DYNAMIC SYSTEM
FOR
CONSTRUCTION PROJECT MANAGEMENT

By

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Abstract

This study considers 'dynamics' as a chain of variables, changes, uncertainties and risks. Various 'dynamics' permeate in the construction project management and affect the project management performance. A model of construction project management system (CPMS) is developed in this study to map the properties and interrelationships of the 'dynamics' influencing construction project management. The project management objectives, project resources and environment factors are considered as the major components of the system, and these components are interdependent and interactive with each other at different levels. The study identifies the major 'dynamics' influencing the CPMS together with its components, and analyzes their impacts on the implementation of project management.

The study develops the framework of CPMS by examining the dynamic nature of the Hong Kong construction industry. It considers that population growth, land supply mechanism, housing policy, construction work force, availability of building materials and technology are the key 'dynamics' influencing the whole construction industry. At project management level, the major 'dynamics' are considered as change of scope, work method, programme, staff turnover, design, and contract terms. The impacts of these 'dynamics' on project management performance are studied through a survey to a group of main contractors in Hong Kong. The survey results indicate the strong awareness of the dynamic project management environment among construction professionals. Survey results show that the 'dynamics' exert a high degree of impact on project manager's decision making and hence the project progress. By presenting the dynamic environment and the impacts of 'dynamics' on decision makers, a dynamic systems approach to manage 'dynamics' is proposed for improving the decision making mechanism.

The major significance of this study to the knowledge is that the researcher explores a distinct system thinking approach to construction project management with the introduction of the properties of 'dynamics' and its relevance to the system model. It provides a stepping stone to bridge the application gap between the construction project management and the principles of 'system dynamics'.

This work includes seven chapters. Chapter 1 introduces the study background, research aim and objectives, and research methodology. Literature studies are conducted in chapter 2. Chapter 3 develops a dynamic systems model for construction project management system(DCPMS). The major dynamics to the DCPMS are identified and analyzed in chapter 4. Chapter 5 examines the dynamic characteristics of construction project management practice in Hong Kong construction industry with a focus on the relationship between the 'dynamics' at construction stages and decision making effectiveness. Chapter 6 evaluates the application areas of the dynamic systems approach developed in this study. Finally conclusions of the study are given in chapter 7.

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Chapter 1

Introduction

1.1 Background of the Study

Construction project stakeholders are now working against the stringent project objectives under an ever-changing project environment. The increasing complexity of a construction project also challenges the construction project management team. The team particularly has to strive for meeting the project requirements not only in terms of time, cost and quality but also safety, environment and other emerging requirements. Project managers are seeking innovative and creative project management approaches to deliver their project successfully.

1.1.1 Introduction to Changes and Dynamics

'Changes' prevail over the construction industry [Hill,1993; Pries et al.,1995]. It can have considerable impacts on the success of construction projects. The urges of embracing or adapting to 'change' also appear to be one of the main themes in the Hong Kong construction industry either at industry or down to project level [Chan and Chan,1997; Tam,1997; Ho,1997]. Previous studies have explored the impacts of dynamic and changing on the management of construction projects [Sidwell,1990; Shen,1996]. Shen's work considers 'dynamics' as a kind of power or forces that can produce 'changes', actions or effects on a project management system. He further suggests a dynamic approach for construction project management so as to respond quickly to the 'changes' in a dynamic environment.

The effect of 'dynamics' on project management highlights the importance of understanding the interactions among various components within project management system. A system framework for understanding 'dynamics' in construction project management is therefore the main focus of this study. The study considers the construction project management as a dynamic system. The demand for quick response to the 'changes' in the construction process has great challenges to decision makers who need to produce action and reaction to the management system and thus improve the project performance. Of course, the decision makers' capability and the decision making mechanism to response to the impacts of the 'dynamics' can affect to a large extent the overall project performance. This study investigates a dynamic system approach for decision makers to cope with the 'changes'.

1.1.2 A New Challenge to Construction Project Management

With the development of the world, it is believed that, in the twenty first century, either social needs, political compromise, economical cooperation, legislation evolution and technological advancement will interact with each other and thus produce a dynamic phenomenon as a chain of variables, changes, uncertainties and risks. The construction industry and construction organizations throughout the world are similarly subject to interacting with such dynamic phenomenon.

Long life expectancy, higher living standard requirement and global society forming, etc. are accelerating the changing pattern of social needs such as more quality living space with flexible design and integrated facilities. The trend of capitalism with democratization is spreading over the world and many emerging regional political or military alliances such as EC and ASEAN inevitably force the individual government policy adapting to the alliance. On the other hand, the international economic organizations such as GATT and APEC are removing the mutual exchange constraints and sharing the fruit of efficient use of resources. As social, political and economic arenas are interactively changing, the legal context is naturally being amended from time to time. At the same time, the pace of advancement on technology will be hastened by investing capital on research and development. It is foreseeable that the construction industry will face a new challenge from the dynamic phenomenon. Particularly, the changing and uncertain environment presents the construction industry, particularly individual construction projects with the challenge of tight schedule, competitive bidding, strict quality standard, stringent safety measures, embracing costly information technology as well as increasing environmental awareness. For example in Hong Kong, these forces are being imposed on project managers since the introduction of the quality assurance system (ISO9000) in 1987, the safety management system under Occupational Safety Charter in 1996 and the environmental management system (ISO14000). Moreover, the rapid expansion of population after World War II protruded the enormous demand of houses and high-rise building. In the past five decades, the Hong Kong construction industry has provided reasonable solutions to match the demand problems. However, the ever-increasing demand will challenge the traditional management practice in the coming years.

Nowadays, the ultimate aim of construction project is not only to provide accommodation to actual users but also to render individual prestige and investment opportunity. The objectives of developing a construction project are therefore changing with time which are not only about beauty and functionality but also buildability, constructability and marketability. Such underlying shift of prime objectives do govern the mechanisms of today's construction behaviour. The land supply mechanism (purpose of use), contemporary design and engineering philosophies, advanced information technology implementation, competitive tender arrangements, construction methods as well as building marketing (sales and rent) lay down a golden rule to individual project that targets at short time, minimum cost, and required quality.

The Hong Kong construction industry is facing a crisis of diminishing profitability due to the cut-throat competition as well as different management related problems [Chan and Chan,1997]. Different project participants have to carry out their management activities by innovative, creative and adaptive manner with respect to the evolutionary or even revolutionary working environment so that they can survive in the industry.

1.1.3 Construction Project Management and System

In the late 1950s, formal project management emerged after the development of management philosophy for the large military and supporting systems [Cleland,1984]. Project management is becoming more popular and widely used in industrial, governmental and educational fields. It also comes out with various system analysis tools such as project planning and control techniques, i.e. CPM, PERT which are available to deal with programming and scheduling. The construction industries in Western countries adopted project management approach firstly in 1970s in UK and USA. The famous construction projects applying project management in Hong Kong include the Hong Kong University of Science and Technology (HKUST) campus [Walker,1994] and Airport Core Programme [Blake, 1995]. The issue of 'over budget' for the HKUST project is obviously controversial even though the project management can facilitate a speedy process to complete the projects. Therefore, such a new project delivery approach induces certain issues to be overcome [Muns and Bjeirmi ,1996].

System concepts has been developed in the management field since the middle of this century. Certain efforts in merging project management and system idea have been devoted by a number of researchers such as Morris(1974), Cleland and King (1983), Kerzner(1984), Patzak(1990), Saunders(1992), Yeo(1993). Professional institutions for project management have developed, such as International Project Management Association (IPMA) and Project Management Institute (PMI). This attempt has provided a new instructional map for project participants driving in a path to meet the new challenge. The blending of both such vital disciplines may create synergy to benefit all project stakeholders against those stringent project objectives.

1.1.4 Concepts of System and Dynamics

Some previous system studies focus on organization framework [Kast and Rosenzweig, 1970; Walker,1984; Newcombe et al.,1990]. System concepts provide an integrative framework for understanding an organization as an open system in which different components such as goals and values, technical, structural, psycho-social and managerial subsystems will interact with its environment. Nevertheless, nowadays organization theory only reflects a search for patterns of relationships, congruencies among subsystems and hence a contingency view which emphasizes more specific features and patterns of interrelationships among subsystems [Kast and Rosenzweig,1985]. It has been recognized that the utility of system concept is effective in a dynamic context, which considers the change and development of system over time [Cleland ,1972]. In the construction field, the construction process is treated as a system. The related studies can be traced from Morris (1974), Walker (1984), Newcombe et al.(1990). The concept of dynamics, refer to the chain of variables, changes, uncertainties and risks is very important in dealing with any kinds of systems. It is understandable that a construction process is full of dynamics as it usually spends several years to deliver a project.

1.1.5 Dynamics in the Hong Kong Construction Industry

Hong Kong is a meeting place of the Western and Eastern culture, a laissez-faire port and a Special Administrative Region (SAR) run under the concept of 'one country, two systems'. The political change with new social ethos and legislature system is reshaping a new Hong Kong. At the handover of sovereignty as well as at the turn of century, the Ports and Airport Development Strategy (PADS) which triggers a lot of construction activities indeed create a stage for not only the Hong Kong government but also developers as well as various professional bodies to play an important role to mark the history. In the cloud of uncertain future and the specific time limit, it is challenging to deliver successfully such a large amount of construction projects in Hong Kong.

Nowadays, the construction activities in Hong Kong are most suitable to be described in terms of dynamic. The PADS programme has brought many large projects including reclamation, the new airport, highways, high technology oriented suspension bridges, railways, container terminals, and new towns development, urban redevelopment schemes, etc.. These large scale projects not only make Hong Kong more spectacular, attractive but also create conditions that encourage investment in new equipment, plant, construction methods, as well as company development and training of manpower, at both the skilled operative and professional level.

A vital criterion to undertake this research within such a changing and uncertain city is keeping abreast with its heart which is evolving over time. This sparks the idea to use the term dynamic system to deliver the research project under the topic - *Dynamic System for Construction Project Management.*

1.2 Plan for this Research

1.2.1 Research Aim

The above background inspires this study to develop a theoretical development of merging project management with system thinking by the introduction of the 'dynamics'. Thus the aim of this study is to apply a dynamic systems approach in decision making process for those people who are working within a construction project management environment.

1.2.2 Research Objectives

The defined research aim will be focused throughout the study by implementing four research objectives planned as follows:

1. to identify the needs of using dynamic system approach for construction project management.
2. to develop a dynamic system framework for construction project management.
3. to investigate the dynamic situation and its impacts on the construction project management.
4. to evaluate the application of using the dynamic systems approach and its role in decision making mechanism.

1.2.3 Research Methodology

The strategy to achieve the research objectives is combined literal inquiry and practical survey. The literature study leads to the identification and justification of the needs of using systems approach in dynamic sense for construction project management. Refer to the systems approach established by Morris (1972), Walker (1987) and Newcombe et al.(1990), a system framework with the sense of dynamic is taken into consideration. A system for construction project management is treated as dynamic system by referring to the studies of interdependencies between the system components as well as the intra-dependencies between the elements within the components. The operational definitions of 'dynamic system' and 'dynamic' are applied in order to clearly define the concepts of dynamic system for construction project management. In line with the principles of system, the dynamic system for project management is to be developed. The major types of dynamics and their properties are further investigated within the construction project management system so that one can clearly know the development of the dynamic system.

The theoretical framework of dynamic system for construction project management can well present a rich picture about management of construction project in a dynamic environment. It is not a model to be tested against the reality at this stage because it is still very strange to system practitioners, in particular to construction professionals. Therefore, it is vital to wave a flag to tell the practitioners that there is a 'way of thinking' or a 'new angle' of tackling the management of construction projects. Why should they be drawn to such new angle is the fundamental question to be answered. Thus, either researchers or practitioners at the very beginning are to know themselves as well as their working environment. For construction practitioners, the effectiveness of management is the main concern in managing a project. For a project environment, the volatility or degree of dynamic is critically influencing the effectiveness of management. Therefore, either the degree of dynamic project environment or the management effectiveness should be carefully investigated. If the project environment is not so dynamic or the current level of management effectiveness is highly satisfied, there is no need to introduce dynamic system approach to construction project management.

By pondering the need of bringing construction practitioners in line with academic inspiration and vice versa, a survey in practice may provide an indicative direction for further investigating such research issue. It is therefore to investigate the dynamic situation and its impacts on the construction project management system by examining the Hong Kong construction industry. The impacts of dynamics on construction project management are planned to be examined with a questionnaire survey to the local construction industry. The underlying hypothesis of the survey is that dynamic environment is related to management effectiveness. As a consequence, the construction practitioners should pay attention to their dynamic working situation and acquire new approach to respond with it.

No matter what is the survey result, the possibility of applying dynamic systems approach should be analyzed especially in the context of decision-making in the construction project management. And, the management of dynamics should be studied with introducing a systematic method which assists project managers in analyzing dynamic environment and finding solutions.

1.3 Structure of the Thesis

The study is organized as a systematic flow shown in Figure 1.1. The first chapter highlights the background and importance of the study, the research aim, objectives and methodology. Chapter 2 delineates literature context relevant to the three main subject matters such as *project management, system* and *dynamics*. The first two chapters serve as the inputs for the researcher to design a conversion mechanism which is called dynamic systems approach. Chapter 3 focuses on the establishment of a dynamic system for construction project management and Chapter 4 emphasizes the elaboration of major dynamics within the dynamic system. The last three chapters act as outputs on the thesis development process. Chapter 5 concentrates on studying the dynamic situation of the Hong Kong construction industry. Particularly, it will also focus on contractor's experience with respect to construction project management system, where the relation of dynamics, management system, and decisions are examined. In Chapter 6, the applications of dynamic systems approach are evaluated. And finally, conclusions are given in Chapter 7. It also explores the coming research directions.

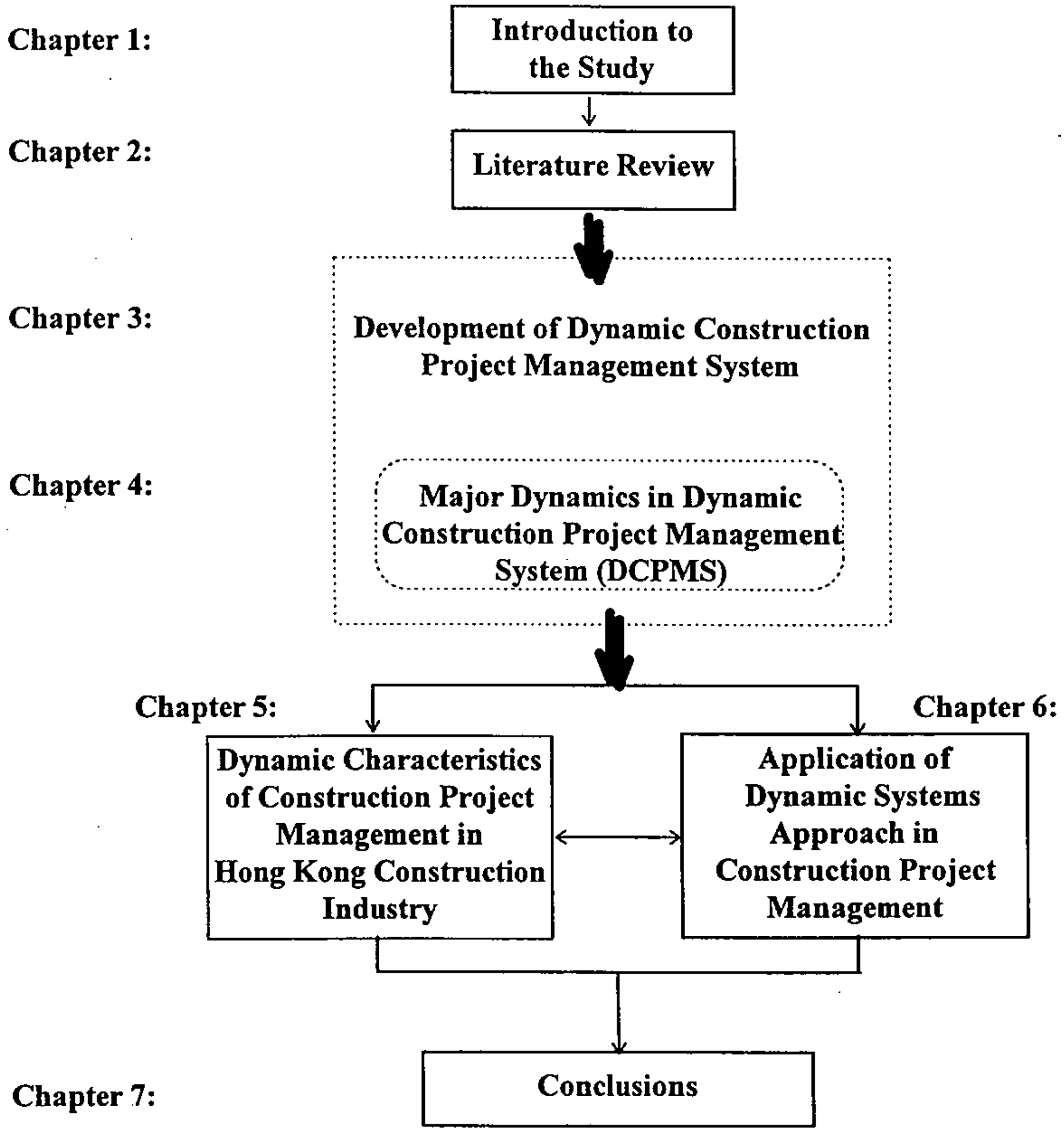


Figure 1.1 A Schematic Diagram for the Development of Thesis

Chapter 2

Literature Review

2.1 Introduction to Literature Study

This chapter is to identify the needs of using dynamic systems approach for construction project management. More specifically, it is going to sort out the research issues. Before studying the development of a dynamic system for construction project management, three areas of literature will be reviewed in this chapter.

Firstly, the concept of project, project management as well as construction project management are investigated to form a more complete picture about management in construction projects. The importance of project management to construction will be discussed. Secondly, the concept of systems is to be studied and its applications in construction sphere will be reviewed in the areas of organization, process, as well as product. Thirdly, the concept regarding dynamic system and dynamics will be reviewed. The perspective of dynamic systems and the definition of 'dynamics' will be studied. The distinction between dynamic system and system dynamics, and some of their applications of system dynamics will be discussed. The dynamics in construction project management will also be discussed.

2.2 Concept of Construction Project Management

2.2.1 Project

There are various definitions of 'project'. The concept of 'project' can be applied to almost all activities in our life and working environment, such as kindergarten pupil's picnic, student's assignment, surgery, fund raising activity, business trading, etc. All of them can be called as a 'project'. Several typical views about the definition of 'project' are provided as follows:

Ralph (1951) describes a general project as

> "any undertaking that has definite, final objectives representing specified values to be used in the satisfaction of some need or desire"

Oberlender (1993) describes simply that

> "a project consist of three components: scope, budget, and schedule."

Allinson (1993) elaborates that

> "... project concept is both an invaluable tool uniquely adapted to constant flux, and neutral with respect to meaning. While bureaucracies search for stable organizational structures and lock separate disciplines together in transient teams and seek to manage *fluiddity* and *ambiguity* using the project vehicle to achieve specific and short term strategic aims."

Cleland (1995) describes a 'project' as

> " a combination of organizational resources pulled together to create something that did not previously exist and that will provide a performance capability in the design and execution of organization strategies.
> Projects have a distinct life cycle, starting with an idea and progressing through design, engineering, and manufacturing or construction, through use by a project owner."

By looking into the above statements, it is hard to summarize 'project' with a single definition, but all of them have indicated the following essential attributes:

- ✓ Need, desire and satisfaction
- ✓ Definite objective
- ✓ Uniqueness
- ✓ Size, or scope
- ✓ Distinct time frame or life cycle
- ✓ Visible resources consumed such as money, material

To carry out a 'project' triggers a process of allocating visible and invisible resources. The process involves a series of activities to be done by various management functions: planning and organizing, communicating and coordination, leading and controlling. The introduction of the term 'management' can confuse the understanding of the concepts of 'project' and 'project management'. It is necessary to make a distinction between the two.

2.2.2 Distinction between Project and Project Management

Munns and Bjeirmi (1996) suggest the distinction between project and project management as:

> "A project can be considered to be the achievement of a specific objective, which involves a series of activities and tasks which consume resources. It has to be completed within a set of specification, having definite start and end dates.
> In contrast, project management can be defined as the process of controlling the achievement of the project objectives. Utilizing the existing organizational structures and resources, it seeks to manage the project by applying a collection of tools and techniques, without adversely disturbing the routine operation of the company. The function of project management includes defining the requirement of work, establishing the extent of work, allocating the resources required, planning the execution of the work, monitoring the progress of the work and adjusting deviations from the plan."

Put simply, 'project' can be conceived physically and mentally as a 'state' in terms of tangible thing or intangible idea, namely 'ends'. In contrast, 'project management' is a 'process' to realize the 'state', namely 'means'. In other words, when 'project management' is taken into consideration, that means it is going to deliver a 'project' by using energy or resources under a certain time frame. The idea of project management is thus worthy of discussion in details in this chapter.

2.2.3 Project Management

Emergence:

> "Formal project or program management emerged in an unobstrusive manner in the late 1950s and began taking on the characteristics of a discipline in its own right. No one can claim to have invented project management. Its early beginnings are found in the construction industry and in more recent years in military weapons and systems development businesses. The origins of many of the techniques of project management can be found in the management of large-scale ad hoc endeavors such as the Manhattan Project, the Polaris submarine program, large construction projects, or the use of naval task forces."
>
> Cleland (1995)

Cleland (1995) delineates here that project management has early related to construction industry. Hammond (1993) mentions that project management has emerged over the past few decades in response to the increasing complexity and the fragmentation of the construction industry and the demand from clients for single point responsibility. By the 1970s notions of project management was acknowledging to construction industry over United Kingdom [Allinson,1993].

Although a preliminary idea of emergence of 'project management' has appeared in the construction industry for some time, project management relatively is a new academic subject. Previous studies have developed various definitions about project management.

Typical definitions are as follows:

Project Management Institute (1987,1996) in the Project Management Body of Knowledge (PMBOK) defines project management as

> "the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. "

Wideman (1983) defines that project management

> "is the art and science of directing human and material resources to achieve stated objectives within the constraints of time, budget and quality and to the satisfaction of everyone involved."

Kerzner (1984) defines that project management

> "is the planning, organizing, directing and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives. Furthermore, project management utilizes the *systems approach* to management by having functional personnel (the vertical hierarchy) assigned to a specific project (the horizontal hierarchy).

Oberlender (1993) defines project management as

> "the art and science of coordinating people, equipment, materials. money, and schedules to complete a specified project on time and within approved cost."

Ahuja et. al (1994) describes that project management

> "is the process of applying management techniques and systems to direct and control suitable resources in order to successfully deliver the intended scope of the project."

Kerzner (1995) states that project management is characterized

> "by new methods of restructuring management and adapting special management techniques, with the purpose of obtaining better control and use of existing resources ... . The project management approach requires a departure from the traditional business organizational form, which is basically vertical and which emphasizes a strong superior-subordinate relationship."

Cleland (1995) defines that project management

> "is a distinct discipline to be applied to the management of ad hoc activities in organizations. As a discipline, project management has become a key philosophy and process to contribute to the strategic management of organizations - the management of organizations as if their future mattered."

Badiru and Pulat (1995) define project management as

> " the systematic integration of technical, human, and financial resources to achieve goals and objectives."

The definition of 'project management' has been refined and enriched with respect to the various attributes of a 'project' as mentioned before. Project management has become a distinct discipline that incorporates general management principles and special management techniques for project.

No matter what different terminology used, the core definition of project management is generally perceived as the triangle of project objectives which shall/can be achieved within the project duration (Time), approved budget (Cost) and specified performance (Quality). In other words, the primary task for project managers is to deliver a project (product or service) against the three project objectives.

2.2.4 Construction Project

A construction project can be represented by a high-rise building, a bridge, a dam, an airport or even renovation work of a flat. However, there are certain characteristics in common. Ritz (1994) lists four common traits for a construction project as follows:

1. Each project is unique and not repetitious.
2. A project works against schedules and budgets to produce a specific result.
3. The construction team cuts across many organizational and functional lines that involve virtually every department in the company.
4. Project comes in various shapes, size and complexities.

In general, construction includes civil and building works as both of them have many common technology and management theories and applications. This study will be focusing on building works, but the term of construction project is chosen rather than building project. Construction projects in Hong Kong are typically classified into several categories, as shown in Table 2.1.

Types	Examples
Residential	: Public housing , Private housing, Village houses
Commercial/retail	: Offices, Hotels, Shopping centers
Industrial	: Factories, Warehouses, Power stations or Services plant
Government	: Gov't department office, District office, Post office
Institutional	: Schools, Training centers, Hospitals, Clinics
Recreational:	: Sports Complex, Parks
Others :	: Church, Temple, Car parks

Table 2.1 Typical Construction Projects

2.2.5 Importance of Project Management to Construction

Referring to the above construction projects, there are many versions of definition applied on construction project management. According to CIOB's publication, project management in construction context is defined in a holistic view as :

> "the overall planning, control and coordination of a project from inception to completion aiming at meeting client's requirements and ensuring completion on time, within cost and to the required quality standards."

As a relatively new management philosophy, construction project management has its importance to the construction industry. There are *industrial needs* , *ethos evolution* and *knowledge construct* which can be examined with respect to its importance. For the first area, there are many evidences showing that the project management is in *need* for construction industry. These can be described as follows:

- ✓ The boosting complex building due to the increasing requirement of more functions within a building.
- ✓ The increasing complicated structure of the construction industry as more new emerging business resulted from the differentiation of the industry.
- ✓ Within project objectives in terms of time, cost and quality, different project parties having their own specific goals.
- ✓ Adapting to pervasive uncertainty and increasing rate of change.
- ✓ The impact of the success of other industries: Manufacturing, Computer hardware and software.
- ✓ Unsatisfactory current management practice: the problem of consistent and often excessive cost overruns of 40-500% over the initial estimates, frequent programme slippage, and other difficulties in the management of major projects.

Coulson-Thomas (1990) conducted a survey on the role of project management. He concludes in his work that :

"Project management appears to be of increasing importance, even in those areas in which it has yet to be recognized as distinct from management generally. Project management skills and competencies are likely to be in greater demand as many organizations make a transition from bureaucracies to flexible networks or portfolios of projects."

Cleland (1995) highlights that the changes continue to herald the need for project management:

"The Changes - organizational downsizing, restructuring, the impact of the computer and telecommunications, empowerment of employees, team management, deregulation, global competition that show no signs of abating. ... these changes continue to herald the need for project management, particularly as contemporary organizational managers grope for ways to survive in the face of these changes."

The concept of project management likes a prism which reflects comprehensive interpretations from different walks of life as time evolves. The theories and their applications in project management are still controversial in some areas. In the construction industry, project management is employed as an alternative of the procurement methods. Correspondingly, there are numerous project management business entities established and going to play a new crucial role within the construction project organization. Project Manager (PM) title is subsequently prevailing across various business companies. Such *ethos evolution* highlights the importance of project management to construction and hence bring an explicitly new role in construction project organizations.

However, the entitlement of PM is criticized that the misuse or abuse are very common in many organizations. There are numerous project managers carrying out various tasks with differing duty and responsibility. Managers in production, purchasing or accounting are found to be entitled as project managers. As a result, the PM title can not demonstrate the actual duty and responsibility for a particular project. Such confusion has been explained by Morris(1994). He argues that project management is widely misperceived as a collection of planning and control techniques rather than as a rich and complex management process. According to the definitions and the needs of project management mentioned before, construction project management cannot be perceived as certain management techniques. It is a management process. Therefore, the clarification of construction project management for this study is essential. In chapter 3, construction project management will be discussed in detail.

The second area showing the importance of project management to construction industry is *knowledge construct* which means how is construction project management concept expressed. It is a challenge to blend various expressions or model used for construction project management. There is a project management community in which the knowledge construct is available and can be served as a basis for developing construction project management model.

The rapid development of project management professional community can be traced from the description by Morris (1994) as follows:

> "Certification was introduced first in the mid-1980s by the (US) Project Management Institute. ...Internet's most developed version, based around the UK's Association of Project Managers, was introduced in the early 1990s; other European countries, notably German, are also developing certification programmes. The Australian Project Management Association is also considering introducing certification."

The project management community will eventually have a great influence across various business organizations. The development in the discipline of project management is continuous, meanwhile, there are still some issues to be overcome in the coming decades. For example, the idea of Business Reengineering Process is a heated subject recently, but the challenges coming on are substantial that how to properly develop and integrate them into the general core of knowledge of the management of projects.

2.3 Application of Systems Idea to Construction Project Management

2.3.1 Concept of Systems

According to the publication of Open University (1978), the emergence of 'system' can be traced back to 1960s.

> "...system approach which has become popular in recent years (1960s). Not long ago the term system was hardly used except in words like systemic, but the idea of a system has gradually assumed more and more importance which is reflected in the widespread use of the term."

It appears that there are two main reasons for system emergence: the limited effectiveness of the traditionally simple management approach, the ever-changing in the complexity of man-made systems. It is obvious that today's overwhelming scientific and technological development are largely contributed by such concept of systems.

Literally, it is found that 'system' is coupled with many terms such as data system, information system, political system, legal system, production system, management system, quality assurance system, soft or hard system, just-in-time system, integrated project system, expert system, decision support system, industrial system, organization system, building system ... and so on. It is difficult to conclude what a 'system' is by scanning these sophisticated terms. Therefore, it is a prerequisite to know, perhaps to understand the implication of "system" and what does it mean throughout this study.

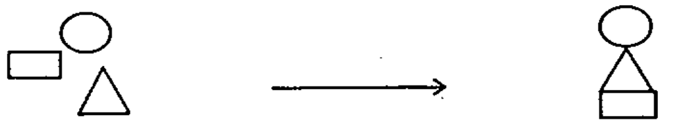
Definition:

The earliest term 'system', in Greek, which is called *'systema'* possessing twofold meanings. *'syn'* means *'together'* and *'histema'* means *'to set'*. In Chinese, *'system'*, namely *'si tong'* also has twofold characters. *'si'* means a group of relational parts while *'tong'* wholly bind together. In Oxford dictionary, the concept of *'system'* can be broadly divided into three types:

1. group of things or parts working together in a regular relation: for example, nervous system, digestive system, a railway system.
2. ordered set of ideas , theories, principles, etc., say, a system of philosophy, a system of government.
3. orderliness (well arranged or organized)

Trio of system:

The above three streams of definition point out a common trait of the subject matter as illustrated in Figure 2.1. The three definitions are complementary with each other to form what a *'system'* is perceived. In Chinese, *'tong'* can be a verb as to set, or simultaneously a noun as a whole. With comparison, three distinguishing aspects of system can be outlined into initial state, conversion process and final state. These are always commonly serving as the fundamental symbols of system model. Though *'systema'* does not explicitly show *what is* to set together, one can realize it implicitly after pondering its context. There are some common terms used in system models. The initial state is termed as elements, components, subsystems, inputs while the final state as whole, system, outputs. The process is generally labeled as transforming or throughputs.



In Greek ***In Chinese***	- *'si'*	to set together *'tong'*	- *'tong'*
Oxford Dictionary	parts, group of things	working together	ordered set
System model	initial state	conversion process	final state
Common terms	elements, components subsystems, inputs	transforming throughputs	whole, system outputs
Question behind	what ?	how ?	what?

Figure 2.1 The Anatomy of System Concept

Duality of system:

In an Open University publication (1974) the explanation for system is given with two aspects such as tangible and intangible, subject and object view, or visible and invisible:

> "..the word (system) core meaning is made up of two aspects: an '*out-there'* aspect which refers to the actual system, and an '*inside-us'* aspect which comes from us, from the person doing the defining."

There are some sorts of intangible, invisible and subjective systems, *inside-us,* maybe in terms of an ordered set of ideas, theories or principles, which define those tangible, objective and visible systems, *out-there,* in form of physical and organic entities.

Functionality of system:

It is likely to be asked that why 'system' is existed or created. One can recognize that system has intrinsic or extrinsic function to reach some goals either natural or manmade, as stated in an Open University publication (1974):

> "Basically any group of entities which are functionally interdependent can be called a system. Any group of entities which are interrelated so as to perform some functions, or reach some goals, can be seen to acting as a system."

Selectivity of system:

> "An essential part of defining a system is the *selection* of that particular set of things to be called a system by the person doing the defining. ...we have looked for a completely independent definition, one which exists outside the person making the definition, but in fact we have had a direct hand in creating the idea of a system in each case because we are applying the idea and we are choosing what to include and exclude in each case."

Open University (1974)

Selectivity brings a vital issue of the boundary of system, that is system environment. Also the size, scope and complexity of systems are determined by such kind of selectivity on which the concept of subsystems is totally relied.

Subsystems:

> "... system appears in a hierarchy, that is, in a structure where the large systems encompass the smaller systems, and the smaller systems themselves are made up of even smaller systems and so on.... The focus of systems theory is upon sub-systems which are interrelated in the pursuit of goals or objectives."
>
> Morris (1973)

Subsystem sometimes is called component, part or element. It can be further divided into more smaller parts as sub-subsystems and so on. The organization breakdown structure (OBS) and work breakdown structure (WBS) are the common examples of using subsystem concept.

Systems Environment:

The changes of some elements and their relative properties, which are not defined in a system, can produce a change in the state of the whole system. Construction industry, a component of economies in a nation, can be seen as a system, of which manufacturing, automobile, retail and trading industries etc. are acting as its environment. In more general sense, the legal, institutional, political, social, or technological systems are engulfing the construction industry.

Open /closed system:

How is the interaction between system and its environment? Such question leads to the thinking of open and closed system as shown in Figure 2.2. Human body is an open system which reacts with system environment such as heat, wind, dust and so forth. Most systems are open system. One particular instance of closed system is vacuum which does not interact with its environment. There comes the selectivity of system definition. So it is wise to distinguish system into relatively open and closed since there are hardly absolute closed systems. One can say a particular business organization is relatively open or closed system.

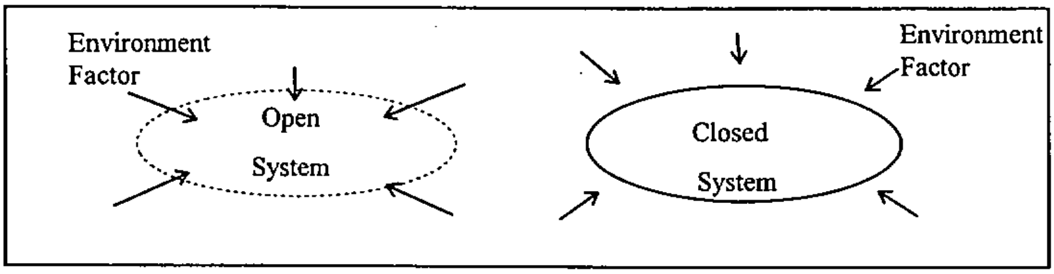


Figure. 2.2 Interaction between System and Environment

Feedback:

As a system reacts with its environment, it acquires stimuli and gives responses to them. Such mechanism is varied by different types of systems. People will naturally give responses to external stimuli. For example, tear is sometimes to drive dust out. Such mechanism is called feedback which is vital to open system or dynamic system.

System as a whole:

The discussion on the functionality of system and the concept of subsystem presents that there exist multiple functions as well as multifold goals in the subsystems. Therefore, a totality for system objectives is very important.

> "....The primary concern of the system approach is that any system should be treated as a whole. It is recognized, however, that individual interests should not go unrecognized obviously the initial step - and one of the hardest - is to define what is being meant by the particular system under consideration. This is done by first defining the objective of the system and then by identifying the parts bearing on the objective."
>
> Morris (1973)

One of the characteristics of systems approach is to focus on the whole rather than on individual elements. Bennett(1991) takes this point as the essential difference between systems thinking and earlier scientific approaches. The holism of systems force theorists and practitioners to consider the interactions between elements.

A way of thinking:

Cleland (1972) suggests that one who recognizes the systems concepts is usually better able to understand today's problems in the light of yesterday's happenings and yesterday's choices.

> "Systems thinking has revolutionized science. In many separate fields new ideas and new ways of thinking about subjects have followed from the adoption of a systems approach."
>
> Yeo (1993)

Previous works also suggest that

> " The systems approach is *a way of thinking* which enables us to cope with complex phenomena by identify their systemic relations."
>
> Open University (1974)

Such claim may release system theorists from stringent construct for system on intellectual basis. Moreover, it provides a vivid and vigorous path for infinitive expansion of the idea of systems thinking. Surely, the attempt to apply systems idea to construction project management for this study is a way of thinking - to seek innovative and creative project management approach.

2.3.2 Characteristics of a System

As system studies move from physical and mechanical to biological, social, cultural, and ideological system, they become progressively more complicated. General System Theory (GST) was thus developed by Bertalanffy in 1950s. GST provides an analytical framework which can be applied to differing types of systems. It is a young science in its state of application, but there are certain traits attributed to GST. The major traits of GST include: goal seeking, holism, hierarchy, inputs and outputs, transformation, energy, entropy and equifinality [Wright,1989]. Based on a basic system model as shown in Figure 2.3, ten typical characteristics of open systems applying to organization are identified by Katz and Kahn (1966,1978) where information and integration or coordination are improved by Newcombe et al.(1990).

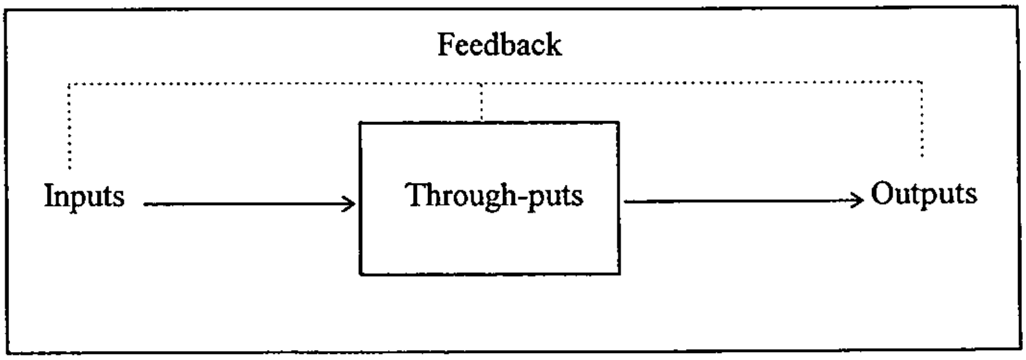


Figure 2.3 A General System Model

Inputs:

" All organizations import some form of energy from the external environment"

Through-puts:

"Open systems transform the energy available to them (all organization)"

Outputs:

"Open system exports some products into the environment, whether it be the invention of an inquiring mind or a bridge constructed by an engineering firm."

Feedback:

"The pattern of activities of the energy exchange has a cyclic character. The product exported into the environment furnishes the sources of energy for the repetition of the cycle of activities"

Negative entropy:

"To survive, open systems must move to arrest the entropic process; they must acquire negative entropy. The entropic process is a universal law of nature in which all forms of organization move toward disorganization and death."

Information:

"The inputs to organizations are not only human, physical and financial resources but also information, in the form of intelligence which provides signals about their environment and the organization's position in relation to that environment."

Steady State:

" The importation of energy to arrest entropy operates to maintain some constancy in energy exchange, so the open systems which survive are characterized by a steady state."

Differentiation:

"Open systems move in the direction of differentiation and elaboration."

Equi-finality:

"... a system can reach the same final state from different initial conditions and by a variety of paths."

Integration and coordination:

"As organizations grow there is a tendency towards increased differentiation or specialization, followed by a complementary need for increased integration or coordination."

2.3.3 Classification of Systems

The classification of systems is largely based on the selectivity of system as mentioned above. Different disciplines have their own system categories for the sake of simplicity or applicability to their subjects A typical classification of system is given by Boulding (1956) in the following nine levels:

(1) The first level is that of *static structure*. It might be called the level of frameworks: for example, the anatomy of the universe.
(2) The next level is that of the *simple dynamic system* with predetermined necessary motions. This might be called level of clockwise.
(3) The control mechanism or *cybernetic system*, which might be nicknamed the level of thermostat. The system is self-regulating in maintaining equilibrium.
(4) The fourth level is that of the '*open system*', or self-maintaining structure. This is the level of at which life begins to differentiate from not-life: it might be called the level of the living organism or cell.
(5) The next level might be called *genetic-societal* level; it is typified by the plant, and it dominates the empirical world of the botanist.
(6) The *animal system* level is characterized by increased mobility, teleological behaviour and self-awareness.
(7) The next level is the *human* level, that is, the individual human being considered as a system with self-awareness and the ability to utilize language and symbolism.
(8) The *social system* or systems of human organization constitute the next level, with the consideration of the content and meaning of messages, the nature and dimensions of the value system, the transcription of images into historical record, the subtle symbolization of art, music and poetry, and the complex gamut of human emotion.
(9) *Transcendental systems* complete the classification of levels. These are the ultimates and absolutes and the inescapable unknowables, and they also exhibit systematic structure and relationship.

Boulding's classification of system provides a hierarchical and structural approach in order to know more about system. Such classification can be traced back by using duality, functionality and selectivity of system concept discussed before. The definition of *static system* and *dynamic system are* on natural and physical basis. They are the subject matters of physics. One can see the embracing of using static and dynamic system or statics and dynamics in the discipline of mechanics and electronics.

Whatever systems are categorized, the functionality of system can not be ignored. Whether it is low or high level, simple or complex, a system is functioned or it has functions. Verstraete (1997) classifies systems as, in general, purposive system, open system and dynamic system.

> "A purposive system is defined as a system that seeks a set of related goals for which it was created."
>
> "An open system is that interact with external entities."
>
> "A dynamic system is defined as which produces something in either a physical or abstract sense."

Verstraete's classification of system is to seek goals or to produce something, however, it is true for business environment that any system within business has to be functional, purposeful or useful. Nowadays, *dynamic system* is being treated in a more higher level or abstract sense.

Patzak (1990) applies systems approach to project management by developing a general model of project management. The model has three distinguished systems involved the following three classes:

The Operating System	: The Project Organization
The Activity System	: The Project Process
The Object System	: The Project Outputs/The Expectations

Patzak's morphological model of project management makes clear the similarity of systems and project management as shown in Table 2.2. It is also supported by Yeo (1993) who claims that the practice of project management has its origin in systems analysis and systems engineering. He also calls for reuniting project management with the extended body of knowledge in systems thinking. The linking concepts of project management and system place a good base to discuss systems approach to project management in this study.

Project Life Cycle		System Life Cycle
Conceptual Phase	:	System needs identification
System Definition Phase	:	System design/engineering
Production/Acquisition Phase	:	System materialization
Integration Phase	:	System installation
Operation Phase	:	System use, maintenance
Removal Phase	:	System phasing out
Restitution Phase	:	System destruction, recycling or modification

Table 2.2 Phase of *Project* Life and *System* Life Cycle Source: Patzak (1990)

By understanding the relevance of project management and system, it is time to look into the relation of system to construction project environment. There are three distinct categories of systems within construction project [Bennett,1991]. One is related to the physical building elements (*what*) while the others are related to project organization as well as processes (*how*). Architects, engineers, surveyors or contractors have ever applied systems ideas in design, engineering and managing activities [Handler,1970; Wright,1989]. In the coming section, certain systems models will be reviewed.

2.3.4 Systems for Construction Organization

Newcombe, et al. (1990) introduces a systems model in discussing building organizations as shown in Figure 2.4. Under the organization system, the following five aspects: strategic, structural, information, social and management are also dealt with in the systems model. The five subsystems also serve as the foundation to introduce a systems model for construction management. The construction management system focuses on how to manage the input-conversion-output processes of the building organization.

> ."Construction organizations can be viewed as open systems and can be shown to exhibit all the characteristics of open systems. Katz and Kahn (1966,1978) who suggested that to understand organizations it is necessary to trace the input-conversion-output processes of the organization, together with the feedback mechanism which reactivate the system."
>
> Newcombe, et al. (1990)

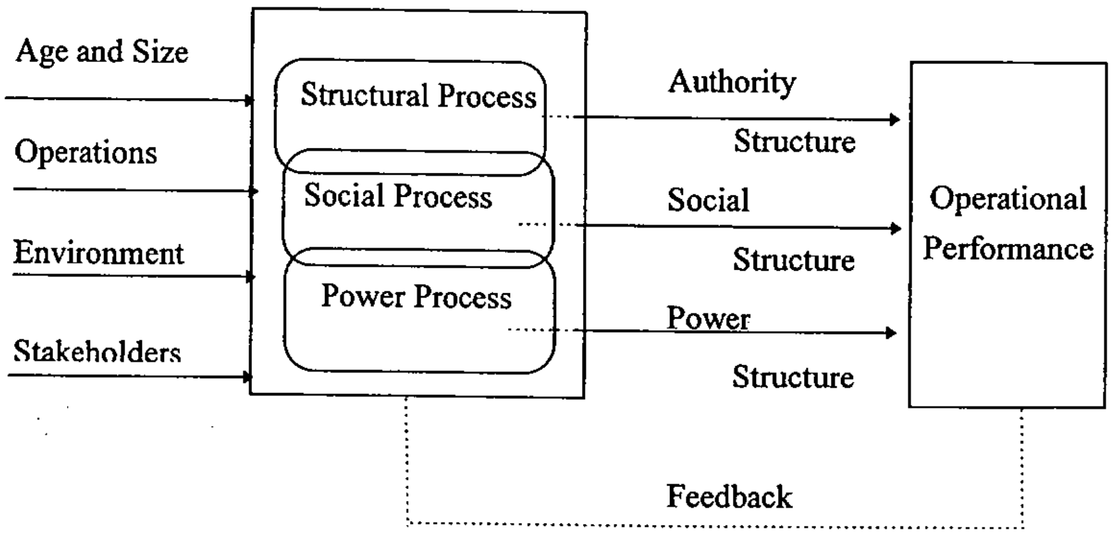


Figure 2.4 A Model for Organization System
Source: Newcombe, et al. (1990)

Walker (1984, 1996) considers construction organization as an adaptive system in terms of general input-output model as in Figure 2.5. The management system of an organization is seen to consist of organization subsystem, behaviour subsystem, technical subsystem and decision-making subsystem.

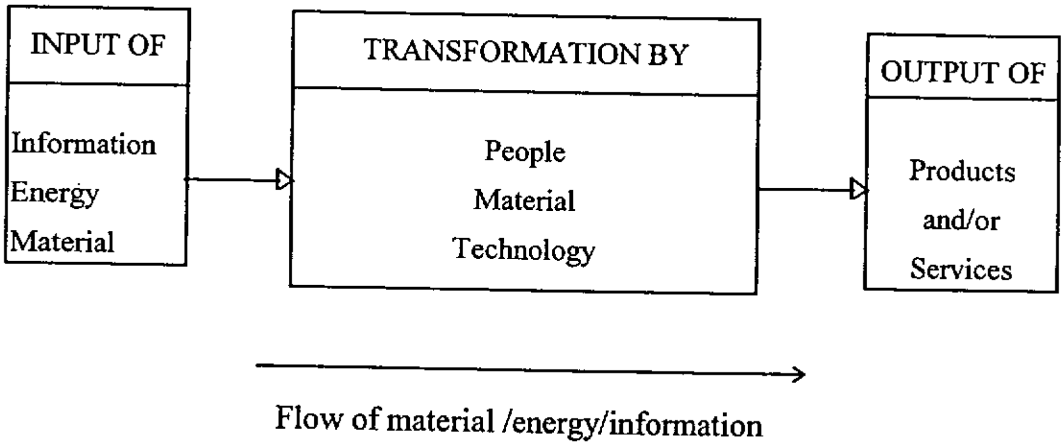


Figure 2.5 A General Model of an Open Organization System.
Source: Walker (1996)

2.3.5 Systems to Construction Process

Morris (1972) suggests a systems model, following Walter's model (1968) - design, design realization and construction, to describe building process by task subsystems used in his research as shown in Figure 2.6. Morris's model is also based on RIBA Plan Of Work and Merten's model (1968) by Building Timetable. The subsystems in the process is selected by the key decision points. Newcombe, et al.(1990) also addresses the systems ideas which are used to manage the building process in terms of manpower, building materials, construction plant, finance, production and marketing sub-systems. Walker(1989) proposed that construction process as a system which is useful to think about the stages of project. The main concept of the system has two primary decision points (Demand and Supply) and three primary stages: project conception, inception and realization. The key decision points and operational decision points serve as the basis for major elements of project coordination.

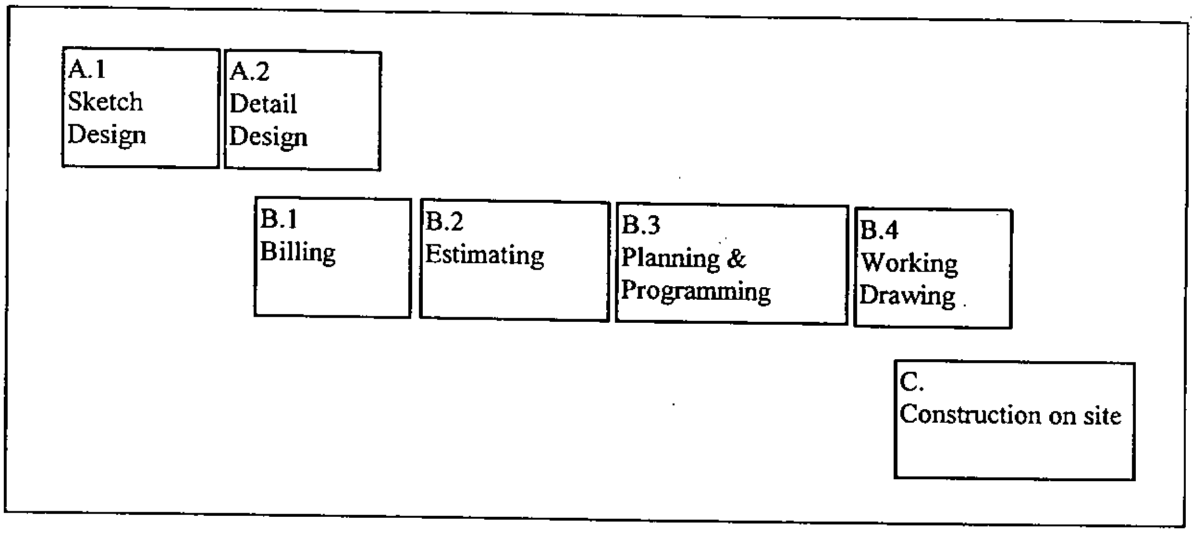


Figure 2.6 A Model of the Building Process for Construction Project
- Showing the Seven Major Task Subsystems in the Process.
Source: Morris (1972)

Walker (1984,1996) suggests a model to construction process in parallel to client's process with the environmental forces as shown in Figure 2.7.

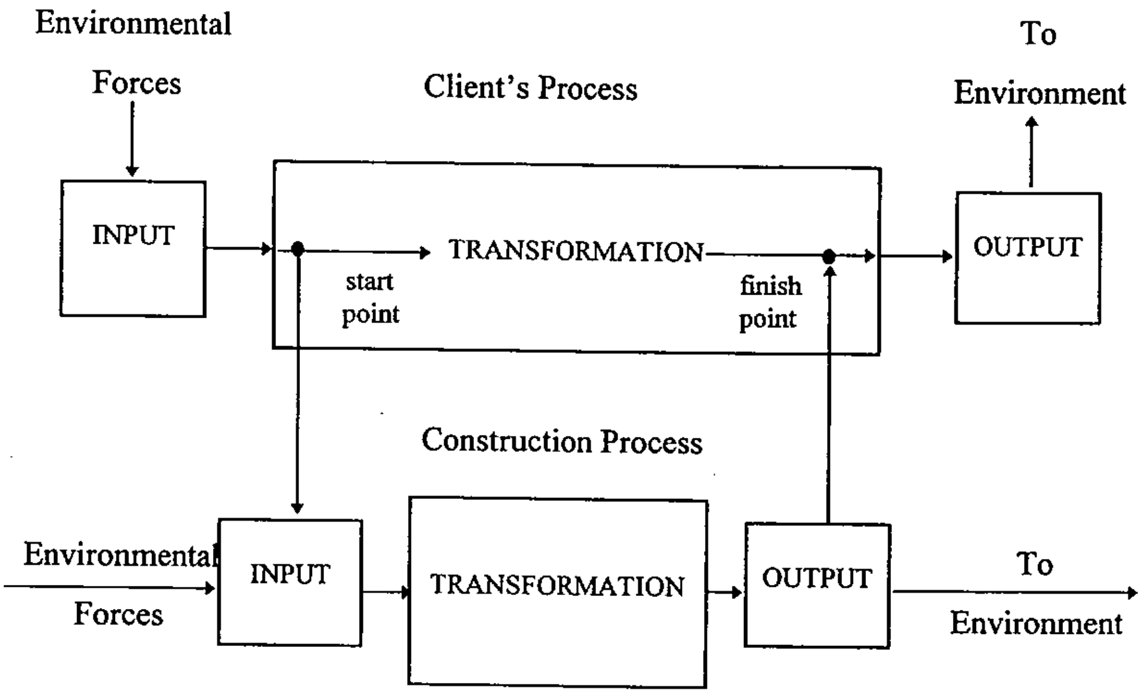


Figure 2.7 An Input-Output Model for Building Process
Source: Walker (1996)

Ritz (1994) illustrates a model of the construction management system by showing the key functions as shown in Figure 2.8.

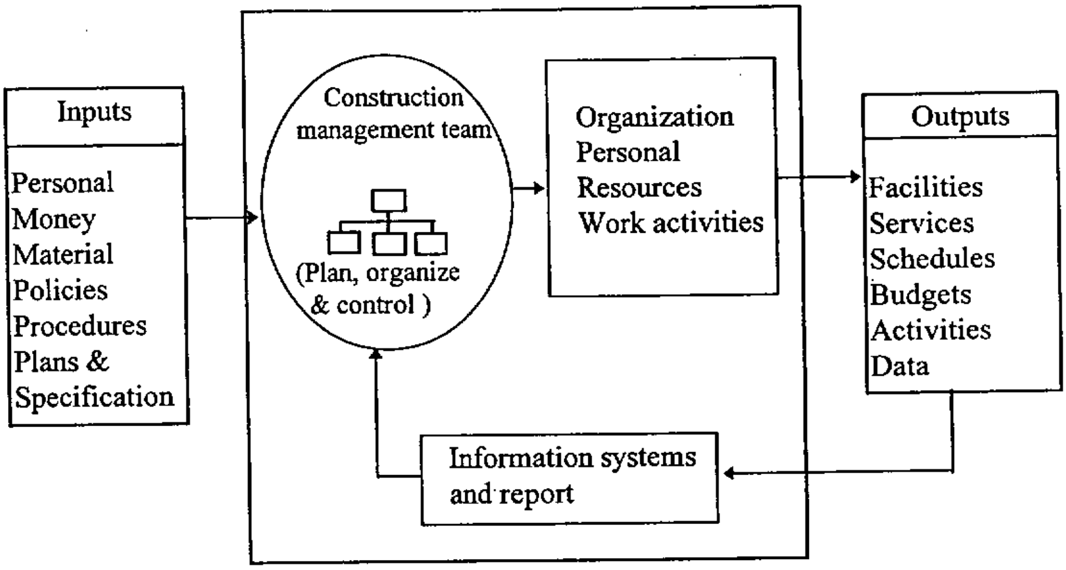


Figure 2.8 A General Model for Construction Management Process
Source: Ritz (1994)

The above models highlight that the importance of system view on construction project management and even construction project managers should have such system view to carry out their management activities. Systems are necessary for operational islands resulted in the combination of horizontal management gaps and vertically functional gaps: departmentalization. Kerzner (1984) claims that the project manager's responsibility is to get the operational islands to communicate cross-functionally toward common goals and objectives. Bennett (1991) suggests that any aspects of construction projects can usefully be treated as systems. He suggests that systems thinking has the potential to provide important new insights into construction project management.

2.4 Dynamics and Dynamic System

2.4.1 Definitions of Dynamics

There are few explanations about the term 'dynamic'. In Longman dictionary, 'd*ynamic*' is described as something that causes actions or changes, the way in which things or people behave, react, and affect each other, the science concerned with the movement of objects and with the forces related to movement. In Cambridge dictionary, 'd*ynamic*' is described as forces that produce movement, and the scientific study of the forces that produce movement. According to Luenberger (1979), *'dynamic'* refers to:

> "phenomena that produce time-changing patterns, the characteristics of the pattern at one time being interrelated with those at other times. The term is nearly synonymous with *time-evolution* or *pattern of change*. It refers to the unfolding of events in a continuing evolutionary process. "

Shen (1997) defines 'dynamic' with respect to project management system as a kind of power or forces that can produce change, action or effects. Forrester (1961) treats 'dynamic' as time-varying with respect to behaviour of industrial organization. In accordance with the definitions provided, a 'dynamic' is related to 'changes' which produce movements and causes actions.

2.4.2 Perspective of Dynamic System

Nelson (1993) states that a system is dynamic if:

> "the latest of values of its variables depend on past values of the energy source. We can think of a dynamic system as having memory; the effects of the energy sources integrate - accumulate over time. For example, the mass in a spring-mass combination oscillates without an applied force, owing to energy stored in the spring and mass by earlier forces. The spring-mass is a simple dynamic system.

The mathematical description of a dynamic system is a differential equation. *Most systems are dynamics*."

Nelson's perspective is closely parallel to Boulding's classification that dynamic system is related to motion at a physical level, for example, a clock or even a spring mass. On the other hand, dynamic system is considered up to more higher levels such as human and social level with respect to Boulding's classification.

According to Lippitt, et al.(1958), they distinguish four types of dynamic systems with respect to different levels of problem-solving effort - the individual personality, the face-to-face group, the organization and the community. What they mean by dynamic is that when examined closely all dynamic systems, there reveals a continuous process of change - adaptation, adjustment, reorganization. Cleland (1972) clearly highlights that social system is dynamic such as organization.

> "... the utility of system ideas is greatest in a *dynamic* context, i.e. in terms of systems which are evolving over time. Most complex systems are dynamic in the sense that they move from state to state as time progresses. The organization is a dynamic system, since each of the descriptors which characterize its state at any given time - resources available, problems to be faced, decisions to be made, inventory level, financial position, etc. - is also constantly evolving. The dynamic nature of a system is one of the most significant characteristics which must be accounted for when a system is to be designed and utilized. This is the case whether *the system is a product to be marketed, a system to be used as a management aid, or an organized system*."

Recently, Verstraete (1997) defines dynamic system that produces something in either a physical or abstract sense. The abstract sense implies that dynamic system can be considered up to transcendental level.

Similar term to dynamic system, system dynamics was introduced by Forrester (1961). The precedent of system dynamics is industrial dynamics which is a way of studying the *behaviour* of industrial systems. The interrelation of policies, decisions, structure, and delays is shown to demonstrate how to influence growth and stability. It is also dealing with an integration of the separate functional areas of management - marketing, investment, research, personnel, production, and accounting.

2.4.3 System Dynamics

Origin:

The idea that Forrester (1961, 1985) presents in industrial dynamics is to analyze the management process through evaluation of realistic models that incorporate decision-making policy. It is given some general principles that should guide the construction of a model of an industrial system as follows:

- ✓ What to include in model.
- ✓ Information-feedback aspects of models.
- ✓ Correspondence of model and real-system variables.
- ✓ Dimensional units of measure in equations.
- ✓ Continuous flows.
- ✓ Stability and linearity.

Under the guidance of the above principles, a basic model structure of dynamic system can be presented as shown in Figure 2.9. The model is suggested with following characteristics:

- ✓ Be able to describe cause-effect relationships as necessary.
- ✓ Be simple in mathematical nature.
- ✓ Be closely synonymous in nomenclature to industrial, economic, and social terminology.
- ✓ Be extendable to large numbers of variables (thousands) without exceeding the practical limits of digital computers.

✓ Be able to handle 'continuous' interactions in the sense that any artificial discontinuities introduced by solution-time intervals will not affect the results. It should, however, be able to generate discontinuous changes in decisions when these are needed.

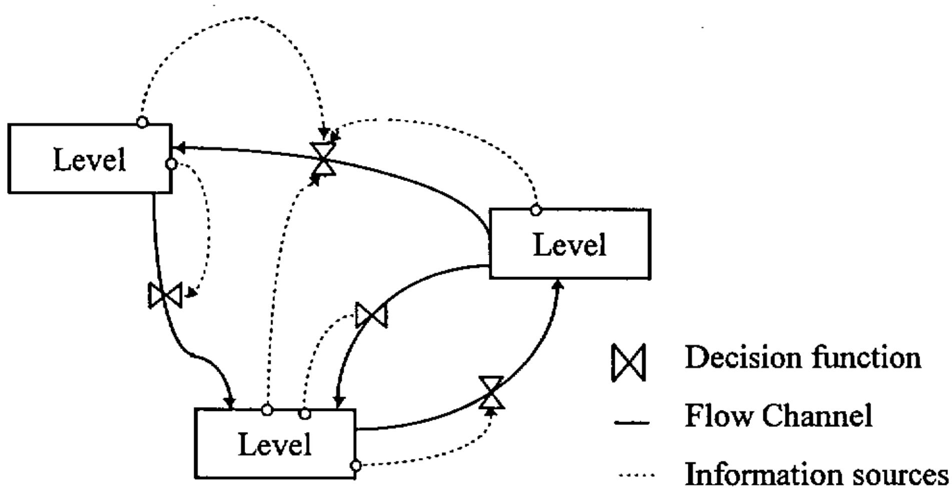


Figure 2.9 A Conceptual Model for Dynamic System
Source: Forrester (1985)

The above model possesses four essential features as follows:

✓ Several levels.
✓ Flows that transport the contents of one level to another.
✓ Decision functions that control the rates of flow between levels.
✓ Information channels that connect the decision functions to the levels.

Classification:

Forrester(1968) classifies systems as 'open' systems or 'feedback' systems by emphasizing 'feedback' or response in the following way:

> "An open system is one characterized by outputs that respond to inputs but where the outputs are isolated from and have no influence on the inputs. An open system is not aware of its own performance. For examples: an automobile and a watch."

"A feedback system, which is sometimes called a "closed" system, is influenced by its own past behaviour. A feedback system has a *closed loop* structure that brings results form past action of the system back to control future action."

The feedback system is a closed loop connecting a decision that controls action, the levels of the system, and information about the level of the system, the latter returning to the decision-making point as shown in Figure 2.11.

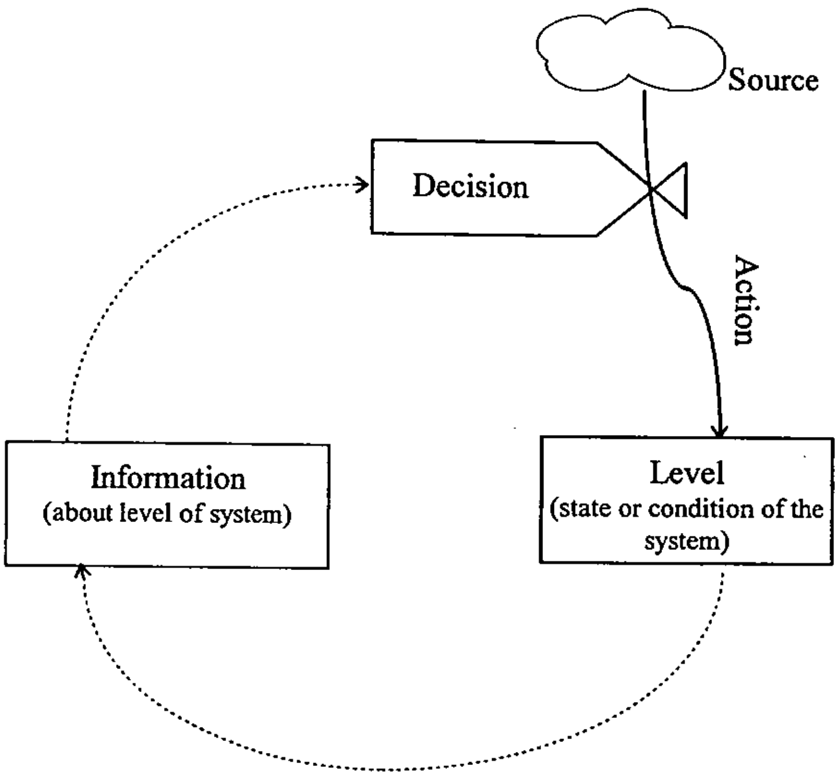


Figure 2.10 Feedback Loop System for Decision
Source: Forrester (1968)

2.4.4 Applications of System Dynamics

The principle of system dynamics has been applied in many areas. A previous work examines the particular areas for application.

"... applications were largely industrial (Forrester 1961). Later the subject broaden

(Forrester 1968) and a number of global and other large scale studies emerged (Forrester 1969, 1971; Meadows et al. 1972). During the late 1970s and 1980s, the scale of individual studies has been reduced, but the scope of application of the method has become extremely wide, covering most traditional academic disciplines of study, but with a strong emphasis on socio-economic areas. (Coyle 1977, Richardson and Pugh 1981, Forrester et al. 1983, Lyneis 1980, Roberts 1978, Roberts et al.1983). The subject now has its own international society, and journal (the System Dynamics Review) and links between System Dynamics and other fields are rapidly forged."

Wolstenholme (1990)

"System dynamics concepts are now used in the analysis and design of many types of interconnected systems including mechanical, electric, thermal and fluid systems. The general methodologies arising from this field have recently been extended to the analysis of many other types systems including economics, biology, ecology, the social science, and medicine."

Derek & Wormley (1997)

It is evident that the applications of system dynamics are interdisciplinary even though the scale of individual studies has been reduced. Specifically, apart from applying to production-distribution system, advertising sector, human resource management, system dynamics also shows its importance to project management in R&D, software development, large design and construction programmes, and decision support. [Rodrigues and Bowers, 1996].

2.4.5 Dynamics in Construction Project Management

There are a number of previous works studying the organization systems, management systems and process systems related to construction industry [Morris,1972; Walker, 1984 ; Newcombe, et al.,1990; Bennett,1991]. Some have discussed the internal and external forces affecting the business organization as well as the project processes.

However, there is still lacking on elaboration of *changes and uncertainties* which are more important to nowadays construction businesses. The using of systems concept is often coupled with computer, and many applications are labeled as dynamic system. It is very common to find some of dynamic programme or dynamic model with respect to computer. A typical example is simulation which considers the uncertainties by using computing programme. However, not many studies *focus on the dynamics or dynamic system in construction project management*, only few clues of such relevant concept can be tracked from Sidwell (1990) and Shen (1996).

Ahuja, et al. (1994) describes that construction is a dynamic process - the application of resources to accomplish a plan for a project. From the viewpoint of project environment, Shen (1996) considers that construction is attached with the process which is under a changing environment. It is obvious that the construction project management system is being considered as dynamic process with respect to the project environment. Kerzner (1995) points out that the rate of change of people, organization, environment and technology is increasing sharply over the time as business goals and objectives are changing correspondingly as shown in Figure 2.11. Sidwell (1990) argues that project managers can cope with known problems, but the rate of changes and the degree of difference in changes in the project environment.

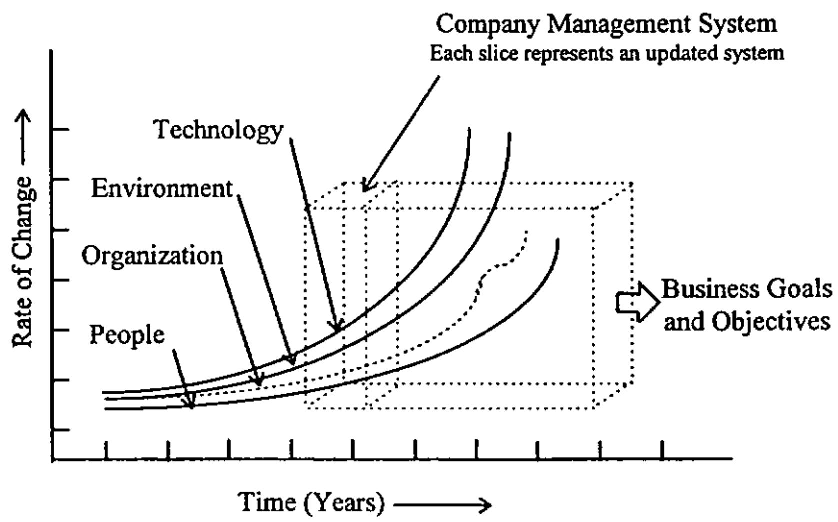


Figure 2.11. Construction Management Systems in a Changing Environment
Source: Kerzner (1995)

2.5 Summary of Chapter Two

This chapter reviews the concept of project management, systems and dynamics. A summary of the main characteristics of project, project management, system and dynamic system are given in Table 2.3. The definitions of 'project' has been conceived as a 'state' in terms of tangible or intangible idea, namely 'ends'. Project management is a 'process' stands for 'means' to realize the 'state'. The emergence of project management has related early to construction industry and emerged in response to the increasing complexity and the fragmentation of the construction industry. The application of systems ideas to organization and process is common in construction companies and projects. It is found that the common point of dynamic system and systems dynamic is to study of the 'change' or 'dynamics' as well as the interrelation between system components. It is also shown that there exists 'dynamics' in construction project management environment. Therefore, dynamic systems approach for construction project management can be developed based on this literature review.

Theme	Main Characteristics
Project	Fragmentation; Complexity One-off; Uniqueness Life cycle
Project Management	Project process Work breakdown structure Temporary organization Differentiation; Coordination; Integration Objectives oriented: Time, Cost, Quality
System	Energy; Entropy Input-through-output-feedback mechanism Goals Hierarchy; Subsystems Wholeness; Holism Environment; Boundary Interdependence; interaction Differentiation; Integration Equifinality Life cycle
Dynamic System	Changes Time-varying behaviour Forces produce changes

Table 2.3 Summary of Main Characteristics of Project, Project Management, System and Dynamic System

Chapter 3

Development of Dynamic Construction Project Management System

3.1 Introduction of Dynamic System Model to Construction Project Management

The uniqueness of a construction project triggers the recognition of project management philosophy either responding to the industrial needs, ethos evolution or emerging knowledge construct. Contemporary managers even treat project management as a way to survive in the face of the 'changes'[Cleland,1995]. Due to the fragmentation of construction industry and the differentiation of project organization, a holistic view on the interactions between different parties by an integration process is crucial to project managers when delivering the project against the project management objectives. Having incorporated the nature of demonstrating a holistic view, interactions between subsystems and an integration mechanism, systems ideas applied to model construction process and organization are evident in the past three decades. Moreover, the innate similarities of systems management and project management that can provide a common platform to unite these two management models [Patzak,1990; Yeo,1993]. The systems approach to project management is thus established as a potential and valuable way in this study to achieve an integration process with a holistic view on construction project management which is a rich and complex management process as suggested by Morris (1994).

The utility of systems idea has its great value in a dynamic context [Cleland,1972]. Systems approach intrinsically exhibits the 'changes' or 'dynamics' properties when it is modeling construction project management as a system, particularly as construction projects are characterized by the project life cycle, the ephemeral organization of the project team, and the susceptibility to influence from the project environment [Sidwell, 1990]. In traditional studies, project management system has been considered rather as a static system which is well designed in terms of goals, functions, components and structures. Little attention has been given to the 'changes' and their impacts to the project management system. It is therefore leading to the exploration of a system for construction project management focusing on the 'changes'.

Various kinds of 'system' can be used to convey their meaning, identity or function in a construction project management environment as shown in Figure 3.1. By definition of a system, many aspects within construction project management can be considered as systems such as procurement and tendering system, design system, cost management system, information system, quality management system, contract system, etc. These systems exist either as mental models, textual or pictorial models, or real operating objects, throughout the whole project process. They interactively contribute to the development of the final physical system: a building. For the management practitioners, these systems may be just a group of parts working together, or an ordered set of idea, principles guiding them to act and react in the management activities, in particular, making decisions.

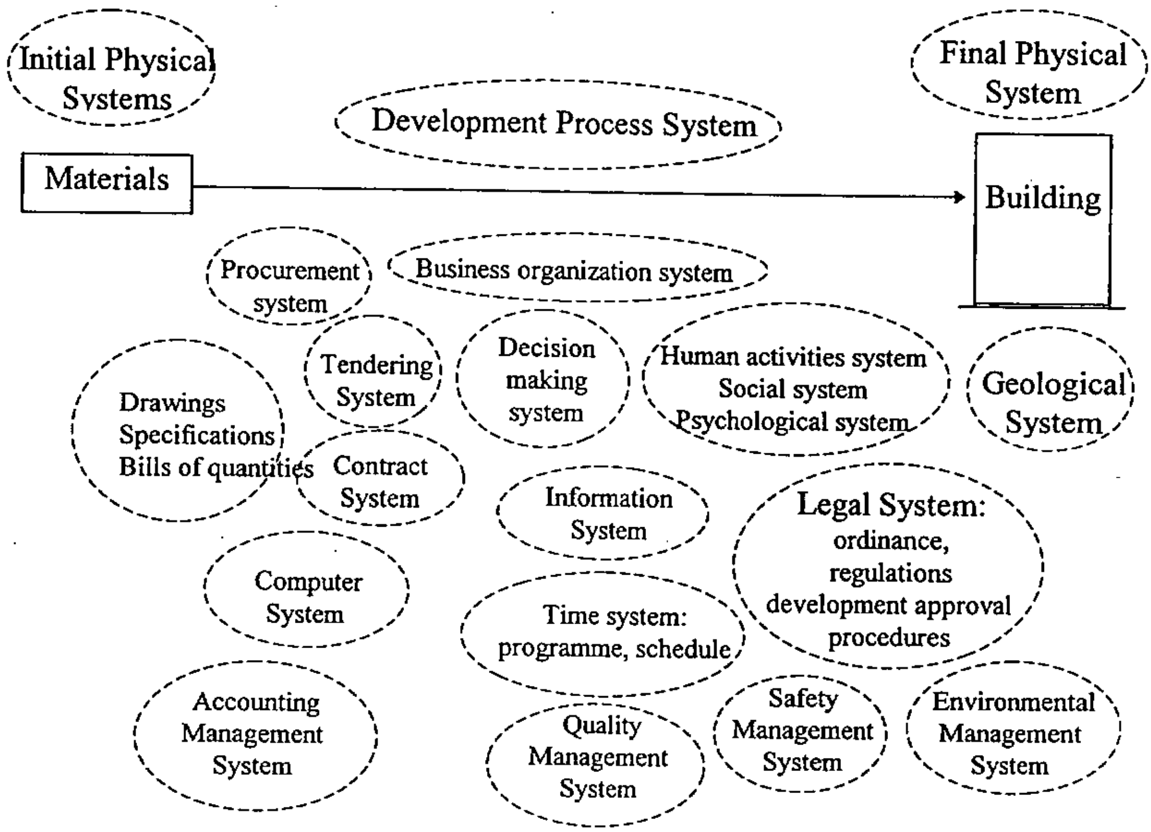


Figure 3.1 Classification of Systems in a Construction Project Management Environment

Construction activities involve an integration process for various resources such as manpower, finance, materials, machinery, information, etc. in order to achieve certain *goals*. The integration effort is a process to set the various resources together. According to the concepts of system mentioned in the last chapter, such an integration of various resources in achieving goals is considered as a *construction project management system* (CPMS) in this study. The overall goal of a CPMS is to complete project as agreed with client's will. In other words, it is a purposeful system for achieving the project client's or the system owner's objectives. The CPMS is subject to the 'changes' in the system environment over the project life cycle. In fact, project managers working in the CPMS always face different degree of 'change' either in terms of implicit and explicit, internal and external, or intrinsic and extrinsic.

The CPMS constitutes various parts/subsystems working against the complexity of a construction project. For the simplicity of modeling, a representation is proposed and illustrated as shown in Figure 3.2. The model intends to serve as a holistic view of dynamic system for construction project management in which three fundamental system components are interacted. The system is called as *dynamic construction project management system* (DCPMS).

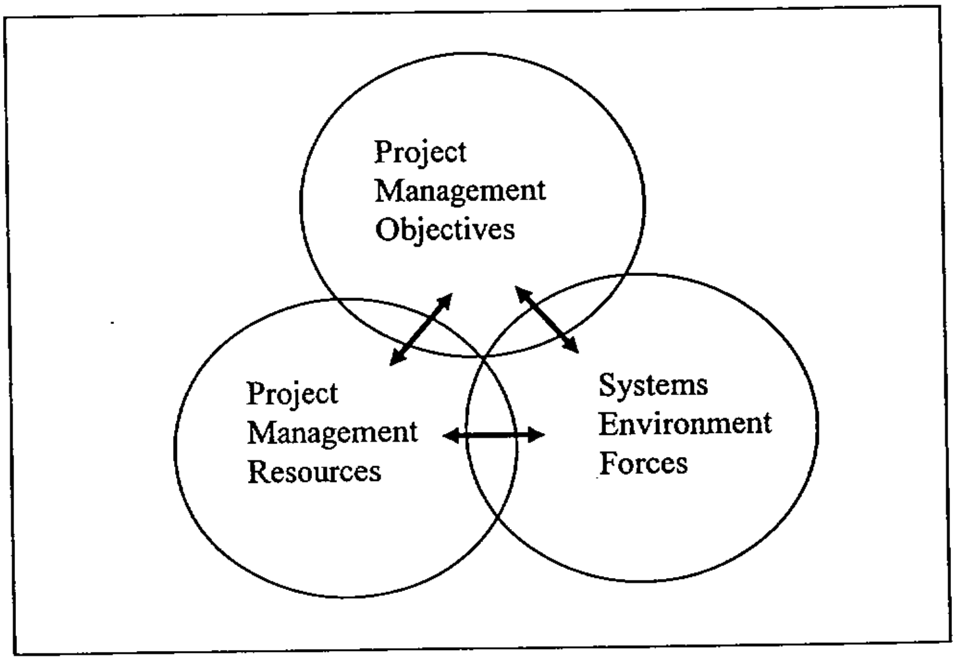


Figure 3.2 A Representation of Dynamic Construction Project Management System

One of DCPMS components is a set of project management system objectives. Previous studies suggest that project management objectives include sub-objectives of *Safety, Environment, Quality, Time, Cost, and Area* (scope of work), abbreviated as SEQACT. The second component is called construction project management system resources (CPMSR). This component typically consists of six variables: *Manpower, Process, Finance, Material, Machinery and Information*. And, the third component constitutes *Legal, Institutional, Political, Sociological, Economic and Technological*, namely LIPSET as a set of system environmental variables. The system component models are shown in Figure 3.3, 3.4 and 3.5. They are interdependent and interactive with each other in the whole project process. They will respond to the changes and uncertainties once a project proceeds against the time frame.

In fact, the three individual DCPMS components themselves can be considered as a system as well. They can be called as subsystems. The concept of subsystems can be differentiated into various hierarchical levels with other names as shown in Table 3.1. For the sake of clarifying 'system' in this study refers to the DCPMS which consists of three *system components. It means that SEQACT, CPMSR* and *LIPSET are called system components*. Each of these system components is called a *subsystem, that is, project management objectives subsystem, project management resources subsystems and project management environment subsystems. Within the subsystems, the breakdowns to any lower levels could be called as elements, members, or units.* The relation is illustrated in Figure 3.6.

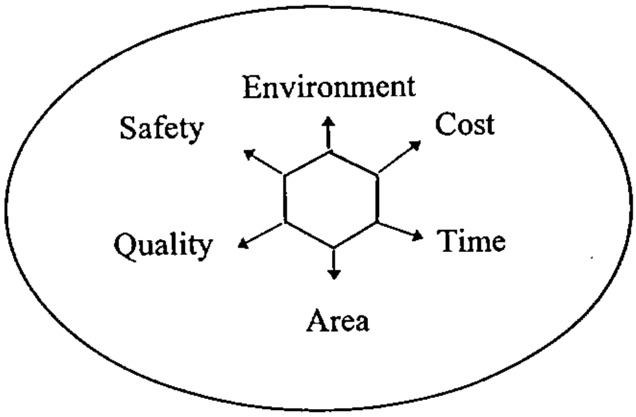


Figure 3.3 Structure of Objectives Elements (SEQACT) for Construction Project Management System

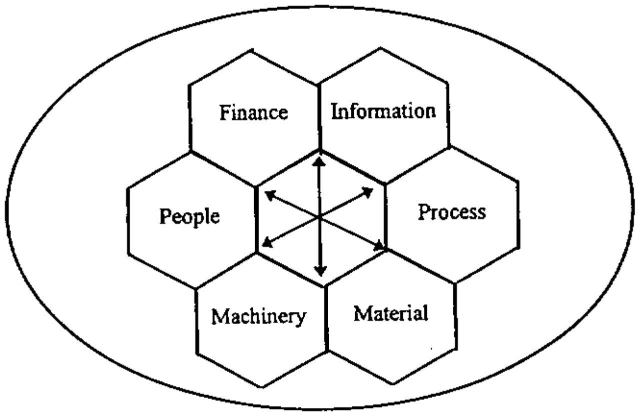


Figure 3.4 Structure of Resources Elements (CPMSR) for Construction Project Management System

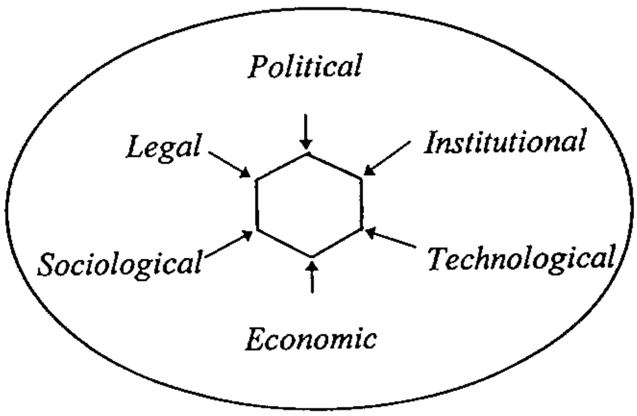


Figure 3.5 Structure of Environment Elements (LIPSET) for Construction Project Management System

Level	System breakdown	System usage	Some common synonyms
1	System	system	whole, totality, aggregation
2	Subsystems	components	ingredients, parts, modules
3	Sub-subsystems	elements	members, units, individuals, factors
4	Sub-sub-subsystems	...	
.....		...	
....		*indivisible*	

Table 3.1 Typical Terminology of System and Subsystems

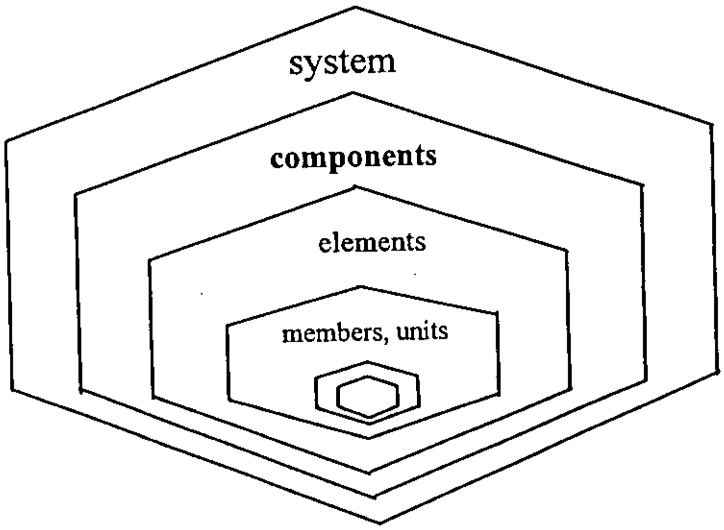


Figure 3.6 The Breakdowns of Systems Languages

3.2 Construction Project Management System Objectives

3.2.1 Conventional Project Management Objectives

As it was discussed in chapter 2, any systems or subsystems will have specified goals. For example, in a project organization system, all involved parties can be considered as subsystems, and they have their own company objectives within a same project. Similarly, all people working in a project environment have their own goals which might be the push-and-pull factors for integrating different parties to accomplish a project together. The conventional project objectives are usually client-driven as focusing on cost, time and quality as shown in Figure 3.7. Another similar triple objectives are schedule, budget and scope [Oberlender,1993].

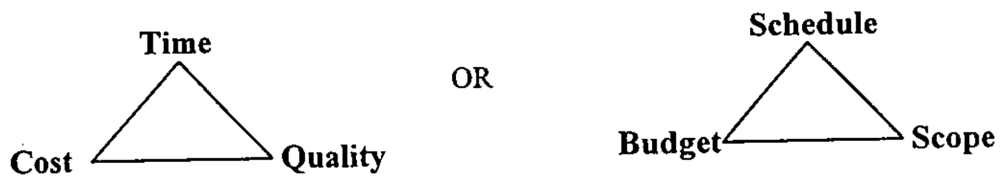


Figure 3.7 Conventional Domination of Project Management Objectives

3.2.2 Environment - Green Concern

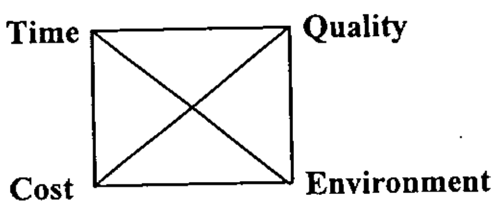


Figure 3.8. The Fourth Project Management Objectives

Gradually, the fourth dimension for managing project as environment reservation has been promoted since last decade. Such project objective is being recognized globally. The environment impact assessment practice and the environmental management system will indeed force different project parties to treat environmental protection of equal important as the conventional objectives as shown in Figure 3.8 [Shen,1993].

3.2.3 Safety - Red Awareness

Safety First! It is a common slogan in construction site. In Hong Kong, safety is a big problem both for construction on site and for existing building stability. Actually, many cases can be avoided by well established project objectives that not just put the emphasis on cost but safety and inner quality of a building.

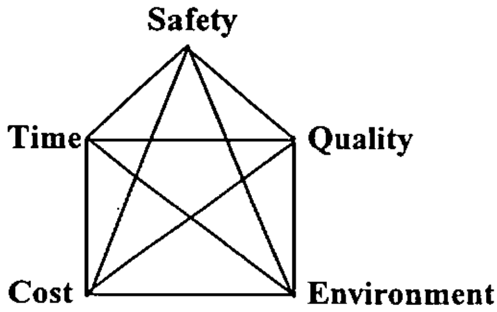


Figure 3.9. The Fifth Project Management Objective

The Buildings Department and the Labour Department of the Hong Kong Government, working with some institutional bodies such as Hong Kong Occupational Safety & Health Association (HKOSHA) and the Safety Specialist Group (SSG) in Hong Kong Institute of Engineers, playing an important role in safety and health for construction industry. It is not only workers' personal objective to safeguard themselves, but also all concerned project parties' responsibility to treat safety as priority. Safety should be treated of equal importance as other project objectives, as illustrated in Figure 3.9.

3.2.4 Differentiation and Integration of Operation Area

The differentiation derived from the combination of horizontal management gaps and vertically functional gaps. It is project manager's responsibility to bridge the gaps to communicate cross-functionally toward common objectives [Kerzner,1984]. Therefore, the sixth dimension of project management objective is considered as an operation area in this study. The 'area' objective, which is dealing with Work Breakdown Structure (WBS), is to manage *system boundary*. The management of boundary is crucial to all level of managers since objective is much more manageable and operational if the boundaries such as duty and responsibility matrix can be clearly shown. This can also relate to Stage Breakdown Structure (SBS), Organization Breakdown Structure (OBS), Cost Breakdown Structure (CBS) and Product Breakdown

Structure (PBS). The operation area is blended with the other project management objectives for the dynamic system in this study as shown in Figure 3.10.

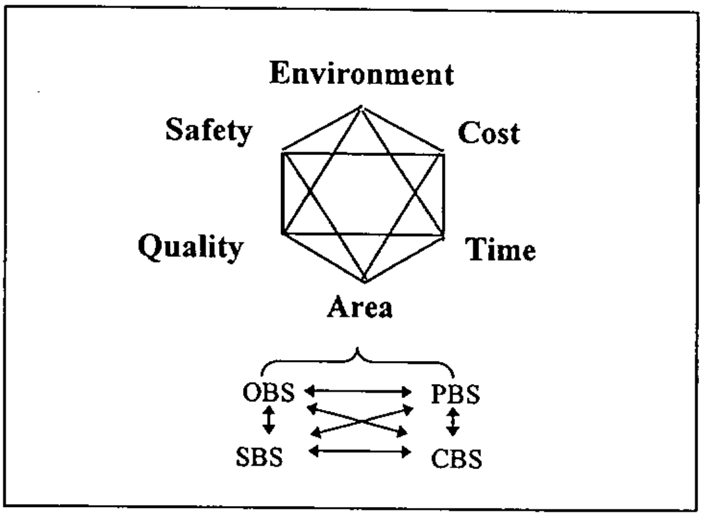


Figure 3.10 The Sixth Project Management Objective - Operation Area.

The common breakdowns are demonstrated in Table 3.2, 3.3 and 3.4. The selection of breakdown has its values and importance to different project stakeholders for their understanding of their work environment as well as for management of project. Table 3.2 shows the breakdowns of a typical building product or facility. It can be treated as four main components, foundation, superstructure, E&M services and furniture respectively. Each main component can also be divided into more further elements. Of course, the detail of division is dependent on the unique project which is delivered by different form of contract and different combination of a project team.

Level	Construction Product
1	building or facility
2	foundation, superstructure, services, furniture
3	electricity, light, water, gas, telecommunications, ventilation, fire, etc.
4	telephone, Cable TV, wireless TV, computer network, etc.

Table 3.2 Product Breakdown Structure (PBS) for a Construction Project

Level	Construction Stage / Process
1	project
2	conception inception realization
3	design realization, construction, commissioning, completion, occupation
4	planning/programming, site mobilization, foundation, superstructure, finishes

Table 3.3 Stage/Process Breakdown Structure (SBS) for a Construction Project

Level	Construction Organization
1	project organization
2	client, project manager, architect, contractor, engineer, quantity surveyor
3	main contractor, specialist SC domestic SC, labour-only SC, nominated SC,
4	excavator, concretor , bricklayer, steel bender, joiner/fitter, welder, glazier, etc.

Table 3.4 Organization Breakdown Structure(OBS) for Construction Project Management

From the viewpoint of development process, a project is generally phased as conception, inception and realization. Some other studies consider the process as from feasibility, strategy, pre-construction, construction, engineering services, commissioning, completion and occupation [CIOB,1992]. The project process division is illustrated in Table 3.3.

From the point of view of organization, a construction project organization is normally structured in different formats. The formal organization structure usually only indicates the existence of certain key parties or departments. For a construction project organization, there exist various main contracting parties who are also constituted by diversified units or departments. The units or departments comprise individuals, that is persons. Table 3.4 illustrates a typical structure for construction project organization.

In fact, some other aspects can also be considered as project objectives, for example, worker's welfare. However, project objectives must react with the changes and uncertainties in the future. For example, project stakeholders may emphasize on knowledge generation, social and global welfare for different projects. That means project management objectives are changing.

3.2.5 Interdependence of Project Management System Objectives

Different parties may have different priority over project objectives. The project management objectives are interdependent with each other. For examples, the implementation of safety may firstly induce the scope (area) of management by proper differentiation and integration. This requires the provision of additional time for safety prevention measures and hence extra management fees. Similarly, the introduction of environmental objective might trigger the extra time and cost to site environment management. Due to the complexity of project objectives, it is important to apply the project game rules, namely contractual terms or conditions to all contractual parties.

Either by the demand of a particular project in terms of contract or industrial practices, there are many *set of procedures, principles, documents or code of practices* available to work against the project objectives as shown in Figure 3.11. The set of procedures, principles, documents or code of practices are often organized in a systematic way.

The six project management objectives must be carefully coordinated and integrated in order to achieve a successful project. After outlining the system of project management objectives, how other project management system components are incorporated to accomplish these objectives will be discussed in the following sections.

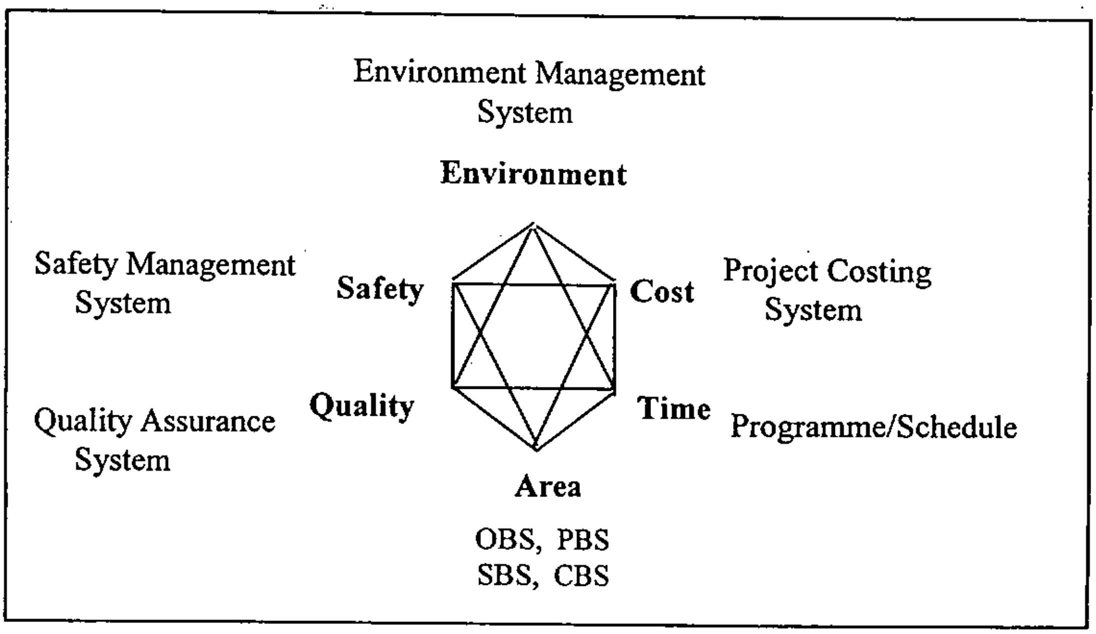


Figure 3.11 Interdependence of Project Management System Objectives

3.3 Construction Project Management System Resources

3.3.1 Manpower Resources

People are the major resources for undertaking a construction project. All individuals work with different areas of a project, but closely interact between various teams. The teams or departments are the inputs to form, by employment contract, a company. For a construction project organization, it is established by involving various companies in the form of business contract. Such kinds of relationships can be illustrated in Figure 3.12.

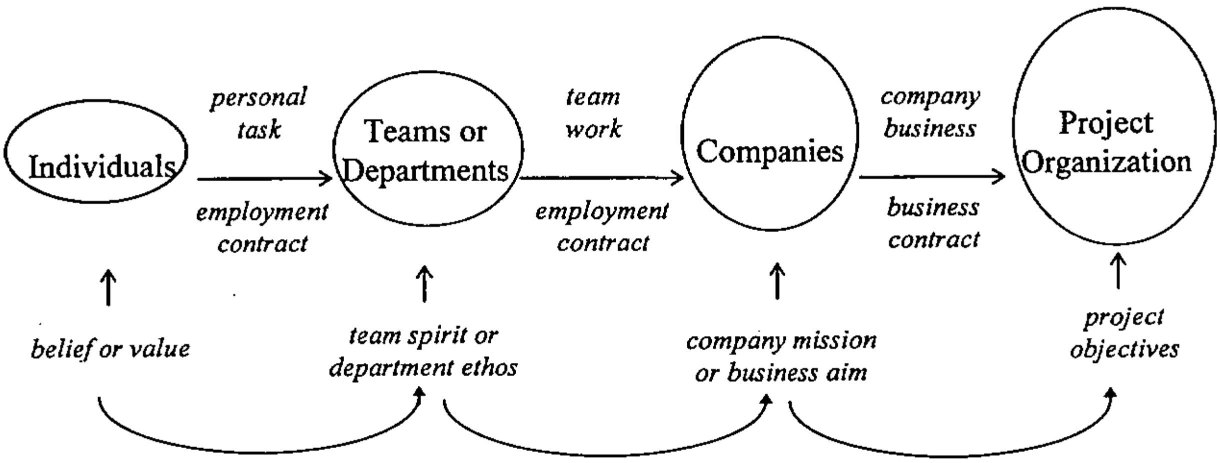


Figure 3.12 Composition of Manpower for Construction Project

Human being resources not only exist in the form of individual, team or company, but also in the form of belief, value, ethos, mission or objective. The personal belief or value, team spirit or department ethos, company mission or business aim, and overall project objectives, if properly integrated, are the impetus for all people to actively and positively participate into a project and make project objectives realized. Nevertheless, their differentiating nature may bring about many conflicts or confrontation which will be hazardous to the overall project objective.

The human resource will be subject to changes as any task or team relationships are vulnerable due to the conflicts or confrontations in terms of power struggle, duty and responsibility assignments. The subsystem is full of uncertainties as project staff is often readily to leave by too much workload at low pay or lack of security. Such political-economic factors impose a great amount of pressure on construction project management to keep a stable workforce in need. Thus, to manage a manpower subsystem, an adaptive recruitment policy as well as project staff caring is needed so that a stable manpower subsystem can be maintained.

Nowadays, many project parties' representatives are employed as the project manager as they are working under a project environment. There may be confusion about the role that a project manager plays because many project managers from different companies work for the same construction project. Usually, Project Manager, capitalized PM, is a client's representative. However, the title of project managers is accepted by this study down to the individual company level. Because such a title reflects the manager's role in a project environment.

It also stresses the importance of identifying the scope of construction project management and the level of project managers in this study. The scope of construction project management includes all levels of management activities for a project over the construction project life as defined from clients' idea to actual completion but not extend to maintenance management. Concerning the definition of project managers, there are basically two level of project managers serving complementarily to target at the six project management objectives. One is commonly recognized as a client's representative at the project level to integrate various project parties and plan the development process by referring to the interdependent project management objectives. One is at project party, that is company project level, to integrate different departments and organize various company resources under company mission and business aim with respect to project objectives. Those under these two types of project managers are treated as project coordinators.

3.3.2 Process Resources

The three main phases of a project, namely, conception, inception and realization are sequentially interdependent. Time objective forces project team to re-engineering of the whole project process in order to minimize project duration.

To manage a process subsystem, the knowledge of key decision points is crucial as other project decisions are greatly affected by them. Moreover, the degree of overlapping between project phases is largely determined by these key decisions. For example, the selection of procurement path is a key decision for client or Project Manager to deliver a construction project. There are several procurement methods available in construction industry such as conventional, design and build, construction management, managing contracting, turnkey or project management. The differentiation of various procurement methods mainly lies in the different arrangements for the risk allocation among Client, Contractor or Development Consultants (Architect, Project Manager).

At different project stages, subsystems or sub-subsystems can be generated, from an intangible idea state to the final tangible product state as shown in Figure 3.13. The degree of overlapping between project phases is mainly dependent on the selection of procurement method which is a strategic decision. The overlappings within specified stages could be increased by certain tactical decisions. For example, the trade off of construction method can either employ off-site prefabrication or on-site production. Furthermore, individuals could improve their serial or sequential works into a parallel process by re-designing the work sequence.

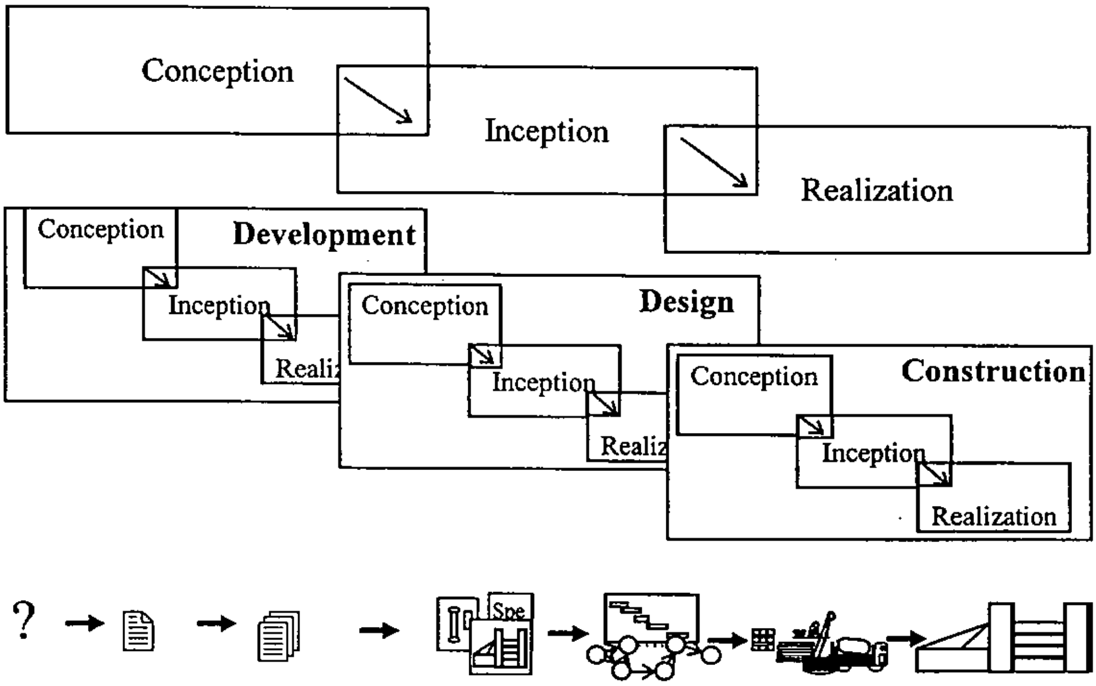


Figure 3.13 Interactions of Construction Project Processes

3.3.3 Finance Resources

Value for money is the basic requirement for a client who invests in a project. The management of finance is critical to all project parties. It contributes to smooth progress of all operating systems and ultimate product quality as well as management service. For a project life, a simple cash flow can be illustrated in Figure 3.14(a). In Hong Kong case, land is most costly for a project in which a great amount will be spent early in the early project stages as shown in Figure 3.14(b).

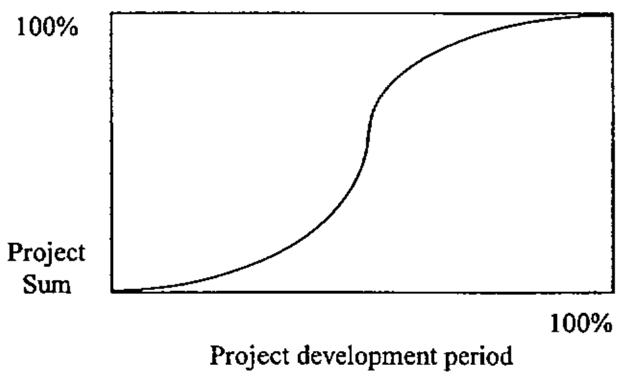


Figure 3.14 (a) General Project Cash Flow

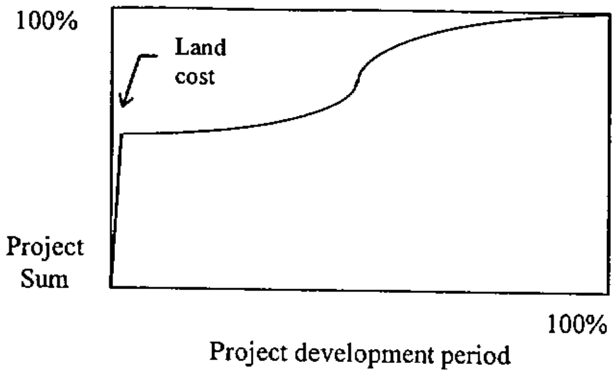


Figure 3.14 (b) Typical Project Cash Flow (in Hong Kong)

The overall price of delivering a project is generally divided into cost and profit. Project costs are comprised of information processing cost, manpower salary, material cost, plant operation cost or land purchasing cost, etc.. A systematic diagram shows the finance flows of a construction project in Figure 3.15.

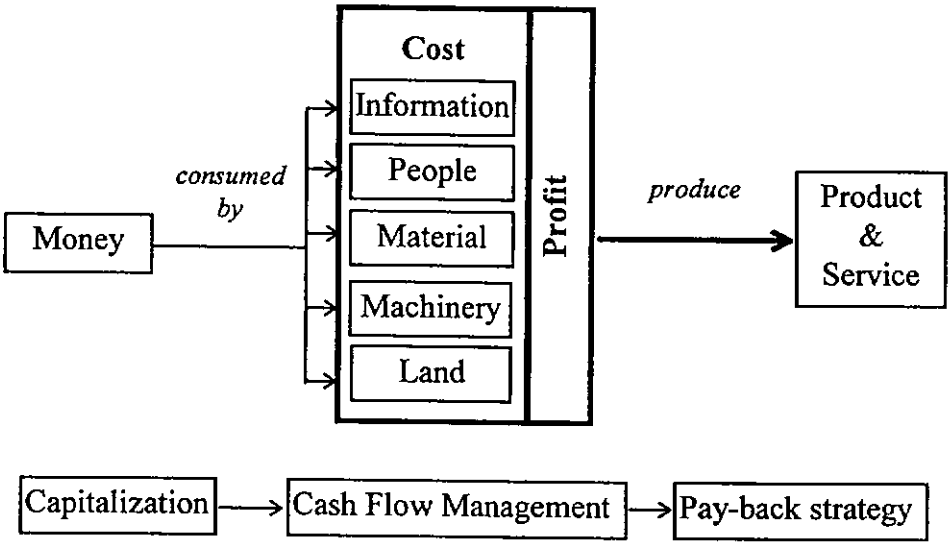


Figure 3.15 Composition of Construction Project Costs

3.3.4 Materials Resources

The material flows originate from raw materials, artificial and construction elements to the whole building product as shown in Figure 3.16 . As the elements of a building are so diverse that global material trading system is usually necessary for a construction project.

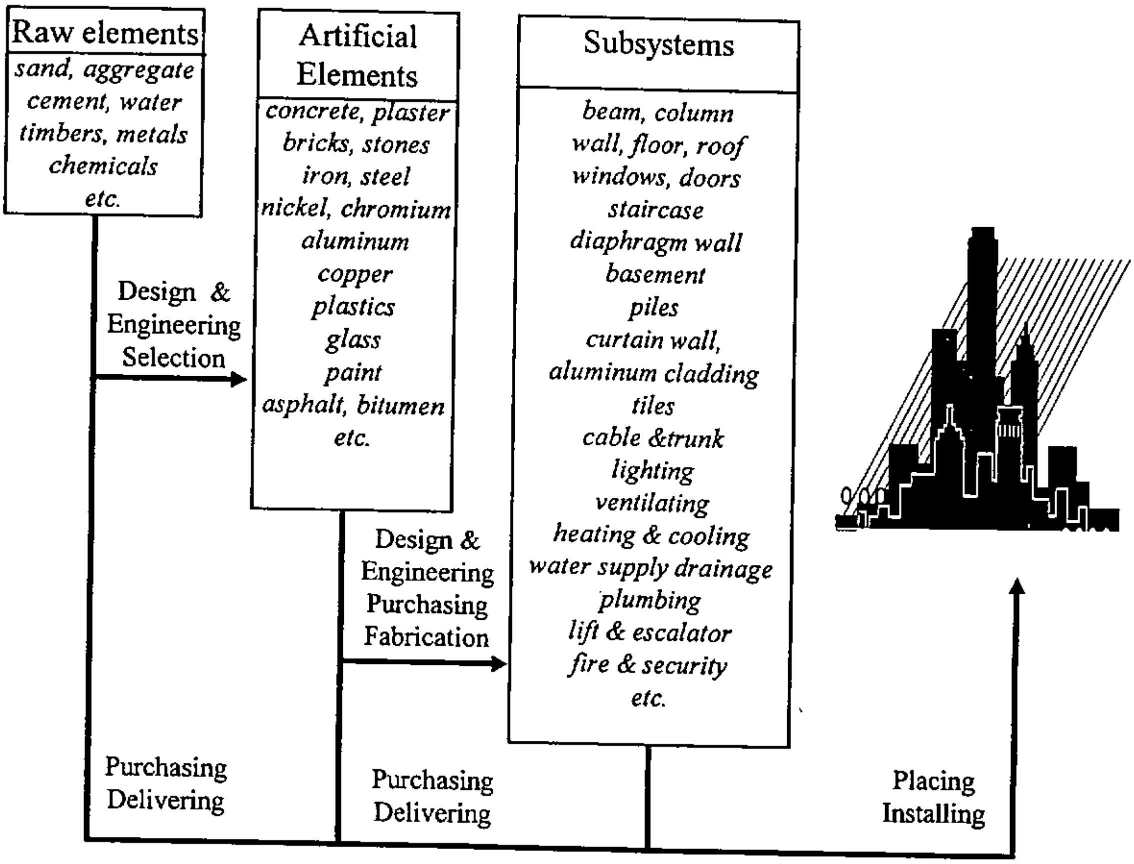


Figure 3.16 Composition of Construction Materials

The classification of material is crucial to the management for the material delivery mechanism from selection, purchase, transportation to installation. A building facility can functionally and technically be divided into structural, connective, communicative as well as decorative parts. For examples, the structural parts include diaphragm wall, basement, beam, column, wall and floor; the connective parts include those of plaster, cables, adhesives and pipes; the communicative parts include windows, doors, stairs and lift; the decorative parts include all sorts of interior or exterior tiles, plastic or rocky tiles, false-ceiling systems, wallpaper and paint. The early acknowledgment or agreement on the classification of material for a project will greatly help on how to manage material delivery and hence the whole project management system.

3.3.5 Machinery Resources

Two major categories of machinery employed in a construction project are either for *handling materials* or *generating information* as illustrated in Figure 3.17. The former is mobilized on site at construction stage while the latter is employed throughout the whole project life. These types of machinery are different to those permanent ones such as E & M appliances and services. Nowadays, the use of computer is prevailing over construction project management. Information system and information technology interactively affect the management activities within a project.

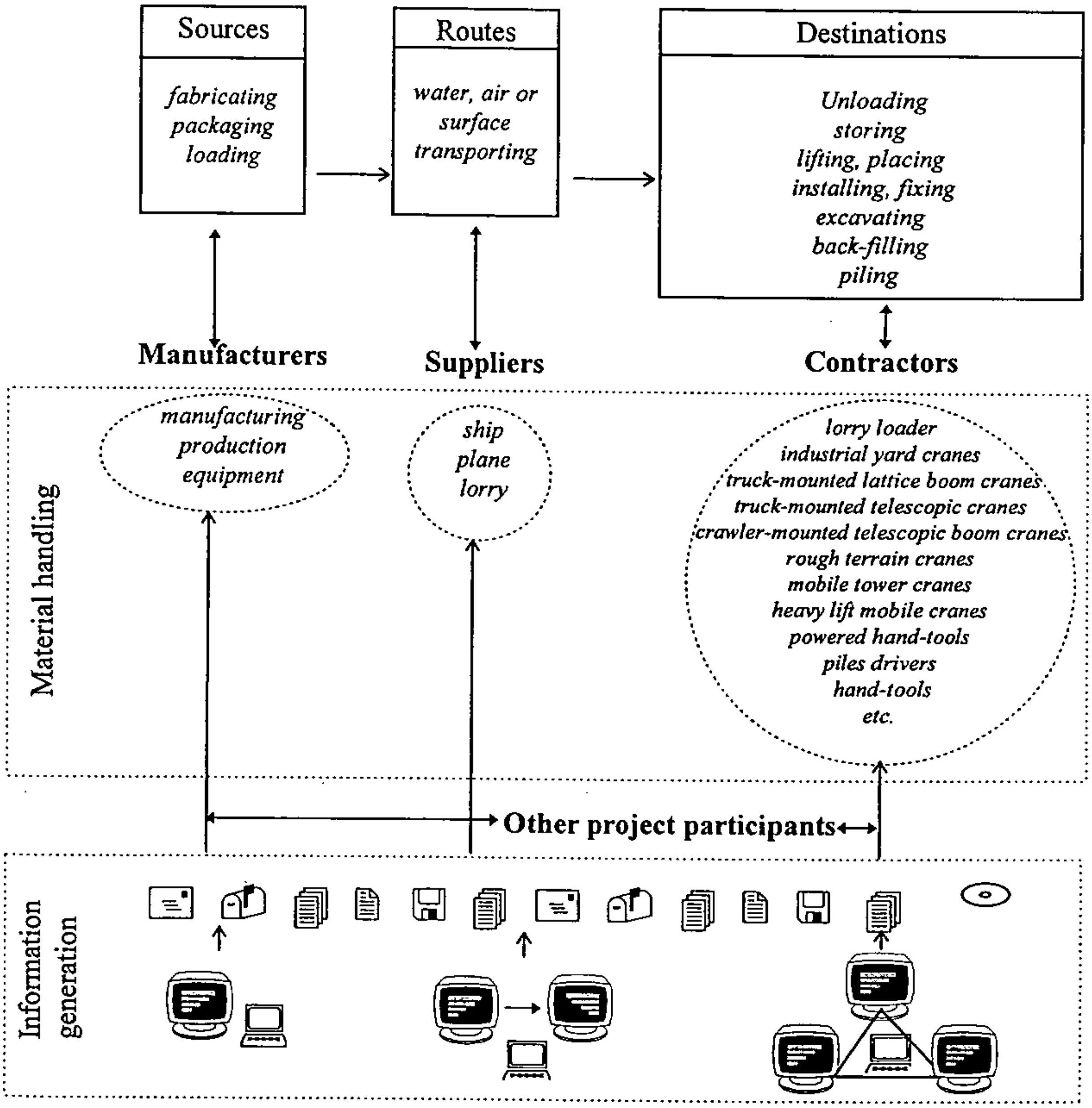


Figure 3.17 Composition of Construction Machinery

3.3.6 Information Resources

The way people understand information will affect the way in which they treat and use information. There are two perspectives of information categorized as resource-driven and perception-driven. The former views information as a resource of which has consistency in its meaning; the emphasis is placed on its transmission. The latter regards information as the outcome of an individual's judgment [Harrington,1991]. Information as a communication means among various project parties is vital in construction industry [NEDO,1990]. The efficient and effective communication between different project parties are determined by the selection of proper information.

Robertson (1977) suggests four main categories of information such as *specific to a project, specific to an organization, specific but supplied from outside sources and general.* Such classification is helpful in understanding the nature of project information. For the information system, the three types of information as *specific to an organization, specific to a project and general* are illustrated with main information flows through different project stakeholders, as shown in Figure 3.18.

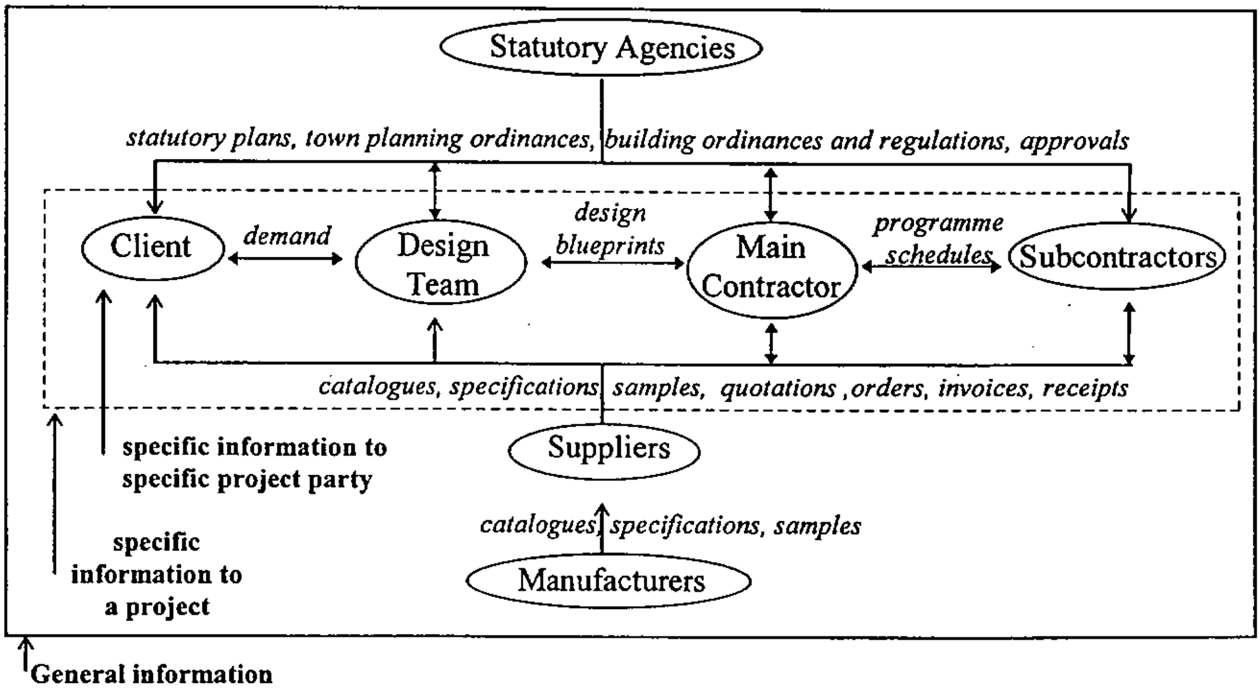


Figure 3.18 Major Information Flow within Construction Project Management Team

Various types of information transmits across different project parties. For example, the Client, Design Team and Contractors interact with government agencies by coordinating statutory documents such as town planning ordinance, building ordinances, application and approvals, etc. The Client's demands of translating design blueprints into specifications and the progamme or schedules, the suppliers' catalogues with manufacturers' information etc., are interactively transferring to ensure actual works to be done.

3.3.7 Interactive Project Management System Resources

The above six elements of project management resources are intrinsically interactive for achieving the project management objectives. Various management activities are designed to apply these resources so as to transform the loose raw materials into a permanent building. Such mechanism presents highly interactive relation between resources and management activities. For instance, when an architect decides to choose a series of colour scheme for external wall, it is a management activity. Such activity will be undertaken with the assistance of information and material subsystems within a project management system. As far as how to integrate material to the facility and how much it will cost, project process and finance subsystems will be applied. How will the material be converted into a colourful wall and by whom will concern machinery and manpower systems correspondingly. Therefore, from input via conversion to output, one could anticipate at the beginning of a project what will be the output or how it will be converted from the input, and similarly one can track what is the input or how it is being converted to the output upon the completion of a project.

Having incorporated other five system resources, the information subsystem is more rather acting as a core managing tool for decision making process as shown in Figure 3.19. There also exists a complete feedback loop for information management.

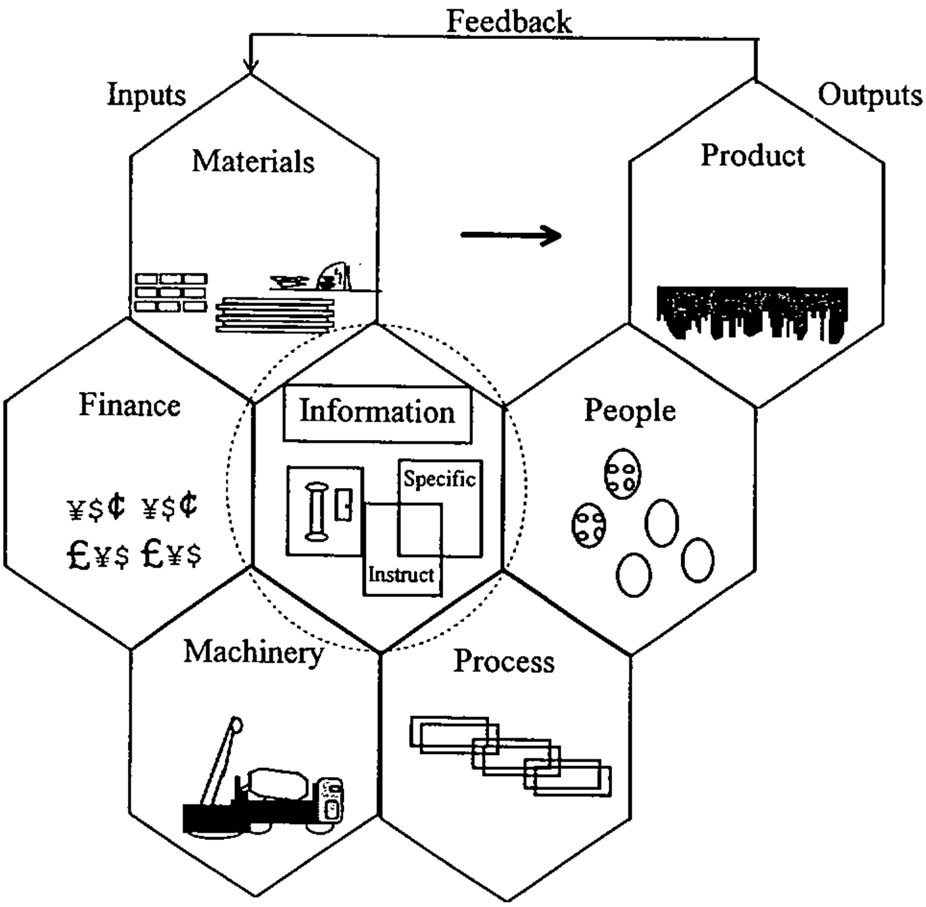


Figure 3.19 Information Orientated Subsystems in Conversion Mechanism

3.4 Construction Project Management Environment Forces

A construction project management system (CPMS) will be established under an environment in which several main forces will affect the effectiveness of the management system. The state of the system and thus its subsystems will be forced to change as the environmental forces are in action over a project duration. In this study, six major environmental forces are identified within a construction project management system.

The environment to a system can be differentiated into macro and micro environment correspondingly. The CPMS is at large affected by government laws, technical ordinances or regulations which exist in a macro environment system. System components are similarly subject to certain legal forces which are not statutory but customary to individuals, say, company regulations and conventional management procedures. These can be called micro environment forces. In this study, only those environment forces with respect to the macro environment will be elaborated, in particular, by referring to Hong Kong situation in the following sections.

3.4.1 Legal Force

Refer to the project management objectives, there are time-related, quality-related, safety-related as well as environment-related ordinances and regulations for guiding the project development. Town planning ordinances control the land use; buildings ordinances regulate the process of construction; factories and industrial undertakings ordinances control the use of operating machinery and care of manpower; environmental impact assessment bill and waste disposal ordinance restrain the design and construction process so that relevant project parties are ensured better use of limited global resources. The development of a project as well as the running of company business are thus framed within numerous legal forces as shown in Figure 3.20.

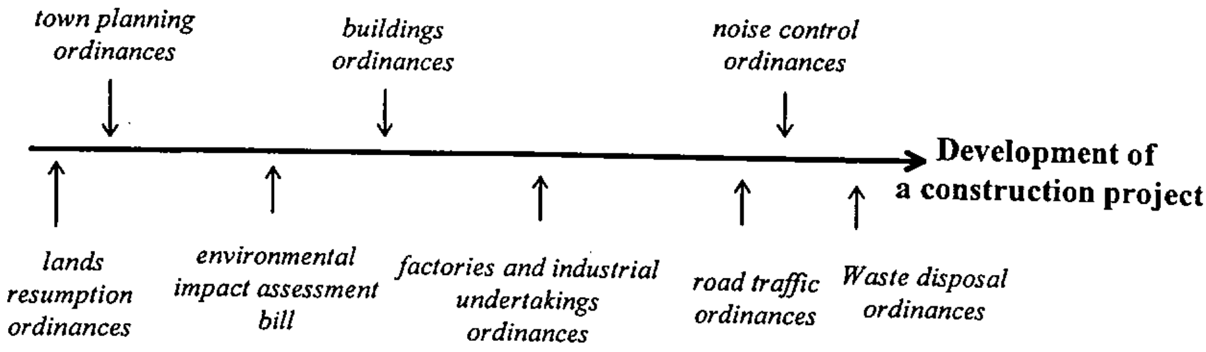


Figure 3.20 Influences of Various Legal Forces on the Development of a Construction Project

3.4.2 Institutional Force

The diversified project participants have their own objectives as mentioned in 3.3.1. The associations or professional bodies from different walks of life demonstrate institutional force on a construction project as shown in Figure 3.21.

The trade and employer associations such as the Hong Kong Construction Association and the Hong Kong Real Estate Agencies Association can affect their members' actions or attitude to other professional or even labour bodies or government's policy. There are numerous professional bodies serving in the Hong Kong construction industry. The Hong Kong Institute of Architects, the Hong Kong Institute of Surveyors, the Hong Kong Institution of Engineers and the Hong Kong Institute of Planners are the four local construction related professional bodies officially recognized by the Hong Kong SAR Government. The Hong Kong Institute of Builders, the Hong Kong Institute of Housing, etc., and those overseas related bodies are also acting as institutional forces on construction industry. Walker (1996) suggests that the influences of the parent company, head office and shareholders are also institutional forces.

Whilst institutional forces are transmitted through rules of conduct, education, and conditions of engagement, the manpower in construction industry are cultivated within the universities, technical institutions as well as training centers. These academic and practical training centers are pressing other kinds of institutional forces on the system.

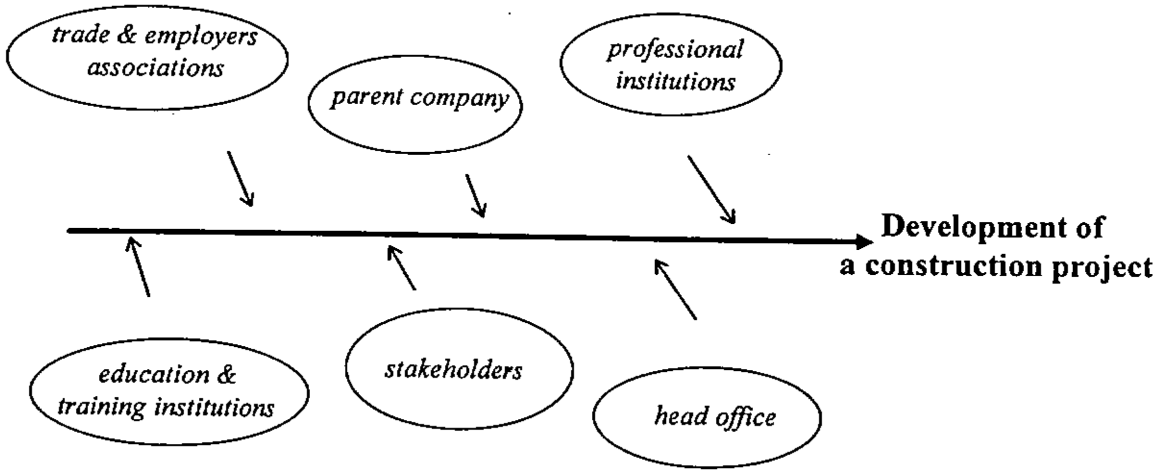


Figure 3.21 The Institutional Forces on the Development a Construction Project

3.4.3 Political Force

The head of a city or nation, that is the government, either central or local, exerts political force onto construction industry and construction projects by different types of policy through different bureaus such as works bureau, housing bureau, education and manpower bureau, planning, environment and lands bureau, etc. The corresponding governmental departments or agencies under the bureaus implement the polices and regulate the construction activities not only by executive but also legislative approach. Therefore, construction project parties have to work interactively with those government departments throughout a project.

Different nations run their government for their own sake either in democracy or autocracy or in-between. Contemporarily, there are two major political blocs or two set of ideology governing the government operation over the world. Capitalism with free market system and socialism with planned market system have different philosophies in ruling a country. Hong Kong is a very special case that it is being run under 'one country, two systems' by which it will continue to develop under free market system.

The booming construction activity in the past decade in Hong Kong acts as a good example in explaining the political force on construction project either for showing confidence, or for gaining experience and economic benefits from such grand projects. It could not be denial that the construction industry is being restructured by the mixing of the British legacy and China concept. More and more China related companies have participated in major Hong Kong economic sectors including construction industry. On the other hand, many Hong Kong development groups have been extending their construction business to China after the 'open-door' policy since late 1970's. This indicated that the mechanism of the Hong Kong construction industry is increasingly interactive with mainland's and being emerged in a new profile.

Under the umbrella of 'one country, two system' and 'highly autonomy', the political parties, representing their service sectors or social classes, are playing another vital political force onto different areas of life including construction activity in the Special Administrative Region. It appears that the Liberal Party, generally for top class in Hong Kong voices for employer. The Democratic Party, for middle class, mainly serves for professional bodies or white collar group. Labour unions, for blue collar group, like the Hong Kong Confederation of Trade Unions represents the construction workers. The political parties compete with each other to seek for more seats in the legislature system so as to influence the government policies. These parties for different interest groups, some are for democracy, some for human right, some for livelihood while some for liberal business arena and so forth. With conflicting political aims, these parties are interacting with each other and thus changing forces produced on construction activities and even construction projects management system.

3.4.4 Sociological Force

Many countries over the world are constituted by different races, tribes or peoples from different colours and languages. Thus there is a polarity of cultures or customs from various groups. Some of these groups can be unified but some may repulse with each other. Building as a symbol of specified cultural, religious or groups is inevitably subject to this sociological force.

The outlook of buildings may reflect what a society looks like. The differentiation of building envelop is obvious between different countries. The shape of a building may also symbolize different society's ethos, particularly in religious purpose. There are numerous landmarks over Islamic, Catholic or Christian, Buddhistic, Lamaist and modernistic society. The building layout plan may also represent society's living custom. In Chinese, kitchen is needed separating form living room because Chinese prefers hot dishes. On the contrary, the West can tolerate the combining cooking area and living room because of prevailing cold dishes.

The social structure changes, from the cradle to the grave, bring certain social problems. The school, eldercare centers as well as appropriate flat sizes to different social members are creating heavy strain onto the demand of construction projects. In Hong Kong, new immigrants from China are almost bracketed into low income class. Such class of new members to Hong Kong society may induce a greater demand of public rental housing scheme or similar economical home ownership scheme as projecting towards 2016 that extra 26.5% of present population will have been accumulated, that is 6.488 million in 1997 to 8.206 in 2016 [Hong Kong Government]. Moreover, the expecting influx of born-in-mainland children having Hong Kong residency as well as the switch to full day mode of operating primary education system will also press the demand of primary school and other community facilities.

The 'two is enough' slogan of family planning which shaping Hong Kong family size is leading the construction design of two or three bedrooms for a standard family. The increasing aging trend urges special design layout and more caring utilities. These forces truly lay much pressure on construction planning and hence the whole construction system.

Critics and public opinion are also in vogue over a rather free society. It is common to see that some public policies or major decisions are tested or resorted to opinion poll by mass media. Such kind of force can affect the operation of a construction project, and eventually affect the CPMS, particularly, management of public construction project.

3.4.5 Economic Force

Construction is an economic activity. The economy puts high exertion on construction project management system as most of the project management objectives are in line with economic philosophy - minimally input but maximally output under limited resource. In a free economy system , the output of construction project management system can be tradable. That is, building flats can be bought and sold under the market conditions. Over the construction project process, the management of construction project development is subject to different forms of economic forces such as financing strategy, financial interest rate, exchange rate, inflation as well as mortgage system.

As a construction project can cost millions and billions of dollars, the method and plan of construction project financing is very important. The source of financing for a project may vary from bank, stock, mutual fund, option or future, bond or treasury which are components of finance and monetary system. The burden of project finance is the interest. The caliber of interest rate greatly affect the project cost and hence profit to any company. For some giant construction projects, the interest per day may be up to several millions. This is why that project completion is normally targeted as early as possible.

The material cost is also subject to fluctuating exchange rate. The global flows of construction material triggering different monetary systems in which exchange rate plays a key role in affecting the material cost. From selection or ordering of a particular sort of material to transportation on site, it may spend months or years before uncertainties and fluctuations happen.

Increase in inflation lifts project cost not only in terms of material cost but also manpower wages. It is not strange to experience over budget in any scale of project. In Hong Kong, the Port and Airport Development Scheme is a typical example that budget escalates fiercely for the sake of political disputes and hence delays in kick-off of projects which bear much inflationary cost.

Competition, a necessary occurrence in free market, compels either developers, designers or contractors to run on fast track project delivery mechanism. Many criticize that the cut-throat bidding price has derived many construction development problems. One is the subcontracting system which may superficially satisfy the overall economy purpose, however, at the expense of risks in differentiation and extra cost for integration.

Property mortgage is another critical economic force regulating the property market. Either the mortgage policy or rate influences the construction delivery process in terms of volume and rate of supply, especially for residential housing market.

3.4.6 Technological Force

Nowadays, all landmarks evidently highlight the contributions from technology. The current high-rise building, large spanning structure, diversified materials, autonomous machinery, creative construction method as well as innovative process management are the graces of technology advancement or science knowledge. These technological forces are pushing, at the same time, pulling the construction project management system to walk along with technological development.

People amaze at such a great scale and large block as Egypt pyramid and other ancient building miracles, but the modern buildings are far more enriched to be utilized effectively by human beings. It is incredible that every aspect of a building is also a sign of technology. But it is a fact! The combination of concrete and steel composes the conventional structure skeleton to withhold the whole building body and thus provides human activity space. Those lightweight concrete, more strong metal alloy and innovative plastic synthesis products are bringing building facilities to a more advanced state.

The prefabrication of building components is a hybrid of material and machinery forces on the CPMS. Prefabricated parts which can be as heavy as several tons, are nowadays becoming popular in construction. It not only revolutionizes the sequence of site production but also lessen the vast demand of skilled labours on site.

Machinery, handling materials and information, is another technological force on the management system. The speed of delivery materials is accelerating from shipping in sea to flying in air. The land survey, materials installing or placing can be aided with more advanced and precise instrument and tools. The introduction of computer, to a greater extent, facilitates the autonomy of operation of different kinds of machinery.

After the machinery era, information is the promising era since 1980s. The fast development of electronic industry and computer industry inevitably attract construction industry to attach to their application so as to increase the overall production rate. The computer softwares such as Autocad, Microstation and Intergraph are prevailing over construction design and engineering. Time-line, Primavera Project Planner , Microsoft Project Planning based on CPA, PERT are very popular over the project planning and scheduling for use. used in System Dynamics community. There are also many other types of specified software such as iThink, Powersim, Vensim and Dynamo being potentially applied to construction project management stakeholders. These information systems coupling with information technology are overwhelmingly driving construction project management to a highly integrative and autonomous management style.

3.4.7 Interdependent System Environment Forces

By looking at the six aspects of system environment forces, they can hardly be isolated but interdependent with each other. Strictly speaking, they have certain kinds of chain of effect or causal relation over the development of a construction project as illustrated in Figure 3.22.

Take the Hong Kong Central Library's design as an example to illustrate how these interdependent environment forces act together on a construction project management system. According to the reports, the design was subject to several changes. The change of design is mainly subject to the need of a state of the art building which symbolizes Hong Kong's achievement (that is technological force). However, the decision process of redesign was fiercely criticized by not following the statutory procedure (that is legal force). This has led different political bodies to speak for their own sake (that is political force) as well as resort to public vote for the designs (that is sociological force). Moreover, it has brought about professional's comments on both old or new design blueprints (institutional force). One of the two main criticizing points on the new design is an extra money paid on redesign fee and an additional HK$100million required for realizing the new design (that is economic force).

Usually, one particular environmental force acting on a project will trigger other environmental forces simultaneously. These forces might be engulfed either in macro or micro environment. Therefore, the project management team should not ignore any one of them. They should also keep abreast to the interactions between the forces and readily respond to them.

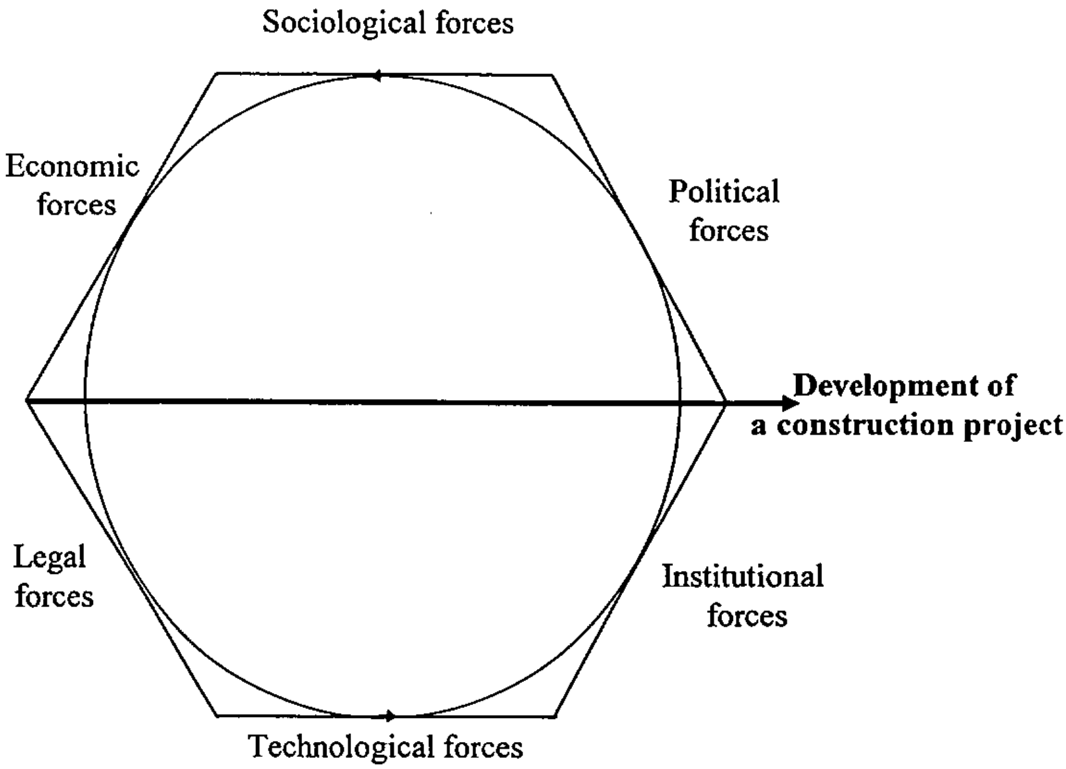


Figure 3.22 Integrated Impacts of Environment Forces on Construction Project Management System

3.5 Dynamics to Construction Project Management System (CPMS)

3.5.1 Characteristics of CPMS Components

Refer to the above three set of system components, they are interactive, interdependent and interrelated with each other. The elements within individual components are subject to changes with time evolving. The basic reason to changes is that all components and elements are inherently full of variables, not constants. And these variables are subject to many uncertainties and risks. Such a chain of variables, changes, uncertainties and risk highly influences the working of the construction project management system. A catchword to unify the chain of these effects can be described as *dynamic*. Intrinsically, '*dynamic*' can be a powerful word which is sufficient to represent the chain of effect. Refer to the concepts of dynamics in 2.2.4, dynamic(s) is defined as (1) something that causes actions or changes; (2) the way in which things or people behave, react, and affect each other; (3) phenomena that produce time-changing patterns; (4) the scientific study of forces that produce movement. The integration of variables, changes, uncertainties and risks is then blending with reference to the general definitions of dynamic(s) so as to facilitate the elaboration and discussion in this study.

A construction project is unique that it possesses many variables with different nature in terms of duration, contract sum, client's nature, types of buildings, etc.. These variables, at large, will affect project management objectives. Therefore, project managers have to work against the multiple project management objectives under a dynamic situation.

CPMS congenitally possesses a state of changing and its components are interacting with each other. For example, manpower utilization throughout a project duration will fluctuate from stages to stages. Information such as drawings, minutes, reports, etc. flow from one party to another or vice versa. Project process progresses sequentially and reciprocally from conception via inception to realization phase. Building materials are transported to a particular site within the project duration from over the world.

There are numerous types of machines work around the clock either to generate information or to deliver, erect or install the materials on site. The project finance accompanying with banking system is transferred from a party to another time by time. Such a sharp fluidity and a high changing rate of different management activities characterize as *dynamic* to all construction professionals including project managers.

The environment outside the system will also change. Changes not only contribute to seek an improvement of project delivery mechanism such as innovative procurement methods, creative design and construction methods, but also change the project stakeholders' attitude toward the built environment.

In short, the study of dynamics is, at its crux, to study project variable, change, uncertainty and risk in a construction project environment. Some definitions of variables, changes, uncertainties and risks will be elaborated in the next section.

3.5.2 Variables, Changes, Uncertainties and Risks

Variables

'Variables' can be defined as something that will/can be changed. Project variables are generally defined into qualitative or quantitative variables. The qualitative project variables may be the end use/function, location, facilities,...etc. For instance, the variables of building function can vary from office, institutional, residential or industrial use. The variables of location may differ from its proximity such as infrastructure, and land uses in terms of commercial (central business district), low or high density residential area or industrial areas. The variables such as population growth, land supply, housing or construction labour force are some quantitative measures which influence the whole construction industry. The uniqueness of a building project under a uncontrolled environment also contributes to certain quantitative variables which may be the project size, usable floor area, total project cost or project duration. A building product is very different from manufacturing products such as automobile, television or computer set which can be produced in a controlled production line. The variances of manufacturing product in terms of cost, production time or size can be more easily minimized to an acceptable level.

Changes

'Changes' are to make or become different, or to develop one thing to another thing. Both qualitative or quantitative project variables are subject to changes. For example, from the point of view of development investment, the determination of end use, the selection of location, the quality of facilities etc. vary greatly with different market conditions. Even after the inception phase of a project development, there are still numerous kinds of variables at project conception and realization phase. Those variables will change or exchange against project objectives and environmental forces. For a general construction project, the design blueprint will be changed, the construction programme will be changed, the project staff will become different, the state of material flows, machinery operations, manpower or finance requirement all will be subject to changes as project progresses over the whole period.

Uncertainties

'Uncertainties' are that something can not be fixed or predicted. Project participants work within a changing environment in which different variables exist. They are under an uncertain situation where many variables are not fixed or not able to be known. For example, a client's decision to upgrade the quality of a project may be reserved for responding to the uncertain property market. Then, architectural or structural design will be sequentially affected by the uncertainty of client's decision. Consequently, construction works will be proceeded under an uncertain design blueprint. It is commonly recognized that, under uncertain instruction, abolishing works are due to insufficient design information and uncertain instructions which are previously caused by client's changing mind in scope of work or new requirements.

Risks

'Risks' are defined as danger of loss and harm, or opportunity of gain. The consequences of project variables, changes and uncertainties will become risks which will fall onto certain project participants. The construction activity with so many changes and uncertainties is usually seen as a high risky business. Both employer or employee, with reference to contractual conditions, may suffer different extent of loss and harm in terms of physical damage or money in case of risks' occurring. On the other hand, they also have the chance to gain financial reward or knowledge in a risk environment.

3.5.3 Definition of Dynamics in Construction Project Management System

Shen (1996) suggests that a dynamic is a kind of power or force that can produce change, action or effect on a system. However, he only illustrates some examples to explain the dynamics that will affect the project progress. No further elaboration of the term "dynamic" is provided in his study. *A "dynamic" here is suggested as a term attributed with an interaction in the chain of variables, changes, uncertainties and risks.* It is suggested that the *dynamics* not only possess qualitative nature but also have quantitative character. The quantitative character of dynamics exists in various forms of forces which interact with the project management system. The attributes of a dynamic can be made as a model shown in Figure 3.23.

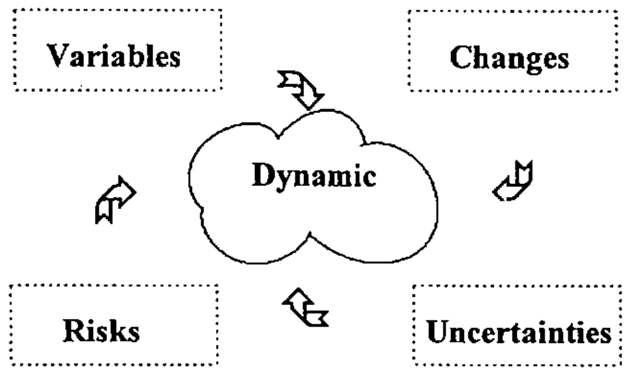


Figure 3.23 Attributes of a Dynamic

An appropriate statement of *dynamic* is very important for communication. For example, time can be called as a dynamic to a construction project management system. Construction period for a project itself is a variable because it can be extended or shortened due to various changes and variations. The changes in project time may then produce some uncertainties or risks to certain project parties as the planned programme is deviated. Furthermore, the uncertainty of completion time could be a price risk which may fall on either developer or contractor side based on the contract terms. This shows that there exists a chain of effect from time variable, that is changes of time; uncertain in completion time as well as time risk as illustrated in Figure 3.24.

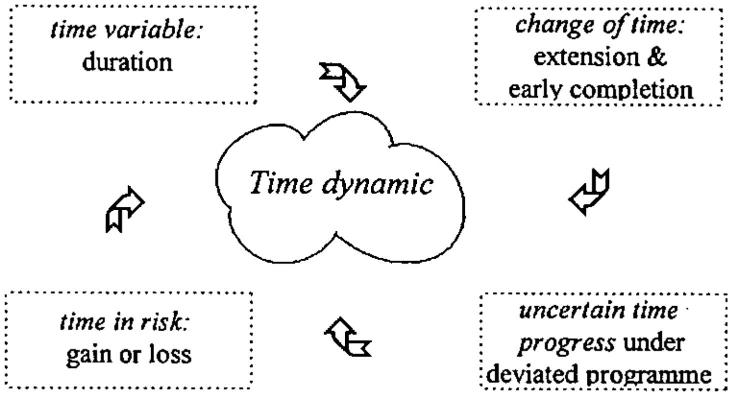


Figure 3.24 Impacts from a Time Dynamic

There exists a changing life pattern for a dynamic in a project management environment from a variable, to change, to uncertainty and to risk as illustrated in Figure 3.25.

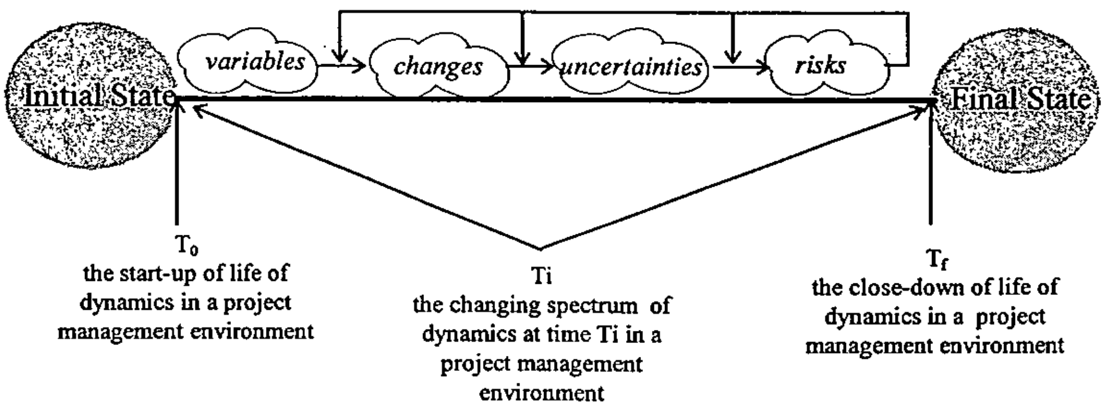


Figure 3.25 The Changing Pattern of a Dynamic in a Construction Project Management System Environment

3.5.4 Static and Static System

In comparison, it is necessary to point out the concept of *'static'* in order to further understand the implications of '*dynamic*' applied in this study. A static is a *relative* concept by referring to a dynamic. The identification of the dynamic is based on the conversion process of a state to another state. The initial or final state of a dynamic is thus called a static. For example, time is a dynamic which is meaningful only within the project duration. Before starting up or after closing down of a project, the concept of time or its implications can be considered as *a static* which represents the initial or final state of a dynamic. The static state will affect the project management system at specific time points. A static system can therefore be defined with respect to a static. A graphic exhibition can show the relation between statics and dynamics in Figure 3.26.

Certain building materials, say, wall tiles that existing in the built environment, before taking into consideration by architects, are statics which has no effect on the design management system. Similarly, those wall tiles before ordering are statics to contractors. But after ordering, contractors need allocating resources in order to manage the delivery of materials. However, from management's point of view, changes can be expected, such as qualitative variables of colours or texture, and quantitative variables such as dimensions, quantities and prices. These changes in materials' requirement also induce uncertainties as well as risks on the project management system, by which abortive work or delay of construction may thus be subsequently resulted. Once the materials are put into the right places for permanent use, they are statics, and the contractor, at that point, will not be anymore affected by such a dynamic either in terms of changes, uncertainties or risks. However, the rework concerning the materials application in case of poor workmanship, accidental hazards or intentional damages are another kinds of dynamics.

For another example, as far as manpower concerned, those who are not yet involved in a particular project, they are statics with respect to project management system. However, once they participate into the project work, they are act as dynamics which will affect the running of the system. Project staff working within office hours are dynamics while they are statics after office hours because they do not affect directly the project management process. Of course, there is an exception that staff have to bear twenty four hours duty and responsibility.

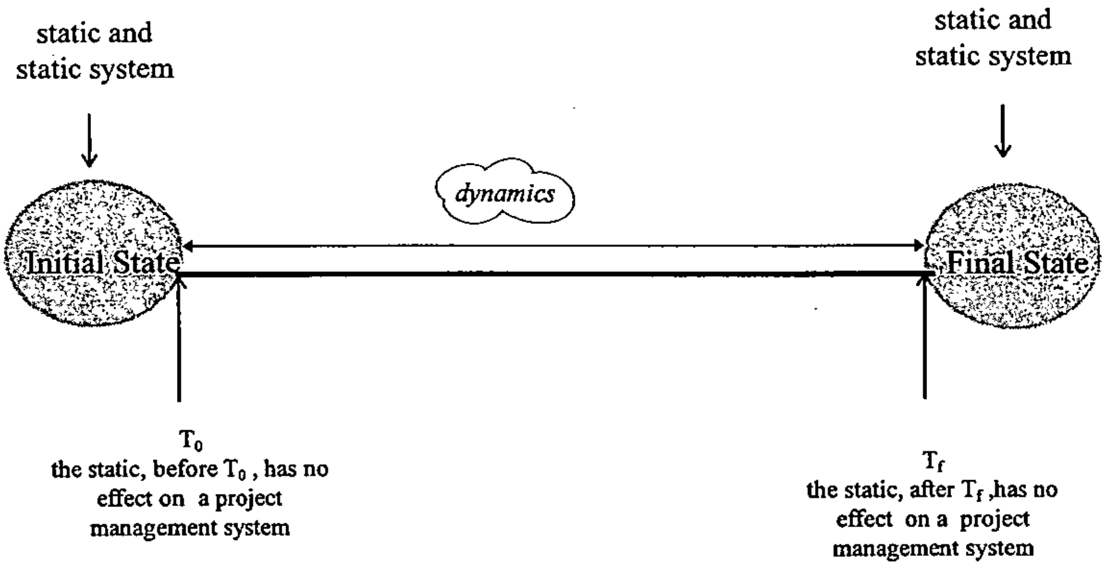


Figure 3.26 Impacts of Dynamics on Static System

3.6 Dynamic Construction Project Management System (DCPMS)

3.6.1 Definition to Dynamic Systems

Based on the concept of dynamic which exists in any construction project management activities, the system for construction project management can be defined as a *dynamic system*. This definition can be stated as:

> *a system, which is targeting at the interdependent project management objectives through the interactive system resources under the interrelated environment forces, in which individual system elements are attributed with a chain of interaction of variables, changes, uncertainties, and risks within a defined project life cycle.*

The dynamic system is a purposive system which incorporates the dynamics within a construction project management system. It is constructed in a *holistic view*. The construction project process is considered as the function of time, from the initial state via numerous transitional states to the final state as illustrated in Figure 3.27.

The transitional states of various kinds of inputs can be expressed in terms of project phases or sub-phases. Say, the integration process of materials to the final product has three basic states by time dependence, that is, material at inception, conception and realization state. For example, when an architect with consent by client has an idea of using marble as external walling, the material is at its conception state. As the architect further specifies qualitative and quantitative property of the marble, the material come to the its inception state. Once the marble is readily to be fixed onto the wall, it reaches to its realization state.

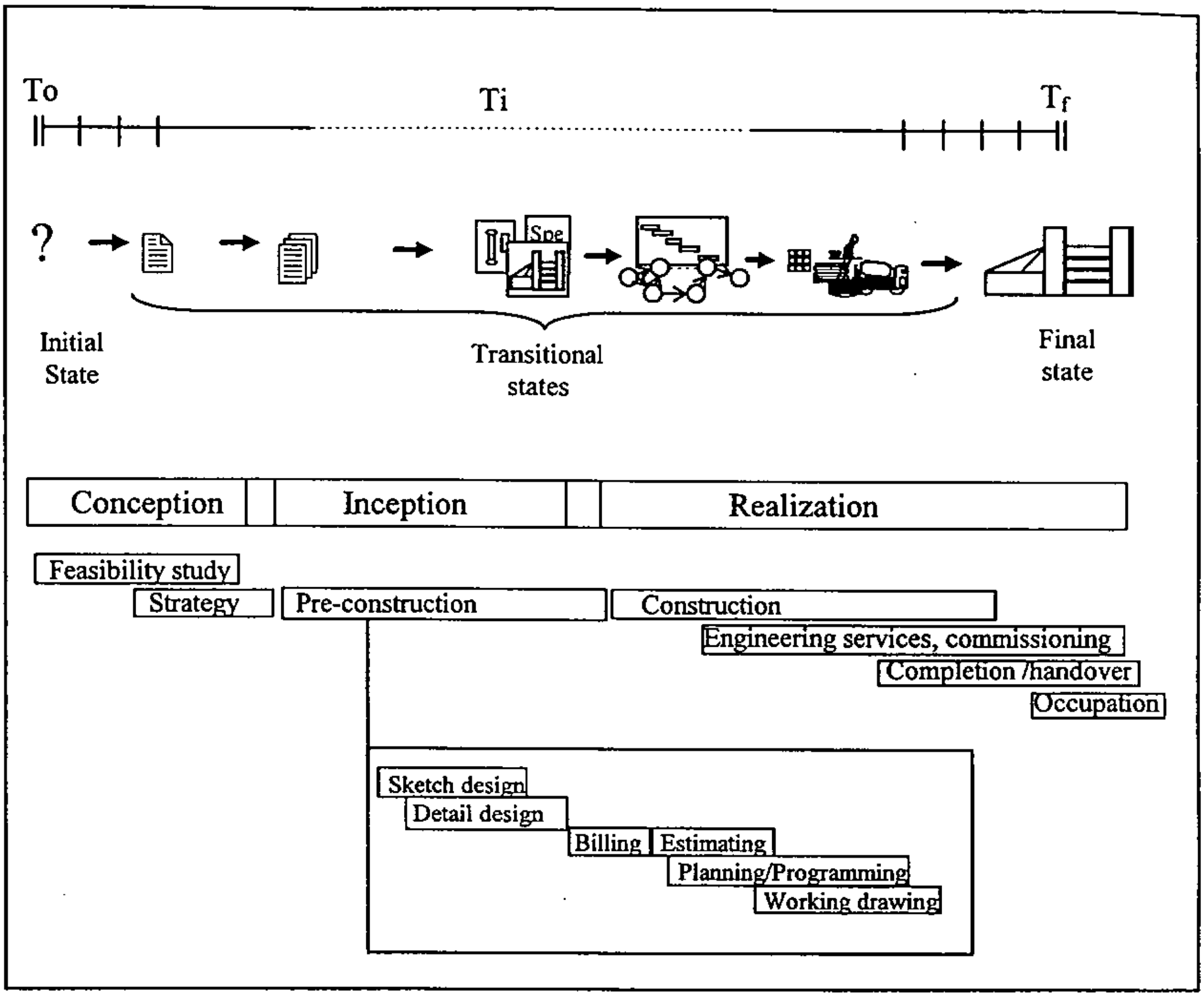


Figure 3.27 The Changing States of a Construction Project Management System

A dynamic systems approach to manpower can, likewise, be applied in line with such concept. The employment or introduction of project parties is in the three similar state of transition. The consideration of invitation of a project party to a project is at a conception state, that is intention of tendering invitation. At the point of invitation and contract signing, the company is at an inception state. After signing contract or agreeing on employment condition, the company enters the state of realization. Another interpretation about manpower utilization is to consider the involvement of efforts in the whole project development process. For example, client and development consultants are the manpower at the project conception state while architect, design engineer and quantity surveyor are manpower at project inception state. The main contractors, trade subcontractors or suppliers are largely involving at project realization state. For individuals, the state of a particular subject varies with different management functions. A client will mainly plan and coordinate at conception state, but he only controls the key personnel at the project realization state. Within construction operating system that can be treated as a project sub-process, the main contractor will commit various management functions with respect to transitional states, similar to that of client's pattern.

Logically, there are many transitional status existed between the three process states - conception, inception and realization. The mobilization of various kinds of machinery can similarly be interpreted in the same way. A dynamic functions through these three states within a construction project management system.

3.6.2 Dynamic Systems Model for Construction Project Management

The dynamic system defined above is not a mechanically dynamic system such as computer or operating engines. Though it can be interpreted by abstract language such as mathematical model, it is not an intention to present by such a way. It is rather a set of principles governing the management of a construction project. This system model has three main parts, input, output and throughput. The dynamic system for construction project management generally possesses different kinds of inputs which generate certain diverse outputs by throughputs as shown in Figure 3.28.

The throughputs are the essential parts. They integrate the system components: SEQACT, CPMS and LIPSET which are interactive. There are different perspectives on treating the inputs or outputs in the model. The selection of terminology is based on individual's will for the area of concern. Generally, the input variables in a construction project may include either consumable or non-consumable things such as materials, manpower, machinery, capital, time, land, technology, idea, information, etc.. The outputs may consist of a tangible building, satisfaction, employment, capital, returns, social activities, technological symbols, usable space, knowledge, experience and so forth.

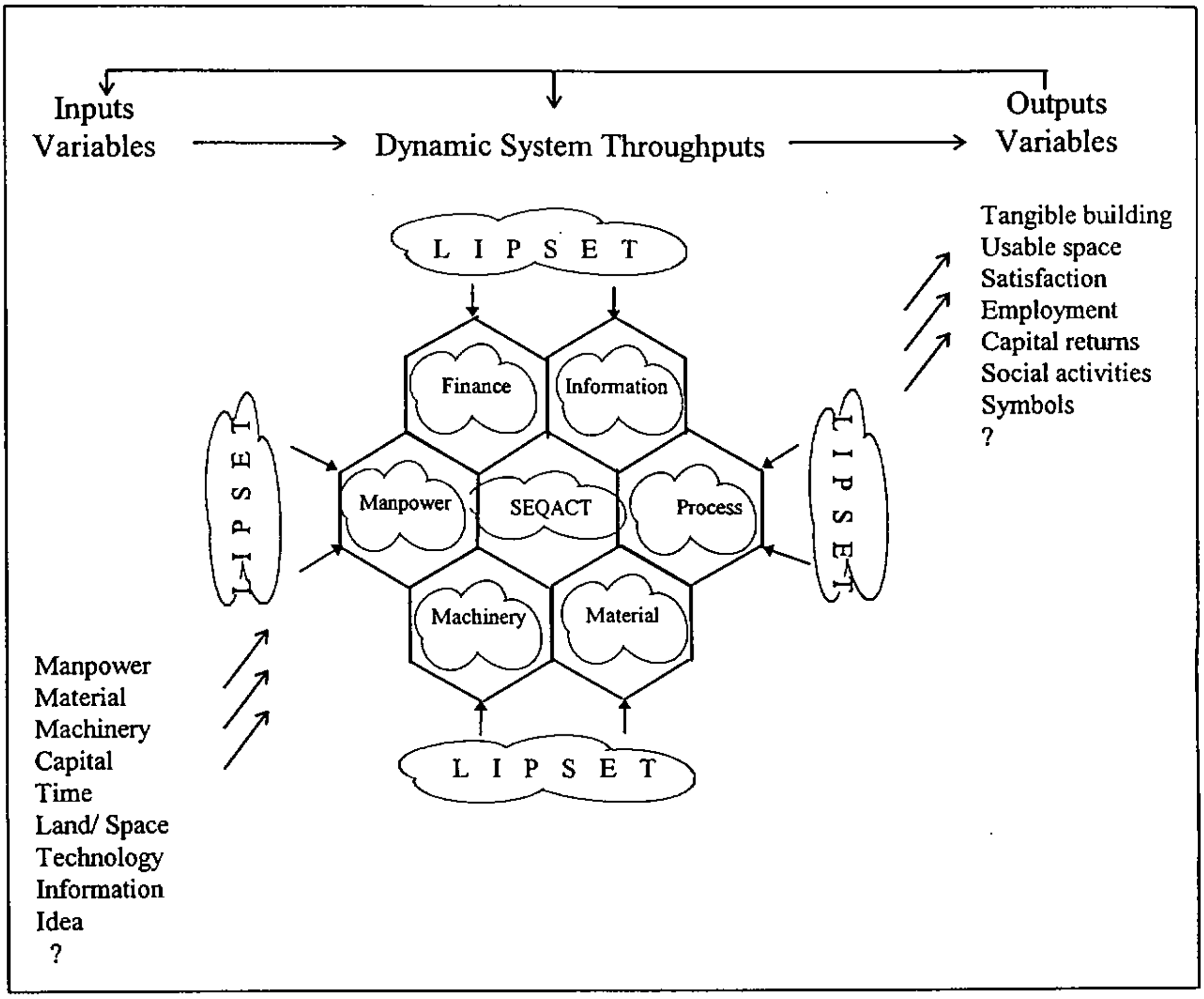


Figure 3.28 A General Dynamic System Model for Construction Project Management (DCMPS)

3.6.3 Characteristics of the Dynamic Construction Project Management System

The characteristics of a dynamic system is generally similar to those of an open system. The major characteristics of a dynamic system can be described as follows:

Inputs:

The DCPMS imports certain form of energy from the external environment throughout the process of a project delivery.

Through-puts:

The DCPMS itself receives and releases energy time by time over the whole construction project process, in responding to dynamics which may consume extra energy.

Outputs:

The DCPMS exports some products into the environment in terms of a tangible building, employment, technological symbols, etc.

Feedback:

The activities in the DCPMS has circulation over the project process. The outputs could be served as the inputs of energy for the repetition of further activities. Moreover, intangible knowledge could be used as the inputs of another project.

Negative entropy:

The DCPMS is in a process of acquiring negative entropy throughout the project life, intensively focus on green concern as a project management objective, but the physical products will ultimately be dismantled while the knowledge remains.

Information:

The information is a key element which serves as a core managing tool in the DCPMS. It is not only just a form of signal but also valuable resource in the construction project process.

Steady State:

The continuous importation of energy which is characterized to the DCPMS through the project process starts at an initial steady state toward a final steady state..

Differentiation:

The three major components of in the DCPMS can further be differentiated into subsystems as well as elements.

Equi-finality:

All sorts of resources in the DCPMS can reach the same final state from different point of time and by different procurement methods.

Integration and coordination:

As a project progresses, different kind of resources such as human effort, material, machinery, etc. are coordinated and integrated in the DCPMS over a project life cycle.

3.7 Summary of Chapter Three

This chapter develops a dynamic system framework for construction project management and elaborates the operational definition of dynamic. There are three interactive system components which are fundamental to construct the dynamic system. For the system objectives component, its constituents - safety, environment, quality, area, cost and time are equally interdependent. Within the system resources component, project process, manpower, machinery, material, information as well as finance are interactive with each other and operated according to the system objectives. In the delivery process of a construction project, the system objectives together with resources are subject to the system environment component which are composed of legal, institutional, political, social, economic and technological forces. These forces are interrelated with each other and affect the working of the project management system. Dynamic is defined as a chain of variables, changes, uncertainties and risks. Such a causal effect of dynamic explain that why dynamic or dynamic situation should be attentive and managed so as to avoid loss from risks. A dynamic systems model for construction project management is illustrated to provided an analytical framework to the construction project environment. The main characteristics of the DCPMS are intrinsically similarly to those of GST or open system such as an organization.

Chapter 4

Major Dynamics in Dynamic Construction Project Management System (DCPMS)

4.1 Introduction to the Dynamics in DCPMS

Having identified the essential system components to construct the dynamic system model and analyzed the interactions between the system components, the major dynamics affecting the system and hence the decision making process are necessary to be identified and discussed with their properties. Therefore, this chapter will concentrate on identifying major dynamics in the DCPMS and examining their properties.

The emergence of a dynamic implies that it has origin or *source* from where the dynamic derives. It is common to identify and classify sources into groups for easy communication. Therefore, three kinds of source of dynamics in the DCPMS are classified as system objectives dynamics (SEQACT), system resources dynamics (CPMSR) and system environmental dynamics (LIPSET). The dynamics also possess *polarity* either in positive or negative effect to the DCPMS. Moreover, the dynamics behave in some relational patterns impacting on the DCPMS. In short, the principal properties of a dynamic include the source, polarity and relational pattern as shown in Figure 4.1.

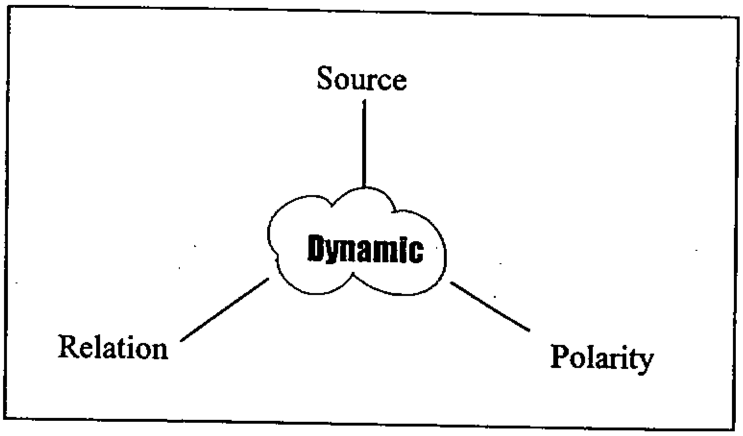


Figure 4.1 The Dimensions of a Dynamic in the DCPMS

4.2 Sources and Classification of Dynamics in DCPMS

4.2.1 Typical Dynamics to Construction Project Management

There are many ways of classifying dynamics with respect to sources. A construction project is unique in the combination of various kinds of variables such as location, functionality, procurement method, project organization, project duration, project cost, and so on. They can be considered as a group of dynamics. Some dynamics are specifically related to changes and risks. Gardiner and Simmons (1992) presents a list of sources which can be considered as dynamics as shown in Table 4.1. They investigate the dynamics through a project process including inception, briefing, tendering, design to construction/operation and project management. More likely, Perry and Hayes (1985) present a list of examples with classification of sources of risks as shown in Table 4.2.

Sources and Classification of Dynamics	Examples
Inception/briefing/tendering	Briefing procedure and co-ordination of information Client and/or users lack experience Getting a consensus view from users User committees: low recognition and lack of authority
Design	Design error Design omission Design not meeting specification Getting written approval from users Interpretation of drawing by client
Construction/operation	Construction: failure to meet design Site: quality of work Cost overrun Running late Operational faults
Project management	Internal politics: planning and approval Lack of internal agreement between users and client project manager By-passing a 'single' point of contact Conflict of loyalty (e.g. clerk of works) Different levels of change control depending upon the nature of the change Different emphasis on project changes as a project progress Maintaining interfaces to serve the client Use/misuse of a quality system Contract condition modifications

Table 4.1 Examples of Source of Dynamics from Client Organizations
Source: Gardiner and Simmons (1992)

The examples given in Table 4.1 and 4.2 can be perceived as dynamics in this study because they exhibit the features of the chain of variables, changes, uncertainties and risks. There are many other ways of classifying dynamics. For the sake of consistence with the DCPMS, dynamics are classified into the three system components: SEQACT, CPMSR and LIPSET.

Source and Classification of Dynamics	**Examples**
Client/Government/regulatory agencies	Bureaucratic delays, changes in local regulations
Funding/fiscal	Changes in government funding policy, liaison between several funders
Definition of project	Change in project scope
Project organization	Authority of project manager, involvement of outside bodies
Design	Adequacy to meet need, realism of design programme
Local conditions	Local customs, weather windows
Permanent plant supply	Degree of novelty, damage/loss during transportation
Construction contractors	Experience, financial stability
Construction materials	Excessive wastage, reliability of quality
Construction labour	Industrial relations, multiracial labour force
Construction plant	Resale value, spares availability
Logistics	Remoteness, access to site
Estimating data	Relevance to specific project availability
Inflation	
Exchange rates	
Force majeure	Earthquakes, Warfare

Table 4.2 Sources of Dynamics - Project Risks Classification
Source : Perry and Hayes (1985)

4.2.2 Dynamics in the DCPMS

Representation of dynamics

There are, by definition, three main categories of dynamics innately existing in the dynamic construction project management system. They are system objectives dynamics (SEQACT), system resources dynamics (CPMSR) and system environment dynamics (LIPSET) as illustrated in Figure 4.2. Any one constituent in the three main components of the DCPMS is called *representative dynamic* which stand for the set of its elements. For example, *time* is a representative dynamic in the SEQACT objectives component, while *manpower* and *society* are the representative dynamics in the CPMSR resources component and the LIPSET environment component.

Elemental dynamics

Each representative dynamic represents a group of elements which are called as elemental dynamics. For example, project duration, programme and schedule are the elemental dynamics with respect to *time*. Tender price and profit margin are elemental dynamics to cost. Other examples of the elemental dynamics in the system are given in Table 4.3, 4.4 and 4.5.

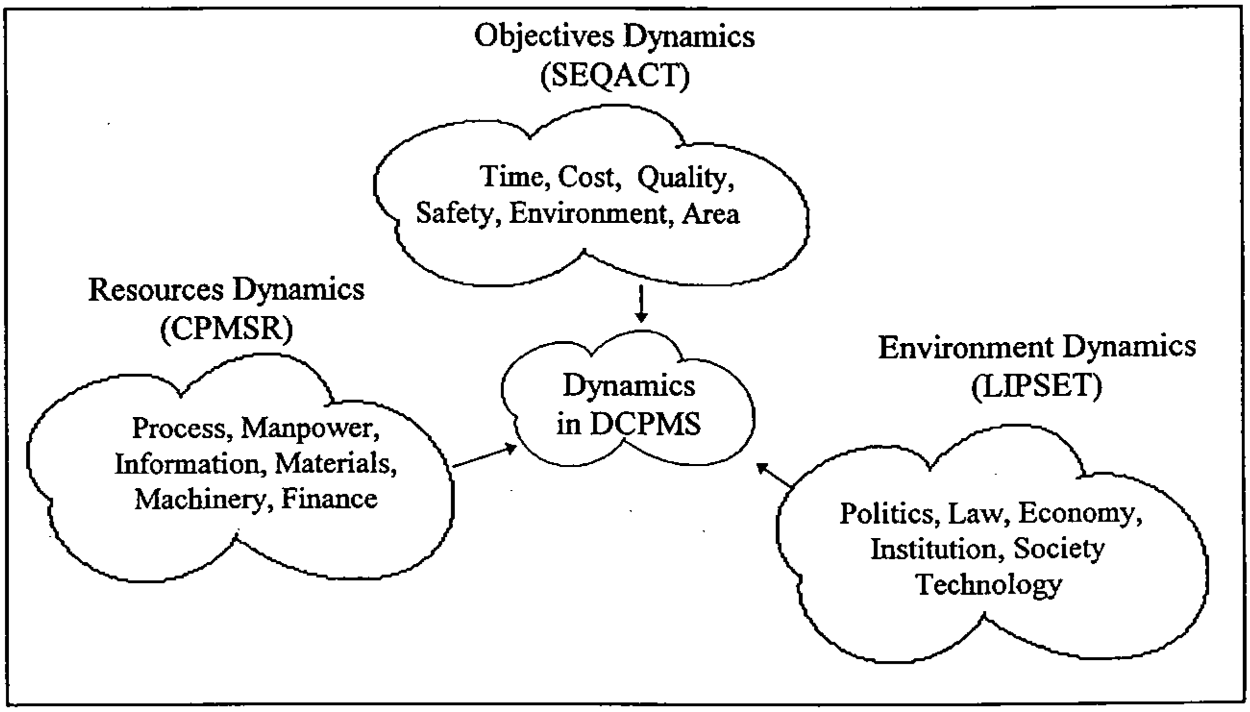


Figure 4.2 Classification of Dynamics in the DCPMS

4.2.3 Dynamics of System Objectives

It is discussed that the objectives within a construction project management system basically consist of SEQACT. Examples of the system objectives dynamics are shown in Table 4.3. The objectives themselves within the DCPMS lay a common yardstick for project managers to manage the project against the objectives. These objectives as dynamics will behave in a chain of effect on the dynamic system. For example, project duration as a time dynamic varies from several months to years. The possibility of early completion or extension is relied on the result of the interactions between other objectives dynamics in the construction project environment. As project duration variable is subject to changes, it leads to uncertainties on project management activities such as work schedules and production progress, and eventually bring risks to project parties, particularly, the client and contractors.

System Objectives	Elemental Dynamics
Time	Duration, programme, schedule
Cost	Tender price, profit margin
Quality	Specification, workmanship, material
Environment	Material, working method, protection policy
Safety	Machinery, workers
Area	Activity; organization, phase

Table 4.3 Classification of System Objectives Dynamics - SEQACT for the DCPMS

4.2.4 Dynamics of System Resources

The six interactive project management system resources can also be defined as dynamics which particularly serve as positive energy making the system forward. The process, manpower, information, machinery, material and finance are the representative dynamics for their own elemental dynamics as shown Table 4.4.

System Resources	Elemental Dynamics
Process	Project life cycle, procurement methods, approval processes, work sequences
Manpower	Individual, team, department, company, project organization
Information	Drawing, specifications, bill of quantity, instructions, meeting records, cost plan, quality plan, programmes and schedules
Material	Source of supply, transportation, quality, quantity
Machinery	Supplier, operator, maintenance
Finance	Method of financing, schedules of payment

Table 4.4 Classification of System Resources Dynamics - CPMSR for the DCPMS

Process itself is a variable which is subject to changes and it is a know-how method. Such a method is something of knowledge as well as resource. So, process in this study is considered as a kind of construction project management resource. The construction development process is highly dependent on development strategy such as the selection of various procurement methods and the corresponding types of contract. Project development strategy is crucial to project managers as different procurement methods will determine different structures of project organization as well as diverse working relationship. For particular project stakeholders, their participating timing cycle to the project varies with their role in the project. For example, the client, architect or project manager may involve from start to finish of a project, whereas the design consultants may be just involved in the early project stages, and contractors at later stages. Their involvement is also varying according to different kind of procurement methods. For the process is defined as a representative dynamic to the resources component within project management system, the procurement method, approval procedure or work sequence etc. become the elemental dynamics in the process.

4.2.5 Dynamics of System Environment

The LIPSET system environment dynamics are those forces acting on the DCPMS. The representative dynamics in the system environment are law, institution, politics, society, economy and technology, as shown in Table 4.5. For the politics dynamic, the elemental dynamics include government nature, land use policy, governmental fiscal or monetary policy, import/export restriction, anti-speculation measure, etc. For example, the change of government land use policy from industrial to residential or commercial may affect the demand and supply mechanism. The changing requirements of safety and health management like statutory obligations or contractual liabilities will help to improve quality and safety standard, but most likely increase the project cost. As far as technology concerned, the rapid development of computer or information technology has brought great impacts on business organizations and all levels of managers who have to adapt to the new technology so that they can compete in the ever-changing market. In fact, these kinds of dynamics are tangibly or intangibly reshaping the management theories and practices. All businesses are changing with the influence from environment dynamics. The legislation is also developing and changing to meet the new situation. Traditional professional bodies are developing the new ones and emerging to extend their impacts on the operation of construction project management. It will be a trend that more and diverse institutional voices rising within the society.

System Environment	Elemental Dynamics
Law	Contractual liabilities, statutory liabilities
Institution	Professional ethics, education, pressure group
Politics	Government nature, land use policy, fiscal or monetary policy, export/import restrictions, anti-speculation measure
Society	Public opinion, work force, family size, user group
Economy	Interest rates, exchange rates, credit polices
Technology	Information technology, construction techniques, machinery

Table 4.5 LIPSET System Environment Dynamics for the DCPMS

4.3 Effects of Dynamics

4.3.1 Polarity of Effects

A dynamic has different effects on a system. It will cause good effects on the DCPMS, but sometimes it will bring bad effects on the system. For instance, a lower tender price as a project cost objective dynamic might be good to client at the beginning. However, the client in this case bears a risk to give the tender to a contractor who works under the target price by possibly supplying lower quality of service and product. Therefore, the dynamic of lower tender price also places negative effect on the client's project management system. Individualism can be a dynamic to an innovative design concept but it could be negative in a team work in a production line. So a dynamic possesses a polarity with respect to its life pattern and its application areas. By analyzing a dynamic, it is therefore important to identify its polar effect on the system. Shen (1997) suggests a way of differentiating positive and negative property of a dynamic by referring to its effect on construction project management system, that is to examine whether the dynamic is in line or against with the project management objectives.

4.3.2 Positive dynamics

Those dynamics work in line with the system objective are called positive dynamics. Fundamentally, SEQACT objectives dynamics are positive with respect to the DCPMS. As a project proceeds, the establishment or setting of the SEQACT objectives points out a direction for the CPMSR to work. A well establishment of project organization, a proper material purchasing management schedule, a project information exchange system, etc. are positive to the DCPMS. Certain LIPSET system environment dynamics can be positive when the changes make the DCPMS good. Say, decrease in interest rate can contribute the saving in project cost. More construction labour training schemes initiated by institutional bodies or government may improve the productivity as well as workmanship. And, an introduction of innovative construction techniques may cope with the problem of labour shortage and save time or money.

4.3.3 Negative dynamics

Those dynamics against the project management system objectives are called negative dynamics. Some of the LIPSET dynamics are obviously negative to the DCPMS. By referring the problems identified by Kaming, et al.(1994) as shown in Table 4.6, most of them are related to construction project management issues which are negative on the DCPMS. For examples, there are several elemental dynamics affecting *material* cost such as fluctuation of the material price, high cost of material, inadequate or shortage of raw material. The negative dynamics in *machinery* aspect are high cost of machinery and high maintenance cost. Those dynamics related to *manpower* are low quality of workmanship, poor image of workers, deficiency in management level and lack of coordination are negative too. Lack of R&D facilities and programmes, poor linkages between R&D and practice may related to the interaction between the LIPSET environment forces.

Problem Classification	Problem Identification
Material Shortage and Technological Problems	-Fluctuation of the price of construction material -High cost of machinery -High cost of material -High transportation and handling cost -High machinery maintenance cost -Inadequate production of raw material in the country -Frequent shortage of construction material -Low level of technological development in most of the industry -Lack of R&D facilities and programmes -Poor linkage between R&D and practice
Underdevelopment of Human Resources	-Low quality of workmanship -Poor image of status of construction workers -Deficiency in management level -Inadequate skilled labour in particular crafts -Low pay for construction worker -Poor industrial relations in construction -Lack of co-ordination between designer and contractors -Excessive bureaucracy of paper work -Unnecessary legality -Communication problems
Financial Problems	-Poor cash flow -Mode of financing and payment for complete work -High interest rates charged by banks on loans -Poor financial control on-site -Wrong method of estimating -Lack of capital -Delay of budgetary allocation
Marketing Problems	-Domination of CI by foreign firms -Numerous constructions going on at the same time -Fluctuating overall level of construction activity
Productivity Problems	-Improper planning -Frequency of design changes -Long period between design and time of tendering -Deficiency of on-site material management -Absence of cost data in construction -Poor working environment -Poor financial incentive programme
Legal Issues and Politics	-Fraudulence and kickbacks -Poor documentation of contract management -Lack of government policies for construction -Lack of legality in solving dispute -Bureaucracy of tendering method -Poor contractual procedure -Unsuitable documents of contract arrangement

Table 4.6 Summary of the Impacts of Negative Dynamics to the DCPMS
Source: Kaming, et al. (1994)

4.3.4 Problematic Perspective of Dynamics

Dynamics request the project participants' attention on them or committing certain resources to deal with them. This implies that dynamics also present certain *problems* to be solved. Referring to the definition of problem in Cambridge dictionary, problem is defined as a situation that persons or thing that needs attention and needs to be dealt with or solved. Most of the negative dynamics mentioned before are problems which need to be paid attention as well as to commit resources to solve it. Maurice (1995) suggests that the concept of 'problem' is central in the business and management studies literature. There are four interrelated conditions which can be used as landmarks(LM) signaling the presence of problems as follows:

LM 1, a past, present or future occurrence, within an organizational context, which is judged as negative by an individual or a group;
LM 2, a preliminary judgment on the intervention capability;
LM 3, an expression of a *prima facie* interest in doing something and committing resources;
LM 4, uncertainty as to the appropriate action and how to implement it.

The above four landmarks, to a certain extent, can highlight the properties of a negative dynamic. Thus a dynamic situation can be viewed as one kind of problem situations. Stephenson (1996) lists 45 types of general problems in practices and procedures within construction process as shown in Table 4.7. They are considered as common problems affecting construction project management practices, many of them act as dynamics on the DCPMS.

The list can be categorized in line with the DCPMS components: SEQACT, CPMSR or LIPSET dynamics. It is interesting that the first five most frequent appearances are directly and highly related to people, which is a key dynamic to the dynamic system.

1. Job management	24. Payment processing
2. Communicating with others	25. Paperwork and administrative work
3. Staff morale and attitudes	26. Approval processes
4. Personnel quality and problems	27. Being a good-off-site neighbour
5. Being a good on-site neighbour	28. Time growth
6. Timely action	29. Policies and procedures
7. Planning and scheduling	30. Inspecting and testing
8. Organization, authority, and responsibility	31. Staffing and personnel
9. Work-site conditions	32. Cost growth
10. Revision processing	33. Substitutions and alternates
11. Construction document quality	34. Maintaining regular project evaluations
12. Programme conditions	35. Safety
13. Submittal processing	36. Regulatory agency matters
14. Issue, conflict and problem resolution	37. Constructability
15. User-group interaction	38. Training
16. Equipment and material problems	39. Value engineering
17. Documents and documentation	40. Labour conditions
18. Decision making	41. Legal matters
19. Procurement of materials and equipment	42. Back-charges
20. Project cost structure	43. Financial matters
21. Closing out the project	44. Weather conditions
22. Contract interpretation	45. Warranty conditions
23. Quality management	

Note: presented in descending order of frequency

Table 4.7 Summary of General Problems in Construction Project Management Practice

Source: Stephenson (1996)

4.4 Interdependence of Dynamics

4.4.1 Concept of Interdependence between Dynamics

It has been discussed that there are various dynamics influencing the management throughout the whole construction project life. The dynamics, sometimes, interact in combination with each other on the project management system. In other words, the dynamics may appear with certain inter-relational patterns. It can be explained by pooled, sequential and reciprocal interdependence which are three types of social situations proposed by Thompson (1967). The pooled dynamics exert discrete impacts on a system without interacting with others. The sequential dynamics act on the system in series while the reciprocal dynamics mutually influence the system. Assume X as a dynamic, the different type of interdependence between dynamics within the system can be illustrated as that in Figure 4.3.

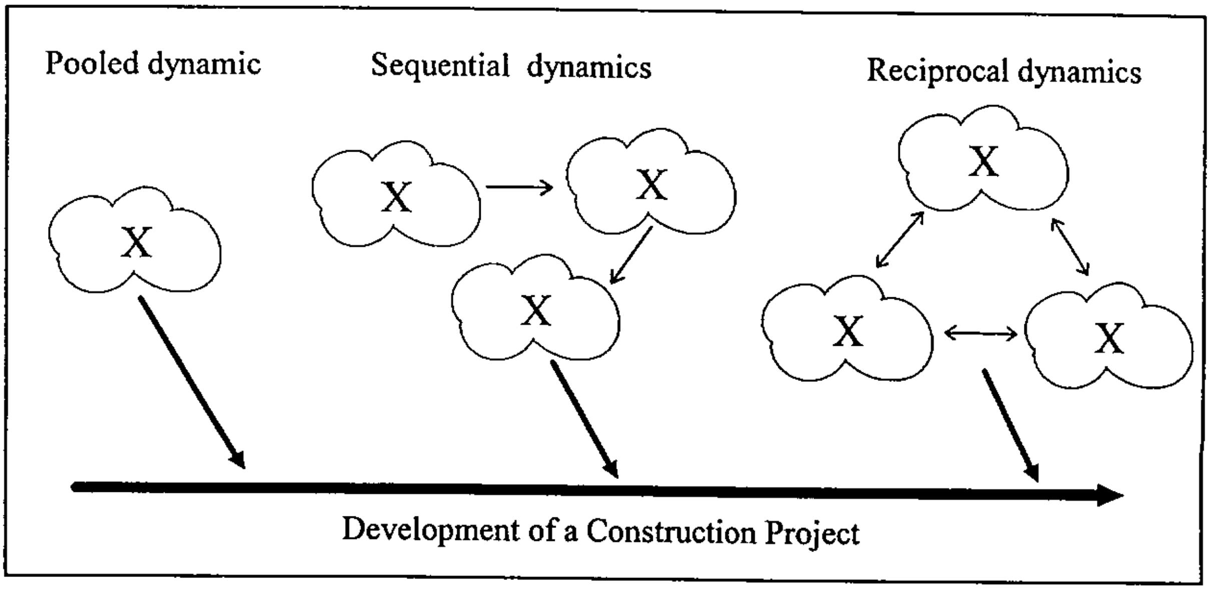


Figure 4.3 Interdependence Pattern of Dynamics

4.4.2 Pooled Dynamics

The recognition of pooled dynamics is totally dependent on the dynamics owner who are concerned the effect of the identified dynamics on the DCPMS. Pooled dynamic, by definition, has no interdependence with each other. So it is more easier to identify and analyze its effect on the system. A typical example of such kind of dynamic is *force majeure* such as natural catastrophe.

4.4.3 Sequential Dynamics

The client's brief, design blueprint, tender document and construction programmes are sequentially interrelated to affect the project management system. Client, architect, quantity surveyor, contractor, or subcontractors are therefore sequentially dependent. There exist many sequential dynamics on the DCPMS. Generally speaking, changes of SEQACT objectives component induce changes in the operation of subsystems. For example, the selection of procurement method varies with the priority of time, cost, quality, and complexity of the project. The contract types are sequentially determined after the selection of appropriate procurement method.

4.4.4 Reciprocal Dynamics

Many aspects in the whole construction project life request for team efforts which are often reciprocally related and affect the DCPMS. For example, the design blueprint is produced by a design team who integrate and coordinate the architectural, structural and servicing drawings and specifications. These drawings and specifications are reciprocally dependent. They are either aesthetically, technically or financially interlocking with each other. When clients, development consultants such as cost engineer, architect work together to study the feasibility of developing a project and outline the development strategy at conception phase, they are reciprocally interdependent as well. At inception phase, architect, structural engineer or service engineers are reciprocally interdependent to produce design work. Likewise, various trade subcontractors are mutually interactive with each other at the realization phase.

4.5 Summary of Chapter Four

This chapter discusses the key properties of dynamic in terms of source, polarity and relational pattern. The source of dynamics in the DCPMS are classified as system objectives dynamics (SEQACT), system resources dynamics (CPMSR) and system environmental dynamics (LIPSET). Dynamics also possess *polarity* either in positive or negative effect to the DCPMS. Those negative dynamics are always relevant to the common problems either at industrial or project level. For some cases, dynamics may act interdependently on the DCPMS. The dynamics behave in relational patterns either as pooled, sequential or reciprocal. Such kinds of interdependence not only illustrate the time dependence of the dynamics but also the degree of working dependence, particularly in team efforts.

Chapter 5

Dynamic Characteristics of Construction Project Management in Hong Kong Construction Industry

5.1 Introduction to Practical Survey

The dynamic systems model has been established and the major dynamics in the DCPMS have been discussed in previous chapters. For the aim of applying dynamic systems approach in decision making process for the managers within a construction project environment, it is firstly to examine whether the whole industrial environment is dynamic in general. Then a questionnaire survey is focused to investigate the construction project management working environment. It is exhaustive to examine all the project parties over the whole project life by practical surveying. Therefore, this study only focused on a particular party at a specified project stage.

The general characteristics of the Hong Kong construction industry include high-rise construction, multi-layers of sub-contracting, labour-intensive construction methods and shortage of labour and high accident rates [Lam,1990]. Some specific characteristics will be studied by referring to the official reports of the Hong Kong SAR government. Furthermore, questionnaire approach has been used to investigate the dynamics and their impacts on construction project management system in the local construction industry. As a pilot study, a main contractor group is chosen to conduct surveying. It is because the management activities engaged by contractor are rather complicated and dynamic with respect to the dynamic systems model during construction stage.

The underlying hypothesis for the questionnaire is that the management effectiveness is correlated to the dynamic working environment. Under the hypothesis, there are three areas to be covered for analysis. Firstly, it will examine the availability and applicability of management systems. Secondly, it will investigate the sources of dynamics and their impacts on the project performance. Thirdly, it will evaluate the decision effectiveness of the respondents.

As the terms related to system and dynamics might be strange to respondents, variables are termed industrial friendly to respondents. For example, the concept of dynamics are expressed in terms of changes or uncertainties which can provide a more understandable basis for different respondents.

Consequently, there were totally 47 returns out of 173 questionnaires which had been sent with personal names so as to increase the responding rate. The effective sample size ultimately reduced to 41, (i.e.25.8%) due to invalid and insufficient information.

The surveying data is stored and analyzed by Microsoft Excel from which the charts and graphics are generated. The correlation coefficients between the research variables are obtained by using the calculation function provided by the Excel.

5.2 Dynamic Construction Industry in Hong Kong

5.2.1 Construction Work Value

The gross value of construction work performed by main contractors at construction sites has been greatly fluctuating as shown in Figure 5.1. The biggest value difference in building project is about HK$5,000 M between HK$9,000 M to HK$14,000 M from 1992 to 1996 while the difference in civil engineering project records about HK$6,000 M from HK$2,000 M to HK$8,000 M. Analyzing by sector, the fluctuating breath in terms of work value in private sector only marks HK$3,000 M while public sector is more significant at about HK$8,000 M.

The more significant figures found in the public sector and civil engineering projects than building projects and private sector are mainly due to the effect of Port And Airport Scheme (PADS). The value in civil engineering projects is declining since 1996 reflects that most of the PADS project were being completed by 1997. Such a dynamic performance can also be traced by the public work programme actual expenditure as shown in Figure 5.2. It shows that expenditure fluctuates significantly between different years.

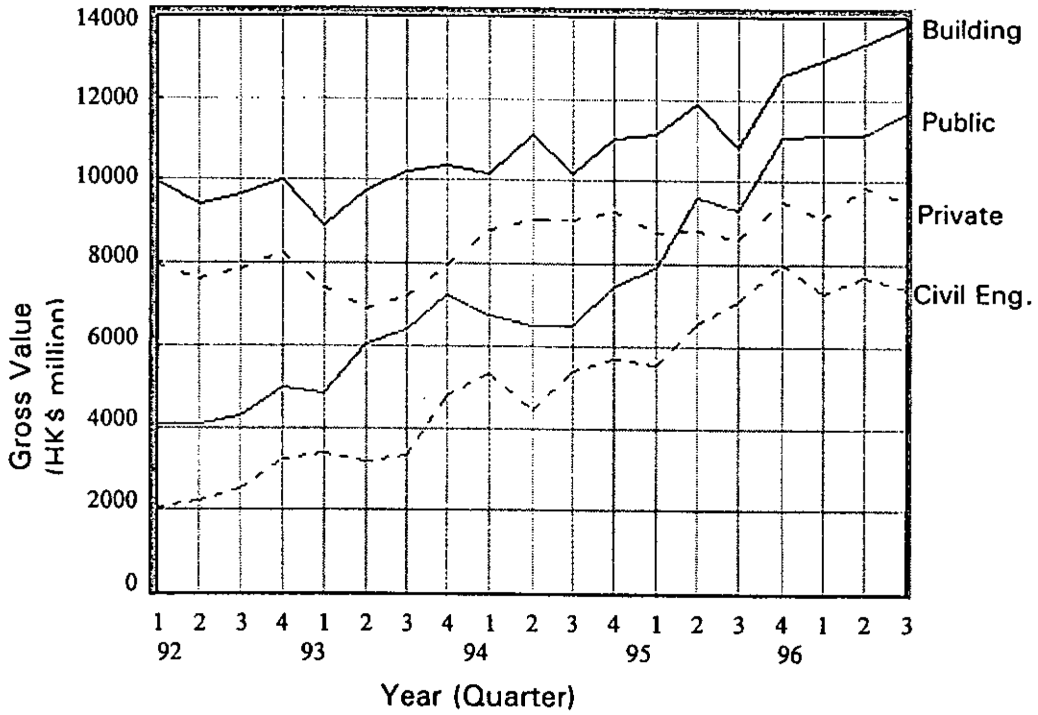


Figure 5.1 Development of Gross Value of Construction Work Performed by Main Contractor at Construction Sites (analyzed by sector or type of project)
Source: Work Digest Issue 28, Hong Kong Government, 1997

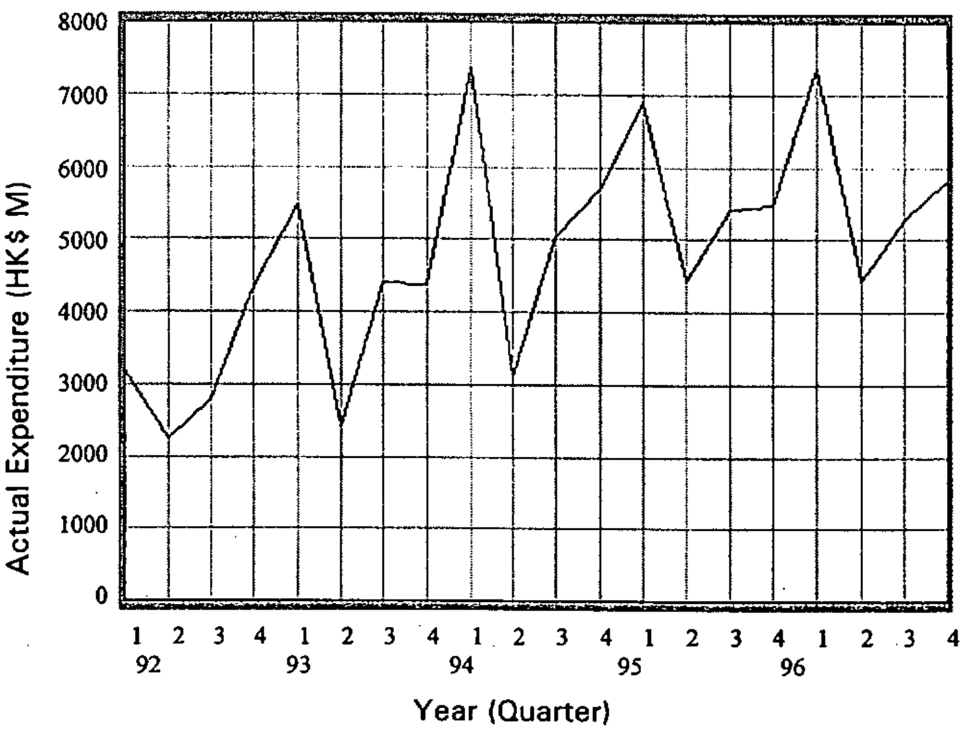


Figure 5.2 Development of Expenditure on Public Work Programme
(including expenditure on the airport core programme)
Source: Work Digest Issue 28, Hong Kong Government, 1997

5.2.2 Construction Work Volume

The figure of construction volume is also a crucial indicator to show the degree of dynamics of the construction industry. In Figure 5.3, it shows the construction volume in terms of usable floor areas. The trend is fluctuating that both buildings completed and new projects for commence work are greatly fluctuated over the five years. It again shows the great degree of dynamics in the Hong Kong construction industry.

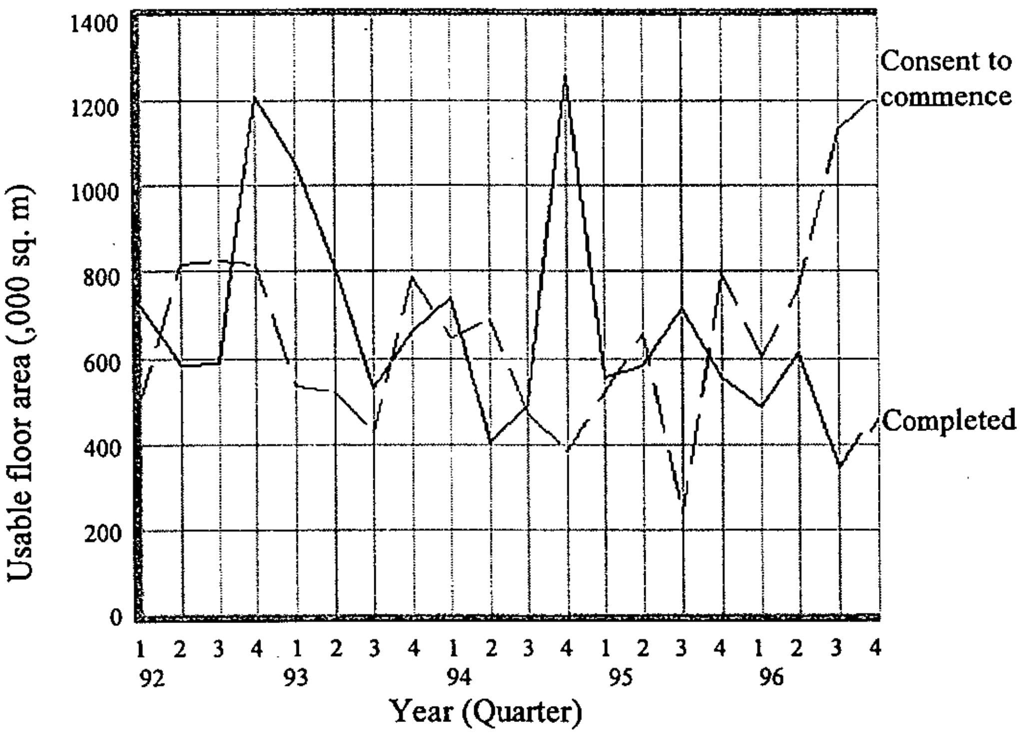


Figure 5.3 Fluctuation in Usable Floor Areas of 'New Buildings Completed' and of New Projects 'Consent to Commence Work'
Source: Work Digest Issue 28, Hong Kong Government, 1997

5.2.3 Construction Workers and Materials

The fluctuation of the engagement of manual workers at construction sites in Hong Kong is similarly significant. Figure 5.4 shows that the number of manual workers has been largely fluctuated in the last five years, particularly there shows 22,000 numbers difference in public sector and 15,000 numbers difference in civil engineering project. The range of total work force in construction industry is about 53,000 at the end of 1993 but up to 77,000 at the end of 1996. This reflects a highly fluctuating situation in construction manpower in Hong Kong.

The workforce in building projects takes up 60% in 1996 and 77% in 1992 of the total work force. This indicates that the major workforce is employed to building projects. The workforce in private sector takes up 66% in 1992 and gradually decrease to 41% in 1996. On the contrary, public sector increases from 34% in 1992 to 59% in 1996. Such changing trend can also be resulted by approaching the completion of major PADS projects before sovereignty handover.

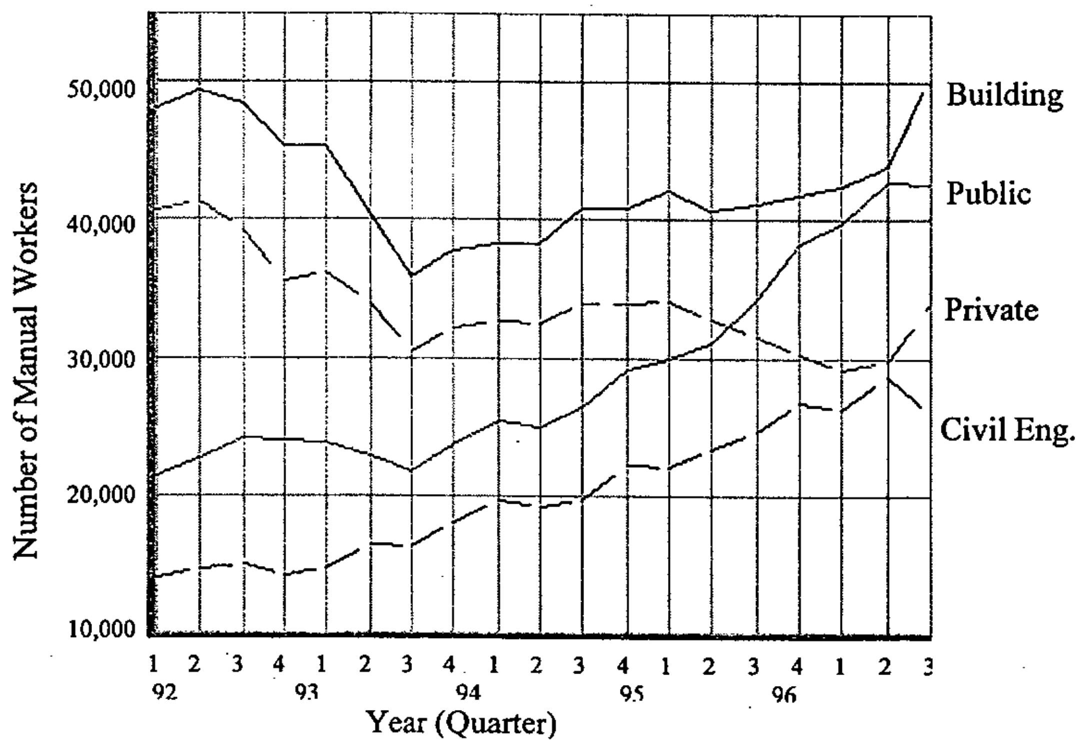


Figure 5.4 Fluctuations in Number of Manual Workers Engaged at Construction Sites
Source: Work Digest Issue 28, Hong Kong Government, 1997

Figure 5.5 shows the indices of the costs of labour and some principal materials used in government contracts. The labour cost index clearly move upwards from time to time. Among the construction materials, the indices cost of cement and aggregates are remaining stable while that of high tensile steel are steadily increasing, but the cost of timber is fluctuated significantly. Such trend of figures also tell construction project managers that both construction labour cost and material cost are subject to fluctuations.

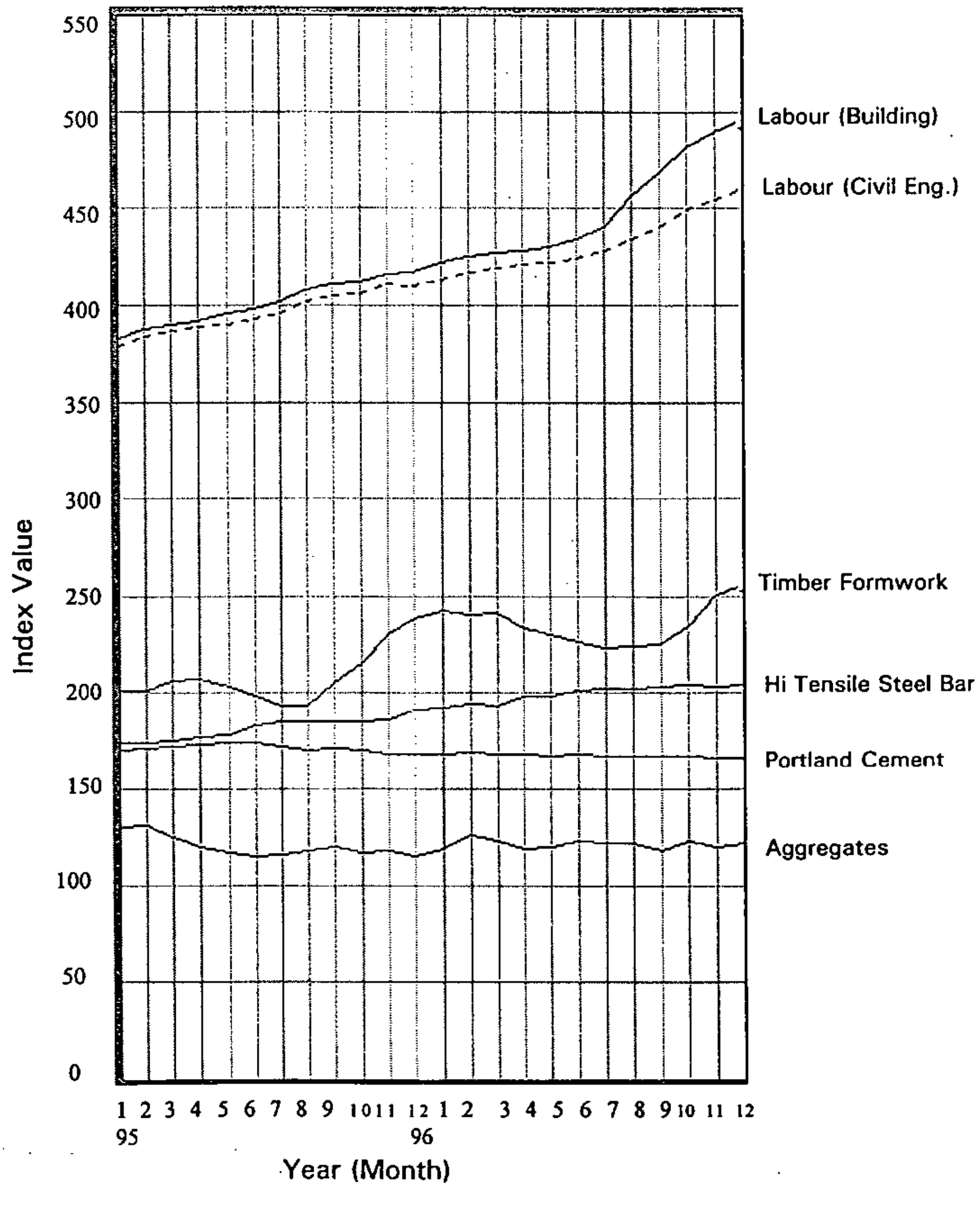


Figure 5.5 Fluctuations in Index Number of the Costs of Labour and Some Selected Material Used in Government Contracts.
Source: Work Digest Issue 28, Hong Kong Government, 1997

Traditional building materials demonstrate a relative minimal changes and uncertainties when comparing with the building service tender price index (BSTPI) as shown in Figure 5.6. In 1990s, the index is fluctuated and increased significantly since mid 1994. The figure of BSTPI is becoming important as the cost contributed form building services components is growing. Some advanced facilities may cost up to 60% of the total construction cost.

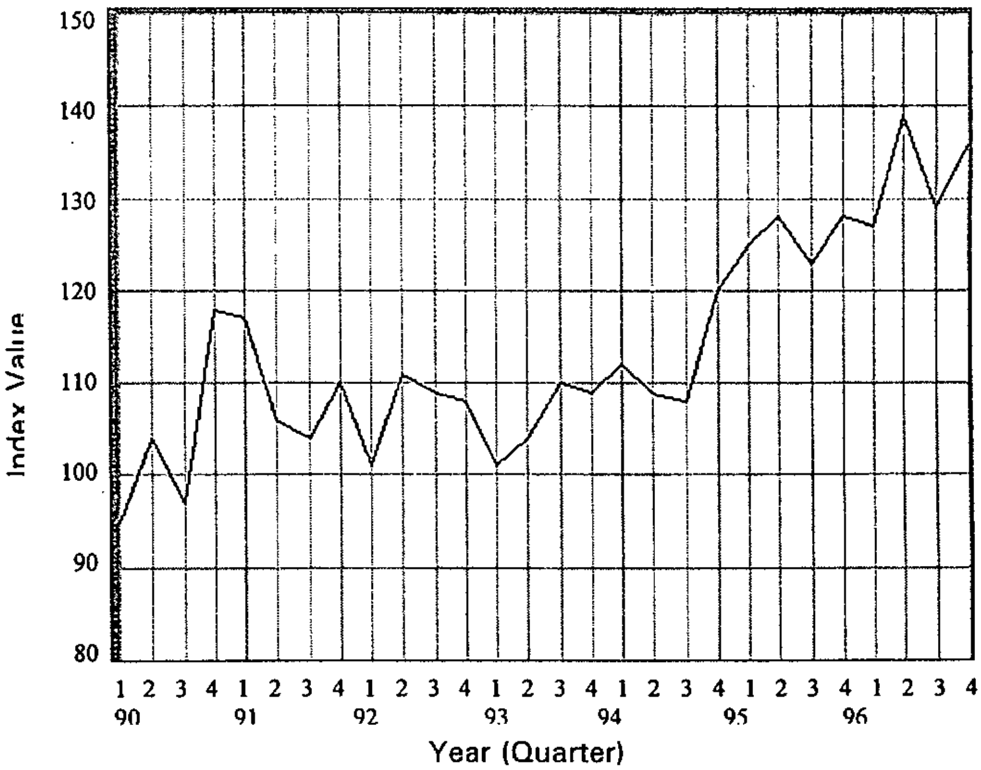


Figure 5.6 Fluctuations in Building Service Tender Price Index (BSTPI)
Source: Work Digest Issue 28, Hong Kong Government, 1997

For the increasing complexity of a project is mainly due to the incorporation of more building services such as traditional E & M, security system and telecommunication system. It is believed that the price of such building service system will be subject to severe changes and uncertainties as more and more advanced technology is being developed in near future.

5.2.4 Dynamics in Construction Demand

Population

Hong Kong indeed is a very unique place where a large amount of people emigrate and immigrate in the past two decades. The rate of change of population is significant, which affects the construction activities. The implications of such change to project management system has been discussed previously in Chapter 3. It is predicted that towards 2016, the current population will be increased by 26.5%, that is 6.488 million in 1997 to 8.206 in 2016 [Hong Kong Government, 1997]. It is foreseeable that there will be a great pressure on the Special Administration Region (SAR) government to cope with such tremendous demand on housing due to the increase in population. The change in population in the coming two decades demonstrates a critical dynamic in Hong Kong construction industry. Therefore, the construction project management system will undergo more challenging time toward the next century.

Land

Land is very scarce in Hong Kong as it only occupies about 1090 sq. km. Its landscape is mountainous and hilly. This is the reason why many pieces of land for development have to be gained from reclamation. There are proposals that further harbour reclamation will be continued to secure more land for use, but legislation against damaging the harbour by reclamation has been put into effect. However, the demand of land is great and urgent as the housing schemes to accommodate the vast population has been on air.

Housing

Housing is one of the major issues that the SAR government is aiming to solve at the list of top priority in the Chief Executive's first policy address. While the population is growing, there are different needs for the elderly, the sandwich class, the newly homeowner and the new immigrants' family. Therefore, the demand of housing is at the brisk as different walks of life either are actively going to improve their living standard or are passively being relocated to rural areas for the purpose of urban renewal.

Construction manpower

The shortage of construction workers has been an old issue for the Hong Kong construction industry for a long time. This is mainly caused by the changing social structure, economical transition and the nature of the industry itself. The population of the contemporary young generation is diminishing as the family planning of 'two is enough' compared with the traditional big family. Hong Kong as an advanced and famous city, is named one of the leading financial centers in Asia or even over the world. The citizens are well educated in common due to the fundamental education being provided. Moreover, the major economic sectors such as commercial service which provides better work opportunity to the youngsters. Few of them would like to develop their career in the construction industry not only because of the dirty and dangerous working environment, but also the insecurity in career under the multi-layers sub-contracting system which is very popular in Hong Kong.

The demand of construction manpower becomes more urgent in order to cope with the big scale of housing scheme. Without doubt, the demand of construction manpower will also be a vital dynamic to the industry and hence the construction project management system.

5.2.5 Dynamics in Construction Supply

Land

As land is highly demanding and critical to the future housing scheme, the land supply includes either reclamation plan, change of land use or even proposal to settle some population in the nearby border line with ShenZhen.

The SAR government has to overcome the shortage of land supply in order to implement its policy address. Reclamation from outlying islands such as Lamma Island is proposed to increase the land supply. Certain agricultural lands have been reviewed to be changed to residential purpose. Rezoning of surplus industrial land for residential use is also under study [Hong Kong government, 1997]. Moreover, there is a study to allocate the overcrowding population by employing lands available in the neighbour city, Shenzhen. There is also changing pace of supplying land in order to meet the demand. Therefore, the land supply as a dynamic will eventually affect the construction project management system.

Housing

The supply of housing in Hong Kong also demonstrate as a dynamic which always stimulates the volume of construction activities, the need in manpower as well as the property market. The housing supply has been planned for new flats from the targeted annual supply of 85,000 units either from new land or redevelopment scheme. The speed of housing supply is being accelerated by change in policy such as the procedure of development, strategic plan on land supply.

Construction manpower

It is always claimed that the construction manpower is in shortage. So, importation of worker is often in the list of the government's agenda. However, the protectionism of local worker is strong to the protection policy as many local workers are half employed. The objections from labour unions are prevalent. This is a significant dynamic affecting the construction project management system since not enough labours found to do required work or insufficient work to be done by those unemployed workers. It is a dilemma that all the project parties in Hong Kong have to confront and to seek a compromise. Otherwise, the whole development of property market and economic prospects will be suffered.

Construction materials and technology

Hong Kong inherently lacks raw materials for construction. Most of the construction material are imported from overseas. The trading of construction material is internationally dependent thus the cost of construction is being influenced by exchange rates and currency values globally. On the other hand, it is hard to find local significant construction technology supplied to the construction industry. This is the major reason why there are still many traditional construction methods being applied. Therefore, the construction project system will be subjected to many uncontrolled dynamics, particularly in terms of economic parameters such as the treaty of the World Trade Organization (WTO), U.S interest rate and currency values.

From the above discussion, it can be concluded that the Hong Kong construction industry is under a dynamic situation which influences all construction project participants. The construction participants in Hong Kong are therefore undergoing a relatively high degree of changes, uncertainties, and risks.

5.3 Practical Survey on Local Contractor's Project Management Practice

5.3.1 Introduction to Questionnaire Survey

The project information

The analysis of the survey is based on the 41 effective replied questionnaires (refer to Appendix), which are concerned with 26 construction projects. The procurement method of the projects is mainly employed traditional management, which has 18 records in the survey. There are 5 projects using design and build method. The remaining three projects are shared by management contracting, construction management and project management.

Regarding the project types, there are 11 residential building projects, 7 institutional buildings, 3 commercial projects, 3 industrial projects, and 2 government projects. The surveyed projects are mainly at the superstructure and finishes stages at which construction activities are more hustling and bustling. The stages of the projects with respect to the superstructure and finishes are 10 and 11 respectively. Those at foundation and completion stage are 4 and 1 respectively.

The construction duration of the surveyed projects varies from 2 months to 50 months while the contract sum varies from HK$ 2 million to HK$ 5,000 million. The average construction project duration and contract sum for all the surveyed projects are 23.2 months and HK$1,388 million respectively.

The respondents' profile

59% of the respondents are at middle management level. It has 24 records. 27% responds from the top and senior level. Only 14% respondents are at junior level. Regarding the working experience in construction field , 44% of the respondents have more than ten years of experience. 17% have five to nine years, and 39% have one to four years of experience.

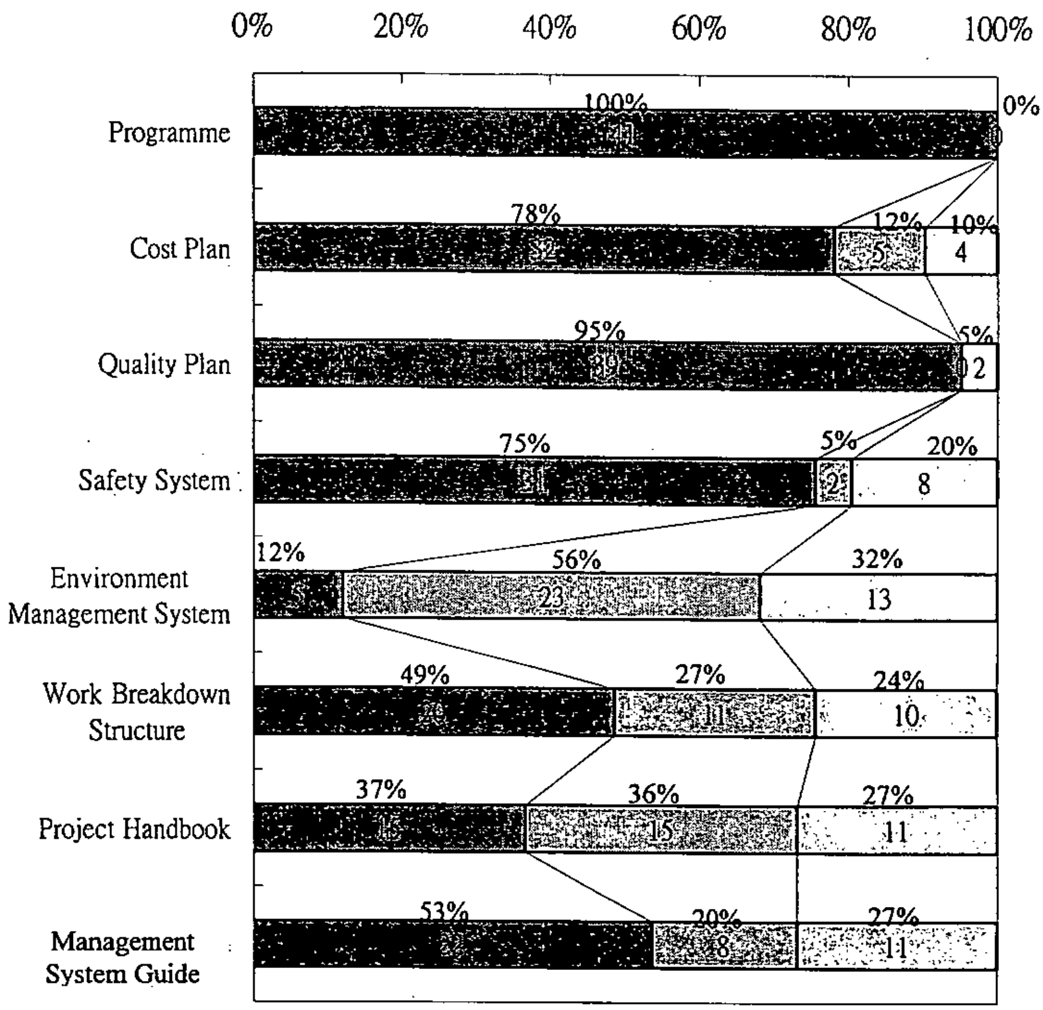
5.3.2 Identification of Management Methods Applied

This section is to investigate management methods applied for different kinds of project management objectives. These methods can be considered as management system guides. They can be in form of documents, plans or structures for the project. In the survey, project programme, project cost plan, project quality plan, safety management system, environment management system and work breakdown structure are chosen to study. Project management handbook and management system guide are also considered because they are basically well established to help managing a project. It is assumed that the more detailed the system guides the more applicable to their management activities. Therefore, the responses to the degree of applicability to those system guides and to the degree of detail of the guides will be investigated. Finally, the correlation between these two parameters will also be examined.

Identification of system guides

To acknowledge the recognition of various system guides, a spectrum of response is shown in Figure 5.7. Almost all the respondents are able to identify project programme (100%) and quality plan (95%) that are available for their existing projects. 78% of them can identify cost plan and 75% can identify safety system for the projects. Nearly half of them can identify work breakdown structure. There are 53% and 37% of respondents who are able to identify the management guide and project handbook respectively. However, only 12% can identify environment management system.

Among the effective samples, 56% of the respondents can identify that there is no system guide for environment management. The rates of identifying no work breakdown structure, project handbook and management guide are 27%, 36% and 20% respectively. Only a small portion of the respondents identify no cost plan (12%) and safety system (5%) in their projects. This group of respondents demonstrate that they are able to identify that particular system guide in their project management environment and hence know the system guides.



Legend: ■Y ▨N ◻U

Y: No. of Respondents who are able to identify the specified system guide in their existing project.
N: No. of Respondents who are able to identify no specified system guide in their existing project.
U: No. of Respondents who are not able to identify or don't know whether the specified system guide is available or not.

Figure 5. 7 The Identification of Various Management System Practices

However, there is a portion of respondents who are not able to identify or don't know whether there is system guide or not. 32% of the respondents are not able to identify or don't know whether the specified environment management system guide is available or not. The feedback rates on safety system, work breakdown structure, project handbook, system guide are 20%, 24%, 27% and 27% respectively. Only 10% and 5% of the respondents don't know cost plan and quality plan. However, nobody don't know programme.

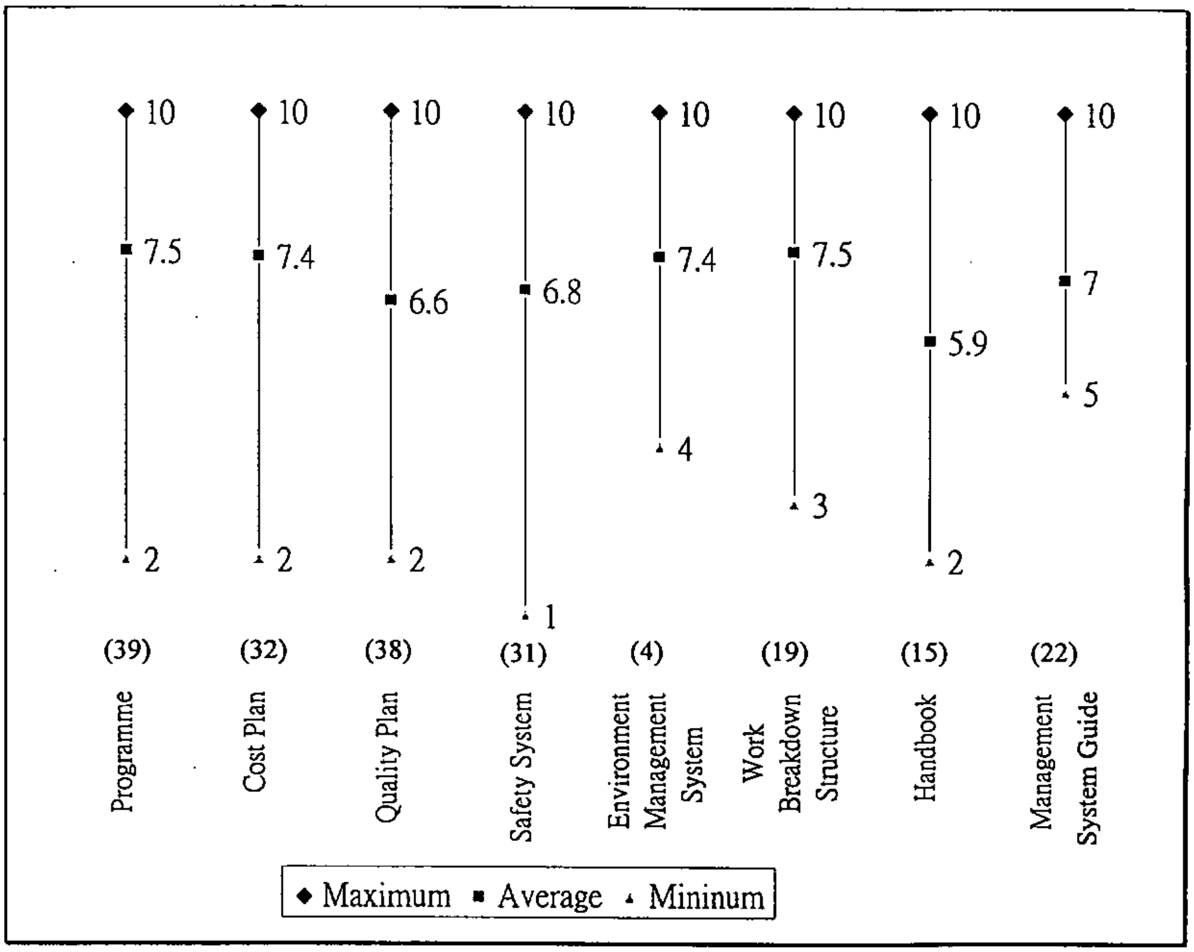
In short, the recognition of the system guides distinctly varies that all the respondents are familiarized with project programme. Over 90% of them know cost and quality system guides. 80% of the respondents know safety system while 68% know environment system. The ratio of the respondents who have knowledge of work breakdown structure, project handbook and management guide are over 70%.

The above findings show that respondents are quite familiarized with those system guides related to the conventional project management objectives. The safety and environment system are considerably recognized. But, the level of application of the environment system to construction project management is still uncommon in Hong Kong. The figure about 30% of respondents who are unable to identify or don't know the other system guides might indicate that some construction companies or projects still neither employ such system guides, nor equip the management practitioners to familiarize the system guides.

Applicability of system guides

The spectrum of respondents' opinion to the applicability of system guides, based on the various effective sample sizes and the scale from the lowest 1 to the highest 10 score, is shown in Figure 5.8.

The four larger effective sample sizes are programme (38), quality plan (38), cost plan (32), and safety system (31). The degree of agreement for the applicability of project programme has scored 7.5 on average with 1.8 standard deviation (S.D). The mean of cost plan is 7.4 with 1.9 S.D. The mean of quality plan is 6.6 with 1.9 S.D, and mean of safety system is 6.8 with 2.3 S.D. The effective sample size of environment management system is only 4 that the mean is 7.4 with 2.7 S.D. . The mean with standard deviation of work breakdown structure, project handbook and management guide are 7.5 with 1.6 S.D., 5.9 with 2.3 S.D. and 7.0 with 1.3 S.D.



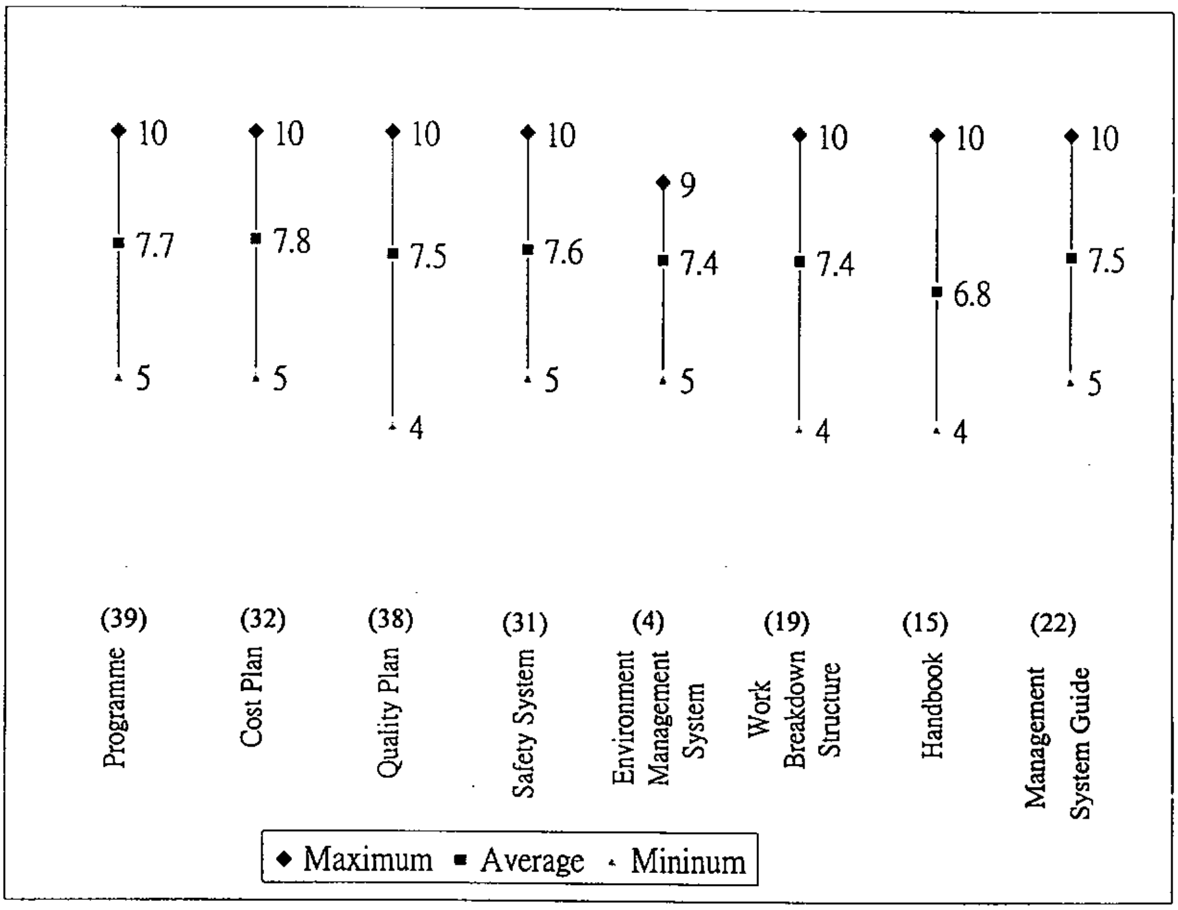
Note: The number in ( ) stands for the effective sample size for analysis

Figure 5.8. Respondents' Perspective on the Applicability of System Guides

The range of the opinion is wide enough that relatively large deviations are found. This shows that the question on applicability of the systems guides are quite controversial. However, there is still room for improvement in employing the various system guides. It is because all the scores in system guides lie at or below 7.5 and the variance are large.

Degree of detail of system guides

The mean of various system guides in terms of degree of detail are obviously larger than that in degree of applicability. The standard deviations for degree of detail are less sparse than that in degree of applicability. This is due to a narrower score range. Such discrepancies can be traced in Figure 5.9 when comparing with Figure 5.8.



Note: The number in ( ) stands for the effective sample size for analysis

Figure 5.9 Respondents' Perspective on the System Guides in terms of Degree of Detail

Regarding the top four effective samples, the mean of programme, cost plan, quality plan and safety system are 7.7, 7.8, 7.5, 7.6 with 1.5 S.D., 1.4 S.D., 1.4 S.D. and 1.3 S.D. respectively. The mean of work breakdown structure, project handbook and management guide are 7.4, 6.8 and 7.5 with 1.5 S.D., 1.7 S.D. and 1.3 S.D respectively. The average score of environment management system is 7.4 with 1.8 S.D.

The discrepancy of the respondents' perspective on the degree of detail of the system guides is shorten as the range of score is more narrow and the variance is reduced.

Correlation

It is important to study the correlation between the degree of detail of the various systems guides and their applicability to the respondent's management activities. If the degree of detail of the system guides is higher, the uncertainty and risk to apply the systems could be minimized. Therefore, the higher value the correlation coefficient, the stronger the relationship between the degree of detail and the applicability. It also gives a clue to reflect the respondent's recognition to the various system guides.

Having more than 30 samples, the coefficients of correlation in programme and cost plan are 0.66 and 0.69 while quality plan and safety system are 0.31 and 0.39. These reflect that the respondents' recognition of programme and cost plan are far better than quality and safety system. The weak relationship for quality and safety system is reasonable as both of them have only been introduced to the industry recently.

Regardless the relative smaller sample sizes, the correlation of other systems guides are worth listing to provide a more complete picture to analysis. The coefficients of correlation of work breakdown structure and project handbook are 0.64, and 0.55 respectively. The correlation on management guide is relatively strong as the coefficient is 0.77. And the coefficient of correlation is 0.90 in environment management system, but it is not significant as only 4 effective samples are being taken into consideration.

Overall, it is found that the respondents have enough knowledge in the conventional project management system guides, but improvement for the new system guides such as safety and environment systems is required. The opinion regarding the applicability of system guides seems not good enough as well as the respondents' perspectives are various. Therefore, there exists room of improvement either for management practitioners or for the systems guides.

5.3.3 Source of Dynamics in Contractors' Management Environment

The dynamics within a construction project management system arise from different parties. The influence from the dynamics will inevitably affect the project performance. Six major types of dynamics which are significant in main contractor's project management system, are selected to investigate their sources and the impact on the project progress. These types of dynamics are: time related (e.g. changes of milestone), manpower related (e.g. frequent staff turnover), information related (e.g. drawing redesign or incomplete design, and implicit terms or conditions), and area (e.g. change of use or increase in facilities) as well as process (e.g. change of work method).

Time dynamic - change of milestone

Figure 5.10 illustrates the occurrence of project parties who originate the changes of milestone. More than 50% of the respondents have identified their client as contributor to this dynamic. Both architectural and main contractor firms have hit 34%. The rate of occurrence in other project parties are distributed as follows: structural engineer, 22%, government agencies,17%, suppliers,15%, HAVC engineers,12%, quantity surveyor, 5%, and telecommunication specialist, 5%. This spreading distribution shows that the sources of change of milestone is not only resulted from client but also from many other project parties.

Manpower dynamic- frequent staff turnover

There is 43% of the respondents claimed that the source of frequent staff turnover is mainly found in their company as shown in Figure 5.11. Particularly, 18% of the respondents indicate that such dynamic is also by company policy. The cause of frequent staff turnover is also due to outsides project parties. The reason may be explained by 20% of the respondents showing that the market condition is one of the major cause to staff turnover.

Information dynamic - redesign or incomplete design

The design related dynamic is obviously caused by design team, particularly, architectural firm as shown in Figure 5.12. 80% of the respondents identify that redesign or incomplete design is caused by the architectural firm. The other significant sources to this dynamic are structural engineering firm, 30%, from client, 25%, and HVAC engineering firm, 25%.

Information dynamic - implicit terms or conditions

The causes of implicit terms or conditions in contract documents are mainly found from client, 38% and quantity surveyor, 33%. The source recognized from main contractor is 20% while from architect is15% as shown in Figure 5.13. Quantity surveying firm identified as an influential party for such dynamic may be related to its function to do material and cost estimating.

Area dynamic - change of use or increase in facilities

Figure 5.14 shows that the source of change of work scope is mainly come from client, 63%. The other sources of the dynamic recognized by the respondents are also come from architectural firm, 23% and HVAC engineering firms,13% respectively. There are several claims that main contractor, government agencies and supplier which are sources of change of work scope.

Process dynamic - change of work method

The source of change of construction work process identified is mostly derived from main contractor, 68%. The other sources are from structural engineering firms, 25%, architectural firm, 20%, and client, 18% as shown in Figure 5.15.

Form the above findings, the sources of dynamics vary from different project parties. The most influential parties to a contractor's project management system are client, architectural firms and main contractor itself. However, structural engineer and quantity surveyor firms are also found to generate particular dynamics. Those dynamics are sometimes resulted from other project parties such as government agencies, HVAC engineering firms, telecommunication specialist and suppliers.

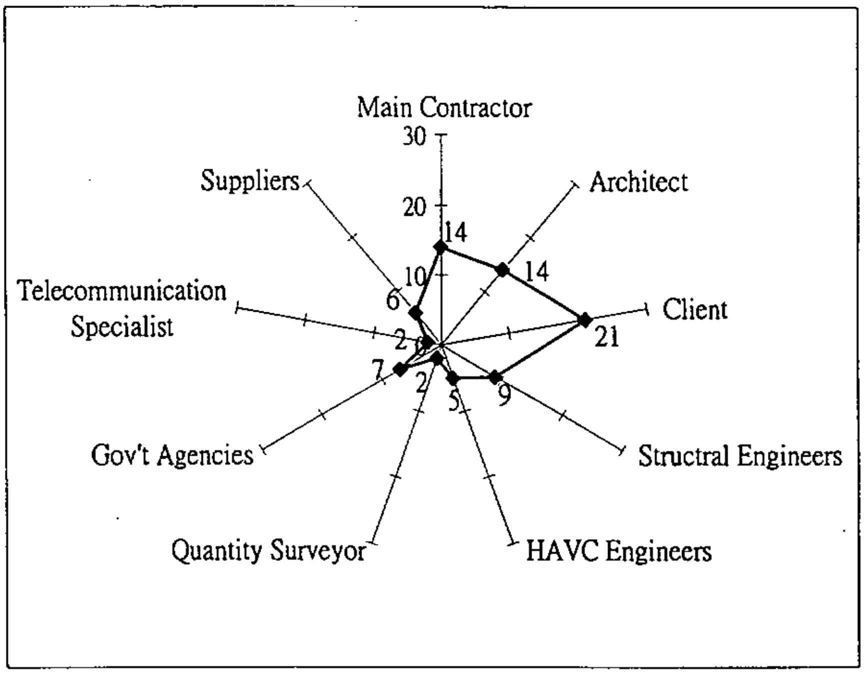


Figure 5.10 The Sources for Changes of Milestone

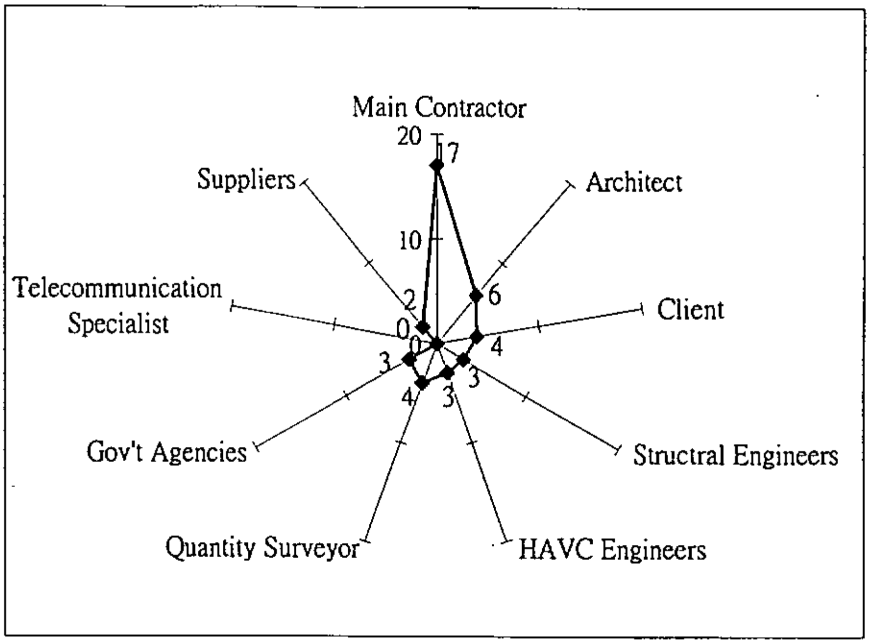


Figure 5.11 The Sources for Frequent Staff Turnover

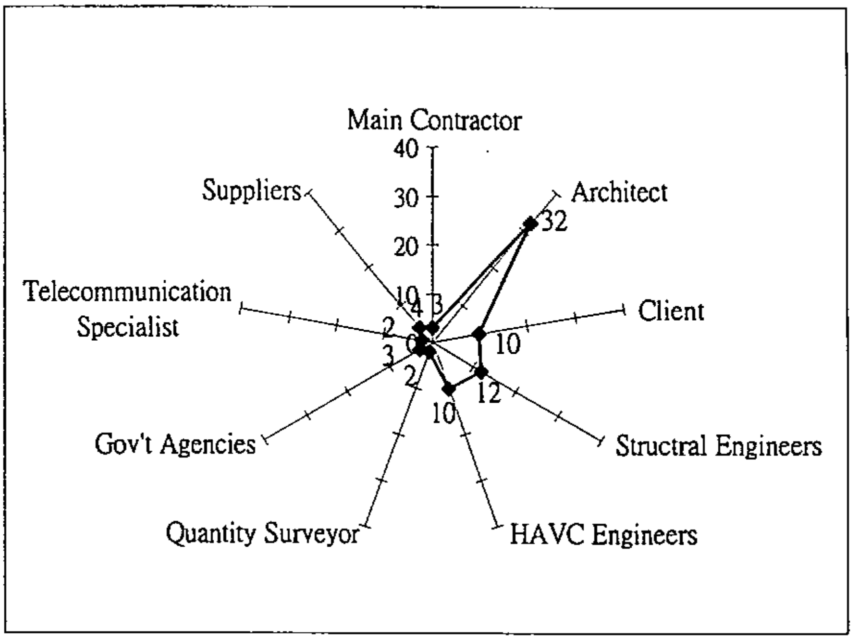


Figure 5.12 The Sources for Redesign or Incomplete Design

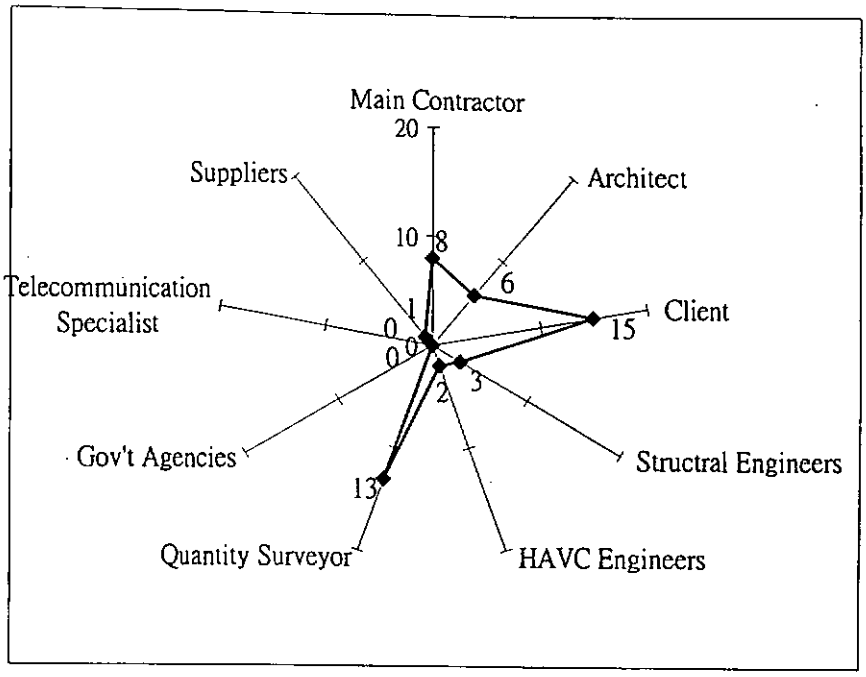


Figure 5.13 The Sources for Implicit Contract Conditions

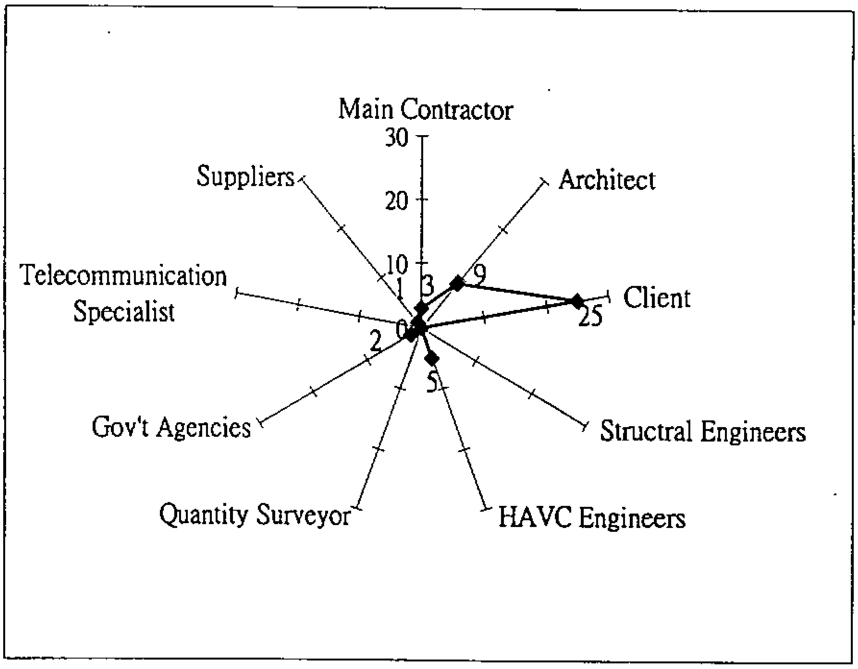


Figure 5.14 The Sources for Changes of Work Scope

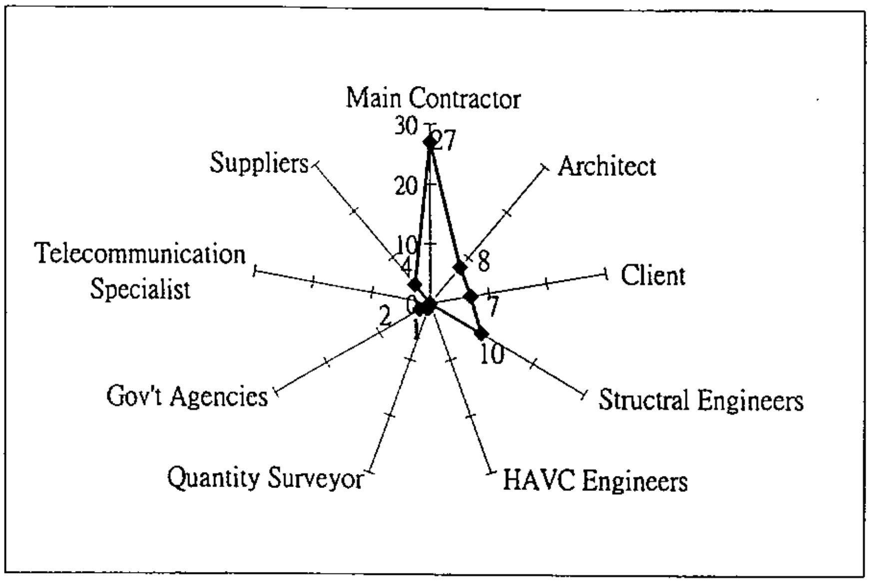


Figure 5.15 The Sources for Adopting Construction Work Methods

5.3.4 Impact of the Dynamics on Construction Project Management

Degree of impact

The degree of impact by the dynamics on the project performance in terms of project progress is shown in Figure 5.16. The degree of influence on the progress by change of milestone is 8.4 on average with 1.1 S.D. The degree of influence by change of design is 7.9 on average with 1.3 S.D. These two dynamics highly influence the project performance with small discrepancy between the respondents.

The degree of impact by frequent project staff turnover is 6.8 on average with 1.9 S.D. The degree of impact by change of work process (i.e. construction method) is 6.6 on average with 1.7 S.D. And the degree of influence by change of scope of work is 6.7 on average with 2.1 S.D. These three dynamics also show a considerable influence on the project performance, but the variance is large that the respondents hold big discrepancy on the impact from these three dynamics.

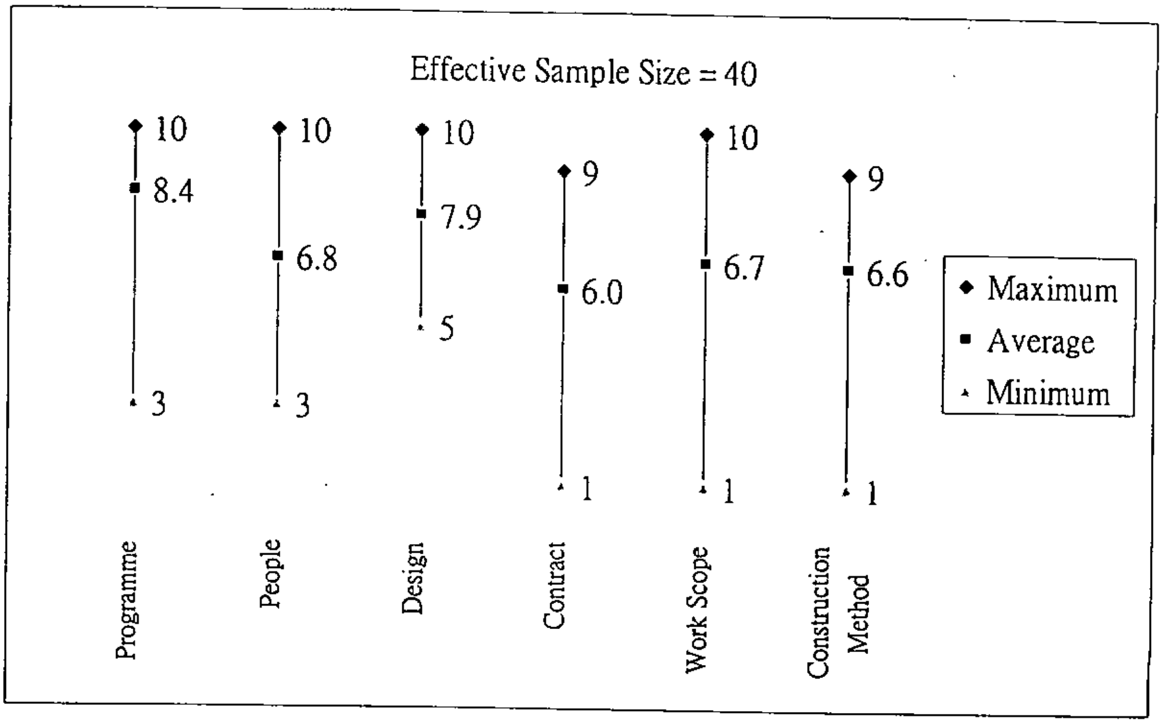


Figure 5.16 The Degree of Impact by the Major Dynamics

The degree of impact by implicit contract conditions is 6.0 with 2.1 S.D. It shows a relative small impact on the project performance with a wide variance. This may imply the great discrepancy on the interpretation in implicit and uncertain contract terms.

Frequency

By considering the occurrence of dynamics, the frequency distribution of facing the major dynamics in management activities per week is shown in Figure 5.17. There are 22% of respondents who are facing different kinds of dynamics by 7 times or more per week. 27% of them are facing 4-6 times per week, and 49% are facing 1-3 times per week.

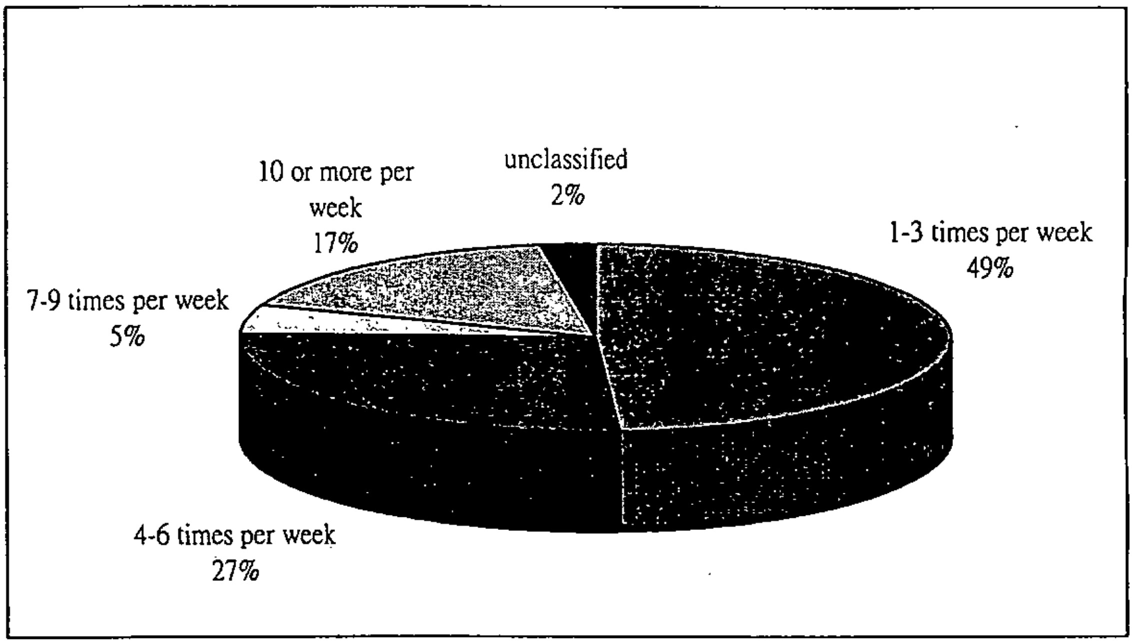


Figure 5.17 The Frequency of Facing Dynamic-Change & Uncertainty in Management Activities.

The above clues indicate that the management practitioners undergo a high degree of dynamic in the working environment. It is critical that nearly half of the respondents have to face those major dynamics day by day.

5.3.5 The Management Effectiveness by Decisions

Figure 5.18 shows the degree of agreement by the respondents on effectively making major decisions. The score of self-assessment on decision effectiveness is 6.6 on average with 1.6 S.D while the score of assessing the overall management levels is 6.0 with 1.6 S.D.

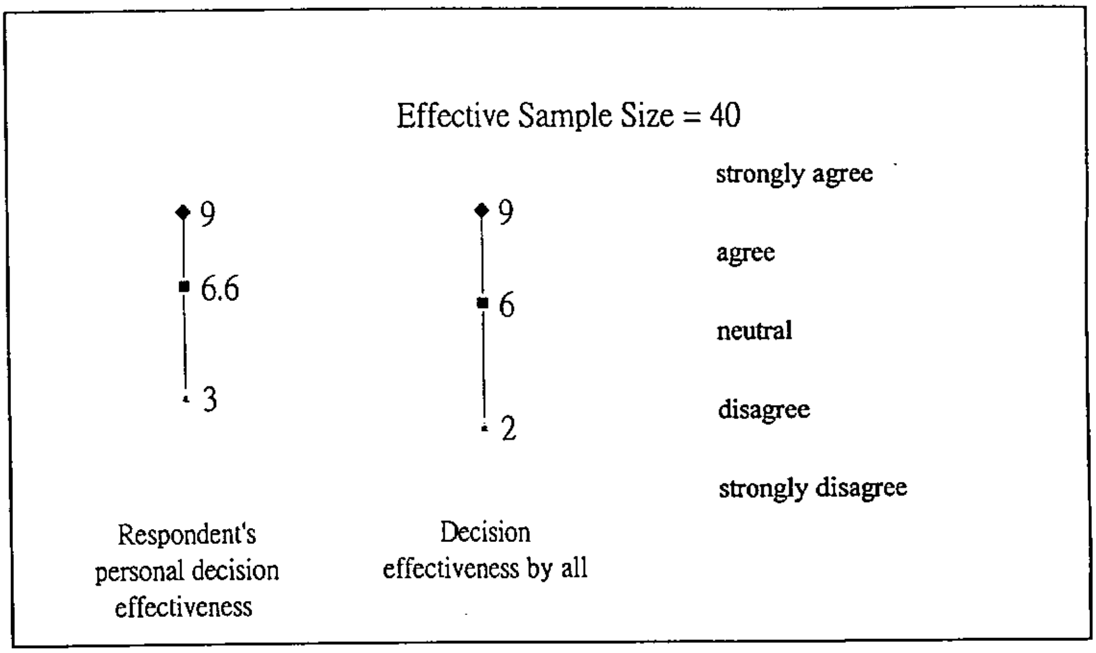


Figure 5.18 The Distribution of Effectiveness of Decision Making in Project Management Activities

It is interesting that the respondents' personal decision effectiveness is slightly better than the overall management levels in general. There also exists relative large discrepancy in the scoring spectrum among the respondents. It might imply that the self-assessment exercise is subjective. However, the factual scores in general show that the management effectiveness by decision making remains plenty of room for improvement.

There is an interesting result by sorting the five extreme cases out for analysis. It is found that the correlation coefficient between the personal management effectiveness and the working experience is 0.93 (highly correlated) while those remaining 36 samples only shows 0.21(slightly correlated) of correlation. It implies that working experience is not the necessary function for decision effectiveness.

When considering whether the identified dynamics can be managed by the system guides or not, the level of agreement is 6.6 on average with 1.6 S.D. as shown in Figure 5.19. Comparing with the feedback on the applicability of system guides, the respondents hold certain reservation to the applicability of the system guides. The capability of the respondents to apply the concept of project management is 6.8 on average with 1.7 S.D while the capability to use system concept is 6.4 on average with 1.6 S.D. It is obviously that the respondents are more confident on project management concept than on system concept. Nevertheless, the discrepancy is fairly wide that the respondents have demonstrated a differentiated level of knowledge toward project management and system concept.

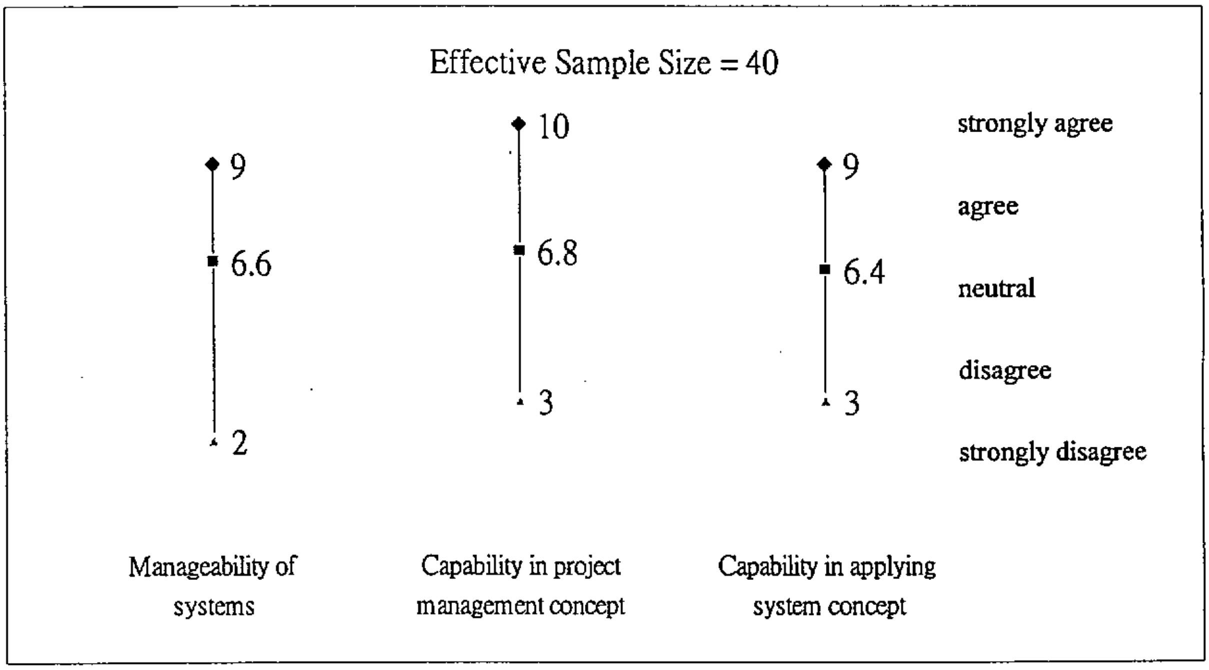


Figure 5.19 The Feedback on the Project Management and System Concept.

By using correlation analysis, there is certain relevance between personal decision effectiveness and project management system. The correlation coefficients between the personal decision making effectiveness and their capability of applying project management and system concept are 0.51 and 0.36 respectively. These figures may provide evidences that there exist certain relationships between the knowledge of project management system and management effectiveness.

5.4 Summary of Chapter Five

The construction industrial activities are dynamic by reviewing the key statistics from 1992 to 1996 related to the Hong Kong construction industry. Construction work value fluctuates dramatically by referring to the gross value of construction work performed by main contractor and the public work programme. Similarly, the construction volume in terms of usable floor area is highly fluctuated over the last five years. These two fluctuating figures reflect that the local construction activities are full of dynamics which inherit the chain of variables, changes, uncertainties and risks. Not strictly following the trend of construction volume, the engagement of construction workers fluctuates in both public and private projects. It may explain why the old issue of importation of more labour for the construction industry still remains controversial. Though the cost index value of major construction materials is relatively stable, the index of timber formwork is still fluctuated. The price index of building service, which is an increasing important component in the building cost, significantly increased since 1995 and extended its fluctuations to the future. Behind such statistics by considering the project management system objectives, resources and environment, there are actually proven evidences to explain why the construction project management should be treated as a dynamic system.

From the point of view on the demand and supply, certain key dynamics which are highly related to the local construction activities are population growth, land supply mechanism, housing policy, construction workforce, and availability of material and technology. They may act as dynamics either in terms of system objectives, resources or environment forces under the framework of the DCPMS in Hong Kong.

By considering the dynamic phenomena in the Hong Kong construction industry, a group of management practitioners from main contractor is focused to survey their working environment against their management effectiveness. The underlying hypothesis for the survey is that the management effectiveness is correlated to the dynamic working environment. There are some existing system guides for working against the construction project management objectives. It is found that the respondent's recognition for various system guides are diversified. Time, quality related system guides which are highly acknowledged to be employed in their existing projects while those related to cost and safety are fairly recognized and applied. The environment management system guide is less familiarized and even 56% of the respondents identified no application of such system guides in their existing projects. Among those who could acknowledge the systems guides such as work breakdown structure and company management guide, about 50% of them identified that they applied these system guides. However, 20% of the respondents who are not able to identify or even don't know whether the safety system guides are available or not. Meanwhile, there is about 30% of such kind of respondents who are not able to identify the environment management system, work breakdown structure, project handbook and management guides. This highlights that some construction companies or projects neither employ such system guides, nor equip the management practitioners to familiarize the system guides.

After evaluating the availability of the system guides, their applicability is examined. There is a wide discrepancy among the respondents' opinions on the applicability of the system guides and the overall scores lie below 7.5. These may show that the respondents are not well content with the applicability of the systems guides at large. On the other hand, the respondents are relatively pleased, with much less discrepancy, to the system guides themselves in terms of degree of detail. By correlation analysis, it is found that the respondents have enough knowledge in the system guides related to conventional project management objectives such as time and cost. However, improvement for the new system guides such as safety and environment systems is required.

The sources of six selected types of dynamics with respect to project parties and the impacts of the dynamics on the project performance are investigated. It is found that the sources of the dynamics vary at different degrees with different project parties. The most influential parties to a contractor's project management system are the project client, architectural firm and the main contractor itself. For examples, the time (programme), information (contract terms) and area (work scope) dynamics are mainly contributed by the client. Time and information (design) dynamics are mostly derived from the architectural firm. The contractor firm generates the dynamics such as time, manpower (staff turnover), process (construction work method). Sometimes, structural engineering and quantity survey firms are also found producing those dynamics over the contractor's management system. The degree of impact on the project performance by time dynamic and information dynamic (design) is relatively high with only a small discrepancy between the respondents. It also shows a considerable impact by the other four types of dynamics on the project performance, but with a wide variance. Concerning the frequency of coming across the dynamics, nearly half of the respondents have to confront those major dynamics daily. It reflects that management practitioners more or less experience a dynamic working environment.

Regarding the management effectiveness in terms of decision making, the respondents do not satisfy their decision making as the level of agreement which is relatively low on average. It reveals that there is plenty of room for the management effectiveness to be improved by focusing on decision making activities.

Chapter 6

Application of the Dynamic Systems Approach in Construction Project Management

6.1 Introduction to Application of Dynamic Systems Approach

Some key dynamics affecting the DCPMS have been investigated with respect to the Hong Kong construction industry in chapter 5. It is evident that the construction project management system is so dynamic either due to the internal changes or the external uncertain environment. Under such a dynamic situation, many respondents do not satisfy in general with their own performance in making decisions. Therefore, this chapter is to evaluate a dynamic systems approach by responding to the dynamics, in particular, referring to the project management's decision making mechanism.

Managers at all levels are decision makers. For construction project management, the role of project managers or coordinators across all functional disciplines is fundamental to make decisions by performing their duty or responsibility over the project life so that the project is ultimately delivered. Project managers or coordinators of all levels from different parties work and interact with each other. They are subject to be influenced by different degree of impacts by dynamics in the decision making process. According to Forrester (1961,1985), a basic dynamic system model consists of feedback systems in which there are four essential features which include decision function, information, level of system, and actions. The decision function controls actions, information and the level of the system. Similarly, the information, actions and the level of dynamic system are controlled by the decision function which is focused on dynamics.

6.2 Identification on Application Areas of the Dynamic Systems Model

6.2.1 General Areas of Application

The establishment of the DCMPS is an endeavour to provide a framework to understand a dynamic situation and the interactions between different system components within the dynamic situation. The introduction of 'dynamics' is necessary to reflect that how the construction project management system is treated as dynamic system and how the dynamic system life is developed. The DCMPS can be, in general, served as an analytical path by referring to the system model in which the possible interdependencies between the three system components can be drawn out. Moreover, the intra-dependencies between the elements of a single system component can be worked out. For example, there occurs a rich picture that reflects the chain of effects among SEQACT once the time objective is changed. At the same time, another rich picture about the chain of actions will be generated over CPMR, the system resource subsystems. By reviewing the cause of changing time objective, one can also find the possible interactions or influences from or to LIPSET environment forces.

Besides providing a holistic view on information, the DCPMS can be served as a new element in problem solving and decision making for anyone who particularly faces the dynamic situation. Even though the system framework is proposed to manage a construction project to deal with 'changes' in a systematic way, it can also be tailored to apply either at industrial or company level.

Industrial level

The construction demand and supply mechanism, the government policy, the construction volume and value trend, the manpower utilization level as well as the material cost index, etc. can be well studied by referring to the DCPMS. Particularly, the incorporation of environment system component in the DCPMS is best suitable to be employed for analysis at the industrial level. Though the environment forces over the construction industry are very complicated, the focus of the interactions between the LIPSET environment forces in the model can provide a means to identify the intricate relations between the different environment forces. Therefore, either the status quo or the future trend of construction industry can be more easily analyzed and hence giving proper conclusions.

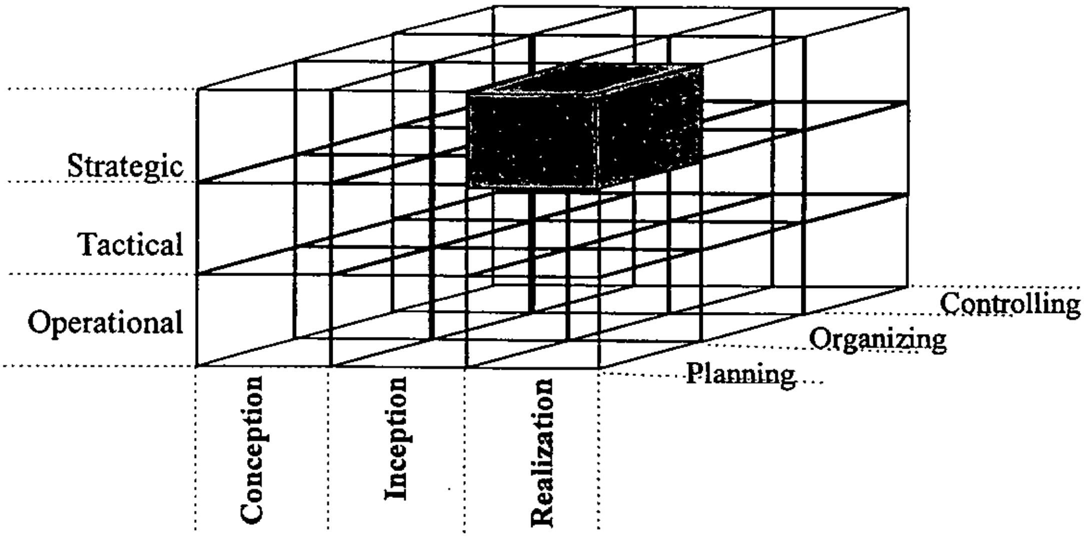
Company level

The DCPMS can be employed to aid in formulating company strategy and policy. It can be used to help developing and procuring projects by considering the SEQACT objectives and CPMSR resources against the LIPSET environment dynamics. The priority of objectives for developing a project can sort out from the analysis of the interactions between the SEQACT system objectives and LIPSET environment dynamics, as well as the intra-dependencies between the SEQACT objectives. On the other hand, any project party which wants to procure or tender for a project, needs to understand the implications of the intra-dependencies between the SEQACT objectives dynamics as well as the interaction of the three system components so as to minimize the risk of taking the project.

Sometimes, an individual project party has many various projects to be handled at the same time, it is thus crucial to allocate appropriate resources to different projects. The company management can apply the DCPMS by examining the intra-dependencies of the CPMR dynamics through the information sub-system, and react properly to different project requirements. Say, keep the manpower, cash flow, machinery utilization in balance so as to ensure that all projects are under control.

6.2.2 Matrix Structure for Application Areas

The DCPMS is originally to deal with 'dynamics' in the construction project environment . The application areas within the construction project environment should be clearly identified so that the DCPMS can be employed by those who are concern about managing dynamics in the project management environment. There are three application profiles with respect to the DCPMS that the focus of dynamics can be traced. They are project management functions, project management levels and project management stages respectively. They form an application matrix for construction project management as illustrated in Figure 6.1. Any cells in the matrix can be served as dynamic signposts for project participants to search their application areas. Any one cell can be further split into multiple smaller cells which are supposed more specific to reflect the dynamic or dynamic situation.



Legend  An application cell
(represents at the realization stage, at strategic level, for planning)

Figure 6.1 Matrix Model for Application Areas

The signposts in the application matrix are used to freeze dynamics to be managed by considering a proper combination of different capability of decision makers and management techniques over the project life. For example, there occurs a change in the time dynamic - programme (e.g. due to the change of work scope or inclement weather) at realization stage. What should the different levels of project managers prepare and react to the situation and how should they carry out the various management functions? The project managers or coordinators may require a different mind-set to manage such a dynamic and adjust certain management efforts. The mind-set in terms of attitude, knowledge and skill are critical to project managers because these influence the ways they respond with the dynamic situation. In other words, the mind-set affects the decision function. Meanwhile the management efforts in terms of planning, organizing, controlling are subject to adjustment by responding to the dynamic situation. Perhaps it requires the reviewing of the plan, re-organizing the system resources and implementing alternative control measures.

Even the system framework is proposed to manage a construction project in dealing with 'changes', the framework can be served as a new element in problem solving and decision making process. Particularly, the decision function controls actions, information and the level of the dynamic system. Therefore, the decision making process in construction project management will be examined in Section 6.3 to identify its relevancy to the DCPMS.

6.3 Dynamic Systems Approach for Decision Making

6.3.1 Concept of Decisions

A decision is very vital to the DCPMS because it controls actions, information and even the level of the system. The status of a project development is totally dependent on the numerous decisions being made within the project life. Therefore, the pace of progress of the DCPMS is driven by the decision function as shown in Figure 6.2.

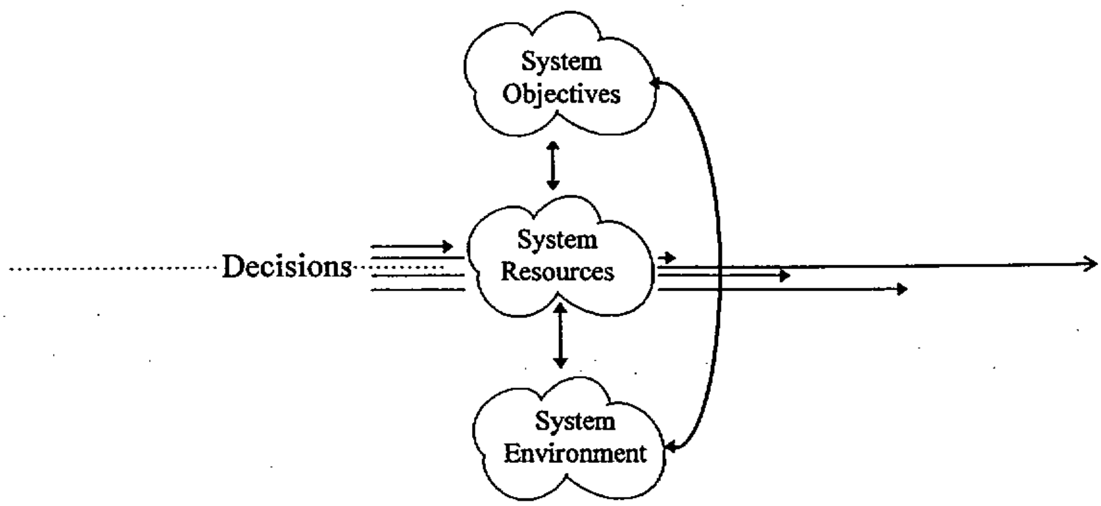


Figure 6.2 A Model of Decision-Driving Dynamic System

In a project environment, Badiru (1991a) states that the essential elements of a decision include the *problem statement, information, performance measure, decision model, and implementation of the decision.* Ackoff (1978) considers problem solving with respect to what a decision maker does about each of these components:

1. Objectives: desired outcomes
2. Controlled variables: course of action
3. Uncontrolled variables: the environment
4. The relationships among these three.

For a decision in respect of dynamic situation, the elements for making decision include the decision maker, the desired outcome, information (includes the DCPMS model, dynamics statement and decision model), action and reaction (feedback). Under a dynamic situation, whether a decision is made effectively, that means whether it achieves the desired outcome, is based on the understanding and manipulation of the interaction between the decision maker's mind-set, a holistic project management information, timing action and responsive reaction.

6.3.2 Decisions in Construction Project Management Process

By making decision effectively, the holistic approach with time dependence is necessary to manage the dynamics which permeate within the construction project management environment. There is a main stream of thinking about decision points by a system approach. The decision points highlighting time dependence are virtually the milestones of the decision function that control the development of the dynamic system. Morris (1972) introduces the concept of decision points as one criterion to define seven basic subsystems as a construction project process model which is shown in Figure 2.7. Walker (1984,1996) elaborates a construction process as a systems model composing subsystems in a hierarchy for which the boundaries are differentiated by primary decisions, key decisions as well as operational decisions points. The differentiation of these major decisions reflects what the roles of various parties are as well as their degree of participation to a construction development project. Bennett (1991) portrays a relationship of various construction project participants' efforts with respect to different project stages according to the key decision points, as shown in Figure 6.3.

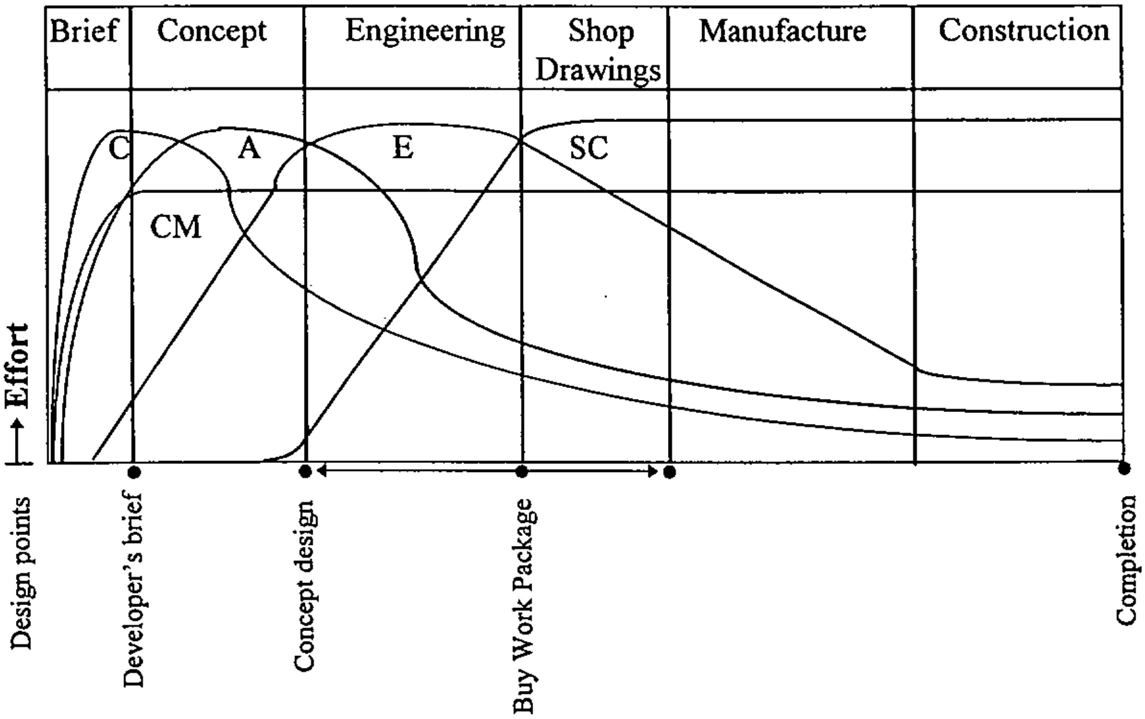


Figure 6.3 Interrelations between Decisions, Project Teams and Project Stages
C-client; A-architects; E-engineers, SC-specialist contractors; CM-construction managers
Source: Bennett (1991)

The first key decision point is to produce the brief as the agreed definition of the problem. The second is at the end of conceptual design as the agreed definition of the solution while the third key point is described as producing the agreed definition of the manufacturing and construction work. There is a spectrum of decision points for the numerous work packages in respect of a whole project. Upon those decision points, it is vital to bear in mind that there exists certain dynamic situations through the project life and hence make appropriate decisions.

On the other hand, Loosemore (1996) distinguishes two types of decisions in construction project context as *organizational and technical decisions*. The technical decisions are directly related to the selection of materials particularly in accordance with their structural functions to a building. The organizational decision is defined as a focal point for *information processing* within an organization The organizational decision process is classified hierarchically into four levels by the nature of their output as follows:

Policy Decision Process:	The highest level of decision making process and represent the boundary of the *project* system.
Strategic Decision Process:	Establish goals and define the boundaries of the *stages.*
Tactical Decision Process :	Devise measures and select resources to attain the stage goals. They define the boundary of the *activities* within each Stage.
Operational Decision Process:	Devise the means by which the resources selected at tactical level will be used to attain the goals at strategic level. They define the boundaries of the *operations*.

The above hierarchical level of decision is also a system approach which is necessary and vital to a construction project management with time dependence. Both the decision points throughout the project life and the level of decisions can be related to the application matrix in which dynamics are located with respect to the DCPMS. The decision points are related to inception, conception and realization phases while the organizational decisions to the various project management levels. Therefore, the types of management decisions in a project organization can also be divided into strategic, tactical or operational decisions. For different management levels and at various project phases, there are different kinds of project management functions which vary with planning, organizing, communicating, coordinating, controlling or leading. The decision makers are therefore playing different roles as planners, organizers, coordinators, controllers or leaders relative to different people with whom they are interacting. The involvement of different management levels are also varied with the management functions in terms of effort or time. The top level decision makers usually make most effort in planning or organizing to make strategic decisions. The middle level usually spend much effort in organizing, leading or coordinating to make tactical decisions. The lower level usually put much effort in leading.

Figure 6.4 tries to portray a proposition of degree of impact by dynamics or dynamic situation on main contractors through the project life. There exists an optimal time point at which dynamics owners should manage the dynamics or the dynamic situation in order to best utilize the positive effect or avoid the negative from the dynamic or dynamic situation. The efforts to manage dynamics could be related to project participant's efforts according to the key decision points as illustrated in Figure 6.3. For example, the top management of the main contractor who want to manage dynamics (e.g. buildability) should be at or before the decision point of concept design. For the tactical level, dynamics should be managed at or before the manufacturing point. And, dynamics should be managed at or before the point of production on site for the operational level.

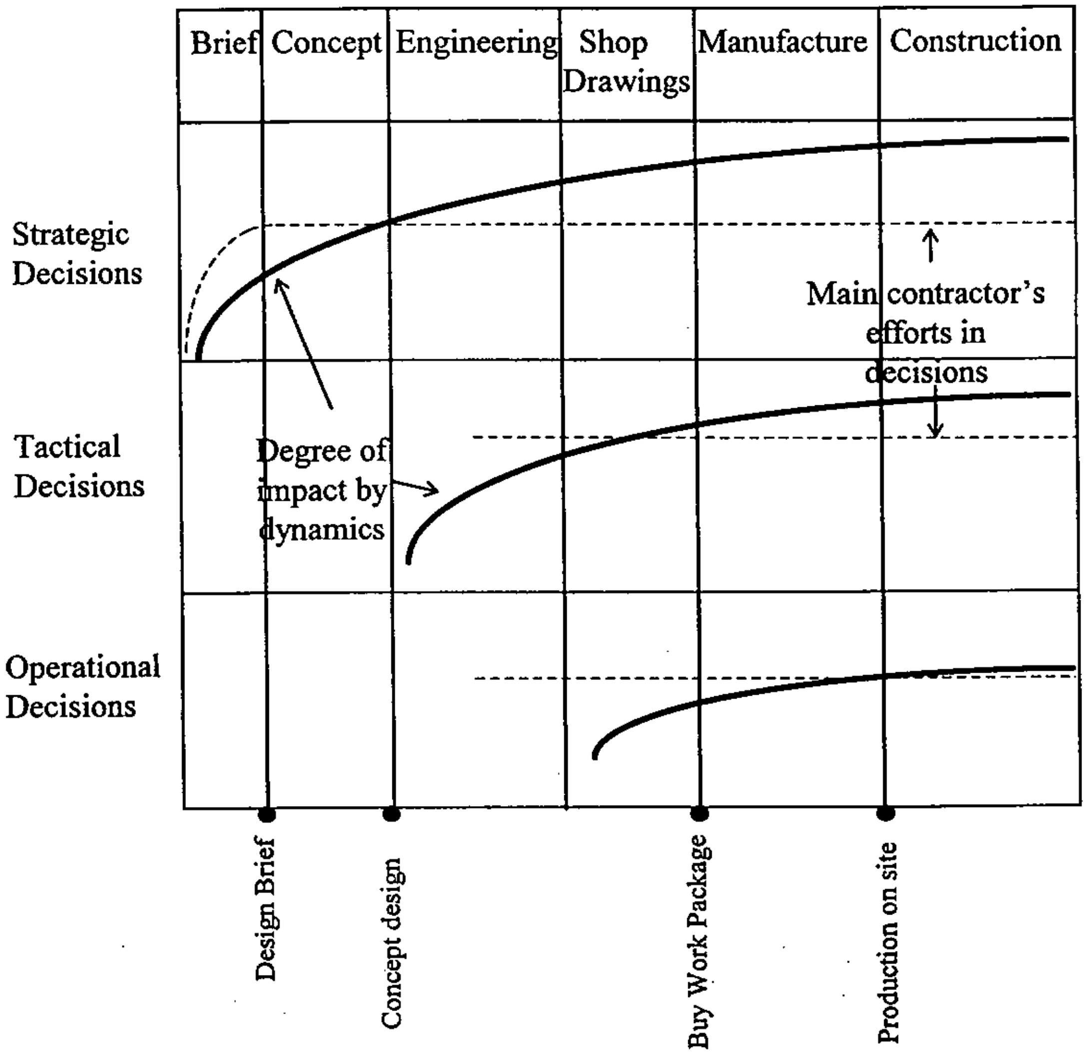


Figure 6.4 A Proposition of the Degree of Influence of Dynamics on Different Organizational Decision Processes through the Project Life

6.3.3 Dynamic Systems Approach for Decision Making

It is very important to clarify 'why' and 'how' the decision is to be made. Crook and Waterhouse (1995) suggest a list of questions which may be a starting point for making decision as shown in Table 6.1. There is no ideal sequence for decision making. The route taken is likely to be cyclical and iterative, and revisiting some stages.

Why is there a need to make a decision?
Who is involved in making the decision?
What are the goals, objectives, or targets that have to be achieved?
How important is the decision?
Does the decision need to be made quickly, or could it be delayed?
Is the decision irrevocable, or could it be changed if it all goes wrong?
What dangers and risks are involved?
What options are available?
How can options be generated?
How much time and effort should be given to the search for options?
What are the criteria for decision making?
How will the choice between alternative courses of actions be made?
Is the decision a 'one-off' or is it dependent on other decisions being made?
Who is involved in implementing the decision?

Table 6.1 A List of Questions behind Making Decisions
Source: Crook and Waterhouse (1995)

The statement of a dynamic situation is important to reach an effective decision. Problem solving activities under a dynamic situation are concerning those dynamics which affect the operations of management system. The decision making process needs a system approach of thinking to problem-solution interaction. With reference to the Checkland methodology (Wilson, 1984) as shown in Figure 6.5, a dynamic situation could be dealt with in parallel to the seven-stages process of analysis which uses the concept of a human activity system as means of getting from 'finding out' about the problem situation to 'taking action' to improve the situation.

A decision making process is the core of any human activity systems. For the decision making process, dynamics can be found out (step 1) and the dynamic situation can be expressed out (step 2) from the real world. The above two steps can refer to the application matrix of freezing dynamics. The DCPMS proposed in this study is the relevant system to dynamics and its root definitions can be referred to chapter 3 (step 3). The conceptual model can refer to the dynamic systems model as shown in Figure 3.28 (step 4). The dynamic situation can be made comparison with the dynamic systems model (step5) and then the desirable outcomes can be defined (step 6). Finally, decision is made and action is taken by responding to the dynamic situation and improve it (step 7).

On the other hand, the decision making mechanism can be presented relating to the systematic approach to managing dynamics. At the outset, the implication of managing dynamics in the project management system should be understood so as to develop a dynamic systems approach to managing dynamics.

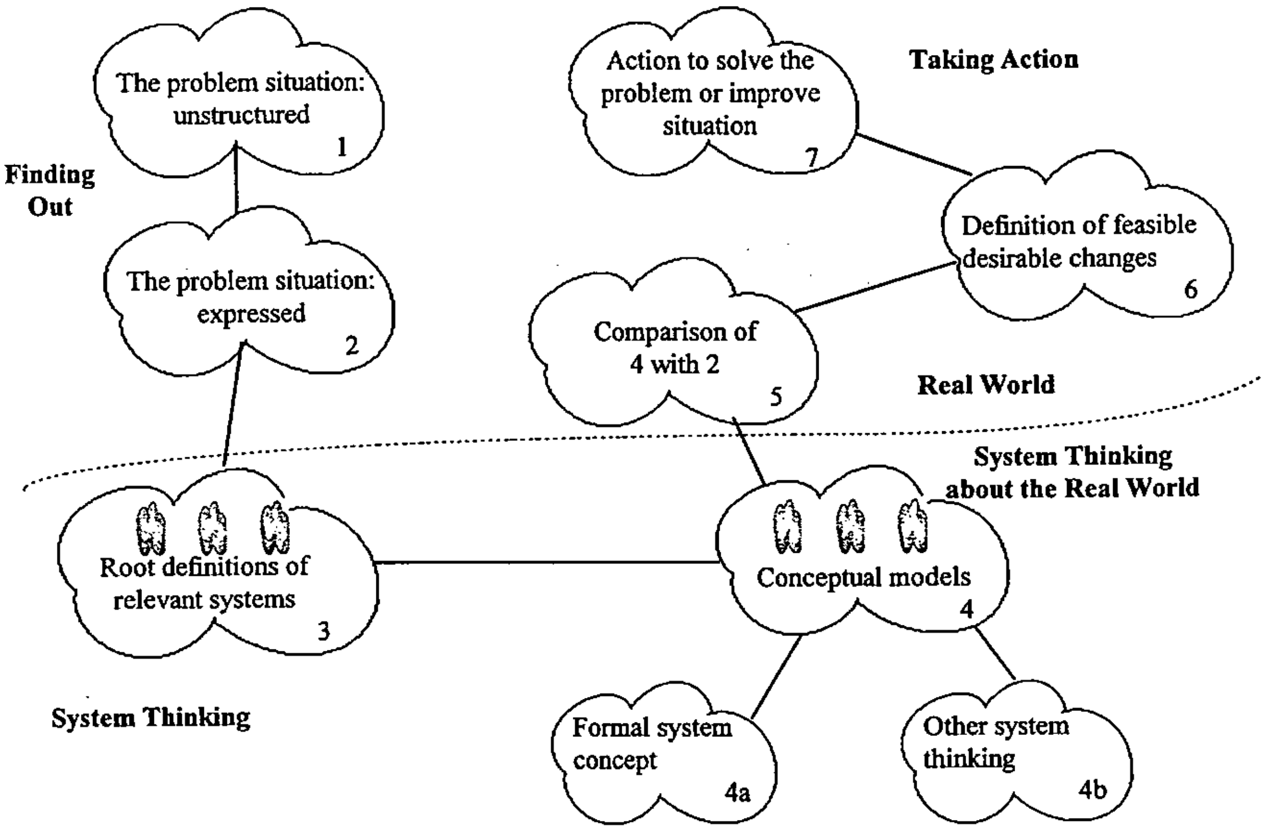


Figure 6.5 A Representation of Checkland's Soft System Methodology
Source: Wilson (1984)

6.4 Dynamic Systems Approach to Managing Dynamics

6.4.1 Implication of Managing Dynamics

A dynamic has possessed uncertainties and risks which may bring loss to any project parties. Therefore, it is worth of committing resources to manage the dynamic. It is also important to develop a proper methodology for managing dynamics and to obtain their positive effect. The methodology should work with the decision making mechanism which is implemented to the project management functions and applied to different project management levels: strategic, tactical or operational throughout the project life. For instance, a bill regarding the release of plot ratio will be enacted in the coming year. Project managers at the strategic level can prepare a contingency plan and organize necessary resources such as personnel to analyze the dynamics and its causal effect. The contingency plan may itemize the possibility for change of work scope, the estimate of extra resources and the prediction of development speed for the project. The project managers should coordinate other project parties so as to understand the contingency plan against the uncertainties and risks. Provided that they treat each other as a project team, it must be carried out with proper communication through formal meeting as well as an understanding memorandum. As the project proceeds, all the project participants should be aware of the implications of the release of plat ratio or the infrastructure proposal so as to react readily with any implications of changes. This is also to ensure that other potential dynamics will be under control with respect to the plan. The dynamics are even most influential to the tactical level but becoming least on the operational level. For such a case, the middle management level may need a higher degree of coordination and communication in order to develop detailed measures for managing the project such as detail design, construction programmes with time buffer, etc. against the change in scope of work and increase or decrease in development pace.

Any dynamics can affect the performance of different levels of managers in terms of decision making effectiveness and hence the whole project management. Therefore, this study proposes a *dynamic system approach* for decision making process to manage dynamics in the construction project management environment.

6.4.2 Identification of Dynamics

As it has been discussed before that the sources of dynamics can be classified to different groups according to the three components affected by various dynamics within the DCPMS. From project conception to realization, there will be numerous dynamics appearing with different properties and affecting the development of the DCPMS. Any individual project party is subject to many combined effects of various types of dynamics throughout the project process as shown in Figure 6.6. The project party is called dynamics owner or dynamics solver when the party is committing resource to tackle the dynamics. For a construction project, the major changes are often from client, architect and contractor. For example, the client changes the scope of work, then architect changes the design blueprint while contractor changes the construction programme.

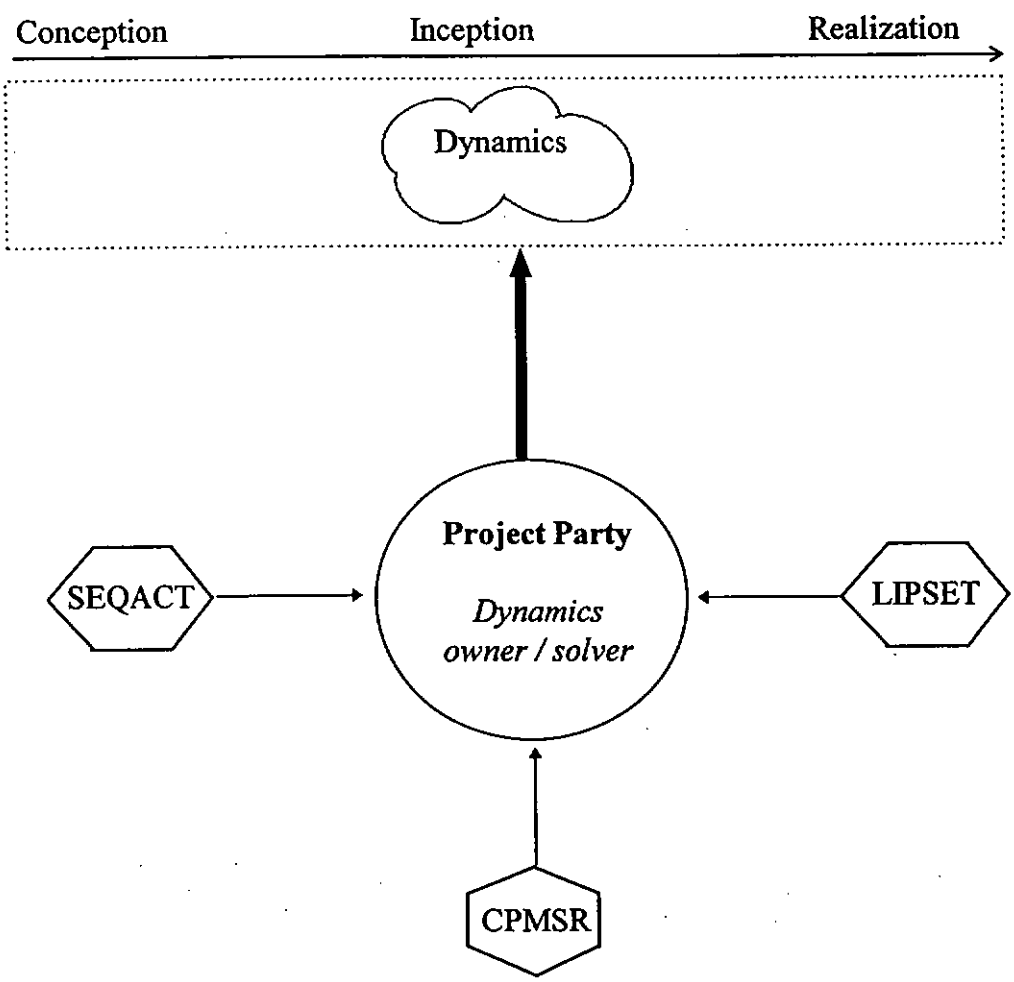


Figure 6.6 The Identification of Dynamics across the Construction Project Process

Major dynamics for client

The major dynamics on construction project management system are usually triggered by a client at the early project stage. The whole development of the project, from the point of view of the client, focuses on the rate of return. However, such focal variable is subject to changes and uncertainties by reacting on the three system components as shown in Figure 6.7. The client's development plan will also affect the scope of work or the selection of procurement path. Thus all these dynamics are substantially influencing the development of a construction project.

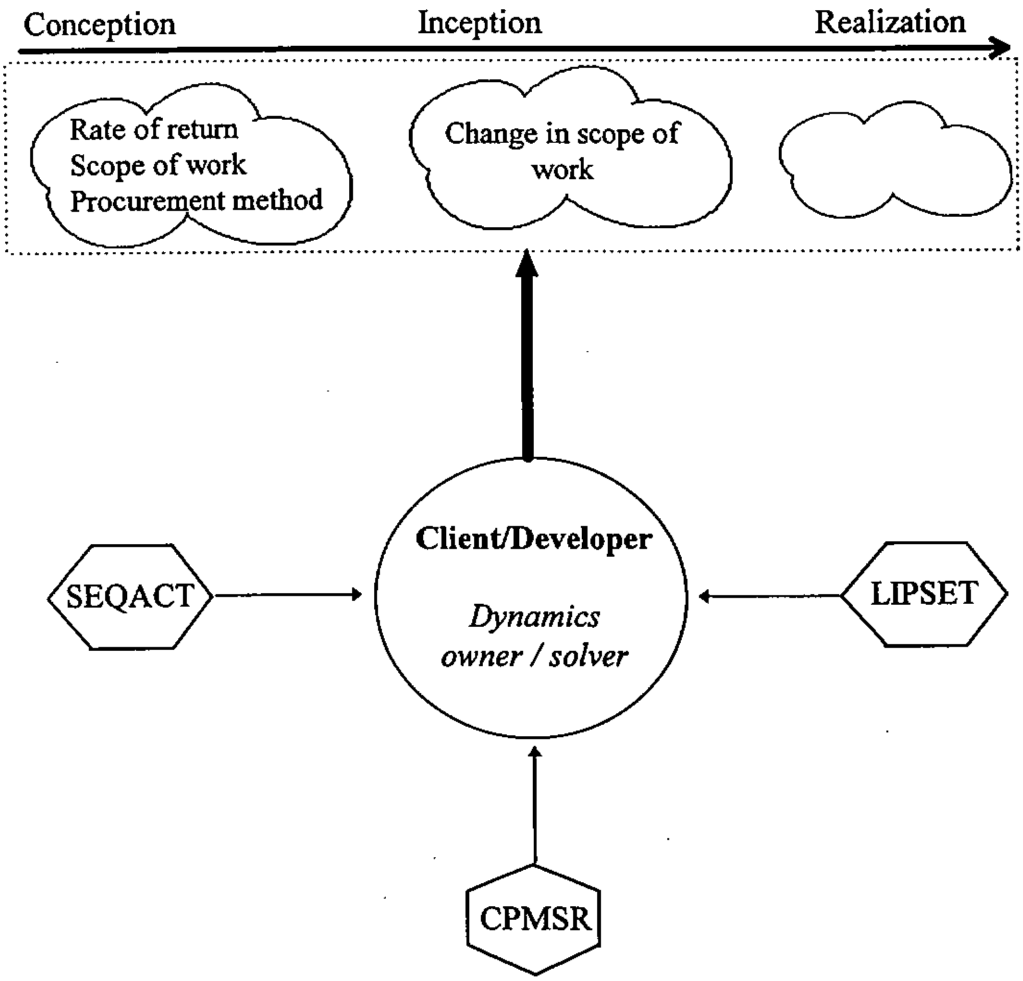


Figure 6.7 Typical Dynamics on the DCPMS from Client

Major dynamics for main contractor

Regarding a main contractor, the major dynamics, as illustrated in Figure 6.8, can be the type of contract, scope of work, design blueprint, programmes, construction methods, human resources including professionals and construction workers. These dynamics may be induced by the client, architect, government departments, or material and machinery suppliers. As the same as those of the client, the identified dynamics will substantially influence the development of a construction project, especially the construction project objectives.

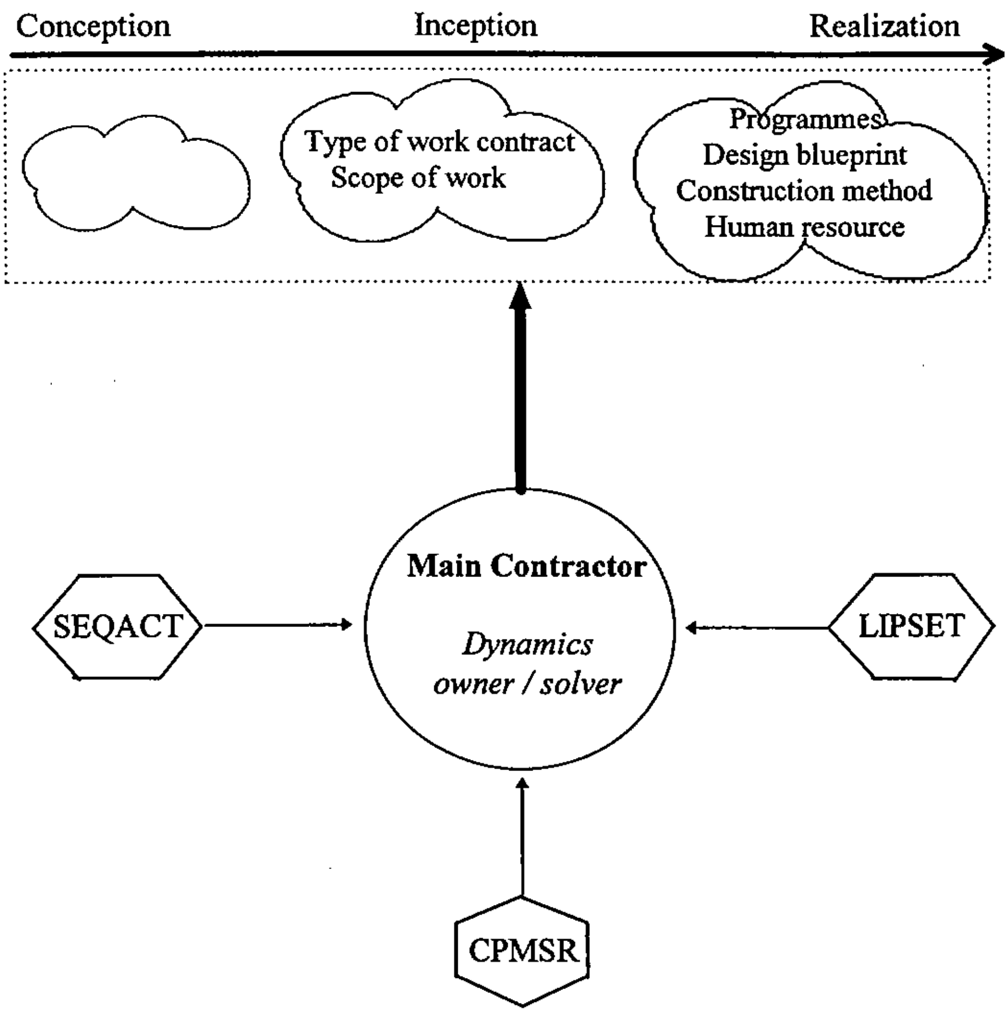


Figure 6.8 Typical Dynamics on the DCPMS from Main Contractor

6.4.3 Analysis of Dynamics

The analysis of major dynamics in the DCPMS is based on the identification of dynamics. The analysis is a systematic process as shown in Figure 6.9. It is concerned with those questions such as where does it originate, does it have positive or negative to the system, how is the pattern of interdependence between dynamics. Investigation to these will help to reveal the intrinsic properties of the dynamics. It can also provide a picture to all project parties with any important or particular dynamics which request for particular actions or responses.

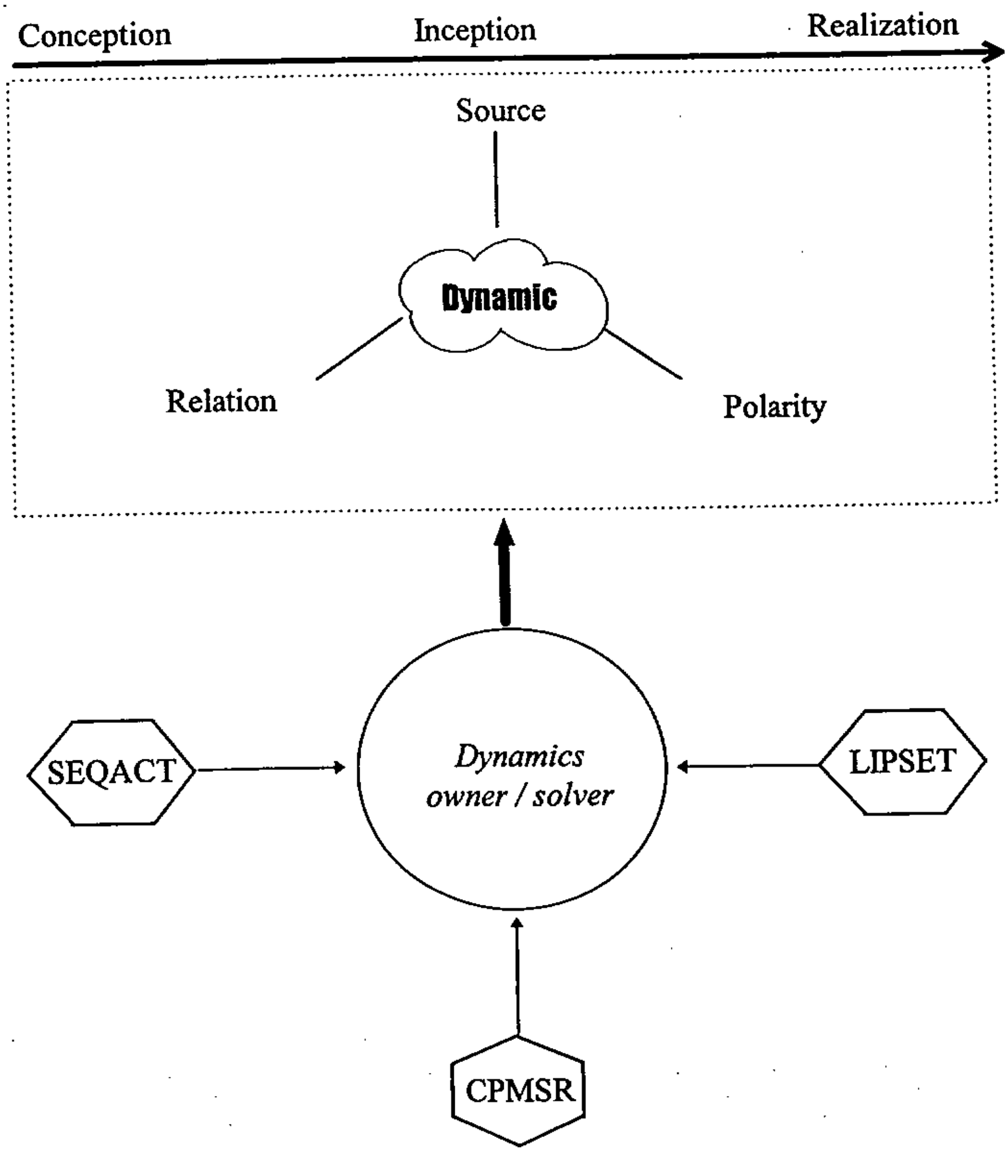


Figure 6.9 An Analytical Framework to a Dynamic in the DCPMS

6.4.4 Response to Dynamics

After analyzing the intrinsic properties of dynamics, all the relevant project parties should coordinate, communicate as well as cooperate with each other so that quick response to dynamics can be enacted. For example, the response to change in scope of work at the realization stage can refer to Figure 6.10 by carrying out analysis.

The change in scope of work as a dynamic, in this case, may derive from client's intention to increase profit margin (box 1). Such a dynamic is then evaluated by its properties such as the source, polarity and relational pattern (box 2). In the analysis, the dynamic is generated by the client. The polarity of the dynamic is negative by considering against the project management objectives. The interdependence of the dynamic act sequentially from increase in profit to rework. Subsequently the increase in profit margin causes to rework which can be further analyzed (box 3).

The above analysis can provide us a conclusion which includes the actual source of generating dynamics, the polar effect onto the project management objectives as well as the relational pattern of the dynamics. When a dynamic situation comes from the client, the other dynamics owners such as architect or main contractor can work closely to give quick response to the dynamic situation. For the client, the dynamic is positive when the gain from change in scope of work outweigh the loss to carry out rework. On the contrary, the loss outweighs the gain that shows negative to the client. However, this dynamic stimulates many other dynamics to other project parties. In the course of response to rework, other project parties will interact with each other, and each company system will be subject to SEQACT system objectives, CPMR resources as well as LIPSET system environmental forces. In this case, the change of work results from client's economic consideration. The cost and quality objectives to client and time objectives to main contractor should be examined so that the conflict of project management objectives can be minimized and the construction project management resources are best utilized. Meanwhile, the other relevant project parties should be taken into consideration and make a proper coordination and effective communication as well as cooperation so as to ensure the DCPMS working.

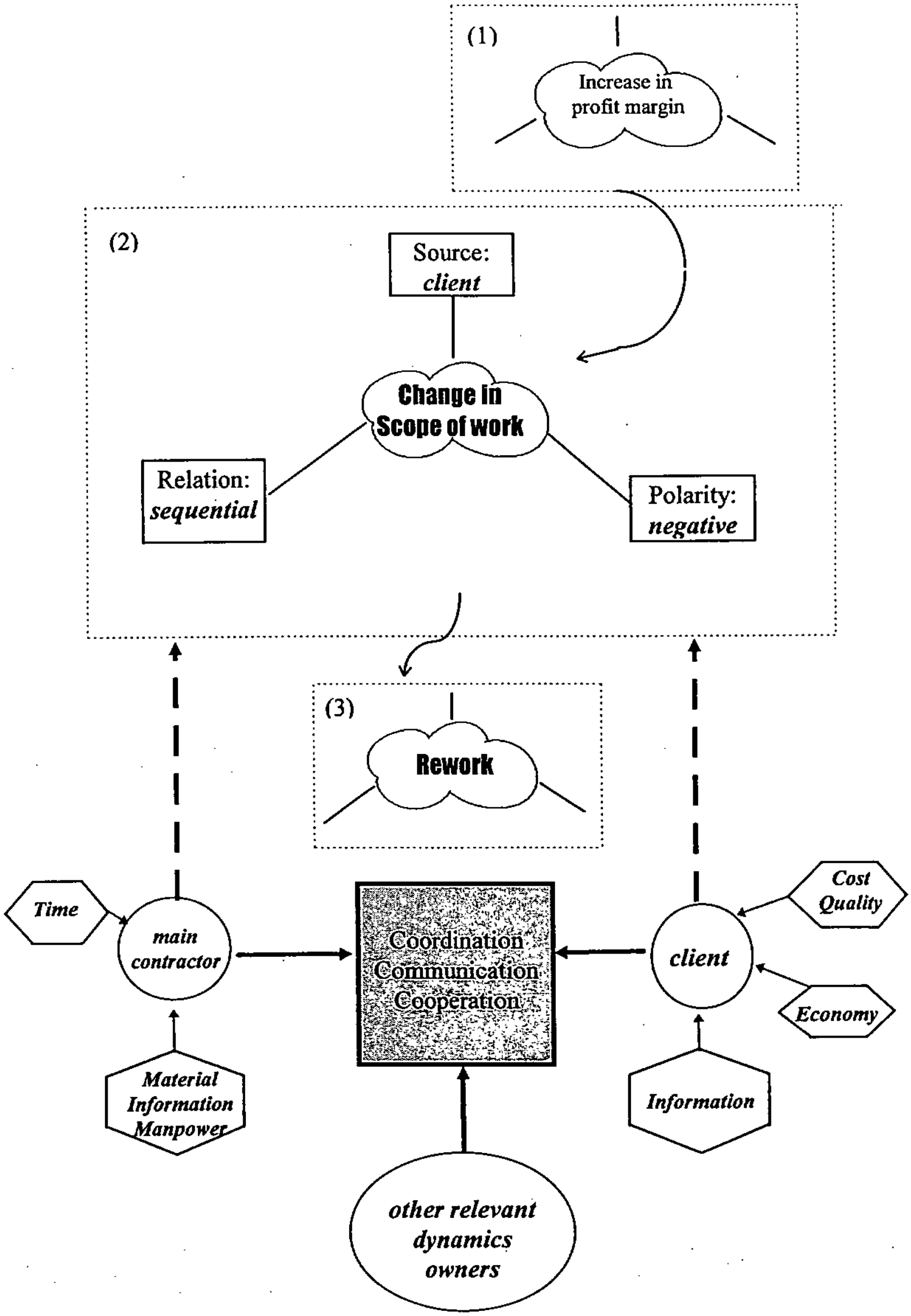


Figure 6.10 Response Process to Dynamics

6.4.5 Guidelines of Implementing Dynamic Systems Approach in Practice

In accordance with the dynamic systems approach, there require some guidelines for decision makers in practice to improve the quality of their decisions. In any practical ways, guidelines for managing the progress of the project development is eminent for project team to respond with any dynamic situations. However, any decision makers should basically have the idea on the causal chain of any dynamics and the system view on managing the project. The guidelines should be administrative in any decision points in the development process. Take weekly site meeting as an example to illustrate the basic guidelines as following:

1. Remind or restate the project management objectives (SEQACT)

Any discussions seem useless if the management team ignore or forget the objectives. It should frequently make sure the decision makers know the objectives.

2. Review the level of resources (CPMSR) and the progress of work packages

There should not have commercial secret on the level of resource in a project team. The real picture about the resources can help the decision makers in understanding the progress of their own work and the implications of communication, coordination and cooperation with other project parties.

3 Report the possibility of any changes or uncertainties in advance

Prevention is better than curing. Frank communication is needed to bring any dynamics out for discussion and to evaluate the impacts against the SEQACT objectives and CPMSR resources. It can create a team spirit to face any dynamics or crisis.

4. Record and agree immediately any concluding remarks within the meeting

Effective decision depends on sufficient information and efficient actions. A good meeting minute is critical for each project team member to act and react with the environment. It is even better to put the concluding remarks within the meeting on one A-4 size and distribute in written form to the members at once. If possible, one can leave agenda for next meeting so that all can prepare necessary information for the meeting.

6.5 Limitations and Potentials of Dynamic Systems Approach

6.5.1 Limitations of Dynamic Systems Approach

Both project management and system thinking are relatively new subjects and their applications are still young to the construction industry. Though systems approach to construction project management started in early 1970s, it seems restricted in the academic cycle. It may be explained by the feedback in the survey which shows that the respondents' capability of applying project management and system concept is limited. Such background implies that it is a challenge for the project management team to recognize the dynamic system model. Moreover, as the systems model is to be employed in the decision making process, the numerous elements and complicated relations may spend the decision makers much time in identifying, analyzing and responding to the dynamics or the dynamic situation. That means, they need to deal with extra details in reaching a decision. Furthermore, the operational definition of dynamics may not be well recognized or accepted by the actual dynamics owner or solver. This is because it may be too broad for one to define what is dynamic. Eventually, the perspective towards a dynamic situation depends on individuals. Since the project team members may act interactively to tackle the common dynamic. It may be a main drawback that it is required for the project team to have consensus on the definition of dynamics but it is hard to do so. In short, the DCPMS model is still needed to be improved, particularly by inspiring the construction practitioners and theorists to pay more attention to the dynamic nature of construction project management system and give feedback to improve the dynamic systems model.

6.5.2 Potentials of Improving Dynamic Systems Approach

The establishment of dynamic system for construction project management is an endeavour to explore a way of embracing 'changes' over the project management environment. It is not intended to provide management procedures or guides to solve the problems caused by 'changes' but to lay an analytical framework in which project stakeholders can have a more holistic view on the various changing aspects in construction project management activities and can gain a picture about the interactions between system components and elements. Consequently, the dynamics owner or solver can realize the dynamic situation and react properly to that situation by making appropriate decisions throughout the project life.

System objectives

In the system objectives component, *area* is suggested as a new objective because the clarification of subsystems or boundaries is crucial to project managers and coordinators who have to carry out management activities from differentiation via coordination to integration. If the project managers or coordinators could understand the implications of breaking down the whole into parts and then linking up the parts to a system, they can recognize the interdependencies between other system objectives and can manage the interactions between different system resources. However, further discussion and improvement is still required to verify it to be a system objective.

System resources

For the inherently complex and dynamic characteristic of project management system, the human effort to carry out analysis and hence making decisions by a systematic approach is tremendous. It is difficult for only human mental model and literal model to recognize the dynamic situation and deal with those corresponding dynamics. Therefore, it requires a computing model which can demonstrate the interrelationships between various system resources. It is suggested that the information oriented subsystem can be acting as a core managing tool for decision making process. The six interactive systems form a flow network which can be further developed in line with Forrester's dynamic system model which is a way of studying the behaviour of industrial system. One of the fundamental challenges to link up with Forrester's dynamic system model is the overcome the determination of dimensional units of measure in equations. There are certain potential computing software such as iThink, Powerism or Dynamo can be integrated into the construction project management information system.

Impacts of dynamics

Regarding the operational definition of dynamics, the chain of effects and the interdependence of the dynamics may be very complicated. Therefore, it needs simulation method which considers the changes and uncertainties.

6.6 Summary of Chapter Six

This chapter investigates the applications of dynamic systems approach in construction project management. The application areas of using the dynamic systems approach are identified for the management of projects. The decision making mechanism throughout the project life is crucial for the project team members who are working under a considerable dynamic environment. A dynamic systems approach is therefore suggested for decision making in a project environment. The approach stresses that the timing in responding to the dynamics or dynamic situations on construction project management is significant. It is because the effects of the dynamics or dynamic situations can greatly affect the overall project performance. Finally, a process of managing dynamics or dynamic situations is discussed with appropriate examples .

Chapter 7

Conclusions

This study considers construction project management as a dynamic system. The study leads to the following major conclusions:

(1) Importance of dynamic phenomenon to construction project management

The traditional static system thinking shows limitation in project management practice. Dynamic systems approach needs to deal with the dynamic phenomenon which is treated as a causal chain of project variables, changes, uncertainties and risks in construction project management.

(2) Theoretical model for construction project management as dynamic system

The theoretical model has been developed to represent the construction project management as dynamic system. The establishment of dynamic system help construction practitioners to understand the dynamic situation with a holistic view on the interactions of system elements.

(3) Strong awareness of dynamics in Hong Kong construction practices

A pilot survey to Hong Kong construction industry have been conducted. The indicative results show that the industry is subject to dynamic and there is a strong awareness of dynamics among the construction professionals. Regarding the management effectiveness in terms of decision making, the respondents do not satisfy themselves in general. It also shows that there is plenty of room for improving decision makers' capability to react with dynamics.

(4) Applicability of dynamic systems approach to construction project management

Dynamic systems approach helps improving the decision making process in construction project management. Nevertheless, this approach is still in a preliminary stage and may not be well recognized among the construction professionals. However, it highlights the importance of further considering dynamic systems approach in construction practice.

(5) Potential of dynamic systems approach to construction project management

The established dynamic system model can help decision makers to identify, analyze and respond to the dynamic phenomenon in a holistic view. The application of the dynamic systems approach has been evaluated and it is a critical role in managing construction project under a dynamic situation.

The need of applying dynamic systems approach

The ever-changing and uncertain environment affects the effectiveness of construction project management system. The tight schedule, competitive bidding, strict ISO quality standard, stringent safety measures, environment awareness, complicated technology oriented construction techniques and computing applications require project participants to be of innovative, creative and adaptive ability to their practices of managing construction projects.

The challenges to the management due to the increasing complexity in technology and organization in construction projects have resulted in the application of project management approach since its introduction in early 1970s. This approach has been widely adopted as an effective management method in construction industry. However, its capability to tackle the uncertainties involved in project management is of limitation. Construction project environment not only becomes more complicated but also more dynamic. There is a resort to merge the project management and system concepts in assisting project participants to meet the new challenges. Across a timeline of several years for delivering a construction, the process of constructing a project is full of variables, changes, uncertainties and risks. They interact as a chain to exhibit dynamic features. The chain of such interaction within the system in the project management environment illustrates that construction project management needs a dynamic approach, thus it is a dynamic system. In other words, dynamic system approach is requested for construction project management.

Development of the dynamic system model

Within construction project management, various systems can be defined as physical, social, legal, geological or procedural. These systems are interactive and interdependent to contribute to deliver not only a final physical system: building, but also human activities, knowledge, satisfaction and so on. The dynamic system for construction project management is constructed as composing of three essential components as project management objectives, project management resources and system environment variables. These components are interactive and changing in the construction process. The project management system objectives (SEQACT) include safety, environment, quality, area, cost and time. The project management system resources (CPMSR) include people, process, finance, material, machinery and information. The system environment forces (LIPSET) mainly comprise of legal, institutional, political, sociological, economic and technological force. Each group of components form their own sub-systems. A construction project management system intrinsically possesses a state of changing as its system components are not only interactive but changing as well. Thus, there is a chain of actions and reactions from management to the system elements, that reflects the dynamic characteristics of the construction project management system.

Definition of dynamics

The feature of the dynamics influencing management can be expressed as a chain of interaction of project variables, changes, uncertainties and risks. The aim of constructing the dynamic system for project management is to achieve the project objectives through the interactive project management system resources under the interrelated environmental variables. The dynamic systems approach is more suitable compared to traditional systems approach since the system is subject to a chain of interaction of variables, changes, uncertainties and risks within a defined project life cycle.

Major dynamics in the systems model

The major dynamics in construction project management system have been identified and classified into three representative dynamics as SEQACT objectives dynamics, CPMSR dynamics and LIPSET environment dynamics. There are different kinds of elemental dynamics within each group of representative dynamics. Individual dynamics can have either positive or negative impacts to the effectiveness of system. Those positive will work in line with project management objectives, whilst those negative will cause certain degree of loss or even project failures. Therefore, it is important for resources to be committed in the way of avoiding negative dynamics and strengthening the positive dynamics so that the system can be better performed to deliver a project successfully. The relations of dynamics have been characterized as pooled, sequential and reciprocal interdependence. Such classification can assist in assessing nature of dynamics. A proper methodology for managing dynamics in order to secure their positive effect is suggested. A systems approach is proposed as an effective way for studying the combined effect of the three groups of dynamics. Several major procedures will be applied in implementing the approach. The first step of this approach is to identify the sources and categories of dynamics with respect to the project phases and various project parties. Secondly, detail analysis on the identified dynamics is undertaken to find out the properties of the dynamics such as its state, polarity as well as interdependence. Finally, a proper responsive strategy or action is formulated to reduce the effects of the dynamic if it is negative, and improve its effects if it is positive dynamic.

Dynamic status of the Hong Kong construction industry

The construction industry in Hong Kong is under a high degree of dynamic in terms of the construction work value, manpower and the application of materials. Typical changes include population level, land use, housing scheme, construction manpower, material, and technology, which all together make the Hong Kong construction industry a very dynamic economic sector. Within such environment, dynamic systems approach is needed for effective management of either individual projects or the industry as a whole.

The dynamic phenomenon in the local construction industry is further supported by conducting questionnaire survey. A group of construction practitioners has been surveyed on the recognition of project management system and dynamics affecting the practice. Based on a scale from 1 to 10 representing the spectrum of 'strongly disagree', 'disagree', 'neutral', 'agree' and 'strongly agree', it has been found that the respondents' average consciousness in applying project management and system idea is below the line of 'agree'. It has also been found that some major project dynamics such as changes of project programme, frequent staff turnover, incomplete design or changes of design, implicit contract terms, changes of work scope as well as the changes of construction methods have different degree of impact on the effectiveness of project management. All respondents come very often across various kinds of major changes or variations. There is a wide spectrum of views among the respondents about whether the various management system guides within organizations are able to manage those dynamics, It implies that those prescribed system guides may not suffice to cope with the dynamic project environment. On the other hand, the practical survey also shows that the respondents' confidence in making effective decision under the dynamic situation is relatively low. This indicates the needs of developing a proper methodology for coping with the changes.

Dynamic systems approach to decision making process in project management

The function of dynamic project management system is determined by the decision mechanism, and the decisions in project management process will influence the behaviour of project dynamics to a large extent. Dynamic systems approach suggests a continuous monitoring, analysis and reaction process. In this process, the negative dynamics will be identified and effects reduced to minimum.

Significance of the study

In short, the significance of this research is the development of a dynamic systems approach to construction project management and explore a new research direction in construction project management with system thinking. However, there are some limitations of this study due to the limited resource and these limitations are being highlighted for future research.

Limitations and Potentials for the development of dynamic systems approach

As the questionnaire approach is just as an indicative survey, further extension of the survey with dynamic system thinking to all major project parties is recommended, in order to secure a more rich picture about the dynamic phenomenon in construction industry. The concepts of dynamics and dynamic system to construction project management are relatively new. It appears still difficult to reach consensus among project team members as they have different perspective on the dynamics or dynamic situation. There is a need of further study on applicable procedures of the new approach.

Simulation approach to dynamic system analysis is necessary. As the process of managing 'dynamic' is rather sophisticated. The impacts of dynamics are so complicated that simulation method is therefore suggested for further analysis. Regarding the decision making process, it needs developing decision-support system and applying computing software to formulate project strategy and policy as well. There are other areas which can be further developed to enrich the dynamic system model. For example, the construction of project management system objectives is very important for project managers and coordinators to implement effectively their management activities. Concerning the system resources for project management, the six interactive resources can be studied with reference to Forrester's dynamic system model which is a way of examining the behaviour of industrial system.

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Appendix

Sample of the Cover Letter for Questionnaire Survey

<<Name>>
<<Company>>
<<address>>
<<address>>

16 July, 1997

Dear <<Name>>,

Re: Academic Survey on Construction Project Management System

I am conducting a survey as a vital part in my thesis for the degree in Master of Philosophy in the Hong Kong Polytechnic University. I am writing to solicit your professional feedback on the attached questionnaire. It will take you **about 15-20 minutes** to complete.

Nowadays, construction project managers are facing an increasing complicated built environment, ever-changing market conditions as well as multiple project management objectives. The managers are inevitably prone to manage the changes and uncertainties under a dynamic construction management environment in order to meet the project management objectives - on time, within budget, with satisfactory quality as well as good site safety record. The focus of this survey is to investigate the degree of relationship between the **Changes or Uncertainties** in the **Construction Project Management System** and the managers' **Decision Making Effectiveness**.

It is much appreciated if you could **return it in the enclosed stamped envelop** or **fax** to 2764[redacted] or 2357[redacted] **by Jul 25,1997(Fri).** It is intended that the conclusive results from this survey will be sent to those of you are interested for reference.

Yours sincerely,

Mr. Fu Chi Sing, Franco
Research Student
Dept. of Building and Real Estate
The Hong Kong Polytechnic University

C.C. Dr. L.Y. Shen , Chief Supervisor
Prof. D. Scott, Co-Supervisor
Mr. Francis Wong, Co-Supervisor

Appendix

Sample of the Questionnaire

Part A General - Confidential

A1. Personal Information *(pls. fill in the blank or put ✓ in the checkbox)*

1.1 Name: ______________________(Dr./Ir./Mr./Ms.)

1.2 Position:______________ as a member in ☐ Top management ☐ Senior mgt. ☐ Middle mgt. ☐ Others_______

1.3 Department: ______________________

1.4 Years of experience in construction: ________

1.5 Tel : ____________ 1.6 Fax:__________

A2. Project Information *(pls. put ✓ in the checkbox or fill in the blank)*

2.1 Current Project Name: ____

2.2 Procurement Method: ☐ Traditional ☐ Project Management ☐ Management Contracting ☐ Turnkey ☐ Design and Build ☐ Construction

Management

☐ Others________________ pls. specify

2.3 Contract Sum: (HK$)____________(Approximately)

2.4 Project Duration: ______________(Approximately)

2.5 Current project stages ☐ Foundation ☐ Superstructure ☐ Finishes ☐ Others______

2.6 Types of Project: ☐ Residential ☐ Commercial ☐ Industrial ☐ Others ______

2.7 Nature of Client: (a) ☐ Public ☐ Private

(b) ☐ Single party ☐ Multiple parties

2.8 Gov't Approved Contractor Grouping: ☐ Class A ☐ Class B ☐ Class C ☐ Others____

Part B Identification of the Management Systems used in the Identified Project

Items	pls. indicate 'Y' if items are identified, otherwise 'N'.	pls. ✓if don't know ?	Degree of details of the identified item	Degree of Applicability to your management
			Opinion 1 2 3 4 5 6 7 8 9 10 (1 lowest, 10 highest) Pls. write the score on the following box.	
B1 Project Handbook				
B2 Mgt. System Guide				
B3 Programme/Schedule				
B4 Budget Plan/ Cost Plan				
B5 Quality Assurance Plan				
B6 Safety System/Plan				
B7 Environmental Mgt. System				
B8 Work Breakdown Structure				
B9 others ________				

Part C Cause of Changes or Uncertainties and Degree of Influence to Progress

Major Types of Changes or Uncertainties	Changes & uncertainties are mainly caused by :	Select any item nos.(a-q) and write in the following box accordingly		*How's the type of changes/uncertainties affecting the project progress* *1 2 3 4 5 6 7 8 9 10* *Least Most*
	Category I - Participants Item no.			
C1 Programme related e.g. change of milestone	a) Clients b) Architectural firms	C1		
C2 People related frequent staff turnover	c) Structural Engineering firms d) HAVC Engineering firms e) Quantity Surveyor	C2		
C3 Design related drawing redesign incomplete drawing	f) Government agencies g) Specialist -Telecommunications h) Suppliers	C3		
C4 Contract related implicit terms or conditions	i) Main Contractor j) Others_______________	C4		
C5 Scope of work change of use, increase in facilities	**Category II - General** k) Procurement System	C5		
C6 Construction method change of work process by applying various pre-cast components	l) Management Systems m) Company Policy n) Manager's tactics o) Market conditions p) Unfamiliarity to the project	C6		
C7 Others(pls. specify)	q) Others_______________	C7		

Part D Decision Making Process *(pls. circle the appropriate one)*

D1. As a manager, I face the **Changes and Uncertainties** in my management activities *(a) 1-3 times a week, (b) 4-6 a week, (c) 7-9 a week, (d) 10 or more* as mentioned above.

D2. Changes and Uncertainties are **Problems** which *are*
(a) factual; (b) intuitive;, (c) both (a) and (b)

D3. For my position, I always make the following types of decision:
*(I) (a) Strategic, (b)Tactic, (c) Operational, (d) Others*______
(II) (a)Structured, e.g. guide by standard procedure *(b) Semi-structured, (c) Un-structured* i.e. ad-hoc basis

D4. I think the above identified changes/uncertainties can **be managed** accordingly by applying the management systems identified in my current project referring to Part B on Page 1.

	Strongly disagree		*disagree*		*neutral*		*agree*		*Strongly agree*	
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
D5. In my management thinking, I can apply the concept of :										
(I) Project Management	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
(II) System	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
D6. I can make major decisions effectively in general	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
D7. All management levels make decisions effectively in general	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*

~ End ~

Thank you very much for your professional feedback!