moreover, the development of an application on affordable widely available hardware, such as IBM-PC micro-computers, was more likely to attract the interest and the participation of the industry in this research project. The decision to use a commercial expert system shell, instead of building a system from scratch using a programming language, was made because of the limited amount of time available for devising the system.

The experts who provided expertise in this study were based in the main office of their respective companies, and were involved in planning the construction stage of house building projects at a tactical level. Their task consisted of producing a general plan of methods, which integrates the entire project. Such a plan establishes a number of key dates related to the production stage, and allows the experts to check the rates of allocation for a number of critical resources. Planning at this level is mainly used for feasibility studies, tendering purposes, as a contractual instrument, and also for monitoring the construction process in a broad basis. Site managers use general plans produced in the main office as a framework for their short term decisions.

Although some elements of CPM were found in the experts' decision making process, the planning strategy usually followed by the experts was not characterized by the bottom-up approach that is the essence of network techniques. The experts' crucial decisions were not primarily concerned with accurate duration estimates and resource allocations for individual tasks. Instead, they involved more aggregate aspects of the job, such as defining a breakdown of locations, sequencing the work through these locations, establishing the pace of work, and estimating the maximum amount of a number of key resources for the whole job. Consequently, the authors decided not to use CPM as a basic structure for developing the system, but rather to develop a heuristic model of the construction process, based on the knowledge elicited from construction planners.

3 Development of the system

3.1 Stages of work

The development of the system can be divided in three main stages: conceptual stage, model building, and model validation.

The objective of the first stage was to establish the boundaries of the knowledge to be elicited, as well as to define the role that the application could assume in the problem environment. A feasibility prototype was developed during this stage, using some expertise elicited from only one expert. A relatively simple rule based shell, named Crystal, was used for implementing the prototype.

The development of an early prototype played a key role in getting the interest of the industry in this research project, and also pointed out the requirements of this study in terms of knowledge representation.

The second phase consisted of performing a detailed elicitation of knowledge and implementing a full version of the system. Five experienced construction planners from three different companies provided expertise during this stage. The majority of the knowledge encapsulated in the system was obtained directly from experts, through informal and structured interviews. Other sources of expertise include the description of a number of past projects (i.e. construction plans, design, site report, etc.), and the literature about productivity in house building.

In the early stages of knowledge acquisition the interviews were very informal. As the main elements of the model were gradually being defined, the interviews became more structured, generally using the historical cases available as a basis for discussion.

The model validation stage consisted of performing a formal validation of the proposed model, at the end of its development. The main objective of this stage was to check whether the system had reached an acceptable level of reliability, and to identify a number of possible limitations of the model. A detailed description of the development and validation of the system is presented by Formoso (1991).

3.2 Choice of the shell

Among several micro-computer based shells available in the British market, Leonardo Level 3 was the one chosen for implementing the full system. The main reasons for this choice are discussed below:

(i) Much of the domain knowledge turned out to be essentially declarative. For instance, it was necessary to describe buildings in a hierarchical way, dividing them into a number of elements at several different levels of detail. Also, it was necessary to create a library of activities, in which each activity had to be linked to several attributes, such as duration, man-hour requirements, dependencies, link type, etc. Frame based formalisms have much more expressive power for structuring this category of knowledge than production rules. Leonardo is one of the few micro-computer based shells available in the British market that provide a hybrid knowledge representation scheme, including both frames and rules;

(ii) The development of the prototype indicated that a relatively large number of rules were needed for developing the system. In most rule based shells, as the knowledge base grows, it becomes more difficult to understand the interactions among the rules, to debug them, and to control their behaviour (Fikes & Kehler, 1985). The frame based formalism available in Leonardo provides a very efficient mechanism for organizing the knowledge base. The rules can be grouped into small, self contained rulesets, each one of them placed in a particular frame;

(iii) The basic rule language used in Leonardo is fairly readable, which makes the knowledge base relatively easy to be checked, updated, and expanded;

(iv) Construction planning requires a considerable amount of numeric calculation, which can be more efficiently performed by using conventional procedural routines. Unlike other shells, Leonardo has its own procedural language, which can be efficiently integrated to rules, without considerably affecting their clarity;

(v) Leonardo inference mechanism includes both backward and opportunistic forward chaining. This is an advantage in terms of efficiency and flexibility, if compared to shells that have only backward chaining;

(vi) There are relatively good facilities in Leonardo for developing the man-machine interface. These include standard screens, a screen designer utility, and the use of procedures for generating screens; and

(vii) Leonardo has a very competitive cost, and it does not require any expanded or extended memory.

4 Features of the system

4.1 General view

The main elements of the system are presented in Figure 1. The system is divided into three separate modules, named Input, Context, and Build. This partition was necessary in order to make the knowledge base easier to be managed, and because Leonardo had some limitations in terms of size of each individual knowledge base.

The three knowledge bases are chained together, so that after running one of the modules the user is given the choice of directly starting any of the other modules, without having to leave the system. The communication of data between the three modules is automatically executed by the system, through a number of external files, most of them configured as ASCII files.

There are also a number of external files configured as DBASE files, which store a number of small databases used by the system, such as the database of building stereotypes, and the library of output rates. Such files can be easily updated by using the database management system DBASE III Plus, which is one of the most widely used software packages of its kind in the UK.

The current version of the system is a fairly large application, if compared to other knowledge based systems developed for standard micro-computers. It contains approximately 1100 rules and 100 procedural routines.

4.2 Input module

In the Input module, the user is able to input a description of the particular project to be planned. This module encapsulates expertise on the way in which construction planners generate default information when the project description available is incomplete. This enables the system to be used during the early stages of the project, when very little information usually exists about the design and site conditions.

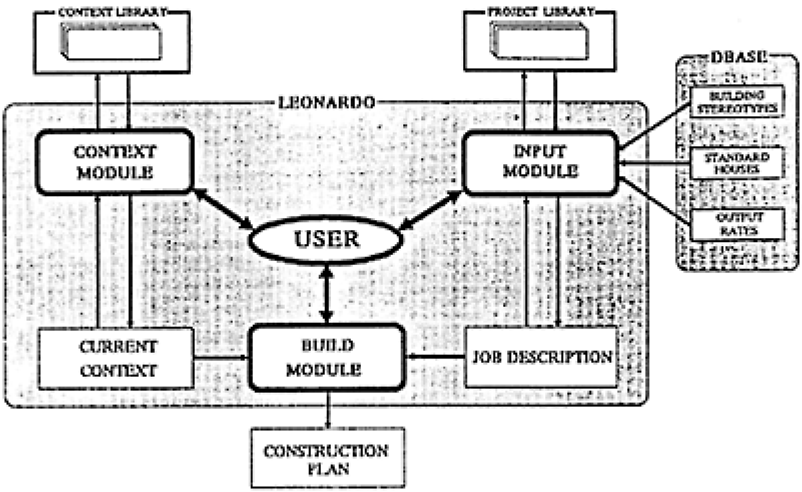

Fig.1. General view of the system

The variables used for describing house building projects in this study were grouped under five main headings, as follows:

(i) General information: includes a miscellaneous of variables related to different aspects of the job, such as contract conditions, restrictions from higher level management, availability of some critical resources;

(ii) Design parameters: comprises all the variables which describe the houses in geometric terms.

(iii) Site conditions: includes all variables related to the current state of the site chosen for the project;

(iv) Specification of components: this heading groups all the variables used for describing the specification of a number of building components that are considered to be of key importance for the construction plan; and

(v) Sequence of construction: contains a number of variables used for describing the sequence in which the houses or block of houses will be built.

This classification was created in order to organize the sequence in which the questions are asked to the user, as well as to take into account some relationships that exist between variables from the same group. From the point of view of the user, it makes much more sense if all the questions related to a particular aspect of the job are asked jointly, rather than spread over the consultation session.

The number of items that the user is required to input varies according to the size and complexity of the job, and the availability of information. It usually ranges from 20 to 200.

4.3 Context module

In the Context module, construction planning experts are given facilities for quickly altering some of the knowledge used by the system for generating construction plans. The portion of knowledge that can be modified in this module is likely to remain constant for a number of similar projects, but may vary according to changes in the environment in which house building projects are carried out, or according to the personal preference of experts.

The Context module makes the system usable for a large number of users. As some of the rules used for generating the construction plan can actually be altered in this module, its use must be restricted to expert users who are familiarized with the knowledge encapsulated in the system.

Several different context files can be created for each user of the system. The possibility of having a number of different sets of context parameters can be useful for contractors that have to carry out house building projects in different environments.

4.4 Build module

Based on the job description created in the Input module, the user can use the Build module for producing a general plan for the construction stage in a conversational fashion: the system suggests values for all the main parameters of the plan, and the user is required to confirm or overwrite them at certain key points. Some kind of explanation can usually be obtained for the suggestions made by the system.

This mode of operation aims at making the system flexible in terms of coping with different levels of expertise. The less experienced planners are likely to accept the suggestions made by the system, and learn from the explanations given. On the other hand, the more experienced users are given the option of altering the system’s propositions, if they find convenient.

In general terms, the process of producing a construction plan in this module can be divided in three phases. Firstly, the system proposes the pace of work by choosing a building rate, expressed in terms of number of houses per week, for each of the main stages of work, i.e. foundations, shell, and finishings. After that, the system breaks down the job into activities, estimates the duration of bar-chart activities, and establishes precedence relationships between them. In the final phase, the system can print or display the construction plan in different formats, and also extract the amount of key resources required in each week.

Once a construction plan is generated, the system tests it against: a number of constraints that might have been imposed by higher level management or by the client, such as maximum duration, maximum period for the first handover, or minimum handover rate. If any of these constraints is not satisfied, the system is capable of suggesting changes in the plan. Sensitivity tests can also be performed by using "what if" scenarios at the end of each session: the user can change the value of a number of key variables, such as availability of resources or imposed restrictions, and go through the the Build module again.

The programme generated by the system is not very detailed, since the system was designed to be used at a tactical level. The number of activities usually ranges from 65 to 85. Although each activity involves only one type of trade, the work breakdown does not correspond to the traditional concept of work package, i.e. an amount of work carried out by a single gang without being interrupted by any other trade: for several activities, some kind of interaction between different gangs is assumed to occur.

The majority of activities overlap with a score of preceding and succeeding items, most precedence relationships being expressed in terms of start-start link or end-end link. The time scale of the plans is expressed in terms of weeks.

Figure 2 presents a screen generated by the system which displays a section of a construction programme. While non-repetitive activities are represented by bar-charts, the repetitive ones are represented by the number of work places handed over each week. Also, there is a third type of activities, named "stretched", which are represented by a thin line. Stretched activities are those carried out by gangs, normally sub-contracted, that do not remain on site continuously: they come and leave the site several times during the project, carrying out the job only when a clear run of work is available. Such activities usually have a duration much shorter than the period available for their execution.

5 Main lessons learnt from the system implementation

The implementation of the system in Leonardo can be described as relatively successful. Its impact in the construction planning process in terms of time savings is fairly good: the user takes between 35 minutes and 2.5 hours to perform a task that can take from one to five working days, when executed manually. Besides this advantages, the system also offers a number of facilities that enable planners to extend their role in the planning task, such as performing sensitivity analysis, or quickly generating a number of alternative plans.

The main lessons learnt from the implementation of the system are outlined below:

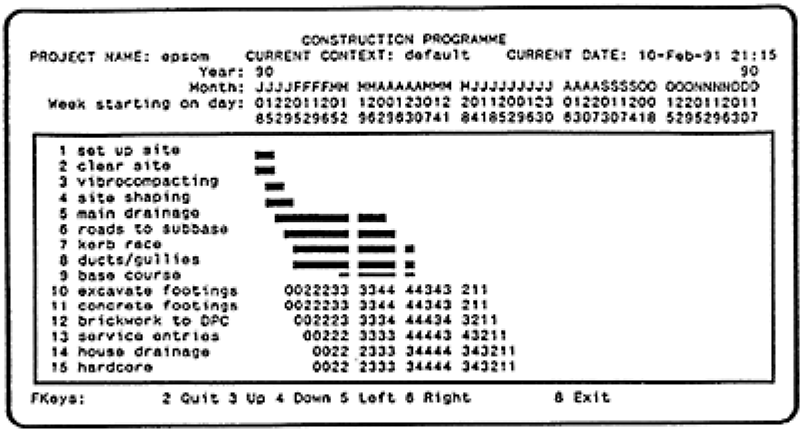

Fig. 2. Screen displaying a section of a plan

(i) Both rules and frames in Leonardo can be designed in a fairly readable way when expressing pure domain knowledge. However, as Leonardo contains no formalism for representing meta-rules, these have to be represented in the same way as rules related to domain knowledge. To some extent, this reduced of clarity in the knowledge base, as well as limited the flexibility of the inference mechanism;

(ii) The very good clarity of some sections of the knowledge base allowed early versions of the system to play an important part in the knowledge acquisition process. The experts were able to criticize some aspects of the model by checking directly frames and rules implemented in the system. To some extent, this reduced the need for keeping a very detailed paper model of the knowledge;

(iii) The default facilities available in Leonardo for enabling the user to control the interaction with the system are relatively limited. Consequently, whenever it was necessary to transfer the control over the consultation to the user, some special purpose facilities had to to be designed, by using procedures or the screen design utility. These usually implied a reduction in the explicitness of the knowledge base;

(iv) As in most other shells, the default explanation facilities provided in Leonardo are based on tracing the rules used by the system. Although these facilities are very useful during the development stage as a tool for debugging rules, they very rarely provide an acceptable explanation to the user;

(v) The development of the application has confirmed the importance of the cost of devising the man-machine interface in relation to the total cost of implementing the system, Approximately 60% of the time necessary for the implementation of the system was actually spent in developing the man-machine interface; and

(vi) The development of an early prototype played a key role in forming a panel of multiple experts, and in keeping them motivated. However, two important pitfalls related this approach were identified in this particular study. Firstly, as the early versions of the system were intensively used during the knowledge acquisition process, a considerable amount of effort had to be spent in keeping the man-machine interface attractive to the experts and the system reasonably debugged. Secondly, as the implementation of the system started when the general structure of the model had not been formed yet, several of the early upgrades of the system required fundamental alterations in the knowledge base, which were relatively time consuming.

6 Conclusions

This paper presents a summarized description of a knowledge based framework that has been devised for supporting construction planners in the decision making process involved in planning house building projects at a tactical level. The framework contains domain knowledge that can be used for generating construction programmes in a very short time, being able to cope with situations in which the information about the design, site conditions and location is incomplete.

As far as the literature in this field is concerned, this is the first knowledge based software tool specifically designed for planning repetitive, low rise, house building projects.

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12
Construction contracting/ subcontracting systems in Japan

S.FURUSAKA

Abstract
Various contracting/subcontracting systems exist in Japan such as the discretionary contracting system, the comparison system of cost estimates, the designated competitive bidding system and the design/build contracting system. The design/build contracting system is very popular in private sector construction projects. The open competitive bidding system is seldom adopted for both private sector projects and public sector projects. The construction management contracting system is not yet adopted. The subcontractors in Japan often have a very close relationship with a general contractor. This exclusive relationship has direct effects upon the case of subcontracting practice. Differences between specialist trades seem to be closely connected with subcontractor selection principles and principles for distribution of responsibility among the general contractor and each subcontractor. Subcontractual relationships are more likely to be based on negotiation between the general contractor and only one subcontractor than on competition. For reinforcement work, 70 percent of the contractors decide the subcontractor of the work first, and 65 percent of them do not adopt the comparison system of cost estimates.

Keywords: Contracting System, General Contractor, Exclusive Subcontractor, Construction Management, Subcontractor Selection, Bidding, Construction Industry

1 Introduction

Construction projects are undertaken by a multitude of firms, which are assembled for brief periods of time, then disbanded. The success of the project depends largely on whether the project team including the architect, the general contractor and subcontractors has been properly engaged and managed. The client has the freedom to arrange the project organization, while the general contractor has the freedom to define the scope of work for each work trade and to select the subcontractor based on the particulars of each project.

The purpose of this paper is to present the real state of the construction industry and contracting/subcontracting systems in japan

2 Construction industry in Japan

The construction market in Japan is extremely important, since it represents 18.5 percent of the gross national product (GNP). GNP at current prices in 1990 amounts to $321 billion (exchange rate: $1=130 Yen) and the construction investment at current prices amounts to $59 billion. Fig.1 shows GNP index and the construction investment index (Fiscal year 1981 base), and the ratio of the construction investment to GNP. The ratio changes with 15 to 20 percent in the last ten years. In Fig.1, GNP. N, GNP. R, INV. N and INV. R mean GNP at current prices, GNP at constant prices, the construction investment at current prices and the construction investment at constant prices respectively.

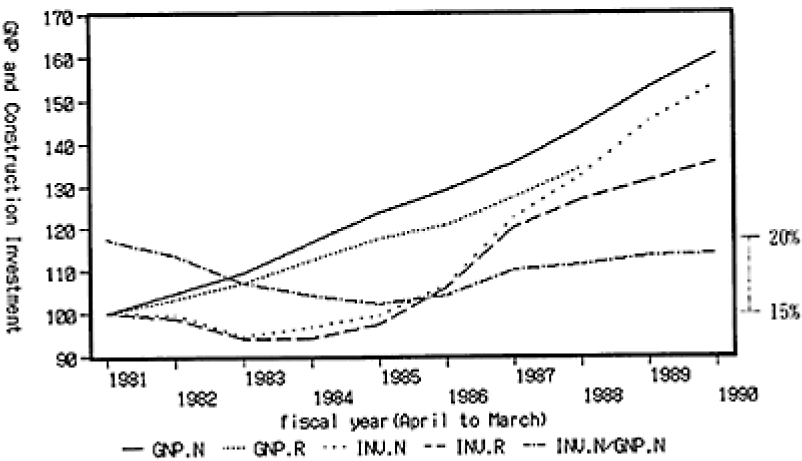

Fig.1. GNP, construction investment and ratio of construction investment to GNP (Fiscal year 1981 base)

Source: MONTHLY OF CONSTRUCTION STATISTICS

On the other hand, the construction industry in Japan is now huge, with more than 510,000 licensed construction enterprises. This includes both specialist and general contractors, and then the industry contains many small firms and a small number of large contractors. Most of the former are specialist subcontractors and local general contractors. The latter are large general contractors. The contractor who has license of civil engineering work/architecture is usually called “a general contractor”.

[FURUSAKA 1990] Most of all construction projects are carried out by these general contractors. Particularly the contracted value of projects by Top 50 general contractors is about $16.8 billion (year 1989), that is, it represents 30 percent of the construction investment. Hereinafter we use the term "Top 50 general contractors" as Top 50 general contractors of the contracted value of construction projects and use the term "Top 10 general contractors" as Top 10 general contractors of the contracted value of design/build contracting system's construction projects. Two construction companies ranked the ninth and tenth in 1989 are different ranking according to the contracted value of construction projects and building construction projects, however the ranking according to the contracted value of building construction projects makes no great difference from another ranking in practice.

3 Construction contracting system

3.1 Construction contracting system in private and public sector

Various contracting/subcontracting systems exist in Japan. In private sector construction projects, two types of contracting systems are usually adopted. One is the discretionary contracting system (DCS), the other is the comparison system of cost estimates (CSCE). Based on Ministry of Construction [MOC 1988], DCS is the system in which the commissioning company selects the firm it deems most suitable for the work on the basis of the type of construction involved and project's specific needs. CSCE is the system in which several firms that are thought to be suitable for the work are invited to present estimate, and the firm whose estimate is considered the most suitable will be selected.

In selecting the contractor, the commissioning company considers not only the contract price, but also operational ability, credit, design capacity, and such factors as convenience of communication. Therefore design/build contracting system (DBCS) is very popular in private sector construction projects.

In public sector construction projects, most of construction contracts are awarded through the designated competitive bidding (DCB). DBCS is not used in public sector construction projects. The open competitive bidding is seldom adopted for both private sector projects and public sector projects because of the advantage of being able to exclude those firms whose operational capacities are insufficient, or who might provide inferior work.

3.2 Contracted value of each contracting system

We cannot determine the value of each contracting system of construction contracts carried out by all general contractors accurately because of the lack of data. Therefore we will estimate the quantitative ratio of each contracting system. Fig. 2 shows the ratio of the 467 building construction projects finished in 1988 (MRC 1990). DCS is the most popular contracting system and the ratio is 60.8 percent. The large general contractors tend to increase DCS contracts in the last five years. Fig. 3 shows the ratio of DCS to orders received for building construction projects by each company that is one of the Top ten general contractors. Then, as above mentioned, DECS is very popular. In the same 467 building construction projects, DECS is adopted with 39.9 percent

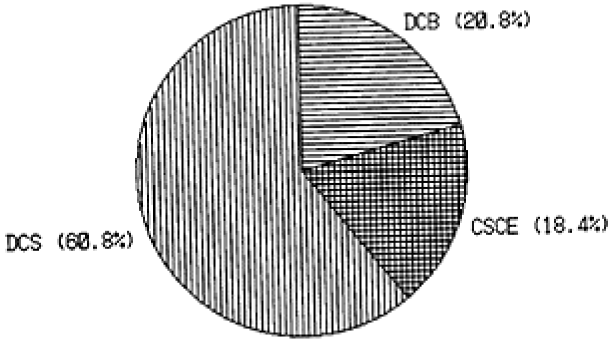

Fig. 2. Ratio of building construction projects by contracting systems

Source: MRC:88 Cost Analysis Information for Building Works

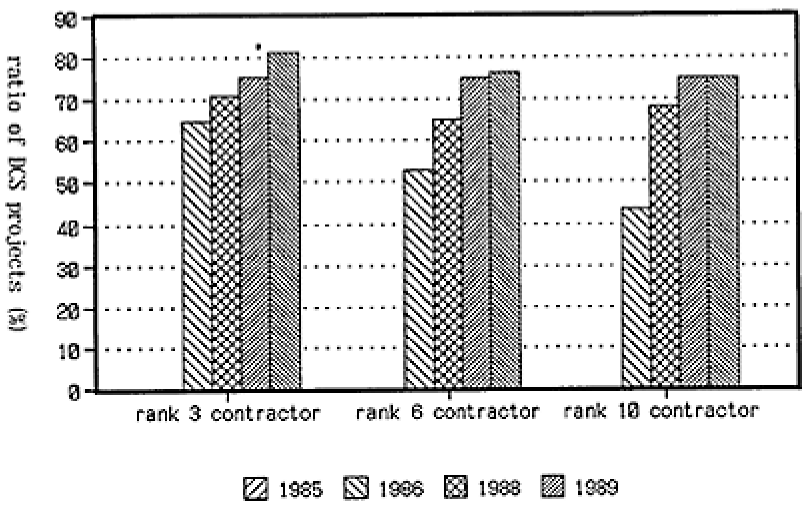

Fig. 3. Ratio of DCS by each company

Source: Financial statement 1987, 1990

Fig. 4 shows the contracted value of construction projects and only building construction projects by Top 50 general contractors, and the contracted value of building construction projects and DECS projects by Top 10 general contractors. During the past four years (1986 to 1989), the contracted value of construction projects by Top 50 general contractors has increased from $9.8 billion to $16.8 billion, the value of building construction projects by them increased from $6.2 billion to $11.8 billion, the value of building construction projects by Top 10 general contractors is from $3.8 billion to $7.2 billion and that of DECS projects by them is from $ 1.5 billion to $3.3 billion. Fig. 5 shows three kind of ratios. First one is the ratio of the contracted value of building construction projects to the contracted value of construction projects by Top 50 general contractors. Second one is the ratio of the contracted value of building construction projects by Top 10 general contractors to the contracted value of building construction projects by Top 50 general contractors. Third one is the ratio of the contracted value of DECS projects to that of building construction projects by Top 10 general contractors. During the past four years, the ratios of the first one and the third one have an increasing tendency every year. The ratio of the second one is about 60 percent every year.

Furthermore Fig. 6 shows the contracted value of building construction projects and DECS projects by each company of Top 10 general contractors in 1989. The ratio of DECS projects changes with 30 to 60 percent among Top 10 companies. In general a large company has such a tendency that DECS projects ratio become

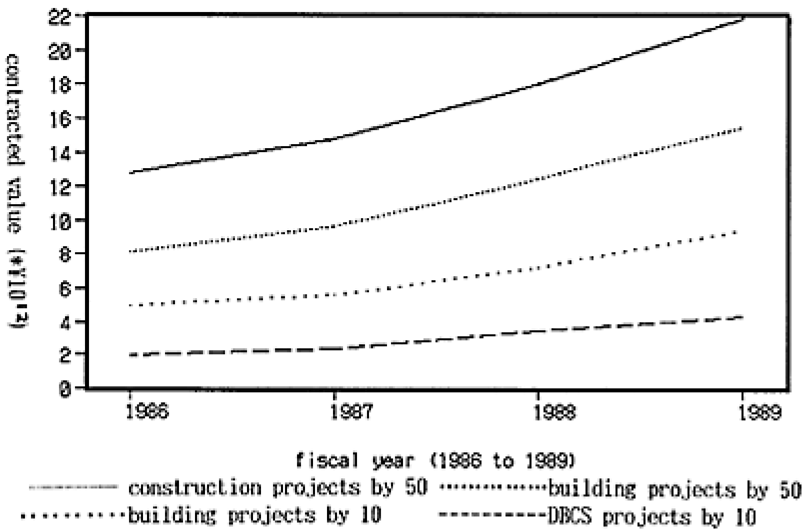

Fig. 4. Contracted value of construction projects by Top 50/10

Source: MONTHLY OF CONSTRUCTION STATISTICS
NIKKEI ARCHITECTURE 1981 to 1990

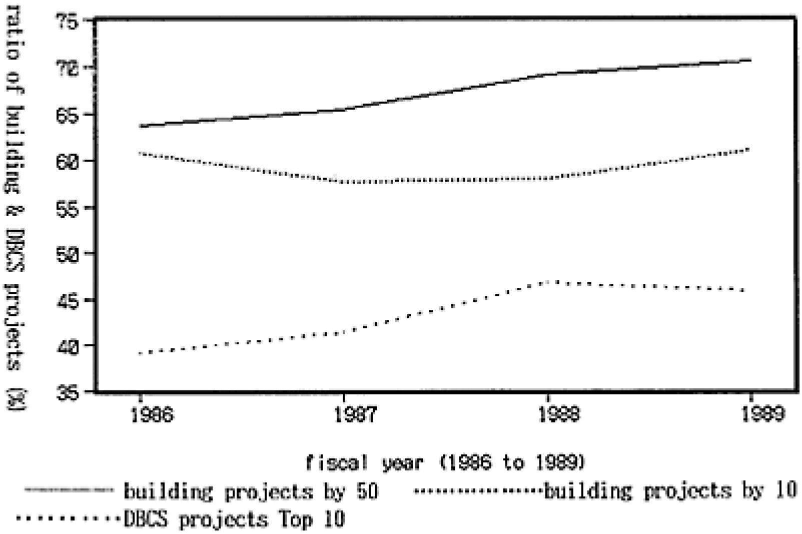

Fig. 5. Three kind of ratios of contracted value

Source: MONTHLY OF CONSTRUCTION STATISTICS NIKKEI ARCHITECTURE 1981 to 1990

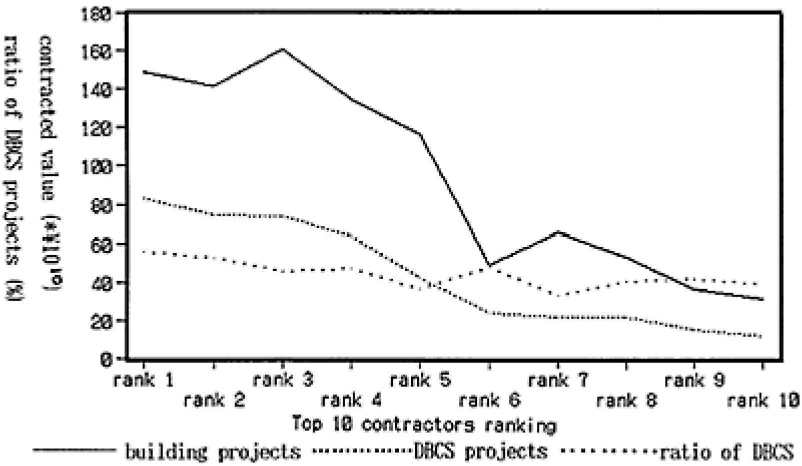

Fig. 6. Contracted value of building construction projects and DBCS projects by each company of Top 10 general contractors in 1989.

Source: NIKKEI ARCHITECTURE 1981 to 1990 higher. Fig. 7 shows the contracted value of building construction projects and DECS projects ratio by each company ranked the first (A company), sixth (B company) and tenth (C company) in the past four years. We can find the similar tendency during the past four years.

While some general contractors examine the feasibility of construction management contracting system (CMCS) in Japan, we do not yet adopt CMCS.

4 Subcontracting system

4.1 Exclusive subcontractors organization

The subcontractors in Japan often have a very close relationship with a general contractor. Many specialist subcontractors will have worked for particular general contractors over many years, and in many cases they will work only for that one general contractor. Based on this special relationship with the general contractor, they form an organization of subcontractors for each general contractor, if the general contractor has some branch offices, the specialist subcontractors form the organization for each branch of the general contractor. In this paper this organization is called “exclusive subcontractors organization”, or in Japanese “kyouryoku-kai”. Therefore this exclusive relationship has direct effects upon the case of subcontracting practice, in general, the exclusive subcontractors organization includes many trades such as scaffolding work trade, form work trade, reinforcement work trade, steel structure work trade and so on. The average number of exclusive subcontractors per

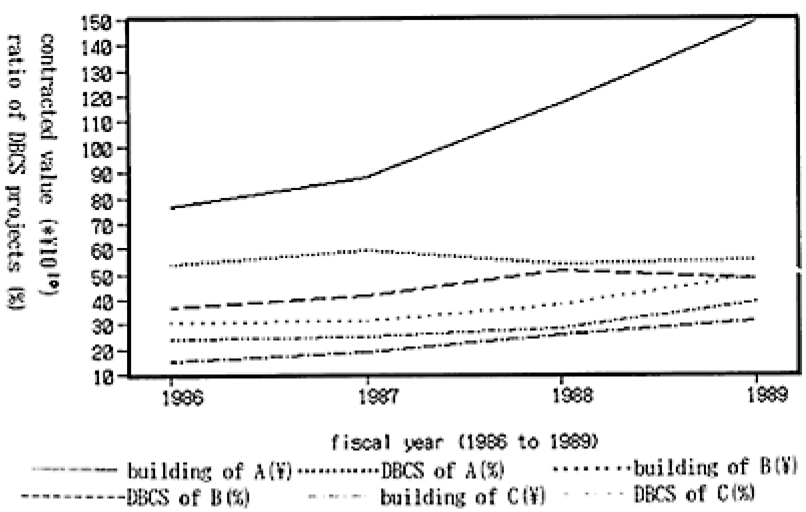

Fig. 7. Contracted value of building construction projects and DECS

projects ratio by each company in the past four years

Source: NIKKEI ARCHITECTURE 1981 to 1990

organization for any trade is about 10.

Table 1 shows the number of general contractors by the ratio of ordering work from exclusive organization. The first column is the kind of trade, and the second to fifth columns show the number of contractor's who are classified according to the ratio. Fig. 8 shows the ratio of the number of general contractors ordering work from exclusive organization. Fig. 8–1 is for scaffolding work and Fig. 8–2 to Fig. 8–4 are for form work, reinforcement work and steel structure work respectively. Let us illustrate how to see the table. In the box of trade "form work" and the ratio of received work ″60–79″, we can find a figure of 14. This figure means that there are 14 general contractors that order 60 to 79 percent of the form work from the exclusive subcontractors organization.

The following phenomena can be recognized from those figures;

(1) The percentage for the exclusive subcontractors organization of structure work trades to carry out more than 80 percent of the work value is high. For example, the ratio of the received work of the scaffolding organization is very high, namely, 81.7 percent of the contractors (58/71) ordered over 80 percent of the work from the organization. However we cannot find such a tendency on the ratio of the received work of the steel structure work organization.

(2) These differences between specialist trades seem to be closely connected with subcontractor selection principles and principles for distribution of responsibility among the general contractor and each subcontractor.

Table 1. Number of general contractors by ratio of ordering work from exclusive organization

trade	range ~39	ratio of 40–59	ordering 60–79	work 80~
scaffolding work	3	3	7	58
form work	3	6	14	48
reinforcement work	3	7	12	49
steel structure work	26	10	17	19

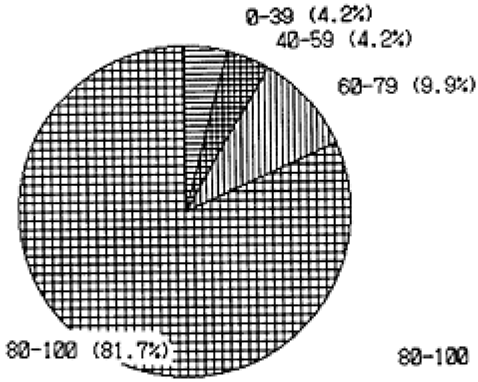

Fig. 8–1. Scaffolding work

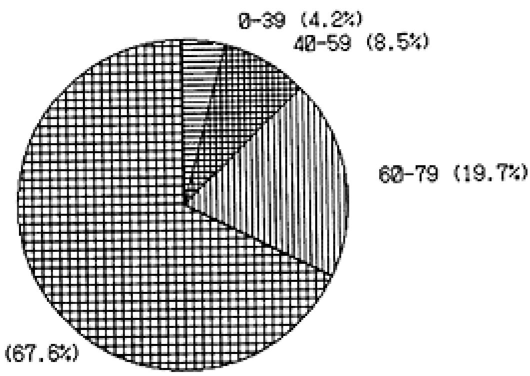

Fig. 8–2. Form work

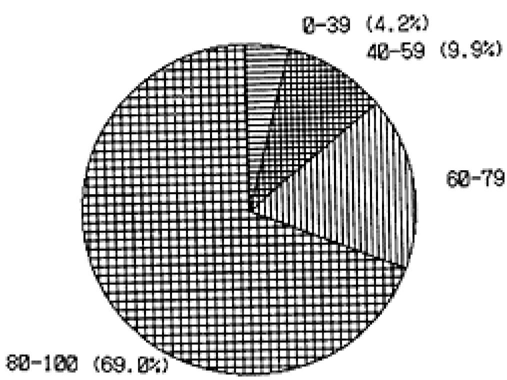

Fig. 8–3. Reinforcement work

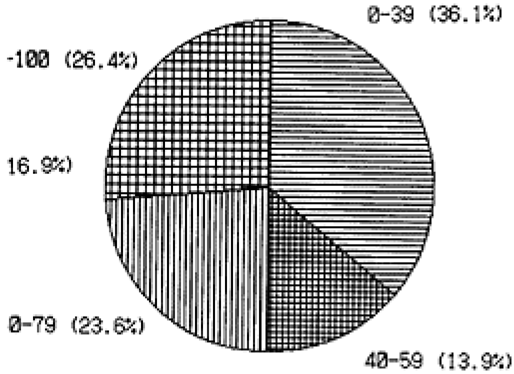

Fig. 8–4. Steel structure work [0–39] [40–59] [60–79] [80–]: ratio of ordering work from exclusive organization

Fig. 8. Ratio of number of general contractors ordering work from exclusive organization

4.2 Which decision is made first, scope of work or subcontractor selection

For three kind of structural work trades, including form work, reinforcement work and scaffolding work, the subcontractor selection is made prior to definition of the scope of work. Conversely for the steel structure work trade, definition of the scope of work is done prior to the subcontractor selection. Table 2 to Table 5 show the number of contractors by these priorities. Each column means whether the general contractor adopts CSCE, above mentioned. In subcontracting practice in Japan, CSCE is called "Aimitsumori". The second column shows "always adopt", the third column to the sixth column show "frequently adopt", "occasionally adopt", "seldom adopt" and "never adopt" respectively. For example, for reinforcement work, 70.7 percent of the contractors (58/82) decide the subcontractor of the work first, and 65.5 percent of them do not adopt CSCE. Namely, subcontractual relationships are more likely to be based on negotiation between the general contractor and only one subcontractor than on competition. Conversely, for steel structure work, 85.5 percent of the contractors (71/83) decide the scope of work first, and over 90 percent of them adopt the "Aimitsumori" system.

Table 2. Number of contractors by subcontractor selection (form work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	0	5	19	24	13	61
scope of work	3	3	11	4	1	22

total	3	8	30	28	14	83

Table 3. Number of contractors by subcontractor selection (reinforcement work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	1	4	15	27	11	58
scope of work	3	4	13	3	1	24
total	4	8	28	30	12	82

Table 4. Number of contractors by subcontractor selection (scaffolding work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	0	3	14	33	14	64
scope of work	2	6	6	4	1	19
total	2	9	20	37	15	83

Table 5. Number of contractors by subcontractor selection (steel structure work)

Aimitsumori priority	always	freq.	occas.	seldom	never	total
sub. selection	6	2	4	0	0	12
scope of work	43	21	6	1	0	71
total	49	23	10	1	0	83

4.3 Distribution of responsibility between general contractor and subcontractor

The basis responsibility required between the general contractor and the subcontractor in the subcontracts can be divided into

provide shop/working drawing
supply material/machinery
provide labor force
provide management/control

and those responsibility are different from each trade. And then the contract approach to the subcontractor can be either by bidding or negotiation. The principle of distribution of responsibility among the general contractor and each subcontractor is shown in Table 6. In general, the following phenomena can be observed:

(1) The general contractor scarcely carries out the work directly, and all the construction work is almost subcontracted. It is the subcontractors who physically carry out the work, combining labor and material into production.
(2) For the specialist trades such as reinforcement work and concrete work, the general contractor will provide material while the subcontractor will only provide labor. For material oriented trades, machinery oriented or construction method oriented specialist trades, the subcontract usually includes labor and material.

For lift machinery, electrical and mechanical installations oriented specialist subcontractors, the subcontract includes shop/working drawing, material/machinery, labor and management/control.

In general, the responsibility for management/control tends to be transferred from the general contractor to the subcontractor. Also, there is a tendency for the labor oriented subcontractors to upgrade their capacity. Therefore they tend to provide both labor and material instead of labor only. Subcontractors such as piling work and steel structure work have been upgraded and are recognized as having a higher overall capacity.

Table 6. Distribution of responsibility

	shop/working drawing	material/ machinery	labor	management/ control
g.t. work	G.C.	G.C.	Sub.	G.C.
excavation work	G.C.	Sub.	Sub.	G.C.
form work	G.C.	Sub.	Sub.	G.C.
reinforcement work	G.C./Sub.	G.C.	Sub.	G.C.
concrete work	G.C.	G.C.	Sub.	G.C.
steel structure work	Sub.	Sub.	Sub.	G.C./Sub.
finishing work	G.C.	Sub.	Sub.	G.C.
lift machinery	Sub.	Sub.	Sub.	Sub.
E/M installations	Sub.	Sub.	Sub.	Sub.

Note: G.C.=General contractor, Sub.=Subcontractor, g.t. work=general temporary work, E/M=electrical and mechanical

5 Conclusion

The Japanese construction market is open to all firms with its system in no way discriminating between foreign and domestic companies. However it is very difficult for outsiders to get a job in the Japanese contracting/subcontracting environment. Of course outsiders does not always mean foreign companies. In the case of contracting practice between the owner and the general contractor, DCS, CSCE and DECS are very popular in private sector construction projects. Furthermore in subcontracting practice between the general contractor and the subcontractor, the general contractor usually adopts DCS for selecting the structural work trades, including form work, reinforcement work and scaffolding work, while he adopts CSCE for the steel structure work and electrical and mechanical installations oriented specialist subcontractors.

On the other hand, due to such a close relationship between the subcontractor and the general contractor, the contract approach is much different from the other countries, and then the following advantage can be observed.

(1) They require no pre-qualification for the subcontractor part i c participation ion.
(2) With such a constant and long-term relationship, the subcontractor will start its work before reaching a contract agreement or confirmation of price.
(3) In most of the cases, the project manager will request from the general contractor that certain preferred personnel are located in the project,
(4) The subcontractor will work very close to and entirely under the supervision of the general contractor.

What is the suitable contracting/subcontracting system and relationship for the owner depends upon the construction industry-environment and type of project.

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13
The sequential procedure: a new productivity route in the building industry

M.GIBERT

Abstract
The sequential procedure, which appeared in the course of the ′80s, attempts to overtake both conventional site organisation founded on the breakdown of work into the various building professions and on attempts made to introduce Taylorization into the building industry, attempts which have failed due to the specific character of on-site work.

Based on the concept of a sequence, defined as a regrouping of tasks referring to functions fulfilled for the building to be erected, the sequential procedure enables productivity gains by minimising non-productive periods.

It constitutes an evolutional element in the relations which exist between economic agents in the concatenation, and can lead to a change in the industrial organisation of building industry enterprises.

Keywords: Sequence, Productivity, Site-organisation, Polyfunctionality.

1 Introduction

In the early ′80s, economic reflections on the determining factors in favour of productivity in the building industry sector were seen to lead to a double statement of failure.

In the first instance, the failure of the Taylorian and Fordian principles had at the time become obvious. The specific nature of work performed on site and the high level of diversity in demand in point of fact stand radically against the principles involving task repetitivity and labour specialisation, against that of a clearly defined division between manual labour and intellectual work, and also against the principle involved in the bulk production of standardised products.

It then became evident that site organisation, founded on the breaking down of work into the various building industry professions and traditional crafts, in the ultimate analysis represents a significant obstacle against any improvement in the level of productivity. Certainly, the professional craftsman can build up a productivity factor due to his capacities both in anticipation and in the mastering of incidents which occur in large numbers on the site. For that matter, the upholding of an extended separation in the field of labour leads to a multiplication in non-productive periods, which relate to time wasted by professionals when they wait for each other and to time lost in the course of numerous travels completed by workers between the head office of the enterprise and the site. Globally speaking, it is apparent that the survival of the traditional crafts involved callts down more drawbacks than advantages in the field of productivity.

It is this double statement of failure which is at the origin of reflections undertaken relative to the sequential procedure, which appeared (especially in France) in the course of the '80s. Initially concentrating exclusively on the field of site organisation, it gradually extended to the Building Industry's production process as a whole, and thus especially to the design phase.

2 The initial reflections

In its original principle, the sequential procedure attempts to design the site in the form of successive realizations of autonomous sequences. The fundamental object, in the field of productivity, is to create a working environment in a manner which enables each enterprise to work without interruptions, and without limitations in simultaneity with respect to one or several other enterprises. The sequence is defined in terms of the regrouping of tasks referring to the functions fulfilled by the building industry, and no longer in terms of traditional techniques and professions. It is in this manner, for instance, that a so-called "walled and roofed" sequence is defined, without explicitly referring to the techniques and crafts involved in masonry, in woodwork and roofwork, and in external joinery.

The regrouping of such tasks into the different sequences is completed with respect to the following criteria:

> Functional unity of place (structures, partitions…) and space related (lodging, staircase…), Unity in time, the tasks in a sequence must be realized with a sufficient level of synchronisation for the sequence to be completed and accepted without reservation within a period of time which is compatible with the global site agenda, Unity of means, the tasks are organized more around the working methods (mounting, assembly, bonding…) than around a technique.

The creative Utopia seen in the initial stages of the sequential procedure leads to organizing the site around three sequences: walled and roofed, technical equipment and finishing tasks. An attempt was made in this manner to find an intelligent compromise between an ideal form of total polyvalence and the reality of individual and collective know-how.

> But the realization of the initial experimental sites pointed to a certain number of difficulties:
>
> Few indeed are the enterprises with the capacity to realize a complete sequence. Due to this fact, a perversion in the procedure has been observed, which consists either in sub-contracting the tasks which the

enterprise in charge of the sequence cannot realize to various speciality operators, or to import the various required professional competencies into the midst of the enterprise holding the prime contract. In these two cases, the effect expected from the procedure on the productivity level is markedly reduced, or even cancelled;

In the few cases where the enterprise attempts to obtain the real versatility which is essential to the realization of a complete sequence, the method generally applied consists in referring to the massive use of products and components acquired from the industry and installed by the enterprise's work force. A double drawback results: on the one hand a relative inadequacy on the part of the industrial products and components manufactured in large batches for constantly singular sites; on the other hand a strong reluctance on the part of the work force to relinquish a professional qualification in favour of a layer/ fitter profile which is considered to amount to a source of devalorisation.

That is why a second stage in the sequential procedure has appeared over the last two or three years.

3 A new stage

This new stage again concerns the organisation of the site proper but, contrarywise to the initial experiments, it extends the scope of the reflection to the complete building production process.

As this involves a site, we observe an increase in the number of sequences and an adaptation of the quantity and content of the sequences to the nature of each site.

Inserting this procedure into the fabric of the enterprises concerned has called down two particularly beneficial effects. In the first instance, the required conversion in the enterprise's competency is easier to obtain. For instance, a masonry enterprise will no longer be entrusted with the whole so-called "walled and roofed" sequence, but only with the integration of electrical and plumbing components in the concrete. A certain trend will then be seen in the modification of the limits of traditional crafts, the most charateristic example being that of the enterprise entrusted with the laying of the gypsum boards which henceforth extends its intervention to the laying of indoor woodwork and to the integration of electrical cables within the partitions. Starting at that point, the profile of the multipurpose layer/fitter becomes unclear, and thus leads to a new type of professional craftsman with a form of competency which refers to a traditional craft, with an added level of laying know-how which is contiguous to this profession. The result is a higher rate of acceptancy in favor of this procedure for building industry labourers.

The second major evolution contributed by the sequential procedure consists in no longer inserting reflection only into the sole process of on-site work, but to extend it to the production process as a whole.

Quite particularly, one has become conscious that the increase in the level of productivity related to the reduction in the number and complexity of interfaces between crafts could not be fully effective unless the concern for productivity was taken into account as of the stage of architectural and technical design. It has thus become apparent that cooperation between the architect and the technical design offices on the one hand and the shell construction enterprises and technical second tier enterprises on the other hand could enable the safeguarding of both the architectural principle and the productivity requirements.

In a concrete manner, this cooperation enables the elaboration of design related solutions which minimise the interfaces between the different crafts and the scheduling of adapted products and components (especially by manufacturing these in the workshops of the enterprises concerned). Under these conditions one ends up with a site which is divided into sequences no longer in an artificial manner but in a manner coherent with the reality both of the site and of the enterprises in charge of the construction.

And, in the end effect, the pivotal phase between the design of the project and the site is also stressed, that is to say the phase during which the realisation is designed, which is also referred to as the site preparation phase. In particular, the definition of a work schedule which is both strict and acceptable to all the enterprises and a reflection on the harmonization of the work rhythms in the different realization teams is assuredly a sign of increased productivity, inasmuch as a strengthened control of the site quite naturally guarantees the observance of engagements undertaken in the course of the realisation phase.

4 Conclusion

In the final effect, the sequential procedure has enabled the notion of the function to be taken into account rather than that of technology, a fundamental substitution on the productivity level, as it is enables a reconsideration of the traditional organisation of the building industry crafts which led to slowing the increase in the level of productivity without for that matter imitating a Taylorian organisation of day-to-day work which is inadequate for the building sector and, for that matter, equally challenged in the other sectors of the industry.

If the initial expectations, based on the extended polyvalent capacity of men and enterprises have not been totally borne out in fact, a new definition is however appearing for the roles of the different actors in the production process, which bears the capacity to increase productivity levels.

As we are referring here to the industrial organisation of enterprises in the building industry, an appreciable evolution is seen in the paradigm founded on the general enterprise in charge of realizing the shell construction and simple coordination between second tier enterprises who are limited in the strict execution of work referring to their speciality. This evolution can, on a medium-term basis, lead to a new industrial organization founded on three major classes of enterprises. The first concerns the general enterprise which sees its role considerably strengthened up-stream of the realization phase, and contributes an effective participation to the project design stages, and also down-stream with the transition from a simple form of work coordination to a real form of control over all the professions involved. The second class relates to second tier technical enterprises, and/or having the capacity for workshop prefabrication. The role of these enterprises at the project design stage appears to be especially strengthened by the sequential procedure. Finally, the third class includes the non-technical second tier enterprises. It is no doubt amongst these enterprises that the clearest format for evolution towards a polyvalent form of task execution is to be sought, and this is the format upon which the sequential procedure was initially founded.

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14
Broadgate—a case study in the application of organisation design for professional construction management

C.GRAY

Abstract
The Broadgate project in the City of London is probably one of the most significant applications of professional construction management in the UK to date. To achieve the necessary levels of co-operation between trade contractors and designers much more responsibility was placed onto the trade contractors and it wasn't until the analysis of their organisational requirements was complete that an understanding of the underlying problems was possible. A technique for organisational analysis normally used within the management structures of single enterprises was developed and used for analysis of the multi organisation structure of a construction project. The primary responsibility of the trade contractors is revealed as is their central position between the design team and the construction manager.

Keywords: Construction Management, Organisation Design, Levels of Discretion

1 Introduction

1.1 Description of the project

The Broadgate project is a major commercial development of over 500 000 square metres of office space built to shell and core standards which is either left to the tenants to fit out or is finished to a basic specification. The space is divided into 14 separate buildings which have been constructed over the period 1986 to 1991. At the peak 6 buildings were being constructed simultaneously. The client, Rosehaugh Stanhope Developments PLC (RSD), has taken direct control of the construction of the project by using professional construction management and it is the development of the management structure of the project that is considered here.

1.2 Speed of construction

For commercial reasons the buildings have been built very quickly (see figure 1). Speed of construction is shown as rate per week, which is the gross floor area divided by the overall number of weeks to build. By comparison with normal UK practice the rate of construction is significantly quicker. To achieve such speed of construction has meant significant change in three major areas: the construction technology with the extensive use of pre-assembled units, site operation organisation through strict work area control and a simplified management structure.

1.3 Management philosophy

The basic thrust of the management approach has been to harness the skills and knowledge of the specialist trade contractors by placing total production responsibility into their control. This is unconventional in UK practice where for instance site management is normally undertaken in detail by the contractor in close collaboration with the sub-contractor. This is changing, but it was not quick enough for the Broadgate project which, in order to achieve the speed of construction, attempted to utilise the design and production knowledge of the specialists and thus there was the need for a new form of site organisation which would allow the trade contractors the freedom they needed, but at the same time work within the many conventions of UK practice.

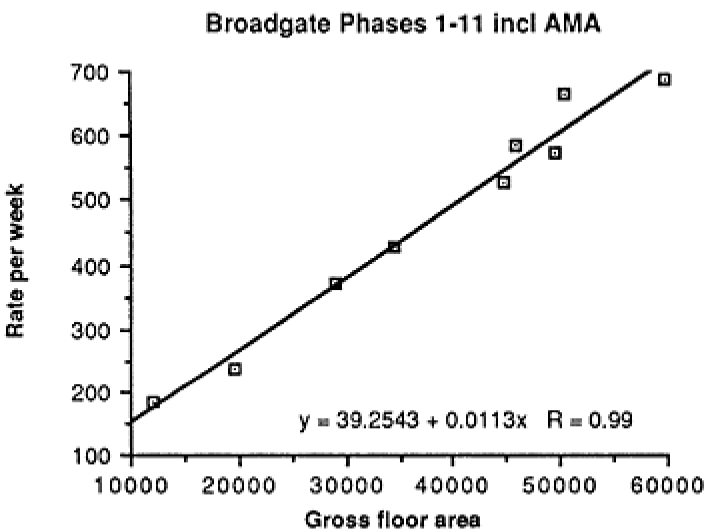

Figure 1 The speed of construction of Broadgate relative to conventional UK performance

In the early days of the first two phases of the project there was considerable conflict between the traditional views of the site management and the trade contractors and the more dynamic approach of RSD. The client had set the principles in the contract agreements, but there was a big barrier to the immediate and full implementation of the approach which was thought to be due to the inflexible attitude of the site personnel of the trade contractor and construction manager. In fact there were more fundamental issues in that the organisational structure had not been designed for the new requirements.

In order to understand the issues more fully an analysis of the existing organisation was undertaken and then a new organisation hypothesised which was then implemented and improved on the later phases of the project.

2 Levels of discretion

The technique of analysis that was used was that of stratified systems theory (Stamp, 1986). There are six levels of decision making, within the hierarchy of production management, that are of importance in this particular context. From level 1 to level 6 the timespan of the work (that is the period between making a decision and seeing the practical results) gets greater and the decisions become more complex. The key personal skill which differentiates between the levels is the ability of the individual to abstract and conceptualise the type of work in his own and lower levels.

Level 1 *Direct operating tasks* which involve working directly on physical objects or serving people, one unit at a time. The work is anchored in the rule which means that the worker is only concerned with his task and does not recognise any of the aspects which control his task or activity.

Level 2 *Direct operating—method* which involves supervisory workers putting together a number of tasks and choosing methods for tasks appropriate to a given situation. The worker has his discretion limited by the framework of rules which control the tasks.

Level 3 *Alternative operating systems* which involve the general management activity of comparing and contrasting alternative operating systems and ensuring that these operating systems have the resources that they require. This requires an ability to understand the rule framework which controls the tasks and create new working patterns by reapplying the basic rule structure to the new task.

Level 4 *Direct operating—systems* which involves the management of a unit moulding operating tasks and operating methods into a system of direct work and making adjustments to the system that changing trends require. Here the rule structure is questioned to seek ways in which it can be developed or extended.

Level 5 *Complex systems* which involve the comprehensive management of operating systems which may require the modification of the context within which other levels operate. At this level the rules and the rule structure are created in response to the analysis of the situation. There is also the recognition that there are many possibilities and that the rules are open ended.

Level 6 *Direct deployment of complex systems* which involve interpreting the overall strategy into operational plans for total business units. This level is outside of the rule framework and is the one that questions and sets the new rule framework.

This is more clearly expressed by looking at the levels which occur in a project organisation:

Level 1 Direct construction work which requires appropriate assembly knowledge and skills but involves no management responsibility.

Level 2 First line management or a foreman of a team of construction workers. The foreman manages the task allocated to his team.

Level 3 Site management which involves selecting methods of working for several construction teams and ensuring that they have the resources they require to complete the tasks.

Level 4 Construction management which involves managing the site organisation including selecting the methods of work and adjusting them as circumstances require.

Level 5 Project director which requires the comprehensive management of all parts which together form the large scale construction project, including shaping their operating environment and creating the policies and systems they will use.

Level 6 Managing director who initiates the creation of the total business represented by the project.

In designing an organisation all of these levels must be present within the authority and control system. They must also be aligned so that authority and responsibilities are clear and unambiguous although each higher managerial level is capable of handling increasing levels of ambiguity. The formal relationships must also not inhibit the authority and responsibilities between the levels. However when this is applied to a multi organisation and multi function structure such as at Broadgate then a rethink of the traditional relationships is required. This is best explained in terms of: the conventional industry approach, the organisation initially developed for Broadgate and then the developed approach which was required to fulfil the simplicity of the RSD philosophy.

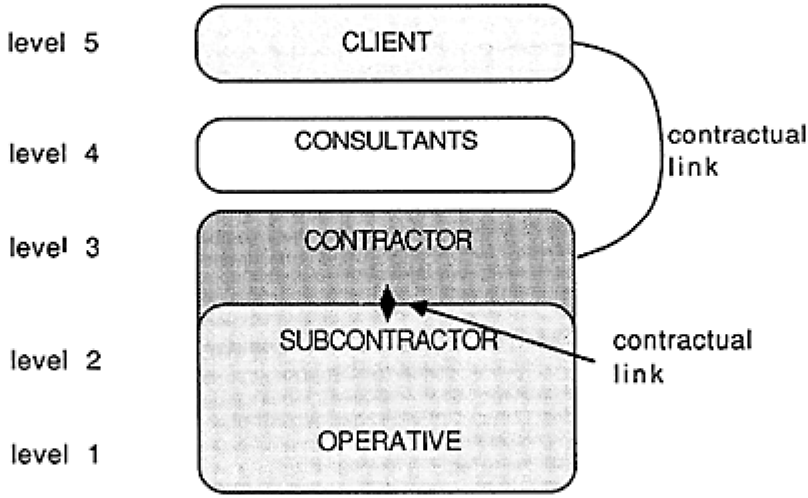

Figure 2 Levels of organisation within a conventional contractual relationship

3 The conventional contract relationship

The general contractor's management, as shown in Figure 2, by working at level 3 manages the subcontractors on a daily basis. The direct contractual link between the client and the contractor is between levels 5 and 3, with level 4, the establishment of the rule structure for the project, being undertaken by the design consultants. The effect of the consultants operating at level 4 is that they set the rules but have no direct responsibility or authority for the outcome. In this way the continuity of responsibility is broken by the role of the design consultants at level 4, which is one of the fundamental problems of the UK construction industry. To try to solve this fundamental problem the traditional approach has been to develop complex and legalistic procedures which stifles initiative and progress.

4 The initial Broadgate management structure

The initial Broadgate management structure was a transition between the complexity and confusion of the traditional approaches and the inherent simplicity of the construction management approach. Two key changes emerge: the removal of the design consultants from within the client/ contractor relationship and thus from the line of responsibility for production, and increased demands on the trade contractors.

The essential feature of the Broadgate model (Figure 3) is that there are four primary parallel organisations: RSD, the Construction Manager, the Trade Contractors and the Designers, each of which should provide a continuous sequence of levels within their organisation. It is also essential to get compatibility of capability across the levels. This caused considerable difficulty by placing new demands on the trade contractors, managers and designers. In many cases these demands were met by apparently demoting senior managers to perform site management tasks, due to the increased scope of the management tasks at the particular level.

The trade contractors were being required to operate at both level 5 and 3, which would normally be done by the architect and contractor respectively. The trade contractors were, therefore, under considerable pressure to develop their managerial capability. Additionally as shown by the authority arrows the site manager is the focus of the production and design authority hierarchies.

To assist the trade contractors to cope with this situation two roles were introduced by the construction manager: the assistant site superintendent and the project manager whose jobs were essentially that of guiding and ensuring that the trade contractors fully understood and complied with their responsibilities of on site and off site management. However, the roles did not have the power of direct line authority and were ambiguous individually and between themselves. Because of the ambiguity the personality of the individual had a powerful effect on the way the role was interpreted and so there were many different interpretations of the roles evident on site and some inevitable confusion.

5 The developed construction management structure

Two further crucial changes were needed to maximise the potential capabilities of the RSD philosophy (Figure 3). The fundamental shift was to complete the integration of the production management role into RSD so that only one apparent contractual relationship; that between RSD and the trade contractors, was perceived by everyone. This gave rise to a new set of roles and relationships.

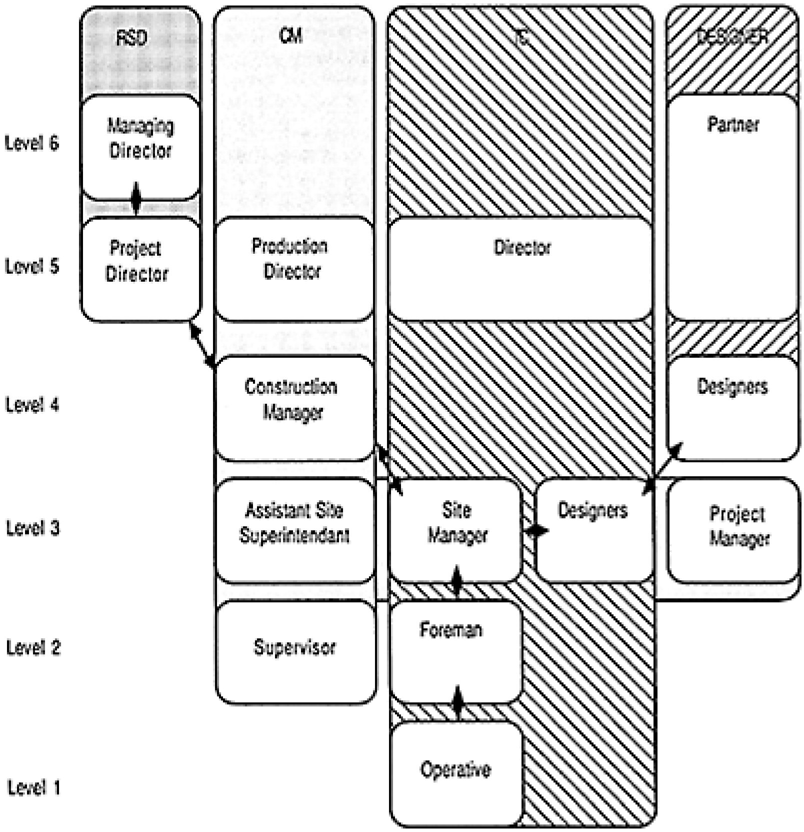

Figure 3: The initial Broadgate management structure

5.1 The Relationship Between RSD and the Construction Management contractor

The construction management approach required that a completely integrated relationship between RSD and their production management team was clearly established. Within their particular form of construction procurement RSD were acting as the client and contractor (in the conventional sense of coordinator of work) for each project. However, because of the size of each project, RSD's own skills needed to be supplemented by high calibre construction skills of an operational and administrative nature. RSD set the objectives, defined the tasks and established the visionary leadership for the project. The Construction Manager was, in effect, a specialist contractor supplying operational management skills.

The Construction Manager's team who were predominantly drawn from people with traditional or management contracting backgrounds consequently had to subjugate their traditional role and effectively became part of the RSD organisation. A simple change of the adoption of the site name—Broadgate in a high profile to the exclusion of any other contractor name boards had the effect of establishing the correct relationship between the client and the trade contractors.

5.2 The relationship with the specialist contractors

The assistant site superintendent and project manager role was phased out (Figure 4) as the trade contractor's management increased in competence so resolving the ambiguity over who should direct the site teams. This was the clear responsibility of the trade contractors. Some trade contractors had already appointed project managers, but their capabilities needed to be enhanced by training in their role to the right level, so that they could fully take over the integration of the off site and on site tasks.

5.3 The relationship with the design team

There were two important issues concerning the management of design; content and schedule. For content there were two providers; the design team and the specialist trade contractors, but for schedule there are three separate sets of needs to be met; the design team's needs, the specialist contractor's needs and the construction site needs. A key feature of this project was that the input to the design by the trade contractor was recognised as forming a larger part of the design than on other, more conventional, projects. The trade contractors were also expected to co-ordinate their design amongst themselves as well as obtain all approvals.

The trade contractor's project manager had to act as the coordinator between the demands of the site and those of the designer. By upgrading the skill and competence at this level the project manager was more effective in performing the trade-off between design and production.

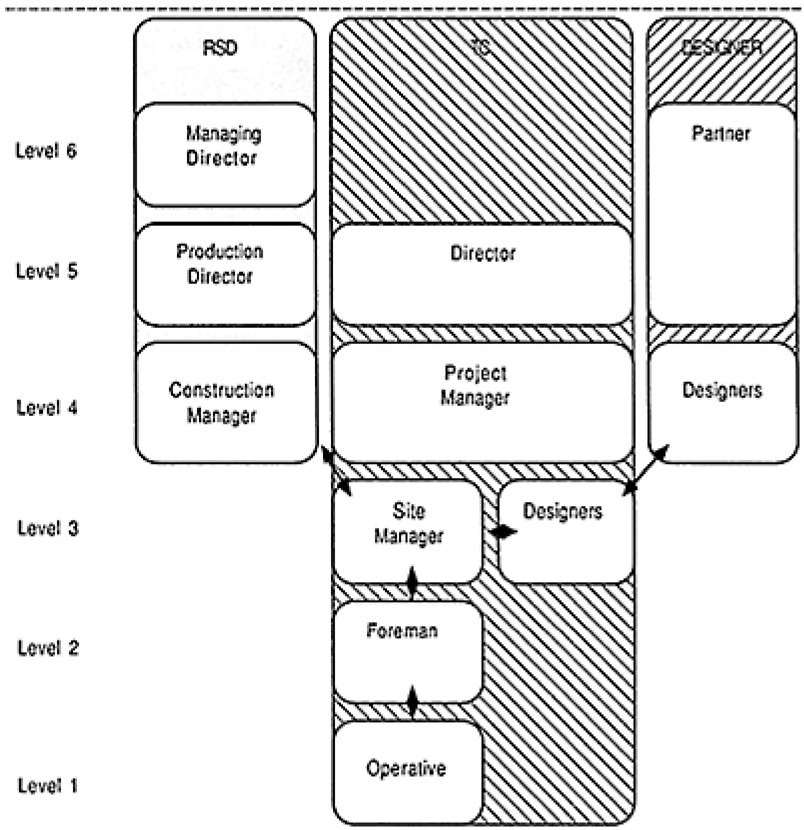

Figure 4: The developed production management organisation

6 Conclusion

It is clear that in order to achieve the speed of construction required by clients such as RSD the whole project organisation must be focused onto the production process. The development of the management structure that has been described arose from conditions off expediency. Eventually a clear and unambiguous management structure was achieved which considered not just the site organisation, but the organisation of the trade contractors and designers.

contractors and designers.

The organisational structure of every participating company must be structured in a way which achieves a clear hierarchy of decision making and when in combination with other organisations achieves a harmony laterally. Where gaps exist then problems of communication and understanding arise and there are ambiguities in the authority structure. Normally these are resolved over time, but where time is not available then organisational design assumes great importance. The traditional hierarchial representation of organisational structures does not represent the types of skill nor the responsibility level that is actually required to achieve the necessary decisions. The charting approach in this paper has pointed to the deficiencies in the traditional methods and offers a new approach to the difficult problem of organisational design.

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15
The cost/time/quality integrated bidding system—an innovation in contract administration

Z.HERDSMAN and R.D.ELLIS

Abstract
The vast majority of construction contracts are procured using the low bid system. In the low bid system, price is the sole basis for determining the successful bidder. This traditional approach has certain drawbacks. In recent years, several innovative modifications to the low bid system have been tried. This paper presents the results of these trials and proposes a more comprehensive approach to bid award criteria. A presentation of a multi-parameter bidding system is made. The multi-parameter bid award system would include various owner-selected parameters such as cost, time and quality. Quantification of these parameters and bidder evaluation methodology is included. Finally, a discussion of the advantages and disadvantages of a multi-parameter bid award criteria system is also presented.

Keywords: Bidding, Time, Cost, Quality, Innovation, Contract Administration.

1 Introduction

In recent years, we witnessed a trend towards looking for new innovations in contract administration. This phenomena was caused by a long list of failures in past projects, especially in the public sector. The major disappointments in project performance were: extensive delays in the planned schedule, cost overruns, very serious problems in quality and an increased number of claims and litigation. A common opinion is that the consumer (the public) does not get the best product for his money.

In order to change this situation, many public (and private) agencies are trying to find new methods to improve the current procedures. The authors (Ellis and Herbsman, 1990) and other researchers (Bower, 1989; Harp, 1990) are convinced that one of the major factors behind those failures is the current bidding system used in the public sector. In order to analyze why this system creates so many problems, one has to understand the historical background of the development of this system which is commonly known as competitive bidding or the lowest bidder award system.

2 Competitive Bidding—An Overview

The competitive bidding concept is rooted very deeply in the American tradition. Harp (1988) shows that competitive bidding has been in practice in New York state since 1847. The principal statutes for highway and bridges contracting in New York state date back to 1898 legislation, which required competitive bidding.

The basic idea behind this concept was that the lower bidder system protected the public from extravagance, corruption, and other improper practice by public officials. The original function of the competitive bidding requirement was to assure that the public received the full benefit of America's free enterprise system by providing public construction at the lowest price offered by competitive bidding (Cohen, 1961; Netherton, 1959).

Over the years, a few modifications to the initial concept occurred. The terms "responsible bidder" and "public interest" have been added to the statutes which control the authority to let and award public works contracts. Other modifications created the concept of prequalified bidder lists and so on. However, the original concept from the 19th Century remains intact. It is very important to understand that not every country around the globe is using this concept in the public works sector. Many nations are using non lower bidder systems.

2.1 Non lower bidder systems

A few countries, such as Italy and Portugal in Europe and Peru in South America, are using a system in which the successful bidder is not the lowest one. The philosophy behind this concept is that the "best bid" is the most reasonable one, not the highest, not the lowest but the one closest to some average. There are many variations of this concept. The Peruvian government bidding system provides an example of one such variation (Henriod and Lanteran, 1988). The procedures are as follows:

1. When three or more bids have been received:
   (a) the average of all bids and the Base Budget will be calculated.
   (b) All bids which lie 10% above and below this average will be eliminated.
   (c) The average of the remaining bids and the Base Budget will then be calculated.
   (d) The contract will be awarded to the bidder whose bid is immediately below the second average or, should none of the bids lie below the second average, the award will be made to the bid which more closely approximates the average.
2. If less than three bids are received, the bidding agency may cancel the process and award the contract to the lowest bidder or to the only bidder if this were the case.

Another similar practice is that of "bracketing," i.e., considering only those bids which lie within a certain range above and below the engineer's estimate. In this system, the lowest responsive bid within the range gets the award.

Some countries such as France or Portugal (World Bank, 1988) try to disqualify what they call "abnormally" low bids. They define abnormal as "any bid whose price appears abnormally low and consequently may cause implementation problems."

The authors analyzed these systems and came to the conclusion that even though these methods have their merits, they would not be generally accepted in the United States because of 150 years of a traditional competitive bidding system.

2.2 Advantages and disadvantages of the competitive bidding concept

The competitive bidder system has one major advantage. It assumes that the bidding process will be independent from any sort of pressure (political, social, economic). Its objectivity is assured because price is the sole criteria for evaluating bids. For many participants in the construction industry, this reason alone makes it all worth the disadvantages related to this practice. However, the disadvantages are numerous. The major one is that the selection process is based only on one element-cost, and other elements such as quality and time are not accounted for. Many other problems have occurred during the last 150 years: unreasonably low bids, bid rigging, unqualified contractors and so on. To compensate for these handicaps, a few adjustments have been made during the years such as qualification lists, deleting "abnormal" low bids, etc., but many construction participants agree that these are temporary solutions and a major change is needed.

The competitive bidding system is very deeply rooted in the American free enterprise tradition. The authors and others are convinced that a total change from the lower bidder system would not be feasible in the short range and would be even more difficult to sustain in the long range. Only a major modification which would remain in the form of the competitive bidding concept would be accepted.

3 The Multi-Parameter Bidding System

The proposed system is based on the idea that the selection process of the contractor will be based on more parameters than just cost. The successful bidder will be selected according to the lower combined bidding value. Most logically, this number will be represented by a dollar value but it can be represented using points, percentages, etc.

The major parameters will be:

Cost—C
Time—T
Quality—Q

Secondary parameters can also be incorporated into the system such as:

Safety—S

Durability—D
Security—S
Maintenance—M
and a few more.

The number of parameters and their related weights will be chosen by the sponsor. Let us demonstrate this concept with an example. The public agency decides to use four (4) parameters. These parameters and their assigned weights are given in Table 1.

Table 1. Parameter List

Number	Parameter	Weight
1	Cost	70%
2	Time	15%
3	Quality	12%
4	Safety	3%

The successful bidder will be the one that has the lowest combined bidding value of the four parameters.

The multi-parameter bidding system remains within the framework of the competitive bidding concept. A few legal experts have stated that as long as the parameters, their system of measurements and their relativity weights are specified in the bid documents, this concept complies with the existing legal status of the current competitive bidding system.

3.1 Quantification of the parameters

The quantification of the parameters is the major problem in developing the multi-parameter concept. There is no clear-cut answer as to which is the best method and many variations can be developed. When additional research has been done, better and more accurate techniques will be established. The following pages describe a few of the options for some of the parameters.

3.2 Cost

Cost refers to the bid price submitted by the bidder. As in the traditional low bid system, cost will be measured in dollars.

3.3 Time

The authors have done extensive research related to this parameter (Herbs-man, 1988) and conclude that there is a very easy, systematic way that can be used. The time element can be quantified using a time value. The owner would establish the value of the time and the contractor would bid a performance time. For example, if the contractor bid 250 calendar days and each day is valued at $10,000, the time value will be 250×$10,000=$2,500,000 and this figure would be added to the cost value. If the owner chooses only two parameters to bid, then it becomes a cost/time bidding system. The cost/ time system has been tested in a few states and the authors have gathered data on 16 projects that were bid using this cost/time concept. This can be demonstrated using a real example from a project in Mississippi. The time value was established by the owner as $7,000/day. The bid tabulation is given in Table 2.

Table 2. Results of Bid Tabulation Using the Cost/Time Concept

Bidder No.	Bid Cost Base	Days Bid	Time Value	Total Amount
1	$15,636,180.56	450	$2,250,000.00	$17,886,180.56*
2	$16,070,558.46	426	$2,130,000.00	$18,200,558.46
3	$15,628,815.06	523	$2,615,000.00	$18,243,815.06
4	$16,231,527.80	646	$3,230,000.00	$19,461,527.80
5	$15,835,768.22	780	$3,900,000.00	$19,735,768.22

*the lowest combined bidder

The time value is established by the owner. There are many ways to figure the value. For example, in highway construction it is done routinely by transportation economists. Fig. 1 is an example from a project in Kentucky where the value was calculated as $5,400/day.

The authors researched the results of bids conducted by seven state transportation agencies using the cost/time bidding system. (Ellis and Herbsman, 1990). A total of fourteen projects were included in the study. Use of the cost/time bidding system resulted in a significant savings in project time and a corresponding cost savings to the owner on eleven out of the fourteen projects. The results of this study are summarized in Table 3. The data presented includes the Case Study No. (1), State (2), Successful Bid Price (3), Savings to the Owner (4) and Time Savings (5).

HIGHWAY ROAD USER COST (RUC) FORMULA

RUC=(Gasoline Consumption×$1.50/gallon)+(VMT×$0.17/mile/vehicle)
+(0.90 VHT×$0.50/vehicle/hour)+(0.10 VHT×$7.00/vehicle/hour)

where:

1. Gasoline consumption is shown in previous table.
2. $1.50/gallon estimated price for 1985.
3. VMT is vehicle mile of travel as shown in previous table.
4. $0.17/mile/vehicle is vehicle operating cost excluding price of gasoline, taxes, tolls and parking.
5. 0.9 VHT is vehicle miles of travel attributed to passenger vehicles.
6. $0.50/vehicle/hour is updated value of non-commercial or non-business auto trip time.

7. 0.10 VHT is vehicle miles of travel attributed to commercial vehicles (trucks).
8. $7.00 vehicle/hour is updated value of commercial truck trip time.

Without Sections 2A and 2B:

RUC=(1,292,000 gallons×$1.50/gallon)+(16,336,490 vehicle miles× $0.17/mile/vehicle)

+(0.90×708,897 vehicle hours×$0.50/vehicle/hour)

+(0.10×708,897 vehicle hours×$7.00/vehicle/hour)

RUC=$1,938,000+$2,777,203+$319,004+496,226

RUC=$5,530,435

With Sections 2A and 2B:

RUC=(1,291,000 gallons×$1.50/gallon)+(16,358,302 vehicle miles× $0.17/mile/vehicle)

+(0.90×702,296 vehicle hours×$0.50/vehicle/hour)

+(0.10×702,296 vehicle hours×$7.00/vehicle/hour)

RUC=$1,936,500+$2,780,911+$316,033+491,607=5,525,051

Daily Road User Benefit (DRUB):

DRUB=$5,530,435−$5,525,051=$5,384

From these calculations the Daily Road User Benefit to the motoring public from the construction of Section 2A and 2B of the Jefferson Freeway is $5,400 per day.

Fig. 1. Calculation of Daily Road User Cost

Table 3. Summary of Case Study Results

Case Study No. (1)	State (2)	Successful Bid Price (3)	Savings to Owner $ (4)	Time Savings To Owner Days (5)
1	Delaware	3,034,765	250,000	50
2	Kentucky	17,886,181	1,387,635	219
3	Mississippi	4,721,599	166,331	49
4	Kentucky	16,329,262	2,885,000	577
5	Kentucky	12,583,349	315,000	63
6	Kentucky	9,186,877	1,620,000	324
7	Kentucky	18,554,123	715,000	143
8	Delaware	2,306,380	175,000	35
9	Maryland	35,087,606	0	0
10	Missouri	1,637,015	(460,000)	(23)
11	Georgia	1,361,009	(147,000)	(21)

12	Texas	39,833,648	150,000	30
13	Texas	39,781,121	300,000	60
14	Texas	15,867,833	55,000	11

The savings to the owner have been calculated taking into account the contractor's price and proposed time, as compared to the owner's cost estimate and normal time. The owner's established time value was used to calculate the value of any time savings.

4 Quality

This parameter is the most complicated and difficult to quantify. There are two totally different approaches to the subject.

4.1 Past performance

This approach takes in consideration past performance and using subjective opinions in evaluating the performance on a scale. The details of the evaluation process are varied from different organizations but all are using the same concept. For example, the Florida Department of Transportation uses it on a permanent basis by using the resident engineer as the evaluator. Although it is based largely on subjective opinion, it is very rare that the contractor (who has a right to appeal) challenges the evaluation. A better quantification method for past quality performance can be based on past test results. This way the evaluation will be less subjective. The details of the quantification system have to be developed using existing standard testing procedures such as concrete strength, pavement strength, tolerance measurements, etc.

4.2 Future performance

A few researchers (Byrd, 1989; Marek, 1989, "Yarbrough, 1990) are against any subjective evaluation and they prefer bidding on quality the same way that the contractor will bid on cost and time. This approach has its merit although it needs more research for various tests. A demonstration of this concept would be the following example: One of the most important factors in highway construction is the roughness of the pavement. This item is measured by inch/ mile using a "profiler." The contractor can bid on the quality of the road by using the parameter (inch/mile). An 8-inch/mile would be better than a 13-inch/mile. The state decides the value of every inch/mile (within certain limitations). Similar measurements can be developed for various types of work.

Both of the two approaches have their merits and handicaps, and more research needs to be done. Even with all the problems associated with quantification of quality, this parameter has to be an essential part of the multiparameter system.

4.3 Measuring quality

An example of quality quantification is provided by the Construction Quality Assessment System (CONQUAS) now in use by the Construction Industry Development Board in Singapore. The CONQUAS system consists of a structured program for inspecting, measuring and recording the quality performance of contractors. Under this system, contractors are assigned quality performance scores on past jobs. A contractor's quality record becomes an essential part of the contractor's performance record. For public projects, contractor's with superior quality scores are given a pricing advantage on competitive bids.

The philosophy of Singapore's Construction Industry Development Board is summarized by Chow Kok Fong, General Manager: "Construction quality is taken too frequently as an abstract notion."—"A commitment to construction quality is only possible if progress in this front can be registered in some manner" (Fong, 1990). According to the CIDB, the CONQUAS system has been applied to over 120 private and public sector projects.

4.4 Minor parameters

In addition to the major three parameters (cost, time, quality), there may be more parameters that can be incorporated into the system. Most of these parameters would be specific to particular industries and these agencies would have the responsibility of figuring the weights and the quantification methods for these parameters.

Such additional parameters could include safety (very important in tunnel and dam projects), security (in military projects), aesthetic quality (shopping centers), and many more. It must be emphasized that new parameters can be added all the time, and their relative importance can be measured by adjusting the weights.

5 The Total System

The multi-parameter bid system would be designed by the owner to include those parameters considered to be most essential. It seems likely that the selected parameters may vary with different owners and with different projects. Regardless of the parameters chosen, all bidders would be fully advised of the basis for successful bidder selection prior to bid preparation.

The total system can be demonstrated with an example. In this case, the owner has established a bidding system based on four parameters. These parameters and their assigned weights are listed in Table 4. This information is provided to the prospective bidders as a part of each bid package.

Table 4. Bid Parameters

No.	Description	Weight %	Quantification Method
1	Cost	60	the actual cost value
2	Time	20	based on $2,000/calendar day

3	Quality	15	past performance in points[1]
4	Safety	5	historical accident records[2]
	TOTAL	100%	

[1]based on average performance in the last 36 months represented in points per hundred, i.e., 97/100, 85/100 and so on.
[2]based on number of accidents per $1,000,000 cost and depending upon the severity of the accidents.

Table 5 presents a tabulation of the bid results. The COST amount is the bid price proposed by the bidders. The TIME amount is the time in calendar days proposed by the bidders for performance of the work. The QUALITY and SAFETY items have been established from the bidders previous performance records.

Table 5. Bid Tabulation

Bidder	Cost ($)	Time (Cal-Days)	Quality (points per 100)	Safety (No. of acc.[1] per 1,000,000)
A	1,100,000	250	89	12
B	1,300,000	230	97	9
C	1,250,000	240	91	17
D	1,100,000	300	85	25

[1]the number of accidents were weighted on a scale: severe accidents (3 points), medium (2 points) and light (1 point).

Given this bidding result, the total bid scores for determining award are listed in Table 6. In this example, Bidder A appears to have made the best proposal. If the project was awarded to bidder A, the contract amount would be $1,100,000 and the specified duration would be 250 calendar days.

Table 6. Bid Calculations

Bidder	Cost Value C	Time[1] Value T	Quality[2] Value Q	Safety[3] Value S	Total[4] B
A	1,100,000	500,000	121,000	12,000	1,733,000
B	1,300,000	460,000	39,000	9,000	1,808,000
C	1,250,000	480,000	112,500	17,000	1,859,500
D	1,100,000	600,000	165,000	25,000	1,890,000

The calculations are based on the following formulas:

[1]Time Value: Calendar day×$2,000/day=CT

(2)Quality Value: 100-points/100$\times C_L = C_Q$

(3)Safety Value: No. of Accidents (1, 2, 3 points)$\times$\$10,000$= C_S$

(4)Total Combined Cost $C_B = C_C \times C_Q + C_T + C_S$

6 Summary and Conclusions

The existing bidding system, which is the competitive bid (or low bidder system) has created many problems in past years. Many modifications have been added to the original concept but the system remains basically unchanged.

The successful bidder is chosen by the lowest, responsible cost. Other factors such as time, quality, etc., have not been taken into consideration. Many practitioners believe that the current bidding system has caused many failures in the form of delays, low quality and numerous other claims. However, a total change of the current bidding system could result in major resistance from various sectors of the construction industry.

The paper introduced a modified bidding system within the legal and conceptional frame of the current practice.

In the modified multi-parameter bidding system, the award would be granted on the total combined cost of a few parameters such as cost, time, quality, etc.

The “weight” of each parameter would be decided by the owner, so he can give a relative opinion of the importance of each parameter. Quality can be a 30% value in one bid and 50% in another. As long as the weights and the quantification method are known in advance by each bidder, the proposed system is legally very sound.

The authors have analyzed a limited version of the new system, bidding on cost and time, and the results show a significant savings in time without any major increase in cost. For the other parameters such as quality, more research must be done on quantification methods. It will not be easy, but it can be done as has been shown in the case of time quantification (road user cost). The proposed multi-parameter system has the potential of improving the construction performance in the USA by giving advanced contractors an incentive to use all of their abilities to give the owner a better product. Its strength is the flexibility of the system while remaining within the framework of the competitive bidding system.

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The management of construction projects with particular reference to human resources

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Abstract
This paper looks at the nature of the construction process, clearly enunciating that it consists of two distinct but interdependent phases—design and building. It makes a case for having these phases closely integrated and placed under the control of a single management entity. Emphasis is placed throughout the paper on the dominant role of human resources in the activity of construction management and the necessity for education and training at all levels and across a wide variety of operations and functions in the construction process. The importance of planning, organisation and control in the management of construction projects is highlighted and the problems encountered in managing human resources stressed. Special mention is made of housing and environmental issues because they exemplify the complex and socio-technical nature of construction and indicate the need for a multi-disciplinary approach, especially in the areas of planning and design,

Keywords: Construction, Education, Environment, Housing, Human Resources, Management, Training

1 Introduction

The management of construction is an activity dating back to mankind's earliest attempts at building dwellings and other structures. It has developed throughout the millenia as an empirical art which has finally evolved into a specific human discipline. It did not, however, acquire a particular name or description until the term *construction management* began to emerge in the last few decades. The term is still undergoing definition, views as to its meaning and nature being as varied and numerous as there are books, papers and symposia on the subject. What seems to be in little doubt, however, is that the construction process is resource-based, proper utilisation of resources being at the core of its successful management.

The resources generally utilised may be broadly classified as being financial, human and physical and, since it is becoming clearer every day that human skills are of primary importance in providing and mobilising all these resources, the focus of attention in the management of construction is increasingly being directed towards the subject of human resources itself. This has been given further impetus by a growing recognition that the construction process is primarily a "people" activity and that successful management of people is essential if desired outcomes are to be achieved.

Discussion of this topic, which forms the central theme of the paper, is best begun by looking at the nature of the construction process itself.

2 Nature of the Construction Process

The construction process may be divided into two distinct but interdependent phases, the first one commencing at the point in time when a facility, be it a simple cowshed or a major highway system, is conceived in an owner's mind. A study of the owner's requirements is followed by a consideration of various design alternatives from which flows a final design and its related documents. The stage is now set for the second phase of actual building and completion of the facility.

Throughout both phases, there are a variety of factors which influence decisions and activities and which are very complex in their interaction. Although it is not proposed to examine these factors in any detail, a few examples are nevertheless given in order to emphasise the degree and extent of human skill required for effective understanding of their influence and the necessity for such understanding to become an integral part of the management of the construction process. These examples are site location and availability, weather conditions, telecommunications, financial resources, legal and environmental requirements, building methods, the provision and deployment of equipment, labour and materials and the control of time and cost. The last two factors, in particular, and the interaction between them are so important that they require the strictest attention. Indeed, it cannot be overemphasised that time and cost are the elements of the second phase most profoundly affected by the end results of the first and that it is essential that the final design and, in particular, the preparation of specifications be undertaken by people with sufficient experience, skill and foresight. This is as true of a simple dwelling as it is of a large power station.

The interdependence of the two phases leads to the inescapable conclusion that they should be closely integrated and placed under the control of a single management entity so that owner, designer and builder can be brought together as a team (Imbert 1981). At least, this is what logic and good sense tells us and that is what used to happen in much earlier periods of human history. The construction of the great edifices of the ancient world, the Great Wall of China, the cathedrals of medieval Europe and, more recently, structures such as the Eiffel Tower and the North American railways exemplifies that reality. In modern times, however, the construction industry has been overwhelmed by an increasingly bewildering array of crafts and professions whose members jealously guard their individual authority and independence. This is a reality which often defies attempts at establishing unity of purpose and endeavour and thus, despite the best efforts at ensuring management of what should be an integrated process, there is often a separation of responsibility between its phases and also within each of them—a separation which does the industry no good and has come to be recognised as a serious impediment to cost-efficient production. Indeed, it is this situation and the consequent need to impose order on a series of disparate entities, activities and specialist groups which have led to the recent emergence of the specific discipline known as construction management, undoubtedly adding to the array of professions previously mentioned but surely contributing to a more integrated approach to the construction process. Let us, therefore, take a closer look at this discipline and examine briefly its major elements, especially in terms of human skills and interaction.

3 Major Elements of Construction Management

Although construction management is still undergoing definition, as indicated earlier, its major elements have been fairly clearly identified as planning, organisation and control. In this context, planning connotes the determination of all construction activities and operations, their sequence and interaction and the formulation of specific arrangements and schedules for their performance. The work must then be so organised that these activities and operations are effectively co-ordinated. This requires the assignment of resources within a distinct framework, streamlined channels of communication and clear definition of lines of authority and areas of responsibility of personnel. Throughout the entire process, control must be exercised, progress being continuously monitored and corrective action taken whenever and wherever necessary. This element of construction management includes surveillance of design and building production, conformance with specifications, revision and updating of plans and schedules, appropriate record-keeping, analysis of performance in terms of quality, time and cost and ensuring that all concerned are kept fully informed. This control function is of paramount importance in these inflationary times when it is so necessary to curb construction costs while producing work of enduring good quality.

As we analyse and examine these elements, what becomes clear is a recognition that the degree of success achieved in them is directly related to the range and extent of the managerial skills available and there is little doubt that, the greater they are, the more efficient will be the conduct of management of the construction process. In this context, it is important to realise that management in construction is both multi-level and multi-function in nature. Thus, we distinguish between the levels of foreman and site manager and between the functions of equipment and purchasing managers, Moreover, we know that many management viewpoints of the use of resources can exist at the same time. For example, whereas a craft supervisor may be concerned with the provision of resources required for a given operation, a site manager has to deal with deployment of such resources for several operations, a project manager with their total utilisation and a financial controller with their time-cost profiles. Similarly, a design manager is usually more concerned with deploying resources so as to keep several projects on stream than would be a section leader whose immediate responsibility is to ensure the expeditious design of a particular project.

What emerges from this discussion is that not only are the development and improvement of managerial skills of paramount importance but that sources of conflict are also inherent in the multi-level, multi-function nature of management in construction. Education and training of managers at all levels and across a wide variety of operations are, therefore, essential, One important by-product of such education and training is the increasing realisation that, since skilled manpower is the construction industry's most precious resource, the skills of all construction workers, be they managers, designers, site foremen or craftsmen, need continuous upgrading and updating. This is what is known today as human resource development and the author wishes to emphasise that experience has shown, and continues to show, that such development is not only essential for successful construction management but also has effects which reach far beyond the construction industry and influence economic planning, policy-making, technological progress and the provision, quantum and distribution of the very resources required for construction.

It would be inappropriate to leave the discussion of education and training without emphasising the difference between the two while recognising that training is an essential element of education in the construction industry. Training is directed at imparting skills and techniques for specific activities and operations whereas education is an exercise which imparts not only knowledge but ideas and perspective, enabling people to think creatively and understand the conduct of human affairs. Training is necessary at all levels and for various functions in construction, the broader activity of education becoming more important as the management tree is ascended. Thus, a concrete foreman must be trained in basic concreting operations whereas the concerns of a senior supervisor would be matters such as quality control, equipment deployment and materials management. Senior managers, in both the design and building phases of the construction process, need to acquire a broad perspective of administration, industrial relations and human behaviour, gain sound knowledge of contract provisions and specifications and receive training in the techniques of planning, organisation and control which are themselves, as already stated, the major elements of construction management.

This brings us right back to the start of the foregoing discussion on these elements and now takes us beyond the subject of human resource development into a discussion of the actual management of human resources themselves, such management being itself inextricably linked with planning, organisation and control.

4 Management of Human Resources

The management of human resources in construction confronts us with a problem full of uncertainties because people are complex and volatile (Kalu 1990), human behaviour being subject to all kinds of whims, attitudes and motivations. This makes performance upredictable and, since performance is a function of the people involved in the construction process (Maloney 1990), construction managers need a wide array of psychological skills and a perspective which sees the process as a series of networks of people and relationships. Moreover, since construction activities and operations tend to involve groups of people rather than individuals, group behaviour needs careful study and managers should endeavour to organise groups which can achieve internal consensus about goals, expectancy and performance and interact efficiently with each other. A recent study on this subject provides interesting reading (Thomas et al. 1990).