

Integrating Building Services Teams

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Abstract

The building services in modern building are becoming more and more complex. This increasing complexity has resulted in more specialists' work on building projects at different stages of the building process. The effective integration of the building services teams is essential to avoid and solve the conflicts expected among various parties that have different disciplines and interests.

The extent of the co-ordination and integration at the design and construction stages of building projects are identified and investigated by a field study which is carried out through questionnaires and interviews with various parties of project teams.

The analysis of the survey findings has concluded that most of the clients' dissatisfaction are for reasons related to engineering building services and therefore the building services engineers should be at the heart of the building process and take an important role at the beginning of the building process in order to have a valuable contribution. Building services maintenance engineers have not been able to participate effectively in the building process and their role may be extended to have a valuable role at the design and construction stages.

The early participation of Building Services engineers in the design process, the wider involvement of maintenance engineers during all stages of the building process, the extensive use of CAD systems and the democratic management style followed by project managers or leaders will greatly improve the integration of Building Service teams and systems.

Chapter 1

Introduction

1.1 Introduction

The volume and complexity of building work have increased rapidly and the society has placed more constraints in the standards that it desires owing to the increasingly more sophisticated way of life. The solution to building problems with a greater amount of scientific and technological knowledge requires an increasing number of specialists at various stages of the building process.

Co-ordination and integration of the efforts of these new specialists are not easy as these specialists often have had different training and education and have difficulty appreciating other areas of the building process.

Building services now represents a considerable portion of the total building cost and plays a major and important part in determining the success of the building process. It is not unusual to have many building services specialist designers, contractors and subcontractors participating in one project. The building services have to be fully integrated in the building process at the design and construction stages to avoid the common problems of inefficient services distribution or performance.

1.2 Hypothesis

1. Most of the clients' and building occupants' dissatisfactions are for reasons related to Engineering Building Services.
2. Services Consultants are still not involved or invited to participate early in order to have a valuable contribution in solving the building's problems.
3. There is no real co-ordination of building services at the design stage. This leads to improper installation and conflicts with other services and systems of the building and cause long delays in sorting out problems which can have an effect on the total cost of the project.
4. There are many problems caused by the absence of building services maintenance engineers to give advice at the design stages. The participation of maintenance engineers at the design stage will prevent most of the problems which are usually experienced after building completion.
5. The lack of co-ordination and integration of maintenance teams cause long delays in rectifying faults that lead to occupants' dissatisfaction.

1.3 Objectives

The objectives of the dissertation are:

1. To find the present level of integration of building engineering services
2. To find the existing problems in the building engineering services field
3. To find how can the integration level be improved in order to produce better buildings in terms of price, time and quality and solve the problems which are now experienced in this industry.
4. Identify the relationship between users' satisfaction and the level of integration of building service design and construction teams.
5. Identify the relationship between clients' or users' satisfaction and the integration of building services maintenance teams.
6. Identify the awareness of clients and buildings' users of the complete life cycle of the project ,before the beginning of the design.
7. Identify the advantages of the involvement of maintenance teams to have an advisory role at the design stage.

1.4 Presentation of the report

The dissertation is structured into eight chapters, as follows:

- Chapter 1 is the introduction which includes the hypothesis and the objectives of the dissertation.
- Chapter 2 covers the integration in organisations in general, the level of integration in various organisational structures and the methods for achieving better integration.
- Chapter 3 covers the building services integration during design and construction stages, and the role of the Building Services engineers during these processes. This chapter also discusses the partnering and the influencing factors on the integration of Building services teams.
- Chapter 4 covers the level of integration in various procurement methods, the conflicts and the roles of various specialists in cost reduction. This chapter also covers the tools for improving the integration of building engineering services.
- Chapter 5 covers the development of computer software and applications in the integration of building service systems.
- Chapter 6 discusses the elements that are required for the successful integration of Building Services teams and systems.
- Chapter 7 describes the survey methodology and discusses the analysis and findings of the survey.
- Chapter 8 summarises the findings of the survey and lists the conclusions and recommendations.

Chapter 2

Integration in Organisations

2.1 Introduction

This Chapter will describe the design and purpose of organisation structures, and the problems of specialisation and co-ordination among units or organisations that has to work together for a common goal.

There are many advantages in specialisation but over specialisation can be detrimental to the overall productivity of the organisation. The greater the need for specialisation or differentiation, the greater is the need for integration or co-ordination. The various types of organisational structures and the methods and approaches for achieving integration are described in this chapter together with the factors affecting specialisation and co-ordination. The project organisation and the factors considered for the selection of project managers are also discussed . This chapter also describes the Project life-cycle and the factors affecting the success of projects.

2.2 organisational structures

Organisational structures arrange the formal relationships among various tasks, activities and people in the organisations. Managers design organisations to accomplish certain goals. The organisational design states the nature and degree of distribution of work force and specifies the co-ordination of efforts to reach the desired results. Proper structure determines how effectively and efficiently an organisation will perform.

2.3 Specialisation and co-ordination

The two problem areas which face every organisation are specialisation and co-ordination. The greater the need for specialisation, the greater is the need for co-ordination. Organisations take on tasks that require a wider variety of skills than can be found in one person, hence specialisation is necessary. There are also other advantages in specialisation;

1. As workers specialise, they often increase their expertise and productivity and develop new and more suitable work methods.
2. It is easier to train new workers in a speciality than in generalised work.

However over-specialisation can be detrimental to both the individual worker and the overall productivity of the organisation.¹

2.4 Differentiation

Differentiation is the difference in cognitive and emotional orientation among managers in different functional departments. The more uncertain the environment, the more differentiation or specialised was the successful firm. Uncertainty necessitates more differentiation.

2.5 Integration

The greater the amount of differentiation or specialisation, the greater is the need for integration or co-ordination. Integration is the quality of the state of collaboration that exists among departments that are required to achieve unity of effort by demands of the environment.

¹ Edgar F Huse, *Management 2nd edition*, West (1982) pp. 227

Organisation which had low differentiation, integration was achieved through a mechanistic approach such as:

- Direct management contact
- Management hierarchy
- Paper system of specifying jobs, rules and procedures.

In moderately certain environment such procedures are helpful but not sufficient in themselves to provide effective integration. Two additional methods are also used.

- Individual integrators who are individuals specifically responsible for the co-ordination of the interdependent activities of various departments
- Temporary cross-functional teams

In highly uncertain environment, the successful organisations are more highly differentiated and requires more integration. This is achieved by all methods listed above and in addition, established permanent cross functional teams and formal departments of integration.

2.5.1 Team building, an aid to integration

Many problems of integration are caused by the hostile feelings that one group or department may have for another. Groups and departments have different goals and criteria of performance, and that it is very easy for them to form unfavourable stereotypes of one another. It is natural for individuals to identify with their own departments or companies rather than with other departments or with the organisation as a whole. People tend to vent their feelings of frustration or aggression on outsiders. The heads of some departments may feel personal antipathy towards each other, and this in turn is likely to be reflected in the attitudes of their respective staffs.

For such reasons it is quite likely that certain feelings of hostility will manifest themselves between different departments or groups which have to work together, and will make it more difficult to achieve an adequate degree of integration. Once conflict

arises, then its effects will often become cumulative. Within a department, these effects typically include more conformity, 'pulling together' and defensiveness. As groups, the departments 'close up', seeing only the best in themselves and the worst in others. Communication between the departments tends to decrease, their members do not listen to the 'adversary', personal relations deteriorate, and scoring political points becomes more important than solving common problems on their merits. In fact, the more that relations between departments are defined in terms of 'if they win, we lose', the more likely is a breakdown in integration. The more that relations are linked in people's mind to joint problem-solving, the less likely is such breakdown.

Lawrence and Lorsch (1967) found that successful integration in the companies they studied was characterised by a great deal of open confrontation of issues by the members of different departments. Understanding and integration can be built between departments or groups by reformulating their objectives or targets in terms of an overriding goal that both can accept as essential and also attainable. If joint projects are called for, then the task forces drawing on members of two or more departments can often provide a positive experience of working together. This can create mutual trust and confidence, as can other ways of bringing members of different departments to work together, such as nominating joint representatives to committees. It has also been found that effective way of broadening the particular view of the world held by specialist and breaking down the stereotypes they have of another department, is to arrange for them to work in that department. Even short-term interchanges of staff for three to six months can bring considerable benefits of relatively minor costs, in additional learning and supervision. These staff not only gain knowledge about other specialists' aims and problems from such interchanges, but they also broaden their attitudes and possibly those of the host department. Those people then become potentially valuable communication links and means of liaison. If, however, a lack of co-operation between departments stems from personal antipathy between their heads or other key personnel, then re-deploying one or both may be required before team building can succeed.

2.6 Interdependence within Organisation

There are many factors affecting specialisation and co-ordination such as

- The number of units and sub-units involved. Usually, the greater the unit the more difficult is the co-ordination.²
- The pattern of interdependence among the units; Pooled, sequential or reciprocal. Figure 2.1 illustrates the three patterns of interdependence.

2.6.1 Pooled Interdependence

This exists when units interact with the central organisation but not with each other. The units are interdependent in that one must succeed if the other to succeed. Each part of the organisation contributes to the whole, and each is supported by the whole. The functions of the units can be co-ordinated through standardised instruction from the home office. For example, Bank and branches.

2.6.2 Sequential Interdependence

This exists when one unit must act before another unit can accomplish its tasks. Each unit is interdependent with the one that precedes it and succeeds it in the flow of work.

The Co-ordination of sequentially interdependent units requires more effort, more planning and more managerial contact than that of co-ordinating units in pooled interdependence. There are more important lateral relationships, and conflict is likely to occur.

² J. Thomson, *Organising in action*, McGraw-Hill, 1967

2.6.3 Reciprocal Interdependence

This exists when the outputs of each unit provide inputs for all others. Reciprocal interdependence incorporates pooled and sequential interdependence. Co-ordination requires mutual adjustment by all units. This type of interdependence demands the most effort of communication and decision making, and it entails the greatest likelihood of conflict because of the greater number and complexity of relationships involved. Co-ordination in reciprocal interdependence is made difficult by the following:

- Frequency of interaction
- Importance of interaction
- Complexity of information exchanged in interaction.

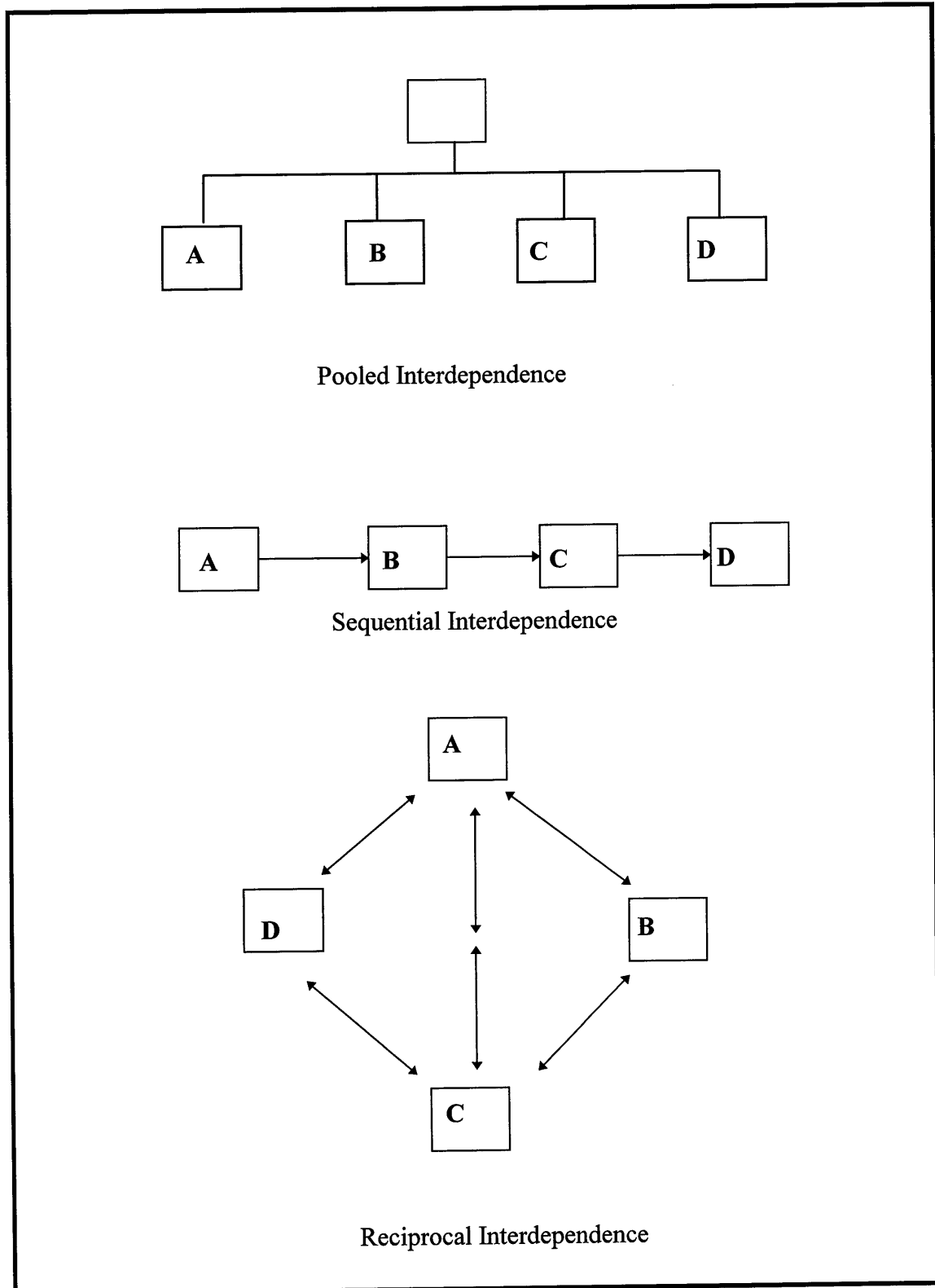


Figure 2.1 Patterns of Interdependence

2.7 Organisational Structures

Projects are performed by organisations using human, capital, and other resources to achieve a specific goal. Many projects cut organisational lines.

Theorists have devised various ways of partitioning an organisation into sub-units to improve efficiency and to decentralise authority, responsibility, and accountability. The mechanism through which this is accomplished is called departmentalisation, and the objective is to arrive at an orderly arrangement of the interdependent components. Departmentalisation is integral to the delegation process.

Organisations may be structured in many different ways based on functional similarity, types of processes used, product characteristics, customer served, and territorial considerations.

1. **Functional:** The organisational units are based on distinct common specialities, such as Mechanical Engineering, Electrical Engineering, and Finance.
2. **Product:** Distinct units are organised around, and given responsibility for a major product or product line
3. **Customer:** Organisational units are formed to deal explicitly with a single customer group.
4. **Territorial:** Management and staff are located in units defined along geographical lines, such as the Northern zone or region.
5. **Process:** Human and other resources are based on a flow of work, such as oil refinery.

2.8 Organising for a project

A variety of structures are used by organisations to perform project work. The actual arrangement may depend on the proportion of the company's business that is project

oriented, the scope and duration of the underlying tasks, the capabilities of the available personnel, preferences of the decision makers, and so on. The following five possibilities range from no special structure to totally separate project organisation.

2.8.1 Functional organisation

Many companies are organised as a hierarchy with functional departments that specialise in a particular type of work. These departments are often broken into smaller units that focus on special areas within the function. Upper management may divide a project into work tasks and assign them to the appropriate functional units. The project is then budgeted and managed through the normal management hierarchy. Figure 2.2 illustrates a typical functional organisation.

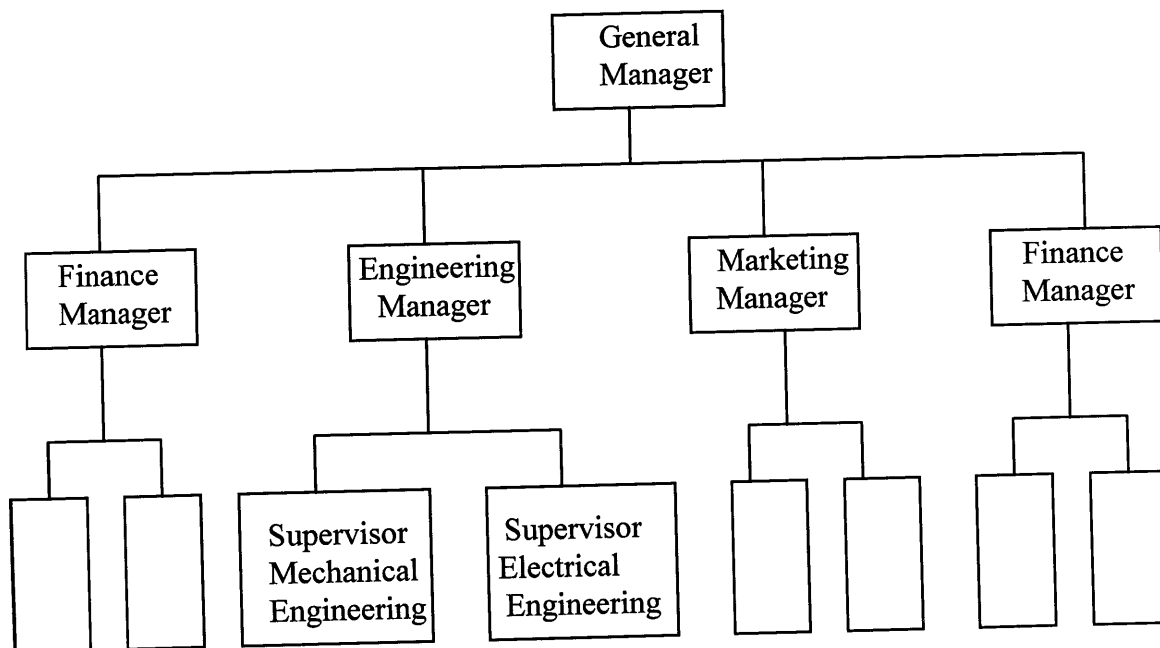


Figure 2.2: Typical functional organisation

The following is a list of advantages and disadvantages of Functional organisations.

Advantages

- Efficient use of collective experience and facilities
- Institutional framework for planning and control
- All activities receive benefits from most advanced technology
- Allocates resources of production elements
- Career continuity and growth for personnel
- Well suited for mass production of items.

Disadvantages

- No Central project authority
- Little or no project planning and reporting
- Weak interface with customer
- Poor horizontal communications across functions
- Difficult to integrate multidisciplinary tasks.
- Tendency of decisions to favour strongest functional group.

2.8.2 Project Co-ordinator

A project may be handled through the organisation as described above, but with a special appointee to co-ordinate it. The project is still funded through the normal channels and the functional managers retain responsibility and authority for their portion of the work. The co-ordinator meets with the functional managers and provides direction and impetus for the project and may report its status to higher management.

2.8.3 Matrix organisation

In a Matrix organisation a project manager is responsible for the completion of project and is often assigned a budget. The Project Manager essentially contracts with Functional Managers for completion of specific tasks and co-ordinates project efforts across the functional units. The Functional Managers assigns work to employees and

co-ordinate work within their areas. These arrangements are depicted schematically in Figure 2.3.

The Matrix organisation is one of a number of approaches developed to handle problems that cannot be handled by the function or product organisations. It is a device for integrating the activities of different specialities while maintaining specialised organisational units.

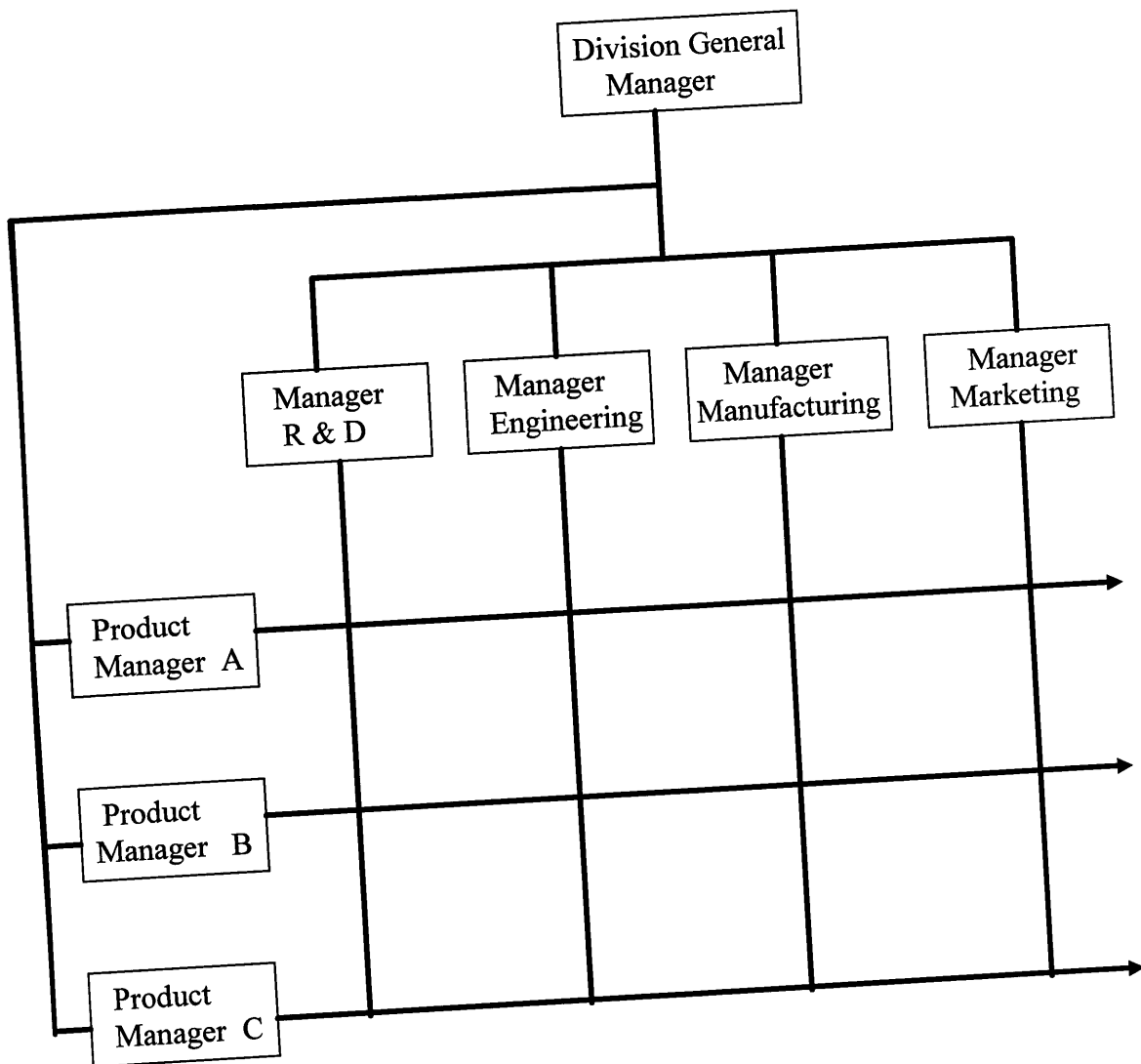


Figure 2.3 - Typical Matrix Organisation

Disadvantages

- Dual accountability of personnel
- Conflicts between Project and Functional Managers
- profit-and-loss accountability difficult.

2.8.4 Project Team

A particularly significant project that will have a long duration and require the full-time efforts of a group may be supervised by a project team; Full-time personnel are assigned to the project and are physically located with other team members. The project has its own management structure and budget as though it were a separate division of the company.

2.8.5 Project organisation

When the project is extremely complex, of long duration, and involves a number of disparate organisations, it is advisable to give one person complete control of all the elements necessary to accomplish the stated goals.

Companies that are frequently involved in a series of projects and occasionally shift around personnel often elect to use a matrix organisation. This type of organisation provides the flexibility to assign employees to one or more projects. In this arrangement, project personnel maintain a permanent reporting relationships that connects vertically to the supervisor, who directs the scope of their work. At the same time, each person assigned to a project has a horizontal reporting relationship to the manager of a particular project, who co-ordinates his or her participation in that project.

The following is a list of the advantages and disadvantages of Project Organisations:

Advantages

- Strong control by a single project authority
- Rapid reaction time

- Encourages performance, schedule, and cost trade-off.
- Personnel loyal to single project
- Interfaces well with outside units
- Good Interface customer

Disadvantages

- Inefficient use of resources
- Does not develop technology with an eye on the future
- Does not prepare for future business
- Less opportunity for technical interchange among projects
- Minimal career continuity for project personnel
- Difficulty in balancing workloads as projects phase in and out.

2.8.6 Shift from Function to Matrix organisations

The co-ordination devices of organisations can be placed on a scale of increasing complexity as follows:

- Rules and programmes
- Hierarchy
- Plans
- Direct contact
- Liaison
- Task Force
- Teams
- Integrators
- Integrating departments
- Matrix organisation

2.9 Interface Management

As organisations grew in size, more and more emphasis was placed on multiple ongoing programs with high-technology requirements. Organisational pitfalls soon

appeared, especially in the integration of the flow of work. As management discovered that the critical point in any program is the interface between functional units, the new theories of “interface management” developed.

Because of the interfacing problems, management began searching for innovative methods to co-ordinate the flow of work between functional units without modification to the existing organisational structure. This co-ordination was achieved through several mechanisms such as Rules and procedures, Planning processes, Hierarchical referral, and Direct contact.⁴

For non-repetitive tasks and projects, the best means for reducing conflicts and minimising the need for communication was detailed planning. Functional representation would be present at all planning, scheduling, and budget meetings.

2.10 Project Organisation

The organisational structure of a project should be designed as early as possible in the project's Life Cycle. A clear definition of communication channels, responsibilities, and the authority of each participating unit is a key element affecting project success. The most appropriate structure depends on the nature of the participating organisations.⁵

The Project Manager has often been described as a conflict manager. In many organisations the Project Manager continually fights fires and crises evolving from

⁴ Jay R Galbraith, “Matrix Organisation Designs” *Business Horizons*, (February 1971), pp. 29-40.

⁵ Shtub, Bard, Globerson, *Project Management, Engineering, Technology, and implementation*, Prentice Hall, (1994), pp. 221-222

conflicts, and delegates the day-to-day responsibility of running the project to team members.⁶

2.11 Factors in selecting a structure for projects

The primary factors that should be taken into consideration when selecting an organisational structure for managing projects are as follows:

1. **Number of projects and their relative importance.** As the number of projects increases and their relative importance increases, the organisational structure should adopt by moving to a matrix structure with a stronger project orientation.
2. **Level of uncertainty in projects.** Projects may be subject to different levels of uncertainty that affect cost, schedule, and performance. To handle uncertainty, a feedback control system is used to detect deviations from original plans, and to detect trends that might lead to future deviations. A project-oriented structure is preferred when high levels of uncertainty are presented.
3. **Type of technology used.** When a project is based on a number of different technologies, and the effort required in each area does not justify continuous effort throughout the project life cycle, the matrix organisation is preferred. If each project concentrates on a technology that is mastered by one functional area, the functional organisation and project co-ordinators of each functional area are the best choice. When projects are based on several technologies and the work content in each area is sufficient to employ at least one full-time person, a project-oriented structure is preferred.
4. **Project Complexity.** High complexity that requires very good co-ordination among the project team is best handled in a project-oriented structure. Low-

⁶ Kerzer H., *Project Management, A Systems approach to planning, scheduling and control*, VNR (1995), PP. 423

complexity projects can be handled effectively in a functional organisation or a matrix arrangement with a functional orientation.

5. **Duration of projects.** Short projects do not justify a special organisation and are best handled within the matrix organisation. Long projects that span many months or years justify a project-oriented structure.
6. **Resources used by projects.** When common resources are shared by two or more projects, the matrix arrangement with a functional orientation tends to be best. If the number of common resources among projects is small, the project-oriented structure is preferred.
7. **Overhead cost.** By sharing facilities and services among projects, the overhead cost of each project is reduced. A matrix organisation should be preferred if an effort to reduce overhead cost is preferred.
8. **Data requirement.** If many projects have to share the same databases and the information generated by projects should be made available immediately to organisational elements not directly involved in these projects, an organisational structure with a functional orientation is preferred.

In addition to these factors, the organisational structures of the client and the contractor also must be taken into account. If both have a functional orientation, direct communication between similar functions in the two organisation might be appropriate. If both are project oriented , an arrangement that supports direct communication links between project managers in their respective organisation would be most effective.

When the contractor and the client do not have similar organisational structure, and when there are several participating units, the client's project managers may have to deal simultaneously with many departments as well as a host of subcontractors, government agencies, and private consultants. In such cases the project orientation should be designed to anticipate and moderate conflicts that arise in scheduling

activities competing for resources, setting priorities for different phases of the work, assigning workers to tasks, and managing technological changes.

2.12 Project Manager

The organisational structure selected for a project is a primary determinant of its success. Once the organisational structure for a project is defined, the selection of personnel for management positions within this structure must be considered. Important attributes of Project Managers are discussed below.

1. **Leadership:** The most essential attribute of a project manager is leadership.

The project manager has to lead the project team through each phase of its life cycle, dealing swiftly and conclusively with any number of problems as they arise along the way. His or her ability to guide the project team smoothly from one stage to the next depends on the person's stature, temperament, skills of persuasion, and the degree of commitment, self-confidence, and technical knowledge.

2. **Interpersonal skills:** The project manager has to achieve a given set of goals through other people. The manager must deal with his or her own superiors, the members of the project team and frequently must interact with representatives from other organisations, including subcontractors, laboratories and government agencies. To achieve the goals of the project, the ability to develop and maintain good personnel relationships with all parties are crucial.

3. **Communication skills:** The interaction between groups involved in a project and the project manager takes place through a combination of verbal and written communications. The project manager must be kept abreast of progress and be able to transmit directions in a succinct and unambiguous manner. By building reliable communication channels and by using the best channel for each application, the project manager can achieve a fast, accurate response from the team with some degree of confidence that his or her directions will be

carried out correctly. The more up-to-date and comprehensive the information the smoother the implementation route will be.

4. **Decision-making skills:** The project manager has to recognise problems and establish the procedures by which they will be documented and addressed. Once the source and nature of a problem are identified, the manager must evaluate alternative solutions, select the best corrective action, and see that it is implemented. These are the fundamental steps in project control. The project manager becomes involved early enough to participate in discussions regarding the organisational structure of the project and the selection of technological solutions. An understanding of the basic technical issues gives the project manager the credibility needed to influence resource allocation, budget, and schedule decision before they are finalised. His or her input on these matters at the initial stages increases the probability that the project will become started in the right direction.

5. **Negotiation and conflict resolution:** Many of the problems the project manager faces do not have a "best solution." The major sources of conflicts are:

- **Scheduling:** Disagreements that develop around the timing, sequencing, duration of projects, and feasibility of schedule for project-related or activities.
- **Managerial and administrative procedures:** Disagreements that develop over how the project will be managed such as the definition of reporting relationships and responsibilities, interface relationships, project scope, work design, plans of execution, negotiated work agreements with other groups, and procedures for administrative support.
- **Communication:** Disagreements resulting from poor information flow among staff or between senior management and technical staff, including such topics as misunderstanding of project-related goals, the strategic

mission of the organisation and the flow of communication from technical staff to senior management.⁷

2.13 Selecting the Project Manager

As project management matured and projects became large and complex, management began to realise that the project manager was a manager of people in addition to being a manager of work. Thus the project manager's behavioural skills became equally as important as his technical skills.

With concurrent engineering, the primary skill of Project Managers should be their multidisciplinary knowledge of the business. The secondary skill should be the ability to analyse and assess risks, especially the risks associated with the integration of work.⁸

2.14 The Integrative Function

Integrative communication functions are those that operate to give the organisation unity and cohesion - defining objectives and tasks for the purpose of facilitating the entry and smooth absorption of appropriate participants, co-ordinating the activities and schedules of various individuals and department, eliminating redundancy and wasted effort. Integrative processes serve to draw the organisations' boundaries, taking in those individuals and activities that contribute to its objectives and excluding those that do not. The design of organisational structure (the provisions for channelling information and authority, power allotment, and the assignment of responsibility) represents an integrative function. The personnel functions, at least in its recruitment aspects, accomplish an integrative purpose. The principle thrust of

⁷ Shtub, Bard, Globerson, *Project Management, Engineering, Technology, and implementation*, Prentice Hall, 1994

⁸ Kerzer H., *Project Management, A system approach to planning, Scheduling and control*, VNR (1995), pp. 1033

integrative communication is in the direction of identity and uniformity.⁹ Organisations attempt to provide the means by which members will identify with the working of the organisation.

2.15 The Co-ordination Role of Communication

Human activity is always directed toward the achievement of objectives. The object of a particular act may not be entirely clear at all times to all observer - or even to the actors- but it is difficult to conceive of any conscious action that is not aimed at producing some change.

An organisation may be defined as a structured system of relationships that co-ordinates the efforts of a group of people towards the achievement of specific objectives. Co-ordinating the actions of two or more individuals towards the achievement of a common goal is a problem for any organisational unit. It is only with the use of communication that co-ordination can be achieved.

As soon as an organised effort is proposed, it becomes necessary to communicate certain basic information in order to assemble the required participants. The organisational objectives must be defined and the role of each individual that he or she expects to play, including the allotment of power and reward, must be described.

Once the enterprise is launched, the necessity for continuous multilevel and multidirectional communication becomes increasingly urgent. Information must be transferred regularly, accurately, and effectively from one individual or one party to another. Activities must be harmonised, and adjustment must be made to integrate all the individual activities into a working accord.

⁹ Koehler, Anatol, Applbaun, *Organisational communication Behavioural Perspectives*, Holt, Rinehart and Wintson 1981, pp. 9

Communication is the mortar that holds organisational structure together. It provides the basis for co-ordinating the relationship between individuals to reach the ultimate organisational objectives.¹⁰

2.16 Project Life Cycle

Every program, project, or product has certain phases of development. A clear understanding of these phases permits managers and executives to better control total corporate resources in the achievement of desired goals. The phases of development are known as Life-Cycle phases. However, the breakdown and terminology of these phases differ, depending on whether products or projects are discussed.

Today, there is no agreement among industries, or even companies within the same industry, about the life-cycle phases of a project. This is understandable because of the complex nature and diversity of projects. The theoretical definitions of the life-cycle phases of a system, as defined by Cleland and King, can be applied to a project include the following phases:¹¹

1. Conceptual Phase
2. Definition Phase
3. Production Phase
4. Operational Phase
5. Divestment Phase

The project life cycle is the evolutionary process or series of identifiable phases through which the project must pass as it develops. The standard in the United

¹⁰ Koehler, Anatol, *Applbaun, Organisational communication Behavioural Perspectives*, Holt, Rinehart and Wintson (1981), pp. 11-12

¹¹ D.I. Cleland and W.R. King, *Systems Analysis and Project management*, 2nd edition McGraw-Hill, (1975), pp. 187-190

Kingdom construction industry is the RIBA plan of work which has a general pattern as follows:

1. Inception
2. Feasibility
3. Briefing
4. Outline Proposals
5. Scheme Design
6. Detailed Design
7. Production Information
8. Tender action
9. Tender reporting
10. Tender acceptance
11. Construction
12. Completion
13. Hand-over
14. Use
15. Feedback

All construction projects follow this basic pattern. The grouped or holistic appraisal of this series of phases is the life cycle of building. The Client and Project Manager must carefully consider all phases of the complete life cycle to avoid any miscalculation which can be very expensive and irreversible.

2.17 Factors affecting the success of a project

Pinto and Slevin (1987) found the following 10 factors to be of primary importance to a project's success.

1. **Project mission and goals.** Well-defined and intelligible understanding of the project goals are the basis of planning and executing the project. Starting at the

conceptual design phase of the project life cycle, the overall mission should be defined and explained to team members, contractors, and other participants.

2. **Top management support.** The continuous involvement of top management throughout the life cycle of the project increases their understanding of its mission and importance. This awareness, if translated into support, may prove invaluable in resolving problems when crises and conflicts arise or when uncertainty strikes. Therefore, continued, solid communication between the project manager and top management is a catalyst for the project to be a success.
3. **Project planning.** A detailed plan that covers all aspects of the project including technical, financial, organisational, scheduling ,communication and control aspects is the basis for implementation. Planning is a dynamic and continuous process that links changing goals and performance to the final results.
4. **Client consultation.** The ultimate user of a building project is the final judge of its success. A project that was completed on time according to the technical specification and within budget but was never or rarely used can certainly be classified as failure. Client input is the basis for setting the mission and establishing goals and continuous consultation with the client can help correcting errors.
5. **Personnel issues.** If relations among team members, between team members and the client, or between team members and other personnel in the organisation are poor and morale problems are frequent, project success is doubtful. Well-motivated teams with a sufficient level of commitment to the project and a good relationship with the client are the key determinants of project success.
6. **Technical issues.** Understanding the technical aspects of the project and ensuring that members of the project teams possess the necessary skills are important responsibilities of the project manager. Inappropriate technologies or

technical incompatibilities may affect all aspects of the project, including cost, schedule, actual performance, and morale.

7. **Client acceptance.** Ongoing client consultation during the project life cycle increases the probability of success regarding user acceptance. In the final stages of implementation, the client has to judge the resulting project and decide whether or not it is acceptable.
8. **Project control.** The continuous flow of information regarding actual progress is a feedback mechanism that allows the project manager to cope with uncertainty.
9. **Communication.** The successful transition between the phases of a project's life cycle and good co-ordination between participants during each phase requires a continuous exchange of information. The organisational structure of the project should specify the communication channels and the information that should flow through each one. The formal communication line, in addition to a positive working environment that enhances informal communication lines within the project team, contribute to the success of the project.
10. **Troubleshooting.** Since uncertainty is always a likely culprit, the development of contingency plans is a valuable preventive step. The availability of prepared plans and procedures for handling problems can reduce the efforts required for dealing with them should they actually occur.

Chapter 3

Integration of Building Services

3.1 Introduction

Building Services are becoming more essential and important as more complex and sophisticated engineering services are required in modern buildings. The co-ordination and integration of services engineering work must take place at the early stage of the design process.

This chapter will discuss the building services integration during the design and construction stages, and the role that the Building Services Engineer must play in order to make a valuable contribution at the heart of the design process. The partnering in the construction industry and how it can help in promoting team work, mutual trust and provide reduction in the construction costs will also be discussed.

The influencing factors on co-ordination and integration of building services at the design stage which include the lack of design information and inadequate design briefing by client will be discussed in this chapter.

3.2 Integration and Co-ordination of Building Services

The integration of engineering services concerns the relationship between engineering services and the remainder of the building project. Conversely, the co-ordination of engineering services concerns the interrelationship of the engineering services themselves. Thus the Architect or the Project Manager integrates the work of the engineering services consultant into the design of the project whereas the Engineering

Services Consultant co-ordinates the plumbing, heating, electrical and air conditioning services.¹

Co-ordination is the art of organisation or logistics - putting a number of individual parts into the right order, or making them relate correctly to each other. Integration is about combining these parts into a whole, and it is this which sets it above the more straight- forward process of organisation.²

3.3 Integration during the design stage

Studies by the Building Research Establishment³ showed that problems on site caused by the conflicting information on architectural drawings and specialist drawings are common to most projects and are usually the most disruptive and difficult to deal with. Any improvement in integration during the design stages should, therefore, play a significant part in ensuring effective integration during the entire process. The cause of these problems can be summarised as follows

a) Differences in terms of commission

A principle cause of poor integration is the different agreement between the client and the architect; and between the client and the services consultants.

b) The provision of Builder's work drawings

The responsibility of the provision of builder's work drawings are not the responsibility of the Services consultant and they are normally delegated to the Services Subcontractor who is not always known at the start of the contract. Consequently, the main contractor either omits to carry out work necessary for the

¹ Parton P. K., *Building Services Integration*, E FN Spon (1983) pp. 1

² CIBSE journal , *Integrated design*, (November 1995) pp. 29-36

³ Grawshaw D, *Co-ordinating Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25*

installation of the services or, in attempting to anticipate the Services Subcontractor requirements, carries out abortive work which often results in an increase in project time and cost.⁴

c) Difference in Communication

The manner in which the information is communicated is an important factor affecting integration during the design stages. While the Architect and structural Engineer produce pictorial and dimensional drawings in the form of plans, sections and elevations, the services Consultant communicates by means of diagrammatic presentation since working drawings are not part of his normal duties. Consequently, pipelines, ductwork and fittings are not drawn accurately in size or position although such consideration may be of crucial importance to structural engineers, when for example, designing a floor slab. A study by BRE⁵ showed that very often separate drawings are produced for separate services which is not conducive to effective integration.⁶

Integration in construction implies a close working relationship between the services consultant and other designers, in particular the architect and the structural engineer. Integration is impossible without the active participation of the other team members. For the process of integration to succeed there must be a common starting point. This prevents pre-conceived ideas or prejudices becoming a fixed part of the design.

Integration emerges from a strong idea. A project can only support a limited number of concepts, and sometimes one can be so powerful as to be so-called idea fix, but usually a number of these will flow through the design.

⁴ Parton P. K., *Building Services Integration*, E FN Spon(1983), pp. 1

⁵ Grawshaw D, *Co-ordinating Working Drawings, The role of site Management*, *Building Technology and Management*, 15th February 1977, pp. 13-25

⁶ Parton P. K., *Building Services Integration*, E FN Spon(1983), pp.1

The initial concept has to be robust enough to hang the design upon, and strong enough to survive the design process. Once this is set, it becomes difficult to unpack or revisit during the design process without having to completely redefine it.

The complex interactions are such that a minor deviation at one level can have significant consequences on another. Clear thinking and a shared vision are perhaps the two most important requirements for the individual and the team technical competency is taken for granted.

Environmental and energy concerns are on increase, and greater emphasis is being placed on environmentally aware designs. The building services engineer is in the best position to be the major player. His knowledge of systems and specialist training in thermodynamics and fluid mechanics must be the ideal characteristics for this new and growing role.⁷

3.4 The Role of Building Services engineer

There is no reason why the services engineer cannot be at the heart of the design process. Services engineers must dispel the feeling that they are systems designers who simply fit engineering services into the performed shell. Services engineers do not operate in a vacuum, and decisions by others have major impact on their work.

The building shell and fabric are inextricably linked to the building services engineer's designs. Inefficient services distribution through poorly thought out plans and uncomfortable indoor climates resulting from ill-suited building forms are common, and unless the building services engineer is involved from day one the chances of making any significant contribution to the overall design process are practically zero.

⁷ *CIBSE journal ,Integrated design, November 1995, pp. 29-36*

Structural engineers are usually consulted early on as they design the foundations, which comes first in the construction chain. Ironically, the structure is frequently either covered up or falls prey to some simplistic economic argument where the weight of steel, for instance, becomes an objective in itself. Other members of the project team are often oblivious to the fact that a small saving in the cost of the structure has a significant impact on the cost of the services installation.

More controversial, however, is the question of attitude. Structural engineers, due to their training and status, feel comfortable taking their place on the top table at the beginning of a project. Conversely, few services engineers have the will to resist half-backed constraints being placed on them due to the lack of knowledge or understanding of others, nor do they argue their case convincingly.⁸

Another major disadvantage for the services industry is the diverse range of its activities, from the design of simple heating systems to complex laboratory services.

Without an invitation to the top table for the building services engineer, integrated design will be pushed to one side and the best that will be on offer is a co-ordinated design that results from solving a puzzle set by others. Integration will be assured once the services engineers are seen as the generator of form, and it is recognised their systems are in fact the fabric of the building, or at least rely heavily upon it for satisfactory performance.

The consultant's attitude towards the design process must change, and perhaps this is the greatest challenge of all. The building services engineers need to move from the culture of problem solving to problem elimination, and to accept as common currency

⁸ *CIBSE journal, Integrated design, November 1995 pp .29-36*

the principle that ideas relating to structure can, in themselves, eliminate problems for building services or the internal environment.⁹

3.5 Partnering

Partnering is not only implies teamwork, but also a bond of friendship and mutual trust between people. If it is properly executed, partnering is claimed to be powerful enough to render formal construction contracts redundant. The Reading Construction Forum at Reading University report “Trusting the team” concluded that partnering could provide the 30% reduction in construction cost saving called by Sir Michael Latham. The report concluded after studying more than 40 construction partnering relationships in United Kingdom and North America, that partnering shows substantial benefits, faster construction times, higher build quality, better certainty and continuity of work and improve profit all round.

There are two types of partnering arrangements in common use:

1. Project partnering, where one-off development is undertaken using a team that agrees to work in partnership.
2. Strategic partnering, where series of on-going construction projects are tackled by the same team.

The Reading University study calculates that saving between 2 to 10% can be achieved on one-off project partnering relationships, while ongoing strategic partnering relationships can realise savings of more than 30%.¹⁰

3.5.1 Project Partnering

Specialist contractors are often excluded from project partnering in an attempt to maintain competitive construction costs. Project partnering will work best on

⁹ *CIBSE journal, Integrated design, November 1995 pp. 29-36*

¹⁰ *CIBSE journal, Integrated design, November 1995 pp. 29-36*

relatively simple buildings constructed under design and build arrangement. Reading University found that some of the best examples of partnering were Under Construction Management, although results from case studies revealed the importance of the client's role in setting up the partnering arrangement.¹¹

Project Partnering depends on an initial workshop where mutual objectives are decided and a problem resolution process agreed, followed by subsequent workshops to define specific project actions. A final workshop is particularly important for identifying lessons for future projects.

The inherent flexibility of partnering enables other initiatives to flourish, such as the setting up of action teams designed specifically to take responsibility for developing certain aspects of the partnering arrangement. An action team can be set up to deal with co-ordination, measuring its success in terms of the number of services conflicts prevented by the team's early review of the drawings.

The payment arrangements are the key to overall success. The most successful projects studied by Reading University were those where financial incentives were provided through profit sharing and that the criteria used to determine each firm's share were carefully related to mutual objectives.

3.5.2 Strategic Partnering

Strategic Partnering differs from Project Partnering in terms of a formula whereby lessons learnt on individual projects are carried to subsequent projects. It is used when clients have a series of construction projects or other ongoing work, like maintenance for example.

¹¹ *CIBSE journal, Integrated design*, November 1995 pp. 29-36

The process of Strategic Partnering is helped by setting a market benchmark against which partner performance can be assessed.

Strategic Partnering allows for more long-term relationships than Project Partnering, and this can be used for the benefit of the partners in many ways such as sharing the same facilities.

3.5.3 Partnering Contracts and Law

A partnering arrangement is not a partnership, and neither can be described as a joint venture. Partnering is more about a spirit of co-operation contained within a partnering charter to which everyone signs up after the partnering workshops.

Users' satisfaction must not be compromised by the urge to maintain good professional relationships. For example, the architect's need to hide ventilation systems in the name of aesthetics must not conflict with the operator's requirements of easy access for maintenance. Rarely, though, are those responsible for operation and maintenance given the opportunity to be part of the team, and this must change.¹²

Partnering should never be adopted to correct a weakness in one party, because that party will be subservient to other parties in the partnering arrangement and will undermine the whole process. The Client, General Contractor and design professionals alike must champion the cause of partnering as champions, provide support to managers who must be innovative, willing to take risks, use sound judgement and make decisions in unfamiliar areas.

3.6 The Design-Construction Interface

A major problem associated with the Design-Construction interface is the accepted practice of nomination of the Services Subcontractor by the Architect. Nominated Subcontractors are seldom appointed at the same time as the Main Contractor. They

¹² CIBSE journal, *Integrated design*, , November 1995 pp. 29-36

may be appointed before the Main Contractor, in which case any planning of their work , upon which they may have based their estimate, cannot have taken into consideration the Main Contractor's overall planning policy of the project. Any discrepancies between the Nominated Subcontractor's plan and the Main Contractor's plan can, therefore, be a source of integration problem throughout the project.

Alternatively, the Nominated Subcontractor may not be appointed until work has started on site with the results that errors or omissions in the work may arise because the Main Contractor is not fully aware of the Nominated Subcontractor's requirements.¹³

3.7 A Framework for Integration

Project Management is one of the new approaches which are devised to alleviate some of the problems outlined above. They all attempt to breakdown the barrier between the design function and the construction function that is present with the traditional practices of open and selective tendering. The services integration will be benefited as project communications tend to be improved.

The integration of engineering services on building projects is affected by technical, organisational and managerial factors, and operates within contractual constraints. These factors are themselves interrelated and therefore affect the building project in a complex manner. If engineering services are to be successfully integrated on building projects, then their relationship with the remainder of the building projects must be considered in terms of the above mentioned factors.¹⁴

¹³ Parton P. K., *Building Services Integration*, E FN Spon(1983), pp. 1

¹⁴ Parton P. K., *Building Services Integration* , E FN Spon(1983), pp. 1

3.8 Design co-ordination and Integration

It would seem to be essential to hold pre-planned meeting where all the design team can get together to examine the totality and integrity of the design of building at the design stage rather than finding the difficulties during construction ¹⁵ .

A study by Property Services Agency has shown that 50% of faults in buildings arise through decisions or actions in the design stage, 40% construction faults and 10% product faults ¹⁶ .

As the design process progresses, it calls increasingly for consultation, preparation and exchanging of technical information, co-ordination and integration of a large number of specialists inputs. Once these principles are fully understood by all design team members, there can be a reduction in cost as wasted time and resources can be avoided. There will also be a rising in standards as repairs and rework should not occur ¹⁷ .

Briefing problems involving building services have increased as building services complexity has increased. The consequences of an inadequate brief for building services can be expensive. If a building environment cannot be maintained at a level compatible with the purpose for which it was intended, the remedial work needed to resolve the problem could involve considerable extra costs, and possibly have a detrimental effect on the overall operation efficiency of the building throughout its life ¹⁸ .

¹⁵ *G.Vincent & E Happold - How to integrate M & E services ,1998*

¹⁶ *Agency Property Services , Quality Assurance Publication*

¹⁷ *T Cornick, Quality Management of Building Design*

¹⁸ *C J Parloe, A Design Briefing Manual*

3.9 Design Co-ordination and Integration of Building Services

Co-ordination is an important aspect of project management and will lead to a full integration of building services with building fabric if carried out properly.

Building services co-ordination and integration are affected by factors such as Conditions of Engagement, uncoordinated working drawings, costs , quality and aesthetic demand.

The different agreements and terms of commission adopted between the client and the architect, the client and the services engineer contribute to the problems and failure of co-ordination, at the design stage, among the group of specialist and professionals from the building design team.¹⁹

a) Uncoordinated Working Drawings

Substantial problems arise in most projects due to the lack of effective co-ordination. Closer collaboration between designers and improved quality control of drawings can improve co-ordination. There is a need that each drawing should have a specific status and purpose.²⁰

Sometimes there is a need for the production of drawings which combine various designer's information in order to recognise conflicts at design stage rather than on site.

Conflicts between architectural or structural drawings with services drawings, or between services drawings (Air-conditioning, plumbing, electrical, etc.) conflicting with each other are the most frequent and mainly caused by:

¹⁹ P Scher, *Working Drawings*

²⁰ D T Crawshaw, *Co-ordinated Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25*

1. Failure to highlight special features when passing drawings to services consultant, such as door swings or one concrete beam being deeper than the rest.
2. Errors from re-drawing by the services consultants. Errors such as openings being omitted during the re-drawing outline.
3. The services consultant working from out-of-date drawing when revising his design. Although services drawings may be up-to-date with respect to the services themselves, they are often out-of-date with respect to the building structure.
4. Holes provision creates one of the most common co-ordination problems. For example, holes are provided at the wrong place, or wrong size or not provided at all. Puncturing holes through critical structure members, especially large ones, can cause structural instability.

Conflicts of services drawings with other services drawings can be the most disruptive and expensive type of conflicts as these will not be notified until installation was well underway and the consequences of abortive work is high.

b) Costs

Mechanical and electrical services are becoming far more important in modern buildings as they become more complex and costly and this leads to problems of co-ordination. The costs can be divided into two categories:

1. Capital and running cost
2. Rectification cost

Building services represent a major initial cost of a building project and subsequently the running cost. The cost of building services in modern buildings can represent up to 50% of the total cost of the building as the choices and decisions made at the early

design stage about the form and fabric of the building , building shape and orientation dictate heating and cooling loads and much of the services installations.²¹

Poor co-ordination between services engineering works and both the architectural and structural works can result in great amount of abortive work and additional work which cause a significant increase in project cost via variations and delays in projects.²²

It is important for the Building Services Consultants to work closely with the rest of designers and co-ordinate their work. The ability to influence the building cost decreases as the project progresses from conceptual planning, design to construction and commissioning (Figure 3.1). Therefore a well co-ordinated and integrated design as early as possible will not only help to minimise the building cost but also the services cost which represent a major part of the total cost of the building. The services zone provided at each level and which affect the overall building height and cost is a good example for planning and co-ordination between architect, structural engineer and services engineer.

c) Quality and Aesthetic Demand

Most clients consider quality and aesthetic of a building as important criteria as the total building cost. The building services are complex, dynamic and sensitive relative to other building elements of the building and they are likely to be the first to go wrong. If these services are not properly positioned or blended within the building fabric and surroundings, they are likely to tone down the aesthetic appearance of the building. This requires close co-ordination between the services engineer and the

²¹ *Design Economics for Building Services Offices, Building Economics Bureau*

²² *D T Crawshaw , Co-ordinated Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25*

architect at the design stage in order to achieve the integration of works to the utmost satisfaction.

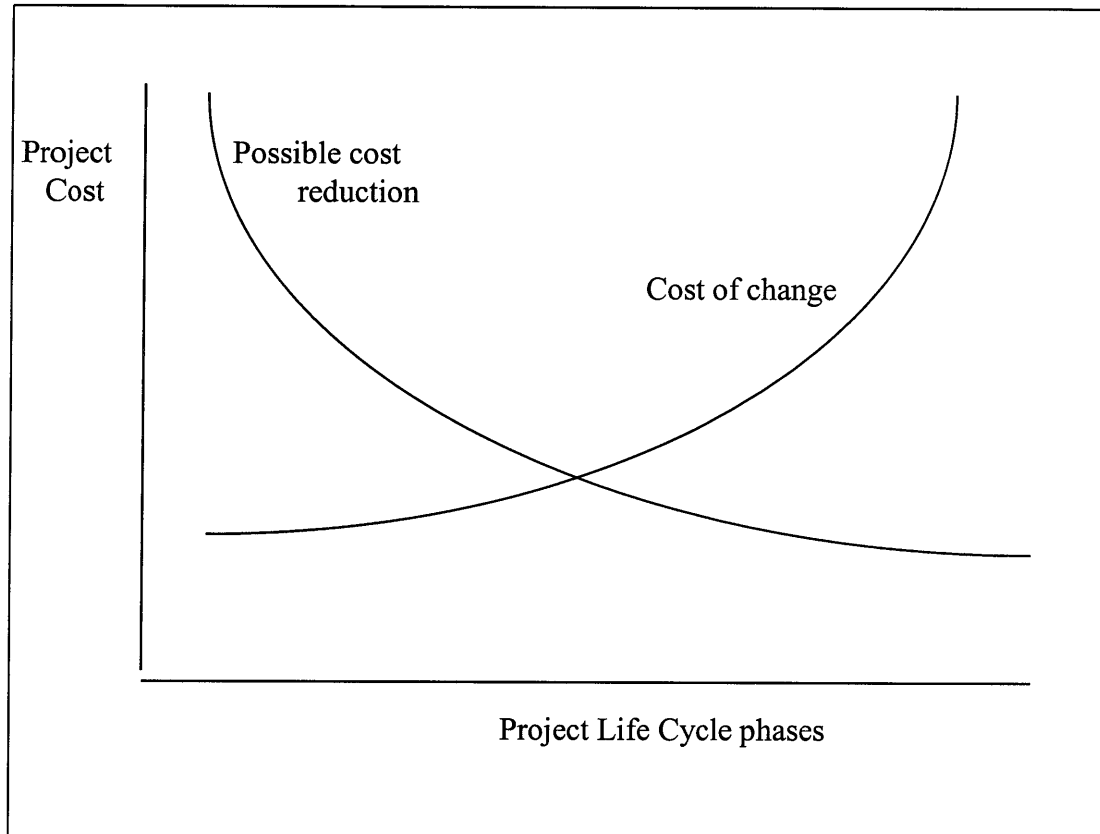


Figure 3.1 Project cost reduction analysis

3.10 Influencing Factors on Co-ordination and Integration of Building Services at Design stage

The lack of design information and Inadequate design briefing by the client has been identified as having a significant influence on co-ordination and integration of building services at design stage.

3.10.1. Lack of Design Information

It has been established that many of the problems which occur on building sites are the results of poor project design information.²³

Services integration needs to be established at an early design stage where information must be shared with the rest of the design team members and established by outline proposal stage²⁴. The flow of design information must be shared among the design team to minimise mistakes.

The lack of design information may be caused by the following:

1. Poor background training and education
2. Duties are not defined properly.
3. Information are received late
4. Communication breakdown

a) Training and education

The background and training of the services engineer in general, has been traditionally limited in terms of his roles within the project team and no appreciation of architectural problems²⁵. Services Engineers' education and training background are often limited to a specific field such as mechanical or electrical. This contributes to the co-ordination difficulty as each member fails to respond sympathetically to the requirement of other members preventing a total design approach. The architect and structural engineers' training also do not emphasis on the problems of services integration and co-ordination.

²³ *L J Wild - Design Information flow*

²⁴ *J Mason & B Venning - Space for Services, Structure & services Part 1*

²⁵ *A Michie, Integration and Co-ordination of Building Services and its relationship with Project Management.*

b) Duties and responsibilities

A study by NEDO ²⁶ indicated that there was insufficient definition of the client's responsibilities that certain general management tasks were either haphazard or neglected and failure to fulfil his roles place the designer in the role of surrogate client which can lead to unfortunate results.

It is important to impose duties and responsibilities to every member of the team and appoint a leader who must insure that all information contributed by each member are reached and well understood. The co-ordinator or lead designer should have total responsibility for ensuring that co-ordination take place through the design process and later stages of building process

c) Late information

The design of building services is usually offered by the services consultants, services contractors or subcontractors. Problems occur when information is contributed late by the specialist subcontractors or services engineer. Usually the services engineer does not produce full details in his design, because most of building services are complex and need more information which can be contributed by the services contractors who are often appointed at a later stage to produce these detailed drawings.²⁷

It is now a practice that 50% of the design drawings are generated by the specialist and they are brought in too late ²⁸. The engineering services requirement may not have been fully taken into account when the architect or structure engineer prepare their design. The co-ordination problems are not discovered until it is noticed during the construction phase.

²⁶ *NEDO - The Public Client and the Construction Industries.*

²⁷ *G Vincent, How to integrate Mechanical and Electrical Services*

²⁸ *C Gray, Design Counsel*

d) Communication Breakdown

A lack of communication or communication breakdown can have a serious effect on the potential for co-ordination. Also when there are too many people involved at consultant level, it will be difficult to know who is in charge and lines of communication can be tangled.

The liaison between clients and designers is weak in the early stage of brief formulation, and there is a frequent mismatch of client's and architect's views on their roles and responsibilities²⁹. Many quality related events in the construction process are the result of poor communication in the design process and errors leading to defects are mostly a result of failing to clearly communicate design requirements to the construction process.³⁰

3.10.2 Inadequate Design Briefing by Client

The brief is the foundation for design and should be an evolving expression of building requirements. Clients must accept that they are part of the building production process and clearly define their requirements. The design team will then take the responsibility for the interpretation of the client requirements into technical requirements during the briefing stage before the design process.

The client's brief at initial design stage is influenced by the client's experience, his ability in the preparation of the brief, his appointment of representatives and his organisation and management. Some clients in the building industry build only seldom and for these it is difficult to know what briefing is all about. Clients often fail to understand the challenging nature of building projects and consequently appoint people of relatively low status and experience as their representatives and these lack the necessary authority and management skills.³¹

²⁹ BRE Survey, *Brief Formulation and the Design of Buildings*.

³⁰ National Economic & Development Office 1987 - *Achieving Quality*

³¹ N.O.Reilly, *Getting a better Building*

Severe problems can arise from the client's organisation and their conduct of the project at the briefing stage. The client difficulties in overall management result in problems in co-ordination and conclusion of the brief.

3.11 Integration During Construction Stage

A research carried out at Salford University³² indicated that one of the major causes of poor integration during construction is the degree of difference between the site personnel of the Main Contractor and the Services Subcontractor. These differences arise because they have allegiances to both the project and to their own parent organisation and can be summarised as follows.

(a) Task

The Main contractor is concerned with the technical and managerial processes of building and consequently is concerned with terminology, practices and tolerances generally accepted in the building industry. Engineering Services Subcontractors, however, have their roots in the engineering industry and, accordingly, adopt different practices and work to different tolerances. These differences often result in problems involving the locations of services fixtures installed by the Services Subcontractor and building elements positioned by the Main Contractor.³³

b) Involvement

Services Subcontractors are only involved with projects for relatively short and intermittent periods, whereas, the Main Contractor is totally involved from the

³² Barton, P.K., *The co-ordination of Mechanical and Electrical services subcontractors within the building process*, MSc thesis, Salford University. (1976)

³³ P K Parton, *Building Services Integration*, E FN Spon (1983), pp. 1

time he signs the contract until the building is handed over. These differing degrees of involvement affect the criteria upon which they base their decisions. Thus we have the typical situation arising when the Subcontractor's operative is ill and not replaced. This is acceptable to the Subcontractor who will no doubt have the rest of his workforce deployed on other projects. However, as far the Main Contractor is concerned on this particular project, it could hold up several prior operations that would be carried out by his own or other Subcontractor's operatives.

(c) Organisation Structure

Main Contractors tend to have a fairly organic structure to cope with the unforeseen problems that may arise on building projects. Engineering Services Subcontractors, however, because of their specialist nature tend to organise themselves in a more rigid way. This results in different levels of responsibility of the respective site personnel, making negotiation difficult.

(d) Social relationships

Engineering Services Subcontractors employ a high proportion of skilled labour on a permanent basis and tend to operate as small organisations. Consequently they normally form very effective social units and, if conditions are unacceptable to them, they may adopt entrenched attitudes based on their prejudices against the Main Contractor. However, if conditions can be made acceptable to them, it will be relatively simple to integrate them into the social system of the site.

Conversely, the Main Contractors rely heavily on casual and part-time labour, most of which is semi-skilled. Furthermore, they tend to be larger organisations than the Service Subcontractors. As a result their operatives do not have a similar set of close social interrelationships. Neither do they have as strong commitment to the goals of either the project or the parent organisation. This lack of social cohesion between the two groups of operatives in turn affects any technical interdependence of their site operations.

3.12 Types of integration in Construction Process

In general, the construction process consists of a more or less strong division of several fragments of construction activities, preferably being carried out by different specialised parties. This result in an increase of contracts with specialised contractors, which can cause a relative greater risk for contractual and organisational problems, and even conflicts. Reduction of these risks by optimising the construction process can be reached with the help of integration. Two main types of integration are; Integration by alliancing and integration by turnkey-concepts.³⁴

3.12.1 Integration by alliance (Arge)

Integration by alliance (Arge) is especially used for larger projects. The large numbers of small specialised contractors can realise larger projects, by using such alliances³⁵. Alliances with qualified contractors in general can result in better and more competitive advantages for realising projects, according to an article by Scott³⁶. There is a need for using clear and official selection procedures for partners (contractors) in the alliance in case of large contract-sums.

3.12.2 Integration by turnkey-concepts

The contractor by choosing the starting of activities with integration by turnkey-concepts could control the whole construction process, and optimisation of this process could be worked out easier.

³⁴ CIBSE journal, *Building services* January 1996.

³⁵ Benish W. *Handbuch der unternehm-chlusse*; quotation; Hrsg. Solter und Zimmerer, Munchen. (1972) pp. 157

³⁶ Scott B. *Competitive advantage through alliance*; article in 'Engineering, construction and Architectural Management'; Vol. 2,; Black well Science, UK. (1995), pp. 83-92

3.12.3 Structure of the Project Organisation

A schematic overview with contractual relationships for the two types of integrated project-organisation is shown in figures 3.1 and 3.2.

It may be clear that in the turnkey-organisation, the contractor can control the whole construction process, from the design to the delivery of the building. When using the way of integration by alliancing organisation, the risk for conflicts between the several partners in the organisation can be quite high ³⁷.

³⁷ *Wilco Tjihulis and Ger Maas, Faculty of Building and Architecture , University of Technology, Eindhoven, The Netherlands.*

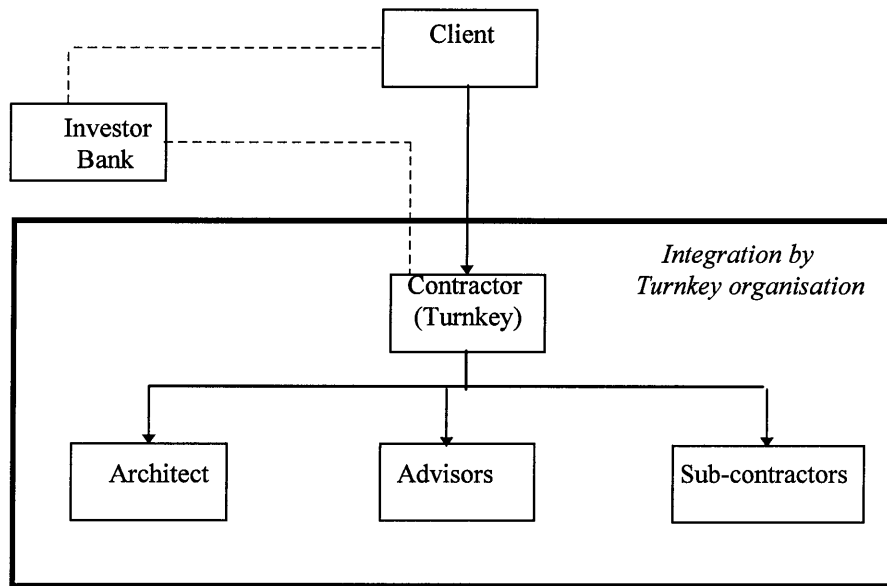


Figure 3.1 - Integration by Turnkey-organisation

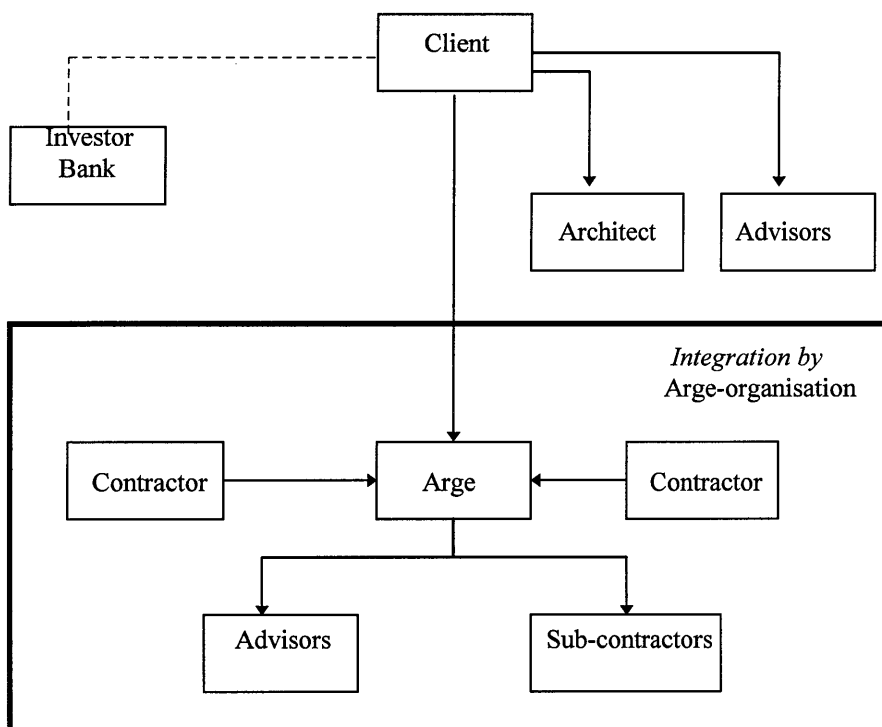


Figure 3.2 - Integration by Arge-organisation

Chapter 4

Integration Improvement Tools

4.1 Introduction

This chapter discusses various types of procurement methods, the level of integration and the conflicts in project teams. It also discusses the roles of various specialists in cost reduction which can be achieved by integration, and the tools for integrating design by specialist contractors.

The factors which influence the co-ordination and integration of project are discussed together with methods of improving integration. The chapter also discusses the adoption of maintenance planning strategy to maintain technical and functional quality of building over time.

4.2 Procurement and Integration

Regardless of its technological complexity, any reasonably sized project involves a high level of organisational complexity which arises because there are many specialised skills and professions with a useful contribution to the process.

The fragmentation of construction into a large number of diverse skills is an inevitable consequence of the economic, technological and sociological environment. There are an extraordinary diversity of professions, specialists and suppliers. The way in which they combine is specific to each project. This uniqueness arises from the individual demands of the project coupled with the continuing evolution of specific roles.

As the technological complexity of any process grows, so the demands for integration and co-ordination increases. In the case of construction industry, this demand led to

the emergence of General Contractors, a role first undertaken by Thomas Cubitt of London in 1870 (Spiers, 1983). Before this, clients would have entered into a series of separate trade contracts with the people who were doing the work.

Recent developments have caused some building firms to move away from a focus of fabrication and more towards a focus of management and co-ordination of trade contractors. Some builders respond to the market by specialising into a narrower field whether technical specialisation or management. Other respond by offering wider, integrated packages such as design and build.

The advancing technological complexity of the industry also led designers to embrace new techniques, and these grew a demand for specialist designers who understood the new technologies. It is useful to think of design as a one whole discipline which has been successively eroded by more specific disciplines. The need for a specialised understanding of new technologies led to the emergence of Building Services Engineering and the need for overall control of the process led to the emergence of Project Management.¹

4.2.1 Roles and Relationships

The process of building procurement involves a series of different specialists contributing to the work at different times. These people have widely differing skills, they often work for different organisations, in different geographic locations and at different times. The level of understanding between them is often less than would be desirable. There are several perennial problems which can stand in the way of effective team-building in construction projects.

There are a number of stylised representations of the process of building procurement. The simplest of these shows the building process as having three stages, discrete steps

¹ *John Murdoch and Will Hughes, Construction Contracts-Law and Management 2nd edition, E & FN Spon, 1996.*

of briefing, designing and constructing. This view is commonly held in theory, but rarely found in practice. There are always overlaps between stages.

Fragmentation is a problem within the construction industry and the result is often internecine strife (Relph-Knight, 1985). The reasons for this fragmentation are associated with the fact that a variety of different people come together on a project, temporarily, each with their own set of objectives and expectations, each from separate firm. The reason for a wide variety in the skills needed on a construction project arises out of the sheer technical complexity of the problems associated with procuring buildings which creates a demand for extremely detailed specialist knowledge. The needs of people to feel as though they belong to a group encourages these technical specialists to group together into professional organisations such as institutions. Each of the specialists tends to be employed by a specialist firm which come together with other firms solely for the purposes of completing a particular project.²

4.2.2 Conflict in project teams

The characteristic grouping of project teams very often results in conflict at a variety of levels. Each project participant has particular aims and objectives and it is rare to find contract structures which encourage harmony among these aims. Project participants expect to enter into confrontations with each other and with the client. This expectation of adversarial conflict is at the root of the internecine strife. It is the purpose of conditions of engagement and other contracts to regulate these confrontations and to provide a basis whereby one part can enforce the promise of another. Their purpose is not simply to avoid or prevent tension and conflict.

One of the purposes of assembling a team of people from different professions is to harness a variety of views. It should be expected that each person brings his or her

² *John Murdoch and Will Hughes, Construction Contracts-Law and Management 2nd edition, E & FN Spon, 1996, pp. 12*

own criteria for decision making; they all have their own agenda and this is as it should be. The tensions thus generated should precipitate debate and dialogue so that clear choices can be made. In other words, controlling conflict is not the same as eliminating it. Conflict avoidance and the failure to develop an organisation equipped to manage it, not conflict itself, disrupt. Open, skilful discussion is needed to turn differences into synergistic gains rather than squabbling losses.

The problem of handling conflict was addressed by the organisational researchers, Lawrence and Lorsch (1967). They identified the task of integrator and stated that such a person, in order to succeed, must be able to deal with conflict. They identified three methods of dealing with conflicts; confrontation (choosing , after discussion, a solution from those put forward for consideration), smoothing (avoiding conflict) and forcing (the naked use of power). They found the most effective integration was achieved in organisations which used confrontation, supplemented as necessary by forcing behaviour to ensure that issues were properly confronted. Smoothing was the least effective method. ³

4.3 Integrating for cost reduction

Building designers must become used to thinking over the whole 60-year life cycle of the building instead of simply getting the building up quickly and at minimum cost. Rather than produce good design, we produced building quickly and spent far more time and money in law courts afterwards than we would have done if we had got the job right in the first place” said Arnold, CIBSE past-president. ⁴ Designers should avoid special fittings and stick to tried and tested off-the-shelf products wherever possible.

³ John Murdoch and Will Huges, *Construction contracts - Law and Management 2nd edition*, F&E Spon, 1996, pp.15

⁴ CIBSE journal, *Building services January, 1996*

We must contrive to work as a single team with a common goal. Some methods of procurement help in this objective more than others. Construction management can promote a truly wonderful team ethos as well as providing greatest opportunity for cost saving.

4.3.1 Design Responsibilities

Design has to be a contiguous process. The idea that the consulting engineer should supply some conceptual drawings from which others can develop detailed design “is absolutely stupid”. That is not to say that contractors should be kept in the cold when it comes to design. Designers must recognise the detailed design expertise and hands-on-experience with the specialist contractor can bring to the process, and involve them fully in the team, said Arnold.

Traditional procurement methods have debarred any real harmonisation between the consulting engineer and the specialist contractor, said Martin Davis, vice chairperson of Drake and Scull Engineering. These methods are all about achieving competition. Nothing wrong with that, but if the specialist is contributing to the design development he is in effect a member of the design team, and a competition about the price for doing the job before the job is fully defined can only set up counter-productive pressures.

A two-stage pricing was proposed by Davis. In stage One, the specialist contractor is selected to carry out some design duties. A basis for payment is established for design services and for stage Two pricing of the work when eventually designed and defined. Stage Two pricing should be initiated as the design develops, and concluded in good time before manufacture and installation are due to start.

By stage Two there must be a firm design and programme of work and a firm price to completion. Issues such as whether to sublet the pipe work installation and so on need to have been decided. A profit formula may be structured to give incentives for an improvement in the clients Mechanical and Electrical objectives. This would have the

effect of bonding together consultant and contractor and rewarding them for exceptional joint performance.

Designers should produce designs and specifications that do not limit the methods or approaches to the installation and its processes. Prefabrication is one option open to the contractor and can bring about huge savings in labour costs.

In designing construction projects, we often ask for drawings and documents to be redrawn and submitted for approval several times as people of different disciplines do not talk to each other. Also during commissioning, we check tests that have already been witnessed and clients ask for additional tests. The reason for this is the lack of trust. Current methods of procuring buildings force individuals to watch their own backs instead of considering the project as a whole and working together as a team. In order to well-serve the client by the building team, the self-interest must take a back seat to collective collaboration.⁵

4.4 Tools for integrating design by different specialist contractors

The role of specialist contractors is being changed in industrialised countries. The specialist contractors have been increasing the ability of designing their products as well as detail design correlated with their products.

Designers of buildings (architects and engineers) and main contractors are becoming distant from technical knowledge of various off-site building products. In other words, building design is being dependent on specialist contractors and off-site component fabricators.

⁵ *CIBSE journal , Building services January 1996.*

The most classical method for inputting industrial knowledge effectively is the “performance base specification” method that certainly has made great contribution for promoting fabricators’ positive input to building design in many projects in industrialised countries.

However, in the circumstances of increasing dependency on specialist contractors, more incentive collaborative design developments between designers of building and specialist contractors are being essential in order to minimise the risk of change of design and cost, and to maximise the capacity to apply innovative and appropriate technology.⁶

4.4.1 Integrating tools

The increasing of dependency on specialist contractors in design development means that parties to produce shop drawings are varied and fragmented. Under this fragmented situation, there are no guarantee that shop drawings made by different specialist contractors have no contradiction and inconsistency. In other words, some single party should draw a sort of comprehensive shop drawing by integrating shop drawings submitted by all parties participating in design development.

Integrators of design have to exchange information and drawings quite frequently and intensively with specialist contractors involved in design development. In case that integrators and specialist contractors are using CAD to draw shop drawings, it is expected that electronic CAD data exchange is done between them.

In Japan, General Contractors are performing the role of integrators in most of the construction projects. Large Japanese contractors are now trying to develop

⁶ Tomonari Yashiro, *Department of Architecture, Musashi Institute of Technology, Tokyo, Japan, Methodology of Specialist Contractors’ involvement in design development for construction*

sophisticated tool for CAD data exchange with specialist contractors who have high potential of offering detail design as a CAD data; Electrical works, air conditioning works, plumbing and others works. It is still certain that electronic CAD data exchange between general contractors and specialist contractors would be increased in the future.

There are needs to establish some standards for increasing electronic CAD data exchange. The idea of standard format for CAD layer is one of the concepts that have developed from this context. Standard format for CAD layer is a standard of categorisation of layers and objects involve in shop drawings. Based on the standard, initial schematic drawing supplied from general contractor to specialist contractors would be a set of graphic objects on multiple layers. Specialist contractors can easily pick up the necessary information by choosing layers among supplied schematic drawings. Successively, specialist contractors draw detail drawings by inputting objects in the layer allocated to the specialist contractor by the standard. The detail drawing is returned to general contractor as a set of graphic objects in the allocated layer.

As an integrator, The General Contractor is able to edit shop drawing simply by “summing up” objects located on different layers. In case that general contractors find inconsistency and contradiction in the “summed up” drawings, then they are returned to related specialist contractors for some change in design. Like this way, the standard is expected to enable efficient feedback between general contractors and specialist contractors during design development process ⁷

⁷ Tomonari Yashiro, *Department of Architecture, Musashi Institute of Technology, Tokyo, Japan, Methodology of Specialist Contractors' involvement in design development for construction*

4.5 Design Co-ordination and Integration

The co-ordination and integration at design stage are influenced by factors such as the nature of project, the number of parties involved, and the project costs.

4.5.1 The nature of project work

Building process has changed from simple process, where a client approaches a master builder to undertake all the works involved from initial design to final completion including services installation, to a complex process.

The increasingly sophisticated lifestyle and greater demands in terms of standards and legislation, the influences of social and economical demands have all contributed in increasing the volume and complexity of building work.

The use of more sophisticated and complicated techniques and the employment of new methods of construction has increased as the industry moves towards an era of high technology.

4.5.2 The Number of parties involved

The need for more scientific and technological knowledge in modern buildings has resulted in an increase in the number of specialist at various stages of the building process. This will require more co-ordination and integration in order to complete the works effectively.

4.5.3 The project Costs

Cost is considered as the most important criteria for most clients. The poor uncoordinated initial design and drawings will lead to variations in work or additional works that will increase the cost of the building.

It is suggested that 80% of the initial cost of a project is determined at the design/briefing stage ⁸. Therefore it is very important to carry out all co-ordination work necessary at the design stage where there is more control over the total cost of the project.

4.6 Integration Improvement

The integration of building services is complex and difficult to deal with and there is no easy solution. However there are some solutions and methods that contribute to the successful integration which include the use of computer-aided design, the independent Design management and the early appointment of Building services contractors.

4.6.1 Computer-aided Design

The computer-aided design (CAD) use in the building industry has been hailed as the answer to the industry's prayer for reducing design repetition and smoothing co-ordination problems. ⁹

The advantage of using CAD is that it allows different information to be added on different layers of the design. The layout can be on one layer whilst the structural details, air-conditioning and ventilation, electrical, etc., can be on different layers. A printed drawing using CAD can show only the architectural layout, the mechanical layout, or any combination of the drawing layers. This enables the designers to reduce the risk of two different elements from different disciplines clashing with one another, or information left out or distorted during the drawing process.

⁸ P. Barton- *A framework for cost Exploration and strategic cost.*

⁹ G Stevenson, *Draw to Draw Salesman*

CAD offers consistency of design, speed of drawing production and a controlled quality of design standards allowing the designer to concentrate efforts on the design. The compatibility of different CAD software is very important as it would be a major hindrance if a designer from the same design team cannot link up his design information and cross reference with other designers because of software compatibility problems.

4.6.2 Independent Design Management

A principle architect/ engineer is appointed to head the multi-discipline design team. The total integration of the design team is the underpinning philosophy of this technique. The following are ten steps that lead to good design management.¹⁰

1. Recognise the complexity of the design
2. Choose designers carefully
3. Change the leadership of the design as it progresses.
4. Integrate information supply with building needs
5. Obtain agreements at key decision points.
6. Integrate the team.
7. Plan and plan again
8. Manage the interfaces
9. Control design development
10. Agreements.

4.6.3 Early Appointment of Services Contractors

Late or inadequate information is a common problem for the contractor, design team, and specialist contractors who have design responsibilities. Proposals by specialists are often not fully checked or understood and there are often incomplete construction

¹⁰ C Gray, *The Successful Management of Design, A Handbook of Building Design Management*.

details at interfaces between building elements, and insufficient co-ordination between building fabric and services.

This can be improved by setting up clear lines of communication and integration at the outset of the project to enable smooth flow of information between the design team and subcontractors. The early appointment of services contractors should enable more pre-contract involvement between the subcontractors and the design team. It will prevent many of the above-mentioned problems and help to formulate better communication, co-ordination which will contribute to the success of the project.

4.7 Integrating Maintenance

The adoption of maintenance planning strategy is based on the preparation of a system of procedures and operations aimed at maintaining the technical and functional quality of a building over time.¹¹

Forecasting and planning maintenance works, within the overall picture of the process of planning, building and managing a building, thus become an integral part of a strategy for global planning for quality.

In this sense the consolidation of an effective integration of architectural and technological design and the construction process becomes essential. This integration is concretised in the methods and instruments used in making the plan an “act of planned forecasting” aimed at obtaining, in construction, and maintaining, in the life cycle of the work, the planned levels of quality.

¹¹ C. Terpolilli, *Maintenance planning and quality control criteria at the design stage*, University of Florence, Italy

The incidence of maintenance activities, or rather the amount of resources needed to carry out the operations required to guarantee efficiency and adaptability of a building, varies according to the quality of design and the execution of the work.

Tackling the maintenance problem at the design stage requires a correct evaluation of the technical solutions based on the requirements which determine durability and reliability performance levels. The need for maintenance activities should also be taken into consideration at the design stage to ensure that maintenance operations such as repairing, checking and replacement works can be carried out with ease. Therefore a series of parameters is needed to be introduced into the criteria used in evaluating building quality. These parameters should help to determine at the design stage and control during construction, the performance of materials and components while taking account of the conditions under which they will have to perform.

The designer will make the choices by defining the requirements of the technical units closely connected with four main types of performance:

1. Durability; the capacity to resist ageing and deterioration over time.
2. Reliability; the capacity under working conditions to satisfy all requirements, thus reducing the probability of breakdown.
3. Possibility of carrying out maintenance work (planning of subsystems and components so that maintenance work can be carried out.
4. Adaptability to changes of use; the capacity of technical system to undergo modification caused by changes in use, while maintaining original quality levels.

The designer will make use of two basic types of operation in fulfilling these needs.

1. Choice of materials and components based on an examination of durability and reliability performance levels;

2. The use of building methods in assembling complex technical units and in installing components , devices and apparatus which guarantee and facilitate the possibility of maintenance, accessibility of hidden parts, inter-changeability of elements, dismantling, etc.¹²

4.7.1 Planning Durability

The ways in which design can positively influence the results of a planned maintenance programme depend not only on choice of materials and “long-lasting” building methods. Maintenance does not only consist of repairing breakdown and replacing element, but to foresee maintenance activities and, thus plan all the various phases, deadlines and operating procedures and, above all, keeping account of the whole process behind maintenance work.

Making design an active part of that process requires an analysis of the maintenance question in all its various aspects. This means that design should tackle the question of quality in the global life cycle of the building strategically, using the tools available during the various phases of construction.

During the phases leading up to executive design the possibility of controlling quality levels over time depends upon correct definition of performance requirements relating to durability, reliability, possibility of carrying out maintenance, and adaptability to changes in the use of the sub-systems. Therefore it is essential that the plan is based upon all the available information related to the “in use behaviour” of materials and components. Knowing about those factors which cause obsolescence, ageing or pathological deterioration in sub-systems allows the designer to individuate their maintenance needs and plan management procedures accordingly such as replacement cycles, operation techniques and procedures for carrying out operations.

¹² C. Terpolilli, *Maintenance planning and quality control criteria at the design stage*, University of Florence, Italy

Reinforcing management and co-ordination functions regarding execution phases at the design stage allows the planner to control more effectively the tools regulating the preliminary phases leading up to an operation. The essential phases in planning quality are :

1. Specification of technical requirements on which maintenance of quality levels over time depend.
2. Clarification in contracts of responsibilities and duties relating to managing quality
3. Definition of services required to check and manage the physical and functional obsolescence of the sub-systems throughout the building's life cycle.

Knowledge of “in use condition” of the building and definition of the performance system relating to every sub-system constitute checkpoints for evaluating how suitable choices of materials and components are to quality and durability requirements. The choice of design solutions which correspond to maintenance possibility requirements is essential for subsystems requiring renovation or frequent replacement of parts. This means designing and building with components organised in open systems which allow the replacement of a single component without having to operate on the entire building.

The possibility to check, and the ease of carrying out maintenance works are very important aspects of a maintenance strategy. The satisfaction of these requirements depends mainly on the technical solution in the final plan.

One of the factors which most influences the cost and effectiveness of maintenance work is the ease with which maintenance staff can gain access to areas in need of maintenance works. Difficulty of access to specific parts of a building very often

prejudices the regularity, if not the possibility of check-ups. It also makes maintenance work more difficult and expensive.¹³ The choices made at the design stage will play an important role with regard to this and will contribute to the possible maintenance level of building in a significant way.

There are many technical solutions which can satisfy this type of requirement. They should generally be evaluated, both from a technical and an economic point of view, in relation to the type and use of the building.

The reduction of interface in maintenance activities can be achieved by eliminating or, where this impossible, simplifying maintenance works which require specialised labourers over and above normal maintenance workers.

Recording information or selecting data which will be useful to maintenance technicians requires the identification of these sub-systems which, depending on execution techniques or use destination of the building, will be more subject to obsolescence and thus the object of more substantial maintenance activity.

The information could be based on the elaboration of documents, already carried out in the design stage and subsequently completed during construction work, containing all the information necessary for the technical management of maintenance work. The documents should contain procedures for disseminating parts, recommendation regarding products, spare parts and materials to be used during maintenance works, and products and suppliers to be contacted for reparation and replacement materials.

¹³ C. Terpolilli, *Maintenance planning and quality control criteria at the design stage*, University of Florence, Italy

These documents will constitute the basis of a “Technical Section” to be inserted in the building’s maintenance manual.¹⁴

¹⁴ C. Terpolilli, *Maintenance planning and quality control criteria at the design stage*, University of Florence, Italy

Chapter 5

Integrated Computer Software

5.1 Introduction

There has been major development in the use of computerised software packages in the design, construction and maintenance of buildings. This chapter will describe the development of computer software products for building design applications and the capabilities for the design of various elements of building services.

5.2 Integrated Building Design Software

Software companies have been developing their products for building design applications for many years. Intergraph Corporation for example, has developed many software packages such as Project Architect, Project Layout, Project Engineer HVAC and Project Engineer Electrical at a relatively low prices and run on different computer systems.

Project architect is a full-function software that supports and automates the entire architectural workflow from schematic design to construction documentation. It helps architects complete projects more quickly, accurately and consistently. Project Architect also generates full 3D models to create high-quality images and animation for presentations.

Project Architect Model captures all design and construction information throughout the design phase of a project and constructs the building data in a central database and control the presentation of information; users can view drawings in plan, side, isometric or perspective views.

Project Layout helps designers lay out and track space, occupants and furniture, fixtures, and equipment in virtually any type of facility. The application helps designers work more efficiently by automating the entire workflow.

Project Engineer Electrical automates layout and analysis of electrical systems. Information from project Architect and other building services applications can be accessed by PE Electrical for co-ordinating projects from beginning to end. Architectural floor plans, reflected ceiling plans and equipment layouts can be used as reference files.

Project Engineer HVAC provides extensive capabilities for the design of air distribution systems. The application assists engineers in laying out and designing duct systems in 3D, accurately sums air flows and performs duct-sizing and pressure drop calculations. The integration of PE HVAC with other building services application allows the creation of a complete environmental control systems for commercial, industrial and institutional buildings. HVAC engineers can work interactively with architectural drawings to accurately place ducts and equipment for heating, refrigeration and air distribution.¹

5.3 The Data Exchange System

The primary requirement of the Data Exchange System is to hold a persistent model of any building, and to be able to extract data from this model which should be held in a robust object database management system suitable for implementation and real use in a commercial building design environment. It should exploit state-of-the-art object technology but not make new research development in this area.

¹ *Intergraph ships Integrated building design software , Internet/netscape/bdmship.htm*

5.3.1 Design Tool Interfaces

The concept of the integrated Building Design System is one of a series of computer design tools, exchanging data in a common format via a central integrated data model. It is assumed that each of these design tools is an existing software package commonly used in the construction industry. The strategy adopted is one of adding an interface onto a design tool so that it can read and write the standard format building data required by the central integrated data model and map this to and from the internal representation of the design tool.

5.3.2 View Integration

Building design is a long process which might last for weeks, months and even years. It involves a design team of which each member is responsible for certain stages of the design process. Because each member of the team only deals with a sub set of the design problem, he or she normally has a partial view of the building description. For example, after the building layout is basically described, the HVAC engineer might start the design of the heating and cooling system while the architect works on the construction, specification, etc. Although they each develop specific areas of the design, some of the information they manipulate such as the building geometry will be shared. During the design period, these partial views of the building must be merged together to form a single coherent building model which must be stored persistently and be readily retrieved when needed. This determines the requirement to maintain a consistent building design model and to support the growth and population of this model through the integration of partial views.

5.3.3 Change Management

If the architect feels the need to make changes to the building layout, it makes sense that the HVAC engineer should be informed to halt the heating and cooling work, since they will have to be re-designed as a result of the building geometry changes. Although this communication can be done by personal contact between the architect

and the engineer involved, in a computer based design support system a degree of automation in the management of change and resolution of conflict is expected. This determines the requirement of the Data Exchange System to provide the underlying support for change management and conflict prevention.²

5.3.4 Design Versions

An essential feature of any design process is the requirement to explore alternative design solutions. The system must allow each of the designers to take a version of the design at any stage. These versions will develop independently and at some later date need to be merged so that there is always one coherent version of the design. To achieve this, it is necessary to be able to branch off one or more design solutions and to merge branches at a later date when a satisfactory compromise has been determined. The Data exchange system is required to support design versions which requires more than one instance of the same object, e.g. building, room, wall to coexist in the same data repository system.

5.3.5 Design History

As the design develops it is also necessary to keep track of these versions so that at any point it is possible to review the design history trail, to examine the decision making process and to rollback to an early consistent state of the design, This mechanism is also needed to allow the comparison of alternative design options. This

² *Combine 2, Department of Architect at Newcastle University & Department of Civil Engineering at the Technical University Delft, the Netherlands, Internet/Netscape/News/Data Exchange System*

is the last Data Exchange System requirement, to audit the evolution of the building design or to manage the design history.³

³ *Combine 2, Department of Architect at Newcastle University & Department of Civil Engineering at the Technical University Delft, the Netherlands, Internet/Netscape/News/Data Exchange System*

Chapter 6

Successful Integration

6.1 Introduction

This chapter discusses the elements that is required for successful integration of building teams. It explains the roles and interrelationships among the highly differentiated operating units, and the techniques and procedures that are required .

The management style, human and social skills, and the use of computers for successful integration are discussed..

6.2 Roles and relationships

The organisation and management of a building project require the co-ordination of a large number of highly differentiated operating units whose roles and interrelationships may change over a relatively short period of time. It is this organisational setting that provides the framework for successful integration. Since the Main contractor and the Services Subcontractor are two such operating units, their differences can be summarised with regard to the following factors:

1. The nature of work they carry out.
2. The amount of time they spend on the project
3. The way in which they are organised.
4. The backgrounds, attitudes and experiences of their work forces.

These differences have to be recognised, and an appropriate set of roles and relationships be created in order to accommodate them. This can be done by designing a formal organisational structure in the following way:

1. Determine the objectives of project, both in overall terms and specifically in relation to the requirements of the building services installation.
2. Create a project task-force to achieve these objectives using a matrix organisation structure. This is a dynamic organisation in which project team members report directly to the project manager on all matters relating to the project and communicate with superiors in their own organisation on other issues not relevant to the project.
3. Produce flexible job descriptions in which roles overlap thus encouraging integration. This should help overcome the problems of conflicting loyalties of the Main Contractor's and Services Subcontractor's staff and result in a communication network which will keep all members of the project better informed.¹

6.3 Techniques and procedures

An important requirement for successful integration is an effective production-planning system. Because of the complex interrelationship between the services work and the remainder of the work, such a system should be based on network planning. This is a technique which demands that the interrelationship of the services and building work can be given serious consideration during the planning stages of a contract; it subsequently provides management with accurate information regarding the effect of any delays or changes that effect either the building work or services work.

There are, however, many situations that are difficult to programme in any detail. These can be coped with by a careful use of meetings, both formal and informal. This facilitates two-way communication and allows group decision-making, both of which

¹ Parton P K, *Building Services Integration*, E FN Spon(1983), pp. 120-130

are useful in resolving integration problems. Such meetings should complement the formal site meetings attended by all members of the project task force and should concentrate solely on matters relating to services integration.

The procedures necessary for successful integration can be divided into:

- 1) Production-planning procedures
- 2) Information flow procedures
- 3) Legal procedures

(a) Production-planning procedures

A production-planning system based on network analysis is necessary for successful integration. It needs to be incorporated into appropriate set of procedures if the system is to be completely effective. These procedures consist of:

- 1) The accumulation of pre-tender report used in conjunction with an outline programme. These can then form a base for initial negotiations with the Services Subcontractor if the Main Contractor is successful with his tender.
- 2) The preparation of a master programme, before work commences on site. This programme should clearly show the interrelationship between the services work and the remainder of the work. Milestones should also be indicated for subsequent monitoring purposes.
- 3) An initial meeting between the Main Contractor and the Services Subcontractor to establish formal communication, attendance and other operational requirements.
- 4) The formulation of short-term programmes by both the Main Contractor and the Services Subcontractor abstracted from the master programme and which can be used as a control document for reviewing progress and act as a focal point for discussions at meetings.

b) Information flow procedures

The flow of information between the Architect, Main Contractor, Services Consultant, and Services Subcontractor is another key factor in successful integration. The formal channels of communication for information need to be supplemented by informal communications in order to make the system dynamic. The most common type of informal communication in relation to services integration is between the Services Consultant and the Services Subcontractor. This is very useful if technical problems arise since both parties talk the same language. Apart from the flow of technical information, there are other matters that affect services integration. Conflicting information on architectural and services drawings are common to most projects.

In addition to the technical information, there are other types of information to be communicated, e.g. information about task requirement, problems and resources. Such information relates to production and should be directed through the formal channels since the Architect and the Main Contractor are the major parties involved in any decisions on these matters.²

6.4 Managerial style

Successful integration demands human skill and energy which can be vital to the technical success of the project. The matrix organisation takes account of informal relations between the Main Contractor, Services Subcontractor, Architect and Services Consultant. However, a manager's social skills need to be used in conjunction with this framework.

These human and social skills, or managerial style, include the art of leadership, the ability to motivate and the appropriate use of power. Their use is vital if the co-operation of the Architect, Main Contractor, Services Consultant and Services Subcontractor is to be obtained. Without this co-operation, integration is virtually

² Parton P K, *Building Services Integration*, E FN Spon(1983), pp. 120-130

impossible. Co-operation is hampered by the differences between operating units. Moreover, the Main Contractor has little control over many factors affecting the motivation of the Services Subcontractor's operatives. Similarly, the site manager has very little chance to exert any power over the Services Subcontractors apart from personal power.

These obstacles can be overcome by obtaining the commitment of the Architect, Services Consultant, Main Contractor and Services Subcontractor to the project goals and by emphasising that these goals can satisfy everybody's needs. A democratic leadership style, in which Services Specialist are involved in all decisions relating to services integration, will assist in obtaining their co-operation. Other means, such as sanctioning prompt payment to the Services Subcontractor, understanding the needs of operating units, becoming more knowledgeable about the Services Subcontractor's work and the technology and skills it demands, all contribute towards successful integration.³

6.5 The use of computers

The use of computers holds the key to overcome co-ordination problems. The following are some of the areas in which computers can assist integration:

1. Network analysis packages
2. Word processing
3. Information retrieval packages
4. Project database
5. Computer-aided design

³ Parton P K, *Building Services Integration*, E FN Spon(1983), pp. 120-130

6.6 Guidelines for successful integration

Services integration is both complex and a major source of problems on the majority of building projects. Similarly, it should be obvious that there is no easy solution. However, it is possible to establish certain guidelines that, if followed, will assist in achieving successful integration. The guidelines can be summarised as follows:

1. Create a matrix organisation structure that incorporates the appropriate formal communication channels required by the contract yet encourages a network of communication within the project team.
2. Produce long and short-term production programmes based on network planning preferably with the aid of a site based computer.
3. Maintain appropriate records and store on a site-based computer for ease of retrieval as required.
4. Complement these techniques and procedures by regular meetings between the Main Contractor and the Services Subcontractors.
5. Adopt a democratic style of leadership and attempt to obtain the commitment of the Services Subcontractors to the goals of the project. Similarly, take advantage of any informal communication that arise on a project.
6. Take advantage of computer applications particularly in relation to a project database and computer-aided drafting. ⁴

⁴ Parton P K, *Building Services Integration*, E FN Spon(1983), pp. 120-130

Chapter 7

Survey Analysis

7.1 Introduction

This chapter describes the objectives of the survey, the methods followed for collecting the data, the problems and difficulties which were encountered. The structure of the survey's questionnaire and the criteria for selecting the organisations that participated in the survey are described.

The questionnaires, which have been sent to Architects, Project managers, Consultants, Main contractors and Building Services contractors covered the client's awareness of the importance of design brief and project's Total Life Cycle, the role of various parties in the design, construction and maintenance of construction project, the level of integration and how to improve it during different stages.

The survey analysis was then carried out and concluded with statements of findings which are illustrated by tables and graphs.

7.2 Objectives of the Survey

This study is comprised of two parts . The first part which consists from chapters 1 to 6 covers the literature review on the Integration of Building Services teams. The second part of the study is the survey, analysis and recommendations. The objectives of the survey are to approve or disapprove the hypothesis made and which are listed in Chapter 1.

The survey is aimed to find the following:

1. The Client's awareness of the importance of design brief and project's Total Life Cycle.
2. The relationship between client's dissatisfaction and the level of integration of building services teams.
3. The role of various parties in the design of the project as a whole.
4. The integration of Building Services during design and construction stages, and how to improve the integration.
5. The role of maintenance engineers in construction projects and the integration of Building Services.

7.3 Survey Methodology

There are many methods for collecting data. It can be collected by mail, through telephonic interviews and personal interviews. Each of these methods has some advantages over the other. For example interviews by telephone provide fast response however the interviewees may not have the time to clarify their answers. Mail data collection and data received through facsimile provide large amount of data throughout a large geographical area. However the response rate is always poor, and the non-contact nature of this method does not allow for clarifications.

Personal interviews provide the face-to-face contact with respondents. The advantages of this method are:

1. The controversial topics can be clearly understood by respondents and therefore a better response is expected.
2. The interviewer can clarify the questions and ask for more details where needed.

3. The interviewer can insure that the respondents are with appropriate knowledge and experience to reply to his questions.
4. The co-operation of the respondents can be won easily.

There are however some disadvantages in personnel interviews. They are expensive and time consuming. The interviewees also think there are more important matters to attend to and they tend to postpone the interviews many times.

In this survey all methods were used for collecting data. Some organisations were interviewed , others responded to the questionnaire and sent their answers by mail, facsimile and electronic mail. Other organisations have given or clarified their answers and opinions on telephone.

7.4 Sampling

This survey is carried out in Bahrain (Appendix D) and all construction organisations which participated in the interviews or questionnaires carryout their business in Bahrain. The selection of architects and contractors for the participation in the survey and interviews were based on their share of the building industry. Large firms were selected as they have much experience and knowledge, and can provide more valuable contribution to the survey by their involvement in design, construction and maintenance of various types of buildings. They are better equipped to handle conflicts and make the necessary changes for better integration of Building Services teams.

Many efforts were made to have responses from as many organisations as possible. Questionnaires were sent to about 100 organisations but only 40 organisations sent their replies and were willing to be interviewed. Some organisations thought that they can not release any information that may not be used in their favour. In their reply, some organisations thought that many aspects of the questionnaire “address information which if disclosed may be detrimental to the capacity of their daily operations”.

7.5 Structure of Survey

Five sets of questionnaires were prepared for five categories of participants in building projects, to avoid any confusion in answering the questions. The five sets were prepared for the following groups of organisations:

1. Clients
2. Architects and Project Managers
3. Building Services Engineers
4. Main Contractors and Building Services Contractors
5. End Users and Maintenance Engineers.

The questions were prepared to provide answers and opinions from different parties to meet the objectives of the survey as mentioned above. Copies of the questionnaires are enclosed in Appendix 1.

7.6 Interview and Data Collection Procedure

Architects, Building Services Engineers, Main Contractors, Building Services Contractors and Maintenance Contractors are selected in addition to major clients to participate in the survey by providing answers to the questionnaires. Larger firms were then approached to allow one of their experienced engineers to be interviewed. Copies of the letters are attached in appendix 2. Questionnaire has been sent to various firms by facsimile and electronic mail, and telephone calls were made to clarify and expedite the replies.

7.7 Survey Analysis.

The data and information which were collected from interviews, telephone calls and replies received through mail or facsimile have been analysed as follows. Findings are stated at the end of each section of the analysis.

7.7.1 Feasibility study & Total Life Cycle

a) The Client and the Building Total Life Cycle

The project life cycle is the evolutionary process or series of identifiable phases through which the project must pass as it develops. The fifteen phases of the Total Life Cycle for construction projects has been identified by RIBA plan of work as follows:

1. Inception
2. Feasibility
3. Briefing
4. Outline proposal
5. Scheme design
6. Detailed design
7. Production information
8. Tender action
9. Tender reporting
10. Tender acceptance
11. Construction
12. Completion
13. Hand-over
14. Use
15. Feedback

In order to identify the awareness of the clients and buildings' users of the complete life cycle of the project and all the phases through which the project must pass as it develops, Clients were asked if they have considered the total life cycle cost of the project before starting the design work and what were the effects of this on their projects.

From the survey carried out, only 32% of the clients said that they have considered almost all phases of the total life cycle before the start of the design work and 68% said that they have not. Clients who have not considered the total life cycle of their projects were asked of the problems they have experienced due to their negligence of the total life cycle. From those who have not considered the TLC, 32% said they experienced high operational and maintenance costs and that their main concern during the design stage was the capital cost of the engineering systems. 24% said that the Plant replacement cycle was shorter than they had expected, 12% said that have difficulty in making alteration and expansion to their projects and they would have chosen a different system to allow making expansion to their project easier and with minimum cost. 20% said that they would prefer to have better control on the operation and environmental conditions inside their buildings and only 12% said that they do not experience any problem. Figure 7.1 illustrates the buildings problems for not considering Total Life cycle of building.

b) Client and Feasibility Study

When clients were asked if they have carried out feasibility studies before employing an architect or project manager to carryout or manage the design of their projects, 45% of the clients said that they have carried a feasibility study before employing an architect and consultants to design their projects. 55% of clients said that the architect or the project Manager had carried out the feasibility study and 20% of clients said that neither themselves nor the architect carried out feasibility studies for their projects.

The survey results showed that only 32% of the clients have considered almost all phases of the total life cycle and that only 45% of clients said that they have carried out an independent feasibility studies before employing architects to design their projects.

The Inception, design and construction stages are relatively very short if compared with the total life of the building. It is very important that the Client considers the

running and maintenance costs of the building as these form the biggest part of the total building cost. The client must seriously consider and select the most suitable building services systems for his use taking into account the total life cycle of the building.

The inexperienced client may select an air-conditioning system which is not very expensive in its capital cost but turn to be very expensive in its running and maintenance costs.

PROBLEM	% OF CLIENTS
HIGH OPERATIONAL AND MAINTENANCE COSTS	32
SHORT PLANT REPLACEMENT CYCLE	24
DIFFICULTY IN MAKING ALTERATIONS	12
NOT VERY GOOD CONTROLS	20
NO MAJOR PROBLEM	12
TOTAL	100

TABLE 7.1: EFFECTS OF NOT CONSIDERING TOTAL LIFE CYCLE DURING DESIGN STAGE

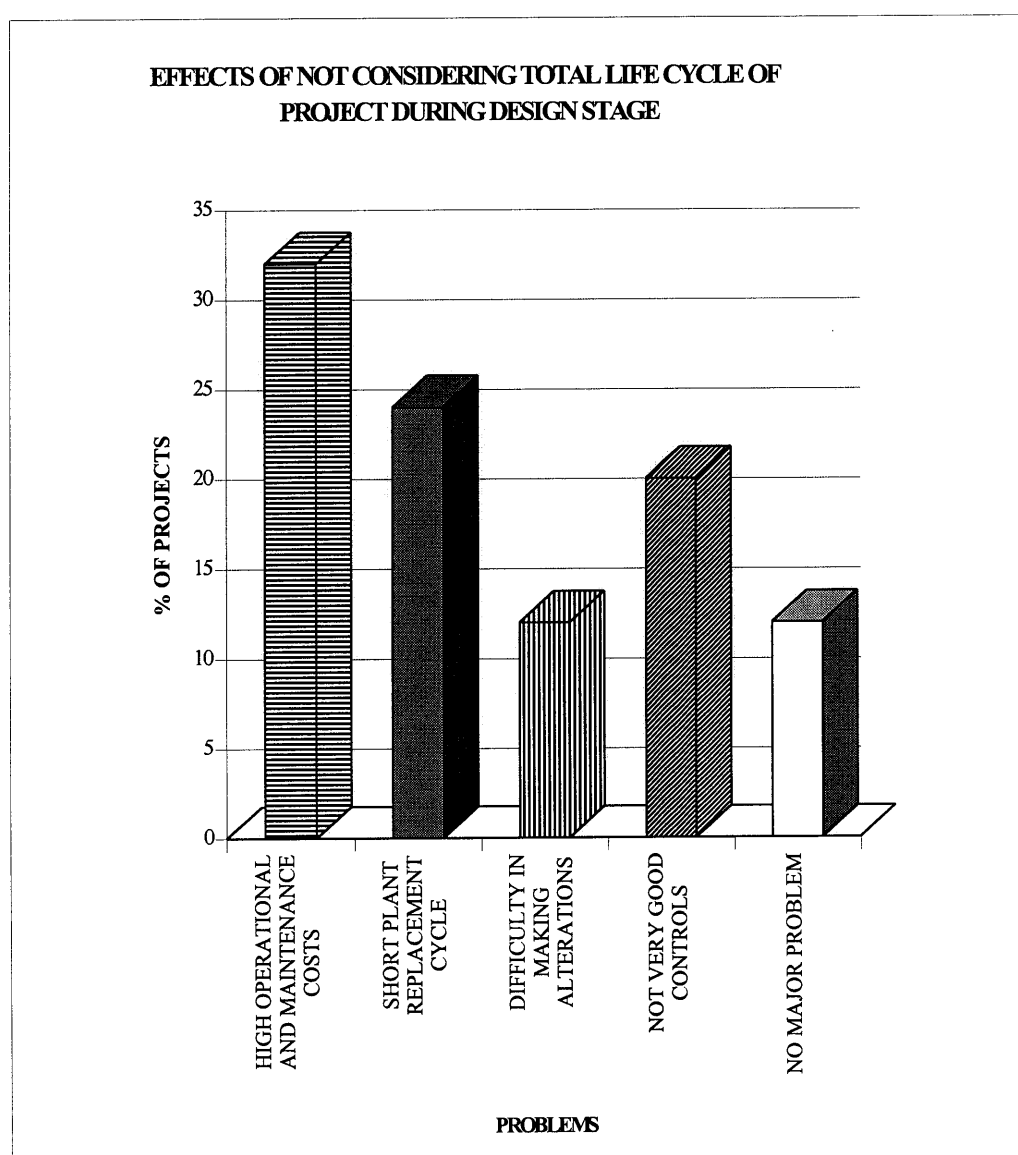


FIGURE 7.1: EFFECTS OF NOT CONSIDERING TOTAL LIFE CYCLE DURING DESIGN STAGE

7.7.2 Project Design Brief

Clients are often blamed for most of the problems in the construction industry because they keep changing their requirements during design and construction stages. In this survey Clients were asked if they have prepared a comprehensive design brief for their projects and have these design briefs included mechanical and electrical requirements.

The survey showed that 60% of the clients said that they have prepared a comprehensive brief for their projects which include mechanical and electrical works. 16% of the clients said they have not prepared brief for mechanical and electrical works and left that to the architects and consulting engineers and 24% of clients said they have not prepared any brief as such for any work and left that to the architects to bring ideas and concepts .

Architects and Consulting engineers were asked if the design briefs submitted by the client were adequate and if mechanical and electrical works requirements were included in the design brief.

Architects said that there are three types of Clients; Corporate Clients who have built many buildings before and the project is just another building. They usually have their own maintenance teams that are responsible for the maintenance of existing buildings. In most cases such clients involve their maintenance engineers in writing the design brief of the project which includes the mechanical and electrical systems. The survey results show that the architects said that only 30% of the clients submit comprehensive design briefs which include mechanical and electrical requirements. The architects said that 50% of the Clients do not think that the maintenance team can participate effectively during the design stage. The clients' main concern at the early stage of the project is for the aesthetic appearance and the architectural aspects of the building. These clients do not provide brief for the mechanical and electrical systems.

First time clients are normally open to concepts and ideas from the Architects and Consulting offices and there is no participation or advice from any other party. The survey concluded that 20% of the clients do not submit any brief and come to architects for ideas and suggestions.

The survey showed that while 60% of the clients thought that they have prepared a comprehensive brief for their projects, architects said that the clients who really submit a comprehensive brief which include mechanical and electrical works only represent 30% of the clients. Clients' lack of basic knowledge in the engineering services field is the reason for not providing any or adequate brief for the building services. The clients should understand the advantages and disadvantages of various systems of building services in terms of capital and operation costs in order to avoid any problem in the future. Clients' maintenance engineers if available must participate to provide the design brief or assist in writing the brief of the building services as they are the best personnel who know what are the clients main requirement in this regards and can advise the clients to make the necessary changes or additions to the systems.

7.7.3 Procurement Method

Clients and Architects were asked of the procurement method they have followed in a particular project, and the criteria that they have considered before deciding which procurement method to follow.

The traditional procurement method was the most followed method. Design and Build procurement method has a great integration advantages but it is not favoured by the clients as it is normally lead to higher costs. Project Management method was followed in only very few specialised projects

90% of the clients followed the Traditional procurement method, 5% followed the Design & build, and 5% followed the Project management. 70% of Clients said

that their first priority was cost, 20% said time and only 10% said quality was their first priority

The Architect or Consultant normally provides the Main contractor with a list of approved Services Sub-contractor to bid for the Building Services system and enter into contract with the Main contractor at a later stage.

Although Design and Build procurement method are rarely used for the whole project, it is widely used for the procurement of Building services systems of the buildings. For example, Air-conditioning contractors are often asked to bid for the design, supply, installation and commissioning of Air-conditioning systems. Similarly, Electrical contractors are asked to bid for the design, supply, installation and commissioning of the electrical and lighting systems.

The survey results show that Building Services contractors have designed and build the Building services systems for 64% of the projects they have participated in, while in 36% of projects the building services contractors have only supply, install and commission the building services systems but have not designed the systems.

The design and build procurement method in which the contractor is responsible for the design and build of Building services systems eliminates many co-ordination problems that is often experienced between the designer and the contractor in traditional procurement method. The Design and Build method provides the client with a single point of responsibility for both the design and installation works. However, the Main contractor or Project Manager may have to co-ordinate and integrate the design of the many Building services sub-contractors participating in the project such as Air-conditioning contractor, Electrical contractor, Plumbing contractor, etc. as each of these contractor is responsible for the design and build of his system only.

7.7.4 Project cost & Building Services

Buildings are becoming more complex as Clients' requirements changes to better and more complex building services systems. In this survey, Clients were asked if their projects actual costs exceeded their budgets and what were the reasons for the difference between the budget and the actual cost

80% of the clients said that their projects have exceeded their budgets by more than 10%, and 20% of the clients said that their projects were within their budgets or they have exceeded their budget by less than 10%.

In the overspent projects, clients were asked for reasons of the overspent. 60% of the clients said that their project overspent was due to some variations in the building services requirements, and 30% of the clients said it was due to changes in the architectural requirement. Only 10% of the clients said there were no additional variations but the overspent was due to original under estimate.

The share of building services costs in the total cost of building projects is increasing. Clients were asked of the costs of the building services as a percentage of the total cost of the building.

In the projects selected for our study , the Building services works represented between 20% and 30% of the total cost of project for 75% of the buildings . The building services represented more than 30% for 10% of projects and it represented less than 20% for 15% of projects. Figure 7.2 illustrates these findings.

Bahrain is a hot and humid country and has long summer seasons when cooling is needed for seven months from April to October. The ambient temperature in summer reaches more than 44 C. The capital costs of cooling equipment are much higher than those for heating equipment and this makes the cost of building services share in the total cost of the building relatively higher than many other countries. For an average

building, the simple Air-conditioning cooling system can represent more than 15 % of the total cost of the building.

Care must be taken in deciding and selecting the building services systems as these represent a large percentage of the total building cost. Recent studies carried out in the United Kingdom has indicated that Building in the United Kingdom costs more than those similar in other countries due to what was called “ Over-Engineering”. The study revealed that there were exaggeration in the complexity of Building services systems ,which contributes in expanding the cost of the building, and that the buildings can do with a simpler, more economical systems. On the other hand there are buildings which are not very effective because the design of their building services systems were inadequate and over simplified that they do not match the clients’ or occupants requirements.

COST OF BUILDING SERVICES TO THE TOTAL PROJECT COST	% OF PROJECTS
LESS THAN 20%	15
BETWEEN 20% AND 30%	75
MORE THAN 30%	10
TOTAL	100

TABLE 7.2 : THE COST OF BUILDING SERVICES IN BUILDING PROJECTS

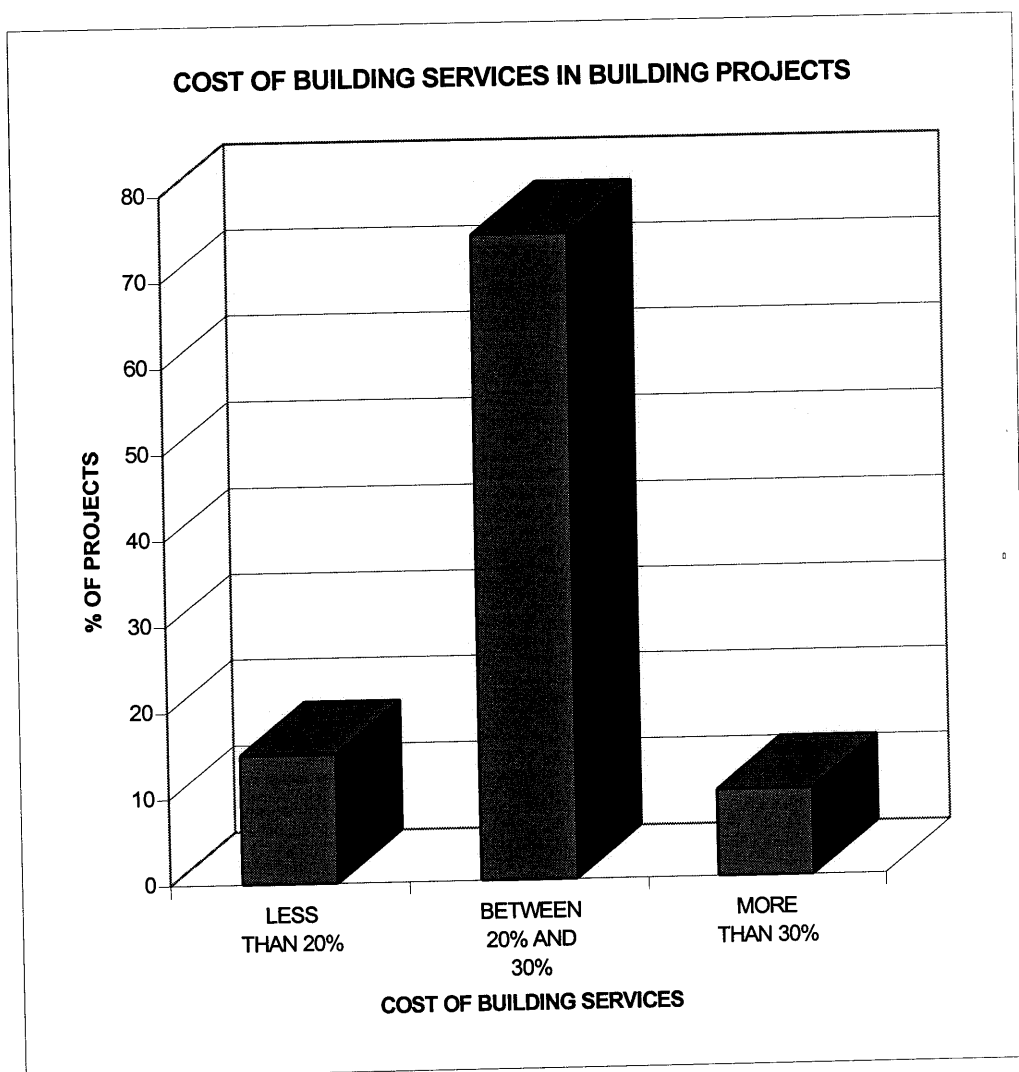


FIGURE 7.2 : THE COST OF BUILDING SERVICES IN BUILDING PROJECTS

7.7.5 Post completion Dissatisfaction

In this survey, Clients and building occupants were asked after the completion of their projects if they were satisfied with their buildings and what were the problems or the reasons for their dissatisfaction, if any, and how these were solved or can be avoided in the future.

It was found that 76 % of the Clients' or Users' dissatisfaction were for reasons related to Building services as compared to only 24% for architectural reasons. 35% of the clients were not satisfied due to deficiencies in cooling or heating systems, 6% of clients complained of inadequate ventilation , 12% complained of inadequate lighting, 18% of clients complained of inadequate water flow and pressure, and 5% of clients were not satisfied with the temperature of the water services system. Only 24% of occupants complained of elements related to architectural design or installation such as sizes of windows, narrow corridors, flooring, and low ceilings.

The survey findings support the hypothesis that Most of clients and buildings' occupants dissatisfactions are for reasons related to building services

Figure 7.3 illustrates the elements of Clients' dissatisfaction and their percentages as collected from the survey.

REASON FOR DISSATISFACTION	BUILDING SERVICES	ARCHITECTURAL
INADEQUATE COOLING OR HEATING	35	
INADEQUATE LIGHTING	12	
INADEQUATE VENTILATION	6	
LOW WATER PRESSURE OR FLOW	18	
LOW WATER TEMPERATURE	5	
LOW CEILING		6
INADEQUATE ROOM SPACE		7
INADEQUATE WINDOW SIZE		6
POOR QUALITY FLOORING		5
TOTAL	76	24

TABLE 7.3 : REASONS FOR CLIENT'S DISSATISFACTION IN BUILDINGS

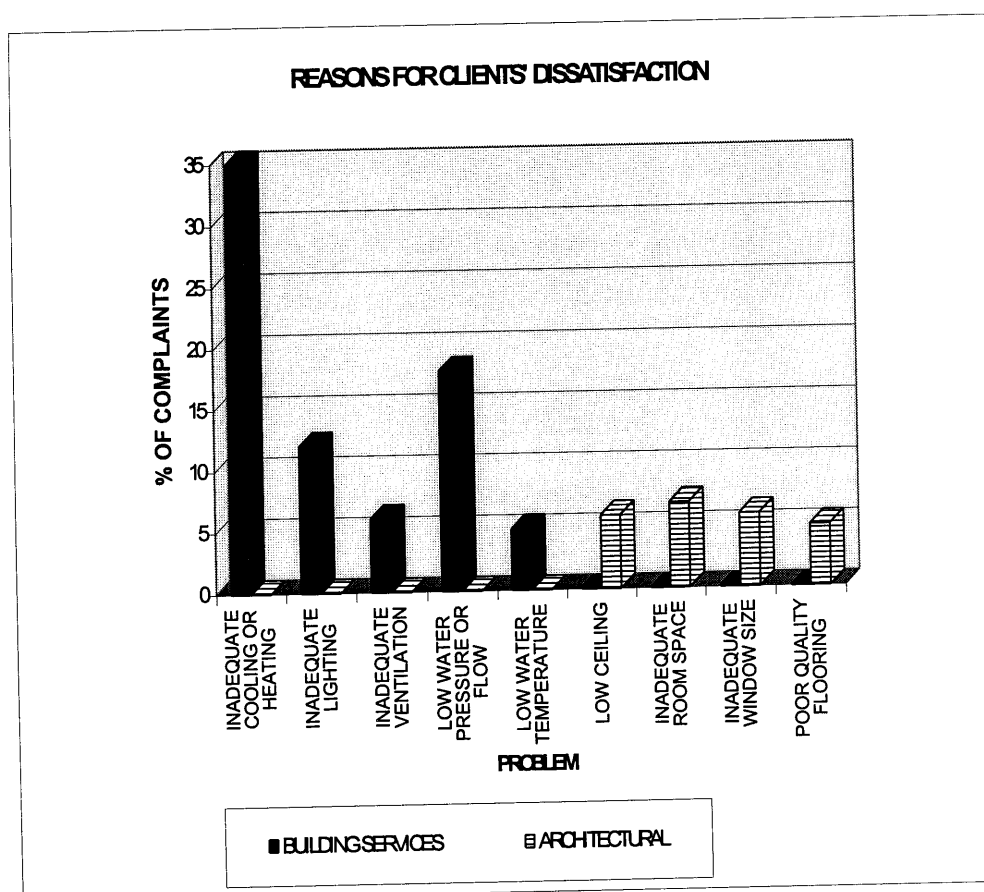


FIGURE 7.3: REASONS FOR CLIENT'S DISSATISFACTION IN BUILDINGS

7.7.6 Integration and User's Satisfaction

Clients usually prefer to deal with one party or contractor to carry out all works as they think that this will minimise the co-ordination problems and put the responsibility on one party, avoiding any conflicts in this regard.

In order to identify the relationship between users satisfaction and the level of integration of building services design and construction teams, Clients were asked questions on their satisfaction with the project in terms of the three stages of design, construction and occupation and if there is a relationship between their satisfaction and the integration of building services design and construction teams.

It was found that clients are most satisfied when there is only one contractor co-ordinating and integrating all works carried out by other contractors and Subcontractors. The more the contractors on one project the more the possibility of conflicts and therefore dissatisfaction of Clients.

Clients prefer to have one Subcontractor for all building services work but this is almost impossible. In Bahrain the Building industry organisations usually specialise in only one field such as Air-conditioning, Electrical or Plumbing. This forces the architect or project manager and sometimes the client to deal with many contractors. In recent years Air-conditioning contractors begun to carryout Plumbing work as there is a similarity in the two types of work; Air-conditioning system such as Chilled water systems have a lot of piping and plumbing work. Also Civil or Main Contractors now carryout plumbing work, as this does not require much expertise and is relatively simple if compared with other Building Services works.

In some small projects, the clients may enter into a contractor with a Civil contractor to carryout the civil part of the building and, at later stages, enter into contracts with other contractors to perform the air-conditioning, electrical, plumbing and other works. In this case the client carries out the co-ordination of the work of the various

parties. These were the areas where most problems and conflicts experienced and where the most dissatisfied clients were found.

Clients were asked about their satisfaction with the progress of the work in their projects, the conflicts experienced, the number of contractors working in their projects and the party who has carried out the co-ordination work.

The survey shows that 68% of the clients were very satisfied with their projects when there were only 2 contractors on site. Only 20% of clients were very satisfied when 5 or more contractors worked on their projects. Figure 7.4 shows that the number of very satisfied clients increases as the number of contractors on site decreases and vice versa.

Figure 7.5 shows that Clients were most satisfied when the co-ordination is carried out by the Main contractor and they were least satisfied when they have to carry out the co-ordination work themselves. The survey findings show that 76% of clients were very satisfied when the co-ordination work is carried out by the main contractor and that only 44% of clients were very satisfied when they have to do the co-ordination work themselves.

NO. OF CONTRACTORS ON SITE	2	3	4	5 AND ABOVE
UNSATISFIED CLIENTS	12	16	28	36
SATISFIED CLIENTS	20	28	32	44
VERY SATISFIED CLIENTS	68	56	44	20
TOTAL	100	100	104	100

TABLE 7.4 : RELATIONSHIP BETWEEN CLIENT'S SATISFACTION AND NUMBER OF CONTRACTORS ON SITE

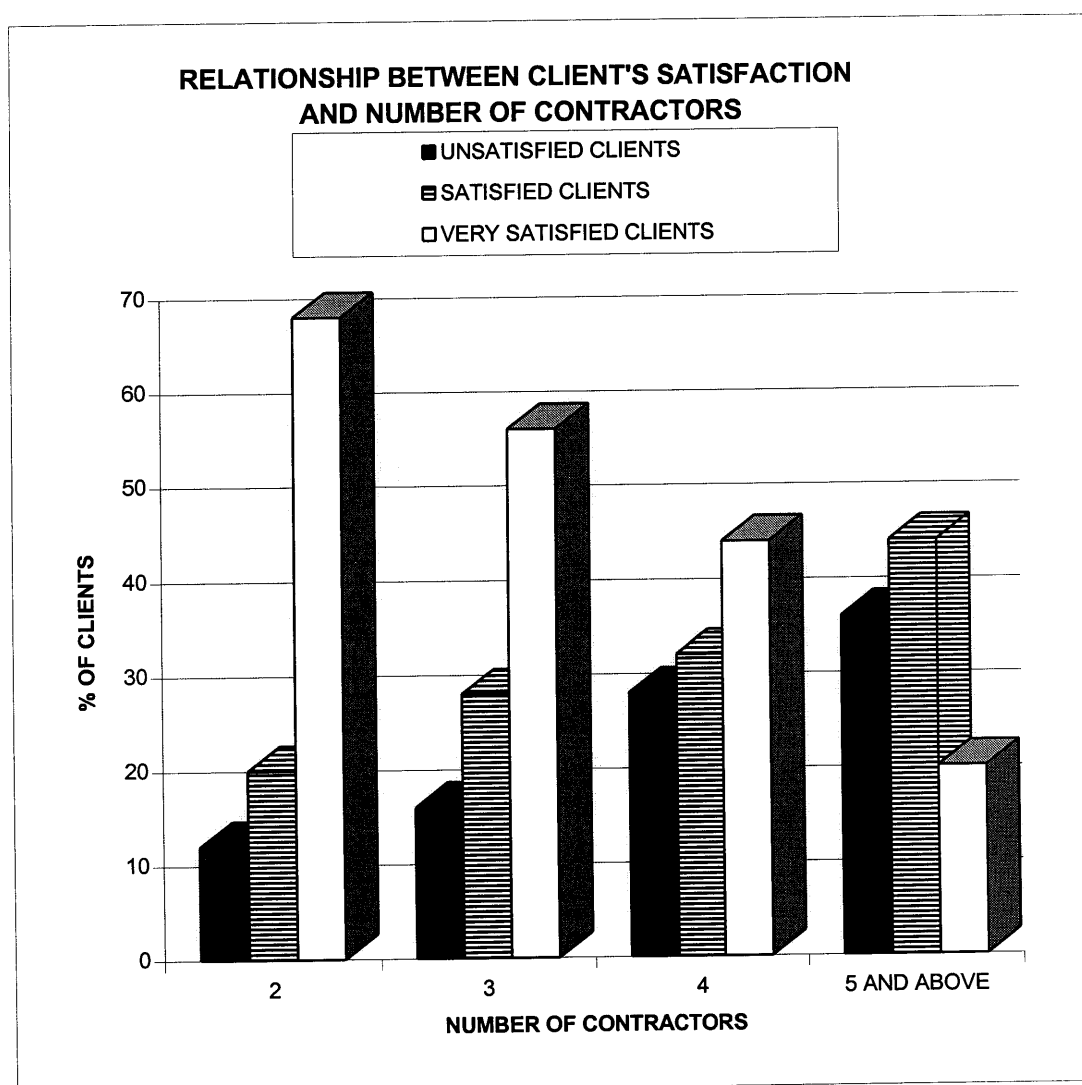


FIGURE 7.4 : RELATIONSHIP BETWEEN CLIENT'S SATISFACTION AND NUMBER OF CONTRACTORS ON SITE

COORDINATOR OF WORK	MAIN CONTRACTOR	PROJECT MANAGER	CLIENT
UNSATISFIED CLIENTS	8	12	24
SATISFIED CLIENTS	16	24	32
VERY SATISFIED CLIENTS	76	64	44
TOTAL	100	100	100

TABLE 7.5 : RELATIONSHIP BETWEEN CLIENTS SATISFACTION AND COORDINATOR OF WORK

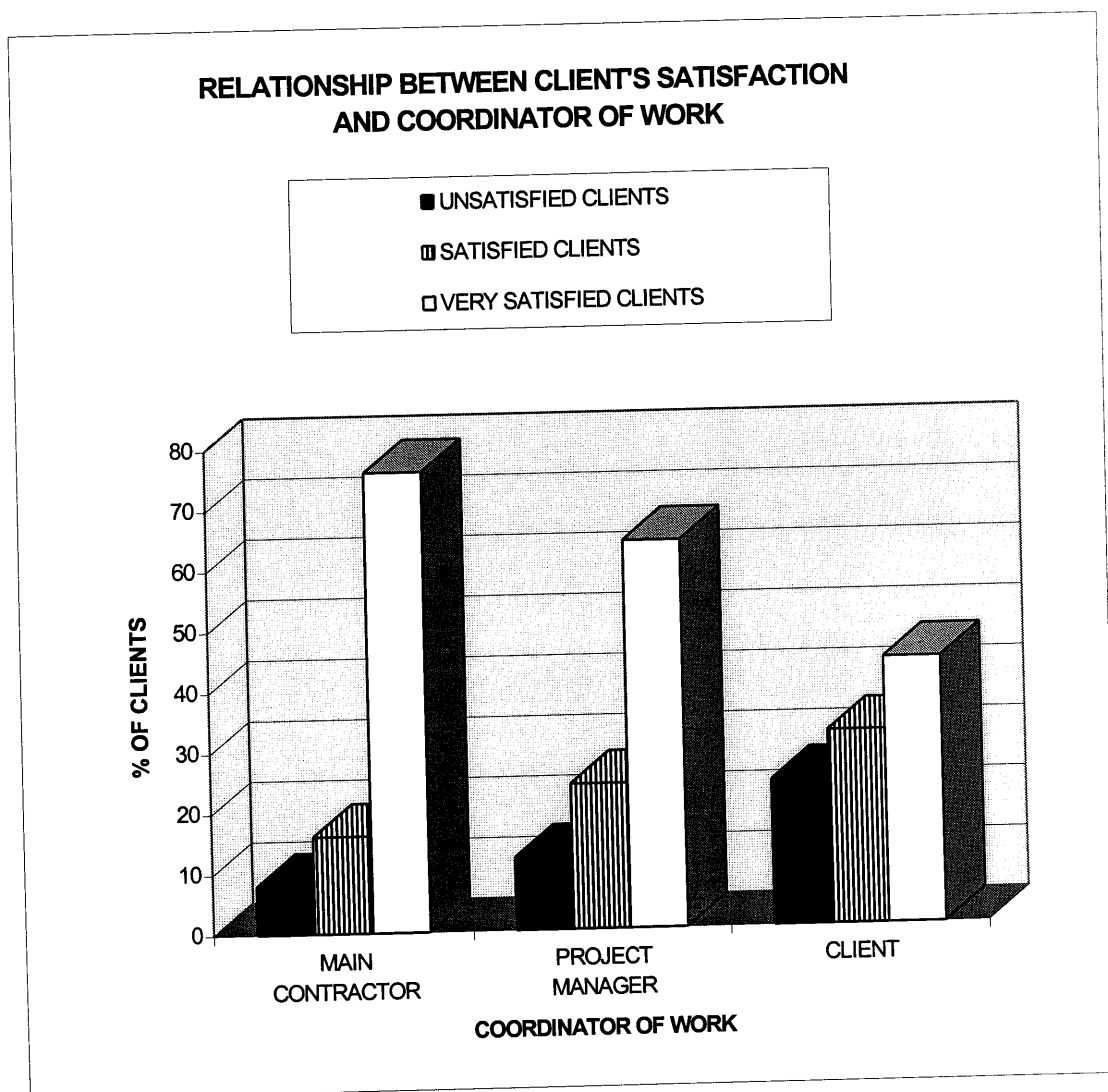


FIGURE 7.5 : RELATIONSHIP BETWEEN CLIENTS SATISFACTION AND COORDINATOR OF WORK

7.7.7 Participation in Design

One of the most common problems of integration in the Building Industry is that caused by the late participation of Building Services Engineers in the design process. They are often not invited early to participate and this discourage their valuable contribution in avoiding or solving the building problems.

Architects and Project Managers were asked when have they invited the Building Services Engineers to participate or advise on the building design.

In Bahrain, Specialist Building Services Consultant offices are very few. The Engineering offices normally have Architects as well as Building Services Engineers who design the building services systems. The multi-disciplinary design offices with architects and building services engineers in the same office have helped in the early participation of building services engineers in the design process. In these offices, at the concept stage, the building services engineers have participated in advising on the type of Air conditioning systems and locations of chillers and Air Handling units.

Building Services Engineers in these offices do not normally produce detailed designs and it is very common that Building Services Contractors develop the design and produce the working drawings for the consultants approval.

The Building Services Engineers were asked if their participation in the design process was late and have they been able to participate effectively in the design process. They were asked if they have been able to change the building layout or concepts to facilitate better building services system design, installation or maintenance.

The survey results showed that almost all Building Services Engineers thought that their invitation to participate in the design was late because it is a normal practice that the services engineers start after the architectural design is approved. The Building Services Engineers, however, said that they have been able to participate effectively

in the design process. None of the Building Services Engineers said that he was able to change the original building layout for better building services system design, installation or maintenance.

The survey findings support the hypothesis that Services consultants are still not invited early . However most of the Services consultants thought they had no major problem although they could not participate effectively in the overall design of the building.

When Building Services Engineers were asked if they think that Clients' Maintenance teams or engineers can play a role during the design process. 80% of Building Services Engineers thought that it is always beneficial to take all the data and requirements of the clients from the maintenance teams who are in a better position to translate the Clients requirements into proper design briefs.

In Traditional procurement method, it is a common practice in Bahrain that Architects offices employ Building Services Engineers who carryout the design and supervision of Building Services. This facilitates and expedites the design process but discourages the competition in the design of building services. The Consulting offices usually have few and inexperienced Building Services Engineers whose educational backgrounds are either Mechanical or Electrical engineering and not Building Services Engineering. This contributes to the co-ordination difficulty as each member fails to respond sympathetically to the requirement of other members preventing a total design approach. Some Consulting offices also use the available Civil Engineers to design simple building services for small projects.

7.7.8 Conflicts during the Design and construction Stages

Architects and Building Services Engineers, Main Contractors and Building Services Contractors were asked about the conflicts during the design and construction stages, their causes and their solutions.

Building Services Engineers and Building Services Contractors who carry out the design of building services said that most of the conflicts during the design stage occur when the Architect makes changes to his original design which has already been sent to Building Services Engineers or contractors for the design of Building Services without informing them of these changes. Building Services Engineers must be updated and informed of any changes made in the architectural, structural or other services designs as these often have implications on the building services design. Building Services Engineers said that co-ordination meetings, CAD systems and Electronic mail should be used extensively for this purpose.

Main contractors and Building Services Contractors said the conflicts during the construction stage are often occurred when there are discrepancies between engineering drawing and specification. The inadequate design brief from clients and the rush of design often lead to changes and variations during construction which have major consequences on the cost and duration of the project. Uncoordinated design drawings from various systems often cause conflicts during construction stage.

Few Building Services Contractors said that most conflicts occurred due to inadequate consultants' input for co-ordination between electrical and mechanical services, and due to "Clever" contract wording in the contract agreement which put the responsibility for solutions on the contractors. They said that there is disproportional effort and time spent by contractors to solve co-ordination problems.

Contractors said that weekly site co-ordination meetings between contractors, client and consultants will help in solving and avoiding most of the conflicts. There should

be regular co-ordination meetings between the Main Contractor and Building Services Sub-contractors to solve and avoid any conflicts between their systems and personnel.

7.7.9 Method of Producing Drawings

CAD systems are now available on all computer systems including personal computers. They are becoming cheaper every day. There are, however, many organisation in the building industry without such system.

Architects, Building Services Engineers, Main contractors and Building Services Contractors were asked if they have CAD system in their offices, and if not are they going to purchase such system soon, and what are the reasons for their decision.

It was found that 80% of architects offices have CAD systems as compared to 72% of building services consultants, 40% of main contractors and 52% of building services contractors. All architects and building services consultants who do not have CAD systems said that they would purchase such system within one year. Figure 7.6 illustrates the extent of the availability of CAD system in the building industry in Bahrain.

All organisations who have CAD systems said that they have used it extensively in designing and preparing of drawings. Other organisations who do not have CAD systems said that they appreciate the benefits of having such a system, and they are going to have a system within one year. Only few Building services contractors thought that introducing CAD system will need an investment in Hardware, software and training which may not be easily recovered. but they will have to have such system in the future. The survey showed that CAD systems are not very popular among main contractors as only 40% of them had CAD system. Those main contractors who do not have CAD system said that that they do not need it as they are not designers. Although no design work is required from the Main contractor for most

projects, he is required to do most of the co-ordination work of other sub-contractors. He is also required to produce As Built or As installed drawings. CAD system will be very useful in this process where the Design drawing can be only updated rather than redrawn from the beginning.

For the Organisations who have CAD systems, computer files have been used among architects, building services consultants, main contractors and building services engineers and sub-contractors, to edit and modify engineering drawings quickly and effectively. This has helped in speeding up the design process, creating better integration among various elements and minimising conflicts that occur among the various elements of the buildings.

%	ARCHITECT	B.S. CONSULTANT	MAIN CONTRACTOR	B.S. CONTRACTOR
HAVE CAD SYSTEM	80	72	40	52
WILL HAVE CAD SYSTEM SOON	20	28	36	32
DONOT CONSIDER HAVING CAD SYSTEM	0	0	24	16
TOTAL	100	100	100	100

TABLE 7.6 : C.A.D. SYSTEMS IN BUILDING INDUSTRY ORGANISATIONS

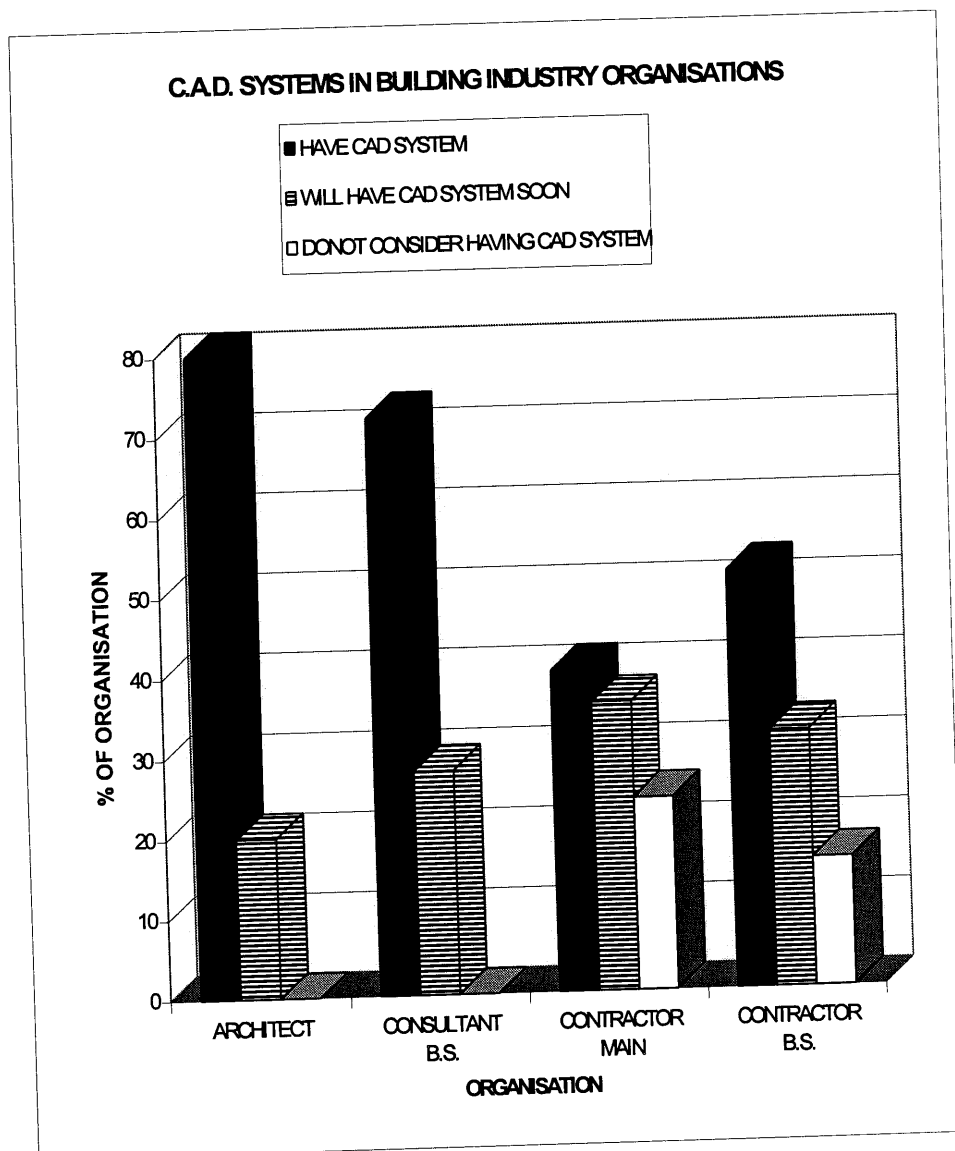


FIGURE 7.6: C.A.D. SYSTEMS IN BUILDING INDUSTRY ORGANISATIONS

7.7.10 The role of Building Services Engineers

Few Services engineers have the will to resist half-backed constraints being placed on them due to the lack of knowledge or understanding of other parties, nor do they argue their case convincingly. Building Services Engineers often change or make changes to their designs and original systems to accommodate architectural requirements and changes, compromising efficiency, ease of maintenance or reliability of the building services systems.

In this survey, Building Services Engineers were asked about the systems they had selected for their building projects and if there were better systems than the one they have designed, and why those were not chosen.

80% of the Building Services Engineers said that there was no better system than the one they had selected for the building . 20% of the Building Services Engineers said that there were better systems than the one they designed for the building and they have been forced to design not very effective systems or made unwise changes by the clients or architects who do not think about or consider, during the design stage, the complete life cycle of the project which includes the operation and maintenance cost over the whole life cycle of the building.

The survey findings support the hypothesis that There is no real co-ordination of building services at design stage and this leads to improper installation and conflicts with other services and systems of the building and cause a lot of delays in sorting out problems which can have an effect on the total cost of the project.

7.7.11 Integration during Design & Construction

Architects, Project Managers, Consultants, Main contractors, Services Sub-contractors, and Maintenance engineers were asked in this survey about the methods used to integrate the design and construction process and how can the integration be

improved during the design and construction stages, in order to produce better buildings in terms of price, time and quality, and solve the problems now experienced in this industry.

Co-ordination Meetings

All parties agreed that in almost all projects there are two types of meetings; Technical meetings and Progress meeting.

There are weekly Technical Co-ordination meetings which are attended by the Architect, Main contractor and all Sub-Contractors. These meetings are normally held at site to report and discuss the progress of work, the percentage of work achieved and the list of queries raised by various parties. There are also monthly Progress Review meetings which are attended by the Client, Architect or Project Manager, and Main Contractor. Sub-contractors do not normally attend these meetings as the Client is only interested to know the progress made and that the project is within budget and on time. He is not interested in detailed technical matters.

Almost all Main Contractors and Building Services Sub-contractors that participated in the survey said that there should always be a pre-planned meeting where all the design team can get together to examine the totality and integrity of the design of building at the design stage, to avoid any difficulties during construction.

Site Offices

In their answers to questions about methods for improving integration during the construction stage, all parties agreed that site offices has always played a very good role in the co-ordination of works carried out by different parties. It is a normal practice in large projects to have a site office for each party of the project team. This facilitates having meetings and answer queries and sort out conflicts as soon as they occur. This has proved to be very effective method in the co-ordination of works that are carried out by different parties, solving and avoiding conflicts quickly and hence

avoiding any unnecessary delays in giving instructions which are often blamed for the project being late and over budget.

Partnering

It is not unusual to see the same Architect, Main Contractor and Services contractors working together on many building projects. This normally creates good understanding, mutual trust and co-operation environment among the parties. All conflict occurred during the design or construction stages can be solved quickly as all parties were ready to provide the utmost co-operation and have trust in each other.

Architects, Building Services Engineers, Main Contractors and Services contractors were asked if they have any preference to work with a particular organisation on projects and the reasons behind that.

It was found that 70% of the organisations prefer to work with a particular party. Mutual understanding between different organisation grows as they work on more projects. Organisations who prefer to work with a particular party said that the other party takes always their interest into account and tries to have the best solution which suits all parties.

7.7.12 Maintenance Teams Involvement in the Building Process

A) Maintenance Teams Involvement at the Design Stage

Clients, architects and even building services engineers do not value, and sometimes even work to eliminate, the participation of maintenance teams in the design process. Many architects and building services engineers think that that the participation of maintenance engineers to have an advisory role at the design stages can delay the

project and increase costs due to the many additional requirements by maintenance teams to facilitate the maintenance in the future.

Interviews were carried out with various parties to identify the advantages and disadvantages of the involvement of maintenance teams to have an advisory role at the design stage.

At the start of the design of the building and even during the construction stage, it is not unusual that the Client does not know who will maintain the building. Clients normally wait until all design and construction works are completed before they invite maintenance firms to bid for the maintenance of their buildings. In this case it is too late for the selected maintenance firm to advise on anything as all design and construction works are completed.

Some clients have their own maintenance departments, and these normally advise on the design of the building especially the building services systems. Their comments usually concentrate on the maintenance aspects of the systems, the spares and the operational costs of the systems. This contributes effectively in providing reliable systems which are not very complicated and which can be maintained without major problems.

Maintenance departments in some organisations prepare design briefs for building services or at least assist and negotiate and influence the selection of the systems taking into account the maintenance and the operational costs of various systems.

In most projects, Clients or Consultants do not invite Maintenance section to participate in progress meetings and this results, in most cases, that the installation has reached a stage where changes can not be done and that the maintenance team has to live with the situation with all its disadvantages and problems.

Clients, project managers, architects and building services engineers were asked if they think that the Client's maintenance team can play a role in the design and construction stages of any project and what are these roles, the advantages and disadvantages of their participation.

The survey results showed that only 25% of clients said that they have involved a maintenance team in their projects. The others said that they do not have a maintenance team but would involve the maintenance team if available in the design and construction stages.

Some Maintenance engineers said that they were discouraged from participating or giving advise during the design and construction stages and that major improvement in the quality and effectiveness of the building services could have been achieved if they had been allowed to participate. They said that they have practical experience in various systems, energy conservation and building management systems fields and they know better than any other party how to maximise the advantages and benefits of these system .

Maintenance Engineers were asked about their participation in the projects. 36% of Maintenance teams said that they have participated in writing the design brief of their buildings, 86% said that they have advised on the consultant's designs, 50% said have assisted in the design, 24% said that they have attended progress meetings, 5% have carried out inspections during construction and 100% of maintenance teams have attended Commissioning and hand over. Figure 7.7 illustrates the results from the survey and interviews.

Almost all clients agreed that Maintenance teams can play a role in sharing their expertise in selecting the equipment and materials particularly in consideration of cost, quality, reliability and durability. They can also assist in monitoring the progress of the project and play a major role during the commissioning and acceptance of the project.

Few clients, however, said the maintenance teams usually have limited knowledge of new products and materials and also their design knowledge is limited and can not depend upon the contemporary of new designs.

Only Few Building Services Engineers, Main contractors and Building Services Contractors mentioned some disadvantages in the participation of maintenance teams. They said that Maintenance engineers sometimes interfere with the work causing delays and requesting unnecessary changes and equipment which only add more cost and delays to the project. Others said that the introduction of new, advanced technology is usually rejected by older generation maintenance personnel who are reluctant to change.

In general, there are many problems caused by the absence of building services maintenance engineers. The participation of maintenance engineers can provide a valuable contribution at the design stage and prevent many of the problems usually experienced after building completion.

The survey findings support the hypothesis that the participation of maintenance engineers at the design and construction stages can prevent most of the problems usually experienced after building completion.

PARTICIPATION OF MAINTENANCE ENGINEERS	%
WRITING DESIGN BRIEF	36
ADVISE ON CONSULTANT DESIGN	86
ASSIST IN THE DESIGN	50
ATTEND PROGRESS MEETINGS	24
ATTEND COMMISSIONING	100
INSPECTION DURING CONSTRUCTION	5

TABLE 7.7 : PARTICIPATION OF MAINTENANCE ENGINEERS IN CONSTRUCTION PROJECTS

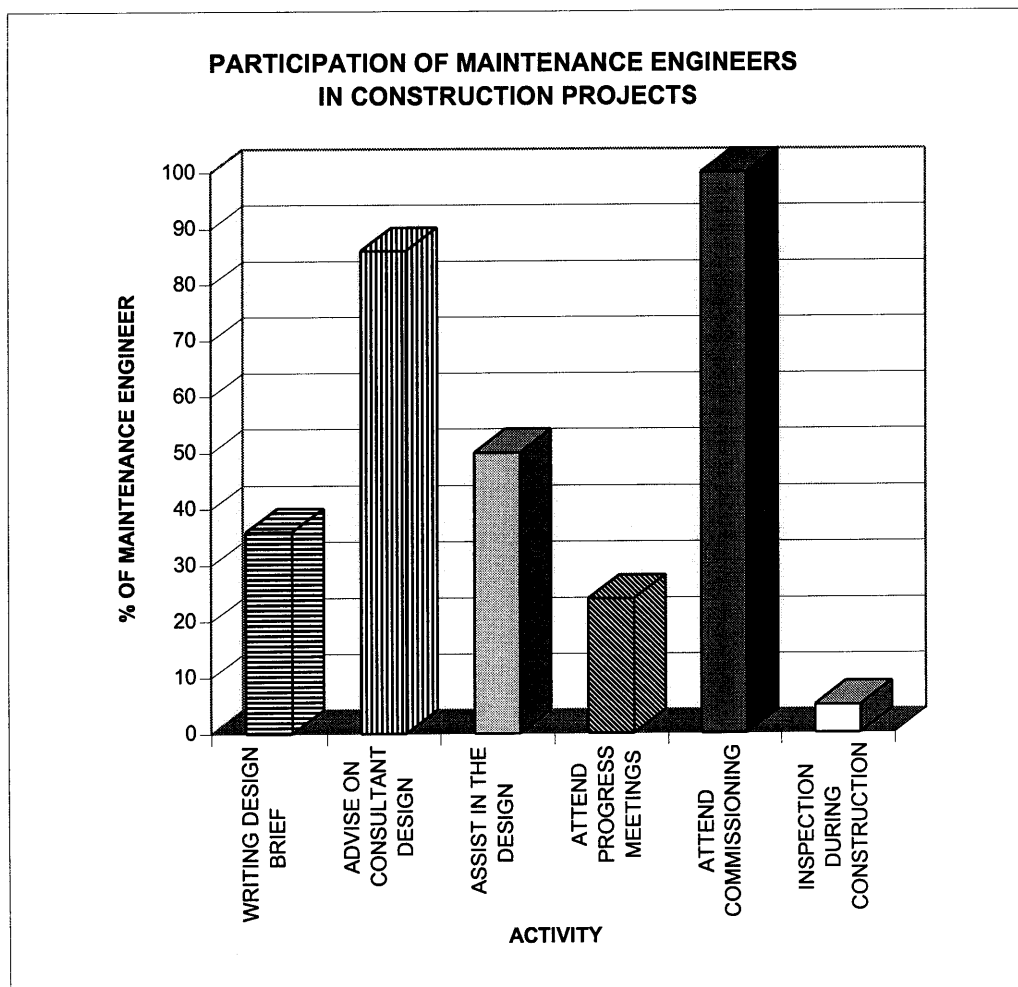


FIGURE 7.7 : PARTICIPATION OF MAINTENANCE ENGINEERS IN CONSTRUCTION PROJECTS

B) Integration of Building Services Maintenance Teams

Clients and building occupants often do not prefer to deal with many maintenance specialist teams and they prefer to deal with one team who has all the specialist personnel to perform all maintenance works. In order to identify the relationship between client's or user's satisfaction and the integration of building services maintenance teams, Clients and building users were asked about the problems they face with the Building services maintenance teams. The survey results showed that most of the clients' or users' dissatisfaction were when the work involves more than one trade. For example, the installation or replacement of an air Conditioning unit or a water heater where an electrician is needed to disconnect the existing unit and later connect the new equipment and a mechanical fitter or Plumber to carryout other works.

Some large organisations who have their own maintenance teams organise their teams by trade such as Mechanical section, Electrical section, Air-conditioning section, Building section, Carpentry section, etc. Other organisations organise their work by users or locations such as Area 1, Area 2 ,etc.

In this survey, clients were asked of the system of maintenance they prefer. 82% of the Clients and building occupants said that they prefer to have one multi-disciplinary maintenance team where they can deal with only one supervisor for all types of maintenance works. They said that this arrangement makes works co-ordination and performance easier and faster.

One maintenance organisation serving twenty different clients or users has changed its organisational structure from division by trade to groups serving particular locations or users by using Matrix organisation. The maintenance organisation has combined and integrated technicians from the Air conditioning, Plumbing, electrical, Carpentry and Masonry sections into Multidisciplinary teams. Each team serves one or more locations.

Six months after this change in organisational structure , the twenty users were asked about the effects and advantages or disadvantages of the change. There has been major improvement in the average response time from initiating the work requisition to starting work. This time was decreased from 6 days to only 2 days. The average number of pending works decreased from 20 to only 12 and the average work duration was decreased from 7 hours to 5 hours. However, this seems to be at the expense of the quality of work as the number of complaints of work quality per week increased from 2 to 4.

The effects of changing from specialist teams to multi-disciplinary teams are illustrated in Figure 7.8.

The change that this maintenance organisation followed is explained in details in Appendix C.

Maintenance Organisation Opinion

Maintenance organisations, while appreciating the many advantages of allocating multi-disciplinary teams for the clients and users , and its effects on improving response time, number of works pending and work duration, think that the quality of works was compromised as reflected by the increase in the number of complaints about work quality. This is caused by the compromising of specialisation and allowing specialist technicians to work on works other than their original specialisation . Maintenance organisation management appreciates the increasing complexities of Building services systems, and that these systems need specialists to understand the systems perfectly and carryout the maintenance works effectively. They have the opinion that keeping specialist teams increases the knowledge and experience of the technicians as well as the quality of work while multi-trade teams force specialists to carryout other works making them less expert in most types of work. It is also easier to train new workers in a speciality than in general works.

The survey findings support the hypothesis that The lack of co-ordination and integration of maintenance teams cause long delays in rectifying faults which leads to occupants' dissatisfaction.

	BEFORE	AFTER
AVERAGE RESPONSE TIME(DAYS)	6	2
AVERAGE NUMBER OF WORKS PENDING	20	12
AVERAGE WORK DURATION (HOURS)	7	5
NUMBER OF COMPLAINTS OF WORK QUALITY/WEEK	2	4

**TABLE 7.8 : EFFECTS OF CHANGING FROM SPECIALIST MAINTENANCE TEAMS
TO MULTIDISCIPLINARY MAINTENANCE TEAMS**

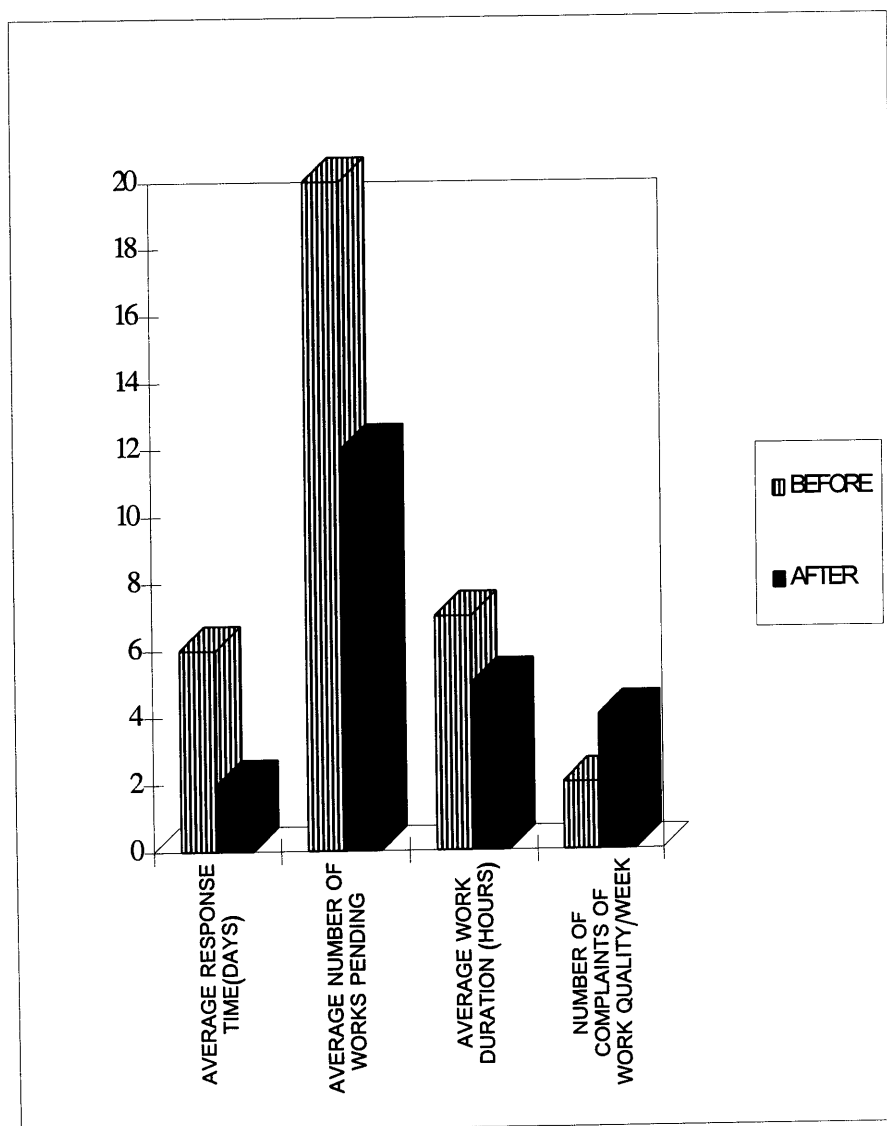


**FIGURE 7.8 : EFFECTS OF CHANGING FROM SPECIALIST MAINTENANCE TEAMS
TO MULTIDISCIPLINARY MAINTENANCE TEAMS**

7.7.13 Management style

The commitment of Building Services Subcontractors to the goals of the project must be obtained. Services Subcontractors were asked if they feel that the Project Manager or Architect does not adopt a democratic style of leadership to obtain their commitment to the project.

Almost all services subcontractors said that the management style differs from one project manager or architect to another. The management style changes gradually from authoritative to democratic as both parties work together on more projects. In this survey, Building Services subcontractor complained of the following.

1. The project manager or architect always takes the client or the main contractor side in any conflict, and tries to impose non standard clauses in the contracts.
2. The architect and main contractor often treat services subcontractors as secondary parties and that their systems are of secondary importance and have to be modified as and when required by other parties. They often can not understand the effects of their requirements on the efficiencies of the building services systems.
3. Building Services Subcontractors are not satisfied with payments made by main contractors. They said that this is a major problem as they had to follow up the main contractor for payments months and sometimes years after the completion of projects. Services Subcontractors prefer to be Nominated Subcontractors and be paid directly by the Client.

Chapter 8

Conclusions and Recommendations

8.1 Introduction

This chapter summarises the findings of the survey, which are discussed in chapter 7, and lists the recommendations made for more effective integration of Building Services teams.

8.2 Conclusion

The main objectives of this dissertation are to investigate the co-ordination and integration of Building Services teams during all stages of the project. The results obtained from the survey have confirmed the vital importance of the building services to the success of building projects. The survey has concluded that more than 70% of clients and users dissatisfaction in buildings are for reasons related to building services and hence it is these elements which should be given more attention in order to produce better buildings and gain the satisfaction of clients.

The complexity of building services systems has produced more specialists contractors that carryout works in one field of the building services such as air conditioning, electrical, fire alarm systems or building management systems. This has created a situation where more and more contractors work on one project and therefore more careful efforts should be used in the integration of all these teams. The survey showed that the clients become less satisfied as the number of contractors in their projects increases and that they prefer that the main contractor perform the co-ordination and integration of various works made by the subcontractors.

Computerised-Aided Design systems should be used extensively by all parties in all projects as the survey showed that these has helped in avoiding and solving most of

the design conflicts among various systems very quickly and effectively. Computers can also assist the integration in areas such as network analysis, word processing, information retrieval , project database and communication through electronic mail.

The survey results showed that clients do not think carefully about the mechanical and electrical requirements for their building and that their design briefs for the building services systems were inadequate . Clients are advised to consider the Total Life Cycle of their buildings including the operational costs as these will lead to a better planning and selection of their building services needs and systems.

The Building Services Engineers are invited late to participate in the design of the building when it is too late to play any valuable role in the layout or orientation of the building which may be a major factor in the operational costs of the building. In this survey 20% of the Building Services Engineers said that they are not very satisfied about their design of the Building services systems due to the ineffective layout of the building or unwise changes by clients. It is advisable that the Building Services Engineer should take a role at the very beginning of the building process in order to have a valuable contribution.

The site offices for all parties , the weekly technical co-ordination meetings for project under construction and the monthly progress meetings provide good opportunities for avoiding and solving conflicts effectively. All parties concerned must attend these meetings even their role at some stages appears minimal.

Building Services Maintenance Engineers can play an important role in the building process as they are probably the best who know about the problems often caused by ineffective design or installation of building services systems. The survey results showed that maintenance engineers have not participated effectively and sometime discouraged from participating in most building projects. It is advisable that clients, architects and building Service engineers give a wider role for maintenance engineers who can play a valuable role for the client in writing the design brief, advise on

consultants design, assist in the selection of equipment and system , advise on construction and commissioning of building services systems.

The survey results showed that multi-skill maintenance teams can be more effective in completing works quickly and they are preferred by clients. However these are at the expense of quality of work which can be achieved better through specialist teams. Care must be taken when organising maintenance team in order to keep a balance between client's short-term satisfaction and the long-term quality of building services systems.

Interviews with building services consultants and contractors have shown some dissatisfaction with the management style adopted by some architects or project managers. They sometimes do not value the importance of building services systems and took them as secondary elements. In order to obtain the commitment of all parties, architects and project managers must adopt a democratic leadership style in which services specialists are involved in all decisions related to services integration.

8.3 Recommendations

The survey findings have confirmed that ineffective building services integration is a major source of problems on the majority of building projects. The following are some recommendations that can assist in making the integration more successful.

1. The project organisation should be created at the beginning of any project and should clearly incorporate the formal communication channels required by the contract and encourage a network of communication among the project team members.
2. A pre-planned meeting should be held where all design team members can get together to examine the totality and integrity of the design at the design stage to avoid the difficulties during construction and later stages.

3. Designers must consider and think over the whole life cycle of the building instead of simply getting the building up quickly and at minimum cost. Designers must get the job right in the first place to avoid spending far more time and money rectifying faults.
4. A site-based computer can be used to produce long and short-term production programmes based on network planning.
5. Drawings and records can be stored on a site-based computer for ease of retrieval as and when required.
6. There should be a commitment from the Main Contractor and Services Contractors to attend all co-ordination meetings that should be held regularly to discuss and solve the technical issues and progress of work.
7. The Project Manager or Architect must adopt a democratic style of leadership to obtain the commitment of Services Subcontractors to the goals of the project and should encourage the informal communication that can assist in solving or avoiding conflicts.
8. All organisations in the building industry including the building services organisations should take full advantage of all computer applications that can help in making successful integration of various elements of the project particularly in relation to computer-aided drafting systems, project database and electronic mail communications.
9. Clients, architects and project managers should facilitate the effective participation of building services maintenance engineers in the design and construction stages of the projects as they are the best positioned to advise on the design and installation methods, hence avoiding future problems in building services which are blamed for most of the clients dissatisfaction. Maintenance engineers can assist in writing design briefs, advise on consultant's design,

selection of equipment, participate in technical and progress meeting and commissioning of projects.

10. The Building Services Engineer should be at the heart of the design process and be involved from day one to make significant contribution to the overall design process in order to avoid inefficient services distribution and uncomfortable indoor climates resulting from ill-suited buildings. They should resist half-backed constraints being placed on them due to the lack of knowledge or understanding of others and they should argue their case convincingly.

8.4 Further Study

This Dissertation highlighted the problems encountered in the absence of effective participation and integration of Building Services teams in construction projects, and made recommendations for improving this integration. Further studies can be made to investigate the possibility of producing standards and new procurement methods that allow the Building Services teams including maintenance teams to participate along with other parties at the beginning of the project and right from the inception stage, in order to further improve the building process.

References

Chapter 2

- ¹ Edgar F Huse, Management 2nd edition, West (1982) pp. 227
- ² J. Thomson, Organising in action, McGraw-Hill, 1967
- ³ Edgar F Huse, Management 2nd edition , West (1982) pp. 260
- ⁴ Jay R Galbraith, “Matrix Organisation Designs” Business Horizons, (February 1971), pp. 29-40.
- ⁵ Shtub, Bard, Globerson, Project Management, Engineering, Technology, and implementation, Prentice Hall , (1994), pp. 221-222
- ⁶ Kerzer H., Project Management, A Systems approach to planning, scheduling and control, VNR (1995), PP. 423
- ⁷ Shtub, Bard, Globerson, Project Management, Engineering, Technology, and implementation, Prentice Hall , 1994
- ⁸ Kerzer H., Project Management, A system approach to planning, Scheduling and control, VNR (1995) ,pp. 1033
- ⁹ Koehler, Anatol, Applbaun, Organisational communication Behavioural Perspectives, Holt,Rinehart and Wintson 1981, pp. 9
- ¹⁰ Koehler, Anatol, Applbaun, Organisational communication Behavioural Perspectives, Holt,Rinehart and Wintson (1981), pp. 11-12
- ¹¹ D.I.Cleland and W.R.King, Systems Analysis and Project management, 2nd edition McGraw-Hill,(1975), pp. 187-190

Chapter 3

- ¹ Parton P. K., Building Services Integration, E FN Spon (1983) pp. 1
- ² CIBSE journal , Integrated design, (November 1995) pp. 29-36

- ³ Grawshaw D, Co-ordinating Working Drawings, The role of site Management, Building Technology and Management , (15th February 1977), pp. 13-25
- ⁴ Parton P. K., Building Services Integration, E FN Spon(1983), pp. 1
- ⁵ Grawshaw D, Co-ordinating Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25
- ⁶ Parton P. K., Building Services Integration , E FN Spon(1983), pp. 1
- ⁷ CIBSE journal ,Integrated design, November 1995, pp. 29-36
- ⁸ CIBSE journal, Integrated design, November 1995 pp .29-36
- ⁹ CIBSE journal, Integrated design, November 1995 pp. 29-36
- ¹⁰ CIBSE journal, Integrated design, November 1995 pp. 29-36
- ¹¹ CIBSE journal, Integrated design , November 1995 pp. 29-36
- ¹² CIBSE journal, Integrated design, , November 1995 pp. 29-36
- ¹³ Parton P. K., Building Services Integration, E FN Spon(1983), pp. 1
- ¹⁴ Parton P. K., Building Services Integration , E FN Spon(1983), pp. 1
- ¹⁵ G.Vincent & E Happold - How to integrate M & E services ,1998
- ¹⁶ Agency Property Services , Quality Assurance Publication
- ¹⁷ T Cornick, Quality Management of Building Design
- ¹⁸ C J Parloe, A Design Briefing Manual
- ¹⁹ P Scher, Working Drawings
- ²⁰ D T Crawshaw, Co-ordinated Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25
- ²¹ Design Economics for Building Services Offices, Building Economics Bureau
- ²² D T Crawshow , Co-ordinated Working Drawings, The role of site Management , Building Technology and Management , 15th February 1977, pp. 13-25
- ²³ L J Wild - Design Information flow
- ²⁴ J Mason & B Venning - Space for Services, Structure & services Part 1

- ²⁵ A Michie, Integration and Co-ordination of Building Services and its relationship with Project Management.
- ²⁶ NEDO - The Public Client and the Construction Industries.
- ²⁷ G Vincent, How to integrate Mechanical and Electrical Services
- ²⁸ C Gray, Design Counsel
- ²⁹ BRE Survey , Brief Formulation and the Design of Buildings.
- ³⁰ National Economic & Development Office 1987 - Achieving Quality
- ³¹ N.O.Reilly, Getting a better Building
- ³² Barton, P.K., The co-ordination of Mechanical and Electrical services subcontractors within the building process, MSc thesis , Salford University. (1976)
- ³³ P K Parton, Building Services Integration, E FN Spon (1983), pp. 1
- ³⁴ CIBSE journal, Building services January 1996.
- ³⁵ Benish W. Handbuch der unternehm-chlusse; quotation; Hrsg. Solter und Zimmerer, Munchen. (1972) pp. 157
- ³⁶ Scott B. Competitive advantage through alliance; article in 'Engineering, construction and Architectural Management; Vol. 2,; Black well Science, UK. (1995), pp. 83-92
- ³⁷ Wilco Tijhulis and Ger Maas, Faculty of Building and Architecture , University of Technology, Eindhoven, The Netherlands.

Chapter 4

- ¹ John Murdoch and Will Hughes, Construction Contracts-Law and Management 2nd edition, E & FN Spon, 1996 .
- ² John Murdoch and Will Hughes, Construction Contracts-Law and Management 2nd edition, E & FN Spon, 1996, pp. 12
- ³ John Murdoch and Will Hughes, Construction Contracts-Law and Management 2nd edition, E & FN Spon, 1996, pp. 15
- ⁴ CIBSE journal, Building services January, 1996
- ⁵ CIBSE journal , Building services January 1996.

- ⁶ Tomonari Yashiro, Department of Architecture, Musashi Institute of Technology, Tokyo, Japan, Methodology of Specialist Contractors' involvement in design development for construction
- ⁷ Tomonari Yashiro, Department of Architecture, Musashi Institute of Technology, Tokyo, Japan, Methodology of Specialist Contractors' involvement in design development for construction
- ⁸ P.Barton- A framework for cost Exploration and strategic cost.
- ⁹ G Stevenson, Draw to Draw Salesman
- ¹⁰ C Gray, The Successful Management of Design, A Handbook of Building Design Management.
- ¹¹ C. Terpolilli, Maintenance planning and quality control criteria at the design stage, University of Florence, Italy
- ¹² C. Terpolilli, Maintenance planning and quality control criteria at the design stage, University of Florence, Italy
- ¹³ C. Terpolilli, Maintenance planning and quality control criteria at the design stage, University of Florence, Italy
- ¹⁴ C. Terpolilli, Maintenance planning and quality control criteria at the design stage, University of Florence, Italy

Chapter 5

- ¹ Intergraph ships Integrated building design software , Internet/netscape/bdmship.htm
- ² Combine 2, Department of Architect at Newcastle University & Department of Civil Engineering at the Technical University Delft, the Netherlands, Internet/Netscape/News/Data Exchange System
- ³ Combine 2, Department of Architect at Newcastle University & Department of Civil Engineering at the Technical University Delft, the Netherlands, Internet/Netscape/News/Data Exchange System

Chapter 6

¹ Parton P K, Building Services Integration , E FN Spon(1983), pp. 120-130

² Parton P K, Building Services Integration, E FN Spon(1983), pp. 120-130

³ Parton P K, Building Services Integration , E FN Spon(1983), pp. 120-130

⁴ Parton P K, Building Services Integration , E FN Spon(1983), pp. 120-130

Appendix 1 - Questionnaires

For Clients

1. Please provide the following information on your project:

Project name: _____

Project location: _____

Project function: _____

Estimated budget before design stage: _____

Estimated budget after design stage: _____

Total cost of the project: _____

Reasons for the difference between budget and actual cost:

2. Who has carried out the following:

Architectural design: _____

Structural design: _____

Air conditioning design: _____

Plumbing design: _____

Electrical design: _____

3. Who has carried out and what was the actual cost of the following works?:

Civil works: _____

Air-conditioning work: _____

Plumbing work: _____

Electrical works: _____

other works: _____

4. Have you carried out a feasibility study before employing an architect or project manager to carryout the design?

5. Have you considered the complete life cycle of the project?

6. Have you prepared a comprehensive design brief to the Architect? If yes, who prepared the brief?

7. Has the brief included mechanical and electrical works?

8. Have you changed your requirements or asked for additional requirements during design or construction stages of the project? Please explain and give reasons.

9. Do you have maintenance team? If yes, what is their role during project design and construction stages?

10. What procurement method you have followed? What criteria have you considered before choosing the procurement method?

11. After the completion of the project are you satisfied with the results? what are the problems, if any, and how could you have solved or avoided such problems?

12. Do you think that your maintenance teams, if any, can play a role during the design and construction stages of projects? Please explain the advantages or disadvantages of their participation.

For Architects / Project Managers

Select a recent large project

1. Please provide the following information on the project:

Project name: _____

Project location: _____

Project function: _____

Estimated budget before design stage: _____

Estimated budget after design stage: _____

Total cost of the project: _____

Reasons for the difference between budget and actual cost:

2. Who has carried out the following:

Architectural design: _____

Structural design: _____

Air conditioning design: _____

Plumbing design: _____

Electrical design: _____

3. Who has carried out and what was the actual cost of the following works?:

Civil works: _____

Air-conditioning work: _____

Plumbing work: _____

Electrical works: _____

other works: _____

4. Has the design brief submitted by the client been adequate and has it included mechanical and electrical works?

5. When have you invited the Building Services Engineers to participate or advise on the building design. Do you think that they can play a better role if they have been invited earlier?

6. Have you decided the project procurement methods? And on what criteria?

7. What problems have you experienced during the design stage in regard to Building Services? And how could these been avoided?

8. What problems have you experienced during the construction stage or hand-over stage in regard to Building services ? and how could these been avoided?

9. What method have you used in producing drawings? And how these been sent to Building Services Engineers?

10. Do you have CAD system? If yes, How useful you find it in your work? If no, Are you going to purchase CAD system in the near future? Please give reasons?

11. What are the method you have used to integrate the design and construction process?

12. Do you think that Client's maintenance teams can play a role during the design and construction stages of projects? Please explain the advantages or disadvantages of their participation.

13. How can the integration be improved during design stage

14. How can the integration be improved during the construction stage.

15. After the completion of the project are you satisfied with the results ? what are the problems ,if any, and how could you have solved or avoid such problems?

For Main contractors / Building services contractors

Choose a recent large project

1. Have you had any valuable input during the design stage? If yes, what were your inputs?

2. Was there a better system? What is its advantages and why it was not chosen?

3. Do you think that the procurement method was the best for the project and why?

4. What conflicts ,if any, occurred during the construction stage and for what reasons and how these were solved? What are the consequences?

5. What was the method used for producing drawings for the project and how these are integrated with other systems of the work.

6. Do you have CAD system? If yes, How useful you find it in your work? If no, Are you going to purchase CAD system in the near future? Please give reasons?

7. How can the integration be improved during design stage

8. How can the integration be improved during the construction stage.

9. After the completion of the project are you satisfied with the results ? what are the problems ,if any, and how could you have solved or avoid such problems?

10. Have you had any role in the design of building services? What was your role?

11. When have you been invited to design the building services? Was the time early or late?

12. Have you been able to participate effectively in the design of the building? Have you been able to change the original building layout/ concepts because of problems in building services design, installation or maintenance?

13. Do you think that Client's maintenance teams can play a role during the design and construction stages of projects? Please explain the advantages or disadvantages of their participation.

For Building services Engineers.

Choose a recent large project.

1. What engineering system you have selected? And why?

2. Was there a better system? What is its advantages and why it was not chosen?

3. Has the Client or the Architect made you change your design or make some modifications which you think were not wise? Please give examples if any.

4. What conflicts ,if any, occurred during the design or construction stage and for what reasons and how these were solved?

5. What was the method used for producing drawings for the project and how these are integrated with other systems of the work.

6. Do you have CAD system? If yes, How useful you find it in your work? If no, Are you going to purchase CAD system in the near future? Please give reasons?

7. How can the integration be improved during design stage

8. How can the integration be improved during the construction stage.

9. After the completion of the project are you satisfied with the results ? what are the problems ,if any, and how could you have solved or avoid such problems?

For End-users/ Maintenance Engineers

1. Have you had any role during the design or construction stages? What was your role ? If not why?

2. Do you experience any problem after the project completion ? What are they? And how could have these been avoided?

3. How do you think we can improve the system in the future?

4. Do you have CAD system? If yes, How useful you find it in your work? If no, Are you going to purchase CAD system in the near future? Please give reasons?

5. How can the integration be improved during design stage?

6. How can the integration be improved during the construction stage?

7. Are you satisfied with the existing system for maintenance? How can the system be improved? What is its advantages and disadvantages?

8. Do you think that you are discouraged from taking a valuable role in the design and construction of projects. If yes, Please give reasons.

APPENDIX-B

The invitation letter to Construction organisations to participate in the survey

ATT: GENERAL MANAGER

Dear sirs,

Integrating Building Services Engineering Teams

I am carrying out a research study concerning the integration of building services trades and teams in the construction industry. The aim is to have a greater understanding of the particular management problems with building services design and installation. The research will form my dissertation as a part of my MSc course in Building Services Engineering Management.

I shall be grateful if you would assist with my study by providing answers to the attached questionnaire. The data collected will be treated with utmost confidential and only aggregated data or unidentified individual response will be included in the report.

For any quires, you may contact me on telephone 9634263 or 279583

Your assistance will be greatly appreciated.

Yours faithfully

Mohamed Najeeb Al Mansoor
General Engineer

Appendix -C

Integration of Building Services Maintenance teams - case study

The Maintenance Department

The Maintenance section at the Directorate of Engineering & Maintenance in the Ministry of Health, State of Bahrain.

The problem:

Health centres and Hospitals have complained that the maintenance technicians take long time to respond to their maintenance or new work requisitions, and that they find difficulties in communicating with the concerned personnel in the Maintenance section to follow up and have information about their works.

Information about the problem:

A survey has been carried out to identify the extent of the problems and how the technicians in the Maintenance section utilise their time and where and how can the non-productive time be reduced. Interviews have also been held with the users in the health centres and hospitals to identify their problems with the services provided by the Maintenance section.

The survey findings has revealed that the technicians spent almost 40% of their time on non-productive activities such as travelling to and from work sites , waiting for vehicles to take them to and from work sites or waiting for withdrawal of materials and spare parts from the Engineering store.

Interviews with the users, the Administrators of the hospitals and health centres, have shown that while they are satisfied with the effectiveness or technical competence of the services, they are not very satisfied with the Maintenance section services in some aspects. Their dissatisfaction is that they have to follow up with many supervisors in the Maintenance section and sometimes they even have to co-ordinate with more than one supervisor for the same work which needs the participation of various trades.

The Improvement Team:

An improvement team was then formed from the engineers in the Maintenance section and the data collected from the survey and interviews has been presented to the team for analysis. The section's senior technicians and foremen were later requested to join the improvement team.

The Problem Analysis and alternatives

The existing grouping of workforce into sections specialised in one field make the customers deal with many supervisors to complete their work requisitions. The creation of co-ordinators to make a single point of contact with users was first considered to solve the problem.

After the analysis of the data collected from the survey and interviews, the following alternatives were made to solve one or more non-productive area.

- 1- The increase in the number of vehicles will shorten the routes to and from work sites and will allow the technicians to drive directly to their work sites without having to take other technician to different sites on their way to and from work sites. This will allow the technician to spend less time in travelling or waiting to take other colleagues.
- 2- Re-arrange and allocate the workforce to serve particular location(s) instead of the existing grouping by trade. This will allow the users to communicate and follow up with one supervisor who have technicians from all trades to perform the works . He can deliver all the information and answers to the users queries about all works
- 3- Much time is wasted in the withdrawal of materials as almost all technicians withdraw their need of materials and spare parts early in the morning before going to work sites, creating long queues before the Engineering store. The withdrawal of materials and spare parts outside peak hours for the next day was considered and

discussed but it was seen as not very practical as this will require the creation of sub-stores and additional duties and responsibilities for store management.

The selection of alternative and the planning for Implementation.

All options were considered to reach the best alternative to solve the problem. After long discussion among the improvement team members, it was decided that the rearrangement and reallocation of the workforce to serve particular locations instead of the existing grouping by trade will solve most of the users' complaints and will allow them to communicate and follow up with only one supervisor who can deliver all the information and answers to the users queries.

The sections were originally grouped by discipline or trade as follows:

1. Mechanical Section
2. Air-conditioning Section
3. Electrical Section
4. Carpentry Section
5. Building Section

Each of these section is headed by a Foreman who is specialised in that field. The technicians in each section carryout the maintenance and repair work on equipment in all locations. Each foreman in this arrangement is responsible for the work in his specialised field only but he is not responsible for other works.

Each user has to deal with the five foremen to cover his work. Sometimes he/she has to deal with more than one foreman for the same work which requires more than one trade. For example when the user need to replace a Water cooler. He has to write many Work requisitions; one to the Air conditioning section to remove the existing Water cooler, A second Work requisition to the Electrical section to disconnect the power from the existing cooler and connect electrical power to the new cooler. A third Work Requisition to the Mechanical section to provide a plumber to disconnect and reconnect the water service. This procedure takes long time.

In order to solve this problem, the groups has been regrouped into sections serving locations covering all trades. With this arrangement, there will be a single point of contact between the user and the Maintenance section which can make the Maintenance section able to respond quickly to users requests and queries and make them very satisfied with the new arrangements.

Implementation:

Several meeting were held with the sections supervisor and technicians to gain their commitment to the improvement plan which will redistribute the workforce into multi-trade groups and therefore the specialist technicians would no longer be in the same group.

There has been some resistance to the change from some supervisors and technicians for various reasons. Some supervisors and technicians feared that the change would diminish their earning due to cut in over time or allowances or may threaten their power by changing the existing pattern of decision-making and power system. Others preferred to follow the well-established methods. Some technicians resisted the change because they do not want to spend time and energy learning new procedures and others resisted the change because it will disrupt the established work groups and may weaken friendship and communications.

To over the resistance to change made by some supervisors and technicians, the management has followed the two-communication way and the Section Head demonstrated that the change is an improvement and held many workshops to sell the proposal to the supervisors and technicians. The management has tried to involve as many employees as possible and was open to their views and suggestions in implementing the change.

After the participation and involvement of supervisors and technicians , five multidisciplinary groups were formed using the Matrix organisational form to serve the following locations or regions.

1. Ministry Head Quarters and Public Health
2. Psychiatric Hospital
3. Manama and Muharraq region
4. The Northern region
5. The Southern region.

Six months after this change in the grouping of workforce, the users were asked about the effects and advantages of the change. They were all very satisfied with the new system of work. There has been major improvement in the average response time from writing the Work requisition to starting work. This average time was decreased from 6 days to only 2 days . The average number of pending works was decreased from 20 to 12 after the change and the average work duration was decreased from 7 hours to 5 hours.

There was however an increase in the number of complaints from user regarding the quality of work as these were increased from 2 to 4 per week.

Appendix-D : Information on Bahrain and its history and economy.

Bahrain

Bahrain is an independent state in south western Asia. It consists of 33 islands located in the Arabian Gulf, 25 kilometres to the east of the Kingdom of Saudi Arabia. It has a total area of 800 square metres. The principle islands include Manama; Muharraq; Umm an Nasan, Sitra, Jedah, and the Hawar group. Manama is Bahrain's capital and the largest city.

The population of Bahrain is 580,000 (1995) and the Annual population growth rate is 2.58%.(1995).

Land and Resources

The islands of Bahrain are low-lying and rocky, with the exception of Bahrain island, which rises to an elevation of 135m in its centre. The climate is arid, with less than 100 mm of rain falling annually, nearly all in the winter months of December to March. The average annual temperature is about 25 C but it reaches more than 45 C in summer. Petroleum, is Bahrain's principle mineral resource. Artesian wells, mainly along the northern and western coasts of Bahrain island, are used for water supply and irrigation. Bahrain depends mainly on the desalination of sea water for its domestic needs of water.

Economy

The economy of Bahrain is based on the petroleum industry and transit trade. Oil refining is also important; crude petroleum is supplied by a pipeline from Saudi Arabia. Other industries have been developed to offset declining oil reserves. Prominent among these are aluminium smelting and products, manufacture of paper products, clothing and consumer goods. Agriculture is important on the irrigated northern coast of Bahrain island; produce includes dates, fruits and vegetables. Fishing is locally important.

A modern harbour at Mina Salman in Manama has strengthened the position of Bahrain as a transit port of the Gulf. The international airport at Muharraq is one of the busiest in the Gulf region. The King Fahad Causeway linking Bahrain and Saudi Arabia is opened in November 1986, leading to a significant increase in local tourism.

History

Bahrain was known as Delmon during the Suzerian civilisation and the Tylos by the Greeks. Evidence of these periods can be seen in Sar, Barbar, Abusaiba and Shakhura, and many other villages. In the 16th century Bahrain became important as a Portuguese way station on the route to India. During the 17th and 18th centuries it was frequently under Persian control. In 1783 the Al-Khalifa dynasty established Bahrain as an independent emirate, but it was soon eclipsed by Britain's growing influence in the region.

Beginning in 1861, the British forced Bahrain to accept a series of treaties giving the British control over its external affairs. The significance of the emirate greatly increase when oil was discovered in the island in 1932. Bahrain remained under British control until its independence on August 15, 1971. Since 1973 it has been a constitutional monarchy and has become increasingly prosperous on the income from oil exports, Petroleum processing and refining, aluminium industries, ship repairing, trading, tourism and banking.